Macroinvertebrate Drift in Taneum Creek, Washington: establishment of baseline conditions from 2004 to 2006

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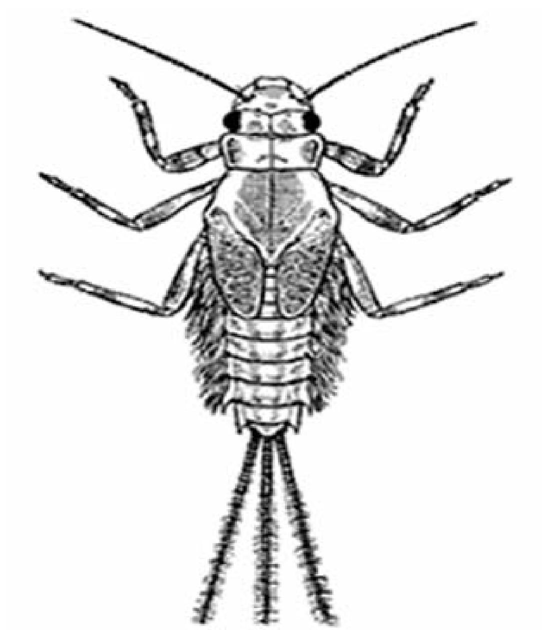

March 2007

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The winter water purchase at Taneum Creek would not have been possible without cooperation and partnership from a number of agencies, including Washington Water Trust, The Washington State Department of Ecology, and the Yakama Nation. I would like to thank the Biology Department at the Washington State University Tri-Cities campus, and especially Meg Mercer, laboratory manager, for allowing me access to their laboratory equipment. Thanks also to Al Scherzinger and Scott Willey with the Bureau of Reclamation for assistance with field activities, and to those who provided comments on earlier drafts of this report, most notably Stan Isley. Finally, I am grateful to Roger Satnik with the Kittitas Reclamation District for providing summarized discharge and water temperature data.

CORRECTION

The y-axis scale of Figure 3, Graph A, of the March 2006 report on the first year of Taneum Creek invertebrate drift sampling should appear as it does in Figure 3 of this report, with a minimum value of 0 and a maximum value of 25. Also, taxonomic drift densities in Appendix Table 1 are shown as number/100 m^3.

INTRODUCTION

Taneum Creek, a tributary to the Yakima River in central Washington, historically supported runs of anadromous steelhead, spring chinook and coho salmon (Forest Service 1995). Currently, spring Chinook and coho salmon are not known to spawn there, and recent steelhead runs have probably numbered fewer than 10 fish annually. A number of factors have contributed to salmon declines in Taneum Creek, including altered flow regimes from human activities, with winter flows–which may be low to nearly nonexistent–being especially problematic. Flow augmentation during the April to October irrigation season was accomplished when the Yakima River Basin Water Enhancement Project (YRBWEP), a water conservation program led by the Bureau of Reclamation, purchased a 374.10 acre portion of the former Heart K Ranch Property, a parcel of land that borders Taneum Creek and includes an irrigation water right of up to 11.03 cubic feet per second (cfs). To improve winter flows, YRBWEP partnered with other agencies to purchase a water right that has historically been used to provide water to stock animals in winter. By leaving water in Taneum Creek that would otherwise be used for winter stock water, YRBWEP will ensure a flow increase of 12.0 to 28.8 cfs between November 16 and February 19, in perpetuity. In practicality, the YRBWEP water purchase could cause Taneum Canal Company to end their canal operations as early as November 1, and not recommence until March, thus increasing the duration of winter water additions to Taneum Creek. Some increased flows were expected to occur beginning November 2005, but the entire flow benefit will not be fully realized until November 2007.

Since aquatic invertebrates require a wetted stream bottom to survive, the current Taneum Creek winter flow regimes, which often leave substantial portions of the stream bed dry, may reduce seasonal invertebrate production. Therefore one important benefit of the YRBWEP water purchase might be an increased overwinter survival of aquatic invertebrates, leading to increased invertebrate food abundance for fish from spring through autumn, when fish consume the greatest amounts of food. To evaluate this potential benefit, I initiated in November, 2004 a monthly sampling program in Taneum Creek to collect baseline data on the abundance, biomass, and composition of invertebrate drift for comparison against similar measurements made after winter flow augmentation begins.

