Sixth Water and Diamond Fork

Sediment Transport, Channel Substrate, and Benthic Macroinvertebrate
FINAL MONITORING REPORT OCTOBER 2013

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SECTION 1: INTRODUCTION

Watershed and Hydrology

The Diamond Fork watershed, part of the Great Salt Lake basin, drains approximately 156 square miles of primarily mountainous terrain in north-central Utah (Figure 1-1). Historically, the watershed has been affected by trans-basin flow imports from streams within the Colorado River basin. The earliest water delivery system, completed in 1913, conveys water from Strawberry Reservoir into Sixth Water Creek, a tributary to Diamond Fork, via the Strawberry Tunnel (Figure 1-2). Imported water was conveyed through Sixth Water Creek into Diamond Fork and the Spanish Fork River for use along the Wasatch Front. The imported water greatly increased the flow volumes primarily during the summer irrigation season in Sixth Water Creek and Diamond Fork relative to their natural summertime flow levels (Figure 1-3), resulting in significant channel incision, erosion, and widening with damaging ecological consequences.

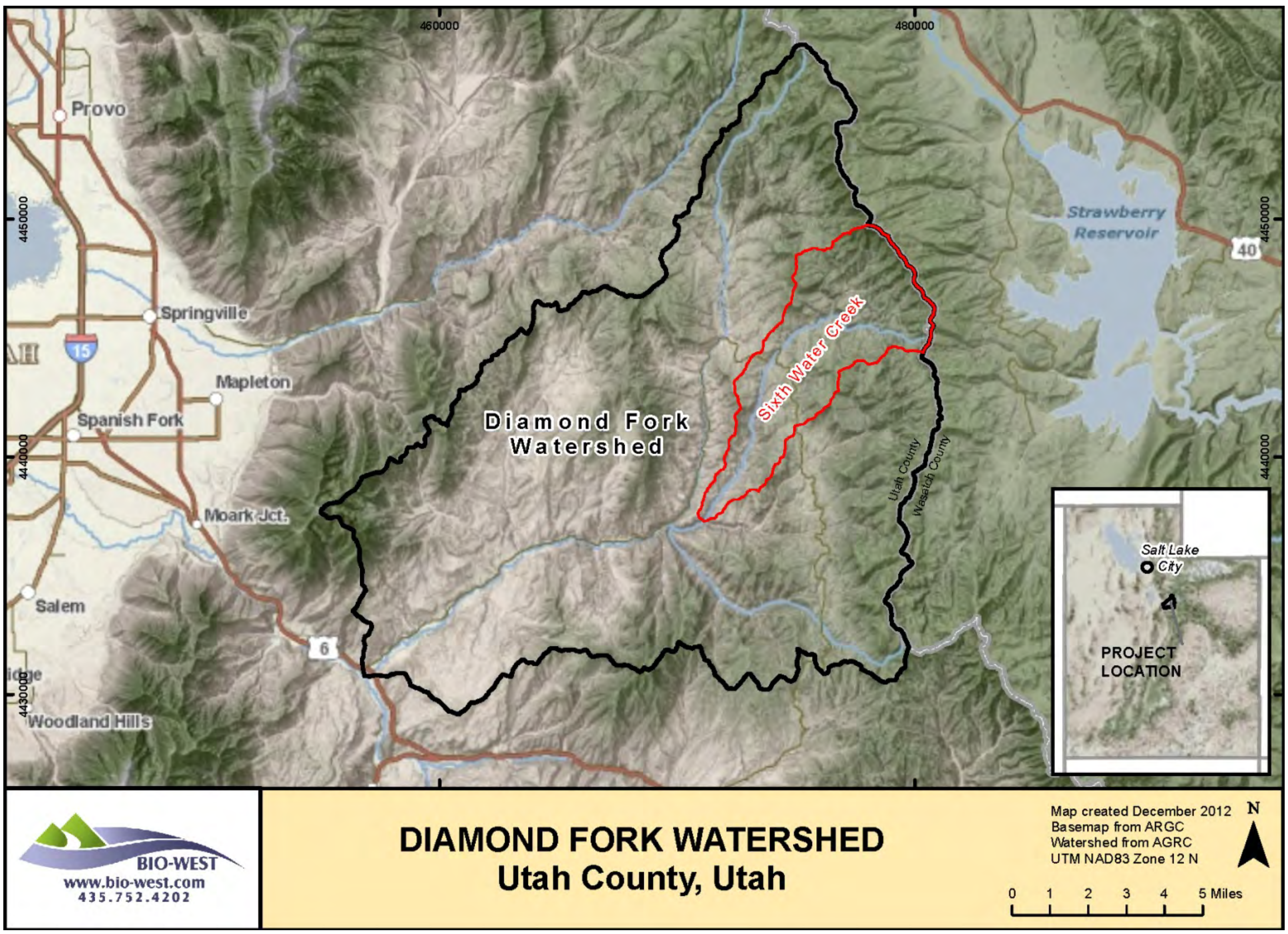


Figure 1-1. General location of the Diamond Fork Watershed.

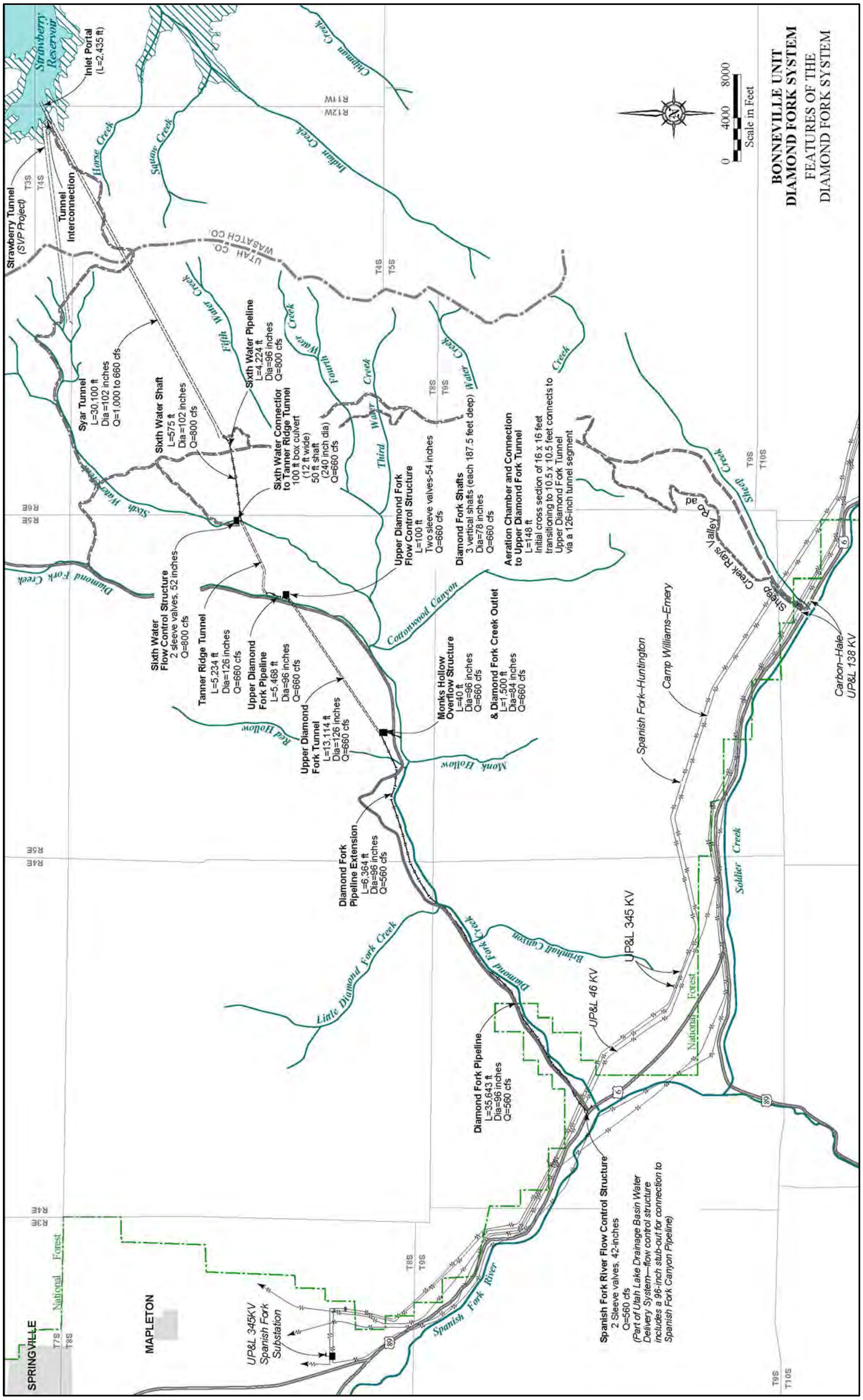


Figure 1-2. The Diamond Fork System, comprised of a series of tunnels and pipelines, delivers water from Strawberry Reservoir to the Spanish Fork River and avoids placing flows directly into Sixth Water Creek and Diamond Fork Creek. Strawberry Tunnel was replaced by Syar Tunnel, but it is still used to convey instream flows to Sixth Water Creek (map provided by the Central Utah Watery Conservancy District).

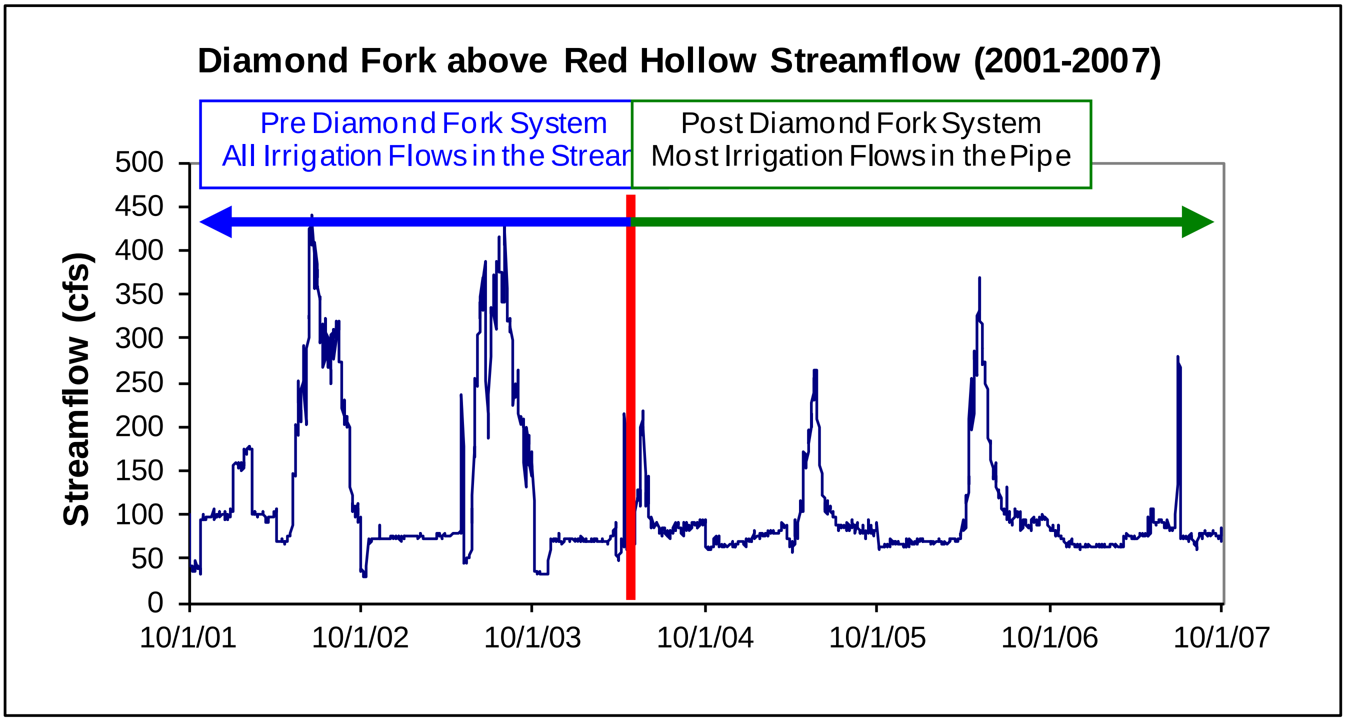


Figure 1-3. Annual hydrographs before and after construction of the Diamond Fork System (USGS 10149400 DIAMOND FORK ABV RED HOLLOW NR THISTLE, UT).

The Diamond Fork water delivery system was completed in 2004 as part of the Bonneville Unit of the Central Utah Project. The Diamond Fork System entailed construction of a series of new tunnels and pipelines that allow the majority of imported flows to bypass Sixth Water Creek and Diamond Fork Creek and instead be delivered directly to Spanish Fork River and/or the Spanish Fork Canyon Pipeline (Figure 1-2). Flow releases into Sixth Water and Diamond Fork are typically made only to meet the minimum instream flow requirements set as part of environmental commitments associated with the construction of the Diamond Fork System and the Central Utah Project Completion Act.

In Sixth Water Creek from the outlet of the old Strawberry Tunnel, minimum flows were established as follows:

- 25 cfs in the winter months of November through April, and
- 32 cfs in the summer months of May through October.

Water to meet these minimum flow requirements is typically delivered via the Strawberry Tunnel.

In Diamond Fork Creek, minimum flows were established between Monks Hollow and Spanish Fork River as follows:

- 60 cfs in the winter months of October through April, and
- 80 cfs in the summer months of May through September.

Water to meet these minimum flow requirements is typically delivered via the Sixth Water Flow Control Structure via the Syar Tunnel located just below Ray's Crossing (Figure 1-2).

Delivery of minimum flows has caused damage to the sleeve valves of the Sixth Water Flow Control Structure, and during November 2011 to April 2012, the sleeve valves were removed for repairs and the structure could not be used to deliver instream flows. Therefore, additional releases were made upstream at the Strawberry Tunnel outlet. This operational change meant that the 2011-2012 winter flows in Sixth Water Creek temporarily increased from the typical 25 cfs to about 38 cfs, and winter flows in Diamond Fork temporarily decreased from the typical 60 cfs to about 50 cfs (Figure 1-4).

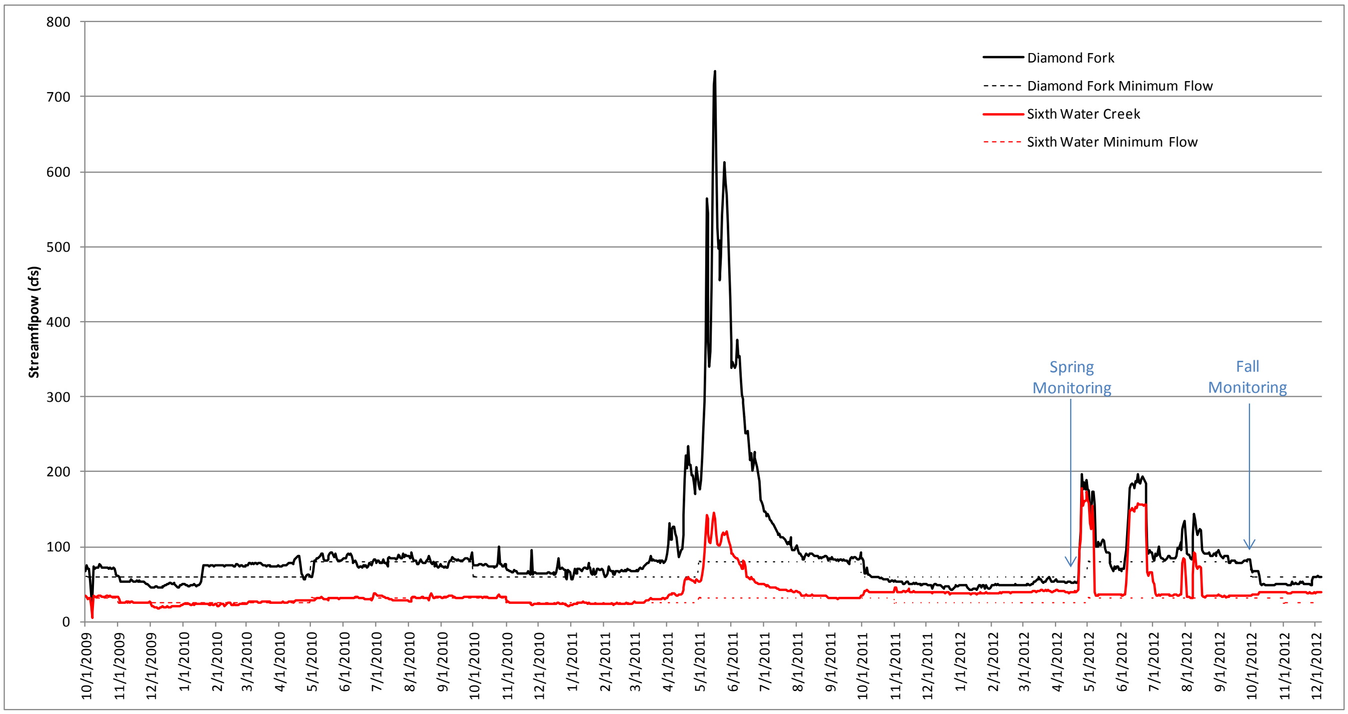


Figure 1-4. Diamond Fork and Sixth Water Creek hydrographs for water years 2010–2012. Required minimum flows are also plotted for comparison.

Also, during spring of 2012, additional repair work to the Diamond Fork water delivery system meant that unusually high flow releases of about 150 cfs were released through the Strawberry Tunnel on two separate occasions, each lasting about 2 weeks (Figure 1-4).

One additional item of note regarding recent streamflow patterns in Diamond Fork and Sixth Water Creek is the magnitude of the spring 2011 flood. The winter of 2010-2011 generated historically high snowpack volumes in much of Utah, and the spring 2011 floods on Diamond Fork and Sixth Water were the highest recorded since the USGS gages at each site became active in 2002 and 2005, respectively. In 2011, flows on Diamond Fork peaked at 887 cfs, which was significantly higher than the previous recorded high peak of 531 cfs in 2006. In 2011, flows on Sixth Water peaked at 171 cfs, which was slightly higher than the 2006 recorded peak flow of 152 cfs.

Study Purpose

The purpose of this work was to conduct monitoring that measured channel substrate conditions and the benthic macroinvertebrate assemblages in select reaches of Sixth Water and Diamond Fork. Monitoring results will assist the natural resource agencies in evaluating, planning, implementing and adapting the recovery and restoration of the aquatic and riparian ecosystems of the two creeks, especially in response to anticipated high flow releases from Strawberry Tunnel in 2012.

Monitoring Plan

Channel substrate and benthic macroinvertebrate conditions were monitored at a total of ten monitoring sites. These sites are listed in Table 1-1 and their locations are shown in Figure 1-5. Specific spring and fall 2012 monitoring dates are listed in Tables 1-2 and 1-3. Channel substrate (substrate mapping, pebble counts, embeddedness) and benthic macroinvertebrate monitoring data have previously been collected at four of the ten monitoring sites: SXW, DFC, MO and OX. In 2007, seasonal embeddedness measurements were also completed at the RC monitoring site. In 2006, the GS monitoring site was established as a control site for benthic macroinvertebrate sampling, and macroinvertebrate data were collected there in 2006 and 2007. Results from the past monitoring work at these sites, which involved data collection in 2005, 2006, and 2007, are summarized in the Sixth Water and Diamond Fork Creeks Final 2007 Monitoring Report (BIO-WEST 2009). For the 2012 monitoring effort, four new monitoring sites (AST, BST, AMH, and BMH) were established where no previous channel substrate or macroinvertebrate data had been collected. These four new monitoring sites not only provide above and below comparisons of Syar and Monks Hollow flow control structures, they also occur in portions of the watershed not well represented in the original 4 monitoring sites. Overall, the 10 monitoring sites represent a range of historical and current flow import effects on stream hydrology (Table 1-1).

As a separate but related effort, sediment transport data were collected during low flow in 2011 and 2012 at the six bridge locations shown in Figure 1-5. Sediment transport data had previously been collected at these same six sites in 2005 and 2006 (BIO-WEST 2006, BIO-WEST 2007).

Table 1-1. Monitoring site descriptions and minimum instream flow requirements.

MONITORING SITE	SITE NAME	CREEK	APPROXIMATE SITE LENGTH (feet)	FLOW IMPORT EFFECTS	WINTER/ SUMMER INSTREAM FLOW (cfs)
SXW[a]	Sixth Water	Sixth Water	560	Affected by Strawberry Tunnel inputs	25/32
RC[b]	Ray's Crossing	Sixth Water	860	Affected by Strawberry Tunnel inputs and landslide sediment inputs	25/32
USWB[c]	Upper Sixth Water Bridge	Sixth Water	n/a	Affected by Strawberry Tunnel inputs and landslide sediment inputs	25/32
AST	Above Syar Tunnel	Sixth Water	179	Affected by Strawberry Tunnel inputs and landslide sediment inputs	25/32
BST	Below Syar Tunnel	Sixth Water	180	Affected by Strawberry Tunnel and Syar Tunnel inputs and landslide sediment inputs	25/32
LSWB[c]	Lower Sixth Water Bridge	Sixth Water	n/a	Affected by Strawberry Tunnel inputs, Syar Tunnel Inputs, and landslide sediment inputs	25/32
GS[d]	Guard Station	Upper Diamond Fork (above Sixth Water Confluence)	216	none (natural hydrology)	n/a
DF3FB[c]	Three Forks Bridge	Upper Diamond Fork (above Sixth Water Confluence)	n/a	none (natural hydrology)	n/a
AMH	Above Monks Hollow	Diamond Fork (below Three Forks)	301	Affected by Strawberry Tunnel and Syar Tunnel inputs	25/32
BMH	Below Monks Hollow	Diamond Fork (below Three Forks)	314	Affected by Strawberry, Syar, and Upper Diamond Fork Tunnel inputs	60/80
MHB[c]	Monks Hollow Bridge	Diamond Fork (below Three Forks	n/a	Affected by Strawberry, Syar, and Upper Diamond Fork Tunnel inputs	60/80
DFC[a]	Diamond Fork Campground	Diamond Fork (lower)	1237	Affected by Strawberry, Syar, and Upper Diamond Fork Tunnel inputs	60/80
MO[a]	Motherload	Diamond Fork (lower)	1682	Affected by Strawberry, Syar, and Upper Diamond Fork Tunnel inputs	60/80
BB[c]	Brimhall Bridge	Diamond Fork (lower)	n/a	Affected by Strawberry, Syar, and Upper Diamond Fork Tunnel inputs	60/80
OX[a]	Oxbow	Diamond Fork (lower)	2668	Affected by Strawberry, Syar, and Upper Diamond Fork Tunnel inputs	60/80
CB[c]	Childs Bridge	Diamond Fork (lower)	n/a	Affected by Strawberry, Syar, and Upper Diamond Fork Tunnel inputs	60/80

[a] Long-term site (substrate mapping, embeddedness, pebble count, macroinvertebrate data).
[b] Long-term site (embeddedness data only).
[c] Sediment transport sampling location.
[d] Long-term site (macroinvertebrate data only).

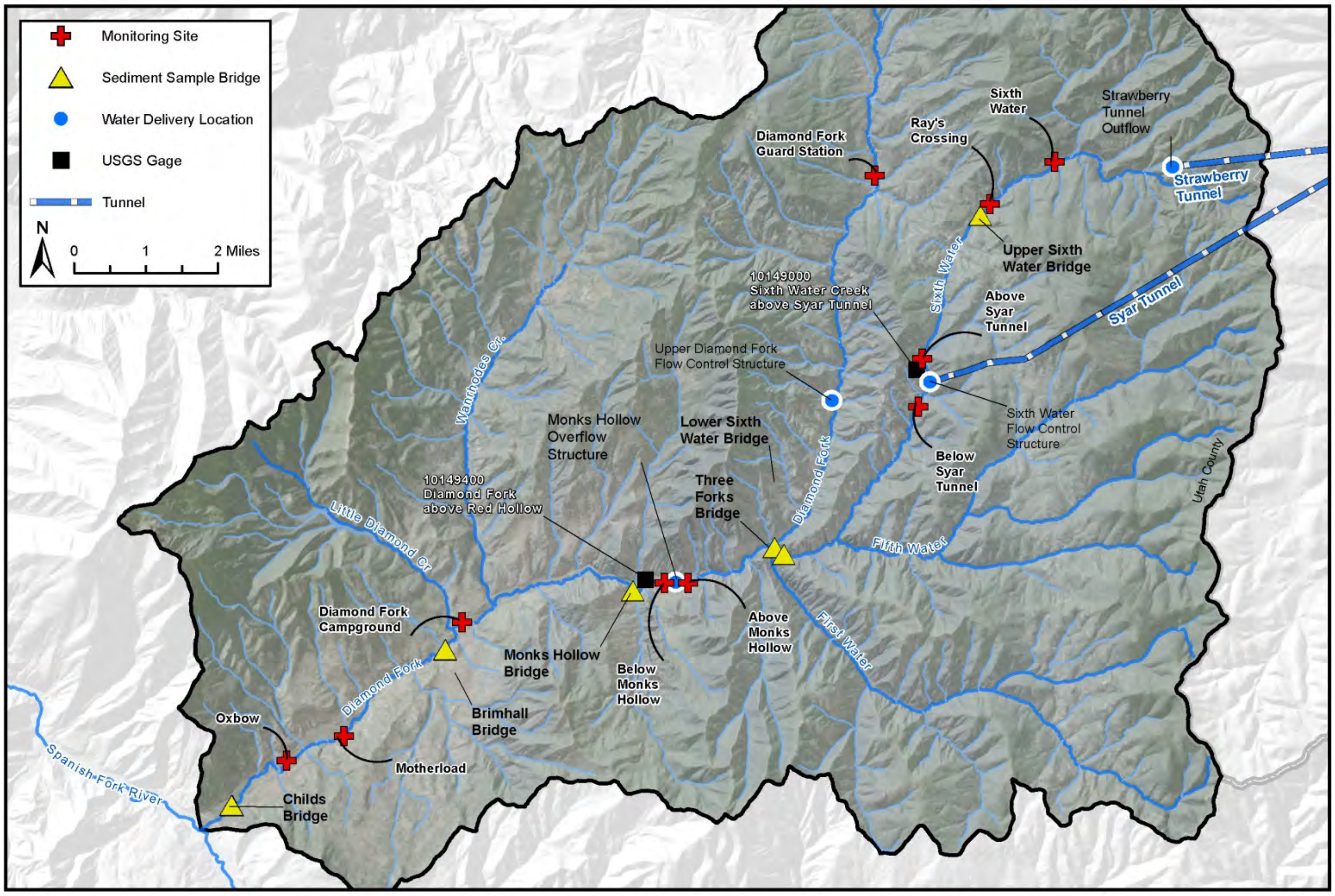


Figure 1-5. Map of 2012 monitoring sites on Diamond Fork and Sixth Water Creeks.

Table 1-2. Spring 2012 monitoring dates.

SITE	SUBSTRATE MAPPING		PEBBLE COUNTS		EMBEDDEDNESS		MACROINVERTEBRATES	
	Date	Flow (cfs[a])	Date	Flow (cfs[a])	Date	Flow (cfs[a])	Date	Flow (cfs[a])
SXW	4/19/2012	41	4/12/12	39	4/12/12	39	4/17/12	40
RC	4/19/2012	41	4/12/12 and 4/13/12	39/38	4/12/12	39	4/17/12	40
AST	4/19/2012	41	4/12/12 and 4/18/12	39/40	4/12/12	39	4/17/12	40
BST	4/19/2012	-	4/12/12 and 4/18/12	-	4/12/12	-	4/17/12	-
GS	4/20/2012	-	4/13/12 and 4/18/12	-	4/13/12	-	4/17/12	-
AMH	4/20/2012	-	4/13/12 and 4/18/12	-	4/13/12	-	4/18/12	-
BMH	4/20/2012	52	4/13/12 and 4/18/12	54/53	4/13/12	54	4/18/12	53
DFC	4/19/2012	53	4/13/12	54	4/13/12	54	4/18/12	53
MO	4/20/2012	52	4/13/12	54	4/13/12	54	4/18/12	53
OX	4/18/2012	53	4/14/12	54	4/14/12	54	4/18/12	53

[a] flow in cubic feet per second (cfs) as reported in USGS provisional daily flow data for gage #10149400 (sites BMH, DFC, MO, OX) and for gage 10149000 (sites SXW, RC, and AST); daily flow data not available for sites BST, GS, AMH.

Table 1-3. Fall 2012 monitoring dates.

SITE	SUBSTRATE MAPPING		PEBBLE COUNTS		EMBEDDEDNESS		MACROINVERTEBRATES	
	Date	Flow (cfs[a])	Date	Flow (cfs[a])	Date	Flow (cfs[a])	Date	Flow (cfs[a])
SXW	9/20/2012	34	9/25/12	34	9/25/12	34	9/20/2012	34
RC	9/20/2012	34	9/25/12	34	9/25/12	34	9/20/2012	34
AST	9/20/2012	34	9/26/12	34	9/26/12	34	9/20/2012	34
BST	9/20/2012	-	9/26/12	-	9/26/12	-	9/20/2012	-
GS	9/20/2012	-	9/25/12 and 9/26/12	-	9/25/12	-	9/20/2012	-
AMH	9/20/2012	-	9/26/12	-	9/26/12	-	9/20/2012	-
BMH	9/21/2012	78	9/26/12	82	9/26/12	82	9/20/2012	79
DFC	9/21/2012	78	9/26/12	82	9/26/12	82	9/20/2012	79
MO	9/21 and 9/23/2012	78	9/27/12	82	9/27/12	82	9/20/2012	79
OX	9/23/2012	78	9/27/12	82	9/27/12	82	9/20/2012	79

[a] flow in cubic feet per second (cfs) as reported in USGS provisional daily flow data for gage #10149400 (sites BMH, DFC, MO, OX) and for gage 10149000 (sites SXW, RC, and AST); daily flow data not available for sites BST, GS, AMH.

SECTION 2: SEDIMENT TRANSPORT

Maintaining the minimum streamflow in Sixth Water and Diamond Fork during the winter months typically requires that the Sixth Water sleeve valves operate at low flows of approximately 20 cfs (additional stream flow is made through the Strawberry Tunnel and from other tributaries). Delivery of the low flows since 1996 damaged the Sixth Water sleeve valves of the Sixth Water Flow Control Structure. The two Sixth Water Sleeve Valves were removed in late 2011 for repairs and therefore flow releases could not be made through the structure. While the sleeve valves were removed, the only location at which releases could be made for instream flow purposes was through the old Strawberry Tunnel. Therefore while the Sixth Water Sleeve Valves were being repaired, winter flows in Sixth Water Creek were temporarily changed from 25 cfs to about 38 cfs (release of 32 cfs plus ~ 6 cfs accretion in the tunnel). Winter flows in Diamond Fork Creek were temporarily changed from a minimum of 60 cfs at Monks Hollow to approximately 48–52 cfs (Figure 1-4).

As a result, flows in Sixth Water downstream of the Sixth Water Flow Control Structure and flows in Diamond Fork Creek dropped below previously sampled levels. The Mitigation Commission contracted with Allred Restoration and BIO-WEST (BW) to collect sediment transport samples in select reaches of Sixth Water and Diamond Fork Creeks during the fall and winter of 2011 and 2012 to continue their habitat monitoring and ongoing investigations into sediment transport dynamics in the streams. This data collection was intended to assist natural resource agencies in planning, implementing and adapting the recovery and restoration of the two streams. Sampling efforts in 2011 and 2012 were a continuation of the sediment transport monitoring that was performed by BW in 2005 and 2006 in the same locations (Figure 1-5 and Table 1-1) as well as the channel substrate monitoring performed in 2005–2007 (Olsen et al. 2005, etc.). In summary, sediment transport has been monitored in Sixth Water and Diamond Fork because of concerns that the current flow regime might be causing sedimentation and fining of the streambed, and negatively affecting habitat quality for aquatic biota. Relationships between flow and sediment transport/sediment accumulations in Sixth Water and Diamond Fork have to be understood at the reach level because of a large known source of sediment in Sixth Water at a landslide between the Strawberry and Syar Tunnel inputs, and the fact that the channel slope transitions from steep in the higher elevation portions of the watershed to relatively flat in the lower elevations, and that the low gradient depositional stream reaches are experiencing significant accumulations of fine-grained sediment during the summer, fall, and winter "low flow" seasons.

Specific questions about sediment transport that will be answered in this chapter of the report are as follows:

1. What was the effect of reducing flow rates on sediment transport?

2. Would reducing instream flows alone resolve the problem of "fining" or sediment accumulation?

3. Would reducing flows in Sixth Water Creek alone (not affecting the flows in Diamond Fork at Monks Hollow) result in the same response as reducing instream flows in both Sixth Water and Diamond Fork Creeks?

Sixth Water and Diamond Fork Creek results relevant to the 2011 and 2012 sediment sampling can be found in Chapter 4 of the 2005–2007 monitoring reports. A brief summary of conclusions from these report chapters is as follows:

2005, Chapter 4, Sediment Transport Monitoring

> The typical Sixth Water flow regime (25 cfs winter, 32 cfs summer) is unnatural and causing unnaturally high yields of both suspended and bedload sediments during all times of the year. The channel is much steeper in Sixth Water than Diamond Fork; therefore, material eroded in Sixth Water is transported through the canyon reaches of Sixth Water and Diamond Fork and often becomes deposited in the flatter reaches of Diamond Fork Creek.
>
> Current bedload transport rates are much greater than what would be predicted by typical bedload transport equations. In fact, the abnormally high sediment supplies from Sixth Water are causing the actual bedload transport rates to exceed predicted rates by more than two orders of magnitude at the lower Sixth Water and main stem Diamond Fork monitoring sites. [BIO-WEST 2006]

2006, Chapter 4, Sediment Transport Monitoring

> Discharge of imported water in Sixth Water Creek and Diamond Fork to augment instream flows to required minimum levels causes the proportion between base flow and peak flow to be approximately 1:2 in Sixth Water Creek and less than 1:10 in Diamond Fork Creek, whereas the natural proportions would be greater than 1:20 as seen at Diamond Fork above Three Forks (above the confluence with Sixth Water and Cottonwood Creeks) and other gauged streams that are not influenced by water imports. In summary, summer and winter base flows are elevated to the point that they cause abnormally high yields of both suspended and bedload sediments.
>
> A potentially alarming problem with the elevated flows is the continuation of fine- and coarse-grained sediment transport after spring runoff subsides, causing significant amounts of associated sedimentation and cobble embeddedness, primarily in the lower reaches of Diamond Fork Creek. Additional comparisons illustrate the fluvial geomorphic significance of the imported water where the threshold of gravel transport lies somewhere between natural and the current elevated base flows. Reductions in base flow sediment transport should benefit benthic macroinvertebrates, fish habitat, and reproduction success in lower Diamond Fork. [BIO-WEST 2007]

2007, Chapter 4, Sedimentation and Embeddedness Monitoring

> Since subsurface cementation has been observed at two of the lower Diamond Fork monitoring sites (MO and OX), both surface and subsurface deposition are suspected. It is likely that the fine particles being transported during base flow start filling the void spaces on and under the surface of the channel following the “flush” or gravel-cleaning function of spring runoff. In other words the “gravel filter” becomes clogged every year. After spring runoff cleans the channel and deposits fresh gravel material, the continued bedload and suspended-sediment transport fills the voids in the substrate, sometimes causing a cementing effect in the surface and subsurface channel material. This fine-particle deposition eventually expresses itself in the fall on the stream

> bed surface because subsurface voids are filled up or cemented in. The flatter reaches of Diamond Fork Creek are becoming significantly embedded, and gravel patches are becoming covered with silt.
>
> Sedimentation and embeddedness of the channel is occurring at very high rates where ideal spawning gravels are located. During the November sampling period several spawning redds (probably brown trout [*Salmo trutta*]) were observed in the MO and OX reaches. Fine-particle deposition occurred very quickly during this relatively sensitive spawning season. The measurable rate of sedimentation is greater in the fall than what was observed immediately following the peak-flow event in early July. It is probable that the macroinvertebrate population differences observed between the spring and fall samples, and between 2005 and 2007 samples, have a direct correlation with sedimentation and cementation of Diamond Fork Creek.
>
> Visual observations made during the substrate mapping efforts indicate that run sections in MO and OX appear to be elongating upstream and downstream, and this, in turn, may be shortening the riffles and pools. It appears that channel cementation may be armoring the heads and tails of riffles and pools. [BIO-WEST 2009]

In summary, a significant amount of bedload and suspended sediments are being transported year round, which is an "unnatural" condition not typically seen in snowmelt-driven stream systems of the Intermountain West. This in turn is causing significant sedimentation in the lower reaches of Diamond Fork Creek and impairing benthic organisms and fish habitat, especially substrate conditions for fall-spawning fish. To better understand this discharge to sediment transport relationship, the 2011 and 2012 sediment samples were collected during a scheduled period of diminished imported water to the Diamond Fork Creek drainage (a scheduled maintenance period) to determine if, and by how much, lower flows might help reduce or eliminate ongoing sedimentation problems in lower Diamond Fork Creek.

An important detail to consider is that because of the temporarily altered instream flow regime, flows through upper Sixth Water Creek were actually higher than normal for that time of year. More water was entering Sixth Water Creek upstream at Strawberry Tunnel to offset flows that would otherwise be delivered at the Sixth Water Flow-Control Structure. A large landslide and significant sediment source is located between these two structures, and the delivery of higher flows farther upstream in Sixth Water Creek could confound the downstream monitoring results.

To clarify results and discussion the following terms are defined as follows:

Sedimentation:	Accumulation of sediment in and on the streambed.
Embeddedness:	Condition where the coarse sediments (gravel and cobble) on the channel bottom are being cemented together by finer grained sediment (silt, sand, and small gravel).
Bedload Transport:	Transport of sediment on the streambed by rolling bouncing or sliding.
Outside the runoff period:	Sediment transport period not during runoff (roughly July to April).

During runoff: Sediment transport period during and shortly after spring runoff (roughly April to July).

Methods

Discharge, suspended sediment, and bedload were sampled on October 3, 2011, December 28, 2011, and October 29, 2012. All the samples collected in 2011 and 2012 were collected when flows in lower Diamond Fork were planned to be at their lowest level compared to previous years (Table 2-1). Samples were targeted for 60 and 50 cfs or lower in lower Diamond Fork following the same methods as were used during the 2006 sampling effort (Olsen et al. 2006).

Table 2-1. The 2011 and 2012 Diamond Fork and Sixth Water Creeks bedload sampling results and estimated thresholds.

SAMPLE SITE	DATE	DISCHARGE	BEDLOAD TRANSPORT (tons/day)	LARGEST GRAIN SIZE IN TRANSPORT	ESTIMATED BEDLOAD TRANSPORT THRESHOLD +/- 10 cfs
Upper Sixth Bridge	10-3-2011	35	0.030	1–2 mm	~ 15 cfs
Lower Sixth Bridge	10-3-2011	73[a]	0.185	4–8 mm	~ 20 cfs
	10-29-2012	40	0.025	2–4 mm	
Diamond Fork at 3 Forks Bridge	10-3-2011	13[b]	0.002	< 1 mm	n/a
	10-29-2012	10	0.002	< 1 mm	
Monks Bridge	10-3-2011	86	0.413	4–8 mm	~ 40 cfs
	12-28-2011	46[a]	0.054	1–2 mm	
	10-29-2012	50	0.039	2–4 mm	
Brimhall Bridge	10-3-2011	88	0.608	8–16 mm	~ 45 cfs
	12-28-2011	67[a]	0.146	2–4 mm	
	10-29-2012	50	0.083	2–4 mm	
Childs Bridge	10-3-2011	88[a]	0.308	8–16 mm	~ 50 cfs
	12-28-2011	64[a]	0.026	1–2 mm	
	10-29-2012	50	0.029	< 1 mm	

[a] Bedload-sample sieve results and transport rates were calculated directly from the sample data. Estimated thresholds assume that the bedload transport threshold is at 0.01 ton/day and that the largest grain size in transport is < 1 mm in diameter. (Note: Discharge values marked with an [a] were collected by BIO-WEST and values marked with a [b] were estimated by subtracting the upstream from downstream discharge values. Discharges reported for the other samples were obtained from U.S. Geological Survey gauges.)

Results

It was noted in the field that there were periods of turbidity in Sixth Water Creek during the October 3, 2011 sample, which correlated with scattered showers in the upper Sixth Water drainage. Photo 2-1 was taken just upstream of the Lower Sixth Water Bridge (LSXW) on 10-3-2011 just after sampling had been concluded. No suspended sediment samples were collected during these periods of high turbidity because this was considered an anomaly compared to other base flow samples. Although un-sampled to date, events like this one that occurred on October 3, 2011 likely occur several times each year.

Photo 2-1. Photo taken of turbid water just upstream of the Lower Sixth Water Bridge on 10-3-2011.

Suspended sediment measurements collected in fall 2011 and 2012 show transport rates similar to those measured during the rising limb of spring runoff in 2005 and 2006 at all bridge sites (Figure 2-1). This elevated amount of suspended sediment in transport is likely the result of elevated Sixth Water base flows from tunnel maintenance activities, warm temperatures that could have melted some of the snow pack and scattered rain showers that occurred in the drainage on the sample days. For these reasons, these data were used to refine the suspended sediment transport to discharge relationship for the rising limb of spring runoff. Overall the samples collected in 2011 and 2012 show a good correlation with rising limb data collected in 2005 and 2006. The 2011 and 2012 samples improved the correlation between discharge and transport for all the rising limb rating curves.

Bedload samples collected at Upper Sixth Water (USXW), DF3F, Brimhall and Childs Bridges during fall low flows in 2011 and 2012 show the lowest bedload transport rates observed at these sites to date (Figure 2-2). Comparing bedload transport rates shows that at lower discharges, transport rates decreased by a factor of approximately 8, 4, and 12 respectively (Table 2-1 and Figure 2-1, D–F). The 2011 and 2012 low flow sampling results show a direct correlation between discharge and sediment transport rates at the Monks, Brimhall, and Childs Bridges bedload sample sites.

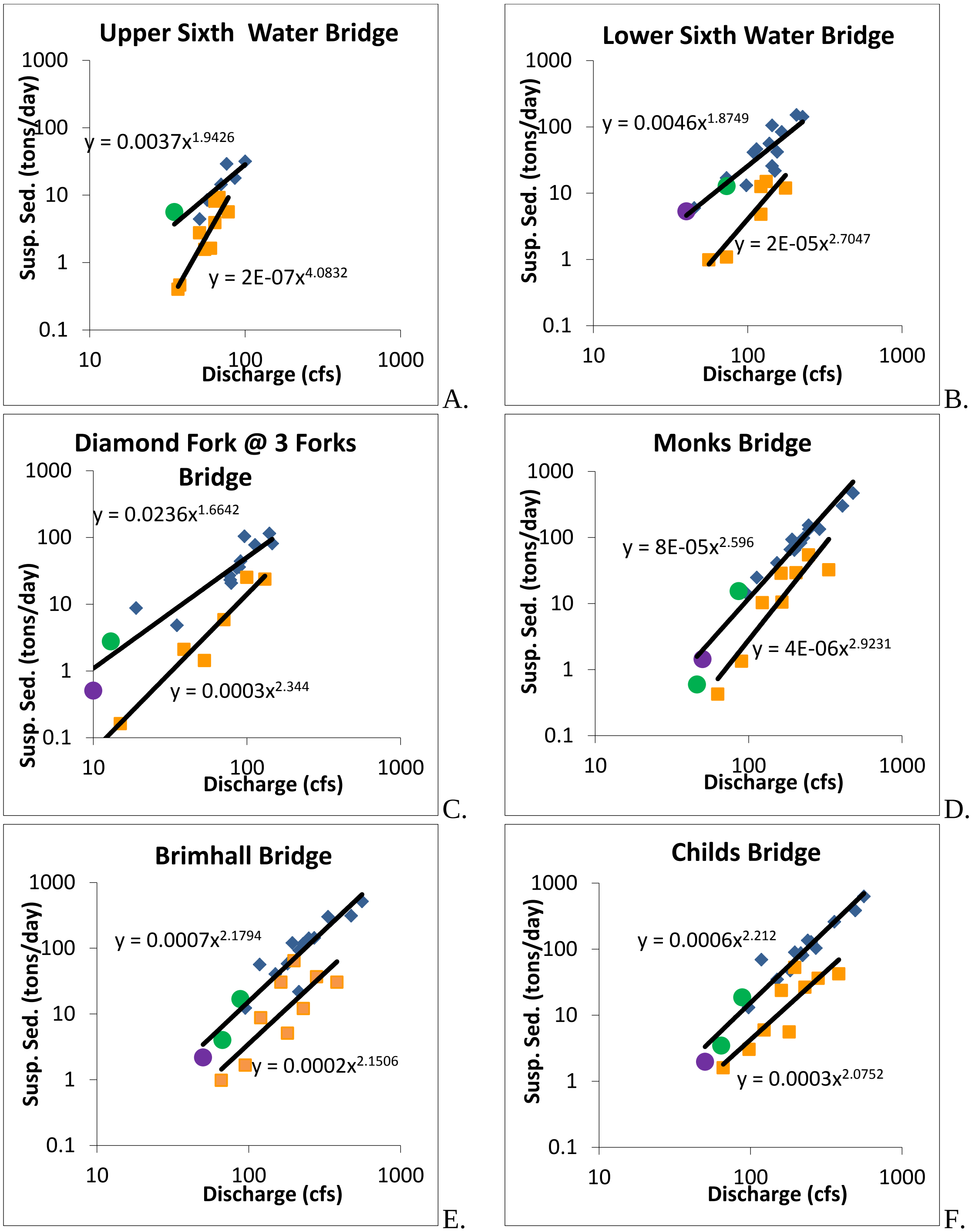


Figure 2-1. Suspended sediment sample data with power regression rating curves for six sites along Diamond Fork and Sixth Water Creeks. Blue data points are samples collected during the rising limb of the 2005 and 2006 spring runoff. Orange data points are samples collected during the rest of the 2005 and 2006 sample year with the green data being collected in 2011 and purple in 2012. The 2011 and 2012 sample data were included with the regression of the rising limb data set (there were elevated Sixth Water Creek base flows from tunnel maintenance activities, several localized storm events in 2011, and some snow melt during the 2011 monitoring period that probably increased turbidity temporally).

Sieve results show there was a reduction in the largest grain size in transport with lower flows at the Monks, Brimhall, and Childs Bridges sample sites (Table 2-1). There was a four-fold reduction in the largest grain size in transport at Monks Bridge (from 4–8 mm to 1–2 mm at discharges of 86 and 46 cfs, respectfully). At Brimhall Bridge there was also a four-fold reduction in the largest grain size in transport (from 8–16 mm to 2–4 mm as discharge is reduced from 88 cfs to 50 cfs), and at Childs Bridge there was more than an eight-fold reduction (from 8–16 mm to <1 mm as discharge is reduced from 88 cfs to 50 cfs) (Table 2-1). Repeat samples collected in 2011 and 2012 at the lower three Diamond Fork Creek sites show that at reduced flows, the larger gravel-sized particles fell out of transport.

Repeat sampling at Monks, Brimhall, and Childs Bridges in 2011 and 2012 shows that transport rates declined significantly with lower flows. However, these lower transport rates were still greater than what would transport naturally outside the runoff period. For example, bedload transport rates at LSXW and all lower Diamond Fork sites were 3 orders of magnitude greater in October than at the DF3F site. Low-flow discharges sampled in December 2011 and 2012 were still above the threshold for sand and small gravel bedload transport at all sites except Childs Bridge at 50 cfs in 2012. The largest grain size in transport of this sample was < 1 mm. Rough empirical estimates of this bedload transport threshold for each sediment sampling site are shown in Table 2-1.

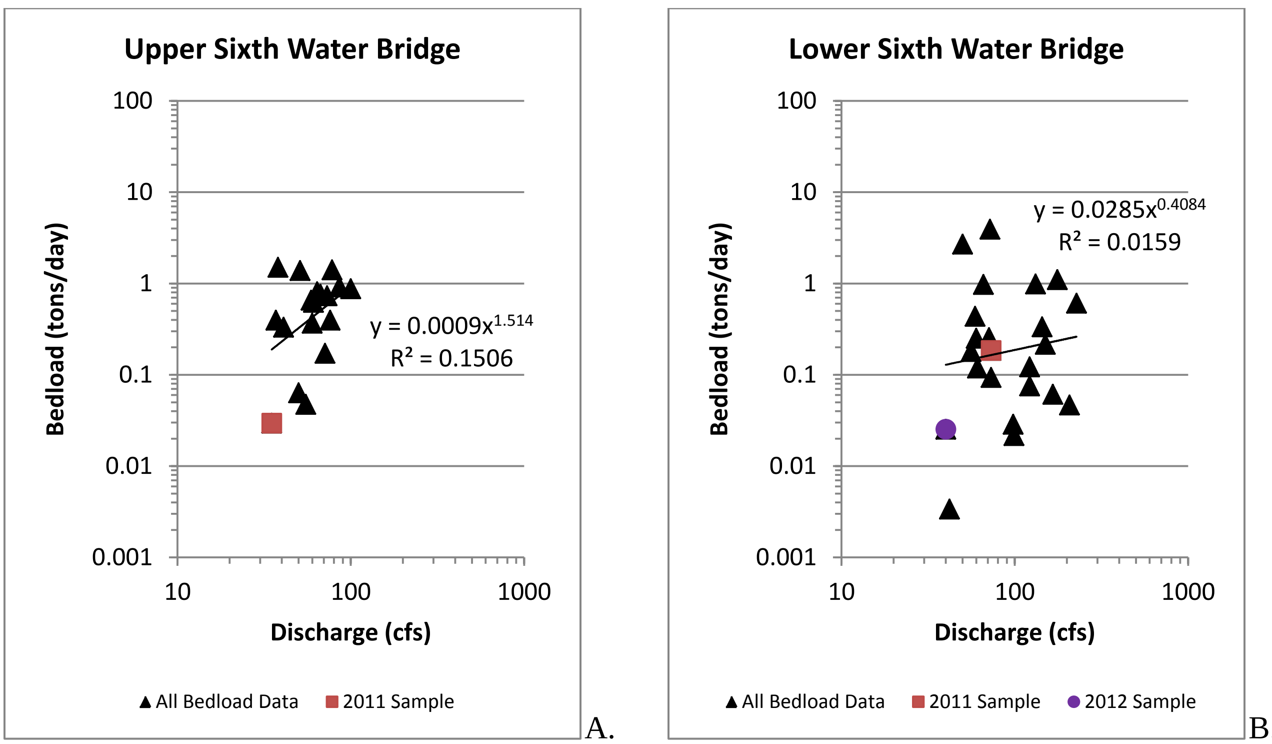


Figure 2-2. Bedload sample data with power regression rating curves for six monitoring sites along Sixth Water and Diamond Fork Creeks. Samples indicated by black points were collected during 2005 and 2006. Sample indicated by red points were collected in the fall and winter of 2011. Sample indicated by purple points were collected in the fall of 2012. Rating curve equations are shown with their corresponding R^2 values (samples collected in 2011 and 2012 were included in the regression). ***(This figure is continued on the next page.)***

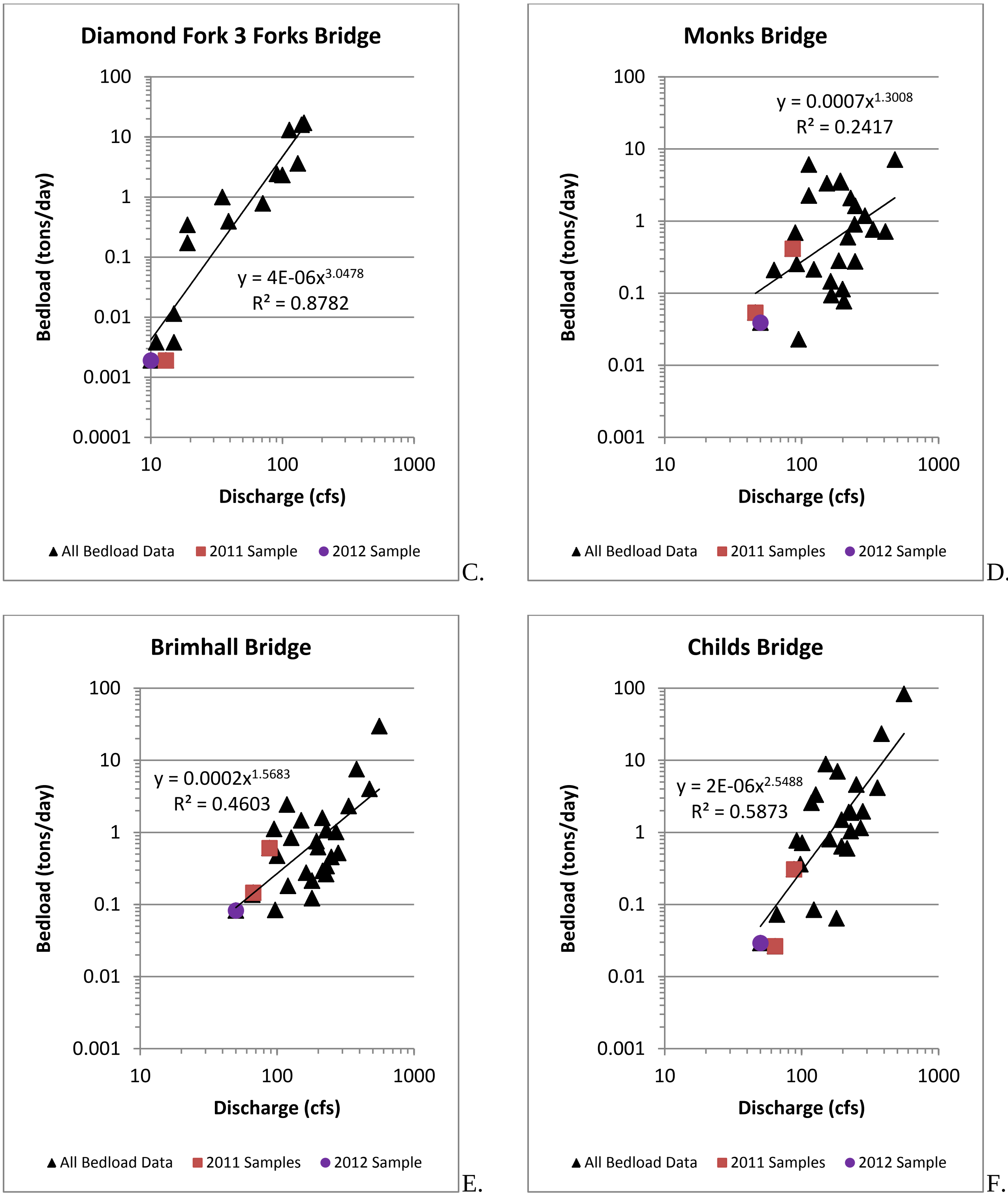


Figure 2-2. (Cont.)

Discussion

Conclusions presented in the 2005–2007 reports are consistent with the 2011 and 2012 low flow sampling results. It appears that there has been no change in the sediment transport regime at the six sites since the 2005 and 2006 sample seasons. In both 2011 and 2012, rates of suspended sediment in transport were similar to samples collected in 2005 and 2006 on the rising limb of spring runoff (Figure 2-1). These high rates of suspended sediment were a product of elevated base flows from imported water, snow melt and scattered showers. They are also a product of the current watershed conditions. In the past, year-round high flows delivered to Sixth Water Creek caused channel erosion and lowered the elevation of the channel and its tributaries. This resulted in increased bank and hillslope relief, which is now contributing high loads of sediment to Sixth Water Creek (which still maintains elevated base flows relative to natural peak flows).

In 2011 and 2012, monitoring at the Monks, Brimhall, and Childs Bridges sites showed a drop in bedload transport rates at lower discharges (Figure 2-2). Further, there was an eight- to four-fold reduction in the largest grain size in transport at lower flows (Table 2-1). However, even at the lower discharges sampled in 2012, relatively high rates of bedload transport occurred and the largest grain size in transport was either sand or small gravel.

When these results are combined with past bedload data, the thresholds for bedload transport at each site are roughly estimated (Table 2-1). In general, these thresholds were determined by using the power equations to calculate the discharge at which bedload transport would drop to less than 0.01 ton per day, with the largest grain size in transport being less than 1 mm. We postulate that if flows were lowered below these thresholds outside of the runoff season, beneficial processes would occur, and the embeddedness problems described in 2005-2007 (BIO-WEST 2007, 2008, and 2009) would be reduced. First, bedload transport rates would decline drastically and sedimentation and embeddedness would return to near natural conditions (likely improving water quality, benthic macroinvertebrate communities, and fish habitat). Second, if Sixth Water Creek discharges were lowered below the calculated thresholds, it is possible that hillslope and bank erosion would decrease, allowing streamside vegetation to establish over time. Sediments that are now effectively evacuating through Sixth Water Creek might be stored longer term near their source, causing the channel and riparian area to aggrade and stabilize further.

By adding the 2011 and 2012 results to the data and conducting further analysis, we have identified a second rating curve that represents the bedload transport conditions outside the runoff period: At each of the sites, a clear distinction was identified in the sample data (Figure 2-3). Bedload data were separated into two groups, samples collected during runoff when high flows had mobilized the bed material and samples collected outside the runoff period when the bed was immobile and embedded. We postulate that once all of the voids in the streambed are filled with fine-grained sediment, the incoming bedload particles simply roll along the top of the flattened surface with less “hiding effect” (Einstein 1950). The difference in these rating curves is roughly one to two orders of magnitude. This means that, outside the runoff period, roughly 10–100 times more bedload sediment is in transport than would occur during spring runoff at the same discharge. Notice that the same method of separating the sample data was attempted with the DF3F regression (natural discharge stream), but a single rating curve for all the data resulted in a higher R^2 value (compare Figure 2-2c and Figure 2-3), meaning that the voids remain unfilled at DF3F during the summer/fall low flow seasons.

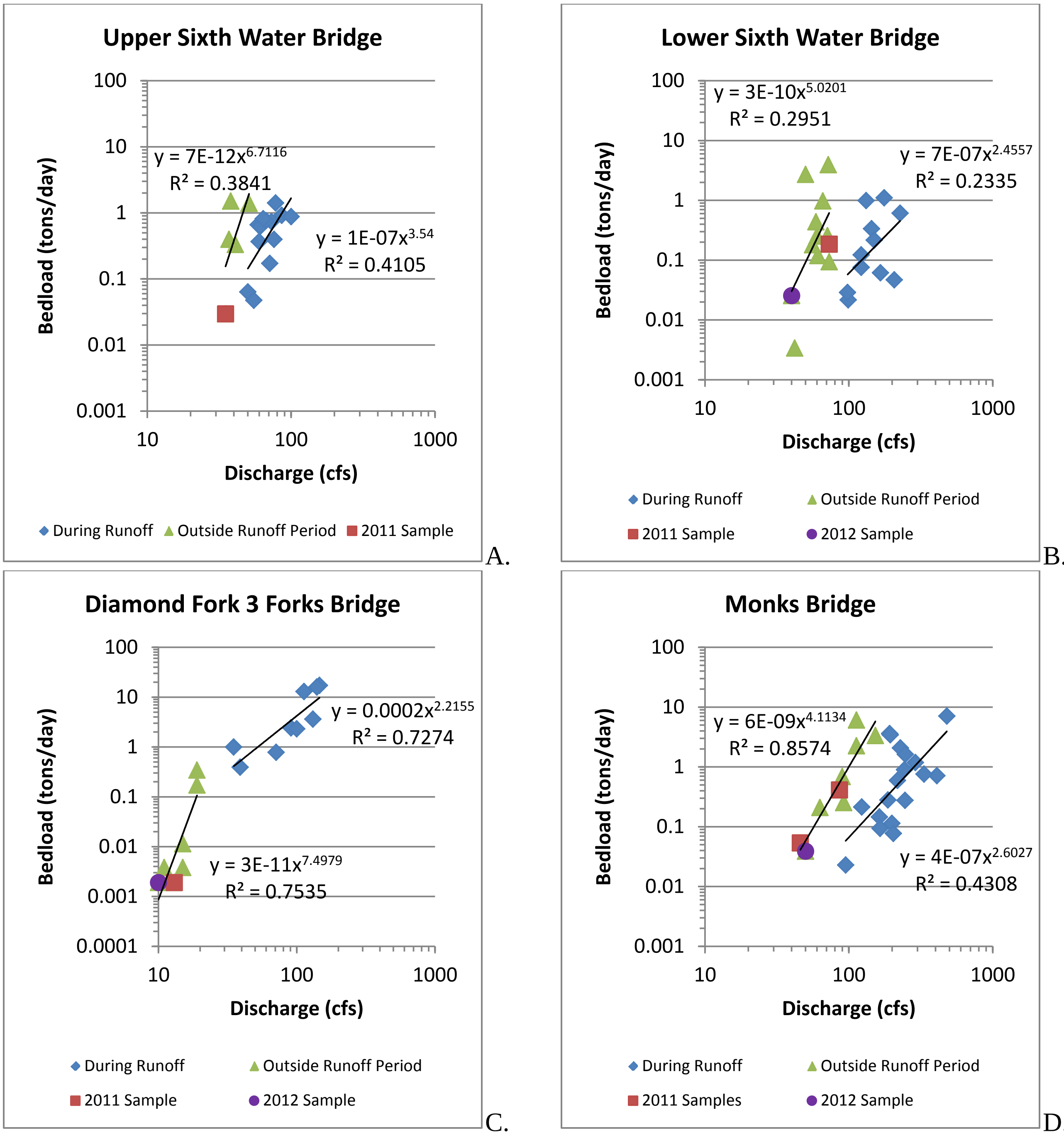
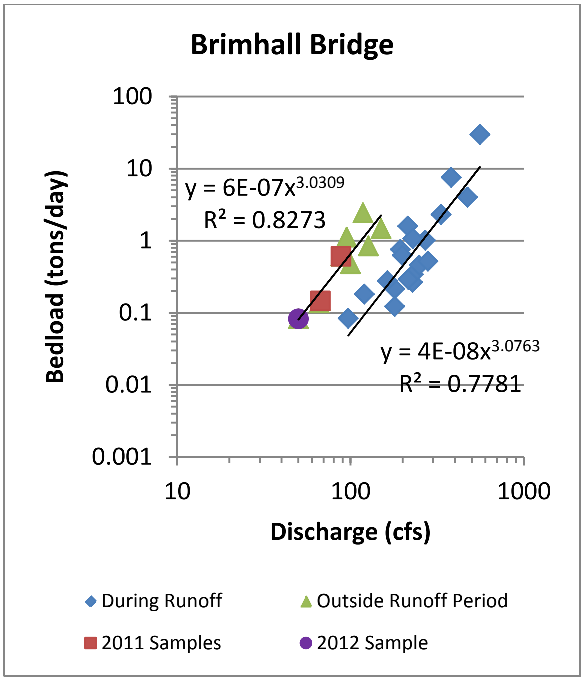
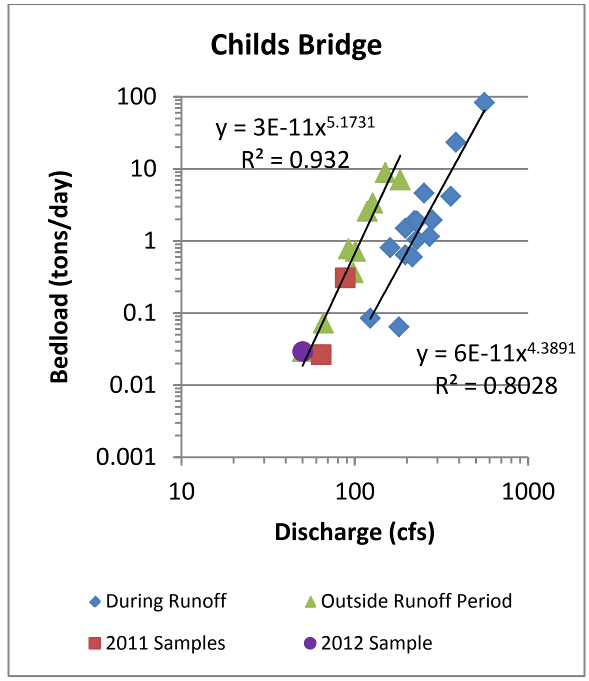


Figure 2-3. Bedload sample data with power regression rating curves for six monitoring sites along Sixth Water and Diamond Fork Creeks. Samples indicated by blue points were collected during spring runoff in 2005 and 2006, while the channel bed material was mobile and not embedded. The samples indicated by green points were collected outside the runoff period during 2005 and 2006 monitoring years, and the samples indicated by red and purple points were collected in the fall and winter of 2011 and 2012. Green and red data-point samples were collected while the channel was embedded. Samples collected in 2011 and 2012 were included in the regression of the outside runoff period data set. ***(This figure is continued on the next page.)***



E.



F.

Figure 2-3. (Cont.)