STUDY AREA

Located in Kittitas County south of Thorp, Washington (47°09′N 120°70′W), Taneum Creek forms at the confluence of North and South Fork Taneum creeks in the Wenatchee National Forest. The creek's average channel bottom width at the study location is approximately 8 m (26 ft), and nearly 100% of the steam bed remains wetted at flows between 11-15 cfs, whereas flows below 10 cfs dry parts of the stream channel. A watershed analysis by the Forest Service (1995) indicates that lower Taneum Creek, in the vicinity of the study location, experiences naturally high levels of instream fine sediments due to soil composition within the basin. Moreover, agricultural and recreational activities, and human encroachment into riparian zones likely increase fine sediment loads to the creek. The analysis also indicated that Taneum Creek has relatively little large woody debris. In consequence, channel complexity is low and there are few pools and gravel tail-outs that provide physical complexity to support a diverse biological community.

METHODS

Three sampling locales (Appendix Figure 1) along a stream reach between River Miles 1.9 and 2.4 on the former Heart K Ranch Property were established for monthly sampling from November 2004 to November 2005 and March to October of 2006. Locales were chosen randomly from within three deep-riffle creek sections, each having a mostly cobble substrate. On each sampling date, 3 to 5 samples were collected (at least one sample per locale) during daylight hours (1100-1600 hrs) using a 363 μm mesh drift net mounted on rebar struts secured into concrete blocks so that the net's mouth extended above the water line. Before each sample effort the depth of the submerged portion of the net mouth was recorded, as was a flow measurement at the mouth of the net. Initially, drift samples were collected for 30 minutes, however due to concerns about clogging with frazzle ice in mid-winter and detritus in other seasons I reduced collections to 15 minute intervals on some dates. Samples were preserved in 70% isopropyl alcohol.

When visual inspection suggested a large number of invertebrates in the sample, I sub-sampled by randomly and evenly distributing the sample on a pie plate divided into eight equal sections, then processed enough sections to achieve a target sub-sample density of at least 100 organisms. Invertebrates were counted and identified to the lowest practical taxon--typically to the family level for nymphal Ephemeroptera, Tricoptera, and Plecoptera-- and sorted into the following taxonomic groups: EPHEMEROPTERA (Mayflies), TRICOPTERA (Caddisflies), PLECOPTERA (Stoneflies), LARVAL DIPTERANS (True flies), ADULT DIPTERANS, and OTHER. Because the objective of this study is to understand potential food-web benefits from increased winter flows, and biomass is a more meaningful measurement of food availability for fish, I estimated the dry weight biomass for each group in each sample by rinsing the organisms into pre-weighed tin sample cups, drying them for at least 24 h in a 60°C oven, and then re-weighing.

Abundance and biomass of taxonomic groups were compared monthly or seasonally using means and ranges. I chose to omit statistical analysis from this report because the data presented herein represent the baseline or "before" treatment condition in a "before and after" study design. An evaluation of the invertebrate community should be completed following higher winter flows beginning in November 2007, and an appropriate statistical analysis should be chosen. An important consideration for choosing the statistical analyses for this project, and indeed for all such similar projects, is a lack of independence between samples collected at each site on a given sampling date. Rank-based analysis of variance (ANOVA) tests, which are more robust than a conventional ANOVA to the assumption of independence, may be an appropriate option for statistical analysis of this study.

One metric commonly used to assess a stream's health is the EPT ratio, calculated as the number of Ephemeroptera, Plecoptera and Tricoptera in a sample, divided by this sum plus the number of chironomidae (EPT/ EPT + Chironomidae; Resh and Grodhaus 1983). I adapted the EPT ratio to this project by using biomass rather than numbers. Since seasonal temperature cues uniquely influence each invertebrate species, I grouped the EPT monthly ratios by season and considered spring to be April through June and autumn to be October and November.