Embeddedness or cementation of the channel is effectively decreasing channel roughness in the Diamond Fork Creek drainage, leaving little hiding space for smaller-grained particles to rest. It appears that transport rates on lower Diamond Fork and Sixth Water Creeks are not only a function of flow but are also a function of the channel conditions changing seasonally, becoming embedded outside the runoff period each year. Presently-managed flows are causing bedload transport of sand and small gravel to occur year round. This year-round bedload transport is causing sedimentation to occur, which eventually embeds the channel bottom and increases transport rates further (Figure 2-3, green, red, and purple data points). This process likely has undesirable implications for stream ecosystem health.

Summary

The 2011 repeat bedload samples collected at the Monks, Brimhall, and Childs Bridges show that at lower discharges bedload transport rates decline and the largest grain size in transport decreases in diameter. However, even the lower discharges sampled in 2011 and 2012 still had slightly above natural transport rates, maintaining some sand and small gravel mobility. Reducing discharges at each site to below the estimated thresholds for bedload transport would decrease bedload transport and sedimentation problems currently present in the lower reaches of Diamond Fork. Reducing sedimentation would likely significantly improve stream habitat and aquatic biota health in Diamond Fork Creek.

Question 1: 1. Did sediment transport rates reduce to a more natural level at lower discharges?

Answer: Yes and the largest grain size in transport was much smaller. However, a relatively small amount of transport was still active.

Question 2: Would reducing instream flows alone resolve the problem of "fining" or sediment accumulation?

Answer: Theoretically yes, with significantly reduced flows and a relatively long period of time for the channel to adjust. However, the geology, watershed conditions, and landslides will create sedimentation and turbid conditions for decades. Currently, high flows outside the runoff period are magnifying the problem by transporting most of the sediment downstream once it enters the channel. With reduced minimum flows, sediment entering the channel would deposit closer to the source and perhaps allow vegetation to establish and the channel to maintain some habitats that are less embedded.

Question 3: Would reducing flows in Sixth Water Creek alone (not affecting the flows in Diamond Fork Creek at Monks Hollow) result in the same response as reducing instream flows in both Sixth Water and Diamond Fork Creeks?

Answer: Probably. Reducing flows in Sixth Water to below the threshold discharges would significantly reduce the constant loading of fines to lower Diamond Fork Creek. However, with base flows equal to or greater than 80 cfs in lower Diamond Fork Creek, significant amounts of bedload is in transport 365 days/year. Reducing flows to around 40 cfs at Monks Bridge (45 cfs at Brimhall Bridge and 50 at Childs Bridge) would drop bedload transport, significantly reduce sedimentation, and maintain the streambed in a much more desirable condition.

SECTION 3: CHANNEL SUBSTRATE

Methods

Substrate Mapping

Substrate classifications throughout each monitoring site were hand delineated in the field on air photo printouts (2011 NAIP imagery; 1 meter pixel resolution) plotted at either 1:1000 or 1:2000 scale. Staff delineated substrate into visibly homogeneous substrate types based on dominant and sub-dominant particle sizes. Classification was based on a modified Wentworth scale (Table 3-1). Bar deposits containing significant amounts of grass or other vegetation were considered to be "vegetated" and were not included in the substrate maps even if they also contained areas of bare cobble, gravel, sand, or silt. In deep areas where visibility was poor, substrate composition was estimated based on the feel of the material underfoot. Poor visibility areas too deep to wade were classified as having an "unknown" substrate type.

Table 3-1. Size classes used for substrate mapping.

SIZE CLASS (millimeters)	DESCRIPTION	ABBREVIATION
<2	sand/silt	SA/SI
2–8	fine gravel	FG
8–32	medium gravel	MG
32–64	large gravel	LG
64–256	cobble	C
>256	boulder	B

Substrate maps were digitized into a geographic information system (GIS) layer using ArcMAP® software with the 2011 orthophotos as base images. Within ArcMAP® each substrate patch (polygon) was attributed with the percentage of the polygon in each substrate size class. These values were multiplied by the area of each polygon to determine the total area of each size class within the entire monitoring site. For mapping purposes, a simplified dominant size class ("major" substrate type) was also identified for each polygon.

The substrate mapping methods employed during 2012 were as similar as possible to those used to map the SXW, DFC, MO, and OX sites during the original 2005–2007 monitoring effort. However, during 2005–2007, topographic surveys of the edge of water and bar and island extents were completed annually as part of related geomorphic monitoring work. This survey data enhanced the accuracy of the channel substrate mapping efforts. In 2012, no geomorphic monitoring or surveying was completed; therefore, substrate mapping relied solely on the available aerial imagery and visual field estimates of distance to establish the boundaries of the wetted channel, bar deposits, and substrate polygons. The extent of the active channel is not always readily apparent in the 2011 orthophotos, which are only of moderate resolution and quality. Therefore, the 2012 substrate maps should not be considered to be of comparable accuracy to the previous years' maps.

Pebble Counts

In addition to the visual substrate mapping effort, quantitative pebble counts (Wolman 1954) were completed at a number of discreet depositional patches, and across the entire wetted channel on at least one transect within each monitoring site. Pebble counts were located primarily in riffles or on bars to facilitate sampling. At the four long-term monitoring sites (SXW, DFC, MO, OX), six pebble counts per site were completed at the same locations sampled in 2007, or as close to the 2007 locations as possible given channel changes that occurred. Of the newer monitoring sites, four pebble counts were conducted at the RC site, and three pebble counts were completed at each of the remaining five monitoring sites (AST, BST, GS, AMH, and BMH).

Pebble counts were repeated at the same locations in the fall as in the spring, and 100 pebbles were counted at each patch and/or transect for every sample. The pebble counts consisted of systematically selecting pebbles across the entire width of the channel or patch area, measuring the b-axis, and then placing the pebbles back in the channel. Great care was taken to pick the pebble that was felt at the very center of the index finger, space the counts evenly across the channel or patch, and place the pebble back in the same area so as not to bias subsequent samples.

Particles were grouped into 10 size classifications (upper limits of 2, 4, 8, 16, 32, 64, 128, 256, 512, and 1,024mm) and plotted to determine grain sizes of the D16, D25, D50, D75, D84 and D90 particles.

Embeddedness

During the summer and fall of 2007, BIO-WEST conducted repeat monthly embeddedness measurements at multiple cross-channel transect locations within each of the long-term monitoring sites (SXW, DFC, MO, OX) as well as at the RC site. A strong seasonal trend of increasing embeddedness with time following spring runoff was evident. In 2012, BIO-WEST conducted embeddedness measurements at the pebble count transect location within each of the ten monitoring sites. The transect selected for each site for both pebble counts and embeddedness measurements corresponds to the riffle or run location used for macroinvertebrate Hess sampling in 2012. Embeddedness measurements were completed two times during 2012 – once in April and once in September.

At the embeddedness transect for each site, a measuring tape tag line was set up across the channel between established rebar endpoints. Wolman pebble counts (Wolman 1954) were consistently performed in the zone between 1-2 meters downstream of the tag line, while the embeddedness estimates were consistently performed 1 meter above the tag line. This methodology was used to prevent the embeddedness estimates from being influenced by disturbance of the streambed when performing pebble counts.

Embeddedness is defined (Sylte and Fischenich 2002) by the percent of the gravel to boulder clasts that have more than half of their mass buried by particles that are less than 2 mm (sand and silt). Embeddedness estimates were categorized into a few basic classifications that could be documented and repeated by the same sampler (Table 3-2). The level of embeddedness was estimated at the same location for the spring and fall samples. The embeddedness estimate was made along the length of the measurement tape tag line in 1- and, in some cases, 0.5- foot intervals. To prevent judgment errors, embeddedness estimates were conducted by the same person for both the spring and fall 2012

Table 3-2. Embeddedness estimate classifications and descriptions.

CLASSIFICATION	DESCRIPTION
Not	< 5% of clasts are embedded
Some	5–50% of clasts are embedded
Most	50–95% of clasts are embedded
Full	> 95% of clasts are embedded

monitoring events. This individual was the same person who completed the 2007 embeddedness sampling. Each cross section was photographed once for upstream, downstream, left bank, and right bank views. Every embeddedness classification for each cross section and sample date was photographed with a digital underwater camera.

The embeddedness estimates for each delineated area (measured in distance across the channel) were then compiled and converted to total percentages of the channel in each embeddedness class per cross section. The spring versus fall results were plotted and compared for each site.

Results

Substrate Maps

Spatial Comparison of Monitoring Sites

Plots and maps of the major/dominant substrate types for each monitoring site (Figures 3-1a to 3-1j and Figure 3-2) illustrate some differences in streambed particle size distributions among the sites. In general, these differences are what would be expected based on channel size and slope differences. The sites located on Sixth Water Creek (SXW, RC, AST, BST) are steeper and coarser-bedded than the sites located on Diamond Fork. Boulders comprise the dominant substrate material at the Sixth Water Creek sites (Figure 3-2). At SXW, AST, and BST, finer-grained particles are generally found only in localized bar deposits and eddy areas, and in small low-velocity "pockets" behind individual boulders within the main channel. The RC site includes a large main channel sand/silt deposit associated with a significant beaver dam in the middle of the site, which creates a slackwater area about 70 feet long (Figure 3-1b). The RC site also includes some low-velocity side channel areas influenced by debris dams and dominated by sand/silt material.

The two downstream-most monitoring sites on lower Diamond Fork (OX and MO) have the finest-grained streambed substrate, with about half of the site area comprised of particles medium gravel-sized (32mm) and smaller (Figure 3-2). The remaining monitoring sites (GS, AMH, BMH, and DFC) have intermediate substrate size distributions and contain significant amounts of both gravel and cobble-sized material (Figures 3-1e to 3-1h and Figure 3-2).

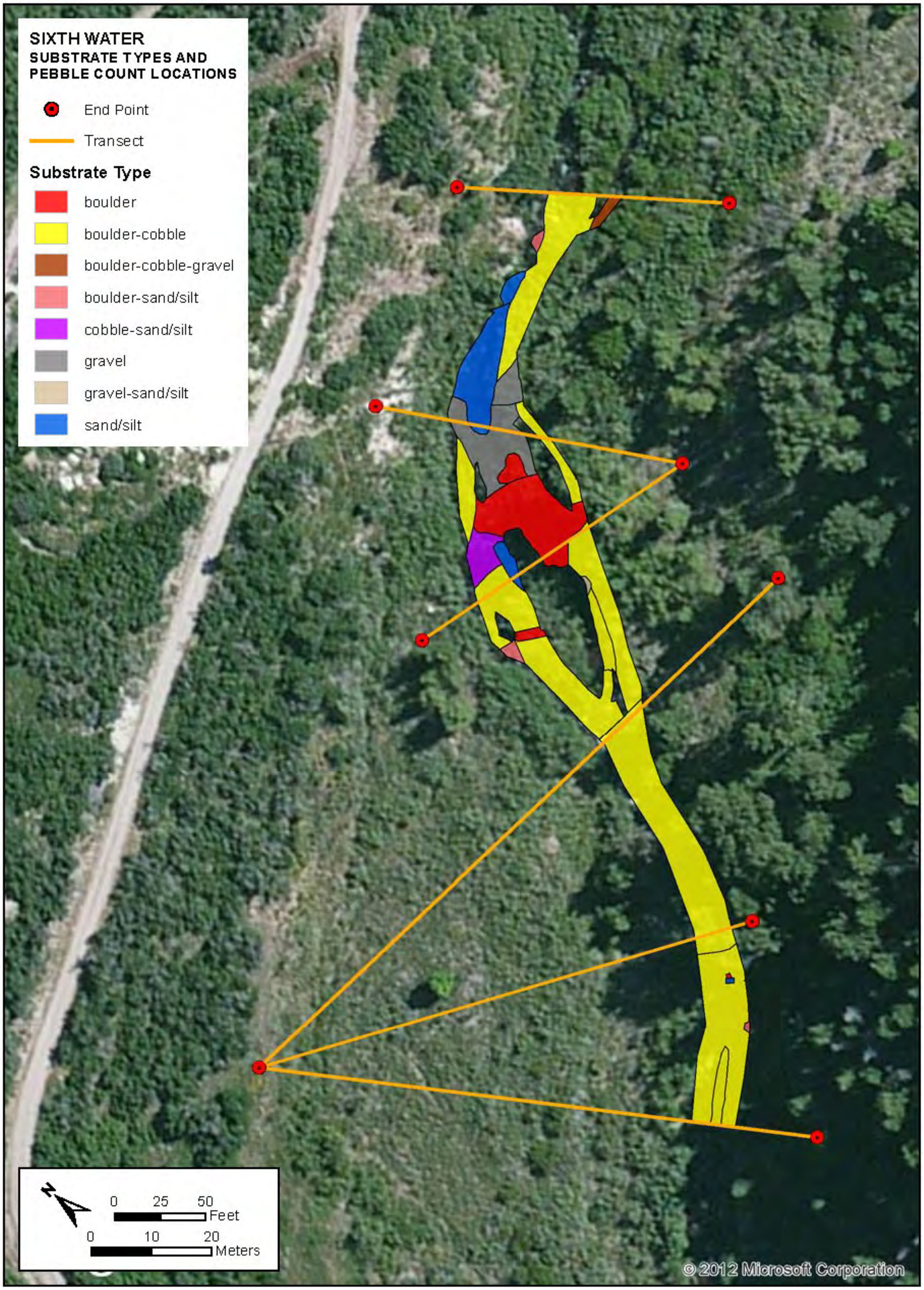


Figure 3-1a. Major substrate types at the SXW monitoring site as mapped in spring 2012.

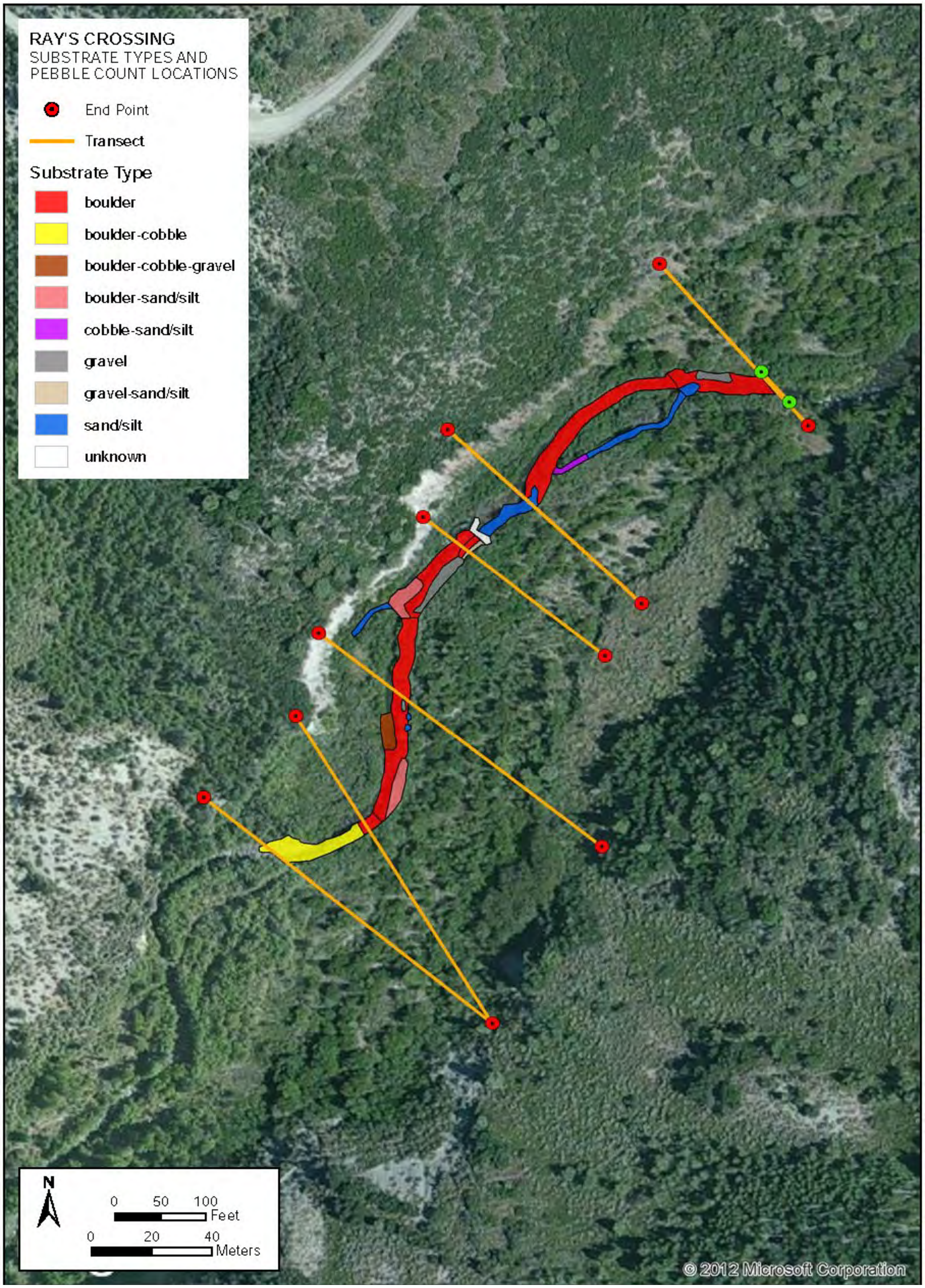


Figure 3-1b. Major substrate types at the RC monitoring site as mapped in spring 2012.

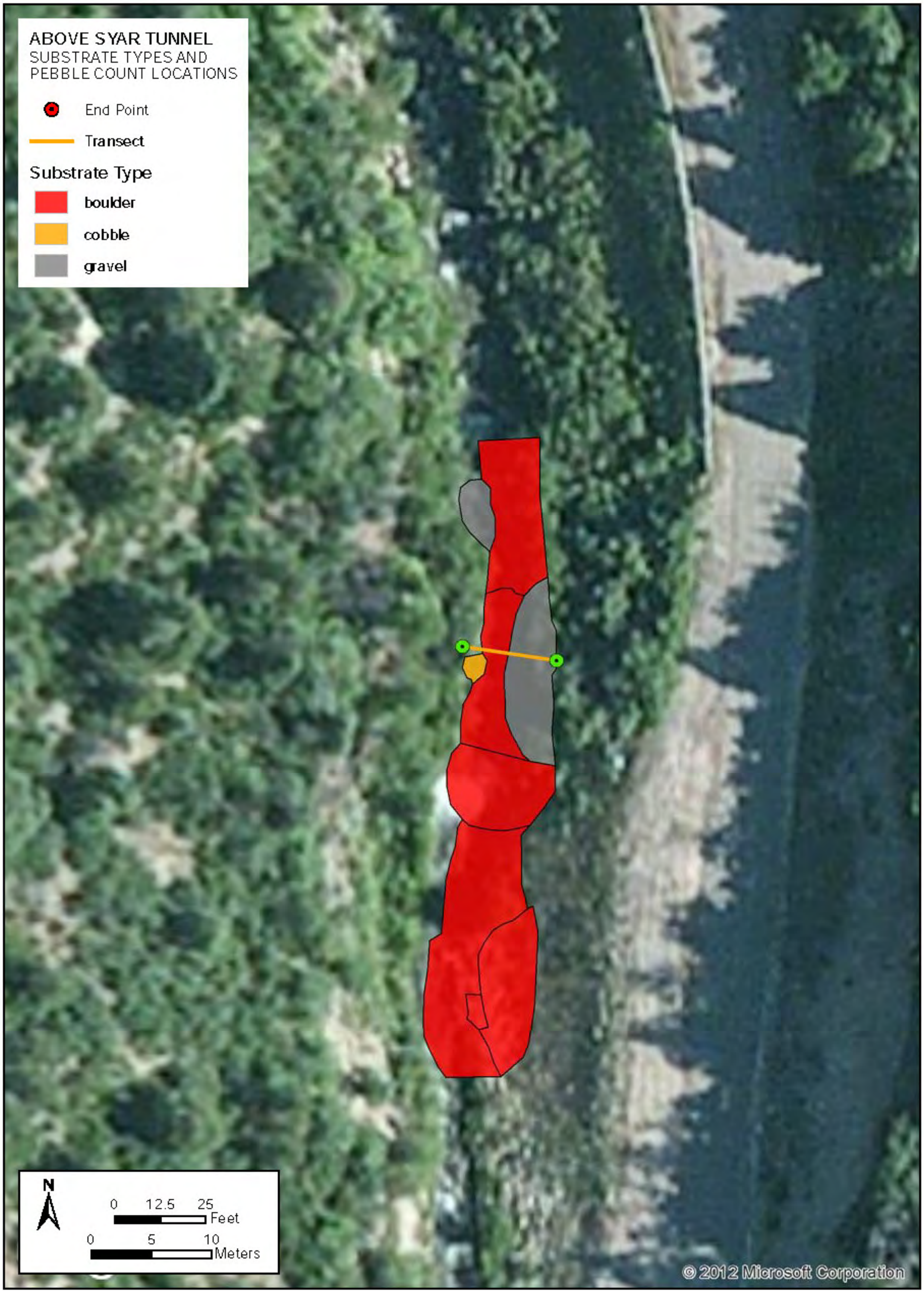


Figure 3-1c. Major substrate types at the AST monitoring site as mapped in spring 2012.

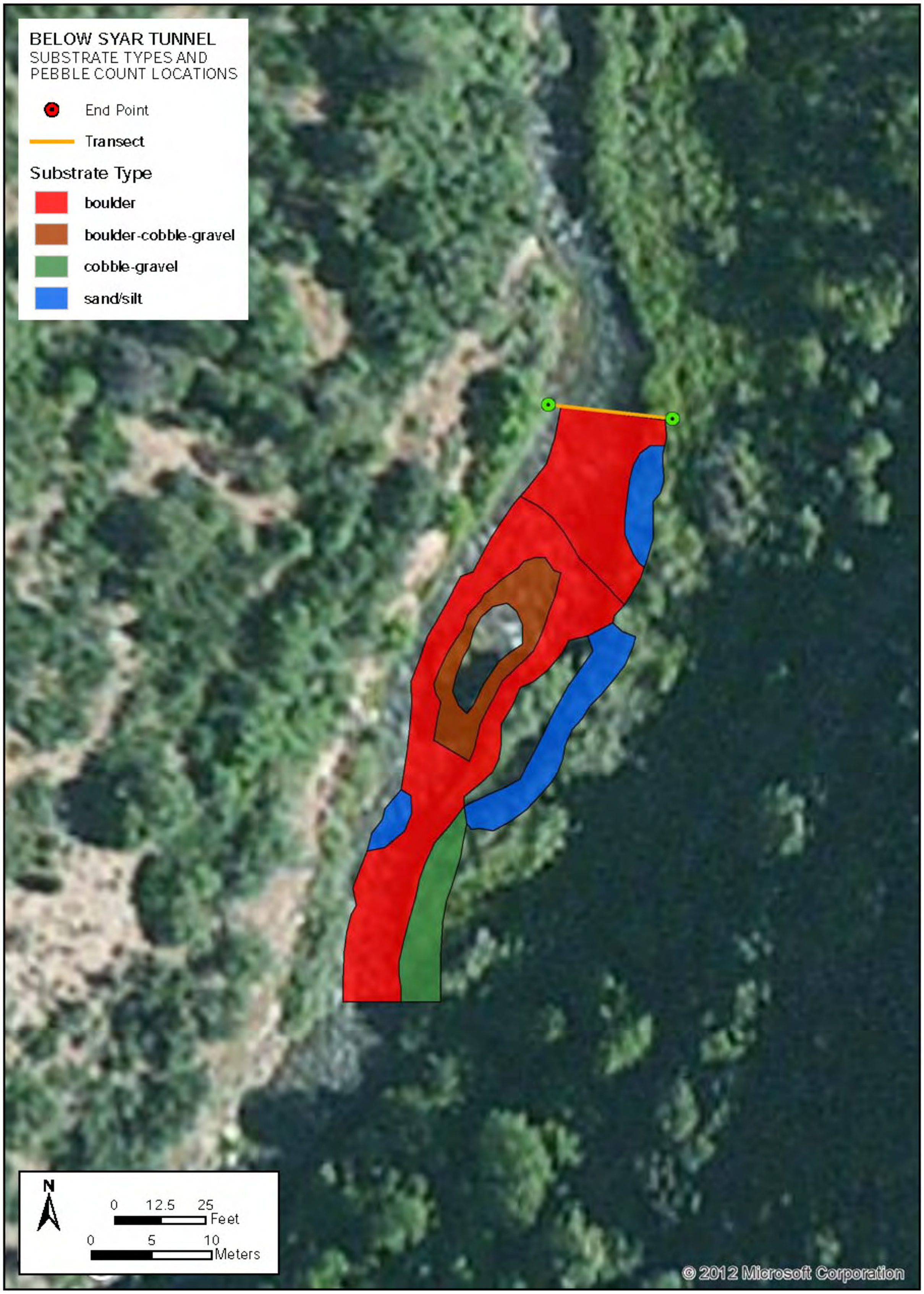


Figure 3-1d. Major substrate types at the BST monitoring site as mapped in spring 2012.

Figure 3-1e. Major substrate types at the GS monitoring site as mapped in spring 2012.

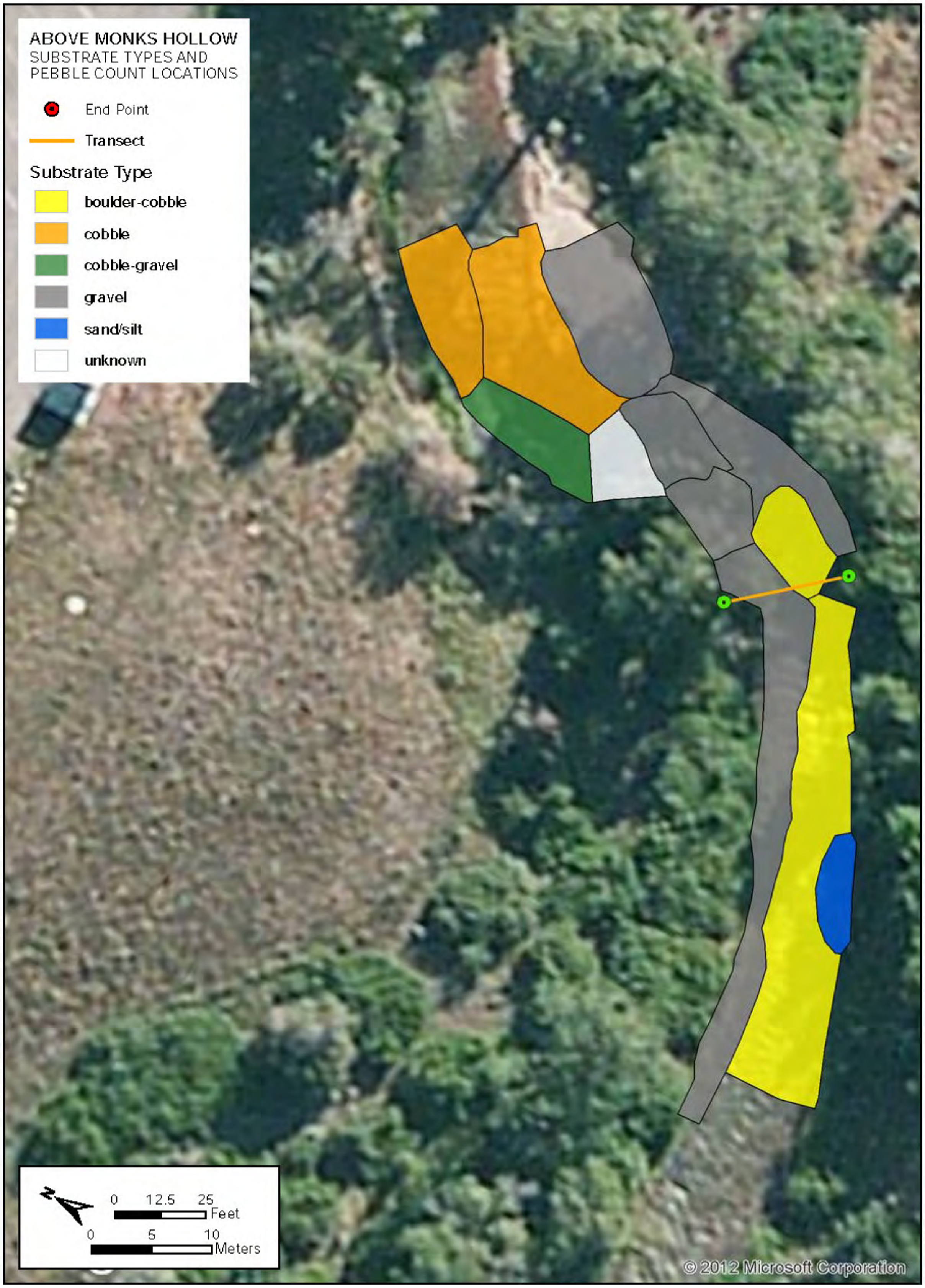


Figure 3-1f. Major substrate types at the AMH monitoring site as mapped in spring 2012.

Figure 3-1g. Major substrate types at the BMH monitoring site as mapped in spring 2012.

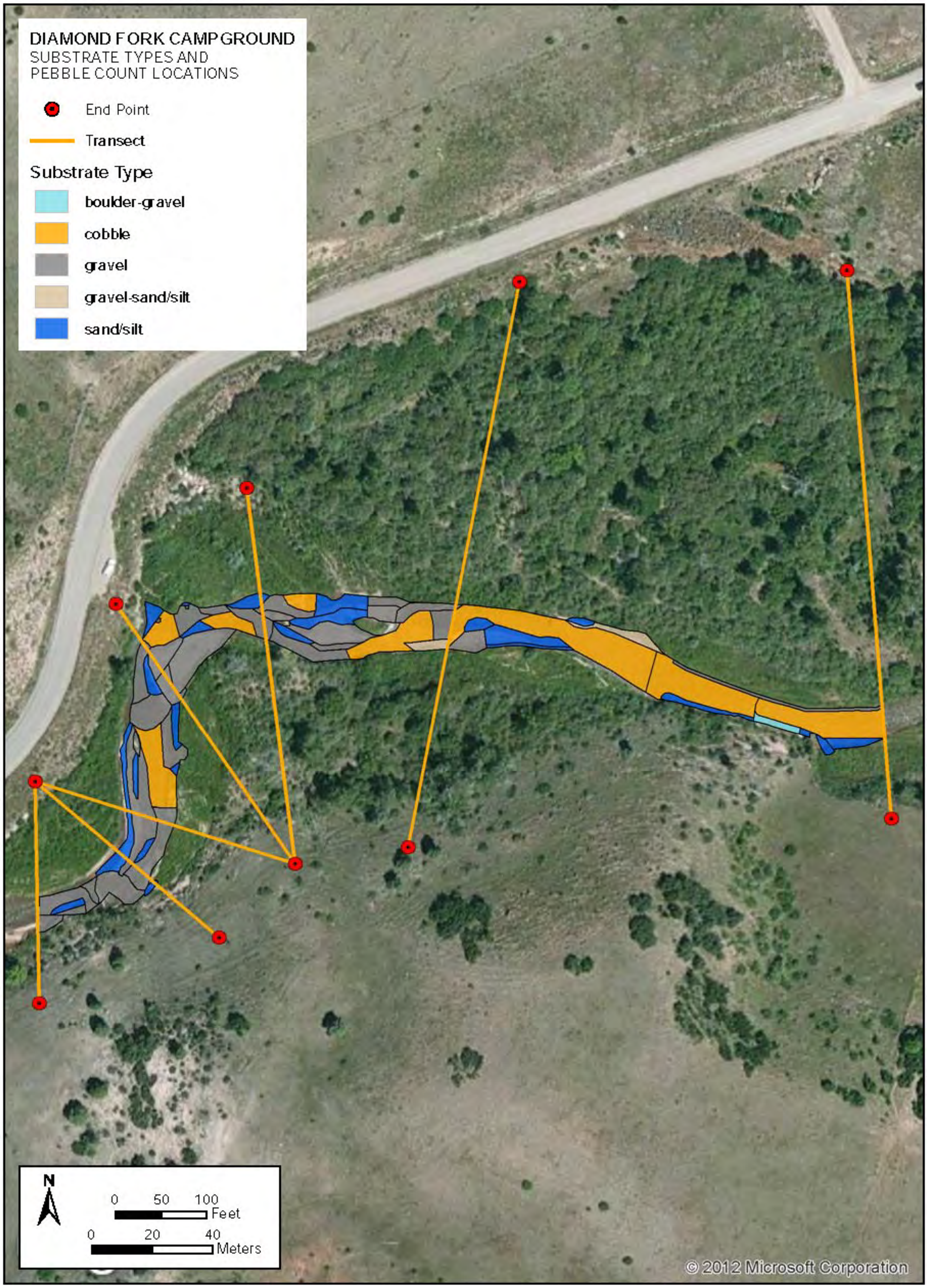


Figure 3-1h. Major substrate types at the DFC monitoring site as mapped in spring 2012.

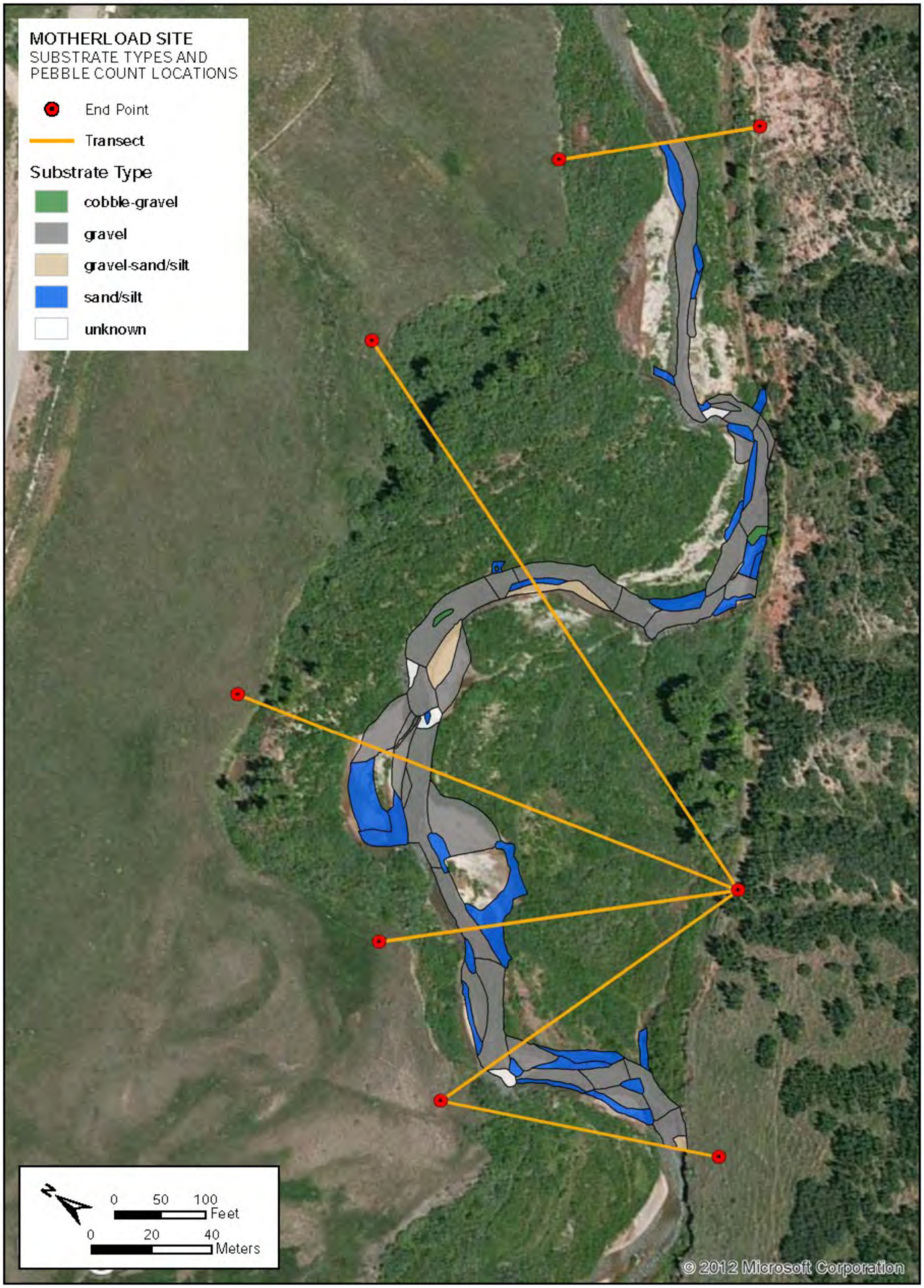


Figure 3-1i. Major substrate types at the MO monitoring site as mapped in spring 2012.

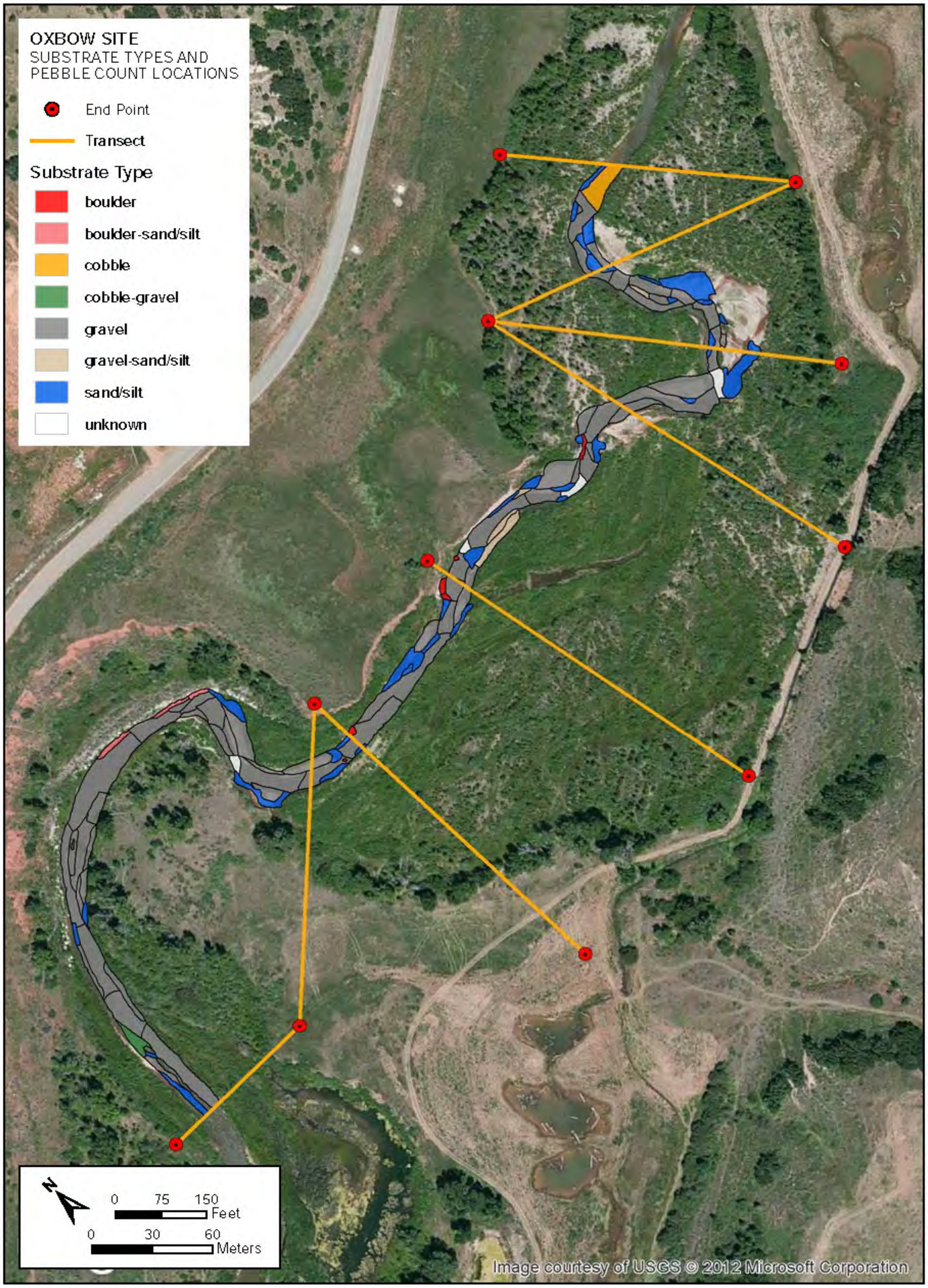


Figure 3-1j. Major substrate types at the OX monitoring site as mapped in spring 2012.

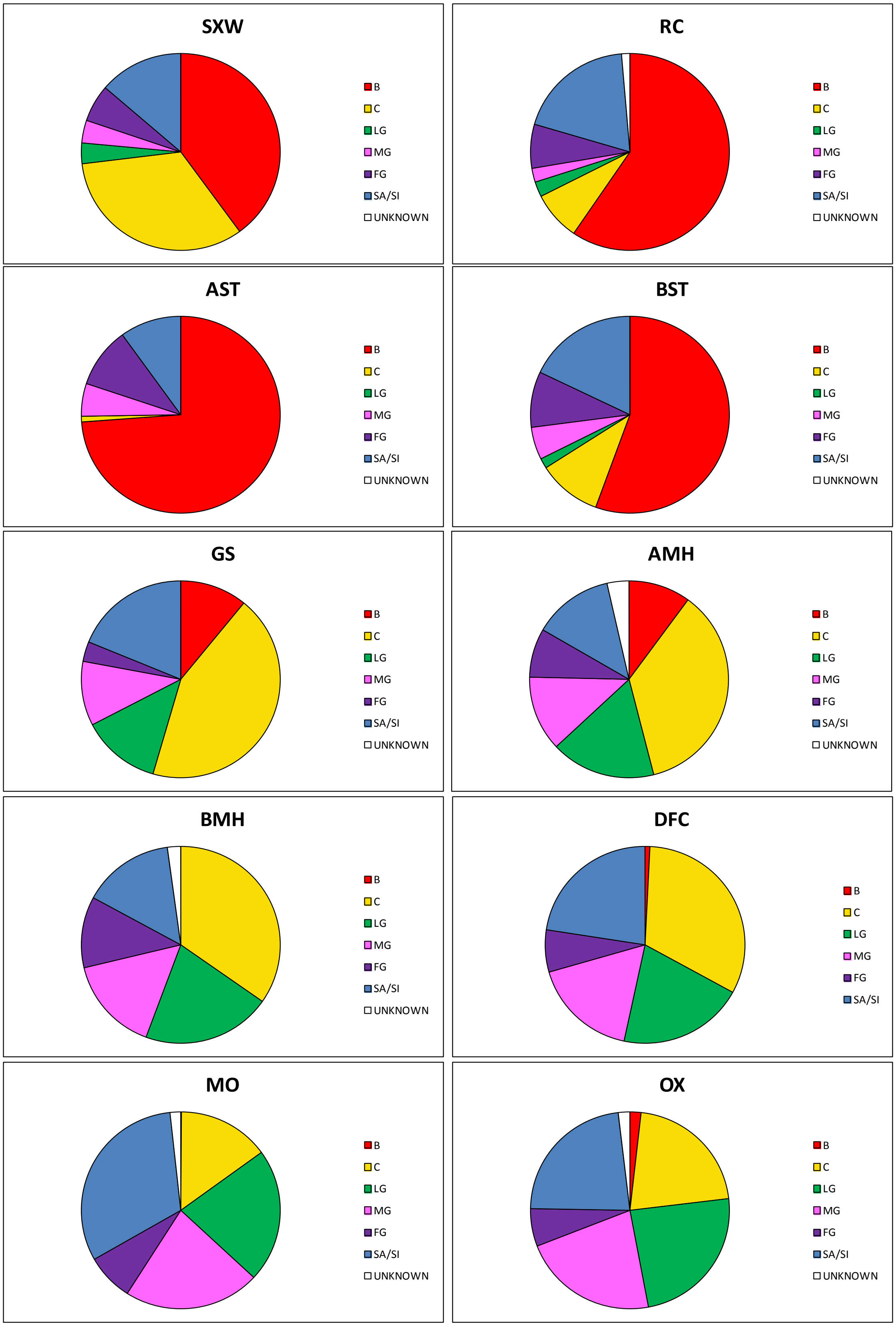


Figure 3-2. Individual plots of proportion of monitoring sites occupied by different substrate sizes, based on field mapping completed during April 2012.

Temporal Changes From Spring to Fall

Overall, substrate mapping results within individual sites were generally similar for the April and September 2012 mapping periods (Figure 3-3). However, some noteworthy differences were evident at some sites. At the SXW site, the percentage of sand/silt material dropped by 3% between spring and fall. The higher proportion of sand/silt in the spring was associated with a slackwater deposit behind a beaver dam that apparently broke apart between the April and September field visits. The woody debris movement evident between spring and fall likely occurred during the high flow releases out of Strawberry Tunnel (Figure 1-3).

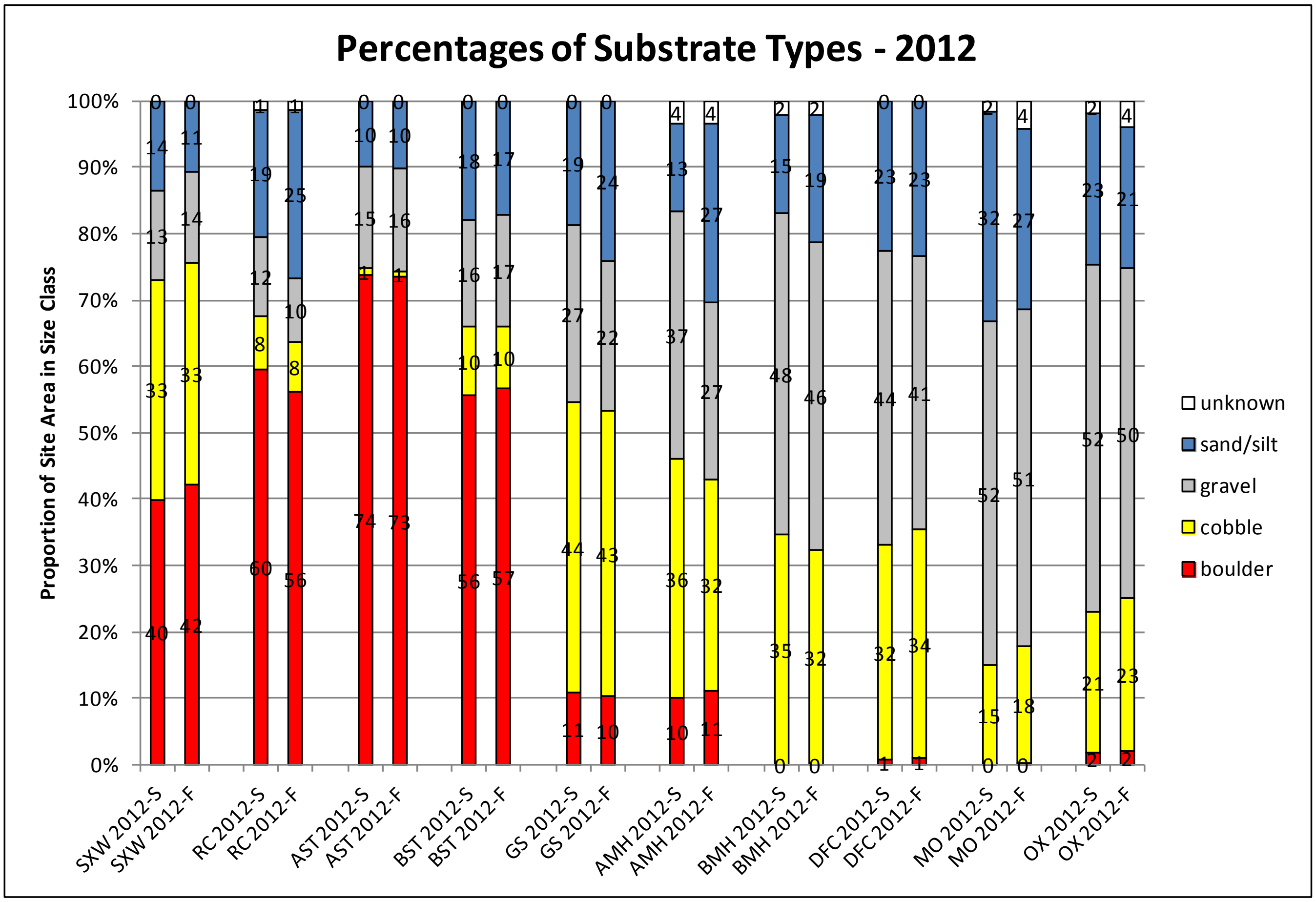


Figure 3-3. Plot of spring versus fall 2012 substrate type percentages for the ten monitoring sites.

At the RC site, the percentage of sand/silt material increased by 6% between spring and fall (Figure 3-3). This change appears to be associated with a general increase in the amount of silt observed in slackwater “pockets” along the channel margins and behind mid-channel boulders rather than any major changes in overall site habitat or geomorphology. Similarly, the overall increase in sand/silt percentage at the GS site (Figure 3-3) also appears to be associated with a general increase in the proportion of fines observed within various substrate patches at the site. The AST and BST sites showed almost no change in substrate size distribution between the spring and fall mapping events (Figure 3-3).

The proportion of sand/silt mapped at the AMH site increased between spring and fall (Figure 3-3). At this site, the increase appears to primarily be the result of new fine sediment deposits associated with new woody debris jams and channel margin silt deposits that developed after the April 2012 field work. In September, fresh silt and stick deposits were evident along the channel edge and on the edges of dry channel-margin bars (Figure 3-4a and b). Some similar new silt deposits were also evident at the BMH site (Figure 3-5), where the proportion of sand/silt also increased (although to a lesser degree than AMH) between spring and fall (Figure 3-3).

Figure 3-4a. Fresh silt deposit along the edge of the channel at the Above Monks Hollow monitoring site. Photo taken in September 2012.

Figure 3-4b. Silt deposit on a dry channel-margin gravel bar at the Above Monks Hollow monitoring site. Photo taken in September 2012.

Substrate differences between April and September 2012 at the downstream-most sites (DFC, MO, and OX) were relatively minor (Figure 3-3). At these sites, the small temporal changes in the proportions of substrate types are primarily the result of dry gravel bar areas becoming vegetated (and therefore removed from the substrate mapping area) between the spring and fall mapping sessions. The exclusion of these bar deposits (which typically contain relatively fine-grained material gravel size and smaller) from the fall mapping area accounts for the minor increase in the relative proportion of coarser cobble–sized material at the three downstream sites (Figure 3-3). Although the overall proportions of different substrate size classes remained fairly constant, notes taken during the September field mapping work mention localized instances of apparent bank erosion/slumping at each of these three downstream sites. This indicates that the high flow releases that occurred between the 2012 sampling periods on Diamond Fork (Figure 1-4) were effective in causing some localized bank erosion and channel change.

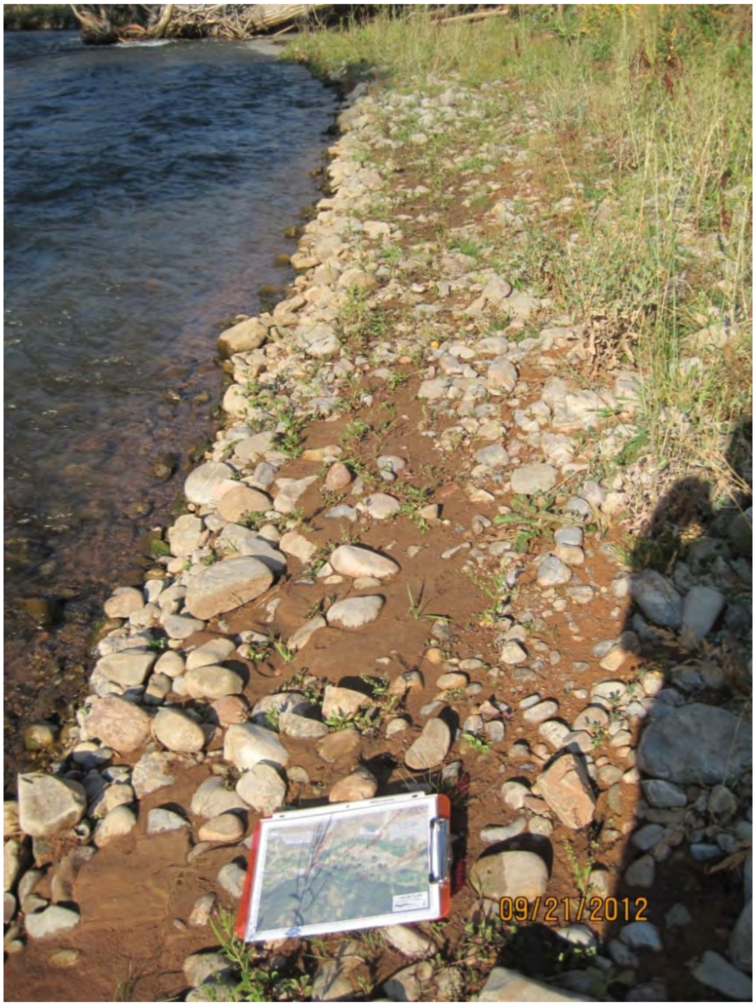


Figure 3-5. Fresh silt on dry channel-margin gravel bar at the Below Monks Hollow monitoring site. Photo taken in September 2012.

Longer-term Temporal Trends

As explained previously, past substrate mapping work has been completed at the four comprehensive long-term monitoring sites (SXW, DFC, MO, OX), allowing for assessment of longer-term temporal trends at these locations including years 2005, 2006, 2007 and 2012. At the lower Diamond Fork sites (DFC, MO, OX), the proportions of different substrate sizes mapped in 2012 were very similar to the results from the 2007 mapping (Figure 3-6), despite some significant geomorphic changes (bank erosion, shifts in gravel bars and side channels, etc.) that occurred over this time period (Figures 3-7a to 3-7d). The trend toward fining of the streambed substrate that was observed during the original 2005–2007 monitoring period (BIO-WEST 2009) appears to have stabilized. One interesting change since the 2005–2007 period at both DFC and OX is a small increase in the amount of boulder-sized substrate particles (Figure 3-6). At DFC, this appears to be the result of channel migration toward the riprap along the road near cross section 4 and toward the hillslope downstream of cross section 6 causing slumping of placed roadway-protection riprap and pieces of exposed bedrock. At OX, part of the increase is also explained by erosion of a rip-rapped bank area. In addition, new boulders were introduced at 3 locations within the OX monitoring site as part of a root wad/boulder “barb” habitat structure placement effort completed between 2007 and 2012 (Figure 3-8).

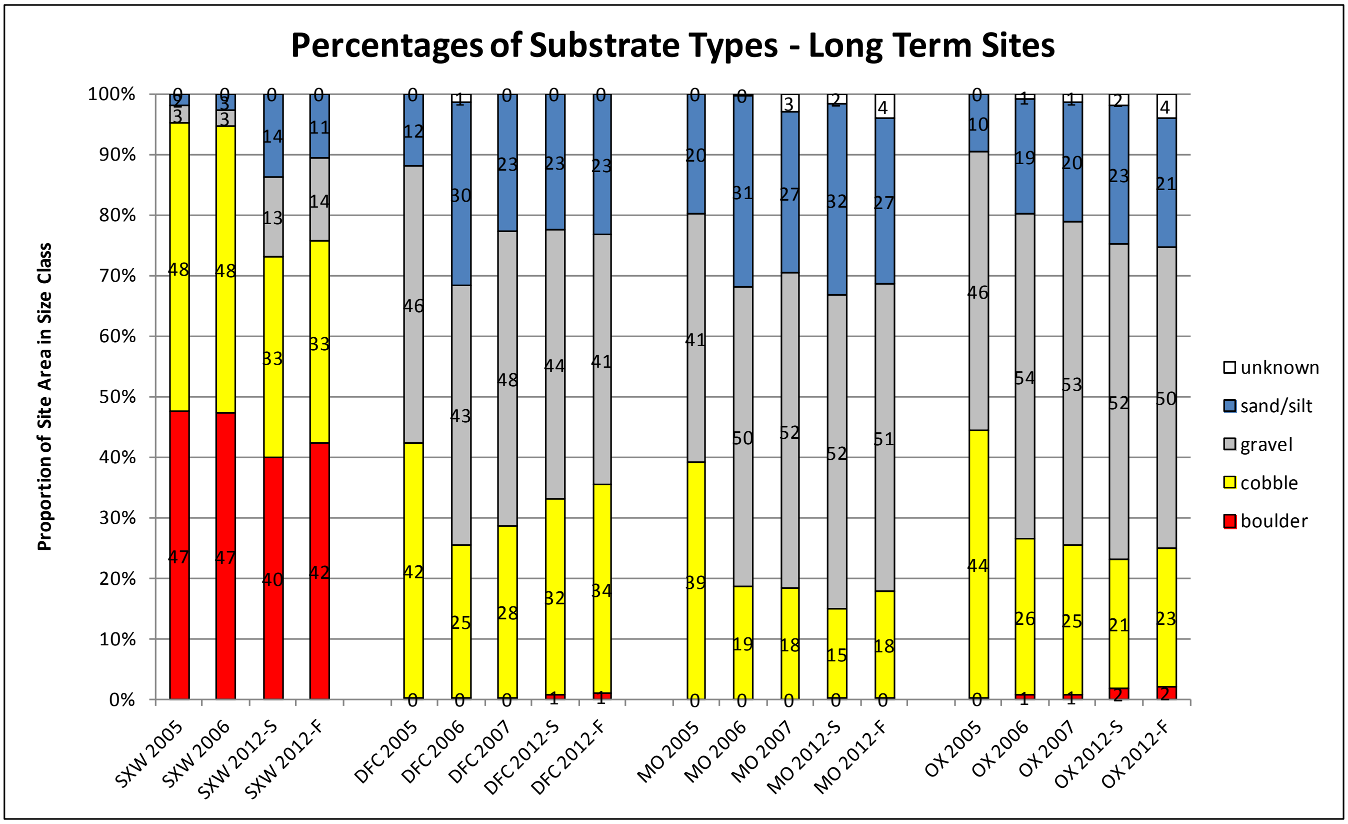


Figure 3-6. Plot of substrate type percentages from 2005 to 2012 for the four long-term monitoring sites.

In contrast to the lower Diamond Fork sites where minimal change in substrate size was observed between 2007 and 2012 and the proportion of fine-grained particles appears to have stabilized, the proportion of finer particles at the SXW site on upper Sixth Water Creek increased significantly between 2007 and 2012 (Figure 3-6). These changes include increased proportions of sand, silt, and fine and medium-sized gravel, and appear to largely be related to beaver activity and increased woody debris accumulations in the upper half of the site that have created lower-velocity depositional areas that were previously absent (Figures 3-9a and 3-9b).

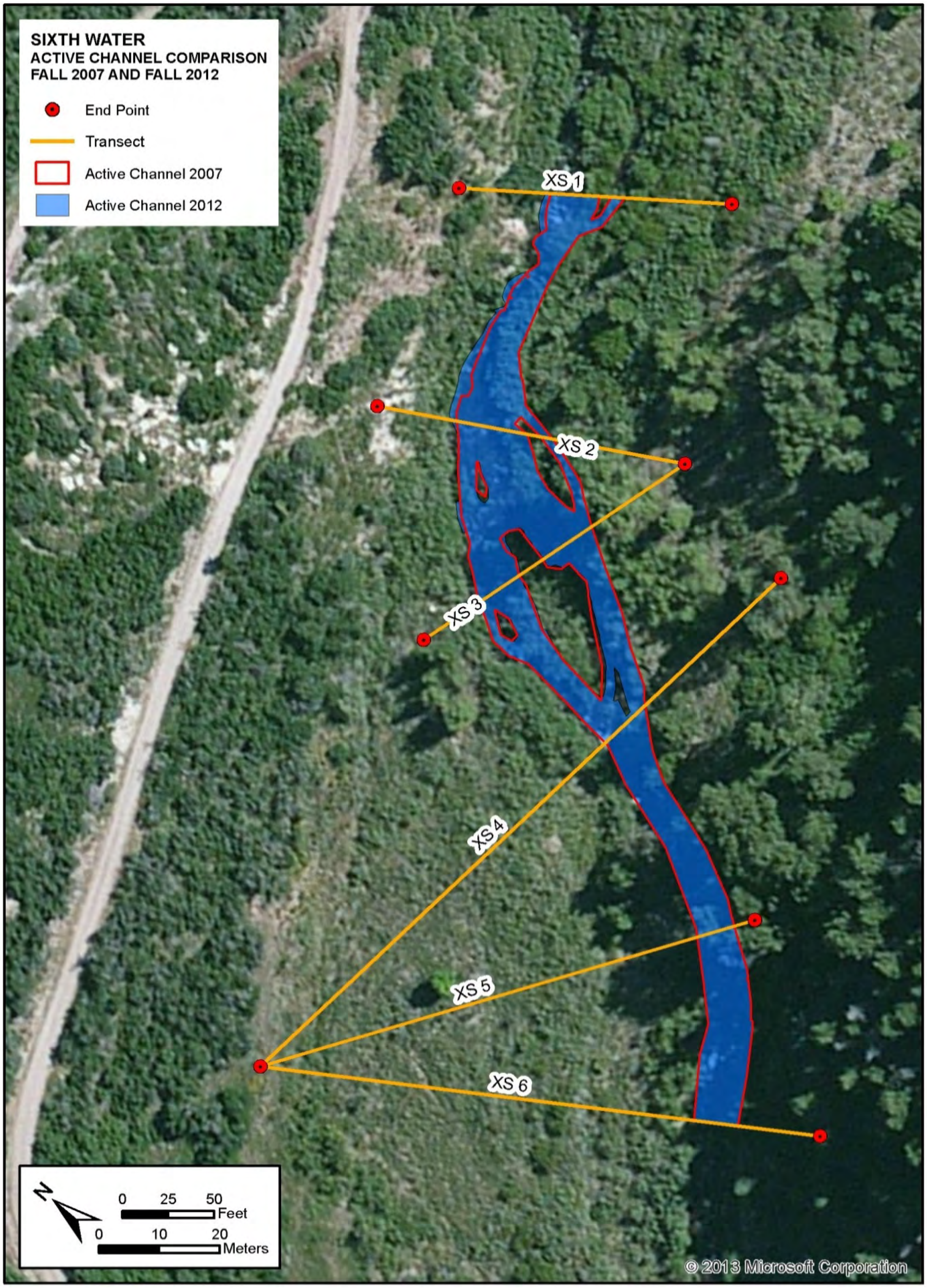


Figure 3-7a. Map of the edge of active channel in 2007 and in 2012 at the Sixth Water monitoring site.

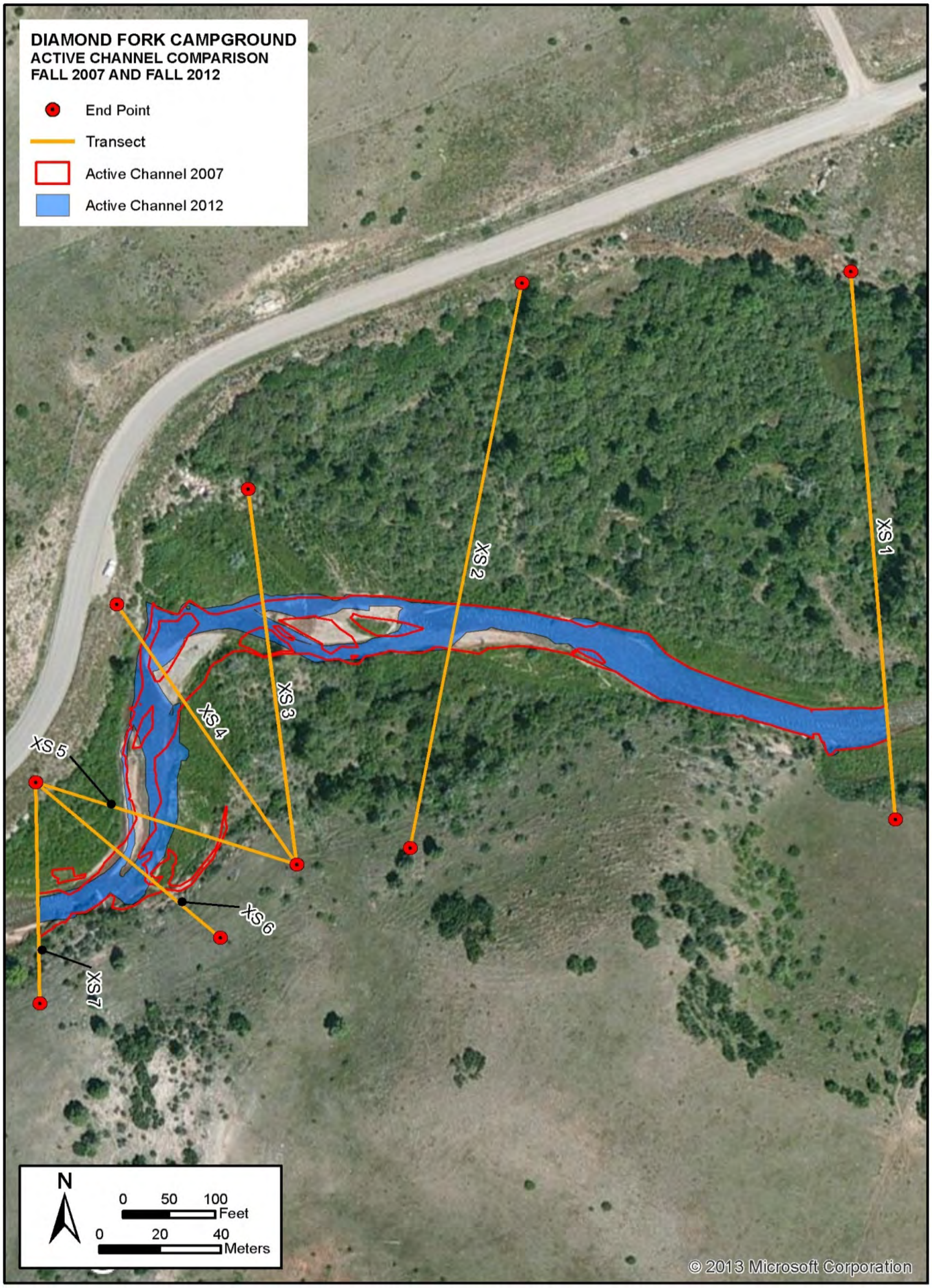


Figure 3-7b. Map of the edge of active channel in 2007 and in 2012 at the Diamond Fork Campground monitoring site.

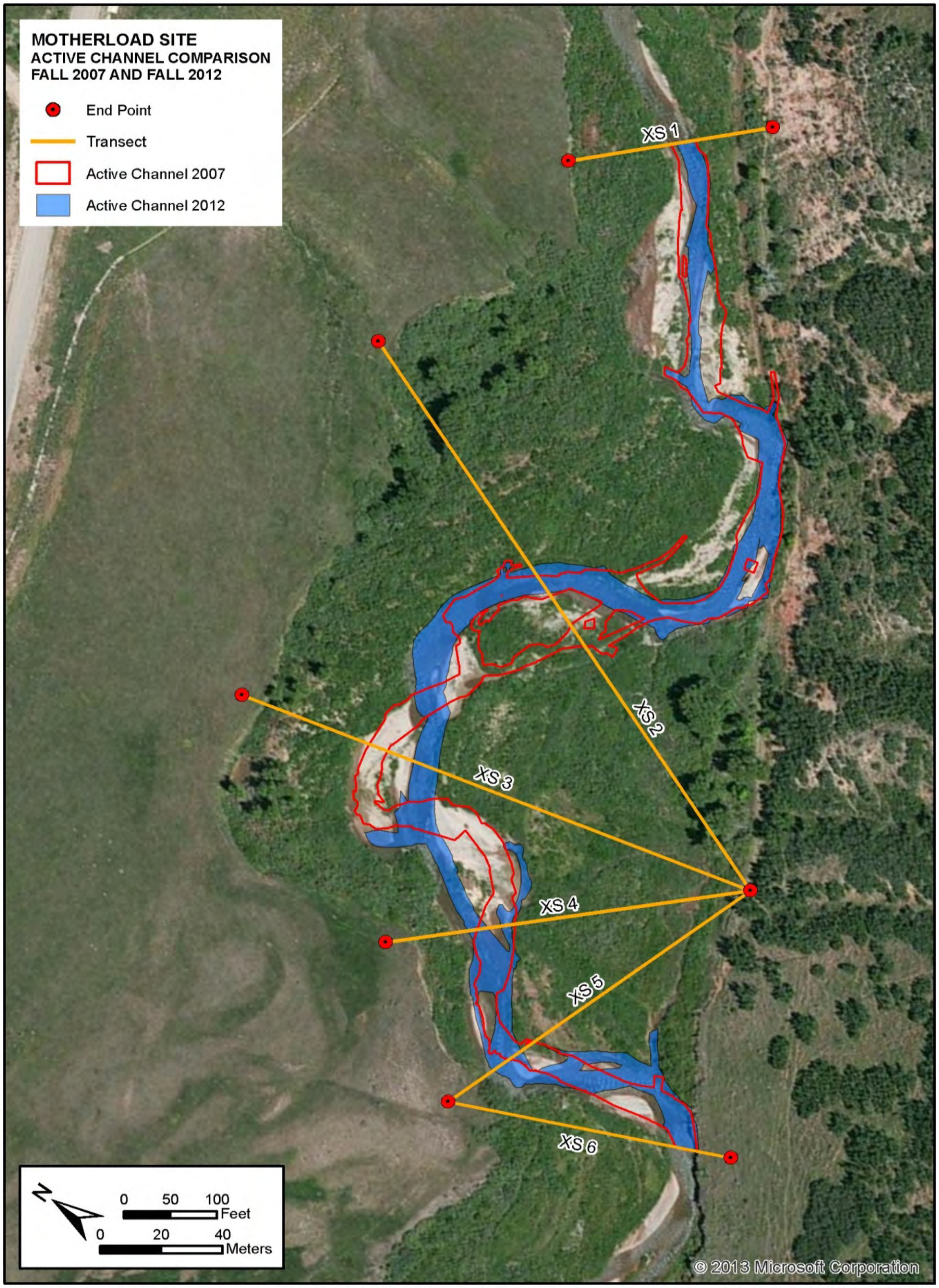


Figure 3-7c. Map of the edge of active channel in 2007 and in 2012 at the Motherload monitoring site.

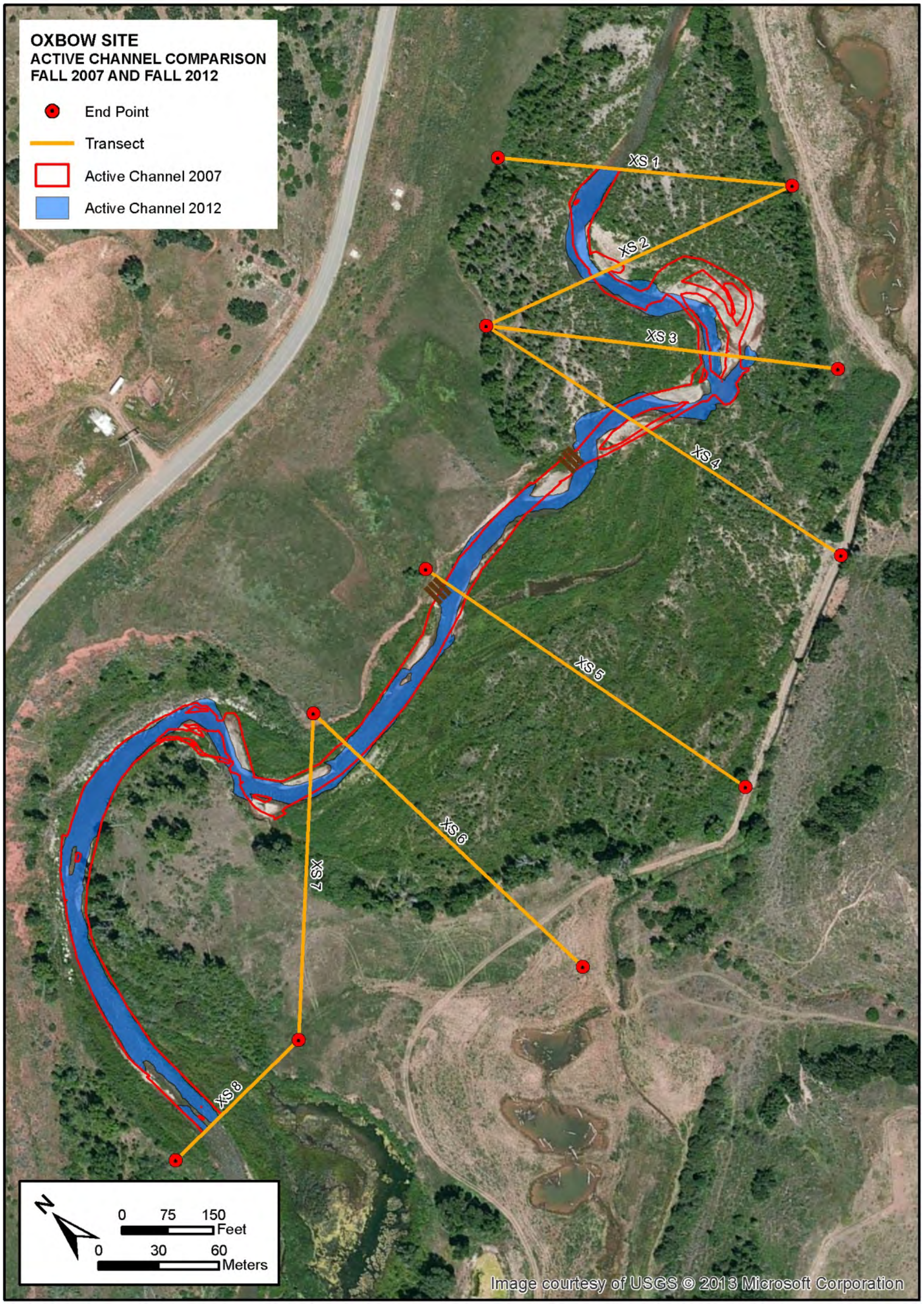


Figure 3-7d. Map of the edge of active channel in 2007 and in 2012 at the Oxbow monitoring site. Large barbs on river right were installed in 2008 to improve habitat and restore a more sinuous channel in an otherwise straight reach.

Figure 3-8. Photo of placed root wad/boulder barb structure at the Oxbow monitoring site.

Figure 3-9a. Photo of beaver dam/stick structure at the Sixth Water monitoring site in April 2012.

Figure 3-9b. Photo of the Sixth Water monitoring site in September 2012; beaver dam/stick structures have partially washed out.

Streambed Cementation

During the 2006 and 2007 mapping work, areas of streambed at the MO and OX sites (and, to a lesser extent at the DFC site) were noted as being "cemented". In these areas, gravel and cobble-sized particles are embedded in a matrix of fine-grained sand and silt that forms a semi-cohesive "brick". This same phenomenon was again observed during the 2012 mapping. Various substrate polygons at the MO and OX sites were noted as being "cemented" or "packed" during both the spring and fall 2012 mapping events. Some smaller and more localized portions of the DFC site were also noted as being cemented during both seasons. At these lower Diamond Fork Creek sites, the streambed cementing phenomenon appears to most commonly occur in main channel run habitats with moderate to shallow water depth and laminar flow. Steeply sloping or near-vertical underwater shelf/ledge features that abruptly transition into deep pool habitats are commonly observed at the downstream end of the cemented run areas. Although cementing was observed during both seasons at these sites, the specific extent and location of the cemented patches shifted between April and September. This suggests that the high flows that occurred between the sampling events (Figure 1-4) mobilized and "broke up" the cementation at least to some degree. It also indicates that the cemented conditions were able to re-establish during the relatively short time period between 2012 flow recession and fall sampling (Figure 1-4).

In 2012, no bed cementing was observed at the SXW, RC, or GS sites. At each of the AST and BST sites, one small localized depositional area was noted as being "cemented" during both the spring and fall, but none of the main channel areas subject to higher velocity flows were observed to be cemented. At the AMH and BMH sites, no cementing was noted during the April 2012 mapping, but during the fall, significant portions of the streambed at both sites were observed to be "cemented", "very embedded" and/or having a "packed" feel underfoot. Field notes taken at the BMH and MO sites during the September mapping also noted that wading conditions were treacherous in areas due to the presence of loose, slippery algae-coated cobble and large gravel particles on top of a “packed” finer-grained subsurface.

Pebble Counts

Locations of specific pebble count sampling locations within each site are shown in Figures 3-10a to 3-10j, and descriptions of each pebble count site are provided in Table 3-3.

To enable comparison among sites and sampling periods, the results for the 3 to 7 pebble counts per site were averaged to generate a single average particle size distribution plot for each monitoring site (Figure 3-11). Site-averaged values for median (D50) particle size and percent fines (% of particles less than 2mm in diameter) were also determined and plotted (Figures 3-12 and 3-13). In addition to the site-averaged data, plots were also prepared using the pebble count data collected at the single embeddedness and macroinvertebrate transect for each monitoring site (Figure 3-14). Because the embeddedness and macroinvertebrate transects have remained in the same location and habitat type for each year sampled, they provide a consistent way of evaluating temporal changes in substrate conditions at a static location. Values for embeddedness and macroinvertebrate transect median (D50) particle size and percent fines (% of particles less than 2mm in diameter) also determined and plotted (Figures 3-15 and 3-16).

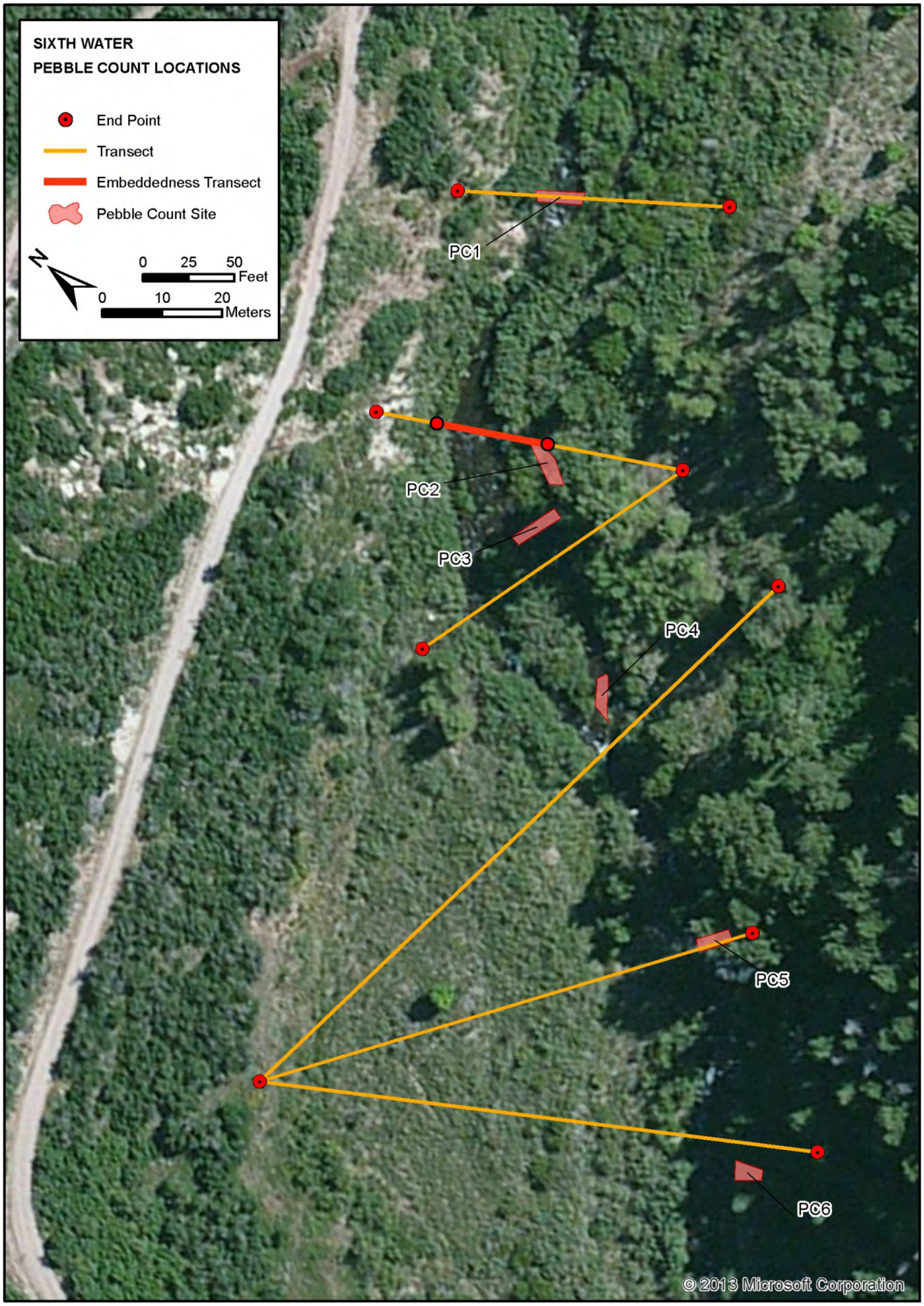


Figure 3-10a. Pebble count and embeddedness monitoring locations at the Sixth Water site. Macroinvertebrate Hess samples were collected at the embeddedness transect.

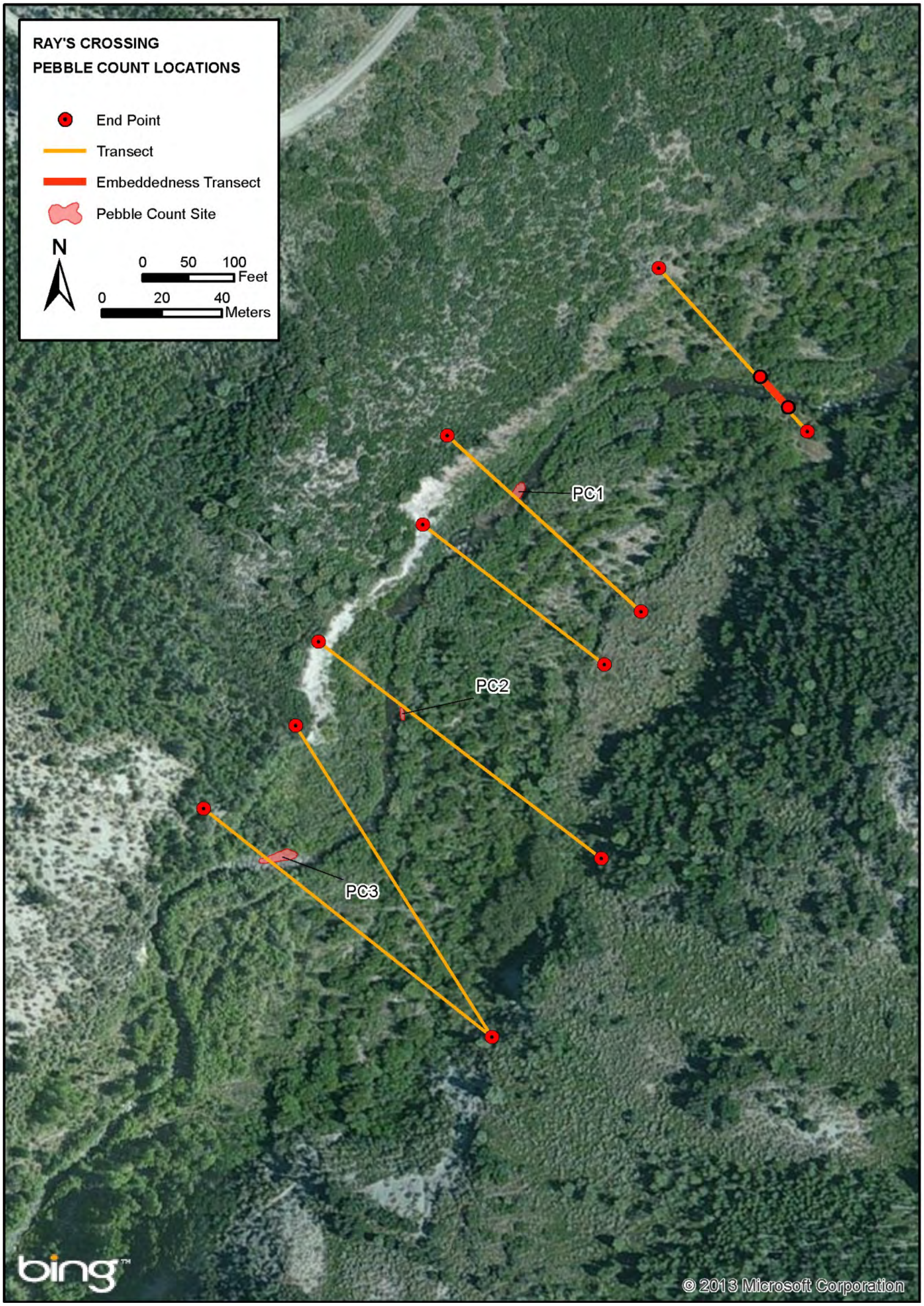


Figure 3-10b. Pebble count and embeddedness monitoring locations at the Ray's Crossing site. Macroinvertebrate Hess samples were collected at the embeddedness transect.

Figure 3-10c. Pebble count and embeddedness monitoring locations at the Above Syar Tunnel site. Macroinvertebrate Hess samples were collected at the embeddedness transect.

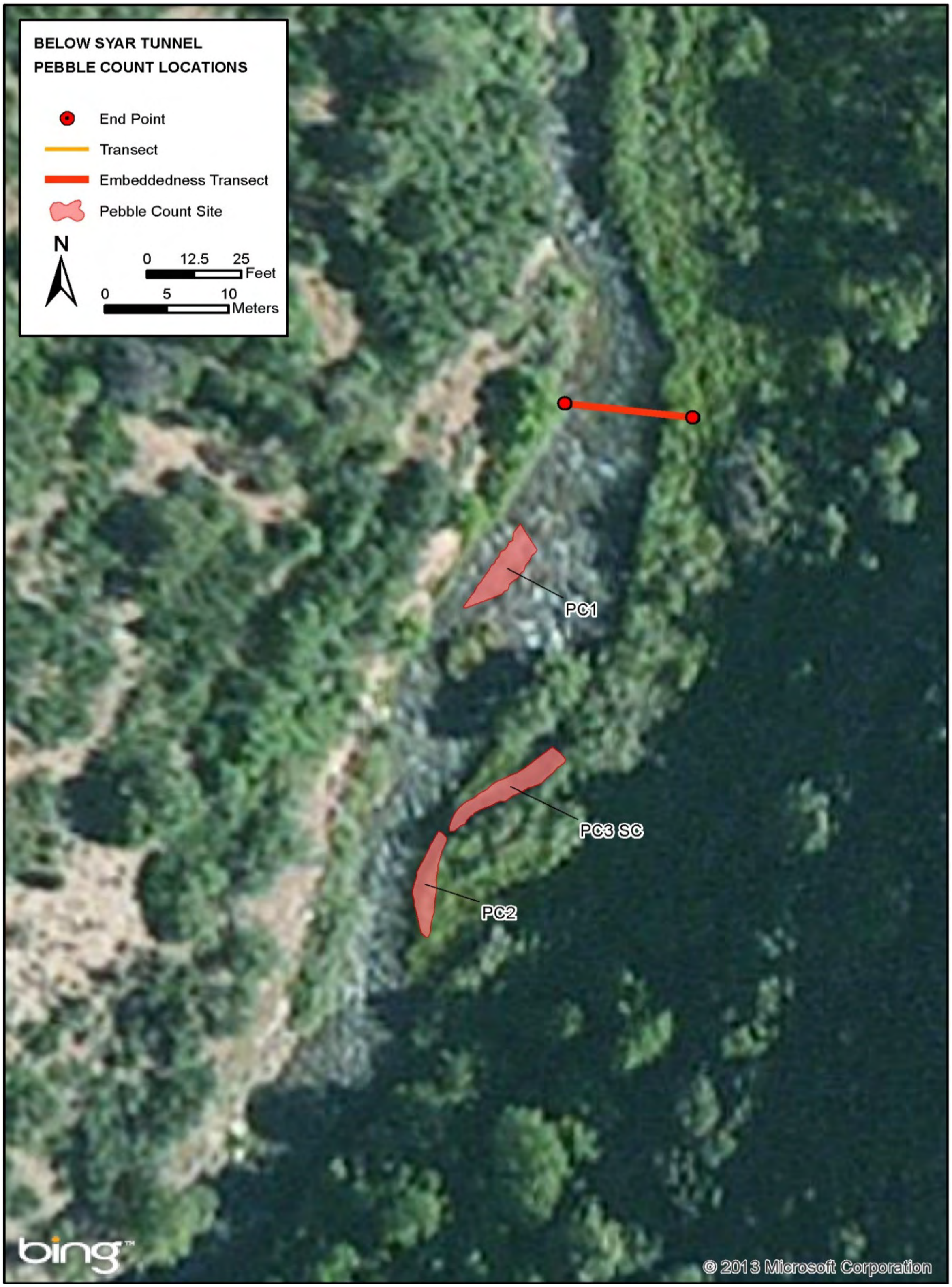


Figure 3-10d. Pebble count and embeddedness monitoring locations at the Below Syar Tunnel site. Macroinvertebrate Hess samples were collected at the embeddedness transect.

Figure 3-10e. Pebble count and embeddedness monitoring locations at the Diamond Fork Guard Station site. Macroinvertebrate Hess samples were collected at the embeddedness transect.

Figure 3-10f. Pebble count and embeddedness monitoring locations at the Above Monks Hollow site. Macroinvertebrate Hess samples were collected at the embeddedness transect.

Figure 3-10g. Pebble count and embeddedness monitoring locations at the Below Monks Hollow site. Macroinvertebrate Hess samples were collected at the embeddedness transect.

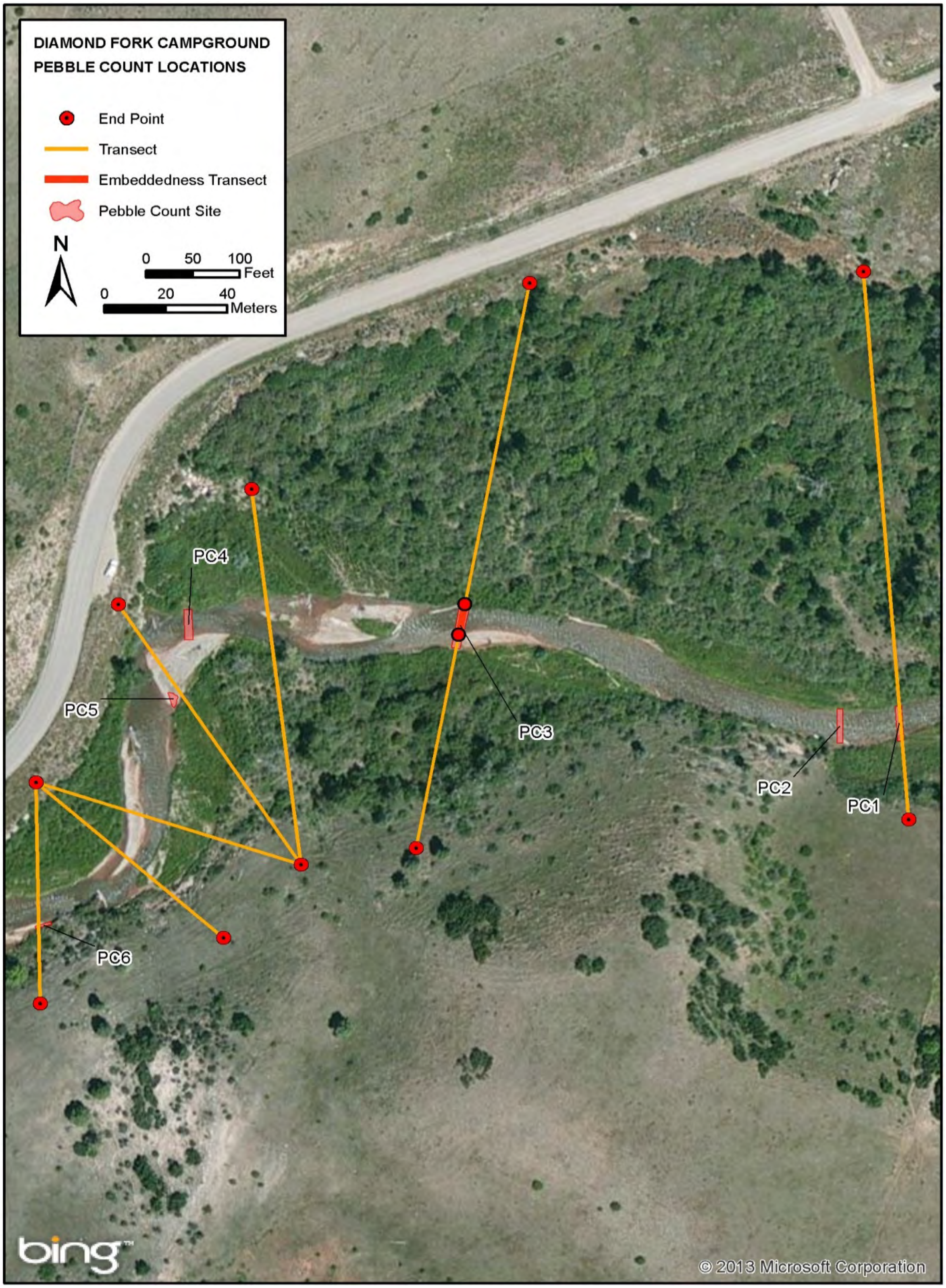


Figure 3-10h. Pebble count and embeddedness monitoring locations at the Diamond Fork Campground site. Macroinvertebrate Hess samples were collected at the embeddedness transect.

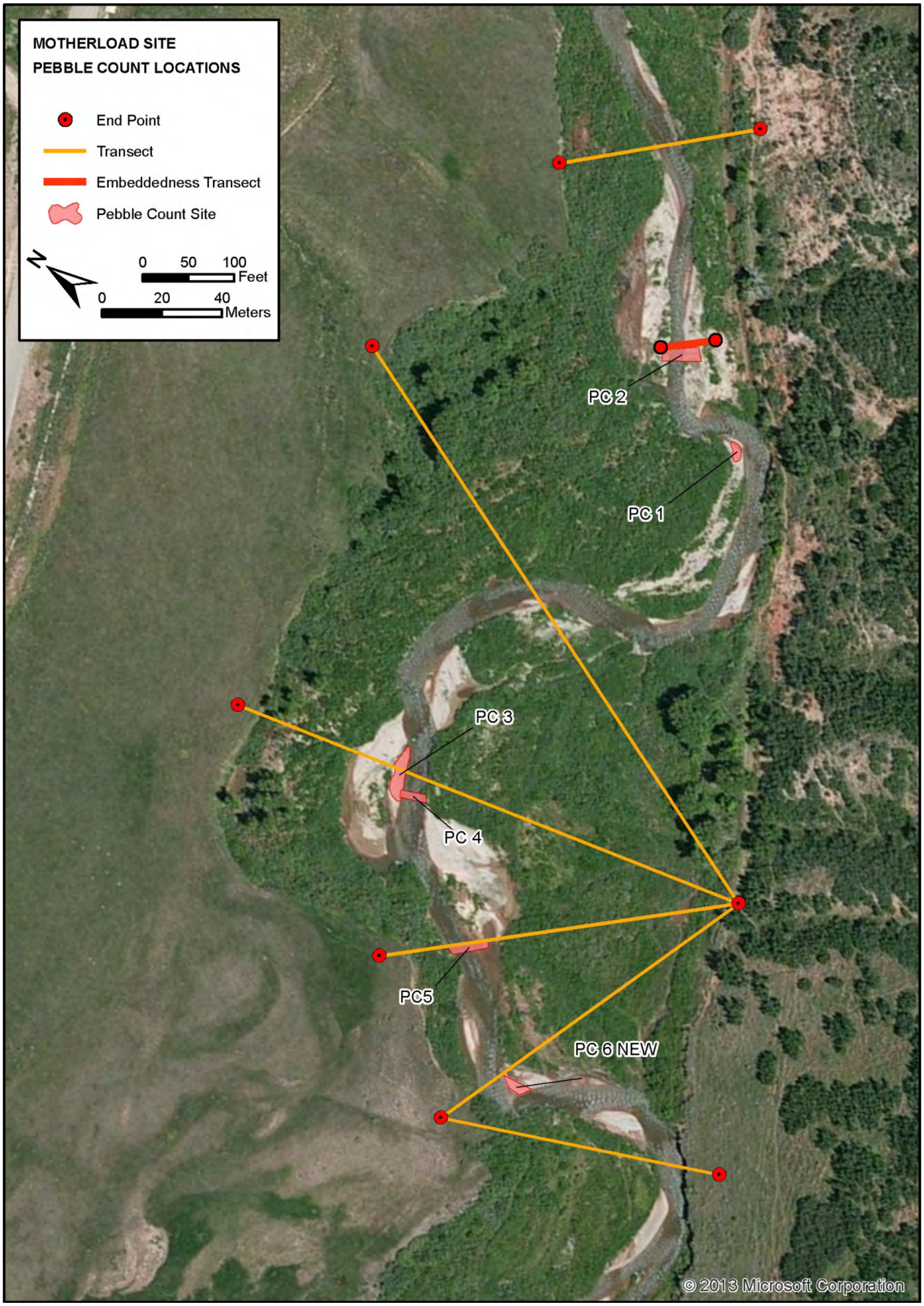


Figure 3-10i. Pebble count and embeddedness monitoring locations at the Motherload site. Macroinvertebrate Hess samples were collected at the embeddedness transect.

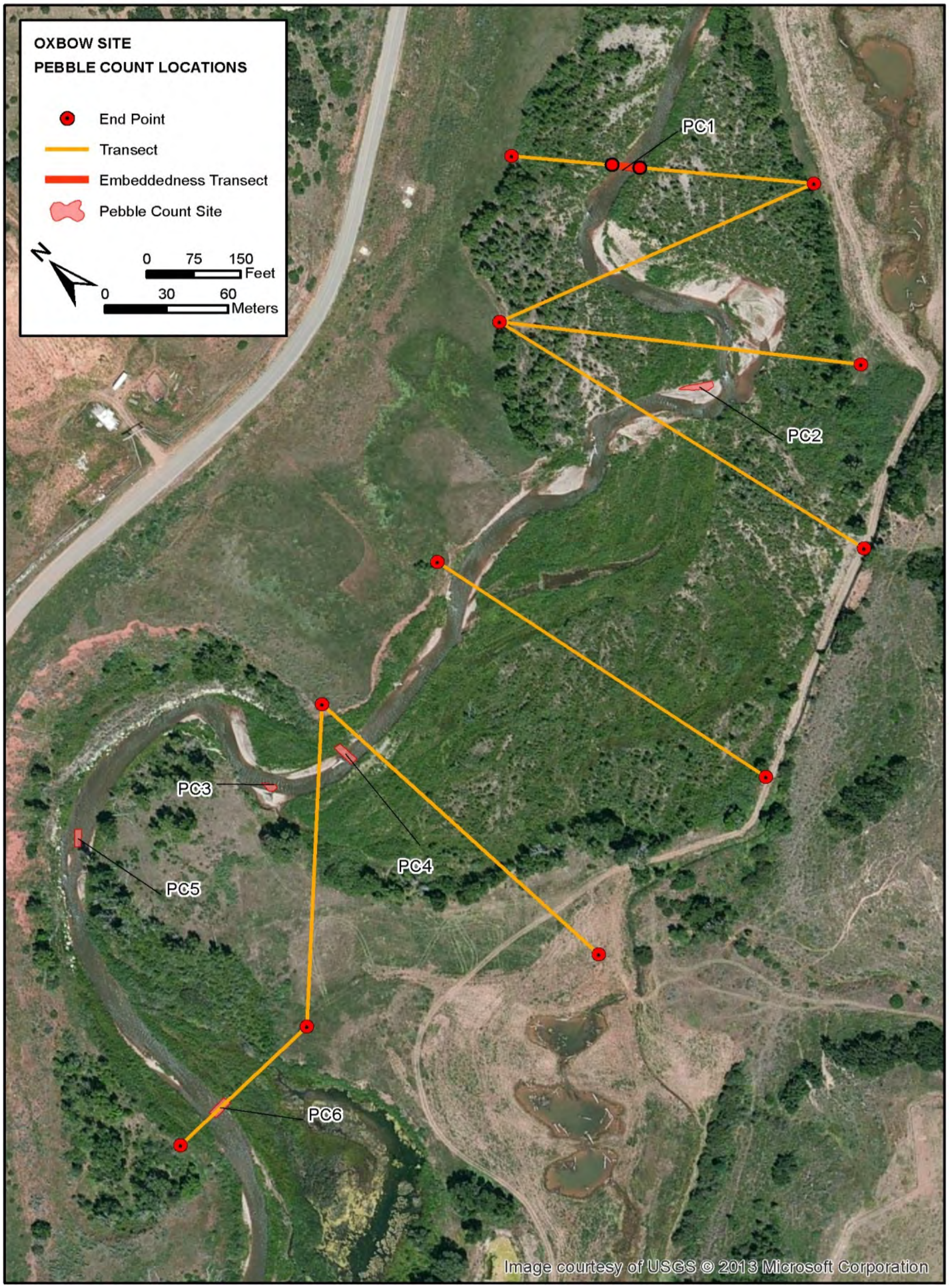


Figure 3-10j. Pebble count and embeddedness monitoring locations at the Oxbow site. Macroinvertebrate Hess samples were collected at the embeddedness transect.

Table 3-3. Descriptions of pebble count locations.

MONITORING SITE	PEBBLE COUNT SITE	TYPE	NOTES/LOCATION CHANGES
SIXTH WATER	SXW PC1	wet riffle	-
	SXW PC2*	dry point bar	Side channel sampled in 2007; in 2012 sampled dry point bar near 2007 PC2 location
	SXW PC3	wet riffle	-
	SXW PC4	wet in-channel patch	-
	SXW PC5	wet riffle	-
	SXW PC6	dry bar	-
	SXW EMB	wet riffle	Embeddedness and macroinvertebrate monitoring transect
RAY'S CROSSING	RC PC1	wet in-channel patch	Influenced by backwater from beaver dam
	RC PC2	wet in-channel patch	-
	RC PC3	wet in-channel patch	-
	RC EMB	wet riffle	Embeddedness and macroinvertebrate monitoring transect
ABOVE SYAR TUNNEL	AST PC1	wet in-channel patch	-
	AST PC2	wet in-channel patch	-
	AST EMB	wet riffle	Embeddedness and macroinvertebrate monitoring transect
BELOW SYAR TUNNEL	BST PC1	wet bar	-
	BST PC2	wet in-channel patch	-
	BST PC3	wet side channel	-
	BST EMB	wet riffle	Embeddedness and macroinvertebrate monitoring transect
GUARD STATION	GS PC1	wet run	-
	GS PC2	wet in-channel patch	-
	GS PC3	wet run	-
	GS EMB	wet riffle	Embeddedness and macroinvertebrate monitoring transect
ABOVE MONKS HOLLOW	AMH PC1	wet in-channel patch	-
	AMH PC2	dry bar	-
	AMH PC3	wet in-channel patch	-
	AMH EMB	wet riffle	Embeddedness and macroinvertebrate monitoring transect
BELOW MONKS HOLLOW	BMH PC1	wet point bar	-
	BMH PC2	wet in-channel patch	-
	BMH PC3	dry bar	-
	BMH EMB	wet riffle	Embeddedness and macroinvertebrate monitoring transect
DIAMOND FORK CAMPGROUND	DFC PC1	wet riffle	-
	DFC PC2	wet riffle	-
	DFC PC3	wet run	Embeddedness and macroinvertebrate monitoring transect
	DFC PC4*	wet riffle	In 2012 sampled area northwest of 2007 location to accommodate shift in main channel position
	DFC PC5*	dry bar	Bar sampled in 2007 is now part of the main channel; in 2012 sampled new bar to the northeast of the 2007 location
	DFC PC6*	dry bar	Bar sampled in 2007 became part of main channel; in 2012 sampled new gravel deposit on opposite site of creek.

Table 3-3. (Cont.)

MONITORING SITE	PEBBLE COUNT SITE	TYPE	NOTES/LOCATION CHANGES
MOTHERLOAD	MO PC1	dry bar	-
	MO PC2	wet riffle	Embeddedness and macroinvertebrate monitoring transect
	MO PC3*	dry bar	2012 location is just south of 2007 location, but main channel has shifted to opposite site of the bar
	MO PC4*	wet riffle	2012 location is south of 2007 location to accommodate shift in main channel position
	MO PC5*	wet riffle	2012 location is slightly west of 2007 location to accommodate shift in channel position
	MO PC6*	dry bar	Bar sampled in 2007 became part of main channel; in 2012 sampled new bar deposit about 70' southwest of 2007 location
OXBOW	OX PC1	wet run	Embeddedness and macroinvertebrate monitoring transect
	OX PC2*	dry bar	Bar sampled in 2007 has become part of floodplain; in 2012 sampled new bar deposit about 35' west of 2007 location
	OX PC3	dry bar	-
	OX PC4	wet riffle	-
	OX PC5	wet in-channel patch	-
	OX PC6	wet riffle	-

Spatial Comparison of Monitoring Sites

Although the number and types of habitats sampled at each site varies (Table 3-3, Figure 3-10), some general observations regarding particle size differences among sites can be made. As with the substrate mapping results, the pebble count results also roughly correlate with site location and slope. Of the long-term sites, SXW has the coarsest D50 values, corresponding to cobble-sized particles (Figure 3-12). The pebble count results for the DFC site have average D50 values corresponding to large gravel-sized particles, while the 2012 results at MO and OX correspond to medium gravel-size material. The results at the more recently-established monitoring sites, which are located in between the SXW and DFC sites, show a mix of average D50 values including both large and medium gravel-sized particles.

Temporal Changes From Spring to Fall

Changes in pebble count results between spring and fall 2012 are summarized in Figure 3-17. At the four monitoring sites on Sixth Water Creek and at the GS site on Diamond Fork Creek, pebble count results tended to show a minor to moderate trend toward coarsening between the spring and fall sampling events. At the AMH, BMH, and DFC sites, the opposite was true: the pebble counts show a minor to moderate trend toward substrate fining (Figure 3-17). The MO and OX sites showed little change in pebble count results between spring and fall (Figure 3-17).

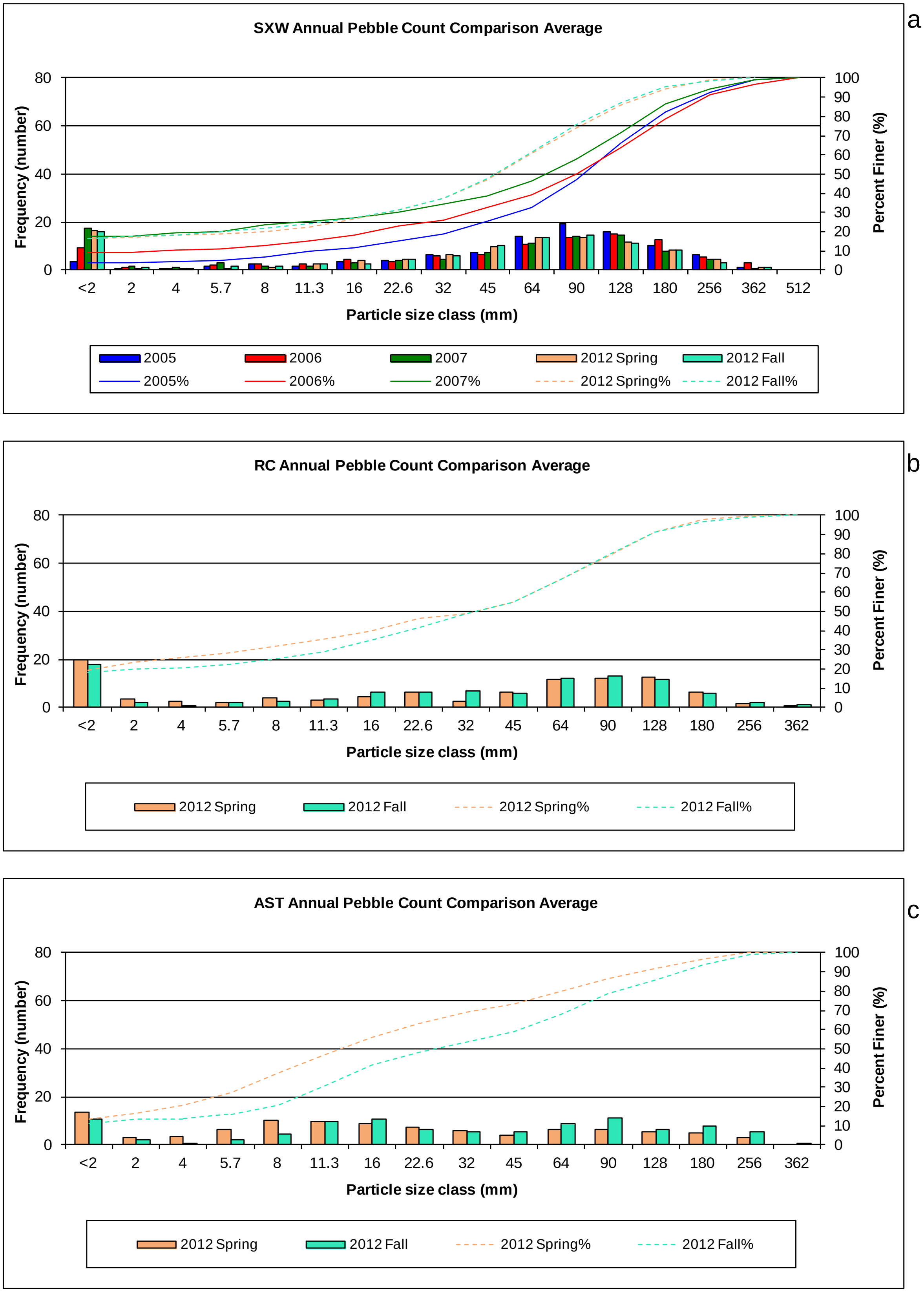
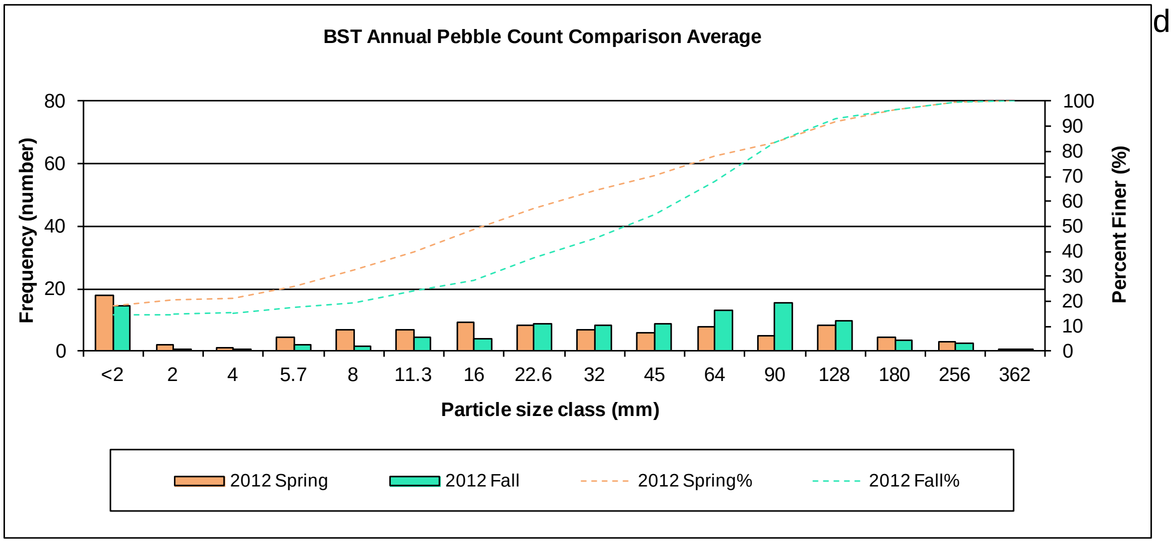
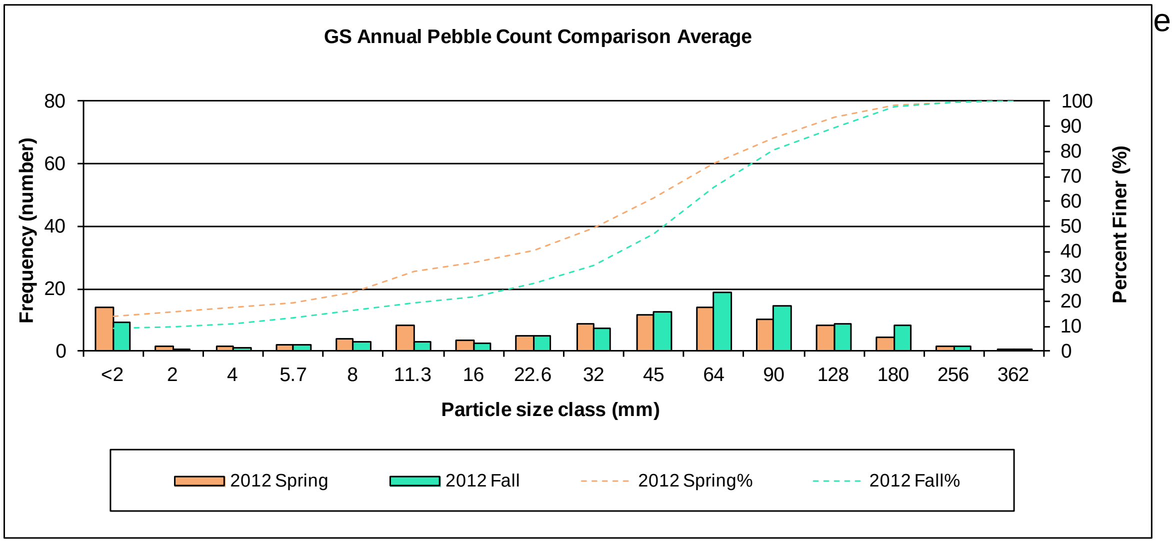


Figure 3-11. Site-averaged pebble count results at each monitoring site for all available years of monitoring data. ***(This figure is continued on the next pages.)***





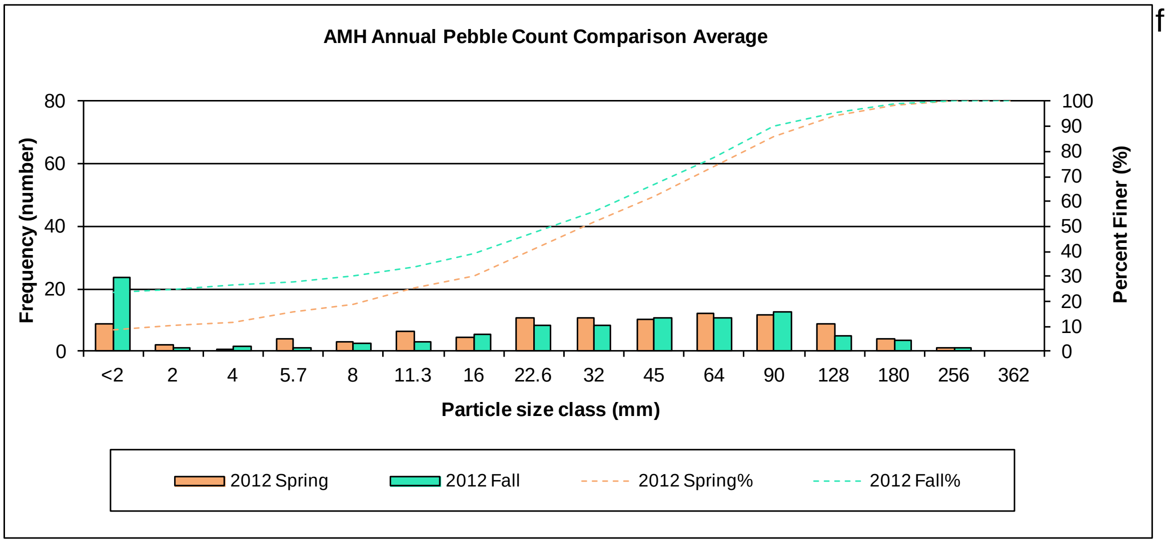


Figure 3-11. (Cont.)

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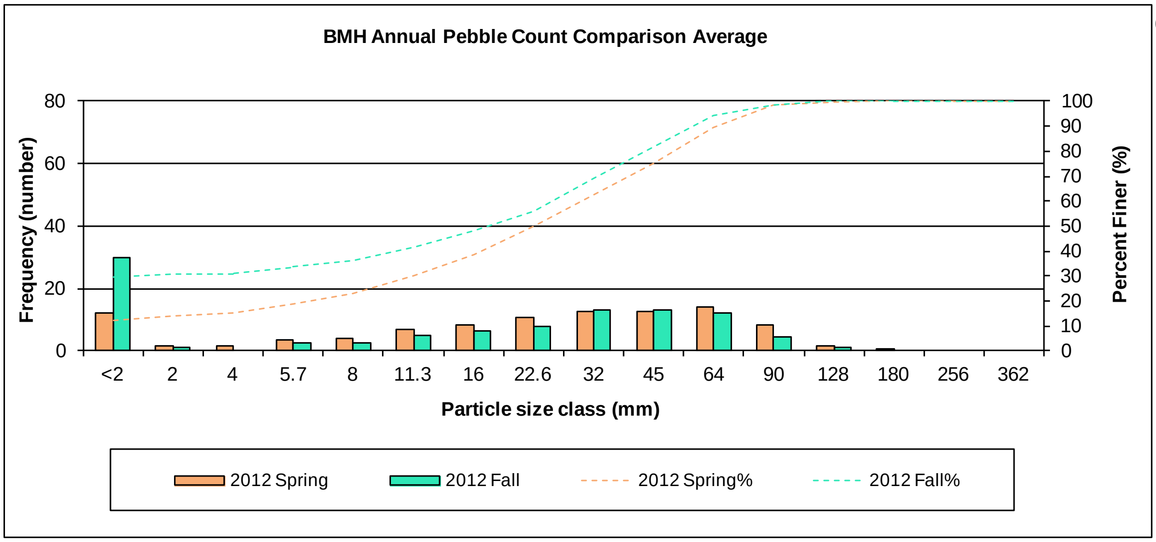

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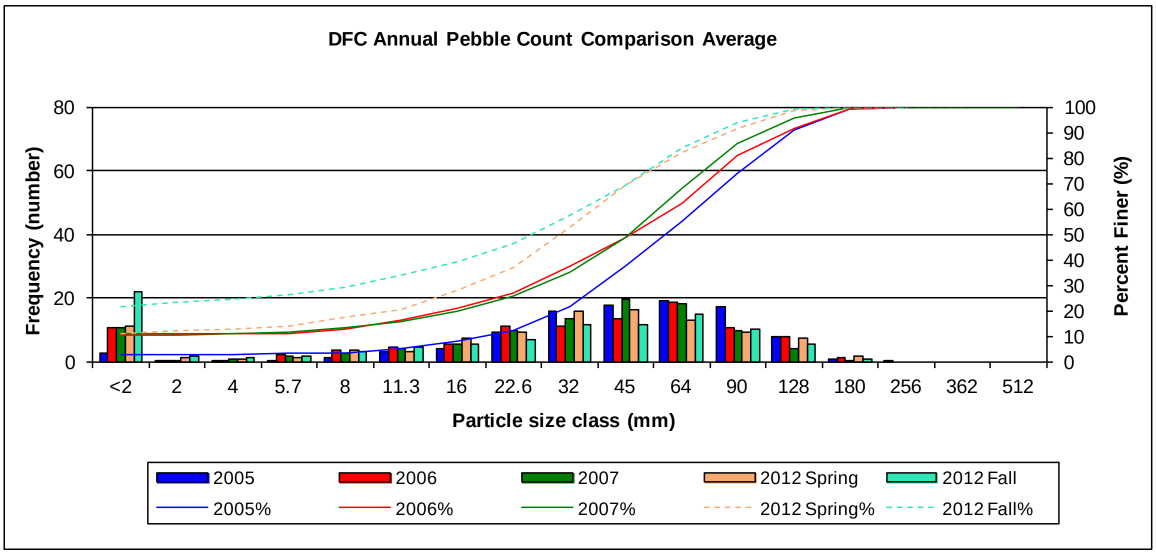

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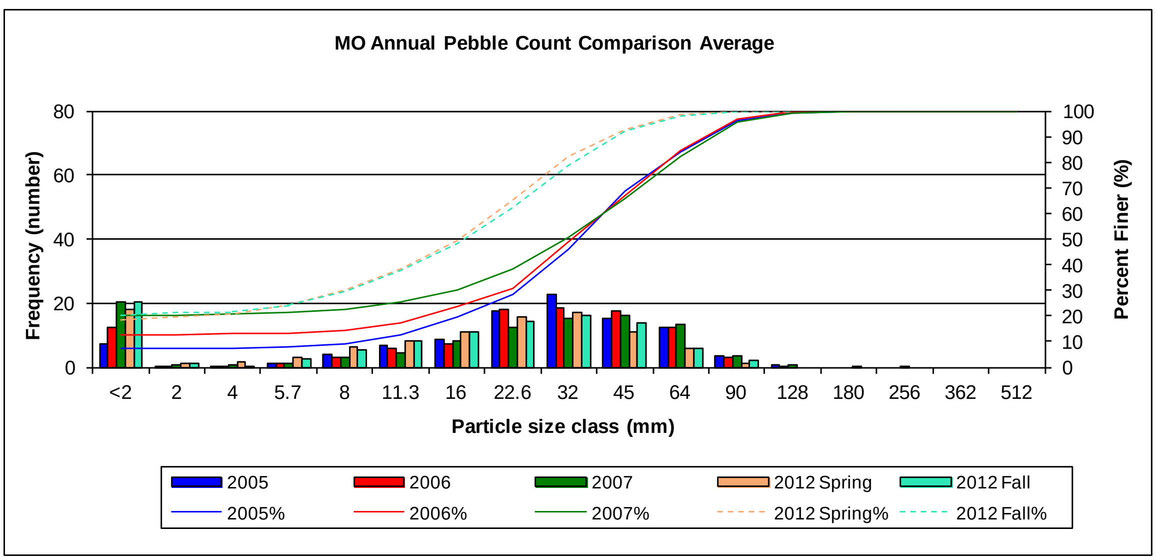
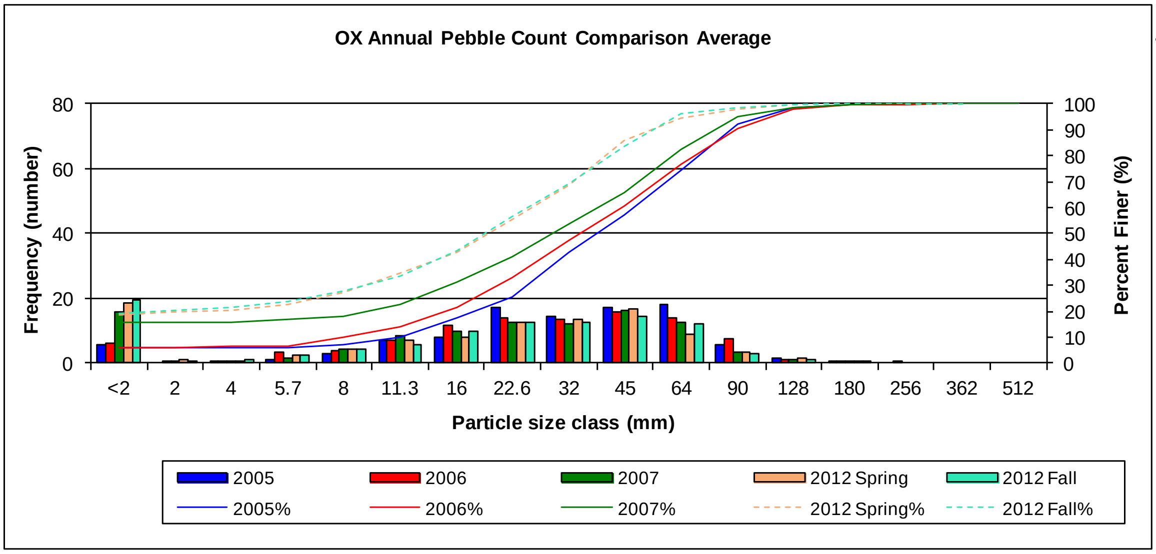


Figure 3-11. (Cont.)



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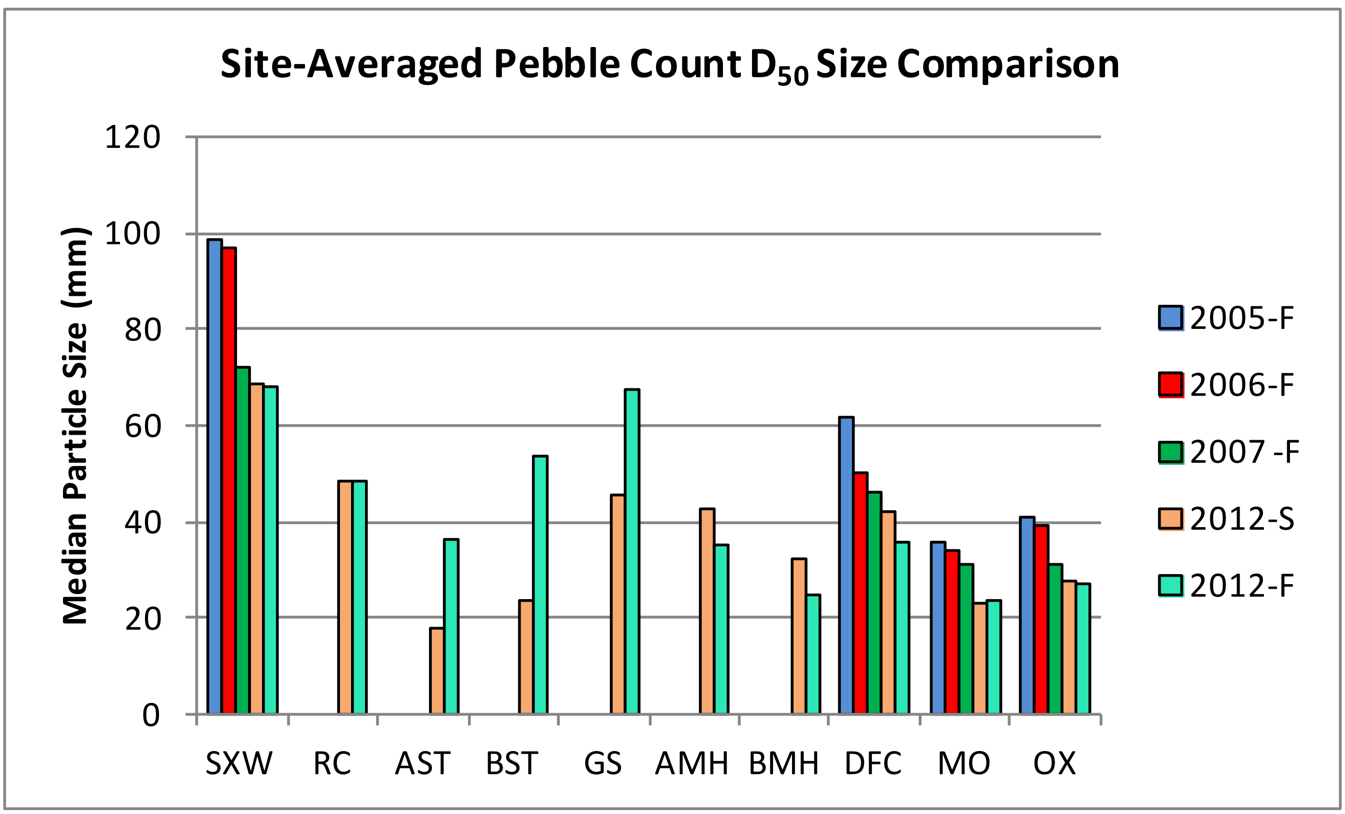


Figure 3-12. Site-averaged pebble count median particle size results for different monitoring years and seasons. Values are based on the average for all pebble counts completed at each monitoring site.

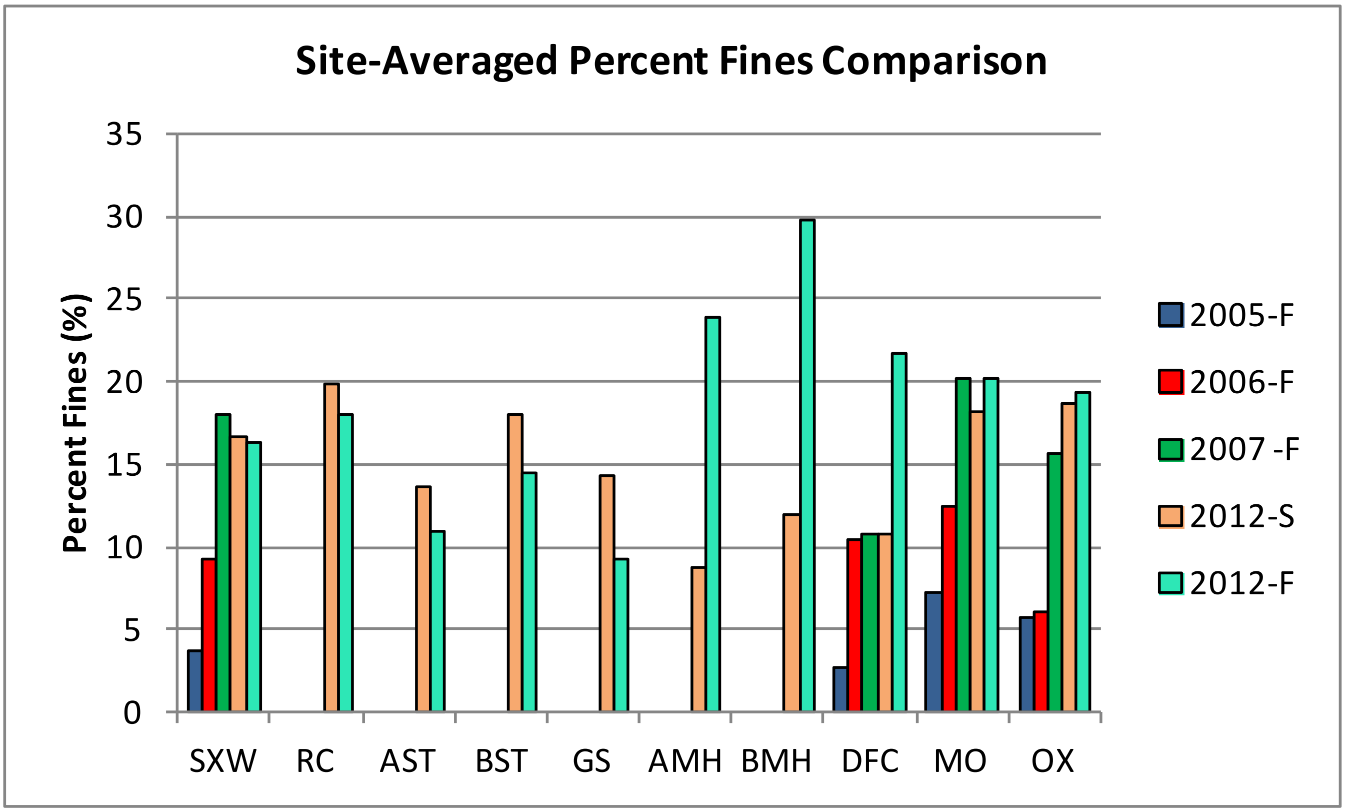


Figure 3-13. Site-averaged percent fines results for different monitoring years and seasons. Values are based on the average for all pebble counts completed at each monitoring site.