Hourly water temperatures and stream flows within the study location were collected at a hydromet data gage (station no. TC060C) operated by the Kittitas Reclamation District. Gage temperatures were not collected during winter months, but were measured with a hand-held thermometer on monthly sampling trips.

RESULTS AND DISCUSSION

From January through March, water temperatures on sampling dates were measured between 4 and 5°C. Hydromet temperature measurements ranged between about 4 and 24°C, with temperatures being just slightly cooler in 2006 (Figure 1). Discharge peaked three times in 2005 at about 110 to 120 CFS (Figure 2), with the third peak being noteworthy because it occurred from late August through most of September; a time when Taneum Creek flows might naturally reach their nadir. The unusual hydrograph resulted from irrigation canal operations in which a portion of water drawn from the nearby Yakima River was diverted to Taneum Creek, entering just upstream from the reach included in this study. No such high summer flows were present in 2006.

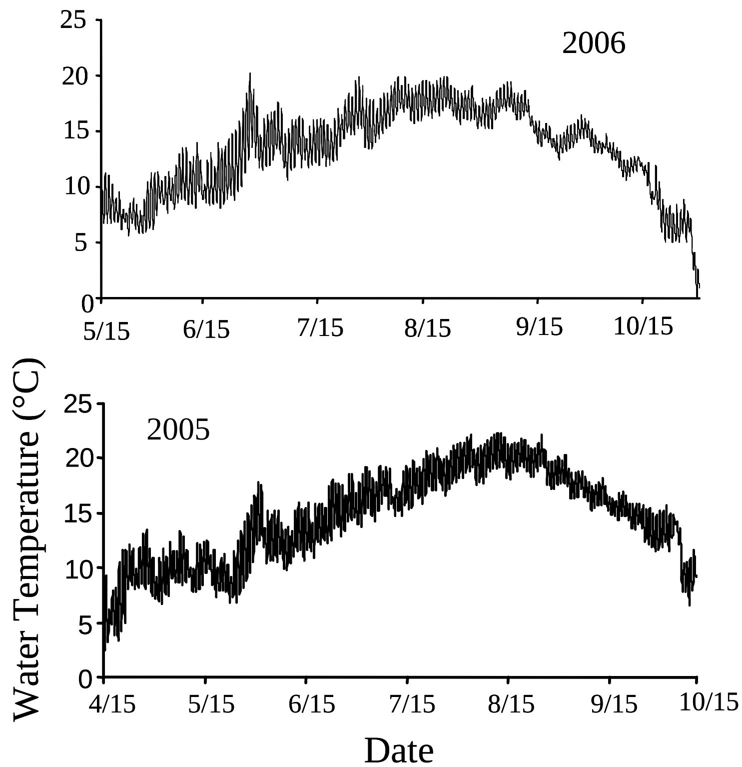

Figure 1. Water temperatures recorded at the hydromet station on Taneum Creek, May to October, 2006 (top panel) and April to October, 2005.

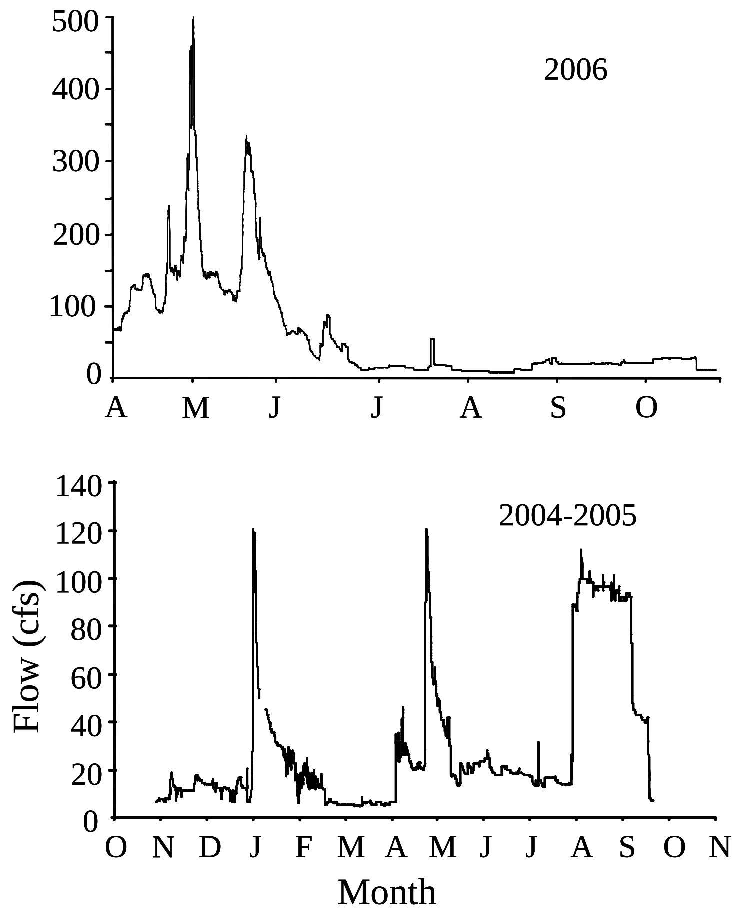

Figure 2. Discharge recorded at the hydromet station on Taneum Creek, April through October 2006 (top panel) and November 2004 to October 2005.

In 2005, total drift densities increased in spring, peaking in April as the hydrograph began to rise, but prior to the highest spring flows in May (Figure 3A, Appendix Table 1). April densities were 72% higher than March densities. In 2006, I measured a larger (146%) increase in April drift densities over those of March, though peak spring drift densities were not as high as in 2005 (Figure 4A, Appendix Table 3). Brittain and Eikeland (1988) report that increasing drift densities at the beginning of the spring freshet is a familiar pattern, potentially occurring because scour dislodges invertebrates, and those that enter the drift have difficulty returning to substrates. However, I measured low drift densities during the high flows of January and September of 2005, which suggests that other factors, such as seasonal warming or increased photoperiod, may have influenced invertebrate behavior during the spring freshet, resulting in the high invertebrate densities I observed in April.

Drift density patterns in the summers of 2005 and 2006 were not similar. In 2005, densities gradually decreased from May through September, with only a slight increase in October, whereas in 2006 densities increased from May to July and were substantially higher in October than in September. One could speculate that the atypical summer hydrograph in 2005 may have altered temporal drift patterns. For example, although 2005 and 2006 September drift densities were roughly equivalent, a much greater absolute number of organisms drifted down the stream channel in September of 2005 because of the high flow volumes. Furthermore, it is possible that those high summer flows induced some invertebrate drift that might have otherwise occurred in autumn; a phenomenon that would also explain the comparatively low drift densities I measured in October 2005. However, since I did not collect data from a control stream section (i.e., a section of Taneum Creek that did not have unnaturally high summer flows) I cannot reliably draw these conclusions.