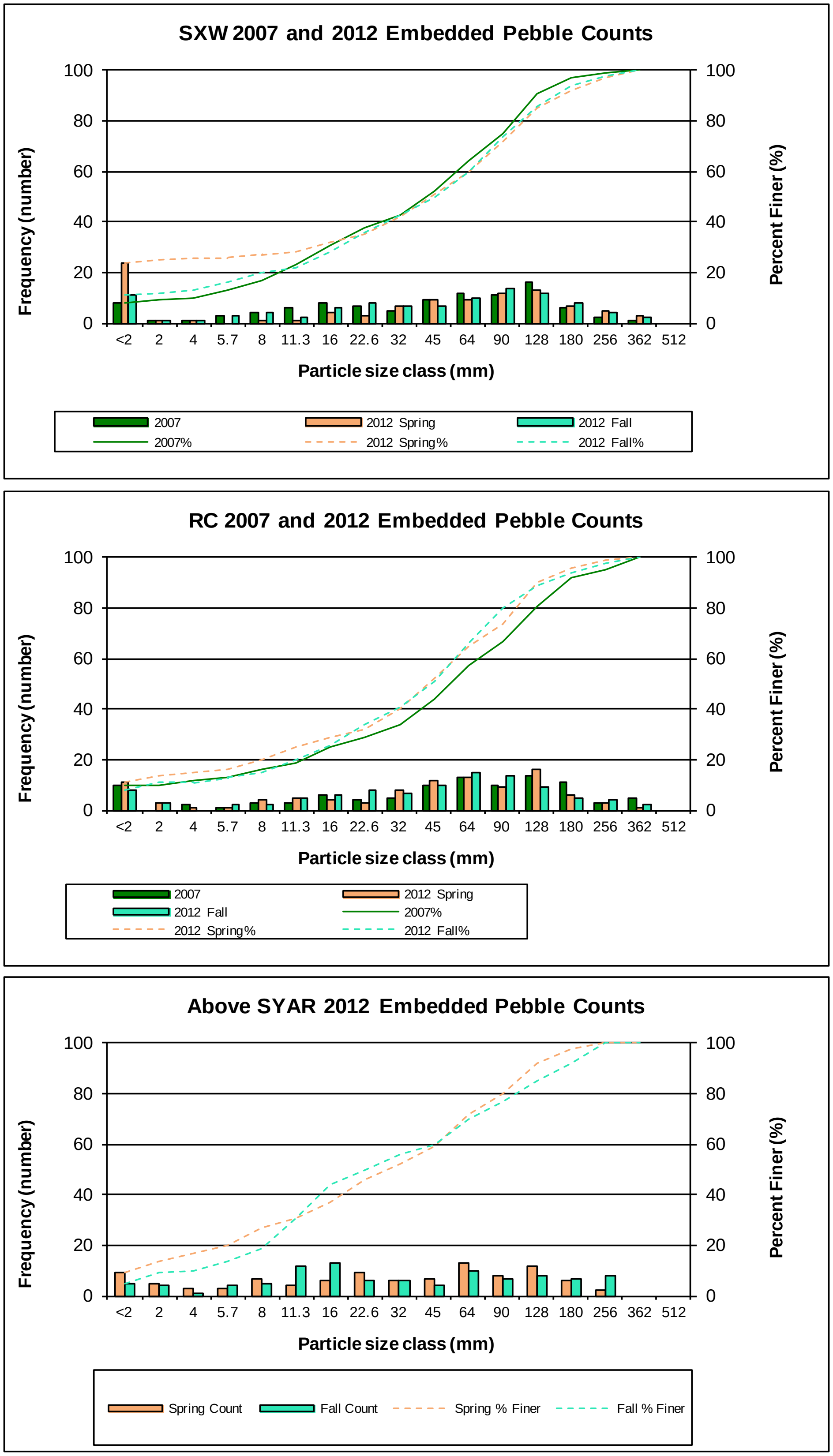
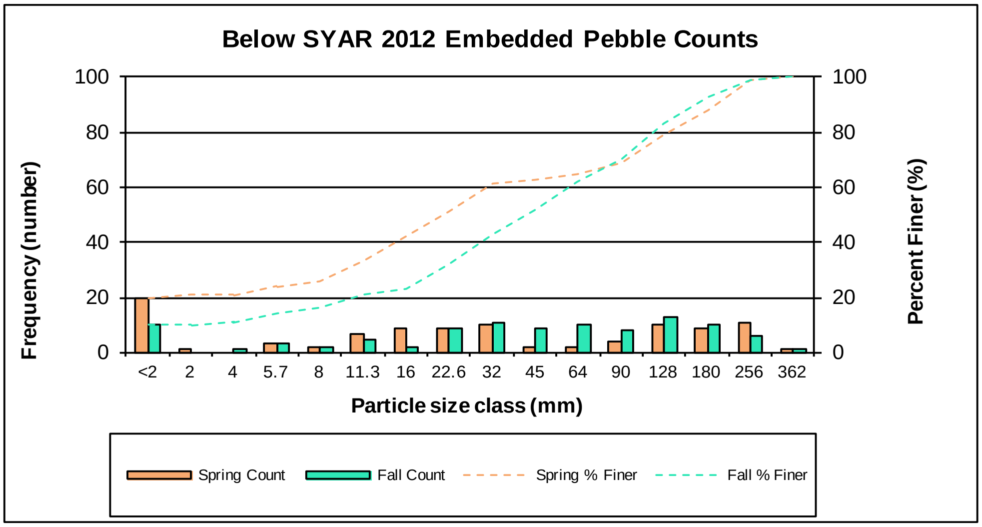


Figure 3-14. Pebble count results at stationary embeddedness transects for each monitoring site.



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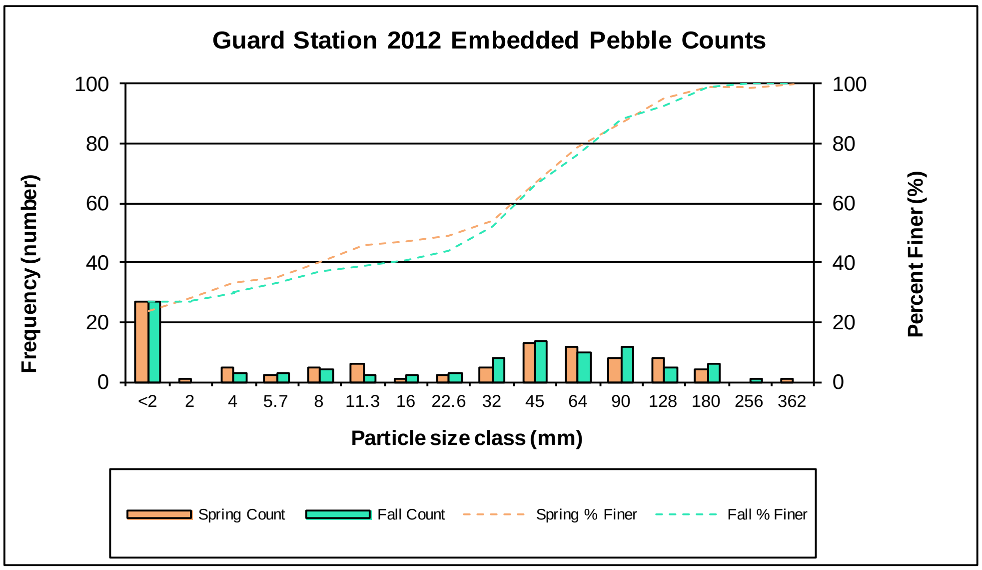

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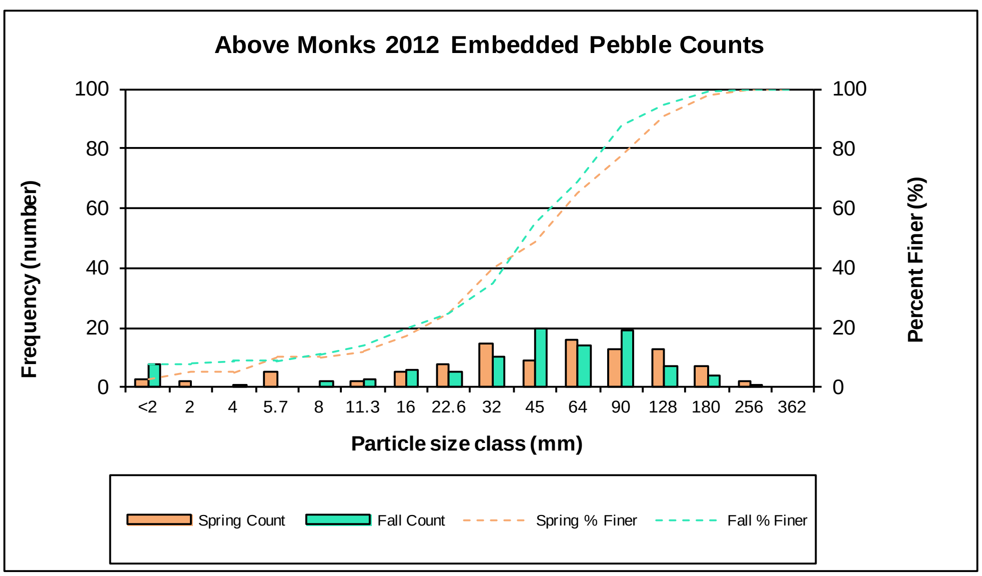

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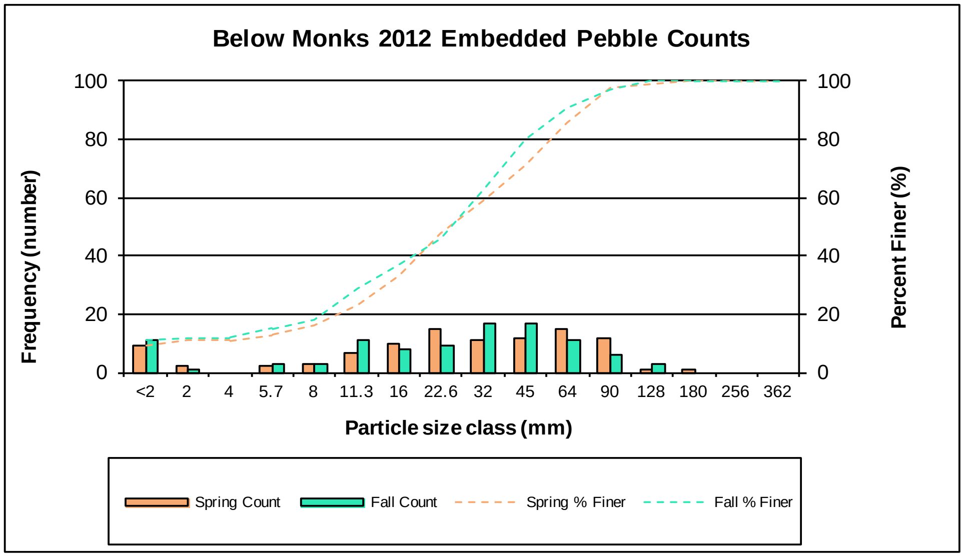
Figure 3-14. (Cont.)



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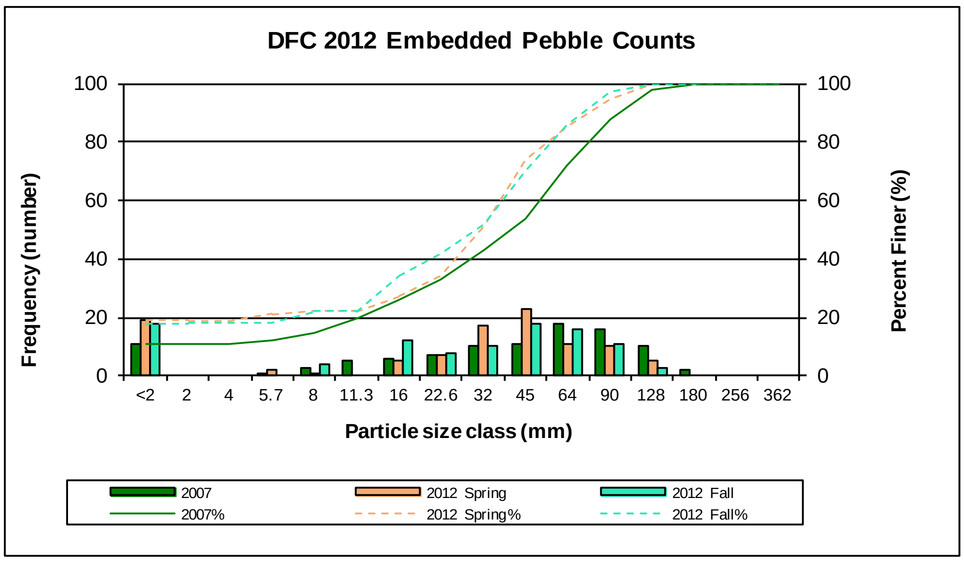

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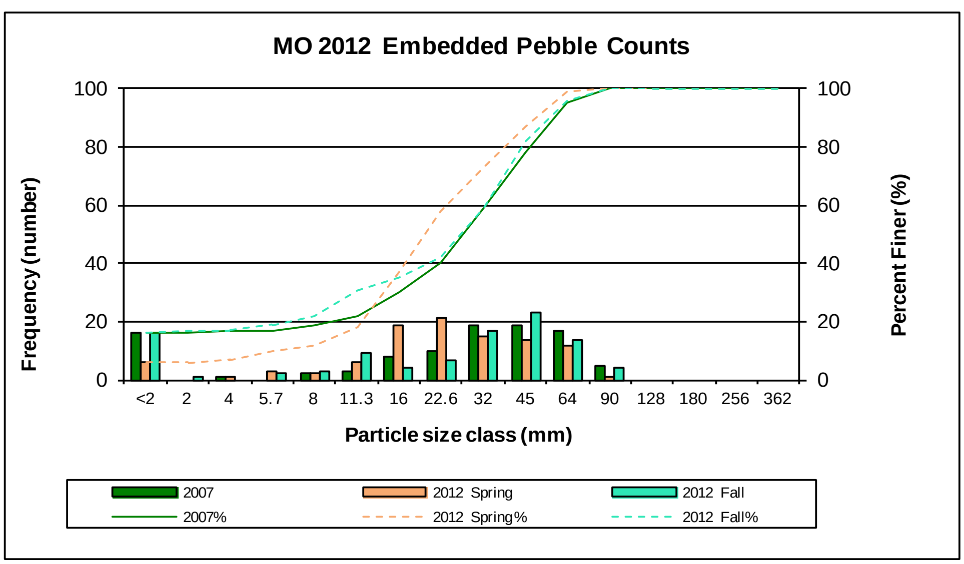

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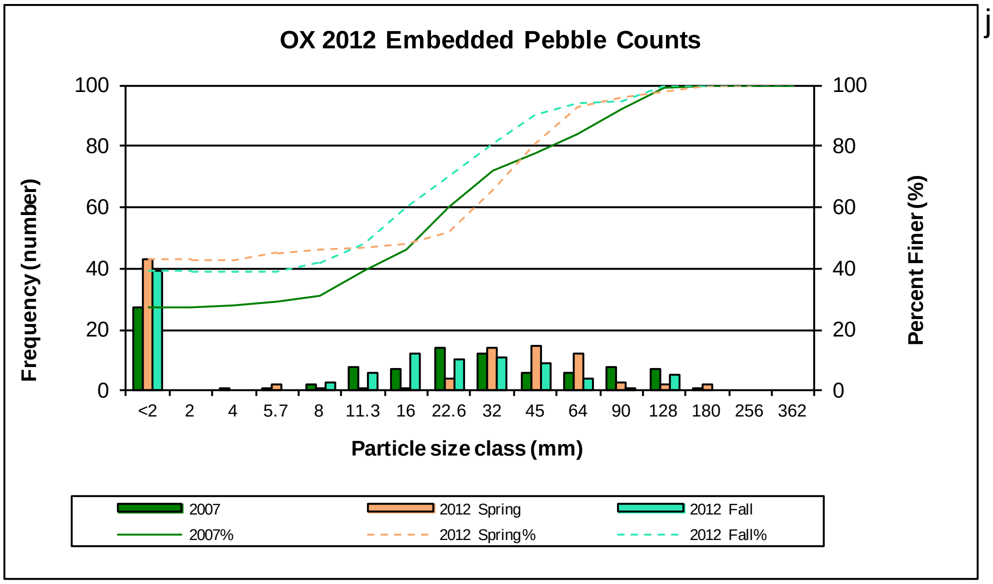
Figure 3-14. (Cont.)



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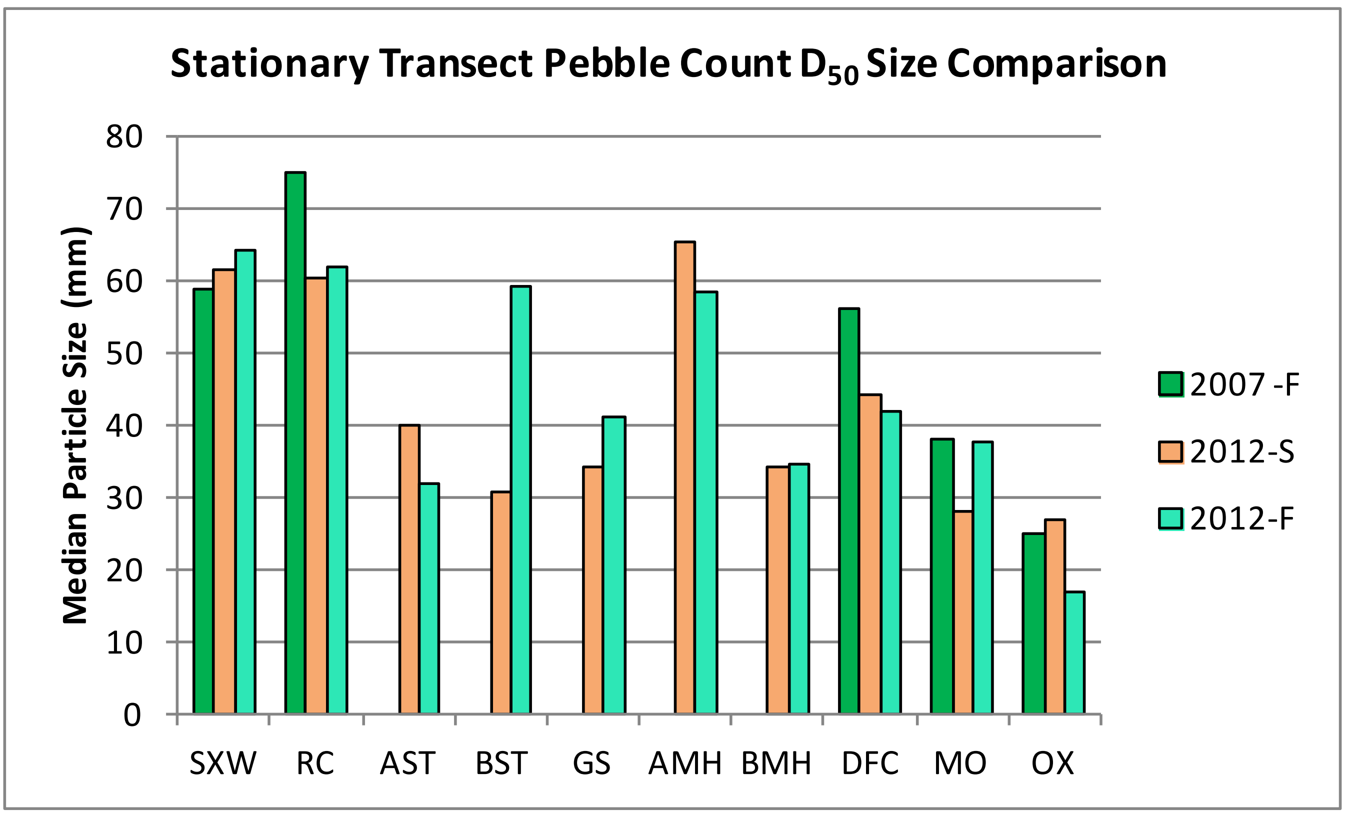


Figure 3-15. Median particle size of pebble counts completed at stationary embeddedness transects at each monitoring site.

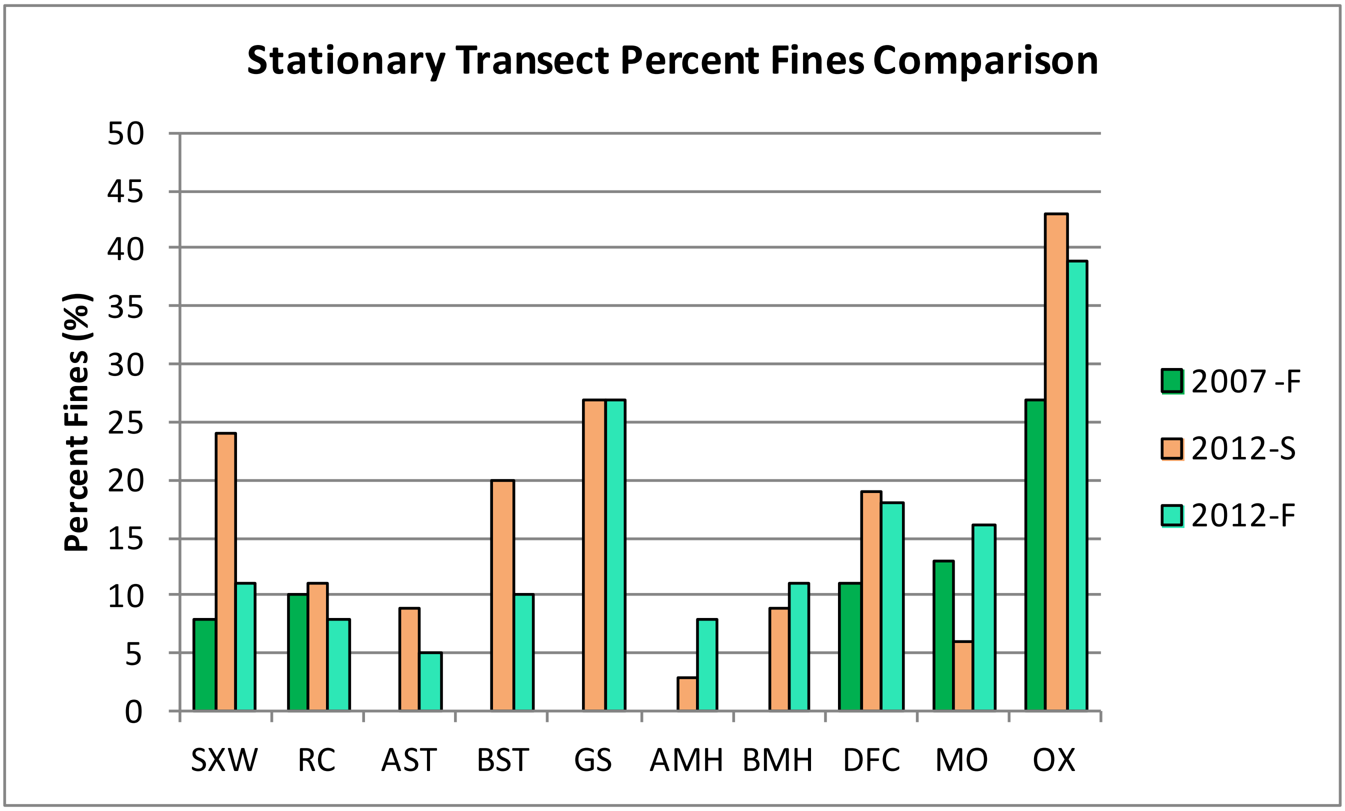


Figure 3-16. Percent fines as measured in pebble counts completed at stationary embeddedness transects at each monitoring site.

Embeddedness

Plots of embeddedness monitoring results are shown in Figure 3-17. In general, the observed temporal changes in embeddedness between spring and fall of 2012 roughly correlate with trends observed in the pebble count data for each site (Figure 3-14). Embeddedness at the four sites on Sixth Water Creek decreased between spring and fall. The GS and DFC sites showed a minor increase in embeddedness between spring and fall, the BMH site a moderate increase, Major increases in embeddedness were observed at the AMH, MO, and OX sites (Figure 3-17).

Some observations of longer-term trends at the SXW, RC, DFC, MO, and OX sites can also be made through comparison of the fall 2012 results with embeddedness results from fall 2007 (Figure 3-17). Embeddedness at SXW and RC has apparently decreased, while the results at DFC, MO, and OX show dramatically higher proportions of "fully" and "mostly" embedded particles in 2012.

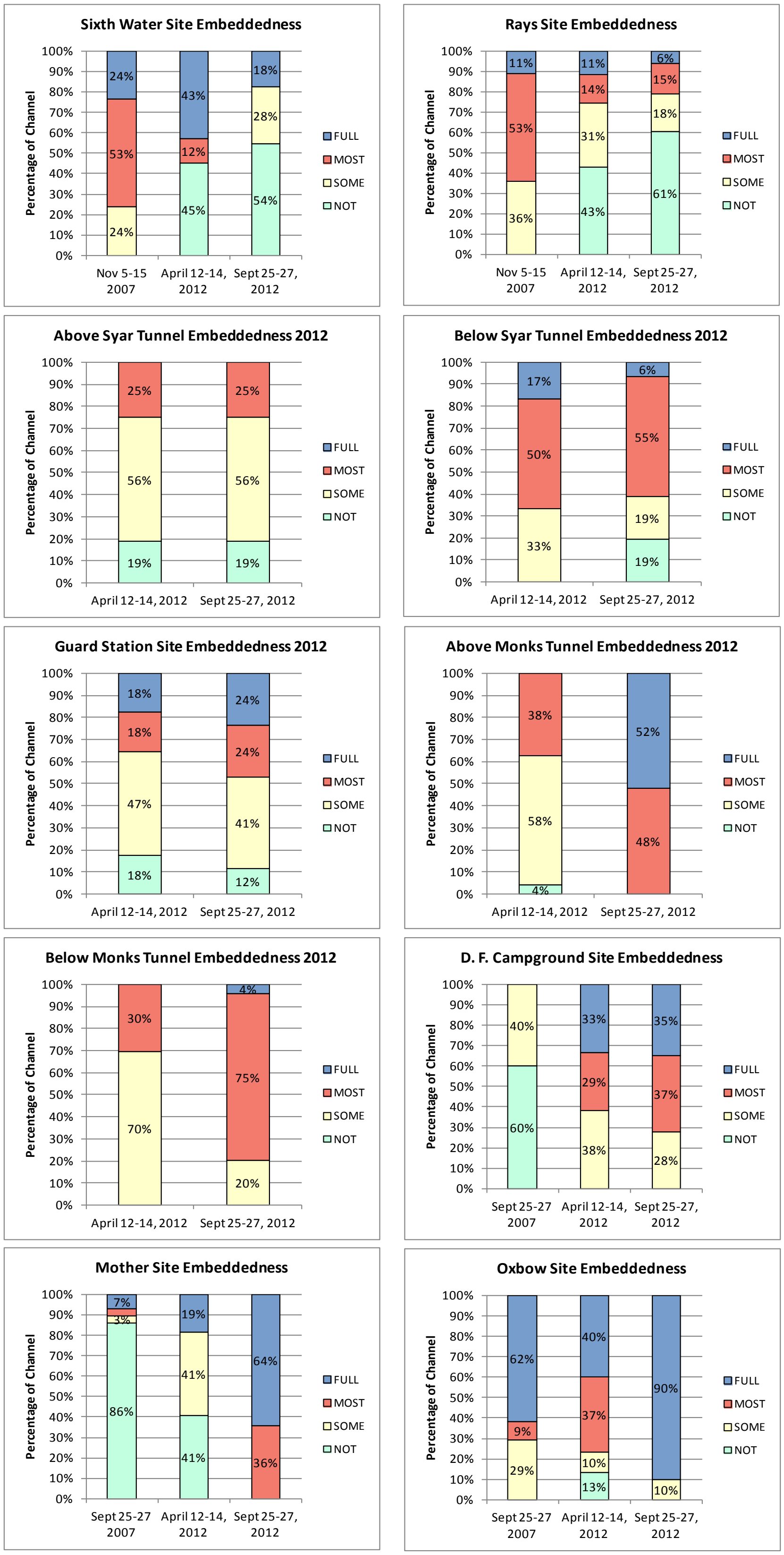


Figure 3-17. Proportion of the embeddedness/macroinvertebrate monitoring transect with embedded particles for each monitoring site and all available years of data.

Summary and Discussion

The new monitoring sites established in 2012 provide a more complete picture of channel substrate conditions along the continuum of the Diamond Fork watershed. The steep, boulder-dominated conditions at the SXW site are also present at the RC, AST, and BST sites located farther downstream on Sixth Water Creek. The coarseness of the substrate at these sites is distinct from all of the monitoring sites located on Diamond Fork Creek, where boulders comprise a much smaller portion of the substrate (Figure 3-2). The newly established sites on Diamond Fork (GS, AMH, and BMH) are dominated by a mix of cobble and gravel substrate, similar to the DFC site, and are coarser than the gravel-dominated MO and OX sites.

Channel substrate changes between April and September 2012 varied among the monitoring sites (Figure 3-18 a-c). Based on all measured parameters, the Sixth Water sites all showed minor to moderate trends toward coarsening and reduced embeddedness from spring to fall. This change may likely be due to sediment evacuation associated with the unusually high flow releases from Strawberry Tunnel. These releases resulted in flows on Sixth Water Creek that exceeded the historically high 2011 snowmelt peak flows Figure 1-4, and destabilized sediment-trapping beaver dams and woody debris accumulations in portions of the creek. On Diamond Fork, the 2012 spring versus fall substrate mapping and pebble count results showed a mixed response at the GS, MO, and OX sites, while the AMH, BMH, and DFC sites became finer-grained. At all six Diamond Fork sites, embeddedness increased between spring and fall 2012 (Figure 3-17).

Channel substrate trends observed during the earlier 2005–2007 monitoring period included a general trend of substrate fining, an increase in the prevalence of “cemented” bed material, and an increase in the amount of sand and silt at the three downstream sites (DFC, MO, OX; BIO-WEST 2009). The SXW site also showed an increase in sand and silt over that time period (BIO-WEST 2009). Comparison of the fall 2012 pebble count and substrate map monitoring results with the 2007 data set indicates that the trends toward substrate fining and increased amounts of sand/silt are continuing, albeit at an apparently somewhat slower rate (Figure 3-19).

The phenomenon of streambed “cementation” or “packing” that was first noted during 2007 monitoring work (BIO-WEST 2009) continued to be observed at the downstream monitoring sites (DFC, MO, OX) in 2012 despite the fact that the high 2011 flood flows significantly re-arranged the channel at these sites (Figure 3-7), and likely broke down some of the cemented bed areas. Although quantitative data on the extent of cemented bed area were not collected, the amount of cementing observed in 2012 appeared to be fairly similar to 2007. Between 2007 and 2012, channel embeddedness increased at the three downstream sites and decreased at the SXW and RC sites (Figures 3-18 and 3-19).

Longer-term Temporal Trends

For the sites where pre-2012 data are available, differences in pebble count and embeddedness results through time are illustrated in Figures 3-11 to 3-17, and are summarized in Figure 3-19.

Site-averaged pebble count results from fall monitoring show a trend toward fining at all four long-term sites (SXW, DFC, MO, OX); this trend was very strong between the 2005 and 2007 monitoring years and continues at least to some extent between 2007–2012 (Figures 3-11 to 3-13). At the lower Diamond Fork sites (DFC, MO, OX) this trend toward fining is also apparent in the fall pebble count results at the stationary embeddedness/macroinvertebrate transects, while the change at SXW and RC sites was minimal (Figures 3-14 to 3-16).

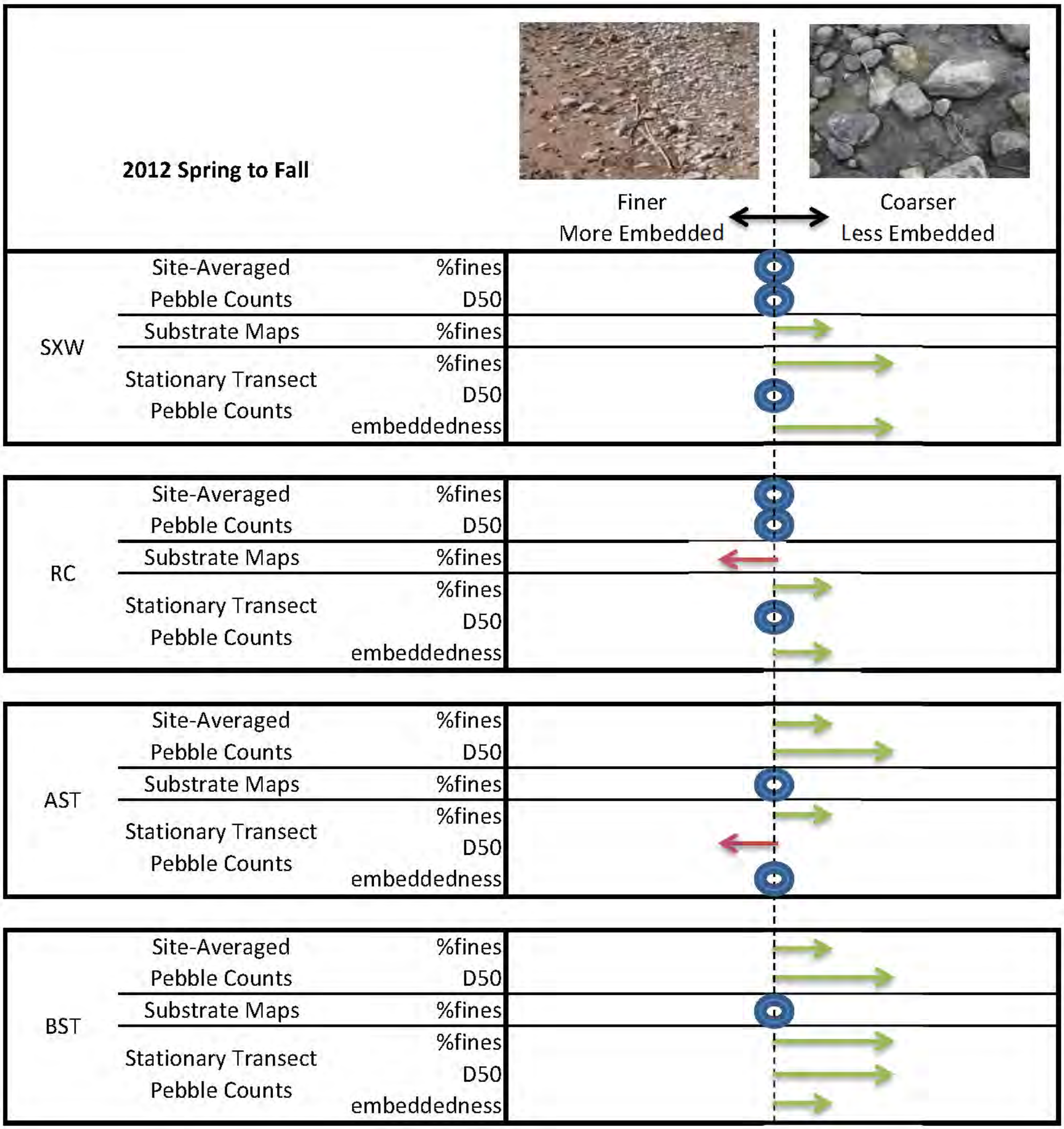


Figure 3-18a. Graphic illustrating types, direction and magnitude of channel substrate changes observed between spring and fall 2012 at the four monitoring sites located on Sixth Water Creek. Circles indicate no change or minimal change; small arrows indicate minor change; medium arrows indicate moderate change; large arrows indicate large change.

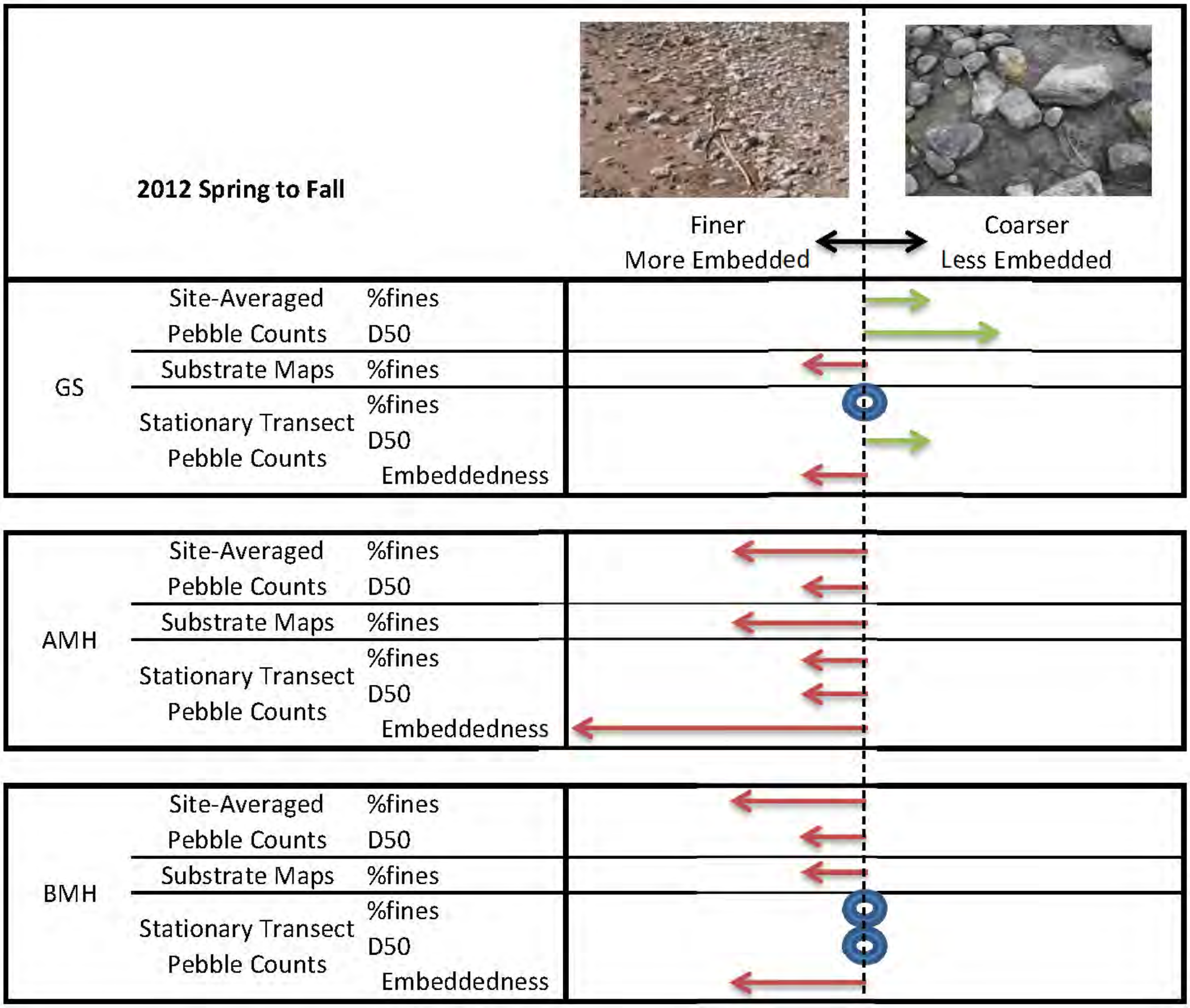


Figure 3-18b. Graphic illustrating types, direction and magnitude of channel substrate changes observed between spring and fall 2012 at the three monitoring sites located on upper Diamond Fork Creek. Circles indicate no change or minimal change; small arrows indicate minor change; medium arrows indicate moderate change; large arrows indicate large change.

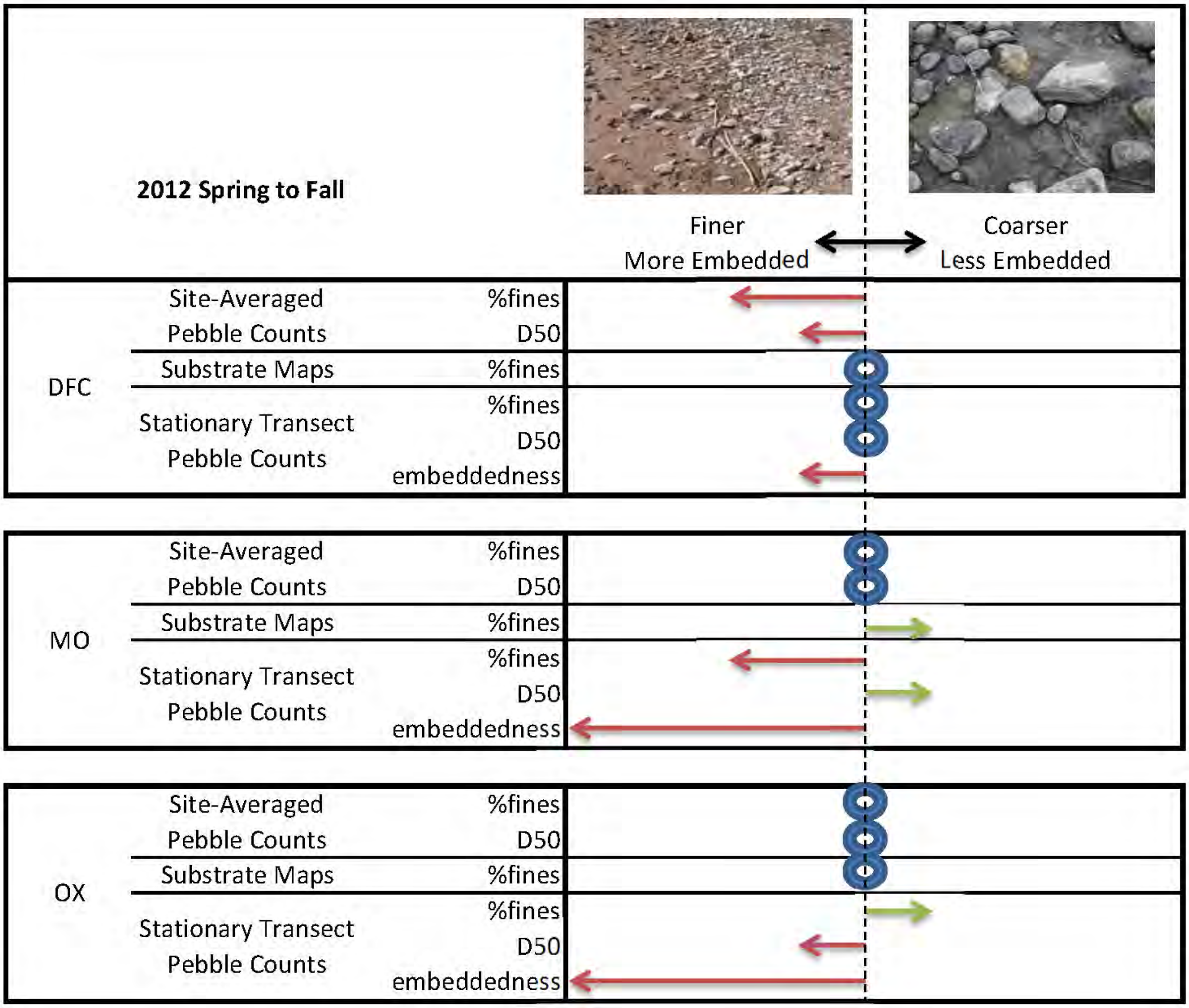


Figure 3-18c. Graphic illustrating types, direction and magnitude of channel substrate changes observed between spring and fall 2012 at the three monitoring sites located on lower Diamond Fork Creek. Circles indicate no change or minimal change; small arrows indicate minor change; medium arrows indicate moderate change; large arrows indicate large change.

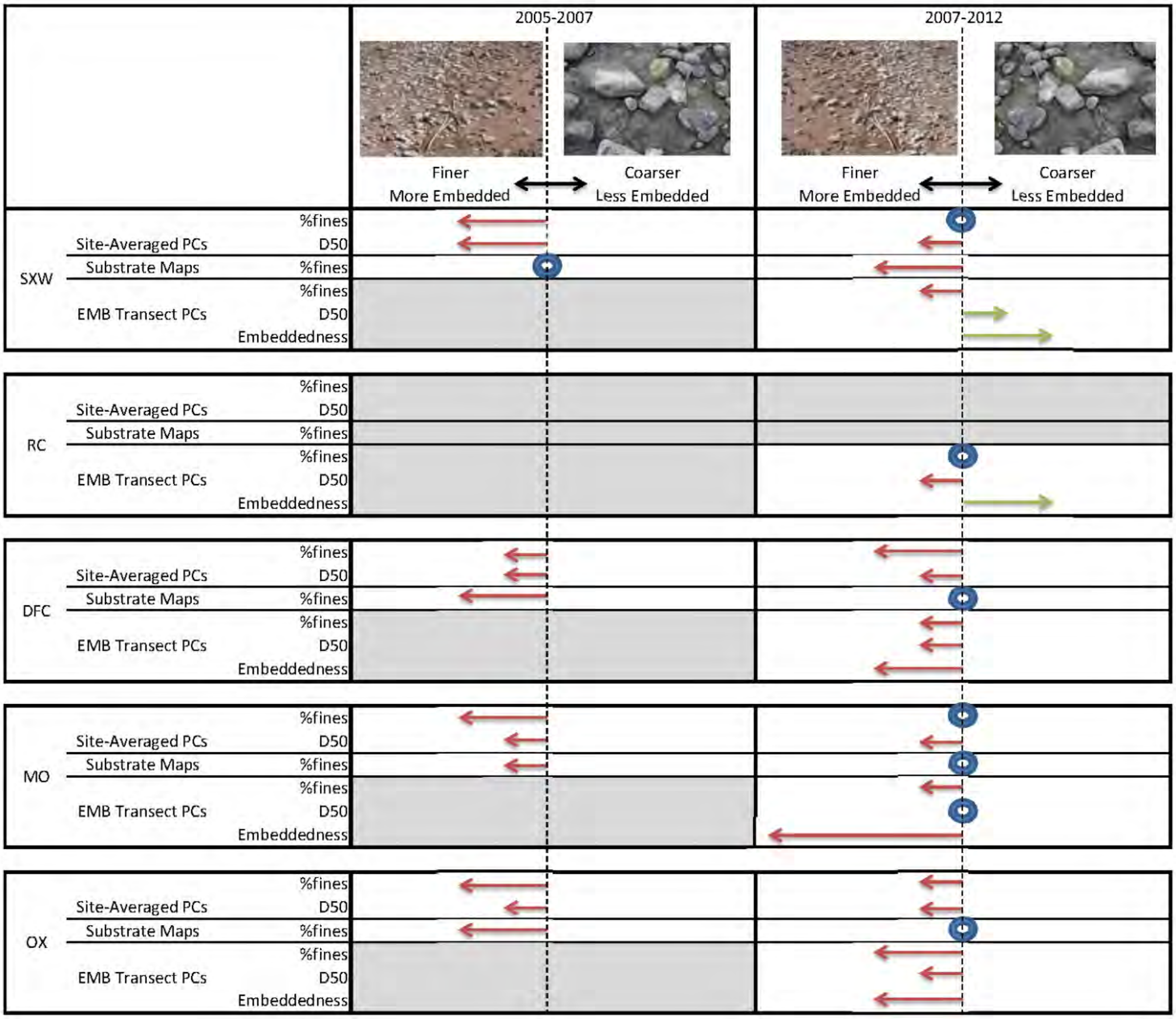


Figure 3-19. **Graphic illustrating types, direction and magnitude of channel substrate changes observed between 2005 and 2007, and between fall 2007 and fall 2012 at the five monitoring sites where past channel substrate data have been collected. Circles indicate no change or minimal change; small arrows indicate minor change; medium arrows indicate moderate change; large arrows indicate large change.**

SECTION 4: BENTHIC MACROINVERTEBRATE MONITORING

Introduction

This chapter describes the results of quantitative and qualitative benthic macroinvertebrate monitoring on Diamond Fork and Sixth Water Creeks in 2012 as well as historic macroinvertebrate data comparisons as applicable. This marks the fourth year of macroinvertebrate monitoring following the completion of water conveyances in 2005 that allow deliveries from Strawberry Reservoir to completely bypass the system (with the exception of minimum instream flows). More specifically, macroinvertebrate monitoring conducted in 2012 focused on examining the biological response to any geomorphological and sediment transport changes, as well as any management actions implemented by the natural resource agencies since implementation of the pipeline project.

The effects of increased base flows (or increased minimum instream flows) during non-peak seasons to the macroinvertebrate community are poorly understood and most studies focus on depleted base flows or increases in peak flows (Carlisle 2012). Thus, it becomes important to understand the effects of increased base flows on the macroinvertebrate community at Sixth Water and Diamond Fork Creeks.

Examining the potential effects that any changes to the benthic community may have to the fishery is an additional goal for the restoration of Sixth Water and Diamond Fork Creeks. Fish habitat appeared to be negatively impacted during the historical water delivery regime by artificially high summer flows (BIO-WEST 2007). Macroinvertebrates are a critical component of a healthy trout fishery as they provide a food source (especially to young trout) (Sigler and Sigler 1996), and play an important role in stream ecosystem function (Covich et al. 1999). Monitoring the macroinvertebrate community can provide indications of changes in water quality and habitat, as well as an index for the quantity and quality of food available to the fishery. Such information can be used to determine whether and which types of adaptive maintenance activities may be needed to assist in returning Diamond Fork and Sixth Water Creeks to a more ecologically desirable condition. Monitoring the health of the macroinvertebrate community over time can help ensure that flow mitigation and habitat restoration efforts are achieving desired outcomes and are helping to maintain and improve biological integrity and recreational opportunities.

Methods

Quantitative and qualitative sampling for benthic macroinvertebrates was conducted at 10 sampling locations in Sixth Water (4 sites) and Diamond Fork (6 sites) Creeks on April 17-18, 2012 (spring) and again on September 20, 2012 (fall) (Table 4-1). Sites along Sixth Water and Diamond Fork Creeks were also sampled in the spring and fall in 2005 through 2007 (BIO-WEST 2006, 2007, 2009). An exception to this sample schedule occurred during the spring 2006 when spring flows were too high for effective sampling (BIO-WEST 2007). Please refer to past BIO-WEST reports for additional details on timing, sampling locations, and methods related to past sampling events. Five of the previously sampled sites (Sixth Water [SXW], Guard Station [GS], Diamond Fork Campground [DFCG], Mother [MO], and Oxbow [OX]) were sampled again in 2012 with the other five sites established as additional baseline data collection sites at Ray's Crossing [RC], above and below the Syar tunnel (AST and BST), and above and below the Diamond Fork Tunnel input (above Monks Hollow (AMH) and below Monks Hollow (BMH)) (Table 4-1). It should be noted that GS is included as a control site that does not receive artificial inputs and lies upstream of the confluence of Sixth Water Creek into Diamond Fork Creek.

Table 4-1. Site names and locations sampled for macroinvertebrates during the spring (April 17–18, 2012) and fall (September 20, 2012).

SITE NAME	SITE ABBREVIATION	LATITUDE	LONGITUDE	DRAINAGE	STREAM	STATE	COUNTY
Sixth Water	SXW	40.16246	111.28114	Diamond Fork	Sixth Water Creek	UT	Utah
Ray's Crossing	RC	40.15335	111.29860	Diamond Fork	Sixth Water Creek	UT	Utah
Above Syar Tunnel	AST	40.11822	111.31448	Diamond Fork	Sixth Water Creek	UT	Utah
Below Syar Tunnel	BST	40.11560	111.31517	Diamond Fork	Sixth Water Creek	UT	Utah
Guard Station	GS	40.15893	111.32904	Diamond Fork	Diamond Fork Creek	UT	Utah
Above Monks Hollow	AMH	40.07634	111.38010	Diamond Fork	Diamond Fork Creek	UT	Utah
Below Monks Hollow	BMH	40.07645	111.38310	Diamond Fork	Diamond Fork Creek	UT	Utah
Diamond Fork Campground	DFCG	40.06834	111.43724	Diamond Fork	Diamond Fork Creek	UT	Utah
Mother	MO	40.04523	111.46825	Diamond Fork	Diamond Fork Creek	UT	Utah
Oxbow	OX	40.04018	111.48325	Diamond Fork	Diamond Fork Creek	UT	Utah

At each sample site , one riffle was chosen for collection of three replicate benthic macroinvertebrate samples within a reach approximately 200 meters [m] in length. A prerequisite of an appropriate site was sufficient size to permit collection of three samples and physical characteristics conducive to effective sampling with the gear. Each of the individual samples was collected with a Hess type cylindrical 0.086 square meters (m^2) bottom sampler with a 250 micron mesh window and 250 micron collecting net and dolphin bucket. The requirements for sampling with this device include substrate sizes ranging from gravel to cobble, water depth of less than two feet, and water velocity that was not too great to prevent holding the sampling gear in place and on the bottom of the streambed. Once secured all rock surfaces confined within the sampler were cleaned of all algae and macroinvertebrates. The substrate was then disturbed vigorously to a depth of approximately 10 centimeters (cm) (Cuffney et al. 1993; Metzeling et al. 2003). All detritus and macroinvertebrates dislodged during this process were washed downstream into the net and ultimately into the attached dolphin bucket. All contents of the dolphin bucket were then rinsed into a 500 milliliters (mL) or 1 liter (L) Nalgene bottle. The contents were then preserved in 95% ethanol to obtain a final concentration of at least 70% (Barbour et al. 1999). Depth and velocity were also recorded at each Hess sampling location. Hess samplers provide a quantitative estimate of both the density (number per area) and composition of the macroinvertebrate community in riffle type habitats within each monitoring site. Since similar habitat types were sampled in each site using the Hess sampler, estimates of richness and abundance are directly comparable among sites.

In addition to the three samples collected with the Hess type sampler, one multi- habitat, composite, kick-net sample was collected within each reach. These composite samples were comprised of 20 individual samples collected in various habitat types, in proportion to their abundance within the reach, using a 500 micron mesh, D-frame kick-net (Cuffney et al. 1993; Barbour et al. 1999). In each of the 20 kick sample locations, a 0.5 m area of substrate was disturbed in front of the D-frame kick-net by kicking at the substrate. In areas with moderate to high velocities, the current carried the invertebrates and periphyton from the disturbed area into the D-frame kick-net below. Areas with low velocity or large amounts of aquatic vegetation were disturbed, and the D-frame kick-net was passed through the water column throughout the disturbed area (Cuffney et al. 1993; Barbour et al. 1999).

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

The NAMC processed and identified organisms in the benthic macroinvertebrate samples. Samples were randomly split to achieve approximately 600 organisms or more per split sample. All organisms were removed from the split sample, counted, and separated by family. These individuals were then identified to the lowest taxonomic level possible by qualified taxonomists. A synoptic reference collection was created, which was checked by a second taxonomist to ensure taxonomic accuracy. The number of each taxa collected was then entered into a spreadsheet, which was used to generate a list of 55 metrics that can be used as an index of the quality and health of the macroinvertebrate community. The NAMC provided the raw data and metrics to BIO WEST, and retained a reference collection within their lab. For additional information regarding the sample processing and metric calculations please refer to NAMC (2012).

During both the spring and fall sampling trips, water quality data were obtained at each site using a Hydrolab Quanta Multi-Probe to determine the current water quality parameters important to general aquatic ecosystem health. Water quality parameters measured included temperature (°C), conductivity (µS/cm), dissolved oxygen (mg/L), percent dissolved oxygen (%), salinity (PSS), pH, and turbidity (nephelometric turbidity units [NTU]).

Data Analysis

Several commonly used metrics were selected to examine differences between sites and seasons sampled during 2012 and in comparison to data obtained during previous sampling events, when appropriate. Total abundance of organisms in all Hess samples was converted into density estimates for the sample site using the 0.086 m^2 open bottom area of the Hess sampler and calculating the number of organisms per square meter. An analysis of variance (ANOVA) was used to test for differences among sites and seasons. Where appropriate, Tukey’s post hoc multiple comparison test was used to compare all differences between means, and a least squares regression was used to determine trends through time. An *a priori* value of 0.05 (5% chance of type I error) was set for all statistical tests and all error bars represent +/- one standard error.

Metrics Used

A complete list of taxa found and metrics generated for each sample collected in 2012 can be found in Appendices 4-1 and 4-2. For data and metrics used during efforts in 2005–2007 refer to BIO-WEST (2006, 2007, and 2009). The metrics used for comparing macroinvertebrate communities among sites (within each season) and within a site (among seasons) included, but were not limited to: total density of all macroinvertebrates (total abundance for kick-net samples), density/abundance of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (collectively referred to as EPT), total taxa richness, EPT taxa richness, the Hilsenhoff Biotic Index (HBI), the USFS Community Tolerance Quotient (CTQd), and functional feeding groups. The relevance of, and calculated values for, each of these metrics from all monitoring efforts during 2012 are described within each results section and are summarized in Vinson (2006).

Results

2012 Data

Data collected from the 2012 sampling event was analyzed and is reported as additional baseline data in an effort to better characterize the macroinvertebrate communities at Sixth Water and Diamond Fork Creeks. This baseline data, which has been collected in 2005, 2006, 2007, and again in 2012, may be compared across and within sites to assess changes over time or trends in the macroinvertebrate community composition.

An effort to sample during similar flows was made in 2012 between spring and fall sampling events. For sampling in April mean discharge was approximately 53 cubic feet per second (cfs) in Diamond Fork Creek above Red Hollow (USGS 10149400) and 40 cfs in Sixth Water Creek above the Syar Tunnel (USGS 10149000). During the fall sampling event discharge at Diamond Fork Creek was 79 cfs while Sixth Water Creek was 34 cfs. The habitat sampled at each of the Sixth Water and Diamond Fork Creeks sites was similar among sampling events as the protocol is designed to quantitatively sample riffles (Hess samples) and qualitatively sample habitat types in proportion to their abundance (D-Frame kick-net) (Figure 4-1). The majority of the habitat at all sites consisted of runs and riffles; however, slackwaters and pools were present at most sites in lower proportions. The exceptions were RC in the fall, AST in both spring and fall, BST in the spring, and DFCG in the spring when no pools were sampled (Figure 4-1). It should be noted that this qualitative characterization is somewhat subjective to the sampler and somewhat dependent on discharge and general conditions at the time of sampling.

Generally, water quality data from both the spring and fall 2012 sampling trips show that with downstream progression water temperature, conductivity, and salinity increase (Table 4-2). Water temperature is most likely a function of season, flow and the time of day for which the sampling occurred while conductivity and salinity a function of the amount of ions present within the water column. Turbidity measurements reveal no longitudinal (upstream to downstream) trend for either the spring or the fall, but do indicate overall higher average turbidity in the spring as compared to the fall sampling event (25.4 and 18.7 NTU, respectively). Temperature, dissolved oxygen, and turbidity for both 2012 sampling events were within ranges identified for biologically healthy and productive systems (Wetzel 1983; Sigler and Sigler 1996; UDAR 2012) while pH values slightly exceeded the 9.0 standard determined for aquatic wildlife in Utah (UDAR 2012). Due to the relatively good water quality, an analysis of the macroinvertebrate community structure should be a good indicator of biological health.

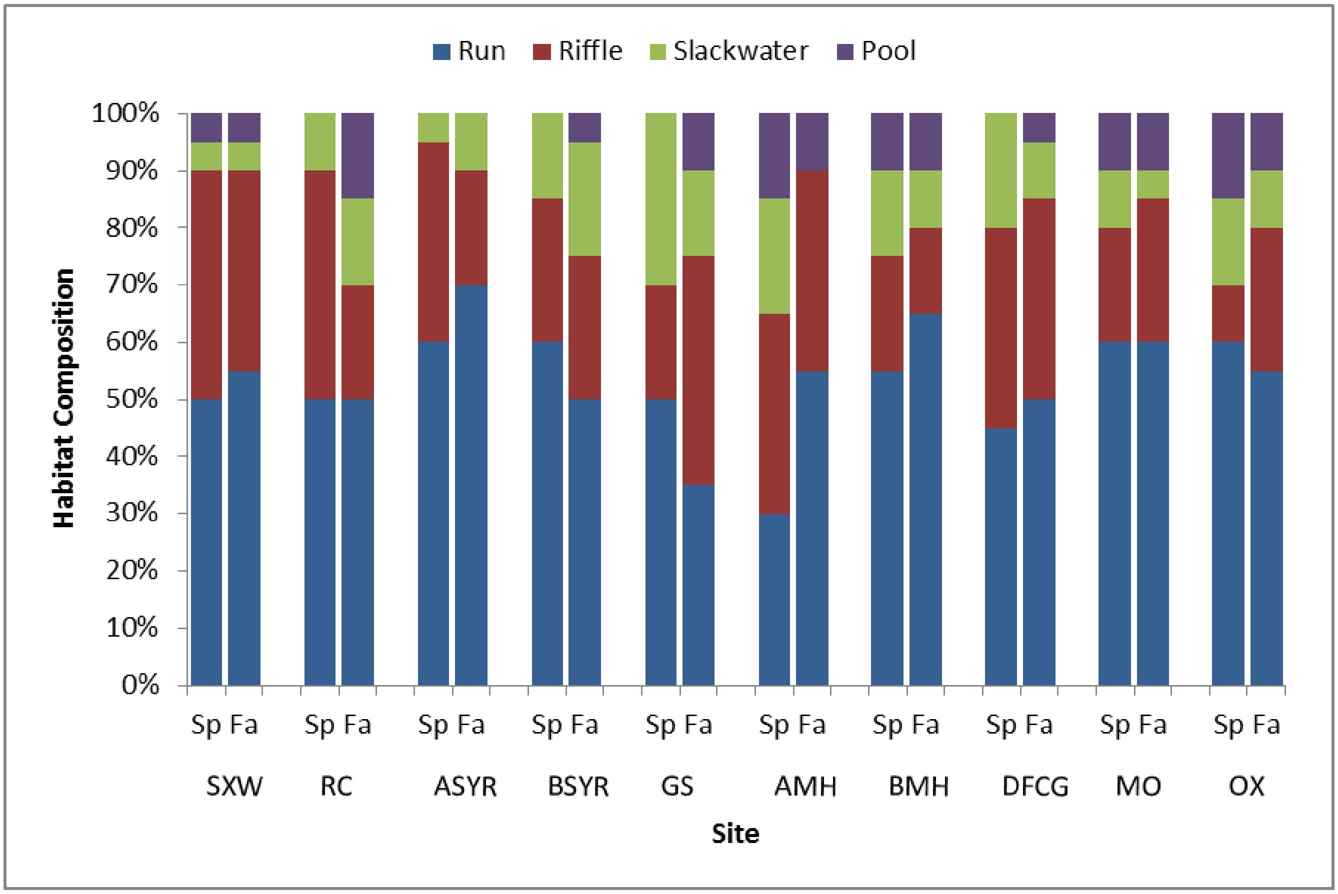


Figure 4-1. Qualitative habitat compositions by site for spring and fall sampling events in 2012 as determined by kick-net samples.

Table 4-2. Water quality data collected at each sampling location during the spring (a) and fall (b) sampling events.

(a)

SITE	DATE	TEMP (C)	COND (mS/cm)	DO (mg/L)	pH	SALINITY (PSS)	DO %	TURB (NTU)
SXW	17-Apr-12	5.29	0.31	11.09	9.01	0.14	88.1	3
RC	17-Apr-12	5.80	0.31	11.24	9.08	0.14	90.3	27
AST	17-Apr-12	6.92	0.31	10.92	9.20	0.14	90.0	32
BST	17-Apr-12	7.02	0.31	12.86	9.27	0.14	96.5	33
GS	17-Apr-12	7.82	0.29	10.52	8.99	0.14	88.6	20
AMH	18-Apr-12	5.33	0.43	11.39	8.80	0.20	90.5	38
BMH	18-Apr-12	5.53	0.44	11.43	8.87	0.20	31.2	34
DFCG	18-Apr-12	6.24	0.46	11.23	8.83	0.22	91.3	29
MO	18-Apr-12	8.18	0.47	12.79	8.92	0.22	99.1	24
OX	18-Apr-12	9.45	0.47	10.67	8.87	0.22	93.8	14

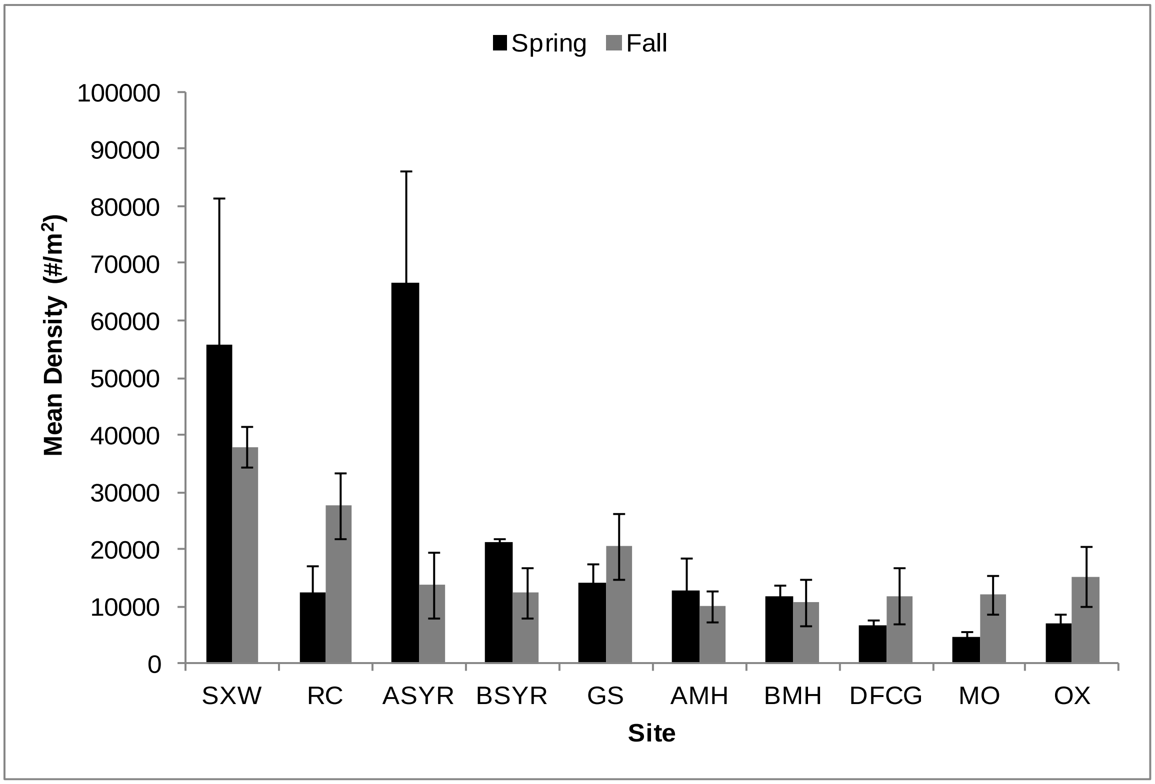
(b)

SITE	DATE	TEMP (C)	COND (mS/cm)	DO (mg/L)	pH	SALINIT Y (PSS)	DO %	TURB (NTU)
SXW	20-Sep-12	12.62	0.30	9.73	8.94	0.14	9.5	9
RC	20-Sep-12	10.84	0.30	10.29	8.77	0.14	96.4	28
AST	20-Sep-12	8.68	0.30	10.37	8.37	0.14	92.4	16
BST	20-Sep-12	9.87	0.30	10.43	8.29	0.14	95.1	14
GS	20-Sep-12	10.43	0.31	10.68	8.54	0.15	99.2	29
AMH	20-Sep-12	13.04	0.38	10.58	8.76	0.18	104.6	24
BMH	20-Sep-12	14.41	0.27	9.70	8.08	0.13	98.5	6
DFCG	20-Sep-12	15.21	0.35	11.96	8.59	0.17	124.4	14
MO	20-Sep-12	16.28	0.35	11.39	8.67	0.17	115.8	20
OX	20-Sep-12	16.25	0.35	12.65	8.68	0.17	129.6	27

Total Macroinvertebrate Density/Abundance

An estimate of the total density of macroinvertebrates provides one means of comparing biological conditions across sites. However, a high overall density may not indicate good habitat conditions and a healthy macroinvertebrate community if it results from an abundance of tolerant species. Very low total density indicates oligotrophic or toxic conditions, while very high total densities of macroinvertebrates are often associated with nutrient enrichment, higher flows, or increases in fine sediments and a degraded condition (Vinson 2006). Mean macroinvertebrate densities from Hess samples indicated a significant difference among sites or among sampling events ($F_{19,59}$=3.96, $p<0.001$) (Figure 4-2a). Post hoc analysis revealed spring densities at AST to be higher than any of the other samples, except spring and fall at SXW and fall at RC. Although sites in Sixth Water Creek appear to have higher densities than sites in Diamond Fork Creek, the spring AST and SXW samples were the only samples displaying statistically different densities than those of Diamond Fork. Although Guard Shack (GS) has been sampled as a control site (above any impact from modified flows) it demonstrated no significant difference with regards to macroinvertebrate densities in comparison to any of the other Diamond Fork Creek sites. In fact AST in the spring was the only Sixth Water site displaying significantly different mean densities from those of GS. With the exception of AST, this analysis of density also shows little variation among season within a particular site.

(a)



(b)

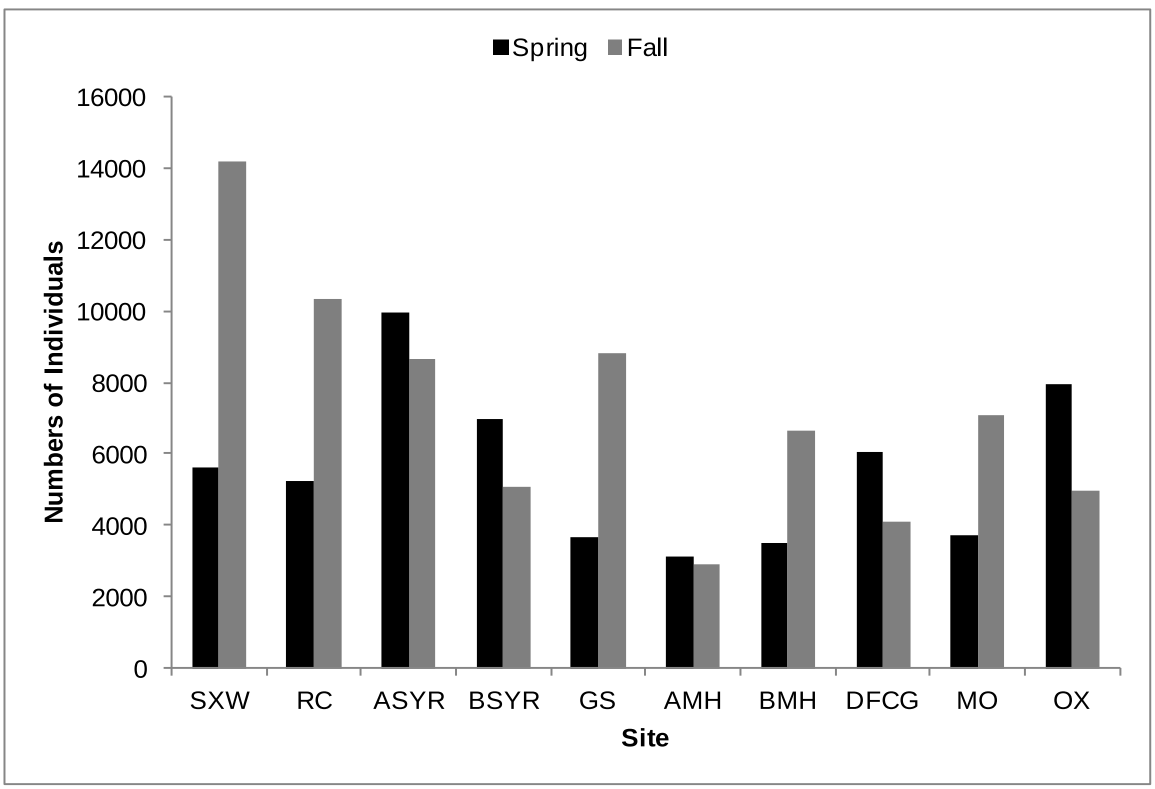


Figure 4-2. Mean density of all macroinvertebrates from three Hess samples (a) and total abundance of all macroinvertebrates from kick-net samples (b) in spring and fall 2012.

Among the composite kick samples, total abundance was often different among sites within a season and even different between seasons at many of the sites (Figure 4-2b). In the spring AST had the highest macroinvertebrate abundance with approximately 10,000 organisms while SXW had the highest abundance in the fall with 14,000 organisms. The lowest abundances came from AMH in the spring and fall.

Ephemeroptera, Plecoptera, and Trichoptera (EPT) Density/Abundance

The EPT taxa (orders) are generally thought of as sensitive to anthropogenic disturbance (Vinson 2006) and provide a means of comparing macroinvertebrate community dynamics among sites at a finer taxonomic level than comparing total density of all organisms. Although EPT taxa density determined from Hess samples was similar among most sites and even between seasons, significant differences were detected ($F_{19,59}$=4.76, p=0.000) (Figure 4-3a). Post hoc analysis indicated three homogenous groups. The spring sample at AST showed higher EPT densities than any other sample except for the spring SXW sample even though the spring SXW sample was similar to all other sampling sites for either season. Significant seasonal variation was only detected among the AST site.

The qualitative kick-net collections for EPT taxa ranged from a low of 1,994 individuals at AMH in the fall to 7,024 individuals at SXW in the fall. Much like the total abundance, EPT taxa abundance varied among sites by season as well as within seasons by site (Figure 4-3b). The GS control site displayed lower EPT abundance than any of the other Diamond Fork sites in spring but displayed relatively higher abundances in the fall. EPT taxa abundance shows a similar longitudinal pattern to total abundance (Figure 4-2b).

Taxa Richness

Taxa richness is the number of taxa observed in each sample (Hess or kick-net) and provides an index for evaluating community diversity, but as with total density, it does not discriminate against taxa by tolerance to altered conditions. Because degraded conditions often lead to a high abundance of just a few tolerant species, higher taxa richness usually indicates greater habitat diversity and/or more suitable water quality, and therefore suitable to a wider range of macroinvertebrates (Vinson 2006).

Taxa richness was remarkably similar across most sites within each season and also similar at each site between seasons. However, statistical analysis revealed significant differences among three distinct homogenous groups ($F_{19,59}$=3.39, $p< 0.001$) (Figure 4-4a). The spring sample richness at GS was significantly higher than five of the other sites during that season while there were no significant differences among any of the sites in the fall. The GS also displayed the highest mean taxa richness for both the spring and the fall compared to all other sampling sites. Sampling sites in Sixth Water and Diamond Fork Creek showed similar taxa richness despite longitudinal hydrologic and geomorphological differences.

The results of the qualitative kick-net collections were similar to those of the Hess samples showing relatively higher taxa richness at GS relative to the other sites (Figure 4-4b). Sites in the lower reaches of Diamond Fork Creek (DFCG, MO, OX) also displayed relatively high taxa richness. The lowest taxa richness reported was at BST in the fall with 17 species. The highest was at GS in the fall with 32 species present.

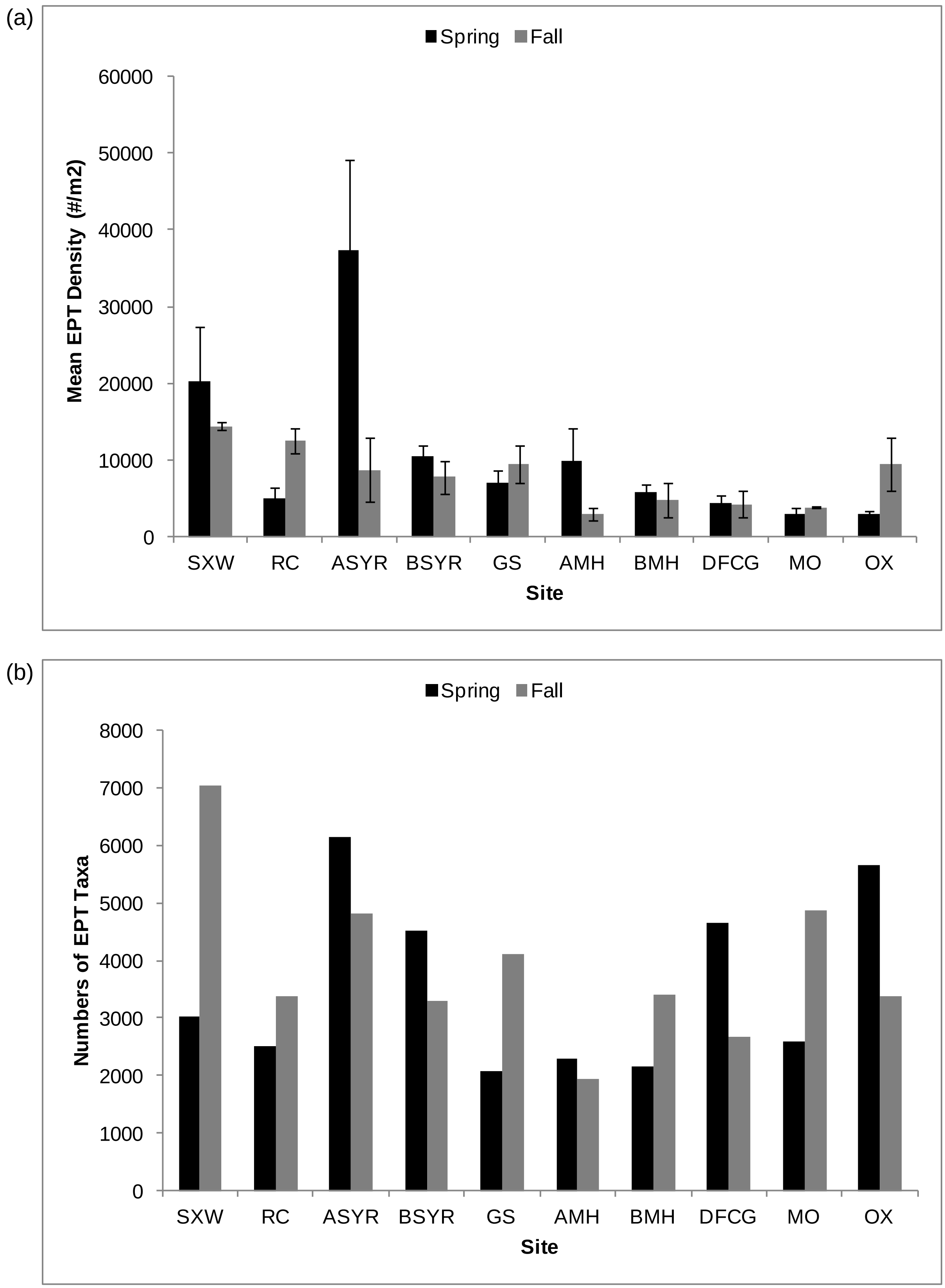
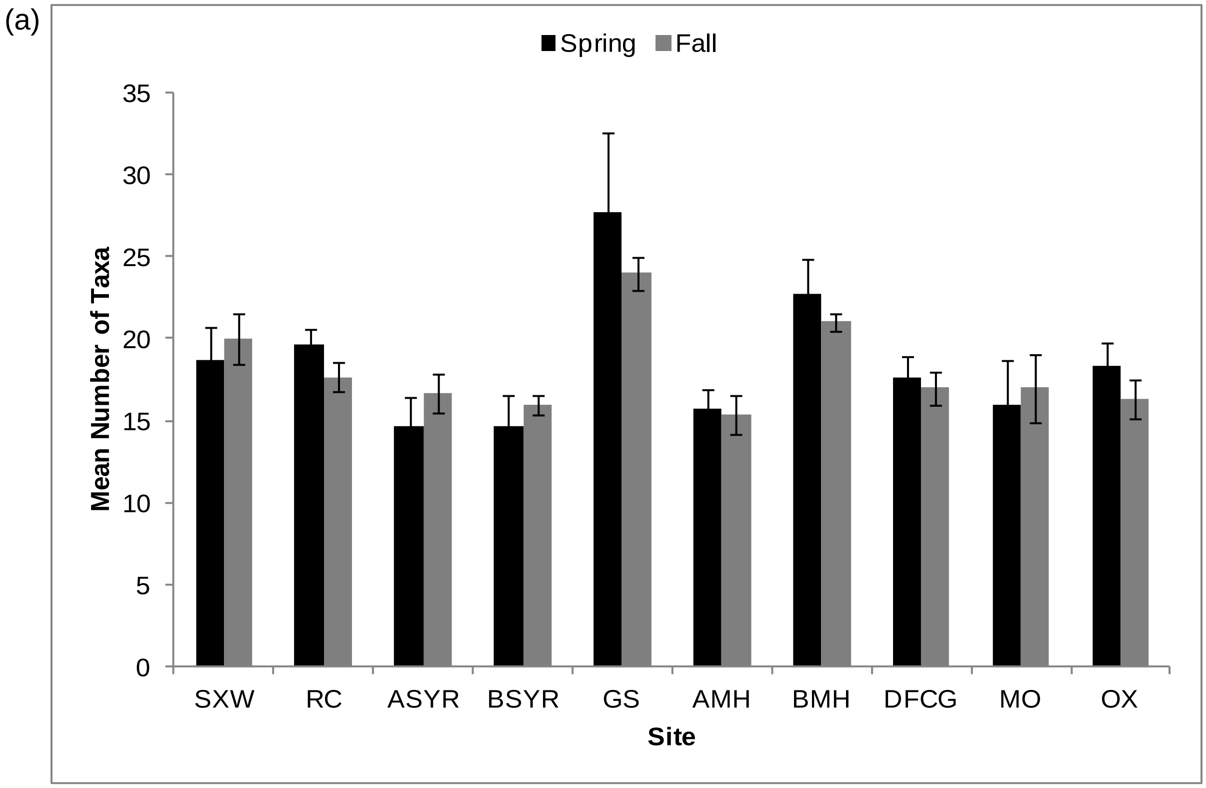


Figure 4-3. Mean density of EPT taxa from three Hess samples (a) and total abundance of EPT taxa from kick-net samples (b) in spring and fall 2012.



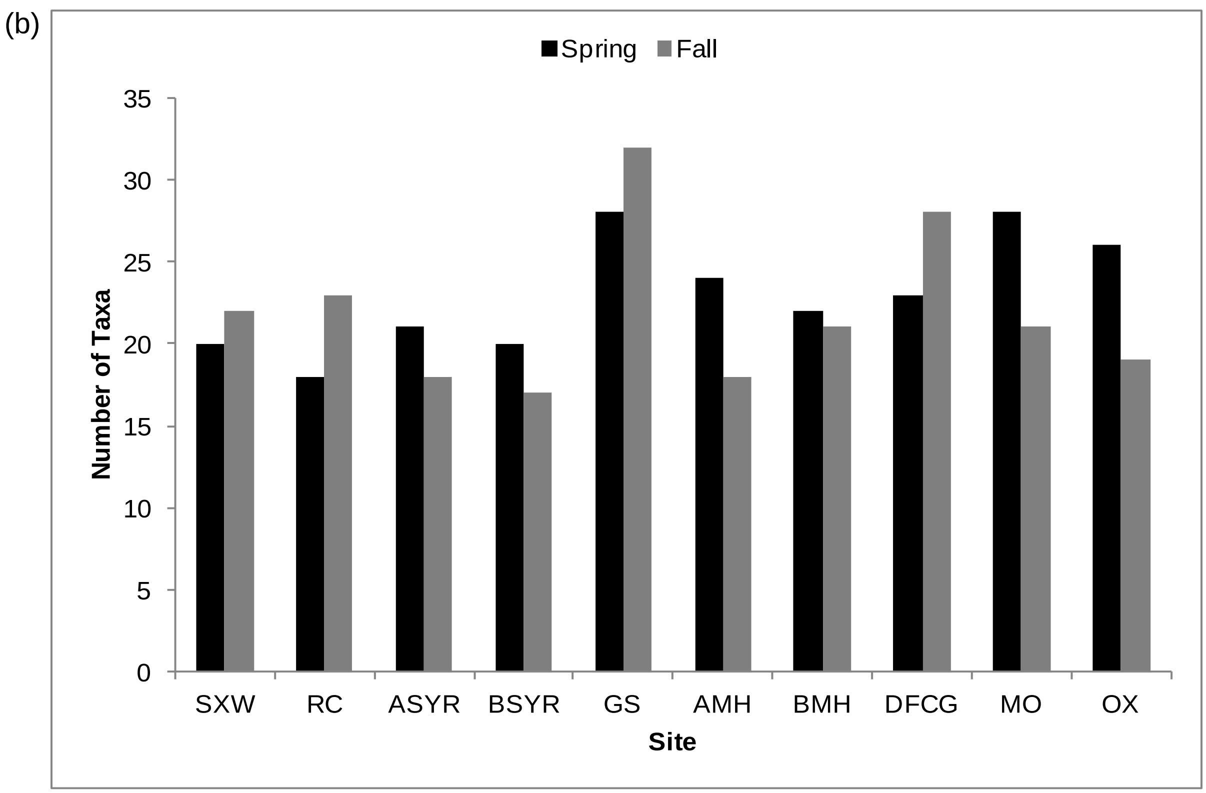


Figure 4-4. Mean taxa richness from three Hess samples (a) and taxa richness from kick-net samples (b) in spring and fall 2012.

Hilsenhoff Biotic Index (HBI) Value

The HBI provides an indication of the overall pollution tolerances of the macroinvertebrate community in a site from the taxa collected (Hilsenhoff 1987 and 1988). This index has been used to detect nutrient enrichment, high sediment loads, low dissolved oxygen, and thermal impacts. It was originally developed to detect organic pollution (Hilsenhoff 1988). Individual families were assigned an index value from 0 to 10. Taxa with HBI values of 0-2 are considered intolerant, clean-water taxa. Taxa with HBI values of 9-10 are considered pollution-tolerant taxa. A family level HBI was calculated for each sample. Samples with HBI values of 0-2 are considered clean, 2-4 slightly enriched, 4-7 enriched, and 7-10 polluted (Vinson 2006).

Among Hess samples, mean HBI values were within the range of 3.5-4.7 (slightly enriched to enriched). Statistical analysis revealed no significant difference between means among sites or within a particular site between seasons ($F_{19,59}$= 1.42, p=0.172) (Figure 4-5a). As in the Hess results, the HBI value calculated from qualitative kick-net collections ranged from slightly enriched to enriched (2.3-4.4) (Figure 4-5b). Although similar, both minimum and maximum HBI values were lower than those calculated for the Hess samples.

USFS Community Tolerance Quotient (CTQd)

The USFS community tolerance quotient has been widely used in the western United States where taxa are assigned a tolerant quotient from 2 to 108 (Vinson 2006). These tolerance quotients were developed by Winget and Mangum (1979), and generally values range from 20-100 with lower values indicating better water quality.

Mean CTQd values for Hess samples ranged from 64.7 (spring BST and spring AST) to 78.0 (fall MO) (Figure 4-6a). These values indicate that water quality is generally the same throughout these sampling sites in relation to taxa tolerance. An ANOVA revealed a significant difference among sites in 2012 ($F_{19,59}$=3.07, p=0.001). Post hoc analysis identified three distinct homogenous groups with spring AST and spring BST having significantly lower values than fall MO. The remaining sites were similar in mean CTQd values for spring and fall. Although not significant, spring CTQd means were lower than fall mean at all sampling sites except for SXW.

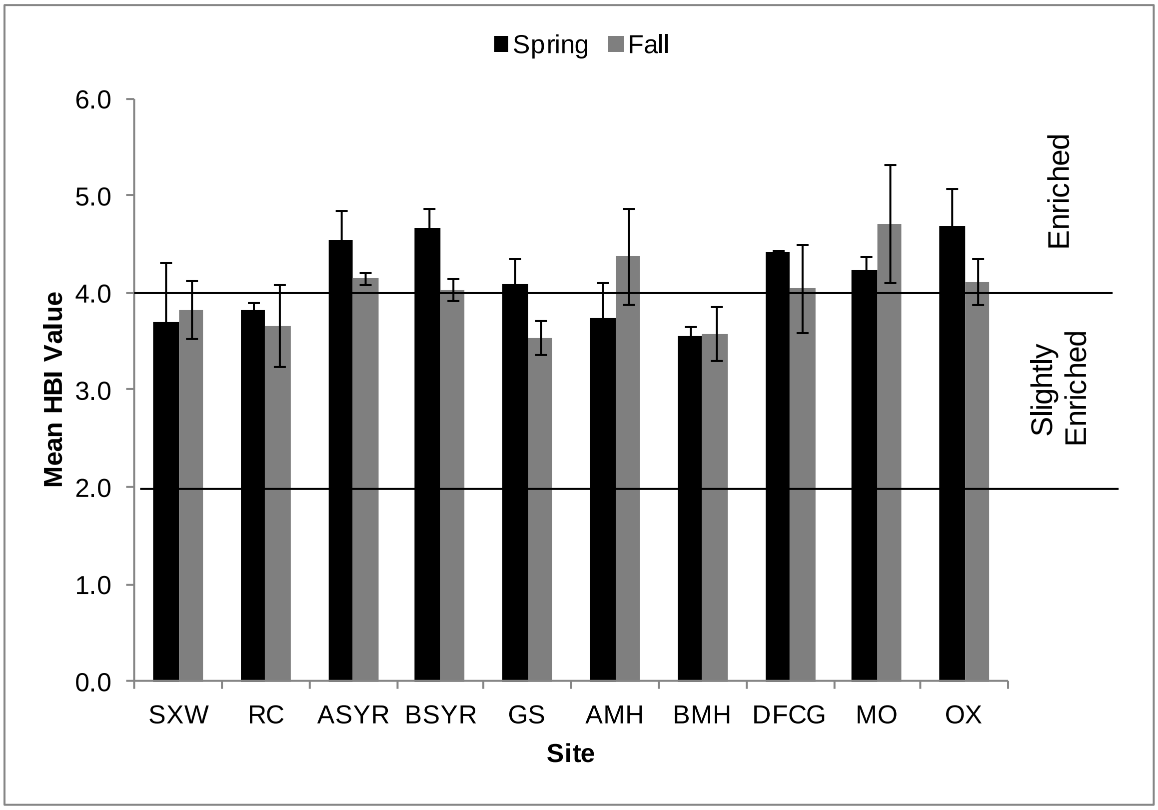
Qualitative results from kick-net samples revealed a CTQd range of 65-82 and showed relatively similar results across samples and between years (Figure 4-6b). The most variation between seasons occurred at OX with the fall displaying higher taxa tolerance. Like the Hess samples, CTQd values were higher in the fall for kick-net samples with the exception of SXW.

Intolerant Taxa Richness

The number of taxa that are intolerant to perturbation and stream pollutants can be used to assess the level of sensitive species that exist within a sample. A higher number of intolerant species typically infers a healthy stream system with less pollution and anthropogenic disturbance. Intolerant taxa richness was calculated as the number of taxa present with an HBI score of less than two.

Hess samples revealed the greatest variation in intolerant taxa richness to be in the spring. The mean number of intolerant species ranged from 3.3 to 8.6 among all sites in the spring with a significant difference detected ($F_{19,59}$=2.59, p=0.006) (Figure 4-7a). Both SXW and AST had significantly lower intolerant taxa richness than GS in the spring. All fall samples were statistically similar between sites.

(a)



(b)

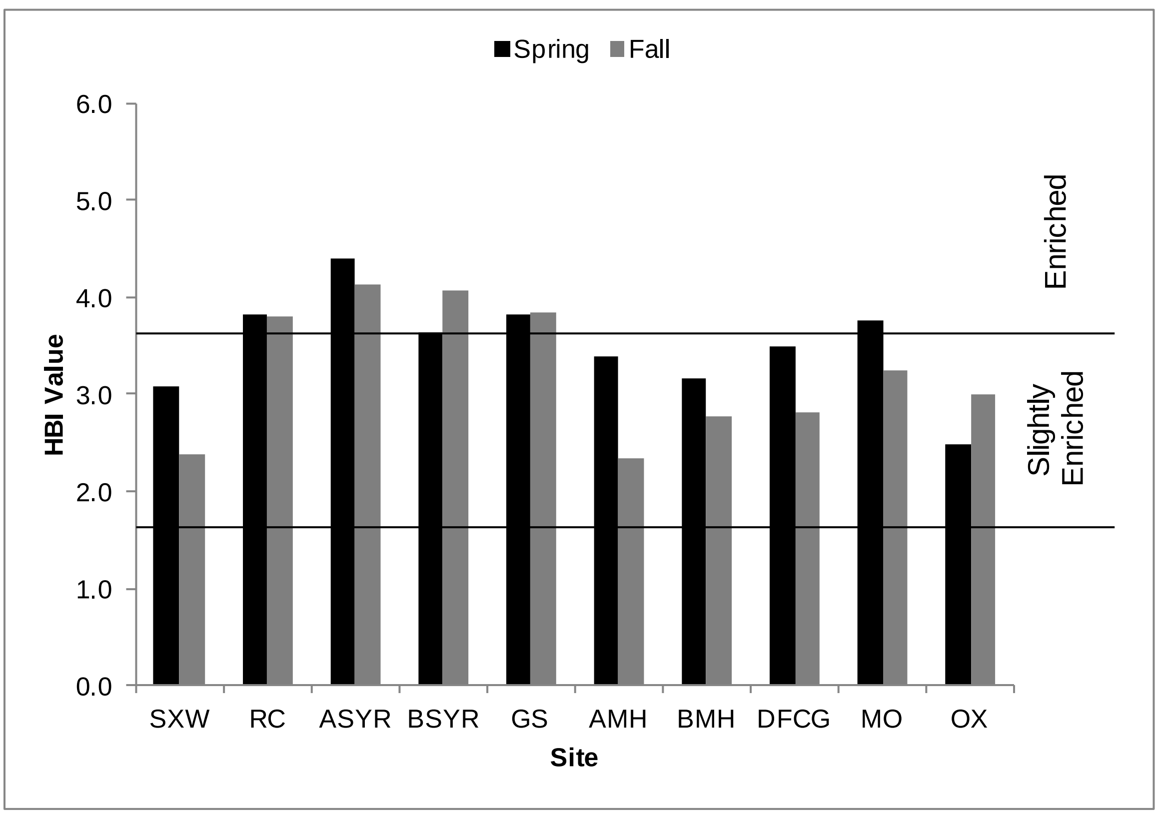
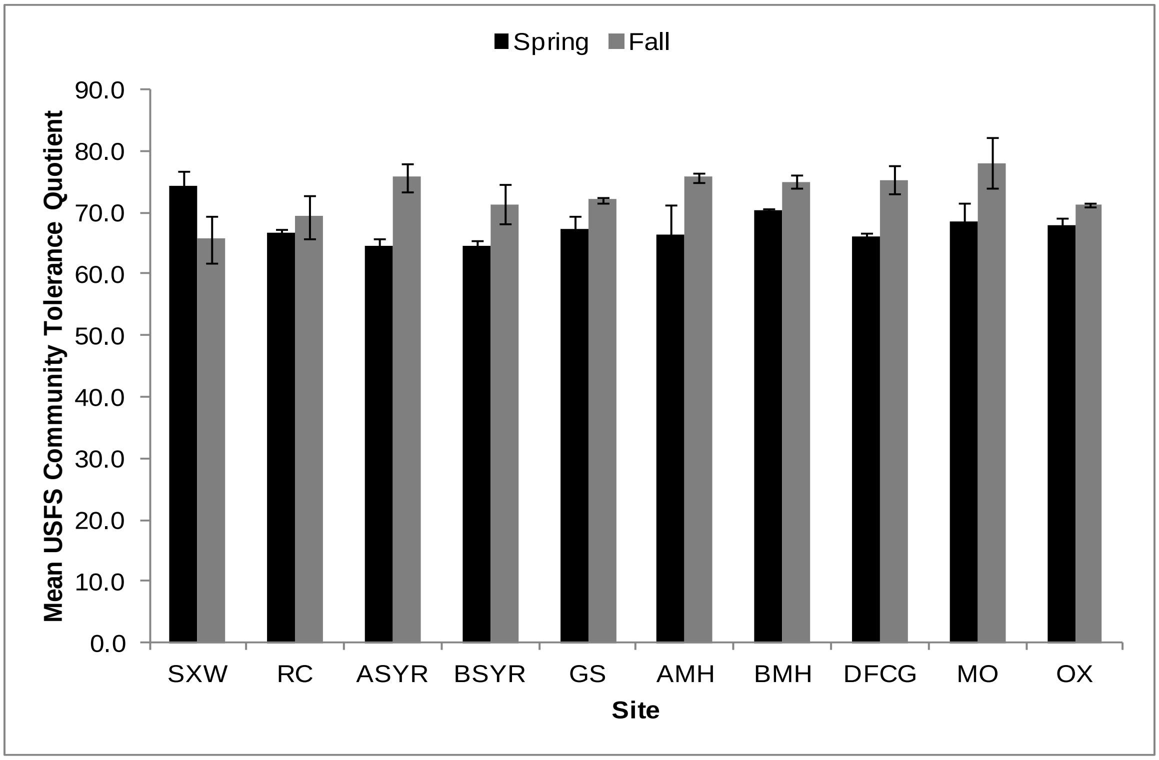


Figure 4-5. Mean HBI value from three Hess samples (a) and HBI values from kick-net samples (b) in spring and fall 2012.

(a)



(b)

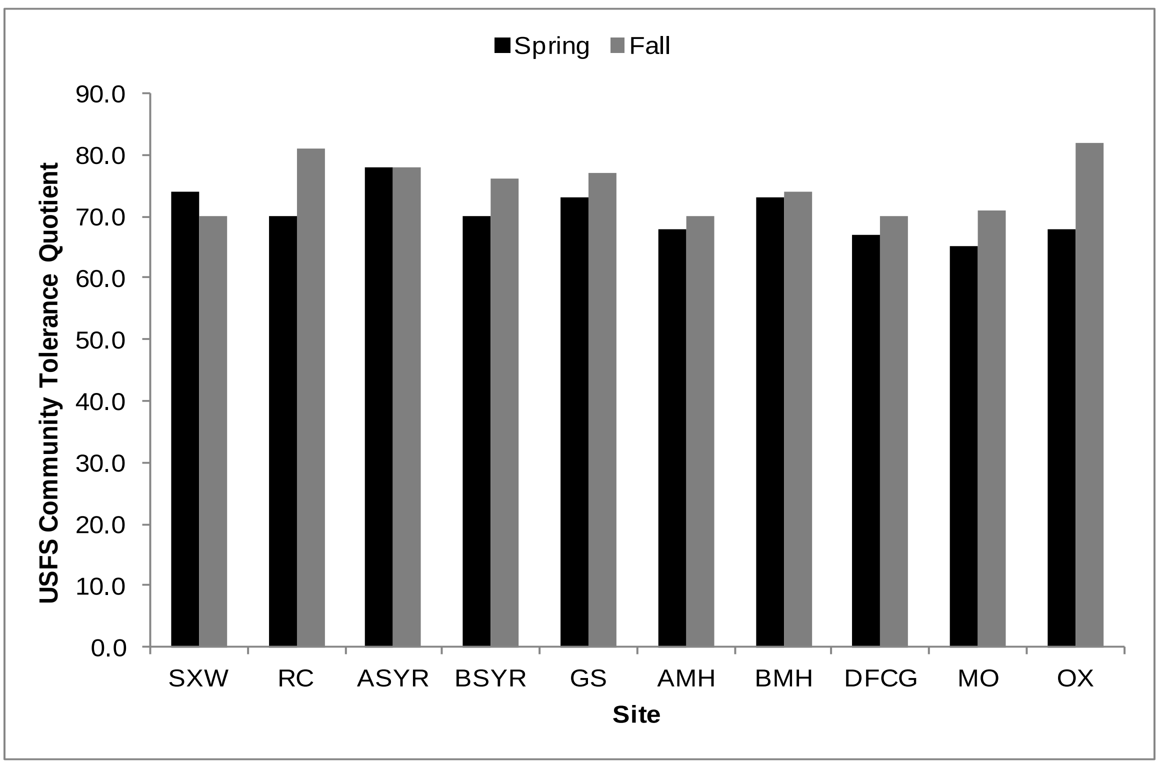


Figure 4-6. Mean USFS community tolerance quotient values from three Hess samples (a) and USFS community tolerance quotient values from kick-net samples (b) in spring and fall 2012.

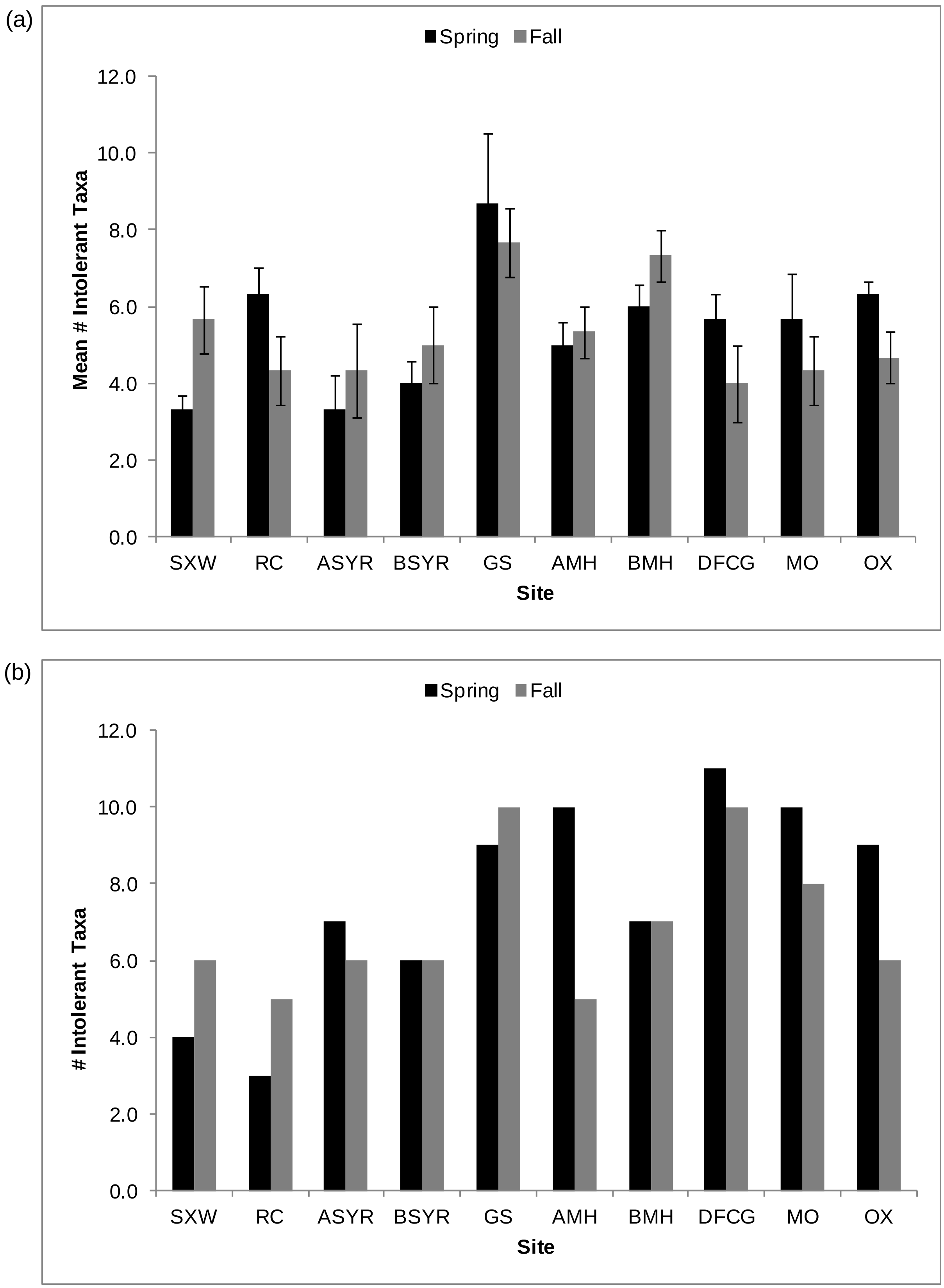


Figure 4-7. Mean intolerant taxa richness from three Hess samples (a) and the number of intolerant taxa from kick-net samples (b) in spring and fall 2012.

The results of the qualitative kick-net collections showed a range of 3-11 intolerant species to be present within all the sites sampled in 2012 (Figure 4-7b). The spring samples revealed higher intolerant species richness among Diamond Fork Creek Sites with the exception of BMH which contained 7 intolerant species in the spring. Fall samples were similar in which all Diamond Fork sites except for AMH and OX had higher intolerant species richness than Sixth Water Creek sites. The results of the intolerant species richness are similar to that of total species richness.

Functional Feeding Groups

Macroinvertebrates can be classified based on their feeding behavior and mechanics. Such groups may be shredders, scrapers, collector-filterers, collector-gatherers, and predators. These feeding mechanisms are primarily based on the location (i.e., water column or stream bed) and the particle size and type (i.e., leaf litter, FPOM, or live prey) of food for which they eat (Vinson 2006). These feeding groups may also help characterize the source of the food resource and whether the habitats sampled are erosional or depositional (Vinson 2006).

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

An analysis of the number of taxa for each functional feeding group by site and by season revealed many statistical differences among 2012 samples. For this reason interpretation becomes cumbersome and less than useful. In fact, it has been documented that functional feeding groups are not necessarily good indicators of anthropogenic alterations as their responses vary across North American streams as a function of stream morphology and type of disturbance (Karr and Chu 1997, 1999). It has also been found that not all macroinvertebrates adhere strictly to their assigned feeding group (most all species are at least at some level omnivorous) (Karr 1999). Therefore, an analysis of feeding group composition at each sampling location for each season was only conducted for 2012 to characterize the macroinvertebrate community and establish baseline conditions (Figure 4-8).

All of the sample sites in 2012 contained all five functional feeding groups except for SXW and AST in the spring where no predators were collected. In both the spring and fall the majority of the macroinvertebrates collected were either predators or collector-gatherers. Scrapers and shredders comprised the smallest functional feeding groups.

Figure 4-8. Functional feeding group taxa composition at each site in the spring (a) and fall (b) 2012.

Historical Data Comparisons

During 1999–2002 the National Aquatic Monitoring Center (NAMC) collected several samples near some of the sites sampled for this study and comparisons to 2005–2007 data were reported by BIO-WEST (BIO-WEST 2006, 2007, and 2009). Samples from that period were collected prior to the complete bypass of transbasin water deliveries and the institution of the minimum- flow requirements on the Sixth Water and Diamond Fork Creeks. These samples were also collected before the increased leaching of hydrogen sulfide into the system. Because these samples were collected using somewhat different methodologies at slightly different locations to the established long-term collection sites on Sixth Water and Diamond Fork Creeks they will not be analyzed in conjunction with the 2005–2007 and 2012 data contained herein. Readers are encouraged to refer to the previous BIO-WEST (2005, 2007, and 2009) reports for more detail regarding those data.

Not all of the sites sampled in 2012 are comparable to historic data from 2005–2007. In addition to the original five sites that have been sampled in previous years (SXW, GS, DFCG, MO, and OX) sites both above and below the SYAR tunnel and above and below Monks Hollow were added in 2012. Ray's Crossing (RC) was also added to the macroinvertebrate sampling in 2012 but has been previously sampled for seasonal sedimentation monitoring. For the purposes of this section comparisons will be made between SXW, GS, DFCG, MO, and OX with data from 2005–2007 and 2012. It should be noted that GS was not sampled in 2005 and spring samples were not collected for SXW, DFCG, MO, or OX in 2006 due to high flows. Thus, regression analysis was not conducted on spring samples due to the missing data from those efforts.

Dominant Taxa

Examining the proportion of the macroinvertebrate community that is comprised of the three most dominant taxa provides an index of evenness in the community. Up to 21 percent of the total number of organisms might be found in the most dominant taxon in high-quality streams in the Wasatch and Uinta Mountains, while the three most dominant taxa might comprise up to 50 percent of the total number of organisms (Grafe 2002, Lester 2005). Additionally, examining the three most dominant taxa at a site can provide additional information about what may be impacting that site.

Among the five monitoring sites there was a diversity of dominant taxa, although many of the same taxa―including many tolerant taxa―were commonly in the top three (Table 4-3). Throughout time the dominant taxa has not changed drastically and there have only been 15 taxonomic groups found to be the three most dominant taxa in samples from 2005–2012. Of these 15 groups representing 5 orders, containing 8 families, 1 subclass (oligocheta), and 1 phylum (nematoda), midges comprised 27 percent of the three most dominant taxa followed by riffle beetles (15 percent) and black flies (11 percent). The tolerant group of midges (Chironomidae) was in the top two most abundant taxa in all sites during each sample, except in the OX site in the fall 2007, GS site in the fall 2012, and OX site in the fall 2012 samples. Midges were relatively uncommon in those samples and comprised less than 10 percent of each sample. Taxa that dominated samples that are intolerant to degraded conditions include two caddisflies of the Family Brachycentridae—*Micrasema* sp. and *Brachycentrus occidentalis*–a third caddisfly (*Oligophlebodes* sp.), and a mayfly (*Ephemerella inermis/infrequens*). Both *Micrasema* sp. and *Oligophlebodes* sp. were found in SXW samples in 2012.

Table 4-3. Three most dominant taxa at the five monitoring sites in spring and fall 2005, 2006, 2007, and 2012.

DOMINANCE	SXW	DFCG	GS	MO	OX
Spring 2005					
First	Chironomidae	Chironomidae	N/A	Chironomidae	Chironomidae
Second	*Baetis tricaudatus*	*Baetis tricaudatus*	N/A	Oligochaeta	Oligochaeta
Third	*Micrasema sp.*	*Ephemerella inermis/infrequens*	N/A	Nematoda	Nematoda
Fall 2005					
First	*Oligophlebodes sp.*	Chironomidae	N/A	Chironomidae	Chironomidae
Second	Chironomidae	Oligochaeta	N/A	*Optioservus sp.*	Oligochaeta
Third	*Micrasema sp.*	*Optioservus sp.*	N/A	Oligochaeta	*Optioservus sp.*
Spring 2006					
First	N/A	N/A	Chironomidae	N/A	N/A
Second	N/A	N/A	*Simulium sp.*	N/A	N/A
Third	N/A	N/A	*Baetis tricaudatus*	N/A	N/A
Fall 2006					
First	*Oligophlebodes sp.*	*Simulium sp.*	Chironomidae	Chironomidae	*Baetis tricaudatus*
Second	Chironomidae	Chironomidae	*Optioservus sp.*	*Simulium sp.*	Chironomidae
Third	*Optioservus sp.*	*Baetis tricaudatus*	Oligochaeta	*Baetis tricaudatus*	*Simulium sp.*
Spring 2007					
First	Chironomidae	*Baetis tricaudatus*	Chironomidae	Chironomidae	Chironomidae
Second	*Ephemerella inermis/infrequens*	Chironomidae	Optioservus sp.	*Ephemerella inermis/infrequens*	*Brachycentrus occidentalis*
Third	*Oligophlebodes sp.*	*Ephemerella inermis/infrequens*	*Baetis tricaudatus*	*Optioservus sp.*	*Optioservus sp.*
Fall 2007					
First	Oligochaeta	*Simulium sp.*	*Optioservus sp.*	*Simulium sp.*	*Simulium sp.*
Second	Chironomidae	Chironomidae	Chironomidae	Chironomidae	Baetis tricaudatus
Third	*Oligophlebodes sp.*	*Brachycentrus occidentalis*	*Hydropsyche sp.*	*Optioservus sp.*	*Optioservus sp.*
Spring 2012					
First	Chirononmidae	*Baetis sp.*	Chirononmidae	*Baetis sp.*	Chirononmidae
Second	*Oligophlebodes sp.*	Chirononmidae	Ephemereliidae	Chirononmidae	*Baetidis sp.*
Third	Baetidae	*Simulium sp.*	Plecoptera	Plecoptera	Ephemereliidae
Fall 2012					
First	Chirononmidae	Elmidae	*Optioservus sp.*	*Simulium sp.*	*Baetis sp.*
Second	*Baetis sp.*	Chirononmidae	*Baetis sp.*	Chironomidae	*Hydropsyche sp.*
Third	*Micrasema sp.*	Elmidae	*Simulium sp.*	Simuliidae	Chironomidae

Total Macroinvertebrate Density/Abundance

An analysis of macroinvertebrate densities from Hess samples by site for all years sampled since 2005 revealed significant differences among sample years at two sites during spring samples (Figure 4-9). Samples at GS showed higher densities ($F_{2,8}$=11, p<0.010) in spring 2007 than any of the other spring sampling events while spring samples in 2005 had significantly higher densities at OX ($F_{2,8}$=11.5, p=0.009) compared to 2007 or 2012. The other three spring sampling locations showed statistically insignificant variation in densities by year. Similarly, a significant difference was found in fall samples collected at OX with 2007 having higher densities than any of the other three years ($F_{3,11}$=9.57, p=0.005) (Figure 4-9). Post hoc analysis of fall mean densities at DFCG revealed three homogenous groups where 2007 was higher than both 2006 and 2012 but not 2005 ($F_{3,11}$=5.61, p=0.022). Even though significant differences were found among years for spring GS and fall DFCG those same differences were not consistent among seasons. SXW also showed relatively high mean densities in fall 2007 but was found to be insignificant when compared to other years ($F_{3,11}$=2.29, p=0.155). Even though spring samples appear to show higher mean densities in 2005 followed by a decline in 2007 and 2012 for DFCG, MO, and OX these differences are not statistically significant nor does the fall show consistent results (Figure 4-9).

Macroinvertebrate abundance from kick-net samples revealed relatively high abundances in the spring 2005 relative to 2007 and 2012 for all sites sampled in 2005 (Figure 4-10). The same was true in the fall for SXW, DFCG, and OX. Spring sampling results show a slight increase in abundance from 2007 to 2012 at all sampling sites after a decline in abundance after 2005 or 2006. Fall abundances decreased in 2006, increased in 2007, and then decreased again in 2012.

EPT Density/Abundance

Comparisons of EPT taxa density among historic samples show variation through years in both the spring and fall (Figure 4-11). The only site to show significant differences among years in the spring was GS ($F_{2,8}$=5.32, p=0.047). EPT densities increased from 2006 to 2012 at GS with 2012 being significantly higher than 2006. This same increase in density through time was also present at SXW for spring samples, but was not found to be significant. In contrast DFCG and OX showed an apparent decline in spring EPT densities through time, but was statistically insignificant. For fall sampling data SXW was the only site with significantly different EPT densities among years sampled ($F_{3,11}$=8.98, p=0.006). For SXW in the fall, 2005 had significantly higher EPT densities than 2006 or 2007 but was similar to the 2012 sampling event. The other sampling sites showed similar EPT densities and patterns to the spring data with the exception of OX which had an increase in EPT densities over time in the fall rather than a decrease as found in spring samples.

EPT abundance from kick-net samples revealed seasonal and annual variation. Abundances were higher in 2005 when looking at the spring data alone (Figure 4-12). These high abundances were also found in SXW in the fall. Although not statistically supported there appeared to be an increase in 2012 abundances after a decline in 2006 and 2007 for both spring and fall. This was true for all sites except fall GS and Fall OX. The EPT taxa abundance for SXW in fall 2005 was more than twice that of spring 2005. The fall 2007 GS also saw an order of magnitude increase in EPT abundance from spring to fall while OX experienced over a 300% increase from spring to fall in 2007.

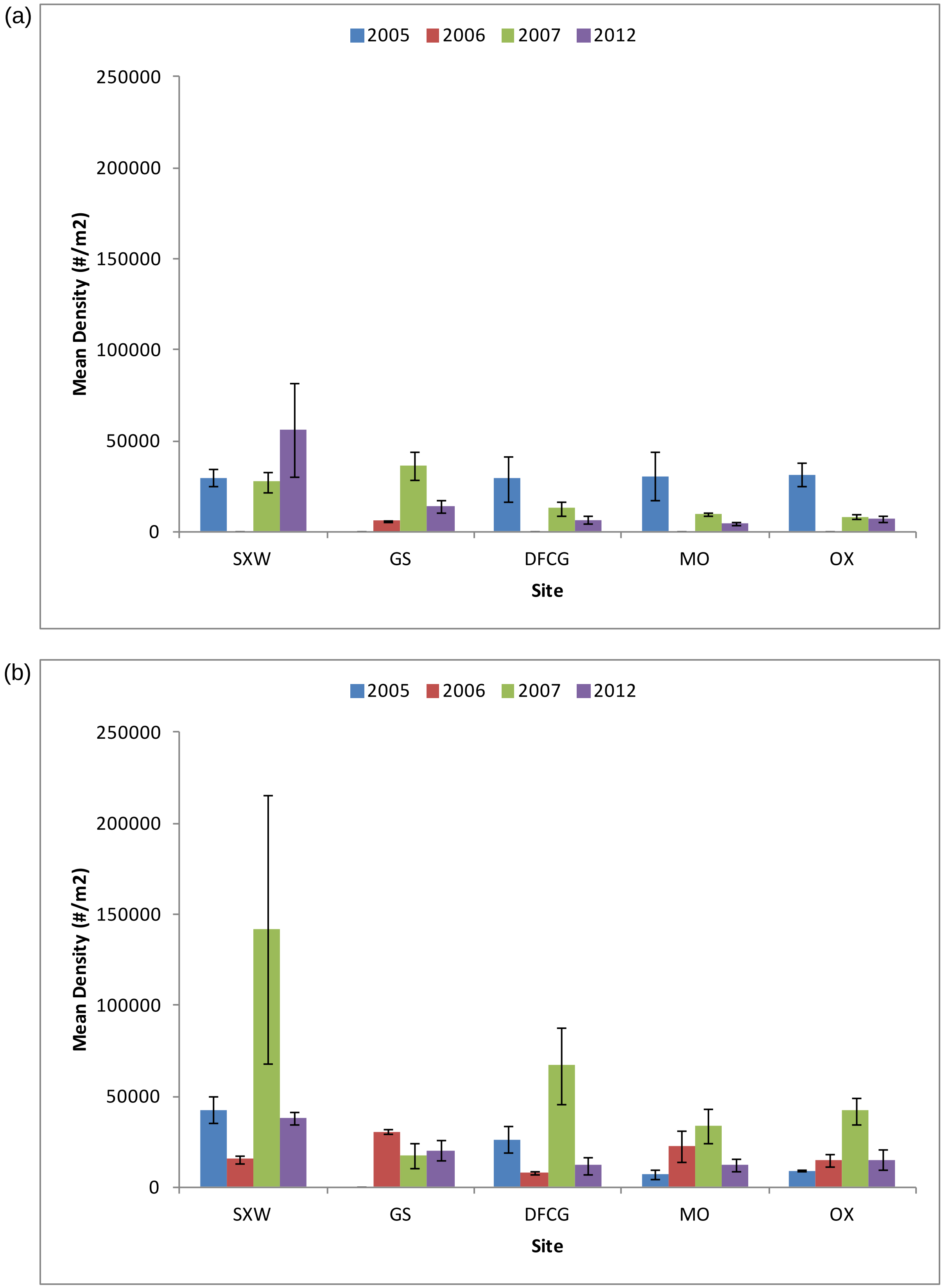
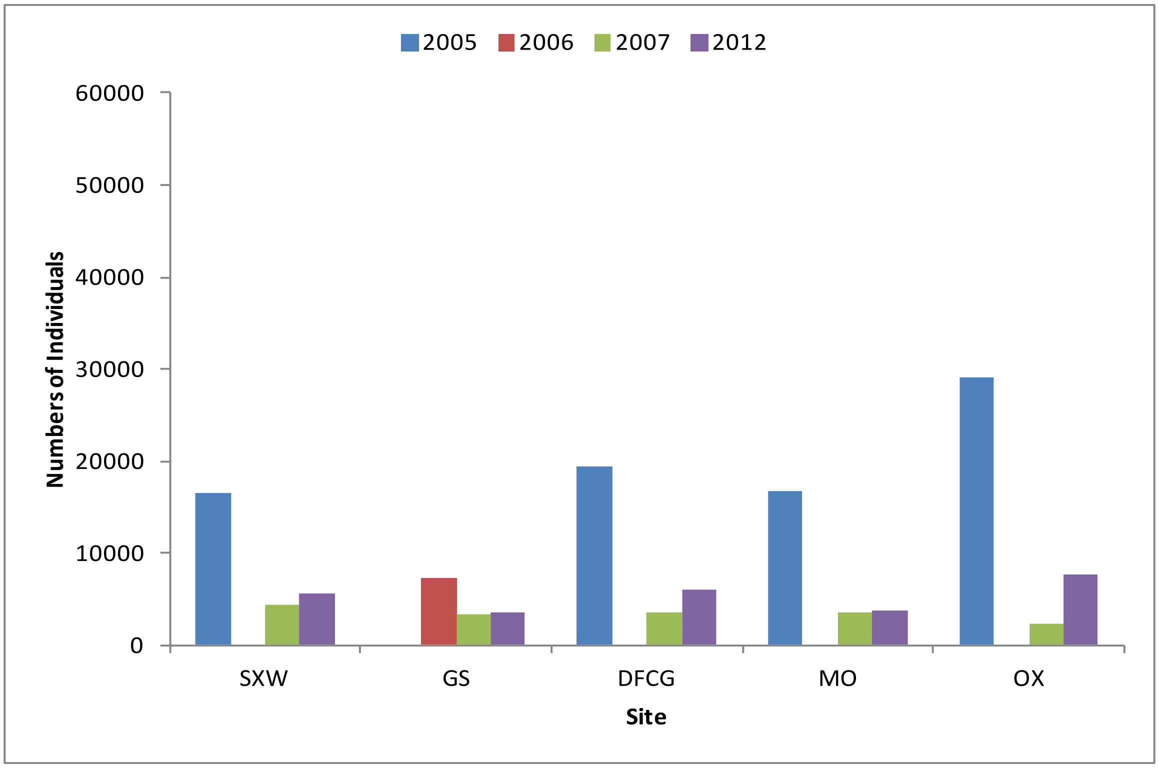


Figure 4-9. Mean macroinvertebrate densities for Hess samples by site in the spring (a) and fall (b) for 2005, 2006, 2007, and 2012.

(a)



(b)

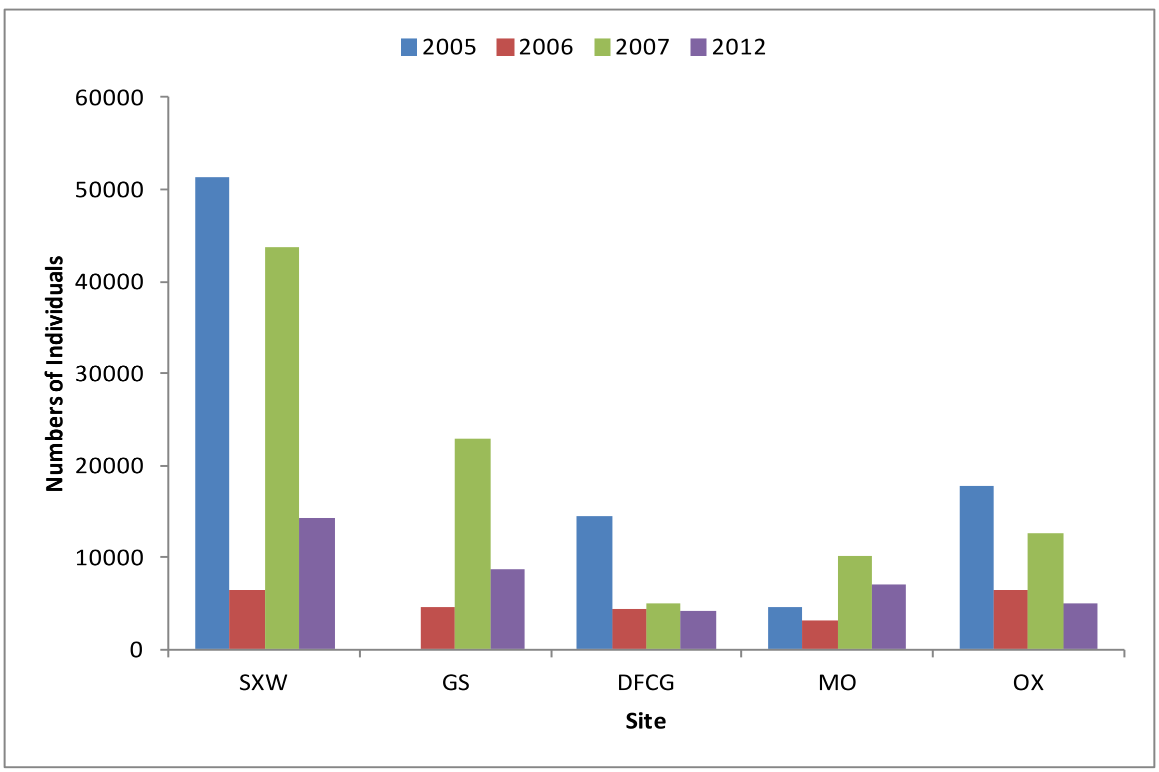


Figure 4-10. Macroinvertebrate abundances from kick-net samples by site in the spring (a) and fall (b) for 2005, 2006, 2007, and 2012.

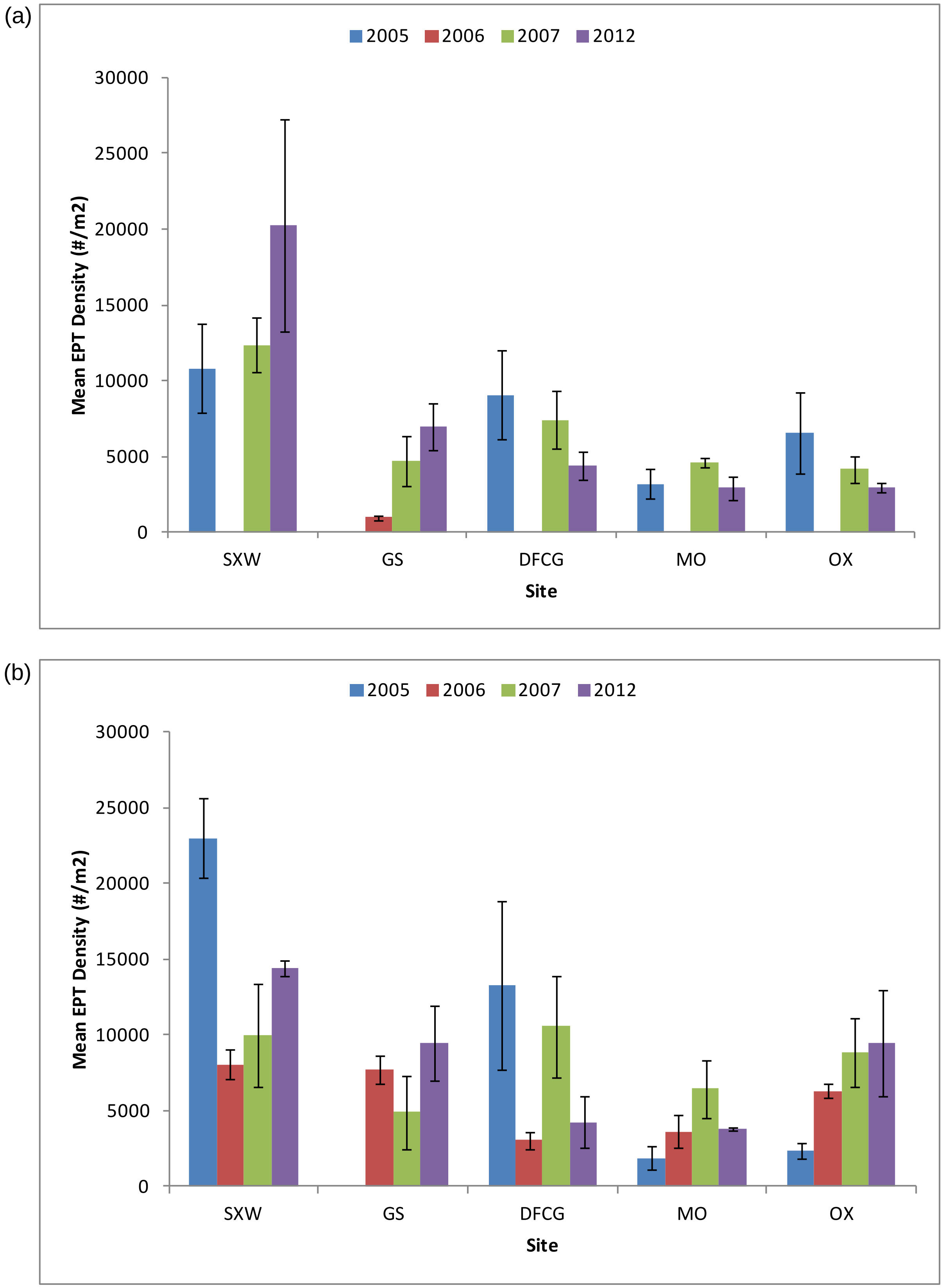


Figure 4-11. Mean macroinvertebrate EPT taxa densities for Hess samples by site in the spring (a) and fall (b) for 2005, 2006, 2007, and 2012.

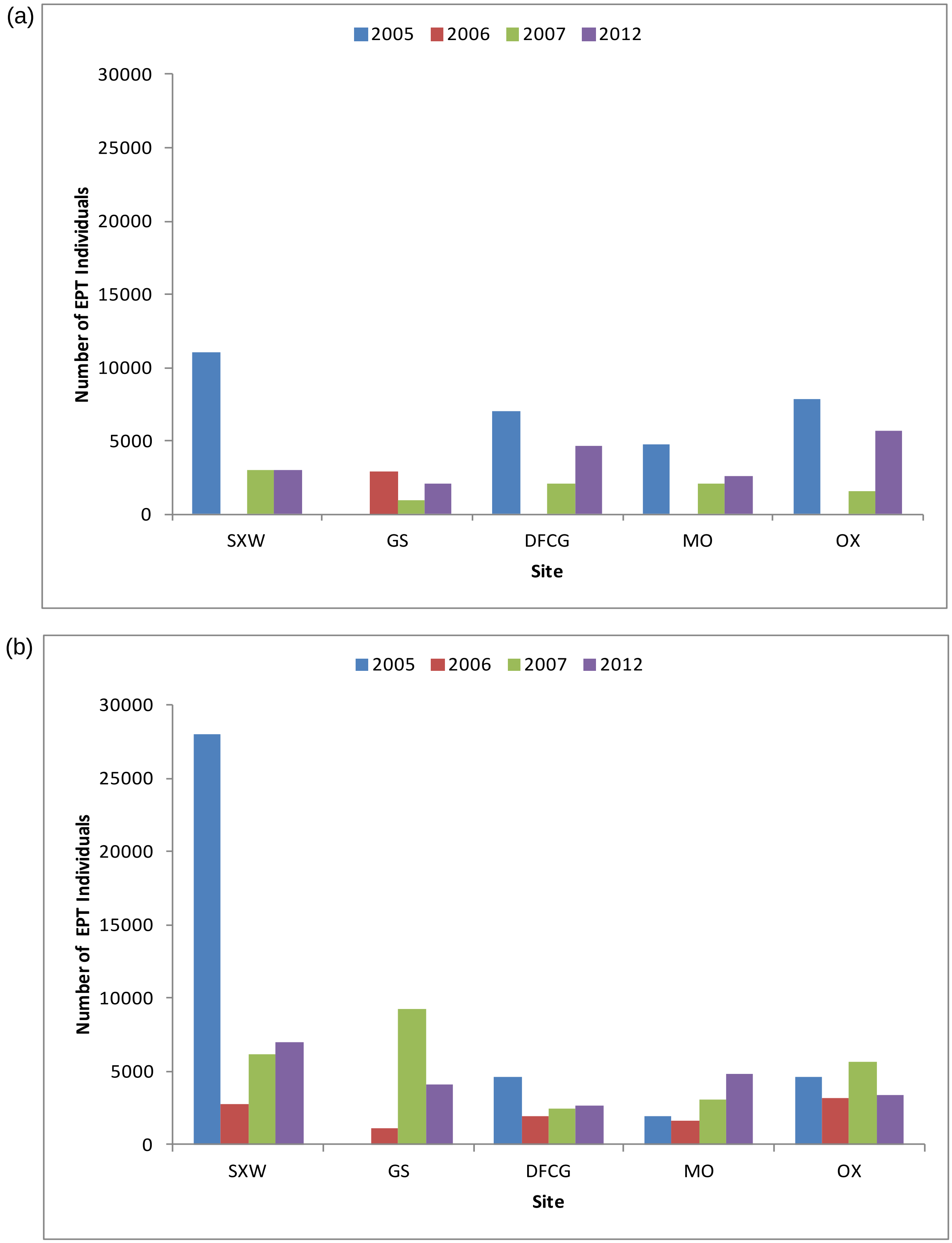


Figure 4-12. Macroinvertebrate EPT taxa abundances from kick-net samples by site in the spring (a) and fall (b) for 2005, 2006, 2007, and 2012.

Taxa Richness

Three out of the five sites sampled in both spring and fall reported significant differences in taxa richness among years sampled (Figure 4-13). For spring samples 2007 had significantly higher taxa richness at DFCG ($F_{2,8}$=5.63, p=0.042), MO ($F_{2,8}$=7.7, p=0.022), and OX ($F_{2,8}$=10.2, p=0.012) than 2012, but similar to 2005. SXW showed decreasing taxa richness from 2005-2012 while GS showed increasing richness. Fall sampling events revealed significantly higher taxa richness in 2005 for SXW ($F_{3,11}$=10.7, p=0.004) compared to the other three years. Taxa richness was also significantly higher at DFCG ($F_{3,11}$=6.57, p=0.015) in 2005 compared to 2012 and a least squares linear regression analysis confirms a decreasing trend in richness through time ($F_{1,11}$=10.49. p=0.009). Similarly, OX had significantly higher taxa richness in 2005 ($F_{3,11}$=6.13, p=0.018) compared to 2007 and 2012 and the least squares regression detected a decreasing trend over time ($F_{1,11}$=8.06, p=0.018). Interestingly, taxa richness at MO revealed no significant difference among years for the fall ($F_{3,11}$=3.84, p=0.057) however, least squares regression indicated a significant trend in decreasing taxa richness through time ($F_{1,11}$=5.57, p=0.040). Lastly, taxa richness at GS was variable among years during fall samples with 2007 having significantly higher richness than 2006 ($F_{2,8}$=7.55, p=0.023).

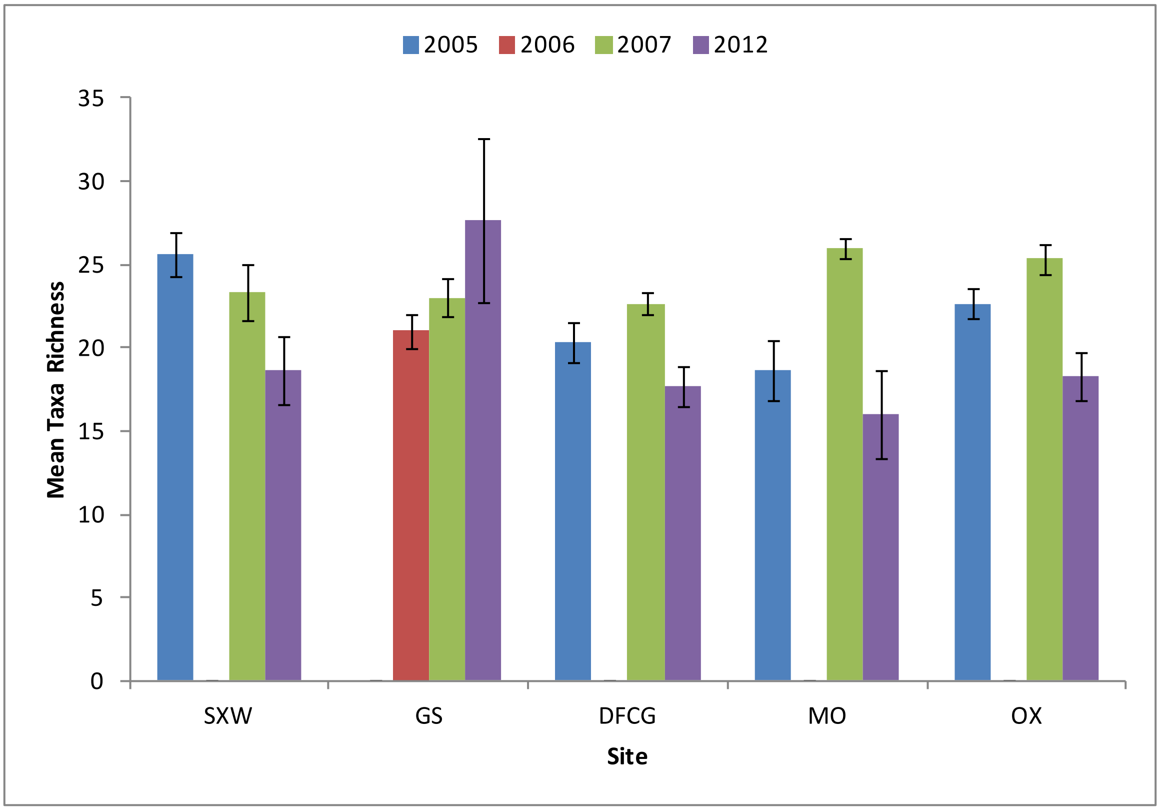
The same pattern of decreasing taxa richness through years was found when analyzing kick-net data for SXW, MO, and OX in the fall (Figure 4-14). The lowest number of taxa found in the spring was 20 at SXW in 2012 while the highest was 32 at DFCG in 2005. Similarly, the highest taxa richness in the fall was also found at DFCG in 2005 (34) while the lowest was also from DFCG in 2007 (19).

EPT Taxa Richness

Variations in EPT taxa richness for spring sampling were variable by site with no clear patterns through time (Figure 4-15). Although insignificant, the spring 2012 sample at GS did have higher EPT taxa richness than 2006 while the other sites sampled showed lower EPT richness in 2012. At SXW and OX spring 2007 had significantly higher EPT taxa richness than 2012 ($F_{2,8}$=5.69, p=0.041 and $F_{2,8}$=11.6, p=0.009, respectively). The 2007 sampling event also had higher EPT abundance than 2005 at OX. The spring macroinvertebrate samples at DFCG had significantly higher EPT richness in 2005 compared to 2012 ($F_{2,8}$=8.67, p=0.017). Fall samples revealed significant differences among years for all sites. EPT taxa richness in the fall was significantly higher in 2005 at SXW (compared to 2007), DFCG (compared to 2012), MO (compared to 2007 and 2012), and OX (compared to 2007) ($F_{3,11}$=5.02, p=0.030, $F_{3,11}$=4.46, p=0.040, $F_{3,11}$=5.66, p=0.022, and $F_{3,11}$=6.74, p=0.014 respectively). At GS 2012 EPT taxa richness was significantly higher than that of 2006 or 2007 ($F_{2,8}$=14.2, p=0.005). A least squares regression indicated an increasing trend in EPT taxa abundance in the fall GS samples ($F_{1,8}$=24.05, p=0.002) and a decreasing trend at MO for fall samples ($F_{1,11}$=5.24, p=0.045).

An analysis of kick-net data reveal very little about patterns or trends in EPT taxa richness through time (Figure 4-16). It is evident that these samples produced variable results through time among sampling sites and overall have produced a minimum of seven ETP taxa (SXW, spring 2012) and a maximum of 17 (DFCG, fall 2005).

(a)



(b)

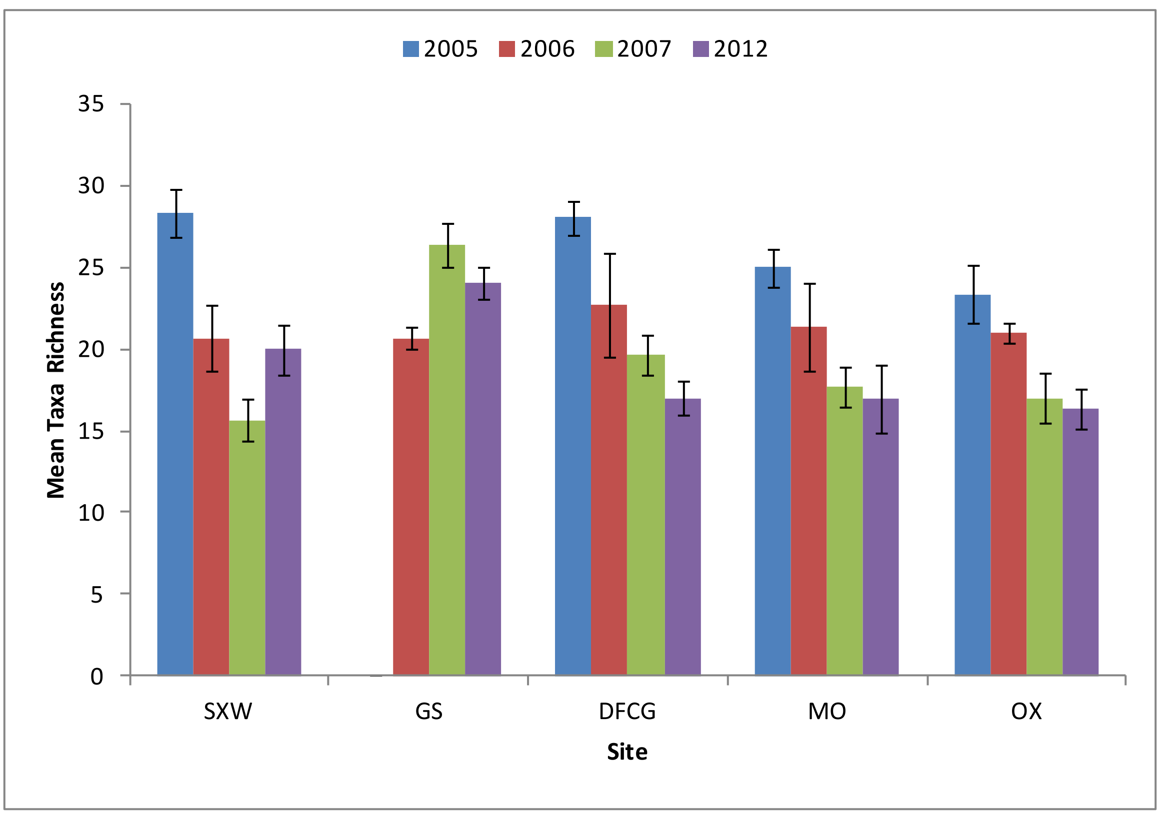
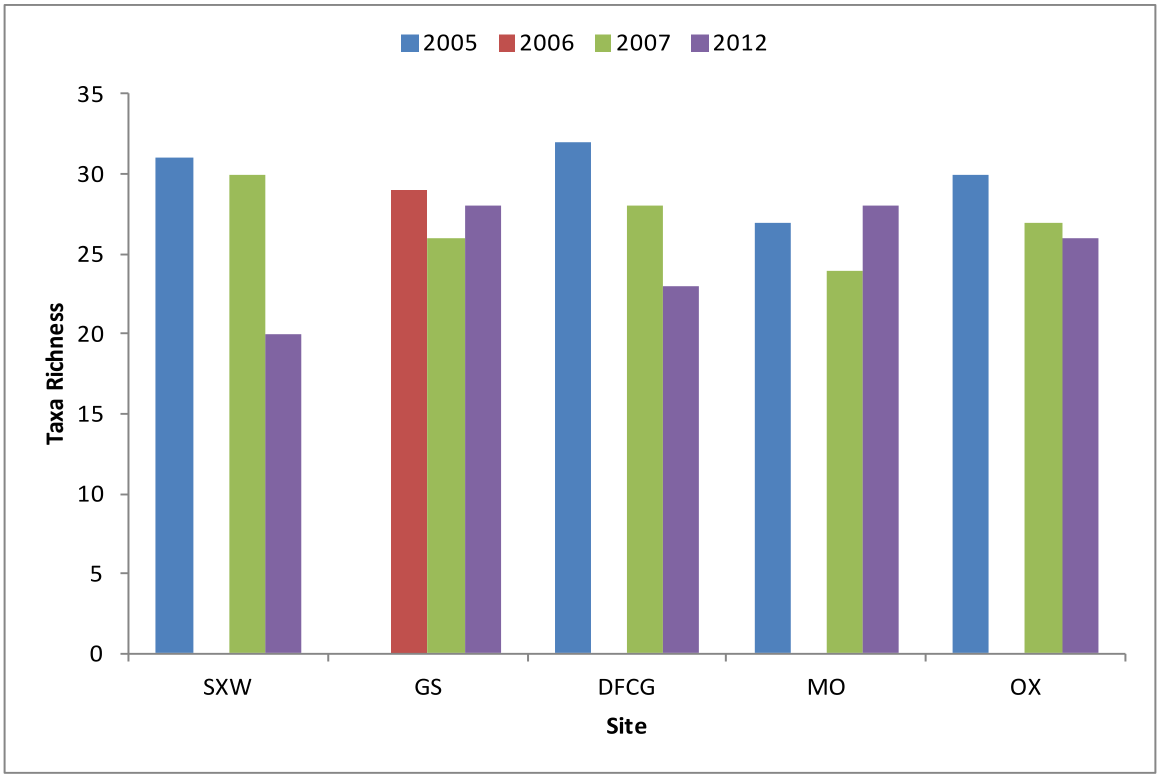


Figure 4-13. Mean taxa richness for Hess samples by site in the spring (a) and fall (b) for 2005, 2006, 2007, and 2012.

(a)



(b)

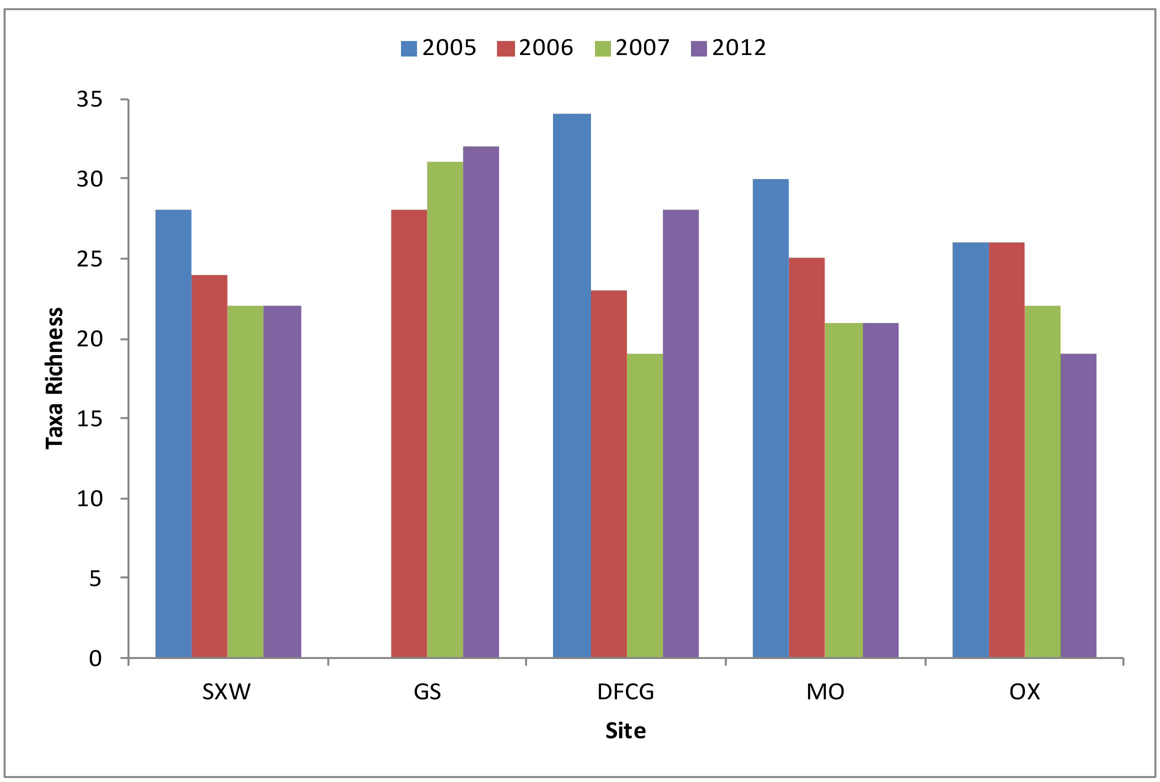


Figure 4-14. Macroinvertebrate taxa richness from kick-net samples by site in the spring (a) and fall (b) for 2005, 2006, 2007, and 2012.

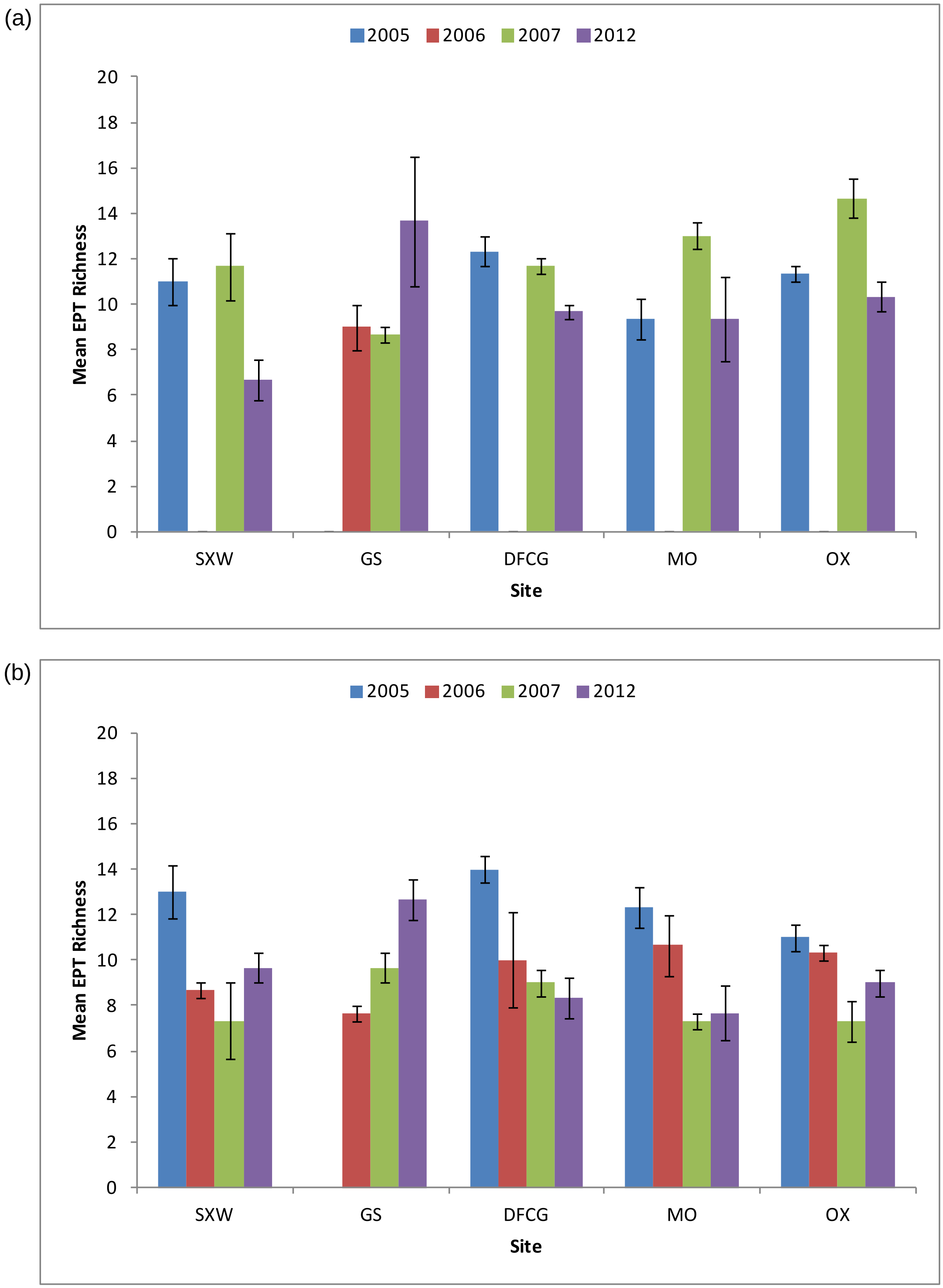
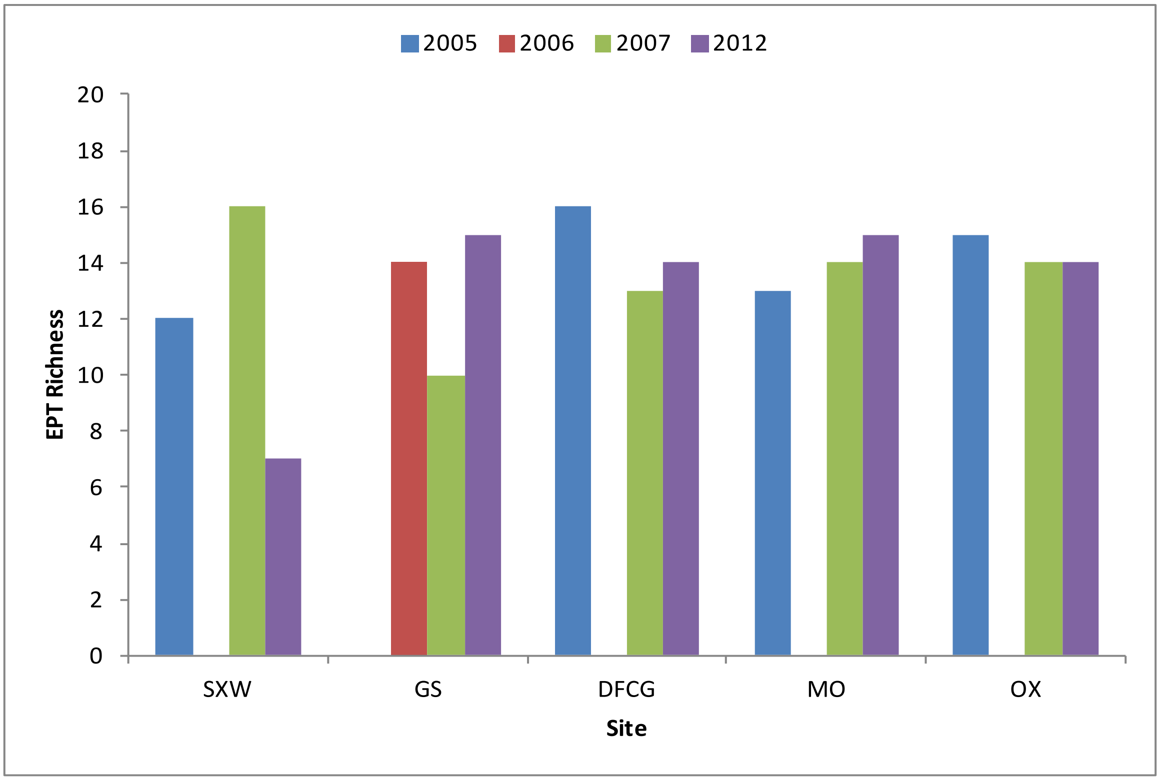


Figure 4-15. Mean EPT taxa richness for Hess samples by site in the spring (a) and fall (b) for 2005, 2006, 2007, and 2012.

(a)



(b)

Figure 4-16. Macroinvertebrate EPT taxa richness from kick-net samples by site in the spring (a) and fall (b) for 2005, 2006, 2007, and 2012.

HBI

The calculated HBI values showed little variation for spring samples from 2005-2012. The only significant differences found were from GS and MO where 2006 and 2007 HBI values were higher than 2012 at GS ($F_{2,8}$=27.1, p=0.001), and 2005 HBI values were higher than 2007 and 2012 at MO ($F_{2,8}$=19.2, p=0.003) (Figure 4-17). An HBI analysis of fall samples revealed statistical differences at SXW, GS, and OX. At SXW HBI values were significantly higher in 2007 as compared to all other years ($F_{3,11}$=27.2, p<0.001). At GS 2006 and 2007 HBI values were significantly higher than 2012 ($F_{2,8}$=67.8, p<0.001), and at OX 2005 HBI values were significantly higher than 2012 ($F_{3,11}$=6.08, p=0.019). The only trend observed from samples collected each of the four years was that of OX in the fall which revealed a declining trend through time in HBI values based on least squares regression ($F_{1,11}$=13.17, p=0.005).

Much like the EPT taxa data, kick-net data reveal very little about patterns or trends in calculated HBI values through time (Figure 4-18). It is evident that these samples produced variable results through time among sampling sites and overall have produced a minimum HBI value of 2.39 (SXW, spring 2012) and a maximum of 5.7 (OX, fall 2005). All samples are within the slightly enriched to enriched range and may be showing a decrease in HBI values as is more evident in the fall samples.

Discussion

Monitoring from 2005-2007 and 2012 revealed trends in the aquatic macroinvertebrate community of Sixth Water and Diamond Fork Creeks. The evaluation of these data was focused on long-term monitoring sites (SXW, DFC, MO, and OX) and a control site (GS) upstream of any artificial water inputs. Additionally, the need to establish baseline conditions among other sampling locations, particularly above and below water input structures, arose to allow for monitoring point source impacts at these delivery locations. These sites were included for analysis in 2012 and provide additional insight into the overall health of the macroinvertebrate community throughout the study area.

2012 Data

Macroinvertebrate densities among sampling sites appeared to be higher in 2012 in Sixth Water Creek compared to Diamond Fork Creek, but statistical analysis showed insignificant variation among most of the sampling locations for either season with the exception of AST in the spring. The same was true for GS which was established as a control site that has not been impacted by flow alterations. Densities of macroinvertebrates at GS were similar to sites downstream in Diamond Fork Creek as well as in Sixth Water Creek. Although species composition likely changed from spring to fall, macroinvertebrate densities remained fairly consistent among sites and between seasons indicating that macroinvertebrates are likely present in fairly uniform numbers all year long.

Densities of EPT taxa were proportionally similar to total densities indicating that most of the sites contain a similar composition of EPT taxa. Again, AST in the spring stood out among sample sites as having significantly high EPT taxa density. Also, like total density, GS showed insignificant differences in EPT density from other Diamond Fork or Sixth Water Creek sites. However, both EPT and total densities at GS were lower in the spring but higher in the fall in 2012 compared to other Diamond Fork Creek sites.

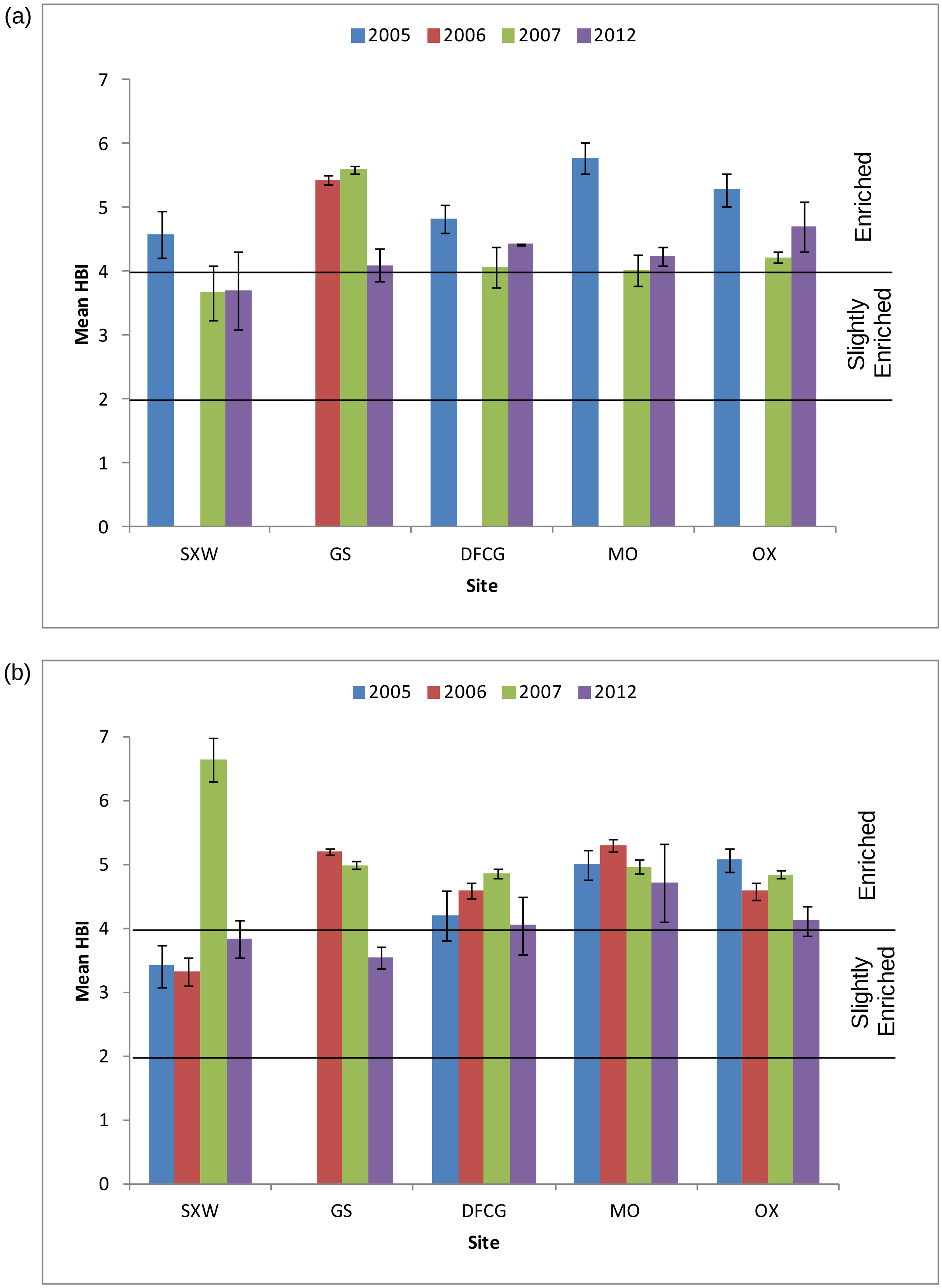
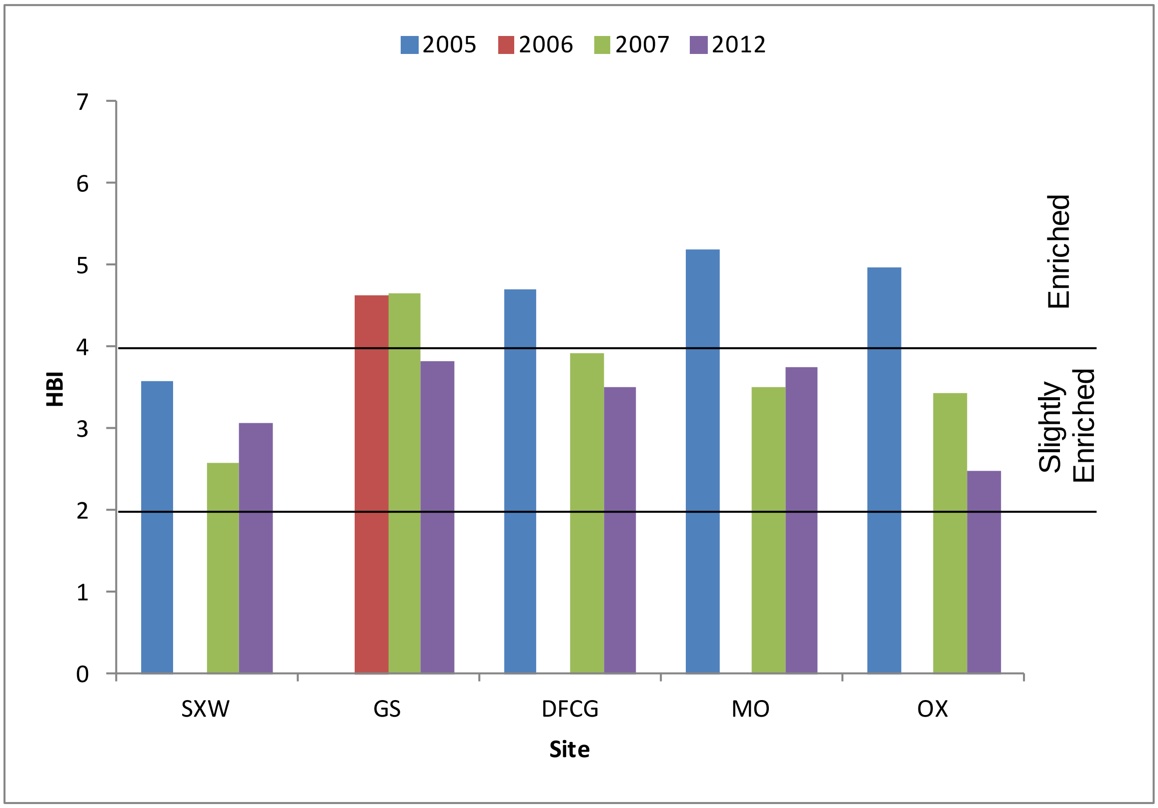


Figure 4-17. Mean HBI values for Hess samples by site in the spring (a) and fall (b) for 2005, 2006, 2007, and 2012.

(a)



(b)

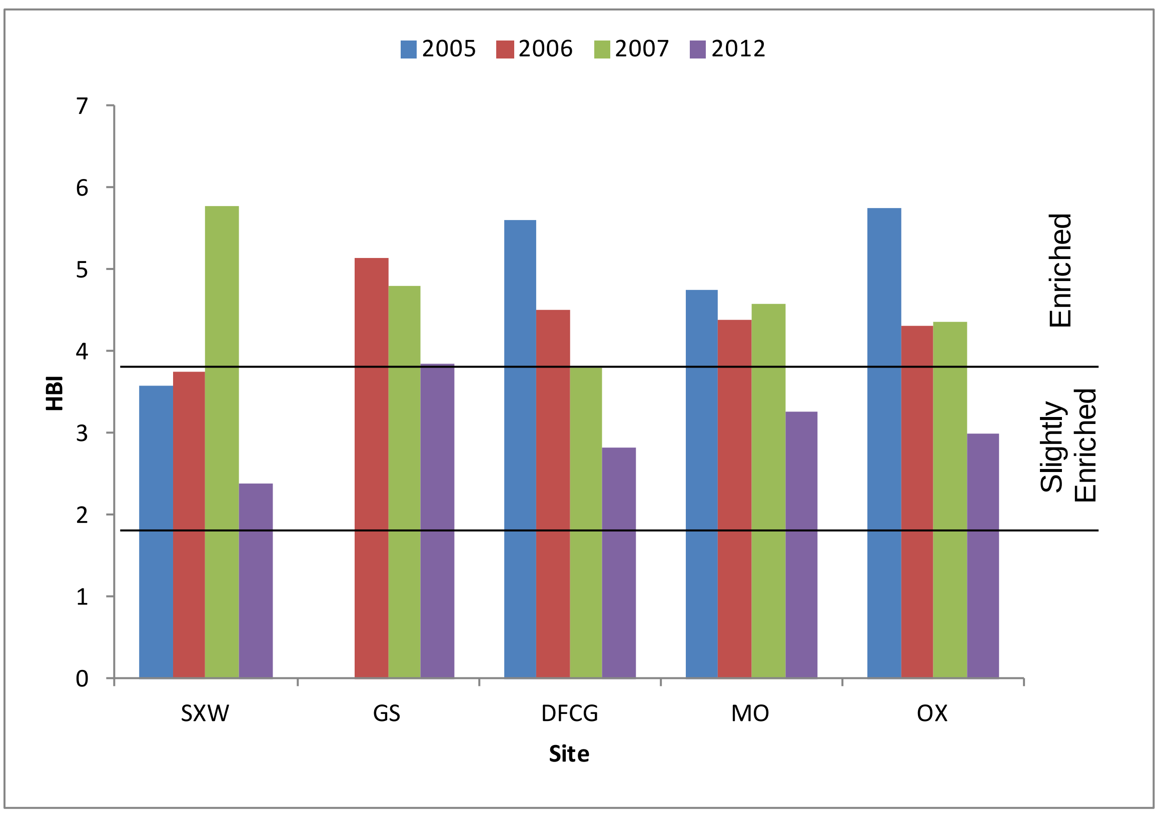


Figure 4-18. Macroinvertebrate HBI values from kick-net samples by site in the spring (a) and fall (b) for 2005, 2006, 2007, and 2012.

Although GS data did not exceed other sites in regards to macroinvertebrate densities there was a significant difference among some sites with regards to taxa richness for both spring and fall. The kick-net data also validated this and indicated that the Hess samples were likely good representations of the species present within the sampled reach. The 2012 data demonstrated taxa richness at the lower Diamond Fork Creek sites (MO and OX) to be higher or comparable to taxa richness in Sixth Water Creek. It was generally thought that macroinvertebrate diversity, or taxa richness, increased as stream size increases up through mid-order streams (Vannote 1980) which would support the findings of the 2012 sampling event. However, more recently, this has been a contentious concept showing much variation throughout geographic regions and landscapes (Clarke et al. 2008).

Interestingly, an HBI comparison among samples in 2012 revealed no significant differences, and found all Sixth Water and Diamond Fork Creek sites to be slightly enriched to enriched. This enrichment or impairment could be due, in part, to nutrients and/or sediment which would hinder some intolerant species from thriving; although, this designation does not mean that intolerant species are not present. The similarity in macroinvertebrate metrics among streams indicates that each is likely impacted equally or not impacted at detectible levels by increased base flows. An analysis of intolerant species was also conducted indicating that intolerant taxa with an HBI score of 2 or less (clean water taxa) do inhabit both Diamond Fork and Sixth Water Creeks. The kick-net data also revealed more intolerant taxa to be present especially at the Diamond Fork Creek sites than was collected in Hess samples, which is the likely cause for decreased (improved) HBI values for kick net samples in 2012. The additional habitats sampled via kick-net helped to validate the fact that intolerant species are present within all sites and perhaps more common at sites further downstream. In support, the CTQd showed a mid-range of tolerance among the taxa present indicating average water quality.

When considering taxa diversity, abundance, density, and HBI scores Sixth Water Creek and Diamond Fork Creek samples in 2012 were similar. GS showed perhaps more sensitivity and slightly higher taxa richness than the other sites. Although there were differences among the macroinvertebrate communities among sites a broad statistical analysis of common metrics did not detect functional differences among sites. Hess samples proved to represent the macroinvertebrate diversity well although kick-net data provided additional information pertaining to intolerant species richness. Similarities among macroinvertebrate metrics among sites indicates that in 2012 flow alterations or exposure to higher base flows either did not negatively impact, or impacted each sampling location similarly. It is likely that there was some impact as GS, the reference or control site, displayed slightly higher taxa richness and intolerant species richness than other sites in 2012 as described in the results. This sites proximity to a road crossing and relatively easy access could perhaps account for some variability or impact unrelated to flow. At this point it is only speculation as to what types of anthropogenic degradation GS endures during a given year or season.

Historical Data

There were some interesting trends observed in the data collected from the four long-term monitoring sites in 2005–2007 and 2012. Of the trends that were observed in the Hess data (which could be evaluated statistically) some were also evident in the kick-net data. Also, some of the trends observed in one metric (such as a change over time or a difference among sites) were persistent among other metrics which further validates the changes that may be occurring to the macroinvertebrate community.

Changes in the seasonal timing of the flow and temperature regimes of a system can impact the life history characteristics of individual species (Stanford and Ward 1979, Vannote and Sweeney 1980, Power et al. 1996). Changes in water velocity can impact channel-forming flows, which structure the bedform and substrate composition of the stream. Reducing spring peak flows can alter the maintenance of certain habitat types. More constant, higher flows can lead to the development of uniform substrates, which reduces the number of niches available (Stanford and Ward 1979). All of these factors may have worked to limit the diversity of habitat available for macroinvertebrates during the past 90 years of water deliveries in Sixth Water and Diamond Fork Creeks. It took many years for the community to adjust to the imported water -affected pattern of flows in this watershed, and it may take many years to see changes resulting from the new flow pattern where water deliveries bypass the stream system.

One of the changes that may be associated with altered flows is often a reduction in species diversity (Ward 1974, Stanford and Ward 1979). For example total taxa richness decreased at DFCG, MO, and OX in the fall from 2005-2012. The EPT taxa richness results from the five long-term monitoring sites were similar to the total taxa richness results in that MO also showed a decrease in EPT richness in the fall. Contrastingly, EPT richness increased at GS from 2005-2012. Thus, a decrease or lack of increase in total and/or EPT taxa richness may be a result of flow alteration on those sites susceptible to the altered hydrograph.

The HBI value is another factor that did not appear to be substantially improving with the change in flow conditions. Results indicated some level of impacts at all five long-term monitoring sites. Three of the long-term monitoring sites (MO, OX, and DFC) fell into the enriched category for HBI values during all samples, while SXW and GS were the only sites where the mean HBI values fell within the slightly enriched category. This occurred in the spring of 2007 and 2012 as well as the fall 2005, 2006, and 2012 for SXW. It also occurred in the fall 2012 at GS. Interestingly, OX was the only site to display a decreasing (improving) trend in HBI values through time for fall samples. Although some caution must be employed when interpreting richness and HBI indices for these data because of the level of taxonomic resolution used in this study and the fact that this index was developed based on Wisconsin streams (Hilsenhoff 1988), there still appears to be an indication of slightly degraded conditions with weak indications of improvement. This perhaps brings up the validity of the HBI metric as a valid metric for assigning impairment to western mountain streams. Comparing HBI metrics with similar streams may be a better indication of the overall degradation.

Patterns in abundance, if they exist, are not clear at this time; however, it appears that abundances have perhaps declined since 2005 at least for the spring samples. BIO-WEST (2007) reported one of the most promising indications that habitat conditions may be improving was a significant trend of increasing EPT density in the MO site. After further analysis with 2012 data, statistically, that trend is no longer supported. An increasing trend of EPT taxa abundance or density in a site suggests that the habitat is supporting more individual organisms that are intolerant to degraded conditions (but not necessarily more taxa). There are indications that trends could be developing at GS, SXW, and OX and perhaps could return to MO as more data is collected. It is not clear why the trend occurred at MO after 2007 when none of the other long-term monitoring sites had a similar pattern. One might anticipate that improving conditions in any of the monitoring sites (particularly any of the four sites in the mainstem Diamond Fork Creek) would be apparent in the other sites as well. One study showed that EPT richness declined with increases in base flows while EPT and total abundance increased. They conclude that although taxa are lost, those that can withstand high flows are able to increase in abundance (Carlisle et al. 2012). Perhaps this is what is happening in Sixth Water and Diamond Fork Creeks; although, the effects of increasing base flows are less understood than that of depleted base flows (Carlisle et al. 2012). Snaddon and Davies (1998) also showed that elevated summer flows from an inter-basin transfer in South Africa (similar condition to the Diamond Fork Creek prior to 2005) resulted in a decrease in taxa richness in the receiving river. It is plausible then that taxa richness may have been suppressed in Diamond Fork Creek as a result of the increased flows in the watershed. Once those conditions changed and excess flows were removed (or substantially reduced) one might anticipate that there would be a corresponding increase in taxa richness as the habitat recovers. However, in DFCG, MO, and OX there appeared to be a trend of decreasing total taxa richness in the fall over the 4 years monitored following flow reduction. Similarly, there was a significant trend of decreasing EPT taxa richness over time at MO in fall samples. A decreasing trend of taxa richness was an unexpected result for these monitoring sites. The change in flow conditions was assumed to be favorable for the aquatic community in each of these sites, however the data suggest very little to no improvement with regards to the macroinvertebrate community.

Four years of data with four years missing is perhaps not enough to generate conclusive observations on biological communities that have great natural variability over time, and are potentially responding to other stimuli or perturbations in addition to, or separate from, the changes in flow patterns. However, decreasing taxa richness and HBI values showing degradation is worthy of subsequent monitoring to determine whether trends will continue and to perhaps better assess what might be causing the undesirable conditions.

Much like the findings from the 2007 analysis (BIO-WEST 2009) the current data suggest little variation among SXW and the Diamond Fork Creek sites with regard to the metrics analyzed. It was originally thought, based on the river continuum concept, that Sixth Water Creek (a second order tributary to the Diamond Fork Creek) would have a lower taxa richness than the downstream Diamond Fork Creek sites (all fourth-order sites on the main stem). Since there were no differences among sites, it was hypothesized that SXW represented a higher-quality condition and that the downstream sites still needed to improve. However, there was a trend of decreasing taxa richness in SXW over the 3-year monitoring period. That same trend is no longer the case for fall samples and the trend was not analyzed for spring samples due to the missing 2006 data. Four years of monitoring data have provided a more complete evaluation of this site and others, and the results vary from earlier reports. The trends and changes observed over time likely substantiate the need for further monitoring.

The trends of reduced taxa richness and increasing dominance of a few taxa in fall samples may be in response to the observed sedimentation in Diamond Fork Creek. Fine sediment transport and deposition can have negative impacts on aquatic invertebrates (Waters 1995). Although large amounts of fine sediment is generally accepted as negatively impacting stream ecosystems and the macroinvertebrate community, the tolerated amount of fine sediment and the threshold at which degradation of the macroinvertebrate community occurs is not yet understood (Hicks et al. 1991). The higher-than-average transport of fine sediments could be impacting the diversity of macroinvertebrates found at all sites, especially MO and OX. The effects of fine sediment on stream insects have been studied in recent years (Relyea et al. 2000). In earlier reports it was noted that a caddisfly classified as intolerant to fine sediment (*Arctopsyche grandis*; Relyea et al. 2000) was present at all four of the monitoring sites for all samples except fall 2007(BIO-WEST 2006, 2009). This same species occurred at all 10 sampling locations for both spring and fall 2012. In addition to *Arctopsyche grandis*, another caddisfly that is intolerant to sediment, *Oligophlebodes* sp., was common at the SXW site but not found in any of the Diamond Fork monitoring sites in fall 2007 or spring 2012 but was found at GS and DFCG in fall 2012.

Based on a Fine Sediment Biotic Index (FSBI) analysis from 2005-2007 the observed trend of the FSBI scores at DFC, MO, and OX indicated sedimentation problems were occurring in lower Diamond Fork Creek during the fall season (BIO-WEST 2009). This is also supported when using embeddedness as a surrogate for the amount of fine sediment that is transported and deposited downstream. It was found that since 2007 all Diamond Fork Creek sites are showing increased embeddedness through time, including GS which shows a slight increase in embeddedness from spring to fall in 2012 (Figure 3-19). The SXW embeddedness transect has shown an overall decrease in embeddedness since 2007 to less than 50% embedded in the fall 2012. Similar results were found at RC with slightly decreased or similar embeddedness from spring to fall and compared to 2007. Although increased embeddedness reduces the amount of interstitial space and consequently macroinvertebrate habitat, the data suggests that this increased embeddedness has not dramatically altered the macroinvertebrate community. It could however account for some loss in diversity among sites and the degraded HBI scores which could be associated with fine sediment (Relyea 2000).

Using macroinvertebrates as a biological indicator of health may help to address any limiting factors that may exist throughout trophic levels. The fishery in Sixth Water and Diamond Fork Creeks is important from an ecological and a recreational standpoint and is of interest to resource managers and the public. More specifically, Diamond Fork Creek is being pursued as a Blue Ribbon fishery (J. Nielson, UDWR, personal communication) by the Blue Ribbon Fisheries Advisory Council to provide “highly-satisfying fishing and outdoor experiences for diverse groups of anglers and enthusiasts” [From UDWR 2012a]. Currently, both Sixth Water Creek and Diamond Fork Creek are managed under general regulations which allow for a four trout bag limit (UDWR 2012b). Based on a conversation with UDWR biologist Jordan Nielson, the trout community in Diamond Fork Creek consists of brown trout (*Salmo trutta*) and cutthroat trout (*Oncorhynchus clarkii*) with an occasional triploid rainbow trout (*Oncorhynchus mykiss*) below Three Forks and only cutthroat trout above Three Forks. Sixth Water Creek contains both brown trout and cutthroat trout while triploid rainbow trout are stocked occasionally (Nielson, personal communication). A cutthroat reintroduction effort occurred above Three Forks on Diamond Fork Creek with promising results and noted reproduction and recruitment in 2011 and 2012. This same reproduction and recruitment was noted for brown trout downstream with a range in size classes being present. Spawning and recruitment are also occurring in Sixth Water Creek (Nielson, personal communication). Although the outlook on the fishery of Diamond Fork and Sixth Water Creeks is positive, condition factors for brown trout in 2009 ranged from 0.95–1.10 from near the confluence to Spanish Fork Creek upstream to Three Forks (Nielson, personal communication). These values are lower than mean condition factors reported by Carlander (1969) in Carter Creek, Utah (1.38); however, within the ranges reported for wild fish in Colorado streams (0.87–1.63) (Carlander 1969). It appears as though the fishery is naturally sustainable with multiple size classes, natural reproduction, and natural recruitment (Nielson, personal communication). Based on the macroinvertebrate data, food in the form of aquatic insects does not seem to be a limiting factor for natural reproduction and recruitment of the fish community. Macroinvertebrate data alluded to slightly degraded stream conditions yet little differences in macroinvertebrate abundance or density from Sixth Water Creek downstream to OX on Diamond Fork Creek. Therefore, fish food availability would also be consistent among sites. There are other factors such as, but not limited to, temperature, flow, and water quality that may also impact the overall condition factor of a fish population at any given sampling period.

In summary, the macroinvertebrate community in Sixth Water and Diamond Fork Creek shows variation among seasons as well as among sites for many of the metrics analyzed in this report. Data for 2012 showed similarities in taxa diversity, abundance, density, and HBI scores. As suspected, GS showed perhaps the most sensitivity and highest taxa richness. Functionally, all sampling sites in 2012 were similar with regards to the sampled macroinvertebrate community and the flows encountered in 2012 appeared to have minimally impacted the macroinvertebrate community (or such impacts extend well beyond the longevity and scope of the macroinvertebrate data collected from within this system). Historical comparisons also showed variation among seasons and between sites. Similarities among sites exist through time since the completion of the water bypass system. The most notable differences was the decrease in total and EPT taxa richness in some Diamond Fork Creek sites and the slightly impaired (slightly enriched to enriched) designation from HBI data. Although the macroinvertebrate community has shown dominance from more tolerant species, intolerant species are present and have remained present since 2005. An analysis of the macroinvertebrate community shows ecological stability through time (since 2005) and does not appear to be a limiting factor as a food source for the fish community.

Recommendations

It is recommended that macroinvertebrate community monitoring continue at all 10 monitoring sites as was conducted in 2012. This marks the first year that five of these monitoring sites have been visited and as such, baseline data has just now been initialized for these new locations. As with most biological monitoring, the more data that can be collected through time, the better the trend analysis becomes. With Diamond Fork and Sixth Water Creeks the community analysis becomes difficult given artificial inputs and the unnatural processes that are occurring. Being able to correlate change to any of the hydrological or biological process will require consistent and frequent monitoring.

As these creeks were affected by artificial hydrographs for 90 years it is difficult to compare the macroinvertebrate community, or any biological community, with any type of comparable baseline or “natural” condition. The importance of reference sites in biological monitoring has been discussed (Bonar et al. 2009; Karr and Chu 1997), and is perhaps applicable for monitoring the overall ecological health of Diamond Fork and Sixth Water Creeks. An effort to establish reference streams and sites within those streams based on geologic, hydrologic, and watershed characteristics and compare those characteristics back to Diamond Fork or Sixth Water Creeks could help to establish expected conditions. Once the expected conditions are established, the deviation of the observed from the expected can be analyzed to determine whether or not conditions are improving or degrading while eliminating natural, environmental factors that may cause variation within the data. This would require the creation of a study design that would allow for statistical analysis, and a thorough investigation of reference site characteristics that may include on the ground measurements to determine similarity to the impact sites.

This chapter is focused on the macroinvertebrate community in an effort to make inferences to the overall biological health of the system and to help determine changes that may be occurring based on changes to water management. Although there are inferences that can be made regarding the fish community based on the characteristics of the macroinvertebrate community, it only provides insight into a piece of the whole. It appears that the fishery of Diamond Fork and Sixth Water Creek is not only important to the general public, but also to resource managers and other interest groups. It is recommended that a more intense look into the reproduction and recruitment of the trout population be conducted. It may be advantageous to incorporate fisheries sampling with the macroinvertebrate sampling in order to make valid seasonal comparisons between the macroinvertebrate community and provide a more direct linkage of food resources utilized by the fish community within this system. The variable season sampling would also allow for a better assessment of reproduction and recruitment from one life-stage to the next and better assess predation and mortality. Even more intensive could be a mark and recapture survey in an effort to assess growth and recruitment with the potential to perform population estimates. Currently length frequency and weight data exists, and at a minimum, this data should be assimilated and analyzed through time to assess the changes that have occurred within the fish community and determine whether or not the fishery is improving or maintaining a healthy condition.

SECTION 5: SUMMARY AND DISCUSSION

The results of the 2012 monitoring of sediment transport, channel substrate, and macroinvertebrates are summarized in Figures 5-1a to 5-1d. Overall, the 2012 monitoring provided an opportunity to revisit and verify some of the trends observed during the original monitoring effort that occurred during the first 3 years following tunnel/pipeline completion and removal of artificial flow augmentation. The new monitoring sites established in 2012 also provide a more complete picture of conditions along the continuum of the Diamond Fork watershed and provide above and below comparisons of the Syar and Monks Hollow flow control structures.

In general, the results of the 2012 monitoring suggest that many of the trends and potential issues of concern that were noted during the initial 2005–2007 monitoring period (BIO-WEST 2009) continue to persist. High levels of embeddedness, particularly in the fall at the lower Diamond Fork sites (AMH, BMH, DFC, MO, and OX), continue to be evident. Streambed cementation and formation of underwater "brick" ledges remains common at the MO and OX sites, and remains evident to a lesser degree at the DFC site. These issues have the potential to degrade aquatic habitat conditions and the reproductive success of species such as trout that rely on access to clean spawning gravels. Macroinvertebrate monitoring results at the lower Diamond Fork Creek sites (DFC, MO, OX) show a trend toward decreasing taxa richness from 2005–2012, suggesting that removal of imported flows has not significantly improved biological conditions. However, other than having slightly higher taxa richness, results indicate that the macroinvertebrate community at the control monitoring site (GS) is quite similar in composition and abundance to all nine of the flow-affected monitoring sites.

Channel substrate and macroinvertebrate monitoring results at the "paired" above/below tunnel input sites (AST/BST and AMH/BMH) were fairly similar and did not show dramatic effects associated with the inputs. At the AMH and BMH sites, this may simply be a function of the fact that the Monks Hollow Overflow Structure does not appear to be used on a regular or consistent basis. At the AST and BST sites, the similarity may be a function of the fact that although Syar Tunnel does add substantial flow on a regular basis, the reaches upstream of Syar already receive artificially high base flows through Strawberry Tunnel. In other words, adding still more base flow to a stream already augmented beyond its bedload transport threshold may not make a noticeable difference in conditions.

In 2011, and 2012, the unusually low Diamond Fork flows associated with sleeve valve maintenance and repair work afforded an opportunity to better assess the bedload transport thresholds at the transport monitoring sites. Although monitoring found that bedload transport rates dropped significantly at these lower discharges and the largest mobile grain size showed an eight- to four-fold reduction, flows never got low enough to fully drop below the transport threshold. However, the 2011 and 2012 samples were collected in the fall, when conditions at the downstream sites were in a seasonally embedded condition, which increases sediment mobility. All of the flow-affected sediment transport monitoring sites show a seasonal separation in bedload rating curves, with lower mobility during the runoff (non-embedded) period and greater mobility when conditions become embedded (non-runoff periods). The October 2012 sample at Childs Bridge was collected at the recommended threshold flow of 50 cfs and, although bedload never dropped to 0.01 tons/day, the maximum particle size transported did drop below 1mm. This provides confidence that, if the recommended threshold flows we recommended in 2011 were achieved at all sites for an entire year such that seasonal embeddedness were to be prevented, bedload transport would effectively cease at the recommended threshold flows.

SIXTH WATER CREEK SITES

SXW, RC, USWB, AST, BST, LSWB

Setting: confined, steep gradient; landslide contributes sediment between SXW and RC sites

Hydrology: elevated base flows (~10x natural) due to imports through Strawberry and Syar tunnels

Sediment Transport: constant bedload transport in LSWB of particles gravel-sized and smaller

Channel Substrate:

- Boulder or boulder-cobble dominated
- Variable levels of embeddedness
- 2012 Spring to Fall: trend of coarsening/reduced embeddedness
- Long-term trends (2005-2012): increased sand/silt at SXW due to increases in woody debris; reduced embeddedness (RC, SXW)

Macroinvertebrates:

- Clean water taxa present, but some indication of enriched/slightly enriched conditions
- Richness (2012 data) slightly lower than control site (GS) and downstream-most sites (MO & OX)
- AST site shows higher densities & EPT densities than other 9 sites (2012 data)
- Overall, communities are similar to Diamond Fork Creek sites
- No major differences from spring to fall 2012 ; no apparent impact from flow releases
- Long-term trends (2005-2012): at SXW, 2005-2007 trend of decreased richness may be stabilizing; no other significant trends toward improvement or degradation evident

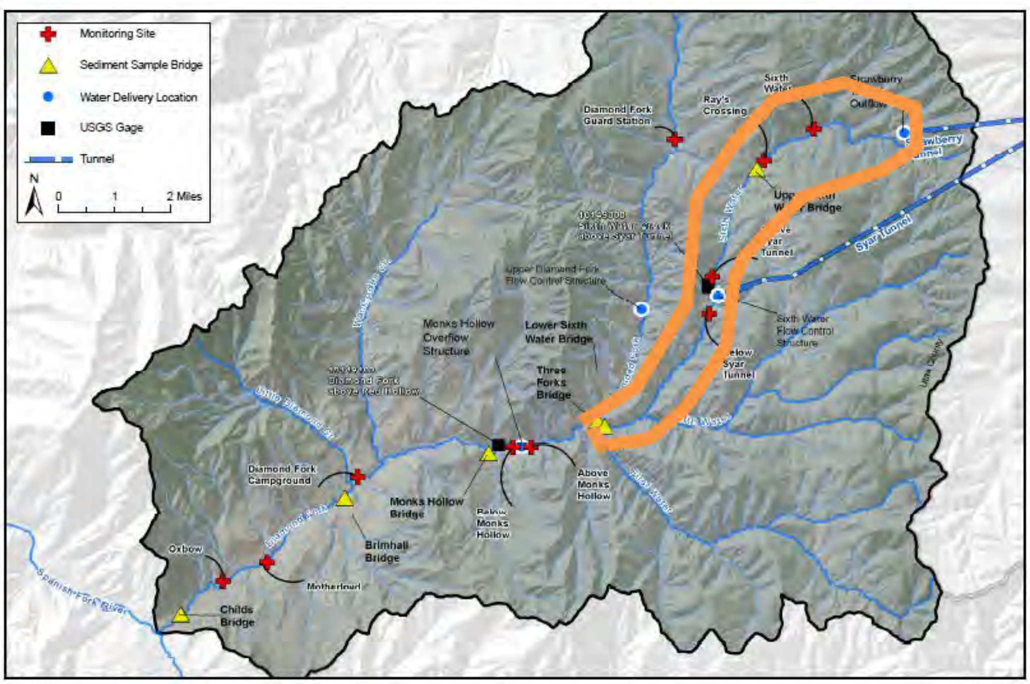


Figure 5-1a. Sixth Water Creek sites summary.

UPPER DIAMOND FORK CREEK CONTROL SITES

GS, DF3FB

Setting: moderately steep and confined; some impacts from grazing and proximity of road to creek

Hydrology: natural flow regime unaffected by flow imports

Sediment transport: bedload transport at DF#FB nearly zero during baseflow conditions; no seasonal separation in rating curve

Channel Substrate (GS site):

- Cobble-dominated
- Moderately embedded
- 2012 Spring to Fall: no major trends; some parameters coarsened, others fined

Macroinvertebrates:

- GS site shows slightly higher taxa and intolerant taxa richness than the other 9 sites (2012 data)
- Densities similar to the other hydrologically-impacted sites
- Trend of increasing EPT richness 2006-2012
- Clean water taxa present, but some indication of slightly enriched conditions
- Overall community similar to other monitoring sites

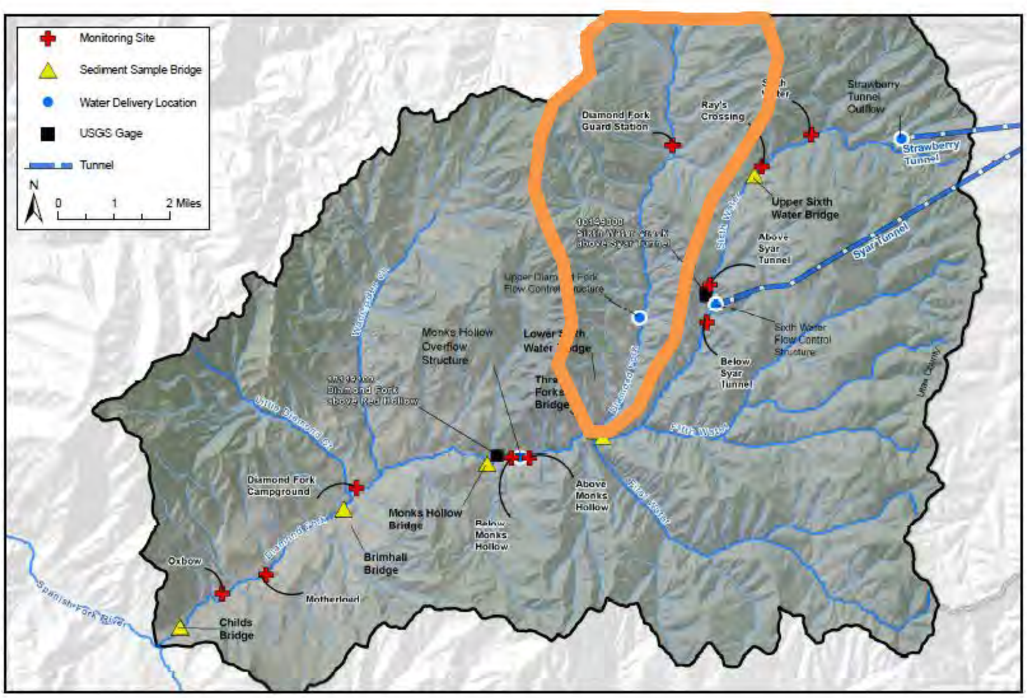


Figure 5-1b. Upper Diamond Fork Creek Control sites summary.

MIDDLE DIAMOND FORK CREEK SITES

AMH, BMH, MHB

Setting: moderate channel gradient (~1-2%) and confinement

Hydrology: elevated base flows (~4x natural) due to imports through Strawberry , Syar, and Upper Diamond Fork tunnels

Sediment Transport: constant bedload transport at MHB of particles gravel-sized and smaller; distinct rating curves during runoff period vs. non-runoff (seasonally embedded) period

Channel Substrate:
- Cobble-gravel dominated
- High levels of embeddedness
- 2012 Spring to Fall: strong trend toward increased %fines and increased embeddedness
- AMH and BMH similar in characteristics

Macroinvertebrates:
- Clean water taxa present, but some indication of slightly enriched conditions
- Taxa richness (2012 data) slightly lower than control site (GS)
- No major differences from spring to fall 2012 ; no apparent impact from flow releases
- Overall, communities are similar to the other 8 sites

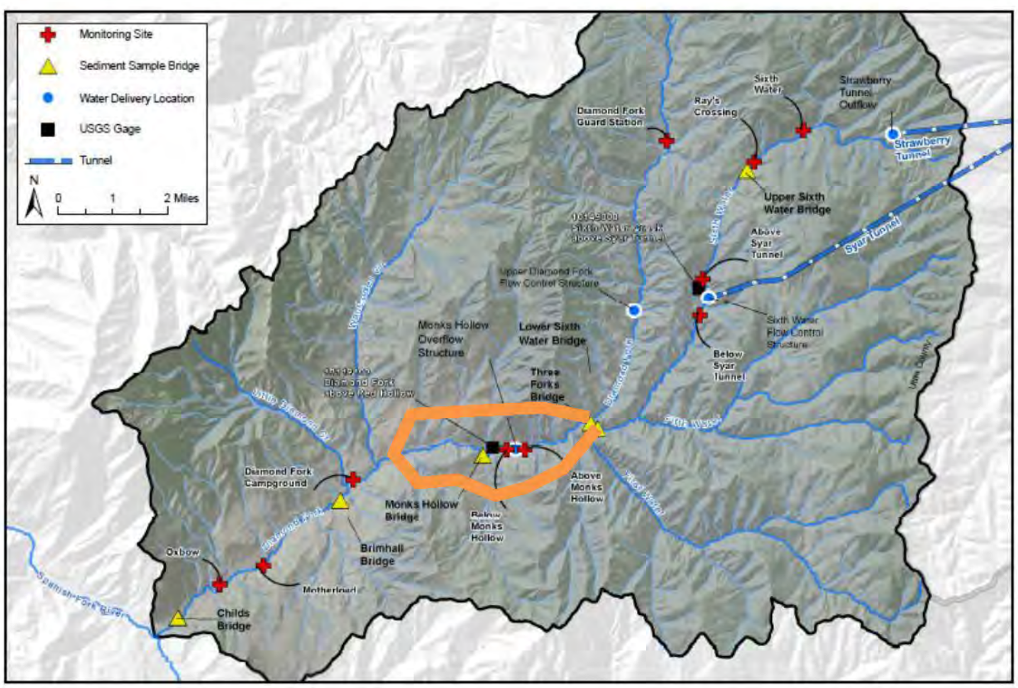


Figure 5-1c. Middle Diamond Fork Creek sites summary.

LOWER DIAMOND FORK CREEK SITES

DFC, BB, MO, OX, CB

Setting: low gradient (~1%) and less confined relative to upstream sites

Hydrology: elevated base flows (~4x natural) due to imports through Strawberry, Syar, and Upper Diamond Fork tunnels

Sediment Transport: constant bedload transport of particles gravel-sized and smaller at BB and CB; distinct rating curves during runoff period vs. non-runoff (seasonally embedded) period

Channel Substrate:

- Cobble-gravel (DFC) or gravel dominated (MO, OX)
- High to very high levels of embeddedness; areas of cemented bed material & underwater ledges common
- 2012 Spring to Fall: strong trend toward increased embeddedness; minor trend toward fining
- Long-term trends (2005-2012): increased substrate fining and embeddedness; rate of fining more rapid in 2005-2007 than in 2007-2012

Macroinvertebrates:

- Clean water taxa present, but some indication of enriched/slightly enriched conditions
- Taxa richness (2012 data) slightly lower than control site (GS)
- No major differences from spring to fall 2012; no apparent impact from flow releases
- Overall, communities are similar to the other 7 monitoring sites
- Long-term trends (2005-2012): decrease in taxa richness; slight decrease in abundance (spring samples); fine sediment biotic index and high embeddedness levels suggest fall sedimentation problems

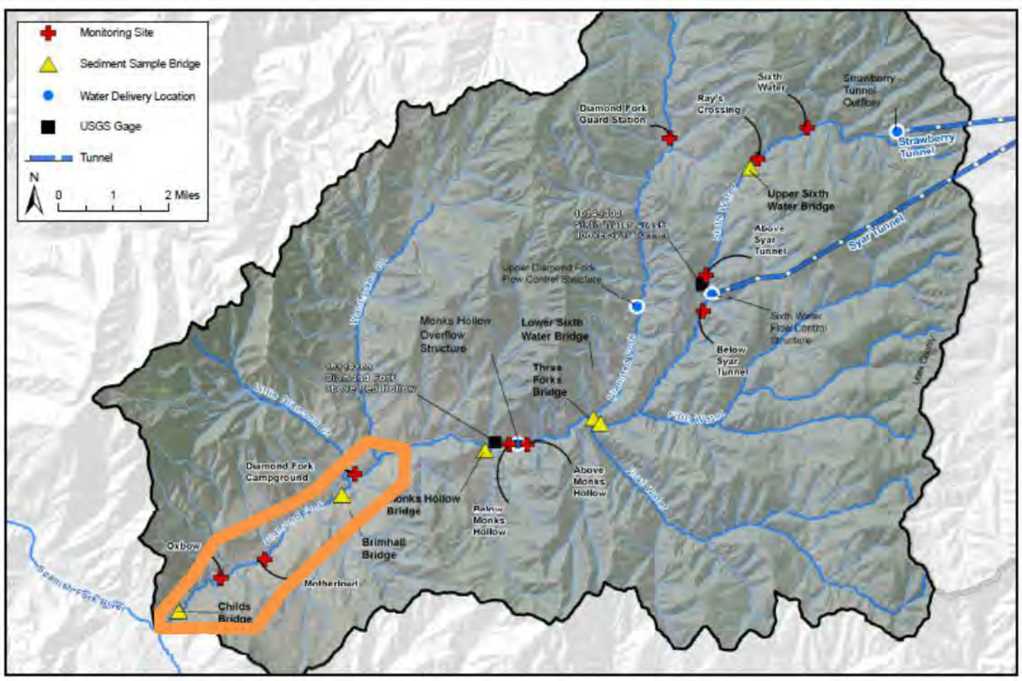


Figure 5-1d. Lower Diamond Fork Creek sites summary.

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APPENDIX 4-1: TAXA FOUND FOR EACH SAMPLE COLLECTED IN 2012

Table 4-1a.

Diamond Fork Benthos Sampling Spring 2012 4/17--4/18/2012		Site Name	Sixth Water	Sixth Water	Sixth Water	Sixth Water	Ray's Crossing	Ray's Crossing	Ray's Crossing	Ray's Crossing	Above Sayr	Above Sayr	Above Sayr	Above Sayr	Below Sayr	Below Sayr	Below Sayr	Below Sayr	Guard Station	Guard Station	Guard Station	Guard Station	Above Monks	Above Monks	Above Monks	Above Monks
		Site	SXW_1	SXW_1	SXW_1	SXW_1	RC_1	RC_1	RC_1	RC_1	ASYR_1	ASYR_1	ASYR_1	ASYR_1	BSYR_1	BSYR_1	BSYR_1	BSYR_1	GS_1	GS_1	GS_1	GS_1	AMH_1	AMH_1	AMH_1	AMH_1
		Replicate	1	2	3	Composite	1	2	3	Composite	1	2	3	Composite	1	2	3	Composite	1	2	3	Composite	1	2	3	Composite
		Date	4/17/2012	4/17/2012	4/17/2012	4/17/2012	4/17/2012	4/17/2012	4/17/2012	4/17/2012	4/17/2012	4/17/2012	4/17/2012	4/17/2012	4/17/2012	4/17/2012	4/17/2012	4/17/2012	4/17/2012	4/17/2012	4/17/2012	4/17/2012	4/18/2012	4/18/2012	4/18/2012	4/18/2012
		Lab Split	16	8	50	13	100	75	50	14	19	6	19	8	50	38	38	13	100	38	100	19	100	94	38	25
		Gear	Hess net	Hess net	Hess net	D-Frame	Hess net	Hess net	Hess net	D-Frame	Hess net	Hess net	Hess net	D-Frame	Hess net	Hess net	Hess net	D-Frame	Hess net	Hess net	Hess net	D-Frame	Hess net	Hess net	Hess net	D-Frame
Order	**Family/Genus/Species**																									
Arhynchobdellida	Erpobdellidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trombidiformes			0	1992	67	64	33	0	0	0	0	711	237	0	44	0	0	24	0	0	56	11	0	0	62	0
Trombidiformes	Wandesia sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	44	0	22	0	0	0	0	0
Trombidiformes	Hygrobatidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0
Trombidiformes	Sperchonidae		0	142	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	30	0	21	0	0	0	0
Trombidiformes	Sperchon sp.		427	0	0	0	0	163	378	0	0	0	0	13	0	0	30	0	11	0	0	0	23	0	0	16
Trombidiformes	Torrenticolidae		0	0	0	0	0	0	0	14	0	178	0	0	0	0	0	0	0	30	0	0	0	0	0	0
Trombidiformes	Testudacarus sp.		0	285	22	8	0	0	0	0	0	0	0	0	44	0	0	8	0	0	22	0	0	0	0	0
Trombidiformes	Torrenticola sp.		355	0	0	8	0	44	67	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0
Collembola			0	142	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	5	0	0	0	0
Coleoptera	Elmidae		213	854	0	0	244	148	311	99	119	4800	0	128	44	1452	89	48	600	859	400	235	140	384	31	124
Coleoptera	Cleptelmis addenda		71	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	33	0	11	0	12	0	0	0
Coleoptera	Optioservus sp.		1100	722	689	144	111	489	1089	45	1007	544	1541	269	589	800	544	332	589	119	1833	144	442	87	744	124
Coleoptera	Optioservus sp.		0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0
Coleoptera	Optioservus quadrimaculatus		0	142	0	16	11	44	111	64	178	356	59	26	22	30	0	57	78	59	89	59	116	87	186	76
Coleoptera	Zaitzevia parvulus		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	144	0	56	37	0	0	0	0
Diptera	Atherix pachypus		0	0	0	0	0	0	22	0	70	0	22	1	0	0	0	10	0	0	0	0	47	37	124	40
Diptera	Ceratopogonidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	30	0	5	0	0	0	0
Diptera	Probezzia sp.		213	0	44	0	11	0	22	0	0	0	59	0	0	59	0	8	78	59	156	5	23	0	0	4
Diptera	Chironomidae		213	996	311	64	22	44	111	35	1422	711	652	179	444	533	267	145	22	296	33	37	105	37	124	16
Diptera	Chironomidae		1280	142	111	56	56	74	178	170	59	2133	889	282	156	89	30	152	233	1037	511	181	23	0	341	36
Diptera	Chironomidae		18270	62773	5089	1696	2133	2578	7667	1610	12385	32356	17007	2231	6556	9244	7319	1264	1367	6304	1200	470	1209	0	2884	140
Diptera	Chironomidae		142	0	0	0	0	0	0	14	0	0	178	64	0	0	0	16	156	119	100	27	0	0	62	0
Diptera	Empididae		0	569	0	0	122	0	0	14	0	356	0	0	0	30	0	0	0	148	0	21	0	12	0	0
Diptera	Neoplasta sp.		0	0	0	8	0	104	89	7	0	0	0	0	22	0	0	0	78	0	11	0	12	0	62	0
Diptera	Wiedemannia sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0
Diptera	Empididae		142	0	0	0	0	119	89	0	0	0	0	0	0	0	0	0	22	0	0	0	23	0	0	16
Diptera	Chelifera sp.		142	0	22	0	0	0	0	0	0	0	0	0	44	0	0	0	0	0	11	0	0	0	0	0
Diptera	Hemerodromia sp.		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	Muscidae		11	164	0	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Pericoma sp.		142	569	89	80	0	0	0	14	0	0	0	0	0	0	0	0	100	89	167	5	0	0	0	0
Diptera	Simuliidae		0	0	0	0	0	0	0	0	0	356	0	0	67	59	0	16	11	59	44	32	0	37	93	0
Diptera	Prosimulium sp.		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	Simulium sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	178	0	0	0	0	16	0	0	0	0
Diptera	Tipulidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	56	11	0	0	0	0
Diptera	Dicranota sp.		307	285	189	25	0	133	289	35	0	356	178	13	33	59	30	0	144	0	133	0	0	0	0	0
Diptera	Hexatoma sp.		11	0	0	0	0	0	0	0	0	0	59	0	0	0	0	0	22	0	33	11	0	0	0	0
Diptera	Antocha monticola		531	1138	178	56	433	1263	2678	216	1537	4978	1656	231	911	963	844	152	411	1344	233	101	360	37	674	36
Diptera	Limnophila sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0
Diptera	Tipula sp.		22	142	56	16	0	0	22	0	0	0	0	5	0	0	0	14	11	59	11	12	0	0	0	4
Ephemeroptera	Ameletus sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	22	16	0	0	0	0
Ephemeroptera	Baetidae		284	12520	0	0	878	0	0	738	0	30756	0	115	0	1481	178	0	0	178	0	48	0	2878	0	12
Ephemeroptera	Baetidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	222	0	0	0	0	0
Ephemeroptera	Baetis sp.		2701	2583	889	720	67	1052	1267	333	22196	2311	4100	1551	5878	800	4337	1208	56	0	22	53	2779	459	15198	1211
Ephemeroptera	Diphetor hageni		142	0	0	0	0	0	22	0	0	0	0	0	0	0	0	0	122	0	0	16	0	0	0	0
Ephemeroptera	Ephemerellidae		7109	3557	289	328	811	1719	2422	546	7822	17067	5748	3462	2456	4326	4207	1528	1400	2430	1311	389	302	247	279	324
Ephemeroptera	Drunella sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0
Ephemeroptera	Drunella doddsii		0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	11	6	0	0	0	0
Ephemeroptera	Drunella grandis		0	0	256	1	67	126	578	108	59	178	485	27	22	81	0	25	44	348	33	44	0	0	23	8
Ephemeroptera	Ephemerella sp.		957	1565	178	248	44	44	144	0	4407	0	4741	269	2022	444	722	1139	267	533	533	80	419	62	845	80
Ephemeroptera	Heptageniidae		0	142	22	0	0	0	22	0	0	0	0	0	0	0	0	0	211	148	33	389	0	149	31	4
Ephemeroptera	Cinygmula sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	233	0	1278	219	0	0	0	0
Ephemeroptera	Epeorus sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	11	0	0	0	0	0
Ephemeroptera	Rhithrogena sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	12	74	79
Ephemeroptera	Leptophlebiidae		0	0	0	0	0	0	0	0	0	0	59	0	22	0	0	0	0	444	267	69	0	136	31	0
Ephemeroptera	Paraleptophlebia sp.		0	0	0	0	0	0	0	0	0	0	0	26	0	0	0	0	156	0	100	0	12	0	62	64
Plecoptera			0	0	0	0	11	0	0	0	0	711	59	0	0	59	0	0	522	2696	1300	107	721	819	1333	0
Plecoptera	Chloroperlidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	44	0	0	0	0	0	0	0
Plecoptera	Triznaka sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33	0	0	0	0	12
Plecoptera	Chloroperlidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	44	0	0	0	0	0
Plecoptera	Nemouridae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	5	0	0	0	0
Plecoptera	Zapada sp.		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	Perlidae		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	Claassenia sabulosa		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	Perlodidae		0	0	0	0	0	0	0	0	178	0	0	51	0	0	89	0	22	30	33	0	12	0	31	8
Plecoptera	Isogenoides sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	6
Plecoptera	Isoperla sp.		0	153	22	24	11	30	22	0	970	567	178	53	300	159	152	129	89	70	33	27	12	50	74	73
Plecoptera	Diura knowltoni		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0
Plecoptera	Skwala americana		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0
Plecoptera	Pteronarcyidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	849	74	0	192
Plecoptera	Pteronarcella badia		0	0	0	0	22	11	22	16	11	0	0	0	0	0	0	1	11	0	44	5	0	37	58	29
Plecoptera	Pteronarcys sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	13
Plecoptera	Pteronarcys californica		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Trichoptera			0	1565	0	0	0	0	0	14	0	178	0	0	0	0	0	0	0	119	0	37	0	0	0	0
Trichoptera	Brachycentridae		0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Brachycentrus sp.		0	0	0	0	0	30	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Brachycentrus americanus		782	996	22	40	122	174	1189	121	0	0	11	13	0	0	0	0	211	1119	500	112	0	0	0	0
Trichoptera	Brachycentrus occidentalis		0	0	0	0	11	148	133	7	0	544	248	0	22	30	0	16	0	0	0	0	35	0	0	16
Trichoptera	Micrasema sp.		2484	1138	44	288	0	0	67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Glossosomatidae		0	0	0	8	0	0	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Glossosoma sp.		71	0	0	0	11	74	67	0	0	0	59	0	0	0	0	0	11	0	0	0	0	0	0	0
Trichoptera	Helicopsyche sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	47	0	0	8
Trichoptera	Hydropsychidae		0	0	0	0	11	0	0	0	237	533	0	26	156	30	0	72	78	474	267	59	35	174	0	8
Trichoptera	Arctopsyche grandis		93	0	100	25	144	59	133	93	315	1444	104	55	278	70	293	28	22	89	44	17	58	12	0	22
Trichoptera	Hydropsyche sp.		0	0	0	0	0	15	67	0	615	711	237	167	889	278	419	152	511	415	389	64	442	421	240	75
Trichoptera	Hydroptilidae		0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Hydroptila sp.		71	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 sp.		0	0	0	0	0	0	44	0	0	0	0	13	22	0	0	0	78	0	122	21	0	0	0	0
Trichoptera	Limnephilidae		0	0	0	56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Hesperophylax sp.		0	0	0	0	0	0	0	8	0	0	0	13	0	0	0	16	22	89	22	177	0	0	0	0
Trichoptera	Rhyacophila sp.		0	711	278	0	111	89	244	85	1185	1244	59	128	156	119	415	64	67	326	78	37	0	0	93	0
Trichoptera	Rhyacophila brunnea/vemna		400	438	356	88	11	30	22	0	0	0	0	0	0	0	0	0	78	289	44	28	0	0	0	0
Trichoptera	Rhyacophila coloradensis		0	0	0	0	0	41	22	0	44	0	11	52	111	0	270	40	0	0	0	0	23	0	23	4
Trichoptera	Rhyacophila hyalinata		0	0	0	0	22	0	0	2	0	0	0	0	0	170	0	0	0	0	0	0	0	62	0	0
Trichoptera	Oligophlebodes sp.		7887	5428	4567	1161	511	648	1267	376	237	900	319	2	167	148	0	40	0	0	0	0	0	0	0	0
Amphipoda	Gammarus sp.		0	0	0	20	0	0	0	0	59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopoda	Caecidotea		0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Veneroida	Pisidiidae		0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Veneroida	Pisidium sp.		213	0	0	64	0	15	44	43	178	0	237	90	0	0	0	24	11	0	67	27	0	0	0	16
Basommatophora	Physa sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Neotaenioglossa	Hydrobiidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96
Neotaenioglossa	Potamopyrgus antipodarum		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phylum: Nemata			498	0	22	0	11	74	0	7	0	0	59	51	22	59	0	0	0	0	33	5	0	0	0	0
Phylum: Platyhelminthes	Class: Turbellaria		0	0	89	0	311	0	467	0	0	0	0	0	111	0	89	0	0	0	700	0	0	12	0	0
Phylum: Annelida	Class: Clitellata		1422	1718	1289	136	67	148	67	234	119	0	119	154	22	237	0	80	0	0	0	107	0	161	0	100

Table 4-1a. (Cont.)

Diamond Fork Benthos Sampling		Site Name	Below Monks	Below Monks	Below Monks	Below Monks	DF Campground	DF Campground	DF Campground	DF Campground	Motherload	Motherload	Motherload	Motherload	Oxbow	Oxbow	Oxbow	Oxbow
Spring 2012		Site	BMH_1	BMH_1	BMH_1	BMH_1	DFCG_1	DFCG_1	DFCG_1	DFCG_1	MO_1	MO_1	MO_1	MO_1	OX_1	OX_1	OX_1	OX_1
4/17--4/18/2012		Replicate	1	2	3	Composite	1	2	3	Composite	1	2	3	Composite	1	2	3	Composite
		Date	4/18/2012	4/18/2012	4/18/2012	4/18/2012	4/18/2012	4/18/2012	4/18/2012	4/18/2012	4/18/2012	4/18/2012	4/18/2012	4/18/2012	4/18/2012	4/18/2012	4/18/2012	4/18/2012
		Lab Split	100	100	63	19	100	100	100	13	100	100	100	19	100	100	100	9
		Gear	Hess net	Hess net	Hess net	D-Frame	Hess net	Hess net	Hess net	D-Frame	Hess net	Hess net	Hess net	D-Frame	Hess net	Hess net	Hess net	D-Frame
Order	**Family/Genus/Species**																	
Arhynchobdellida	Erpobdellidae		0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	21
Trombidiformes			0	47	19	0	0	0	12	0	35	47	12	0	0	0	47	107
Trombidiformes	Wandesia sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trombidiformes	Hygrobatidae		0	0	0	0	0	0	0	0	0	0	0	5	12	0	0	0
Trombidiformes	Sperchonidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trombidiformes	Sperchon sp.		0	0	0	0	0	0	0	0	0	0	0	5	47	23	0	0
Trombidiformes	Torrenticolidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trombidiformes	Testudacarus sp.		0	23	0	0	0	0	0	0	0	0	47	0	0	0	0	0
Trombidiformes	Torrenticola sp.		0	0	0	0	0	0	0	0	0	0	0	5	23	0	0	0
Collembola			0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	11
Coleoptera	Elmidae		616	0	395	0	116	23	81	32	0	0	0	149	35	116	0	0
Coleoptera	Cleptelmis addenda		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Optioservus sp.		698	2337	1900	508	151	12	465	512	116	198	198	251	58	35	453	721
Coleoptera	Optioservus sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Optioservus quadrimaculatus		70	47	74	27	0	0	0	64	12	12	23	64	35	23	0	149
Coleoptera	Zaitzevia parvulus		0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Atherix pachypus		58	105	105	33	0	0	0	8	0	0	0	0	0	0	0	0
Diptera	Ceratopogonidae		0	0	19	0	12	12	0	0	12	0	0	5	12	23	128	0
Diptera	Probezzia sp.		12	70	37	0	12	12	12	0	0	0	0	0	12	0	47	0
Diptera	Chironomidae		81	140	93	16	35	0	35	40	12	81	47	16	58	70	58	11
Diptera	Chironomidae		23	0	372	315	47	47	105	120	0	0	47	267	35	256	70	192
Diptera	Chironomidae		1163	1430	2121	267	1035	767	1302	296	756	640	1860	229	1186	5465	3360	362
Diptera	Chironomidae		302	35	409	5	12	0	12	0	0	0	0	11	163	70	35	11
Diptera	Empididae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Neoplasta sp.		0	70	37	0	0	23	23	8	0	0	0	11	0	0	0	0
Diptera	Wiedemannia sp.		12	12	19	16	0	0	0	0	0	0	0	5	0	0	0	0
Diptera	Empididae		47	0	0	0	0	0	0	0	0	0	0	0	0	23	0	0
Diptera	Chelifera sp.		0	105	37	5	0	12	0	8	0	12	0	11	0	0	12	11
Diptera	Hemerodromia sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11
Diptera	Muscidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Pericoma sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Simuliidae		0	0	0	0	58	0	23	0	0	0	0	0	0	12	0	0
Diptera	Prosimulium sp.		0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0
Diptera	Simulium sp.		0	12	0	0	942	733	0	56	23	140	140	21	0	0	0	0
Diptera	Tipulidae		0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Dicranota sp.		0	0	19	0	0	0	12	16	12	0	0	0	0	0	0	11
Diptera	Hexatoma sp.		0	0	19	5	0	0	0	0	0	0	0	5	0	0	0	0
Diptera	Antocha monticola		35	256	172	27	35	12	70	35	58	23	0	0	12	23	12	64
Diptera	Limnophila sp.		0	0	0	0	0	0	12	0	0	0	0	0	12	0	0	0
Diptera	Tipula sp.		0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	11
Ephemeroptera	Ameletus sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Baetidae		0	0	0	0	105	70	0	0	0	0	0	0	35	0	0	0
Ephemeroptera	Baetidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Baetis sp.		895	3198	1765	395	4698	3477	1395	2428	1535	1593	2919	1354	1267	1977	1674	991
Ephemeroptera	Diphetor hageni		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Ephemerellidae		1105	407	335	352	116	47	70	400	0	105	198	368	209	500	151	522
Ephemeroptera	Drunella sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Drunella doddsii		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Drunella grandis		23	0	37	21	0	0	0	8	0	12	0	11	12	0	0	38
Ephemeroptera	Ephemerella sp.		174	1093	433	627	12	47	174	576	35	174	163	71	128	35	151	480
Ephemeroptera	Heptageniidae		12	35	19	11	0	70	58	16	0	23	12	0	0	70	0	11
Ephemeroptera	Cinygmula sp.		0	0	37	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Epeorus sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Rhithrogena sp.		58	209	1300	27	442	314	93	115	0	58	140	87	47	128	58	43
Ephemeroptera	Leptophlebiidae		0	0	651	16	0	0	0	0	0	12	0	0	0	0	163	0
Ephemeroptera	Paraleptophlebia sp.		35	337	0	0	116	81	140	184	0	0	23	75	23	58	0	107
Plecoptera			477	802	1135	91	0	0	547	72	256	23	663	0	0	0	105	0
Plecoptera	Chloroperlidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Triznaka sp.		0	0	12	5	0	12	12	0	0	0	0	5	0	0	0	0
Plecoptera	Chloroperlidae		0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Nemouridae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Zapada sp.		0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0
Plecoptera	Perlidae		0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
Plecoptera	Claassenia sabulosa		0	0	0	0	0	0	0	0	0	35	12	0	12	12	23	47
Plecoptera	Perlodidae		58	0	0	0	12	0	23	0	0	0	0	21	23	0	0	32
Plecoptera	Isogenoides sp.		0	0	49	2	0	23	0	27	0	0	12	5	0	23	0	11
Plecoptera	Isoperla sp.		221	128	233	79	70	58	47	61	12	93	47	54	128	93	81	133
Plecoptera	Diura knowltoni		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Skwala americana		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Pteronarcyidae		314	81	0	27	291	47	140	144	0	81	81	107	151	337	12	75
Plecoptera	Pteronarcella badia		12	35	37	16	23	47	12	42	12	12	81	38	116	12	23	51
Plecoptera	Pteronarcys sp.		0	0	0	0	0	0	0	0	0	0	0	51	0	0	0	0
Plecoptera	Pteronarcys californica		0	12	0	2	0	0	0	19	0	47	35	0	0	0	0	0
Trichoptera			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Brachycentridae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Brachycentrus sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Brachycentrus americanus		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Brachycentrus occidentalis		198	151	0	250	0	23	0	115	12	47	0	169	349	140	12	1533
Trichoptera	Micrasema sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Glossosomatidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Glossosoma sp.		0	0	12	5	12	23	12	0	0	12	0	5	0	12	0	0
Trichoptera	Helicopsyche sp.		0	0	37	16	0	12	12	40	12	23	0	16	163	128	0	469
Trichoptera	Hydropsychidae		12	105	74	0	0	0	12	16	23	23	23	5	0	23	0	11
Trichoptera	Arctopsyche grandis		140	81	19	12	47	0	12	15	0	12	0	11	0	23	0	29
Trichoptera	Hydropsyche sp.		221	593	265	69	23	47	35	72	35	70	12	33	58	47	35	292
Trichoptera	Hydroptilidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Hydroptila sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Lepidostoma sp.		0	0	0	5	0	0	0	24	12	0	0	16	12	23	12	149
Trichoptera	Limnephilidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Hesperophylax sp.		0	0	0	5	0	0	0	0	0	0	0	5	0	0	0	0
Trichoptera	Rhyacophila sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Rhyacophila brunnea/vemna		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Rhyacophila coloradensis		0	0	12	0	47	12	0	16	0	0	0	0	0	0	0	0
Trichoptera	Rhyacophila hyalinata		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Oligophlebodes sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Amphipoda	Gammarus sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopoda	Caecidotea		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Veneroida	Pisidiidae		0	0	37	0	0	0	0	0	0	0	0	0	0	0	0	0
Veneroida	Pisidium sp.		0	23	0	27	0	0	0	0	0	0	0	11	0	0	0	11
Basommatophora	Physa sp.		0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	32
Neotaenioglossa	Hydrobiidae		0	12	93	64	0	12	0	32	0	0	0	16	0	0	0	139
Neotaenioglossa	Potamopyrgus antipodarum		12	0	0	5	0	0	0	16	0	0	0	0	35	0	0	0
Phylum: Nemata			419	326	595	0	0	23	0	0	0	12	0	0	58	0	12	21
Phylum: Platyhelminthes	Class: Turbellaria		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phylum: Annelida	Class: Clitellata		291	58	1730	0	58	0	0	88	70	23	0	21	12	0	0	332

Table 4-1b.

Diamond Fork Benthos Sampling		Site Name	Sixth Water	Sixth Water	Sixth Water	Sixth Water	Ray's Crossing	Ray's Crossing	Ray's Crossing	Ray's Crossing	Above Sayr	Above Sayr	Above Sayr	Above Sayr	Below Sayr	Below Sayr	Below Sayr	Below Sayr	Guard Station	Guard Station	Guard Station	Guard Station	Above Monks	Above Monks	Above Monks	Above Monks	Below Monks	Below Monks	Below Monks	Below Monks
Fall 2012		Site	SXW_1	SXW_1	SXW_1	SXW_1	RC_1	RC_1	RC_1	RC_1	ASYR_1	ASYR_1	ASYR_1	ASYR_1	BSYR_1	BSYR_1	BSYR_1	BSYR_1	GS_1	GS_1	GS_1	GS_1	AMH_1	AMH_1	AMH_1	AMH_1	BMH_1	BMH_1	BMH_1	BMH_1
9/2/2012		Replicate	1	2	3	Composite	1	2	3	Composite	1	2	3	Composite	1	2	3	Composite	1	2	3	Composite	1	2	3	Composite	1	2	3	Composite
		Date	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012
		Lab Split	18.75	25	25	6.25	25	25	56.25	7.81	100	50	50	7.82	100	100	37.34	14.06	100	62.5	37.5	7.81	50	100	75	25	50	100	75	12.5
		Gear	Hess net	Hess net	Hess net	D-Frame	Hess net	Hess net	Hess net	D-Frame	Hess net	Hess net	Hess net	D-Frame	Hess net	Hess net	Hess net	D-Frame	Hess net	Hess net	Hess net	D-Frame	Hess net	Hess net	Hess net	D-Frame	Hess net	Hess net	Hess net	D-Frame
Order	**Family/Genus/Species**																													
Arhynchobdellida	Erpobdellidae		0	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	0
Rhynchobdellida	Glossiphoniidae		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	16
Trombidiformes			310	326	140	0	419	93	0	38	0	209	163	90	0	12	0	21	12	167	124	0	0	116	78	4	116	70	31	80
Trombidiformes	Protzia sp.		0	0	0	0	0	0	21	0	0	0	0	0	0	0	0	0	12	0	155	0	0	0	0	0	0	0	0	0
Trombidiformes	Wandesia sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	81	0	0	0	0	0	0	0	0	0	0	0
Trombidiformes	Hygrobatidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	4	0	0	0	0
Trombidiformes	Lebertia sp.		0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trombidiformes	Sperchonidae		0	0	0	368	0	0	0	218	0	0	140	0	0	0	125	0	0	0	0	0	93	0	388	0	0	0	248	0
Trombidiformes	Sperchon sp.		0	0	372	0	512	372	351	0	0	0	0	0	12	0	0	0	47	0	0	38	0	0	0	60	23	0	0	0
Trombidiformes	Torrenticolidae		0	0	0	80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31	0
Trombidiformes	Testudacarus sp.		124	233	0	0	279	0	0	38	0	23	0	26	0	0	0	0	0	0	62	0	23	0	0	0	0	0	0	0
Trombidiformes	Torrenticola sp.		0	0	140	0	0	93	21	0	0	0	0	0	0	0	0	0	23	37	0	0	0	0	0	8	0	0	0	0
Coleoptera	Curculionidae		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	0
Coleoptera	Helichus sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0
Coleoptera	Oreodytes sp.		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	0
Coleoptera	Elmidae		0	1209	837	368	1070	3116	351	832	0	1000	1023	243	686	151	1682	57	2186	967	1674	512	2186	163	1488	108	279	0	2527	184
Coleoptera	Cleptelmis addenda		0	0	0	0	186	0	53	0	0	0	0	26	12	0	0	0	0	19	0	51	0	0	0	12	23	12	0	8
Coleoptera	Optioservus sp.		868	1442	372	64	5814	1442	1298	384	779	4953	791	1407	326	349	1133	533	1314	5553	7380	448	523	291	1109	310	3035	558	1853	1256
Coleoptera	Optioservus sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0
Coleoptera	Optioservus quadrimaculatus		0	105	47	80	558	186	21	179	0	35	47	38	12	0	62	36	35	123	341	232	23	12	527	81	116	12	357	193
Coleoptera	Zaitzevia parvulus		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70	142	217	78	0	0	0	0	0	0	0	8
Coleoptera	Haliplus sp.		0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0	0	0	0	0	16	0
Diptera	Atherix pachypus		0	0	0	0	12	47	12	0	0	23	23	26	0	0	12	0	0	0	0	0	35	58	70	48	163	35	89	34
Diptera	Ceratopogonidae		0	0	0	0	47	0	0	0	0	0	0	0	0	0	0	0	23	0	93	0	0	0	0	0	0	0	0	0
Diptera	Probezzia sp.		0	47	0	0	0	0	0	13	0	0	0	0	0	0	31	14	70	74	403	51	0	0	0	0	47	0	0	0
Diptera	Chironomidae		868	372	279	112	419	279	186	205	23	140	93	179	35	209	249	64	35	130	496	64	0	58	31	8	116	47	16	16
Diptera	Chironomidae		124	140	47	80	605	47	21	538	58	70	70	26	0	35	93	0	233	744	1209	307	0	12	0	20	23	0	16	32
Diptera	Chironomidae		24264	14140	11116	2640	6605	12744	2935	3305	198	1593	2326	1292	419	1674	4017	871	826	830	1736	1076	9047	1849	1500	124	3233	872	1876	656
Diptera	Chironomidae		0	47	0	0	0	0	0	13	0	23	0	0	0	12	0	0	58	67	310	346	0	12	0	0	0	12	0	0
Diptera	Meringodixa chalonensis		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0
Diptera	Empididae		0	0	0	80	0	0	0	115	0	0	70	0	0	0	62	0	0	0	0	0	0	0	31	0	0	0	0	0
Diptera	Neoplasta sp.		0	186	140	0	186	419	269	26	0	23	23	0	0	12	0	7	12	56	0	0	0	0	0	0	0	0	0	0
Diptera	Wiedemannia sp.		0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	47	0	0	8
Diptera	Empididae		62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0
Diptera	Chelifera sp.		0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	12	0	0
Diptera	Hemerodromia sp.		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	0
Diptera	Muscidae		85	12	0	33	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Pericoma sp.		124	186	47	16	47	140	83	0	0	0	0	0	0	0	0	0	47	37	155	51	0	0	0	0	0	0	0	0
Diptera	Ptychoptera sp.		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	0	0	0
Diptera	Simuliidae		0	0	0	16	0	93	0	0	337	0	349	51	35	12	0	14	0	19	0	13	0	70	16	0	23	23	155	8
Diptera	Simulium sp.		0	0	0	0	0	0	0	0	47	47	47	77	23	0	0	0	23	0	62	26	0	0	0	16	140	163	0	96
Diptera	Euparyphus sp.		0	12	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	Tabanus sp.		0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Tipulidae		0	0	47	0	0	0	0	0	0	0	0	26	0	0	0	28	12	0	93	0	23	0	0	0	0	0	0	8
Diptera	Dicranota sp.		0	140	47	0	47	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Hexatoma sp.		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	42	74	59	0	0	0	1	0	0	0	0
Diptera	Antocha monticola		2667	1500	1628	176	419	1023	1282	77	35	116	47	179	58	233	249	64	453	551	1612	576	116	81	155	0	70	0	47	8
Diptera	Tipula sp.		74	47	0	1	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Ephemeroptera			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Ameletus sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	62	51	0	0	0	0	0	0	0	0
Ephemeroptera	Baetidae		0	0	977	944	0	2233	289	410	0	0	6744	0	419	0	1962	0	221	0	31	51	512	0	1411	16	0	0	946	0
Ephemeroptera	Baetis sp.		4849	3233	1965	1088	1163	2791	1886	333	209	2767	372	972	674	1570	915	851	686	1695	3229	691	349	1430	736	494	1047	337	880	874
Ephemeroptera	Centroptilum sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0
Ephemeroptera	Diphetor hageni		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	453	607	1860	13	0	0	0	0	0	0	0	0
Ephemeroptera	Ephemerellidae		186	1302	1674	1216	1814	3535	124	179	23	2256	2302	729	3895	2407	5792	633	395	744	341	230	0	23	47	0	23	12	47	32
Ephemeroptera	Drunella doddsii		0	0	0	0	0	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Drunella grandis		756	977	1163	416	3035	1372	1886	257	0	186	151	90	105	81	448	100	209	495	415	218	0	0	140	41	47	0	101	1
Ephemeroptera	Ephemerella sp.		0	0	1116	0	0	326	207	0	0	0	0	0	58	0	0	0	58	0	0	51	0	0	0	0	0	0	0	0
Ephemeroptera	Ephemerella sp.		992	2000	0	0	233	0	0	0	0	163	163	51	0	47	0	107	0	123	217	0	0	23	0	0	0	0	0	8
Ephemeroptera	Heptageniidae		0	0	0	0	0	0	0	0	23	23	0	0	12	0	0	0	663	1023	1736	179	0	12	171	8	209	12	357	128
Ephemeroptera	Epeorus sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	19	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Rhithrogena sp.		0	0	0	0	0	0	0	0	12	0	0	0	12	23	0	0	0	0	0	0	0	0	0	28	140	0	0	72
Ephemeroptera	Leptophlebiidae		0	0	0	0	140	0	0	0	0	140	0	77	0	12	0	0	0	1079	0	0	0	0	0	0	23	0	0	0
Ephemeroptera	Paraleptophlebia sp.		0	0	0	0	0	0	0	0	140	0	0	0	116	0	0	14	651	312	1531	282	0	0	0	0	0	0	0	0
Plecoptera			0	93	93	288	0	0	0	51	12	70	512	0	12	12	0	0	0	0	0	0	23	0	16	0	0	12	109	0
Plecoptera	Sweltsa sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	81	184	198	26	0	0	0	0	0	0	0	0
Plecoptera	Chloroperlidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	407	637	620	102	0	0	0	0	0	0	0	24
Plecoptera	Nemouridae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0
Plecoptera	Zapada sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Zapada cinctipes		0	0	93	96	0	0	0	38	0	0	0	0	0	0	0	0	0	0	31	13	0	0	0	0	0	0	0	0
Plecoptera	Claassenia sabulosa		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	0
Plecoptera	Hesperoperla pacifica		0	0	0	1	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Perlodidae		186	140	605	0	279	605	331	0	0	372	0	243	198	47	529	121	47	67	155	128	0	23	0	28	116	12	0	64
Plecoptera	Isogenoides sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	12	23	23	16	56
Plecoptera	Isoperla sp.		12	407	233	320	140	47	41	26	0	651	488	269	23	93	354	199	23	12	93	0	0	12	47	0	326	23	31	104
Plecoptera	Diura knowltoni		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0
Plecoptera	Skwala sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26	0	0	0	0	0	0	0	0
Plecoptera	Skwala americana		0	0	0	0	0	0	0	0	0	0	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Pteronarcyidae		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	35	0	0
Plecoptera	Pteronarcella badia		0	58	23	16	23	128	239	14	0	47	0	38	12	0	23	8	58	42	66	162	128	70	229	223	1081	128	415	640
Plecoptera	Pteronarcys sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70	512	93	0	208
Plecoptera	Pteronarcys californica		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	59	140	12	105	43
Trichoptera			0	0	0	144	0	0	0	512	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0	8
Trichoptera	Brachycentridae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0
Trichoptera	Brachycentrus sp.		0	0	512	0	0	1070	1158	0	0	47	0	0	0	0	0	0	140	149	341	115	0	12	0	0	0	0	0	0
Trichoptera	Brachycentrus americanus		1922	1058	1047	624	4512	465	599	883	0	23	47	64	0	23	93	21	12	74	0	0	0	0	0	0	0	0	0	0
Trichoptera	Brachycentrus occidentalis		0	0	0	0	0	0	41	0	58	35	0	39	12	0	0	28	0	0	0	0	605	35	229	567	3523	23	240	670
Trichoptera	Micrasema sp.		2853	1256	2256	656	326	0	124	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0	0	0	0	0	0	0
Trichoptera	Glossosomatidae		62	698	372	144	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	16	0
Trichoptera	Glossosoma sp.		0	0	279	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	70	23	62	0	35	47	16	9
Trichoptera	Helicopsyche sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	349	35	78	92	302	0	217	113
Trichoptera	Hydropsychidae		0	93	47	96	93	186	413	154	0	1756	1791	1036	163	58	747	199	314	949	589	448	0	256	651	24	186	81	326	48
Trichoptera	Arctopsyche grandis		248	663	1128	178	233	826	811	53	12	244	326	94	35	58	335	76	35	135	116	52	0	23	27	23	186	23	31	16
Trichoptera	Hydropsyche sp.		62	47	47	16	477	186	496	51	81	2081	1209	910	395	558	666	656	547	774	1233	755	23	93	628	106	953	372	380	163
Trichoptera	Hydroptilidae		0	0	47	64	279	0	21	0	0	0	0	0	35	0	62	21	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Hydroptila sp.		310	0	140	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 sp.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	31	0	35	0	62	26	0	0	0	0	0	0	0	0
Trichoptera	Oecetis sp.		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	0
Trichoptera	Limnephilidae		0	0	0	32	0	0	0	64	0	0	0	0	0	0	0	0	58	56	465	192	0	0	0	0	0	0	0	0
Trichoptera	Hesperophylax sp.		0	0	0	0	0	0	0	0	12	0	0	13	0	0	0	15	35	12	202	27	0	0	0	0	0	0	0	0
Trichoptera	Rhyacophila sp.		0	326	93	16	93	93	207	90	0	128	233	90	128	47	31	114	12	19	124	38	23	23	31	12	0	12	0	0
Trichoptera	Rhyacophila brunnea/vemna		0	337	477	49	23	0	32	26	0	0	0	0	0	0	0	0	35	53	93	51	0	0	0	0	0	0	0	0
Trichoptera	Rhyacophila coloradensis		0	0	0	0	0	0	0	0	0	0	12	13	23	0	0	0	12	0	0	0	0	0	0	0	0	12	0	0
Trichoptera	Oligophlebodes sp.		992	1814	930	560	1395	326	331	166	23	47	23	0	0	0	62	36	12	0	0	0	0	0	0	0	0	0	0	0
Amphipoda	Gammarus sp.		198	128	93	80	0	0	0	27	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydroida	Hydridae		62	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
Veneroida	Pisidiidae		0	93	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
Veneroida	Pisidium sp.		434	0	0	96	233	0	0	166	23	0	0	64	0	0	62	43	23	0	93	128	0	0	0	0	0	0	16	0
Basommatophora	Physa sp.		0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	12	0	43	320	0	0	0	0	0	0	0	24
Neotaenioglossa	Hydrobiidae		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	16	0
Neotaenioglossa	Potamopyrgus antipodarum		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	395	35	16	60	70	0	16	0
Neotaenioglossa	Pyrgulopsis sp.		0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phylum: Nemata			62	0	0	0	0	0	0	38	0	0	0	0	0	0	218	0	0	0	0	0	0	0	0	0	605	58	16	8
Phylum: Mollusca	Class: Gastropoda		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	16
Phylum: Platyhelminthes	Class: Turbellaria		74	1953	0	2384	0	837	62	26	35	12	70	0	0	12	31	0	547	0	837	0	0	0	0	0	0	0	0	0
Phylum: Annelida	Class: Clitellata		0	1628	698	464	47	93	0	627	0	47	93	0	0	337	1121	0	0	0	0	102	105	0	589	40	256	81	202	496

Table 4-1b. (Cont.)

Diamond Fork Benthos Sampling		Site Name	DF Campground	DF Campground	DF Campground	DF Campground	Motherload	Motherload	Motherload	Motherload	Oxbow	Oxbow	Oxbow	Oxbow
Fall 2012		Site	DFCG_1	DFCG_1	DFCG_1	DFCG_1	MO_1	MO_1	MO_1	MO_1	OX_1	OX_1	OX_1	OX_1
9/2/2012		Replicate	1	2	3	Composite	1	2	3	Composite	1	2	3	Composite
		Date	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012	9/20/2012
		Lab Split	37.5	100	62.5	18.75	100	50	62.5	9.38	62.5	100	31.25	15.625
		Gear	Hess net	Hess net	Hess net	D-Frame	Hess net	Hess net	Hess net	D-Frame	Hess net	Hess net	Hess net	D-Frame
Order	**Family/Genus/Species**													
Arhynchobdellida	Erpobdellidae		0	0	0	7	0	0	0	0	19	0	0	0
Rhynchobdellida	Glossiphoniidae		0	0	0	0	0	0	0	0	0	0	0	0
Trombidiformes			0	0	149	64	23	23	0	21	74	12	223	0
Trombidiformes	Protzia sp.		0	0	0	0	0	0	0	0	0	0	0	0
Trombidiformes	Wandesia sp.		0	0	0	0	0	0	0	0	0	0	0	0
Trombidiformes	Hygrobatidae		0	0	0	0	0	0	0	11	19	0	37	0
Trombidiformes	Lebertia sp.		0	0	0	0	0	0	0	0	0	0	0	0
Trombidiformes	Sperchonidae		341	0	484	0	0	0	0	0	0	0	0	0
Trombidiformes	Sperchon sp.		0	58	0	16	0	0	0	75	74	35	633	58
Trombidiformes	Torrenticolidae		31	0	0	0	0	0	0	0	0	0	0	0
Trombidiformes	Testudacarus sp.		0	0	0	0	0	0	0	0	0	0	0	0
Trombidiformes	Torrenticola sp.		0	0	0	0	0	0	0	32	0	0	37	0
Coleoptera	Curculionidae		0	0	0	5	0	0	0	0	0	0	0	0
Coleoptera	Helichus sp.		0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Oreodytes sp.		0	0	0	0	0	0	0	11	0	0	0	0
Coleoptera	Elmidae		2698	233	3107	37	70	744	651	416	1619	256	2270	198
Coleoptera	Cleptelmis addenda		0	0	0	5	0	0	0	0	0	0	0	0
Coleoptera	Optioservus sp.		496	651	1381	665	326	581	184	586	1767	186	2351	461
Coleoptera	Optioservus sp.		0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Optioservus quadrimaculatus		93	0	79	75	12	0	0	160	149	0	186	45
Coleoptera	Zaitzevia parvulus		0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Haliplus sp.		0	0	0	0	0	0	0	0	0	0	0	0
Diptera			0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Atherix pachypus		0	0	0	8	0	0	0	14	0	0	0	7
Diptera	Ceratopogonidae		0	0	56	0	0	0	74	0	0	0	186	0
Diptera	Probezzia sp.		93	0	0	0	0	209	0	11	0	0	409	32
Diptera	Chironomidae		124	12	19	5	12	23	0	11	19	12	74	6
Diptera	Chironomidae		0	12	260	59	35	23	37	43	37	0	0	128
Diptera	Chironomidae		2605	442	1258	165	640	2140	1842	288	670	1802	1898	237
Diptera	Chironomidae		0	0	0	0	0	23	37	0	0	0	0	26
Diptera	Meringodixa chalonensis		0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Empididae		0	0	130	0	0	0	37	0	0	0	0	0
Diptera	Neoplasta sp.		0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Wiedemannia sp.		0	0	0	11	0	0	0	0	0	0	0	0
Diptera	Empididae		0	0	0	0	0	70	0	0	0	0	0	0
Diptera	Chelifera sp.		0	0	0	0	12	0	0	32	0	0	0	0
Diptera	Hemerodromia sp.		0	23	37	0	0	0	0	0	19	0	112	0
Diptera	Muscidae		0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Pericoma sp.		0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Ptychoptera sp.		0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Simuliidae		3225	0	19	5	151	1465	1991	43	37	128	0	0
Diptera	Simulium sp.		3217	151	0	48	314	7895	3923	341	279	686	335	90
Diptera	Euparyphus sp.		0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Tabanus sp.		0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Tipulidae		0	12	0	0	0	0	0	0	0	0	0	0
Diptera	Dicranota sp.		0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Hexatoma sp.		31	0	0	1	12	0	12	0	0	0	0	0
Diptera	Antocha monticola		31	35	819	11	23	23	0	0	37	35	447	6
Diptera	Tipula sp.		0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera			0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Ameletus sp.		0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Baetidae		2140	47	335	0	0	233	614	85	484	663	856	45
Ephemeroptera	Baetis sp.		1147	233	291	517	942	1267	756	1131	1209	3628	4712	874
Ephemeroptera	Centroptilum sp.		0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Diphetor hageni		0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Ephemerellidae		155	0	37	5	12	23	0	53	205	58	595	19
Ephemeroptera	Drunella doddsii		0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Drunella grandis		0	0	37	28	0	0	0	32	0	0	0	6
Ephemeroptera	Ephemerella sp.		0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Ephemerella sp.		0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Heptageniidae		713	47	0	53	756	140	912	192	521	198	372	45
Ephemeroptera	Epeorus sp.		0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Rhithrogena sp.		0	70	0	112	1081	663	477	363	428	128	372	26
Ephemeroptera	Leptophlebiidae		0	0	19	0	0	0	0	0	74	0	0	0
Ephemeroptera	Paraleptophlebia sp.		0	0	0	16	0	0	0	32	0	23	558	0
Plecoptera			434	0	19	0	0	0	0	0	0	0	0	0
Plecoptera	Sweltsa sp.		0	0	0	0	0	0	0	0	19	0	0	0
Plecoptera	Chloroperlidae		0	0	0	5	47	0	19	0	19	0	0	0
Plecoptera	Nemouridae		0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Zapada sp.		0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Zapada cinctipes		0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Claassenia sabulosa		0	0	0	0	70	35	0	13	0	47	37	8
Plecoptera	Hesperoperla pacifica		0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Perlodidae		0	23	0	32	12	140	0	181	149	12	521	32
Plecoptera	Isogenoides sp.		85	0	0	71	116	105	216	25	35	0	0	13
Plecoptera	Isoperla sp.		322	0	0	49	47	0	56	0	0	0	0	0
Plecoptera	Diura knowltoni		0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Skwala sp.		0	0	0	0	0	12	0	11	0	0	0	0
Plecoptera	Skwala americana		0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Pteronarcyidae		0	12	0	0	0	0	0	0	37	0	74	0
Plecoptera	Pteronarcella badia		601	12	56	212	221	209	153	330	93	81	298	91
Plecoptera	Pteronarcys sp.		0	12	0	32	0	35	0	32	93	0	37	6
Plecoptera	Pteronarcys californica		43	12	0	14	23	0	12	39	56	0	109	1
Trichoptera			0	0	205	11	0	0	0	0	0	0	0	0
Trichoptera	Brachycentridae		0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Brachycentrus sp.		0	0	0	0	0	0	0	0	0	0	37	26
Trichoptera	Brachycentrus americanus		0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Brachycentrus occidentalis		155	0	526	507	0	0	37	763	19	128	565	573
Trichoptera	Micrasema sp.		0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Glossosomatidae		0	93	37	0	0	0	0	0	0	0	0	0
Trichoptera	Glossosoma sp.		31	326	0	48	0	0	0	22	0	12	0	0
Trichoptera	Helicopsyche sp.		0	47	1221	448	58	0	0	429	874	81	779	993
Trichoptera	Hydropsychidae		744	105	316	48	70	488	242	203	670	81	2493	70
Trichoptera	Arctopsyche grandis		147	23	19	36	0	0	0	24	72	0	23	7
Trichoptera	Hydropsyche sp.		744	523	581	129	163	535	470	437	1642	174	3814	218
Trichoptera	Hydroptilidae		0	0	0	0	0	0	0	0	0	0	0	6
Trichoptera	Hydroptila sp.		0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Lepidostoma sp.		0	0	0	75	0	0	0	192	37	0	186	90
Trichoptera	Oecetis sp.		0	0	0	5	0	0	0	0	0	0	0	6
Trichoptera	Limnephilidae		0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Hesperophylax sp.		0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Rhyacophila sp.		0	0	0	0	0	0	19	0	0	0	0	0
Trichoptera	Rhyacophila brunnea/vemna		0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Rhyacophila coloradensis		0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Oligophlebodes sp.		31	0	0	0	0	0	0	0	0	0	0	0
Amphipoda	Gammarus sp.		0	0	0	0	0	0	0	0	0	0	0	0
Hydroida	Hydridae		0	0	0	0	0	0	0	0	0	0	0	0
Veneroida	Pisidiidae		0	0	0	0	0	0	0	0	0	0	0	0
Veneroida	Pisidium sp.		93	0	0	21	23	140	223	0	0	0	0	116
Basommatophora	Physa sp.		0	0	0	27	0	0	0	75	0	0	0	0
Neotaenioglossa	Hydrobiidae		0	0	0	0	0	0	0	0	0	0	74	122
Neotaenioglossa	Potamopyrgus antipodarum		0	12	56	128	47	0	37	0	0	0	0	38
Neotaenioglossa	Pyrgulopsis sp.		0	0	0	0	0	0	0	0	0	0	0	0
Phylum: Nemata			0	0	19	0	0	93	0	0	0	0	0	0
Phylum: Mollusca	Class: Gastropoda		0	0	0	0	12	0	0	0	0	0	0	0
Phylum: Platyhelminthes	Class: Turbellaria		0	0	0	0	0	0	0	0	0	0	0	0
Phylum: Annelida	Class: Clitellata		31	0	242	48	570	70	0	21	0	23	0	0

APPENDIX 4-2: METRICS FOR EACH SAMPLE COLLECTED IN 2012

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

							Abundance Measurements					Dominance Measurements			
SampleID	Site	Station (NAMC)	Replicate	Collection Date	Collection Method	Lab Split	Abundance	EPT Taxa Abundance	Ephemeroptera abundance	Plecoptera abundance	Trichoptera abundance	Dominant Family	Abundance of Dominant Family	Dominant Taxa	Abundance of Dominant Taxa
148786	Sixth Water	SXW	1	9/20/2012	Hess net	18.75	43829	13430	6783	198	6450	Chironomidae	25256	Orthocladiinae	24264
148787	Sixth Water	SXW	2	9/20/2012	Hess net	25	38442	14500	7512	698	6291	Chironomidae	14698	Orthocladiinae	14140
148788	Sixth Water	SXW	3	9/20/2012	Hess net	25	31360	15314	6895	1047	7372	Chironomidae	11442	Orthocladiinae	11116
148789	Sixth Water	SXW	Composite	9/20/2012	D-Frame	6.25	887	439	229	46	164	Chironomidae	177	Orthocladiinae	165
148790	Ray's Crossing	RC	1	9/20/2012	Hess net	25	31767	14256	6384	442	7430	Elmidae	7628	Orthocladiinae	6605
148791	Ray's Crossing	RC	2	9/20/2012	Hess net	25	35209	14186	10256	779	3151	Chironomidae	13070	Orthocladiinae	12744
148792	Ray's Crossing	RC	3	9/20/2012	Hess net	56.25	16244	9258	4413	611	4234	Chironomidae	3142	Orthocladiinae	2935
148793	Ray's Crossing	RC	Composite	9/20/2012	D-Frame	7.81	807	263	93	12	158	Chironomidae	319	Orthocladiinae	260
148794	Above Syar Tunnel	ASYR	1	9/20/2012	Hess net	100	2140	605	407	12	186	Elmidae	779	Optioservus	779
148795	Above Syar Tunnel	ASYR	2	9/20/2012	Hess net	50	19349	11035	5535	1140	4360	Elmidae	5988	Optioservus	4953
148796	Above Syar Tunnel	ASYR	3	9/20/2012	Hess net	50	19791	14419	9733	1047	3640	Baetidae	7116	Baetidae	6744
148797	Above Syar Tunnel	ASYR	Composite	9/20/2012	D-Frame	7.82	676	376	150	43	183	Hydropsychidae	165	Optioservus	110
148798	Below Syar Tunnel	BSYR	1	9/20/2012	Hess net	100	7953	6326	5291	244	791	Ephemerellidae	4058	Ephemerellidae	3895
148799	Below Syar Tunnel	BSYR	2	9/20/2012	Hess net	100	8081	5035	4140	151	744	Ephemerellidae	2535	Ephemerellidae	2407
148800	Below Syar Tunnel	BSYR	3	9/20/2012	Hess net	37.34	21198	12051	9116	907	2028	Ephemerellidae	6240	Ephemerellidae	5792
148801	Below Syar Tunnel	BSYR	Composite	9/20/2012	D-Frame	14.06	714	464	244	49	171	Hydropsychidae	137	Orthocladiinae	125
148802	Guard Station	GS	1	9/20/2012	Hess net	100	11419	5256	3384	616	1256	Elmidae	3605	Elmidae	2186
148803	Guard Station	GS	2	9/20/2012	Hess net	62.5	18840	9279	6098	960	2221	Elmidae	6805	Optioservus	5553
148804	Guard Station	GS	3	9/20/2012	Hess net	37.5	31004	13833	9422	1186	3225	Elmidae	9612	Optioservus	7380
148805	Guard Station	GS	Composite	9/20/2012	D-Frame	7.81	687	320	139	46	135	Chironomidae	140	Orthocladiinae	84
148806	Above Monk's Hollow	AMH	1	9/20/2012	Hess net	50	14698	2105	860	151	1093	Chironomidae	9047	Orthocladiinae	9047
148807	Above Monk's Hollow	AMH	2	9/20/2012	Hess net	100	4849	2093	1488	105	500	Chironomidae	1930	Orthocladiinae	1849
148808	Above Monk's Hollow	AMH	3	9/20/2012	Hess net	75	10512	4516	2504	291	1721	Elmidae	3124	Orthocladiinae	1500
148809	Above Monk's Hollow	AMH	Composite	9/20/2012	D-Frame	25	728	486	158	110	218	Brachycentridae	150	Brachycentrus occi	150
148810	Below Monk's Hollow	BMH	1	9/20/2012	Hess net	50	17279	8872	1488	2198	5186	Brachycentridae	3523	Brachycentrus occi	3523
148811	Below Monk's Hollow	BMH	2	9/20/2012	Hess net	100	3267	1314	360	337	616	Chironomidae	930	Orthocladiinae	872
148812	Below Monk's Hollow	BMH	3	9/20/2012	Hess net	75	11752	4229	2329	674	1225	Elmidae	4736	Elmidae	2527
148813	Below Monk's Hollow	BMH	Composite	9/20/2012	D-Frame	12.5	829	425	142	145	138	Elmidae	207	Optioservus	157
148814	Diamond Fork Campg	DFCG	1	9/20/2012	Hess net	37.5	20601	7492	4155	1484	1853	Simuliidae	6442	Simuliidae	3225
148815	Diamond Fork Campg	DFCG	2	9/20/2012	Hess net	100	3221	1581	395	70	1116	Elmidae	884	Optioservus	651
148816	Diamond Fork Campg	DFCG	3	9/20/2012	Hess net	62.5	11812	3698	719	74	2905	Elmidae	4567	Elmidae	3107
148817	Diamond Fork Campg	DFCG	Composite	9/20/2012	D-Frame	18.75	772	499	142	99	258	Elmidae	150	Optioservus	128
148818	Mother	MO	1	9/20/2012	Hess net	100	5895	3616	2791	535	291	Heptageniidae	1837	Rhithrogena	1081
148819	Mother	MO	2	9/20/2012	Hess net	50	17407	3884	2326	535	1023	Simuliidae	9360	Simulium	7895
148820	Mother	MO	3	9/20/2012	Hess net	62.5	13030	3981	2758	456	767	Simuliidae	5914	Simulium	3923
148821	Mother	MO	Composite	9/20/2012	D-Frame	9.38	664	456	179	71	206	Baetidae	115	Baetis	107
148822	Oxbow	OX	1	9/20/2012	Hess net	62.5	11553	6735	2921	500	3314	Elmidae	3535	Optioservus	1767
148823	Oxbow	OX	2	9/20/2012	Hess net	100	8488	5314	4698	140	477	Baetidae	4291	Baetis	3628
148824	Oxbow	OX	3	9/20/2012	Hess net	31.25	25712	16440	7465	1077	7898	Hydropsychidae	6330	Baetis	4712
148825	Oxbow	OX	Composite	9/20/2012	D-Frame	15.625	774	527	162	33	332	Helicopsychidae	161	Helicopsyche	161

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

SampleID	Site	Station (NAMC)	Replicate	Collection Date	Collection Method	Lab Split	Richness Measurements									
							Richness*	# of EPT Taxa*	# of Ephemeroptera taxa*	# of Plecoptera taxa*	# of Trichoptera taxa*	# of Coleoptera taxa*	# of Elmidae Taxa*	# of Megaloptera taxa*	# of Diptera taxa*	# of Chironomidae taxa*
148786	Sixth Water	SXW	1	9/20/2012	Hess net	18.75	18	9	3	0	6	1	1	0	4	1
148787	Sixth Water	SXW	2	9/20/2012	Hess net	25	23	9	3	1	5	1	1	0	8	3
148788	Sixth Water	SXW	3	9/20/2012	Hess net	25	19	11	3	1	7	1	1	0	4	1
148789	Sixth Water	SXW	Composite	9/20/2012	D-Frame	6.25	22	10	2	2	6	1	1	0	6	2
148790	Ray's Crossing	RC	1	9/20/2012	Hess net	25	18	8	3	0	5	2	2	0	6	2
148791	Ray's Crossing	RC	2	9/20/2012	Hess net	25	16	7	3	0	4	1	1	0	5	1
148792	Ray's Crossing	RC	3	9/20/2012	Hess net	56.25	19	10	3	1	6	1	1	0	6	2
148793	Ray's Crossing	RC	Composite	9/20/2012	D-Frame	7.81	23	9	2	2	5	2	1	0	5	2
148794	Above Syar Tunnel	ASYR	1	9/20/2012	Hess net	100	15	8	3	0	5	1	1	0	4	2
148795	Above Syar Tunnel	ASYR	2	9/20/2012	Hess net	50	16	8	3	2	3	1	1	0	5	2
148796	Above Syar Tunnel	ASYR	3	9/20/2012	Hess net	50	19	9	3	2	4	1	1	0	6	2
148797	Above Syar Tunnel	ASYR	Composite	9/20/2012	D-Frame	7.82	18	9	3	2	4	2	2	0	4	1
148798	Below Syar Tunnel	BSYR	1	9/20/2012	Hess net	100	17	11	5	2	4	2	2	0	3	1
148799	Below Syar Tunnel	BSYR	2	9/20/2012	Hess net	100	15	8	4	1	3	1	1	0	4	3
148800	Below Syar Tunnel	BSYR	3	9/20/2012	Hess net	37.34	16	8	2	1	5	1	1	0	3	2
148801	Below Syar Tunnel	BSYR	Composite	9/20/2012	D-Frame	14.06	17	10	4	2	4	1	1	0	4	1
148802	Guard Station	GS	1	9/20/2012	Hess net	100	25	14	5	2	7	2	2	0	6	3
148803	Guard Station	GS	2	9/20/2012	Hess net	62.5	22	11	6	1	4	3	3	0	7	3
148804	Guard Station	GS	3	9/20/2012	Hess net	37.5	25	13	5	3	5	2	2	0	7	3
148805	Guard Station	GS	Composite	9/20/2012	D-Frame	7.81	32	15	7	3	5	3	3	0	10	3
148806	Above Monk's Hollow	AMH	1	9/20/2012	Hess net	50	13	7	1	1	5	1	1	0	2	1
148807	Above Monk's Hollow	AMH	2	9/20/2012	Hess net	100	17	9	2	2	5	1	1	0	5	2
148808	Above Monk's Hollow	AMH	3	9/20/2012	Hess net	75	16	8	2	2	4	1	1	0	4	1
148809	Above Monk's Hollow	AMH	Composite	9/20/2012	D-Frame	25	18	9	3	2	4	2	2	0	4	2
148810	Below Monk's Hollow	BMH	1	9/20/2012	Hess net	50	22	10	2	4	4	1	1	0	7	2
148811	Below Monk's Hollow	BMH	2	9/20/2012	Hess net	100	20	10	1	4	5	2	2	0	5	2
148812	Below Monk's Hollow	BMH	3	9/20/2012	Hess net	75	21	11	2	4	5	1	1	0	4	1
148813	Below Monk's Hollow	BMH	Composite	9/20/2012	D-Frame	12.5	21	11	3	4	4	2	2	0	5	2
148814	Diamond Fork Campg	DFCG	1	9/20/2012	Hess net	37.5	19	10	1	4	5	1	1	0	5	1
148815	Diamond Fork Campg	DFCG	2	9/20/2012	Hess net	100	16	8	2	2	4	1	1	0	5	2
148816	Diamond Fork Campg	DFCG	3	9/20/2012	Hess net	62.5	16	7	2	1	4	1	1	0	4	2
148817	Diamond Fork Campg	DFCG	Composite	9/20/2012	D-Frame	18.75	28	15	4	4	7	3	2	0	5	2
148818	Mother	MO	1	9/20/2012	Hess net	100	21	10	2	6	2	1	1	0	6	2
148819	Mother	MO	2	9/20/2012	Hess net	50	16	6	2	3	1	1	1	0	5	2
148820	Mother	MO	3	9/20/2012	Hess net	62.5	14	7	2	3	2	1	1	0	4	3
148821	Mother	MO	Composite	9/20/2012	D-Frame	9.38	21	12	4	3	5	2	1	0	4	2
148822	Oxbow	OX	1	9/20/2012	Hess net	62.5	17	9	2	3	4	1	1	0	5	2
148823	Oxbow	OX	2	9/20/2012	Hess net	100	14	8	2	2	4	1	1	0	3	1
148824	Oxbow	OX	3	9/20/2012	Hess net	31.25	18	10	3	3	4	1	1	0	5	1
148825	Oxbow	OX	Composite	9/20/2012	D-Frame	15.625	19	9	2	3	4	1	1	0	5	3

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SampleID	Site	Station (NAMC)	Replicate	Collection Date	Collection Method	Lab Split	# of Crustacea taxa*	# of Oligochaete taxa*	# of Mollusca taxa*	# of Insect taxa*	# of Non-insect taxa*	# of clinger taxa*	Community Composition Coleoptera abundance	Elmidae abundance	Megaloptera abundance	Diptera abundance
148786	Sixth Water	SXW	1	9/20/2012	Hess net	18.75	0	0	1	14	4	8	868	310	0	28267
148787	Sixth Water	SXW	2	9/20/2012	Hess net	25	0	0	1	18	5	9	2756	512	0	16826
148788	Sixth Water	SXW	3	9/20/2012	Hess net	25	0	0	0	16	3	10	1256	233	0	13349
148789	Sixth Water	SXW	Composite	9/20/2012	D-Frame	6.25	0	0	1	17	5	9	32	4	0	199
148790	Ray's Crossing	RC	1	9/20/2012	Hess net	25	0	0	1	16	2	9	7628	4047	0	8395
148791	Ray's Crossing	RC	2	9/20/2012	Hess net	25	0	0	0	13	3	7	4744	791	0	14791
148792	Ray's Crossing	RC	3	9/20/2012	Hess net	56.25	0	0	0	17	2	10	1724	661	0	4807
148793	Ray's Crossing	RC	Composite	9/20/2012	D-Frame	7.81	0	0	2	16	7	8	110	24	0	340
148794	Above Syar Tunnel	ASYR	1	9/20/2012	Hess net	100	0	0	1	13	2	6	779	779	0	698
148795	Above Syar Tunnel	ASYR	2	9/20/2012	Hess net	50	0	0	0	14	2	9	5988	2163	0	2035
148796	Above Syar Tunnel	ASYR	3	9/20/2012	Hess net	50	0	0	0	16	3	8	1860	837	0	3047
148797	Above Syar Tunnel	ASYR	Composite	9/20/2012	D-Frame	7.82	0	0	2	15	3	10	134	79	0	147
148798	Below Syar Tunnel	BSYR	1	9/20/2012	Hess net	100	0	0	0	16	1	12	1035	349	0	570
148799	Below Syar Tunnel	BSYR	2	9/20/2012	Hess net	100	0	0	0	13	2	9	500	174	0	2186
148800	Below Syar Tunnel	BSYR	3	9/20/2012	Hess net	37.34	0	0	1	12	4	7	2877	1152	0	4714
148801	Below Syar Tunnel	BSYR	Composite	9/20/2012	D-Frame	14.06	0	0	1	15	2	9	88	54	0	153
148802	Guard Station	GS	1	9/20/2012	Hess net	100	0	0	1	22	3	11	3605	686	0	1791
148803	Guard Station	GS	2	9/20/2012	Hess net	62.5	0	0	0	21	1	11	6805	2660	0	2551
148804	Guard Station	GS	3	9/20/2012	Hess net	37.5	0	0	1	22	3	10	9612	2915	0	6244
148805	Guard Station	GS	Composite	9/20/2012	D-Frame	7.81	0	0	2	28	4	11	108	41	0	213
148806	Above Monk's Hollow	AMH	1	9/20/2012	Hess net	50	0	0	1	10	3	8	2733	302	0	9244
148807	Above Monk's Hollow	AMH	2	9/20/2012	Hess net	100	0	0	1	15	2	10	465	256	0	2140
148808	Above Monk's Hollow	AMH	3	9/20/2012	Hess net	75	0	0	1	13	3	9	3124	1163	0	1802
148809	Above Monk's Hollow	AMH	Composite	9/20/2012	D-Frame	25	0	0	1	15	3	10	133	52	0	64
148810	Below Monk's Hollow	BMH	1	9/20/2012	Hess net	50	0	0	1	18	4	11	3453	1163	0	3884
148811	Below Monk's Hollow	BMH	2	9/20/2012	Hess net	100	0	0	0	17	3	10	581	581	0	1163
148812	Below Monk's Hollow	BMH	3	9/20/2012	Hess net	75	0	0	3	16	5	11	4736	1333	0	2213
148813	Below Monk's Hollow	BMH	Composite	9/20/2012	D-Frame	12.5	0	0	1	18	3	12	207	78	0	117
148814	Diamond Fork Campg	DFCG	1	9/20/2012	Hess net	37.5	0	0	1	16	3	9	3287	372	0	9326
148815	Diamond Fork Campg	DFCG	2	9/20/2012	Hess net	100	0	0	1	14	2	9	884	651	0	686
148816	Diamond Fork Campg	DFCG	3	9/20/2012	Hess net	62.5	0	0	1	12	4	8	4567	1079	0	2598
148817	Diamond Fork Campg	DFCG	Composite	9/20/2012	D-Frame	18.75	0	0	3	23	5	14	151	63	0	62
148818	Mother	MO	1	9/20/2012	Hess net	100	0	0	2	17	4	9	407	233	0	1198
148819	Mother	MO	2	9/20/2012	Hess net	50	0	0	1	12	4	5	1326	302	0	11872
148820	Mother	MO	3	9/20/2012	Hess net	62.5	0	0	2	12	2	6	835	93	0	7953
148821	Mother	MO	Composite	9/20/2012	D-Frame	9.38	0	0	1	18	3	9	110	38	0	76
148822	Oxbow	OX	1	9/20/2012	Hess net	62.5	0	0	0	15	2	8	3535	1377	0	1098
148823	Oxbow	OX	2	9/20/2012	Hess net	100	0	0	0	12	2	9	442	93	0	2663
148824	Oxbow	OX	3	9/20/2012	Hess net	31.25	0	0	1	16	2	9	4807	1563	0	3460
148825	Oxbow	OX	Composite	9/20/2012	D-Frame	15.625	0	0	3	15	4	7	110	38	0	84

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SampleID	Site	Station (NAMC)	Replicate	Collection Date	Collection Method	Lab Split	Chironomidae abundance	Crustacea abundance	Oligochaete abundance	Mollusca abundance	Insect abundance	Non-insect abundance	Big Rare Count	Functional Feeding Groups: Shredder Abundance	Scraper abundance
148786	Sixth Water	SXW	1	9/20/2012	Hess net	18.75	25256	0	0	434	42566	1264	20	2926	1922
148787	Sixth Water	SXW	2	9/20/2012	Hess net	25	14698	0	1628	93	34081	4360	66	1360	3953
148788	Sixth Water	SXW	3	9/20/2012	Hess net	25	11442	0	698	0	29919	1442	37	2419	1953
148789	Sixth Water	SXW	Composite	9/20/2012	D-Frame	6.25	177	0	29	6	670	217	6	51	48
148790	Ray's Crossing	RC	1	9/20/2012	Hess net	25	7628	0	47	233	30279	1488	16	349	7209
148791	Ray's Crossing	RC	2	9/20/2012	Hess net	25	13070	0	93	0	33721	1488	20	128	1767
148792	Ray's Crossing	RC	3	9/20/2012	Hess net	56.25	3142	0	0	0	15789	455	21	363	1650
148793	Ray's Crossing	RC	Composite	9/20/2012	D-Frame	7.81	319	0	49	14	713	94	8	12	44
148794	Above Syar Tunnel	ASYR	1	9/20/2012	Hess net	100	279	0	0	23	2081	58	0	12	826
148795	Above Syar Tunnel	ASYR	2	9/20/2012	Hess net	50	1826	0	47	0	19058	291	52	47	5023
148796	Above Syar Tunnel	ASYR	3	9/20/2012	Hess net	50	2488	0	93	0	19326	465	8	0	814
148797	Above Syar Tunnel	ASYR	Composite	9/20/2012	D-Frame	7.82	117	0	0	6	657	19	12	6	110
148798	Below Syar Tunnel	BSYR	1	9/20/2012	Hess net	100	453	0	0	0	7930	23	0	12	337
148799	Below Syar Tunnel	BSYR	2	9/20/2012	Hess net	100	1930	0	337	0	7721	360	0	0	349
148800	Below Syar Tunnel	BSYR	3	9/20/2012	Hess net	37.34	4360	0	1121	62	19641	1557	10	54	1195
148801	Below Syar Tunnel	BSYR	Composite	9/20/2012	D-Frame	14.06	134	0	0	6	705	9	18	11	80
148802	Guard Station	GS	1	9/20/2012	Hess net	100	1151	0	0	35	10651	767	0	198	2000
148803	Guard Station	GS	2	9/20/2012	Hess net	62.5	1772	0	0	0	18635	205	105	128	6577
148804	Guard Station	GS	3	9/20/2012	Hess net	37.5	3752	0	0	136	29690	1314	29	919	9202
148805	Guard Station	GS	Composite	9/20/2012	D-Frame	7.81	140	0	8	35	641	46	27	42	54
148806	Above Monk's Hollow	AMH	1	9/20/2012	Hess net	50	9047	0	105	395	14081	616	14	174	1337
148807	Above Monk's Hollow	AMH	2	9/20/2012	Hess net	100	1930	0	0	35	4698	151	7	70	395
148808	Above Monk's Hollow	AMH	3	9/20/2012	Hess net	75	1531	0	589	16	9442	1070	12	229	1434
148809	Above Monk's Hollow	AMH	Composite	9/20/2012	D-Frame	25	38	0	10	15	683	45	68	97	119
148810	Below Monk's Hollow	BMH	1	9/20/2012	Hess net	50	3372	0	256	70	16209	1070	32	1733	3651
148811	Below Monk's Hollow	BMH	2	9/20/2012	Hess net	100	930	0	81	0	3058	209	0	267	640
148812	Below Monk's Hollow	BMH	3	9/20/2012	Hess net	75	1907	0	202	47	11178	574	12	519	2488
148813	Below Monk's Hollow	BMH	Composite	9/20/2012	D-Frame	12.5	88	0	62	5	749	80	28	115	192
148814	Diamond Fork Campg	DFCG	1	9/20/2012	Hess net	37.5	2729	0	31	93	20105	496	9	643	1271
148815	Diamond Fork Campg	DFCG	2	9/20/2012	Hess net	100	465	0	0	12	3151	70	0	58	1174
148816	Diamond Fork Campg	DFCG	3	9/20/2012	Hess net	62.5	1537	0	242	56	10863	949	11	56	2695
148817	Diamond Fork Campg	DFCG	Composite	9/20/2012	D-Frame	18.75	43	0	9	33	712	60	58	69	255
148818	Mother	MO	1	9/20/2012	Hess net	100	686	0	570	81	5221	674	0	244	1198
148819	Mother	MO	2	9/20/2012	Hess net	50	2209	0	70	140	17081	326	43	244	721
148820	Mother	MO	3	9/20/2012	Hess net	62.5	1916	0	0	260	12770	260	15	165	1133
148821	Mother	MO	Composite	9/20/2012	D-Frame	9.38	32	0	2	7	642	22	31	62	119
148822	Oxbow	OX	1	9/20/2012	Hess net	62.5	726	0	0	0	11367	186	8	316	3163
148823	Oxbow	OX	2	9/20/2012	Hess net	100	1814	0	23	0	8419	70	0	81	477
148824	Oxbow	OX	3	9/20/2012	Hess net	31.25	1972	0	0	74	24707	1005	32	705	3577
148825	Oxbow	OX	Composite	9/20/2012	D-Frame	15.625	62	0	0	44	721	53	42	37	265

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

										Functional Feeding Groups Richness					Diverstity Index/Evenness	
SampleID	Site	Station (NAMC)	Replicate	Collection Date	Collection Method	Lab Split	Collector-filterer abundance	Collector-gatherer abundance	Predator abundance	# of shredder taxa*	# of scraper taxa*	# of collector-filterer taxa*	collector-gatherer taxa*	# of predator taxa*	Shannon's Diversity*	Simpson's Diversity*
148786	Sixth Water	SXW	1	9/20/2012	Hess net	18.75	2667	34345	1597	1	3	4	6	2	1.68267729	0.6559866
148787	Sixth Water	SXW	2	9/20/2012	Hess net	25	1953	27802	3174	1	2	3	7	8	2.30650847	0.8166332
148788	Sixth Water	SXW	3	9/20/2012	Hess net	25	2779	20477	3407	1	4	2	5	6	2.14666243	0.7890747
148789	Sixth Water	SXW	Composite	9/20/2012	D-Frame	6.25	66	598	88	2	2	5	6	5	2.39879187	0.8699666
148790	Ray's Crossing	RC	1	9/20/2012	Hess net	25	5547	12558	5081	1	2	4	6	3	2.04446402	0.8278038
148791	Ray's Crossing	RC	2	9/20/2012	Hess net	25	2826	27163	3140	0	2	4	5	3	1.75231264	0.6861093
148792	Ray's Crossing	RC	3	9/20/2012	Hess net	56.25	3519	7426	3191	2	2	3	6	4	2.38586945	0.8808919
148793	Ray's Crossing	RC	Composite	9/20/2012	D-Frame	7.81	104	515	70	1	3	4	5	6	2.01416178	0.7673579
148794	Above Syar Tunnel	ASYR	1	9/20/2012	Hess net	100	558	733	0	1	2	5	6	0	1.97733976	0.7982152
148795	Above Syar Tunnel	ASYR	2	9/20/2012	Hess net	50	4233	8302	1640	1	1	4	5	4	1.87332566	0.8008473
148796	Above Syar Tunnel	ASYR	3	9/20/2012	Hess net	50	3767	13302	1349	0	2	4	5	6	2.17318911	0.8302262
148797	Above Syar Tunnel	ASYR	Composite	9/20/2012	D-Frame	7.82	189	298	68	2	1	5	5	3	2.08124736	0.8332441
148798	Below Syar Tunnel	BSYR	1	9/20/2012	Hess net	100	663	6372	500	1	1	4	6	3	2.10019169	0.8373901
148799	Below Syar Tunnel	BSYR	2	9/20/2012	Hess net	100	709	6709	302	0	1	3	6	4	1.78572317	0.7643032
148800	Below Syar Tunnel	BSYR	3	9/20/2012	Hess net	37.34	1903	16111	1592	1	2	4	4	3	2.02898696	0.7948049
148801	Below Syar Tunnel	BSYR	Composite	9/20/2012	D-Frame	14.06	152	381	82	1	2	5	5	3	2.02164509	0.8305017
148802	Guard Station	GS	1	9/20/2012	Hess net	100	1093	6814	767	2	1	5	7	7	2.59670324	0.907068
148803	Guard Station	GS	2	9/20/2012	Hess net	62.5	2100	7840	1274	0	1	3	9	6	2.03457925	0.7542921
148804	Guard Station	GS	3	9/20/2012	Hess net	37.5	2434	14973	2298	2	1	4	8	7	2.46621395	0.8661538
148805	Guard Station	GS	Composite	9/20/2012	D-Frame	7.81	121	342	88	2	1	5	11	9	2.83756777	0.9207581
148806	Above Monk's Hollow	AMH	1	9/20/2012	Hess net	50	628	12314	174	2	3	2	3	1	1.01043467	0.3956522
148807	Above Monk's Hollow	AMH	2	9/20/2012	Hess net	100	488	3640	244	1	3	4	4	3	1.55774949	0.6872687
148808	Above Monk's Hollow	AMH	3	9/20/2012	Hess net	75	1566	5957	783	1	3	3	3	4	2.17083049	0.8509922
148809	Above Monk's Hollow	AMH	Composite	9/20/2012	D-Frame	25	196	220	69	2	2	4	4	3	2.32379794	0.8697882
148810	Below Monk's Hollow	BMH	1	9/20/2012	Hess net	50	5012	5209	930	2	2	4	5	6	2.3375776	0.8670234
148811	Below Monk's Hollow	BMH	2	9/20/2012	Hess net	100	686	1349	209	2	2	4	2	7	2.21813583	0.845474
148812	Below Monk's Hollow	BMH	3	9/20/2012	Hess net	75	1147	6554	547	2	4	5	3	5	2.12964673	0.8259532
148813	Below Monk's Hollow	BMH	Composite	9/20/2012	D-Frame	12.5	133	302	55	2	1	4	7	4	2.34761793	0.8715496
148814	Diamond Fork Campg	DFCG	1	9/20/2012	Hess net	37.5	8326	8930	903	2	3	5	3	5	1.8110061	0.7304571
148815	Diamond Fork Campg	DFCG	2	9/20/2012	Hess net	100	802	1081	105	2	3	3	5	1	2.10642078	0.8473354
148816	Diamond Fork Campg	DFCG	3	9/20/2012	Hess net	62.5	1460	6386	893	1	2	3	4	3	2.26909972	0.8782386
148817	Diamond Fork Campg	DFCG	Composite	9/20/2012	D-Frame	18.75	162	192	76	4	3	5	7	6	2.59793125	0.8935786
148818	Mother	MO	1	9/20/2012	Hess net	100	721	3384	291	2	2	3	5	7	2.34030308	0.8781048
148819	Mother	MO	2	9/20/2012	Hess net	50	10523	5209	616	1	1	3	3	6	1.48851858	0.6103902
148820	Mother	MO	3	9/20/2012	Hess net	62.5	6886	4377	451	1	2	4	4	3	1.50316078	0.6469342
148821	Mother	MO	Composite	9/20/2012	D-Frame	9.38	178	238	52	3	2	3	6	5	2.50255055	0.8960758
148822	Oxbow	OX	1	9/20/2012	Hess net	62.5	2719	4781	407	3	1	3	5	3	2.08528268	0.8413824
148823	Oxbow	OX	2	9/20/2012	Hess net	100	1198	6628	105	1	2	3	4	2	1.55356249	0.6944036
148824	Oxbow	OX	3	9/20/2012	Hess net	31.25	7267	11781	2195	3	2	3	5	3	2.16338371	0.8388406
148825	Oxbow	OX	Composite	9/20/2012	D-Frame	15.625	188	244	32	3	3	4	3	4	2.19981647	0.8509476

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

								Biotic Indices		Karr BIBI Metrics		
SampleID	Site	Station (NAMC)	Replicate	Collection Date	Collection Method	Lab Split	Evenness*	Hilsenhoff Biotic Index*	Community Tolerance Quotient (d)*	Long-lived Taxa*	Taxa abundance	Taxa abundance
148786	Sixth Water	SXW	1	9/20/2012	Hess net	18.75	0.58216639	4.41	69	2	6969	124
148787	Sixth Water	SXW	2	9/20/2012	Hess net	25	0.73561241	3.463333	70	2	8558	186
148788	Sixth Water	SXW	3	9/20/2012	Hess net	25	0.72905652	3.606667	58	2	9942	47
148789	Sixth Water	SXW	Composite	9/20/2012	D-Frame	6.25	0.77604624	2.386667	70	2	224	1
148790	Ray's Crossing	RC	1	9/20/2012	Hess net	25	0.70733601	3.096667	70	3	10628	47
148791	Ray's Crossing	RC	2	9/20/2012	Hess net	25	0.63201319	4.483333	75	2	7686	140
148792	Ray's Crossing	RC	3	9/20/2012	Hess net	56.25	0.81029679	3.4	63	3	5022	83
148793	Ray's Crossing	RC	Composite	9/20/2012	D-Frame	7.81	0.64237458	3.8	81	3	121	0
148794	Above Syar Tunnel	ASYR	1	9/20/2012	Hess net	100	0.73017101	4.225989	80	2	221	0
148795	Above Syar Tunnel	ASYR	2	9/20/2012	Hess net	50	0.67565941	4.016667	73	3	4070	0
148796	Above Syar Tunnel	ASYR	3	9/20/2012	Hess net	50	0.7380656	4.211409	74	2	3465	0
148797	Above Syar Tunnel	ASYR	Composite	9/20/2012	D-Frame	7.82	0.72006217	4.13	78	4	136	0
148798	Below Syar Tunnel	BSYR	1	9/20/2012	Hess net	100	0.74127552	3.941176	65	4	4570	0
148799	Below Syar Tunnel	BSYR	2	9/20/2012	Hess net	100	0.65941287	4.253333	74	2	2756	0
148800	Below Syar Tunnel	BSYR	3	9/20/2012	Hess net	37.34	0.73180236	3.896667	75	2	7314	0
148801	Below Syar Tunnel	BSYR	Composite	9/20/2012	D-Frame	14.06	0.71355202	4.076667	76	3	192	0
148802	Guard Station	GS	1	9/20/2012	Hess net	100	0.80671122	3.193333	73	3	1779	47
148803	Guard Station	GS	2	9/20/2012	Hess net	62.5	0.65821783	3.763333	71	4	3372	37
148804	Guard Station	GS	3	9/20/2012	Hess net	37.5	0.76617244	3.67	72	3	3752	155
148805	Guard Station	GS	Composite	9/20/2012	D-Frame	7.81	0.81874899	3.85	77	5	121	4
148806	Above Monk's Hollow	AMH	1	9/20/2012	Hess net	50	0.39393942	5.093333	77	3	884	0
148807	Above Monk's Hollow	AMH	2	9/20/2012	Hess net	100	0.54981722	4.593333	76	3	302	0
148808	Above Monk's Hollow	AMH	3	9/20/2012	Hess net	75	0.7829616	3.426667	74	3	868	0
148809	Above Monk's Hollow	AMH	Composite	9/20/2012	D-Frame	25	0.80397891	2.333333	70	5	295	0
148810	Below Monk's Hollow	BMH	1	9/20/2012	Hess net	50	0.75624248	3.033333	75	4	6012	0
148811	Below Monk's Hollow	BMH	2	9/20/2012	Hess net	100	0.74043193	3.976744	77	5	488	0
148812	Below Monk's Hollow	BMH	3	9/20/2012	Hess net	75	0.69950108	3.746667	73	4	1074	0
148813	Below Monk's Hollow	BMH	Composite	9/20/2012	D-Frame	12.5	0.77109562	2.773333	74	5	252	0
148814	Diamond Fork Campg	DFCG	1	9/20/2012	Hess net	37.5	0.61505982	4.926667	72	4	1391	0
148815	Diamond Fork Campg	DFCG	2	9/20/2012	Hess net	100	0.7597307	3.792952	74	3	488	0
148816	Diamond Fork Campg	DFCG	3	9/20/2012	Hess net	62.5	0.81840473	3.42	80	3	712	0
148817	Diamond Fork Campg	DFCG	Composite	9/20/2012	D-Frame	18.75	0.7796434	2.816667	70	5	239	0
148818	Mother	MO	1	9/20/2012	Hess net	100	0.768693	3.493333	70	4	500	0
148819	Mother	MO	2	9/20/2012	Hess net	50	0.53686959	5.336667	84	3	558	0
148820	Mother	MO	3	9/20/2012	Hess net	62.5	0.56958247	5.31	80	3	493	0
148821	Mother	MO	Composite	9/20/2012	D-Frame	9.38	0.8219846	3.25	71	5	184	0
148822	Oxbow	OX	1	9/20/2012	Hess net	62.5	0.73601329	3.86	71	3	816	0
148823	Oxbow	OX	2	9/20/2012	Hess net	100	0.58868084	4.593333	72	4	360	0
148824	Oxbow	OX	3	9/20/2012	Hess net	31.25	0.7484794	3.9	71	5	3019	0
148825	Oxbow	OX	Composite	9/20/2012	D-Frame	15.625	0.74710887	2.996667	82	4	155	0

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

SampleID	Site	Station (NAMC)	Replicate	Collection Date	Collection Method	Percent Subsampled	Abundance Measurements					Dominance Measurements		
							Abundance	EPT Taxa Abundance	Ephemeroptera abundance	Plecoptera abundance	Trichoptera abundance	Dominant Family	Abundance of Dominant Family	Dominant Taxa
148174	Sixth Water	SXW	1	4/17/2012	Hess net	15.63	48707	22982	11194	0	11788	Chironomidae	19905	Orthocladiinae
148175	Sixth Water	SXW	2	4/17/2012	Hess net	7.81	103573	30797	20367	153	10277	Chironomidae	63912	Orthocladiinae
148176	Sixth Water	SXW	3	4/17/2012	Hess net	50	15356	7044	1656	22	5367	Chironomidae	5511	Orthocladiinae
148177	Sixth Water	SXW	Composite	4/17/2012	D-Frame	12.5	701	378	163	3	212	Chironomidae	227	Orthocladiinae
148178	Ray's Crossing	RC	1	4/17/2012	Hess net	100	6444	2878	1867	44	967	Chironomidae	2211	Orthocladiinae
148179	Ray's Crossing	RC	2	4/17/2012	Hess net	75	9744	4289	2941	41	1307	Chironomidae	2696	Orthocladiinae
148180	Ray's Crossing	RC	3	4/17/2012	Hess net	50	21478	7778	4456	44	3278	Chironomidae	7956	Orthocladiinae
148181	Ray's Crossing	RC	Composite	4/17/2012	D-Frame	14.1	738	355	245	4	106	Chironomidae	258	Orthocladiinae
148182	Above Syar Tunnel	ASYR	1	4/17/2012	Hess net	18.75	55411	38278	34485	1159	2633	Baetidae	22196	Baetis
148183	Above Syar Tunnel	ASYR	2	4/17/2012	Hess net	6.25	104978	57144	50311	1278	5556	Chironomidae	35200	Orthocladiinae
148184	Above Syar Tunnel	ASYR	3	4/17/2012	Hess net	18.75	39370	16419	15133	237	1048	Chironomidae	18726	Orthocladiinae
148185	Above Syar Tunnel	ASYR	Composite	4/17/2012	D-Frame	7.8	778	479	426	10	43	Ephemerellidae	294	Ephemerellidae
148186	Below Syar Tunnel	BSYR	1	4/17/2012	Hess net	50	21633	12500	10400	300	1800	Chironomidae	7156	Orthocladiinae
148187	Below Syar Tunnel	BSYR	2	4/17/2012	Hess net	37.5	21811	8196	7133	219	844	Chironomidae	9867	Orthocladiinae
148188	Below Syar Tunnel	BSYR	3	4/17/2012	Hess net	37.5	20500	11081	9444	241	1396	Chironomidae	7615	Orthocladiinae
148189	Below Syar Tunnel	BSYR	Composite	4/17/2012	D-Frame	12.5	872	566	491	18	57	Ephemerellidae	340	Ephemerellidae
148190	Guard Station	GS	1	4/17/2012	Hess net	100	8533	4289	2522	689	1078	Chironomidae	1778	Ephemerellidae
148191	Guard Station	GS	2	4/17/2012	Hess net	37.5	20437	9796	4081	2796	2919	Chironomidae	7756	Orthocladiinae
148192	Guard Station	GS	3	4/17/2012	Hess net	100	12822	6833	3856	1511	1467	Elmidae	2389	Optioservus
148193	Guard Station	GS	Composite	4/17/2012	D-Frame	18.75	686	387	251	30	106	Chironomidae	135	Orthocladiinae
148194	Above Monk's Hollow	AMH	1	4/18/2012	Hess net	100	8302	5756	3523	1593	640	Baetidae	2779	Baetis
148195	Above Monk's Hollow	AMH	2	4/18/2012	Hess net	93.75	6534	5641	3943	1029	669	Baetidae	3336	Baetidae
148196	Above Monk's Hollow	AMH	3	4/18/2012	Hess net	37.5	23783	18395	16543	1496	357	Baetidae	15198	Baetis
148197	Above Monk's Hollow	AMH	Composite	4/18/2012	D-Frame	25	786	575	450	88	37	Baetidae	308	Baetis
148198	Below Monk's Hollow	BMH	1	4/18/2012	Hess net	100	7791	3953	2302	1081	570	Chironomidae	1570	Orthocladiinae
148199	Below Monk's Hollow	BMH	2	4/18/2012	Hess net	100	12384	7267	5279	1058	930	Baetidae	3198	Baetis
148200	Below Monk's Hollow	BMH	3	4/18/2012		62.5	14781	6460	4577	1465	419		3479	Orthocladiinae
148201	Below Monk's Hollow	BMH	Composite	4/18/2012	D-Frame	18.75	653	403	274	48	81	Ephemerellidae	190	Ephemerella ine
148202	Diamond Fork Campground	DFCG	1	4/18/2012	Hess net	100	8535	6023	5488	407	128	Baetidae	4802	Baetis
148203	Diamond Fork Campground	DFCG	2	4/18/2012	Hess net	100	6105	4407	4105	186	116	Baetidae	3547	Baetis
148204	Diamond Fork Campground	DFCG	3	4/18/2012	Hess net	100	4953	2791	1930	779	81	Chironomidae	1453	Baetis
148205	Diamond Fork Campground	DFCG	Composite	4/18/2012	D-Frame	12.5	753	583	472	58	53	Baetidae	307	Baetis
148206	Mother	MO	1	4/18/2012	Hess net	100	3047	1942	1570	279	93	Baetidae	1535	Baetis
148207	Mother	MO	2	4/18/2012	Hess net	100	3640	2453	1977	291	186	Baetidae	1593	Baetis
148208	Mother	MO	3	4/18/2012	Hess net	100	6791	4419	3453	930	35	Baetidae	2919	Baetis
148209	Mother	MO	Composite	4/18/2012	D-Frame	18.75	696	487	376	58	53	Baetidae	258	Baetis
148210	Oxbow	OX	1	4/18/2012	Hess net	100	4547	2733	1721	430	581	Chironomidae	1442	Baetis
148211	Oxbow	OX	2	4/18/2012	Hess net	100	9779	3640	2767	477	395	Chironomidae	5860	Orthocladiinae
148212	Oxbow	OX	3	4/18/2012	Hess net	100	6733	2500	2198	244	58	Chironomidae	3523	Orthocladiinae
148213	Oxbow	OX	Composite	4/18/2012	D-Frame	9.38	747	530	211	48	271	Brachycentridae	171	Brachycentrus c

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

								Richness Measurements						
SampleID	Site	Station (NAMC)	Replicate	Collection Date	Collection Method	Percent Subsampled	Abundance of Dominant Taxa	Richness*	# of EPT Taxa*	# of Ephemeroptera taxa*	# of Plecoptera taxa*	# of Trichoptera taxa*	# of Coleoptera taxa*	# of Elmidae Taxa*
148174	Sixth Water	SXW	1	4/17/2012	Hess net	15.63	18270	22	8	3	0	5	2	2
148175	Sixth Water	SXW	2	4/17/2012	Hess net	7.81	62773	15	5	2	0	3	1	1
148176	Sixth Water	SXW	3	4/17/2012	Hess net	50	5089	19	7	4	0	3	1	1
148177	Sixth Water	SXW	Composite	4/17/2012	D-Frame	12.5	212	20	7	2	1	4	1	1
148178	Ray's Crossing	RC	1	4/17/2012	Hess net	100	2133	18	10	3	2	5	1	1
148179	Ray's Crossing	RC	2	4/17/2012	Hess net	75	2578	20	10	3	1	6	1	1
148180	Ray's Crossing	RC	3	4/17/2012	Hess net	50	7667	21	8	3	0	5	1	1
148181	Ray's Crossing	RC	Composite	4/17/2012	D-Frame	14.1	227	18	7	2	1	4	1	1
148182	Above Syar Tunnel	ASYR	1	4/17/2012	Hess net	18.75	22196	12	6	2	1	3	1	1
148183	Above Syar Tunnel	ASYR	2	4/17/2012	Hess net	6.25	32356	14	7	2	1	4	1	1
148184	Above Syar Tunnel	ASYR	3	4/17/2012	Hess net	18.75	17007	18	9	3	1	5	1	1
148185	Above Syar Tunnel	ASYR	Composite	4/17/2012	D-Frame	7.8	270	21	11	4	1	6	1	1
148186	Below Syar Tunnel	BSYR	1	4/17/2012	Hess net	50	6556	17	9	3	1	5	1	1
148187	Below Syar Tunnel	BSYR	2	4/17/2012	Hess net	37.5	9244	16	8	3	1	4	1	1
148188	Below Syar Tunnel	BSYR	3	4/17/2012	Hess net	37.5	7319	11	6	2	1	3	1	1
148189	Below Syar Tunnel	BSYR	Composite	4/17/2012	D-Frame	12.5	191	20	10	3	1	6	1	1
148190	Guard Station	GS	1	4/17/2012	Hess net	100	1400	34	17	8	2	7	3	3
148191	Guard Station	GS	2	4/17/2012	Hess net	37.5	6304	18	8	2	1	5	1	1
148192	Guard Station	GS	3	4/17/2012	Hess net	100	1833	31	16	7	4	5	2	2
148193	Guard Station	GS	Composite	4/17/2012	D-Frame	18.75	89	28	15	7	2	6	2	2
148194	Above Monk's Hollow	AMH	1	4/18/2012	Hess net	100	2779	18	9	4	1	4	2	2
148195	Above Monk's Hollow	AMH	2	4/18/2012	Hess net	93.75	2878	15	9	3	3	3	1	1
148196	Above Monk's Hollow	AMH	3	4/18/2012	Hess net	37.5	15198	14	5	3	1	1	1	1
148197	Above Monk's Hollow	AMH	Composite	4/18/2012	D-Frame	25	305	24	14	5	4	5	1	1
148198	Below Monk's Hollow	BMH	1	4/18/2012	Hess net	100	1163	21	10	5	2	3	1	1
148199	Below Monk's Hollow	BMH	2	4/18/2012	Hess net	100	3198	20	8	4	1	3	1	1
148200	Below Monk's Hollow	BMH	3	4/18/2012		62.5	2121	27	11	5	3	3	1	1
148201	Below Monk's Hollow	BMH	Composite	4/18/2012	D-Frame	18.75	120	22	11	4	2	5	1	1
148202	Diamond Fork Campground	DFCG	1	4/18/2012	Hess net	100	4698	17	10	4	3	3	1	1
148203	Diamond Fork Campground	DFCG	2	4/18/2012	Hess net	100	3477	16	9	4	3	2	1	1
148204	Diamond Fork Campground	DFCG	3	4/18/2012	Hess net	100	1395	20	10	4	2	4	1	1
148205	Diamond Fork Campground	DFCG	Composite	4/18/2012	D-Frame	12.5	307	23	14	5	4	5	1	1
148206	Mother	MO	1	4/18/2012	Hess net	100	1535	15	8	2	2	4	1	1
148207	Mother	MO	2	4/18/2012	Hess net	100	1593	21	13	4	4	5	1	1
148208	Mother	MO	3	4/18/2012	Hess net	100	2919	12	7	3	3	1	1	1
148209	Mother	MO	Composite	4/18/2012	D-Frame	18.75	258	28	15	5	4	6	1	1
148210	Oxbow	OX	1	4/18/2012	Hess net	100	1267	21	11	5	2	4	1	1
148211	Oxbow	OX	2	4/18/2012	Hess net	100	5465	18	11	4	2	5	1	1
148212	Oxbow	OX	3	4/18/2012	Hess net	100	3360	16	9	3	3	3	1	1
148213	Oxbow	OX	Composite	4/18/2012	D-Frame	9.38	171	26	14	5	4	5	1	1

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

SampleID	Site	Station (NAMC)	Replicate	Collection Date	Collection Method	Percent Subsampled	# of Megaloptera taxa*	# of Diptera taxa*	# of Chironomidae taxa*	# of Crustacea taxa*	# of Oligochaete taxa*	# of Mollusca taxa*	# of Insect taxa*
148174	Sixth Water	SXW	1	4/17/2012	Hess net	15.63	0	7	2	0	0	1	17
148175	Sixth Water	SXW	2	4/17/2012	Hess net	7.81	0	6	2	0	0	0	12
148176	Sixth Water	SXW	3	4/17/2012	Hess net	50	0	5	2	0	0	1	13
148177	Sixth Water	SXW	Composite	4/17/2012	D-Frame	12.5	0	7	2	0	0	1	15
148178	Ray's Crossing	RC	1	4/17/2012	Hess net	100	0	4	2	0	0	0	15
148179	Ray's Crossing	RC	2	4/17/2012	Hess net	75	0	5	2	0	0	1	16
148180	Ray's Crossing	RC	3	4/17/2012	Hess net	50	0	7	2	0	0	1	16
148181	Ray's Crossing	RC	Composite	4/17/2012	D-Frame	14.1	0	7	3	0	0	1	15
148182	Above Syar Tunnel	ASYR	1	4/17/2012	Hess net	18.75	0	2	1	0	0	1	9
148183	Above Syar Tunnel	ASYR	2	4/17/2012	Hess net	6.25	0	5	2	0	0	0	13
148184	Above Syar Tunnel	ASYR	3	4/17/2012	Hess net	18.75	0	6	3	0	0	1	16
148185	Above Syar Tunnel	ASYR	Composite	4/17/2012	D-Frame	7.8	0	5	3	0	0	1	17
148186	Below Syar Tunnel	BSYR	1	4/17/2012	Hess net	50	0	4	2	0	0	0	14
148187	Below Syar Tunnel	BSYR	2	4/17/2012	Hess net	37.5	0	5	2	0	0	0	14
148188	Below Syar Tunnel	BSYR	3	4/17/2012	Hess net	37.5	0	4	2	0	0	0	11
148189	Below Syar Tunnel	BSYR	Composite	4/17/2012	D-Frame	12.5	0	6	3	0	0	1	17
148190	Guard Station	GS	1	4/17/2012	Hess net	100	0	12	3	0	0	1	32
148191	Guard Station	GS	2	4/17/2012	Hess net	37.5	0	8	3	0	0	0	17
148192	Guard Station	GS	3	4/17/2012	Hess net	100	0	9	3	0	0	1	27
148193	Guard Station	GS	Composite	4/17/2012	D-Frame	18.75	0	8	3	0	0	1	25
148194	Above Monk's Hollow	AMH	1	4/18/2012	Hess net	100	0	6	2	0	0	0	17
148195	Above Monk's Hollow	AMH	2	4/18/2012	Hess net	93.75	0	3	0	0	0	0	13
148196	Above Monk's Hollow	AMH	3	4/18/2012	Hess net	37.5	0	7	3	0	0	0	13
148197	Above Monk's Hollow	AMH	Composite	4/18/2012	D-Frame	25	0	5	2	0	0	2	20
148198	Below Monk's Hollow	BMH	1	4/18/2012	Hess net	100	0	8	3	0	0	0	19
148199	Below Monk's Hollow	BMH	2	4/18/2012	Hess net	100	0	7	2	0	0	1	16
148200	Below Monk's Hollow	BMH	3	4/18/2012		62.5	0	9	3	0	0	2	21
148201	Below Monk's Hollow	BMH	Composite	4/18/2012	D-Frame	18.75	0	7	3	0	0	3	19
148202	Diamond Fork Campground	DFCG	1	4/18/2012	Hess net	100	0	5	3	0	0	0	16
148203	Diamond Fork Campground	DFCG	2	4/18/2012	Hess net	100	0	5	2	0	0	0	15
148204	Diamond Fork Campground	DFCG	3	4/18/2012	Hess net	100	0	8	3	0	0	0	19
148205	Diamond Fork Campground	DFCG	Composite	4/18/2012	D-Frame	12.5	0	6	2	0	0	1	21
148206	Mother	MO	1	4/18/2012	Hess net	100	0	4	1	0	0	0	13
148207	Mother	MO	2	4/18/2012	Hess net	100	0	4	1	0	0	0	18
148208	Mother	MO	3	4/18/2012	Hess net	100	0	3	2	0	0	0	11
148209	Mother	MO	Composite	4/18/2012	D-Frame	18.75	0	7	3	0	0	3	23
148210	Oxbow	OX	1	4/18/2012	Hess net	100	0	5	3	0	0	1	17
148211	Oxbow	OX	2	4/18/2012	Hess net	100	0	5	3	0	0	0	17
148212	Oxbow	OX	3	4/18/2012	Hess net	100	0	5	3	0	0	0	15
148213	Oxbow	OX	Composite	4/18/2012	D-Frame	9.38	0	5	3	0	0	2	20

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

SampleID	Site	Station (NAMC)	Replicate	Collection Date	Collection Method	Percent Subsampled	# of Non-insect taxa*	# of clinger taxa*	Coleoptera abundance	Elmidae abundance	Megaloptera abundance	Diptera abundance	Chironomidae abundance	Crustacea abundance
									Community Composition					
148174	Sixth Water	SXW	1	4/17/2012	Hess net	15.63	4	8	1384	853	0	21427	19905	0
148175	Sixth Water	SXW	2	4/17/2012	Hess net	7.81	2	5	1718	142	0	66779	63912	0
148176	Sixth Water	SXW	3	4/17/2012	Hess net	50	5	7	689	289	0	6089	5511	0
148177	Sixth Water	SXW	Composite	4/17/2012	D-Frame	12.5	4	7	20	9	0	262	227	0
148178	Ray's Crossing	RC	1	4/17/2012	Hess net	100	3	10	367	122	0	2778	2211	0
148179	Ray's Crossing	RC	2	4/17/2012	Hess net	75	4	10	696	341	0	4315	2696	0
148180	Ray's Crossing	RC	3	4/17/2012	Hess net	50	4	7	1511	511	0	11167	7956	0
148181	Ray's Crossing	RC	Composite	4/17/2012	D-Frame	14.1	3	6	33	9	0	301	258	0
148182	Above Syar Tunnel	ASYR	1	4/17/2012	Hess net	18.75	3	5	1304	533	0	15474	13867	0
148183	Above Syar Tunnel	ASYR	2	4/17/2012	Hess net	6.25	1	6	5700	889	0	41244	35200	0
148184	Above Syar Tunnel	ASYR	3	4/17/2012	Hess net	18.75	2	8	1600	830	0	20700	18726	0
148185	Above Syar Tunnel	ASYR	Composite	4/17/2012	D-Frame	7.8	4	8	33	15	0	240	215	0
148186	Below Syar Tunnel	BSYR	1	4/17/2012	Hess net	50	3	7	656	178	0	8233	7156	0
148187	Below Syar Tunnel	BSYR	2	4/17/2012	Hess net	37.5	2	7	2281	563	0	11037	9867	0
148188	Below Syar Tunnel	BSYR	3	4/17/2012	Hess net	37.5	0	6	633	326	0	8667	7615	0
148189	Below Syar Tunnel	BSYR	Composite	4/17/2012	D-Frame	12.5	3	8	59	26	0	230	198	0
148190	Guard Station	GS	1	4/17/2012	Hess net	100	2	14	1456	578	0	2700	1778	0
148191	Guard Station	GS	2	4/17/2012	Hess net	37.5	1	8	1037	148	0	9544	7756	0
148192	Guard Station	GS	3	4/17/2012	Hess net	100	4	12	2389	856	0	2700	1844	0
148193	Guard Station	GS	Composite	4/17/2012	D-Frame	18.75	3	11	89	28	0	177	135	0
148194	Above Monk's Hollow	AMH	1	4/18/2012	Hess net	100	1	9	709	349	0	1814	1337	0
148195	Above Monk's Hollow	AMH	2	4/18/2012	Hess net	93.75	2	9	558	174	0	161	37	0
148196	Above Monk's Hollow	AMH	3	4/18/2012	Hess net	37.5	1	4	961	372	0	4364	3411	0
148197	Above Monk's Hollow	AMH	Composite	4/18/2012	D-Frame	25	4	12	81	28	0	73	48	0
148198	Below Monk's Hollow	BMH	1	4/18/2012	Hess net	100	2	10	1384	547	0	1733	1570	0
148199	Below Monk's Hollow	BMH	2	4/18/2012	Hess net	100	4	8	2384	895	0	2244	1605	0
148200	Below Monk's Hollow	BMH	3	4/18/2012		62.5	6	10	2370	912	0	3458	2995	0
148201	Below Monk's Hollow	BMH	Composite	4/18/2012	D-Frame	18.75	3	11	102	53	0	130	113	0
148202	Diamond Fork Campground	DFCG	1	4/18/2012	Hess net	100	1	8	267	105	0	2186	1128	0
148203	Diamond Fork Campground	DFCG	2	4/18/2012	Hess net	100	1	7	35	12	0	1628	814	0
148204	Diamond Fork Campground	DFCG	3	4/18/2012	Hess net	100	1	8	547	407	0	1605	1453	0
148205	Diamond Fork Campground	DFCG	Composite	4/18/2012	D-Frame	12.5	2	11	76	33	0	77	57	0
148206	Mother	MO	1	4/18/2012	Hess net	100	2	7	128	128	0	872	767	0
148207	Mother	MO	2	4/18/2012	Hess net	100	3	13	209	209	0	895	721	0
148208	Mother	MO	3	4/18/2012	Hess net	100	1	6	221	105	0	2093	1953	0
148209	Mother	MO	Composite	4/18/2012	D-Frame	18.75	5	12	87	36	0	109	98	0
148210	Oxbow	OX	1	4/18/2012	Hess net	100	4	9	128	47	0	1488	1442	0
148211	Oxbow	OX	2	4/18/2012	Hess net	100	1	8	174	23	0	5942	5860	0
148212	Oxbow	OX	3	4/18/2012	Hess net	100	1	8	453	233	0	3721	3523	0
148213	Oxbow	OX	Composite	4/18/2012	D-Frame	9.38	6	11	88	39	0	64	54	0

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

												Functional Feeding Groups		
SampleID	Site	Station (NAMC)	Replicate	Collection Date	Collection Method	Percent Subsampled	Oligochaete abundance	Mollusca abundance	Insect abundance	Non-insect abundance	Big Rare Count	Shredder Abundance	Scraper abundance	Collector-filterer abundance
148174	Sixth Water	SXW	1	4/17/2012	Hess net	15.63	1422	213	45792	2915	65	2506	9057	1089
148175	Sixth Water	SXW	2	4/17/2012	Hess net	7.81	1718	0	99294	4279	13	1280	6293	996
148176	Sixth Water	SXW	3	4/17/2012	Hess net	50	1289	22	13822	1533	34	100	5300	144
148177	Sixth Water	SXW	Composite	4/17/2012	D-Frame	12.5	17	8	660	41	14	45	165	17
148178	Ray's Crossing	RC	1	4/17/2012	Hess net	100	67	0	6022	422	0	22	633	300
148179	Ray's Crossing	RC	2	4/17/2012	Hess net	75	148	15	9300	444	9	11	1226	441
148180	Ray's Crossing	RC	3	4/17/2012	Hess net	50	67	44	20456	1022	33	156	2444	1589
148181	Ray's Crossing	RC	Composite	4/17/2012	D-Frame	14.1	33	6	689	49	13	6	64	38
148182	Above Syar Tunnel	ASYR	1	4/17/2012	Hess net	18.75	119	178	55056	356	27	11	1244	1344
148183	Above Syar Tunnel	ASYR	2	4/17/2012	Hess net	6.25	0	0	104089	889	8	0	1444	3589
148184	Above Syar Tunnel	ASYR	3	4/17/2012	Hess net	18.75	119	237	38719	652	18	0	1919	837
148185	Above Syar Tunnel	ASYR	Composite	4/17/2012	D-Frame	7.8	12	7	752	26	16	7	23	31
148186	Below Syar Tunnel	BSYR	1	4/17/2012	Hess net	50	22	0	21389	244	29	22	756	1411
148187	Below Syar Tunnel	BSYR	2	4/17/2012	Hess net	37.5	237	0	21515	296	11	0	948	467
148188	Below Syar Tunnel	BSYR	3	4/17/2012	Hess net	37.5	0	0	20381	119	29	0	544	889
148189	Below Syar Tunnel	BSYR	Composite	4/17/2012	D-Frame	12.5	10	3	855	17	24	10	50	42
148190	Guard Station	GS	1	4/17/2012	Hess net	100	0	11	8444	89	0	122	1078	844
148191	Guard Station	GS	2	4/17/2012	Hess net	37.5	0	0	20378	59	10	148	267	2156
148192	Guard Station	GS	3	4/17/2012	Hess net	100	0	67	11922	900	0	267	3189	1311
148193	Guard Station	GS	Composite	4/17/2012	D-Frame	18.75	20	5	653	33	8	45	148	62
148194	Above Monk's Hollow	AMH	1	4/18/2012	Hess net	100	0	0	8279	23	0	849	488	570
148195	Above Monk's Hollow	AMH	2	4/18/2012	Hess net	93.75	161	0	6360	174	3	161	236	644
148196	Above Monk's Hollow	AMH	3	4/18/2012	Hess net	37.5	0	0	23721	62	32	58	775	333
148197	Above Monk's Hollow	AMH	Composite	4/18/2012	D-Frame	25	25	28	729	57	17	62	58	38
148198	Below Monk's Hollow	BMH	1	4/18/2012	Hess net	100	291	12	7070	721	0	326	721	570
148199	Below Monk's Hollow	BMH	2	4/18/2012	Hess net	100	58	35	11895	488	0	140	2384	965
148200	Below Monk's Hollow	BMH	3	4/18/2012		62.5	1730	130	12288	2493	52	37	2098	395
148201	Below Monk's Hollow	BMH	Composite	4/18/2012	D-Frame	18.75	0	18	635	18	29	12	115	80
148202	Diamond Fork Campground	DFCG	1	4/18/2012	Hess net	100	58	0	8477	58	0	314	163	1070
148203	Diamond Fork Campground	DFCG	2	4/18/2012	Hess net	100	0	12	6070	35	0	93	128	814
148204	Diamond Fork Campground	DFCG	3	4/18/2012	Hess net	100	0	0	4942	12	0	151	547	81
148205	Diamond Fork Campground	DFCG	Composite	4/18/2012	D-Frame	12.5	11	6	736	17	41	35	77	50
148206	Mother	MO	1	4/18/2012	Hess net	100	70	0	2942	105	0	23	128	93
148207	Mother	MO	2	4/18/2012	Hess net	100	23	0	3558	81	0	140	256	291
148208	Mother	MO	3	4/18/2012	Hess net	100	0	0	6733	58	0	198	209	174
148209	Mother	MO	Composite	4/18/2012	D-Frame	18.75	4	6	683	13	19	44	54	51
148210	Oxbow	OX	1	4/18/2012	Hess net	100	12	35	4349	198	0	279	256	407
148211	Oxbow	OX	2	4/18/2012	Hess net	100	0	0	9756	23	0	372	244	244
148212	Oxbow	OX	3	4/18/2012	Hess net	100	0	0	6674	58	0	47	453	47
148213	Oxbow	OX	Composite	4/18/2012	D-Frame	9.38	33	17	682	65	74	34	132	214

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

									Functional Feeding Groups Richness					Diverstity Index/Evenness	
SampleID	Site	Station (NAMC)	Replicate	Collection Date	Collection Method	Percent Subsampled	Collector-gatherer abundance	Predator abundance	# of shredder taxa*	# of scraper taxa*	# of collector-filterer	# of collector-gatherer	# of predator taxa*	Shannon's Diversity*	Simpson's Diversity*
148174	Sixth Water	SXW	1	4/17/2012	Hess net	15.63	33265	2150	0	2	3	7	5	1.79268946	0.75052397
148175	Sixth Water	SXW	2	4/17/2012	Hess net	7.81	88557	4739	0	2	1	6	4	1.06255529	0.4432107
148176	Sixth Water	SXW	3	4/17/2012	Hess net	50	8533	1256	0	3	2	6	4	1.8265583	0.76659978
148177	Sixth Water	SXW	Composite	4/17/2012	D-Frame	12.5	429	41	1	2	3	7	5	1.91376976	0.81447046
148178	Ray's Crossing	RC	1	4/17/2012	Hess net	100	5067	389	1	3	2	5	5	1.84328338	0.72361204
148179	Ray's Crossing	RC	2	4/17/2012	Hess net	75	7070	878	0	3	3	5	7	2.09431063	0.82309922
148180	Ray's Crossing	RC	3	4/17/2012	Hess net	50	15333	1844	1	3	4	5	5	1.9410612	0.75984392
148181	Ray's Crossing	RC	Composite	4/17/2012	D-Frame	14.1	566	50	2	2	3	5	5	2.02246218	0.7709699
148182	Above Syar Tunnel	ASYR	1	4/17/2012	Hess net	18.75	50126	2507	0	2	3	5	2	1.45312845	0.67259755
148183	Above Syar Tunnel	ASYR	2	4/17/2012	Hess net	6.25	95111	3589	0	2	4	4	3	1.36302232	0.54037384
148184	Above Syar Tunnel	ASYR	3	4/17/2012	Hess net	18.75	34970	1467	0	3	4	5	5	1.6911364	0.69257525
148185	Above Syar Tunnel	ASYR	Composite	4/17/2012	D-Frame	7.8	674	37	2	1	4	6	6	1.94221137	0.76044593
148186	Below Syar Tunnel	BSYR	1	4/17/2012	Hess net	50	18622	778	1	2	2	5	5	1.70424649	0.73926421
148187	Below Syar Tunnel	BSYR	2	4/17/2012	Hess net	37.5	19570	678	0	2	3	5	5	1.37952836	0.54185061
148188	Below Syar Tunnel	BSYR	3	4/17/2012	Hess net	37.5	18081	985	0	1	3	5	2	1.45359631	0.67121516
148189	Below Syar Tunnel	BSYR	Composite	4/17/2012	D-Frame	12.5	718	44	2	2	4	5	6	2.03010367	0.82013378
148190	Guard Station	GS	1	4/17/2012	Hess net	100	4744	967	3	4	5	9	10	2.82023372	0.90095875
148191	Guard Station	GS	2	4/17/2012	Hess net	37.5	13515	1478	2	1	4	5	5	1.78528226	0.7077369
148192	Guard Station	GS	3	4/17/2012	Hess net	100	5489	811	2	3	5	8	8	2.54705405	0.88024526
148193	Guard Station	GS	Composite	4/17/2012	D-Frame	18.75	338	47	3	4	5	7	6	2.75228	0.90943144
148194	Above Monk's Hollow	AMH	1	4/18/2012	Hess net	100	5360	186	0	1	2	7	5	1.76875605	0.73509476
148195	Above Monk's Hollow	AMH	2	4/18/2012	Hess net	93.75	4426	161	2	1	3	4	4	2.10101185	0.83220036
148196	Above Monk's Hollow	AMH	3	4/18/2012	Hess net	37.5	20543	554	0	1	2	6	4	1.20763969	0.52214047
148197	Above Monk's Hollow	AMH	Composite	4/18/2012	D-Frame	25	560	49	2	2	4	7	7	2.05757132	0.73426979
148198	Below Monk's Hollow	BMH	1	4/18/2012	Hess net	100	4477	733	1	1	3	7	8	2.3474799	0.87023411
148199	Below Monk's Hollow	BMH	2	4/18/2012	Hess net	100	7128	593	0	2	3	6	7	2.12153199	0.82876254
148200	Below Monk's Hollow	BMH	3	4/18/2012		62.5	9367	1079	1	3	3	6	11	2.45189238	0.8864437
148201	Below Monk's Hollow	BMH	Composite	4/18/2012	D-Frame	18.75	385	38	2	3	4	6	6	2.31646303	0.86911929
148202	Diamond Fork Campground	DFCG	1	4/18/2012	Hess net	100	6814	163	1	2	2	7	5	1.36250066	0.58767001
148203	Diamond Fork Campground	DFCG	2	4/18/2012	Hess net	100	4884	163	1	1	2	7	3	1.32369523	0.576767
148204	Diamond Fork Campground	DFCG	3	4/18/2012	Hess net	100	3465	163	0	2	3	7	6	1.79733596	0.75426979
148205	Diamond Fork Campground	DFCG	Composite	4/18/2012	D-Frame	12.5	548	26	3	2	3	7	7	1.90807857	0.71295429
148206	Mother	MO	1	4/18/2012	Hess net	100	2465	70	2	1	3	4	3	1.34385966	0.60995312
148207	Mother	MO	2	4/18/2012	Hess net	100	2709	198	2	2	4	5	5	1.84180532	0.71926923
148208	Mother	MO	3	4/18/2012	Hess net	100	5395	128	2	1	2	5	1	1.32565936	0.62416945
148209	Mother	MO	Composite	4/18/2012	D-Frame	18.75	503	32	3	3	5	7	8	2.11944052	0.77117057
148210	Oxbow	OX	1	4/18/2012	Hess net	100	3058	453	2	1	2	7	5	2.0470829	0.79431438
148211	Oxbow	OX	2	4/18/2012	Hess net	100	8628	267	1	1	4	7	3	1.31135045	0.56996656
148212	Oxbow	OX	3	4/18/2012	Hess net	100	5698	372	2	1	2	6	4	1.37207453	0.61696767
148213	Oxbow	OX	Composite	4/18/2012	D-Frame	9.38	297	54	3	2	3	8	7	2.50153802	0.88173913

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

SampleID	Site	Station (NAMC)	Replicate	Collection Date	Collection Method	Percent Subsampled	Evenness*	Biotic Indices: Hilsenhoff Biotic Index*	USFS Community Tolerance Quotient (d)*	Karr BIBI Metrics: Long-lived Taxa*	Intolerant Taxa abundanc	Tolerant Taxa abundanc
148174	Sixth Water	SXW	1	4/17/2012	Hess net	15.63	0.57996274	3.53333333	78	3	0	142
148175	Sixth Water	SXW	2	4/17/2012	Hess net	7.81	0.39236913	4.83333333	75	2	0	569
148176	Sixth Water	SXW	3	4/17/2012	Hess net	50	0.6203417	2.73	70	1	0	111
148177	Sixth Water	SXW	Composite	4/17/2012	D-Frame	12.5	0.63883204	3.08	74	2	0	10
148178	Ray's Crossing	RC	1	4/17/2012	Hess net	100	0.63773228	3.82333333	66	3	0	0
148179	Ray's Crossing	RC	2	4/17/2012	Hess net	75	0.69909806	3.68666667	66	2	0	0
148180	Ray's Crossing	RC	3	4/17/2012	Hess net	50	0.63755851	3.98	68	2	0	0
148181	Ray's Crossing	RC	Composite	4/17/2012	D-Frame	14.1	0.69972389	3.82	70	3	0	2
148182	Above Syar Tunnel	ASYR	1	4/17/2012	Hess net	18.75	0.58478191	4.01	67	1	0	0
148183	Above Syar Tunnel	ASYR	2	4/17/2012	Hess net	6.25	0.51648076	5.11355311	64	2	0	0
148184	Above Syar Tunnel	ASYR	3	4/17/2012	Hess net	18.75	0.58509304	4.48333333	63	2	0	0
148185	Above Syar Tunnel	ASYR	Composite	4/17/2012	D-Frame	7.8	0.6379363	4.39	78	2	0	0
148186	Below Syar Tunnel	BSYR	1	4/17/2012	Hess net	50	0.60152424	4.29	64	1	0	0
148187	Below Syar Tunnel	BSYR	2	4/17/2012	Hess net	37.5	0.49755968	4.96666667	64	1	0	0
148188	Below Syar Tunnel	BSYR	3	4/17/2012	Hess net	37.5	0.60619674	4.75	66	1	0	0
148189	Below Syar Tunnel	BSYR	Composite	4/17/2012	D-Frame	12.5	0.67766525	3.64	70	2	0	0
148190	Guard Station	GS	1	4/17/2012	Hess net	100	0.79975763	4.09666667	64	4	0	100
148191	Guard Station	GS	2	4/17/2012	Hess net	37.5	0.61766527	4.53666667	71	2	0	89
148192	Guard Station	GS	3	4/17/2012	Hess net	100	0.74171914	3.65	67	4	0	167
148193	Guard Station	GS	Composite	4/17/2012	D-Frame	18.75	0.82596371	3.82	73	3	0	1
148194	Above Monk's Hollow	AMH	1	4/18/2012	Hess net	100	0.6119476	4.09666667	66	2	0	0
148195	Above Monk's Hollow	AMH	2	4/18/2012	Hess net	93.75	0.77583933	3	58	3	0	0
148196	Above Monk's Hollow	AMH	3	4/18/2012	Hess net	37.5	0.45760267	4.13333333	75	1	0	0
148197	Above Monk's Hollow	AMH	Composite	4/18/2012	D-Frame	25	0.64743124	3.39333333	68	4	0	0
148198	Below Monk's Hollow	BMH	1	4/18/2012	Hess net	100	0.77105029	3.69	70	3	0	0
148199	Below Monk's Hollow	BMH	2	4/18/2012	Hess net	100	0.70818478	3.61666667	70	2	0	0
148200	Below Monk's Hollow	BMH	3	4/18/2012		62.5	0.74393621	3.34333333	71	2	0	0
148201	Below Monk's Hollow	BMH	Composite	4/18/2012	D-Frame	18.75	0.74941159	3.16	73	3	0	0
148202	Diamond Fork Campground	DFCG	1	4/18/2012	Hess net	100	0.48090295	4.38333333	65	2	0	0
148203	Diamond Fork Campground	DFCG	2	4/18/2012	Hess net	100	0.47742213	4.42333333	66	2	0	0
148204	Diamond Fork Campground	DFCG	3	4/18/2012	Hess net	100	0.59996548	4.46333333	67	1	0	0
148205	Diamond Fork Campground	DFCG	Composite	4/18/2012	D-Frame	12.5	0.60854157	3.50333333	67	4	0	0
148206	Mother	MO	1	4/18/2012	Hess net	100	0.49624622	4.29661017	71	3	0	0
148207	Mother	MO	2	4/18/2012	Hess net	100	0.60495705	3.98233216	62	5	0	0
148208	Mother	MO	3	4/18/2012	Hess net	100	0.53348457	4.44	72	3	0	0
148209	Mother	MO	Composite	4/18/2012	D-Frame	18.75	0.63604755	3.76333333	65	4	0	0
148210	Oxbow	OX	1	4/18/2012	Hess net	100	0.67238227	3.92	68	3	0	0
148211	Oxbow	OX	2	4/18/2012	Hess net	100	0.45369612	5.18333333	66	2	0	0
148212	Oxbow	OX	3	4/18/2012	Hess net	100	0.49487128	4.97333333	70	4	0	0
148213	Oxbow	OX	Composite	4/18/2012	D-Frame	9.38	0.76779125	2.49333333	68	4	0	0