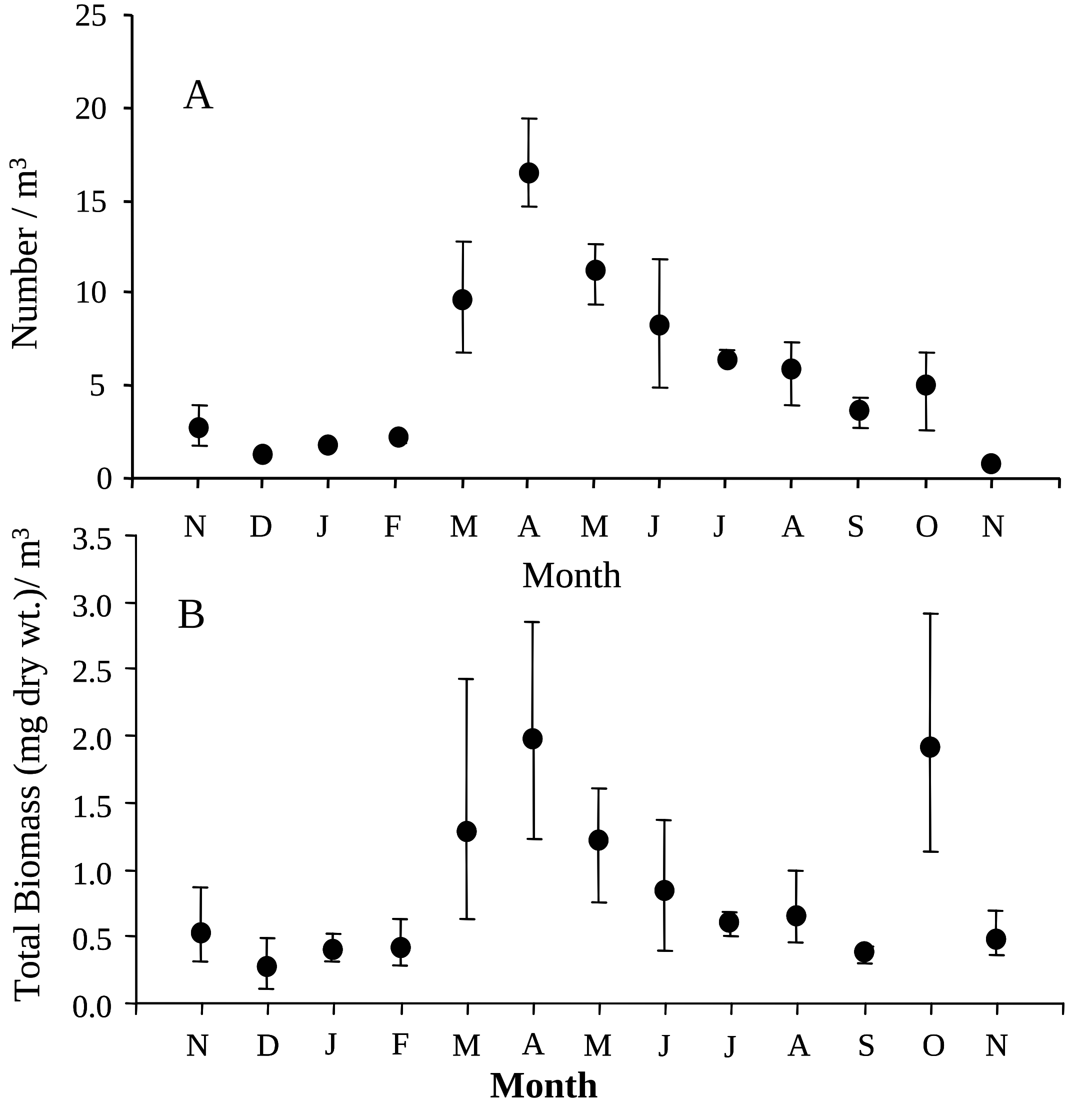

Figure 3. Monthly invertebrate density (A), and total biomass (B) in the drift from November 2004 to November 2005. Vertical bars represent the range of values measured.

The effect of high summer flows on benthic invertebrate community dynamics in Taneum Creek would be an interesting avenue for future research, and would have implications for invertebrate dynamics in the main-stem Yakima River, which also experiences unnaturally high summer flows. If high summer flows are reducing autumn drift, then this may have implications for over-winter survival of juvenile salmon, since studies have demonstrated that age-0 fish exhibiting slow growth and inadequate energy reserves in autumn are less likely to survive winter (Post and Parkinson 2001).

Comparisons of drift densities in lower Taneum Creek with those reported in other studies should be made cautiously, because a variety of abiotic and biotic variables affect invertebrate production in streams, and the number of invertebrates available to enter the drift. However, such a comparison suggests the presence of potentially lower than average drift densities in lower Taneum Creek. For example, numerous studies in coldwater streams have reported mean total drift densities greater than 0.5 individuals/m^3 (Sagar and Glova 1992; Martin et al. 2000; Collier and Quinn 2003; Hieber et al. 2003), with total drift densities, and even values for individual species, sometimes approaching 100/m^3 (Brittain and Eikeland 1988). In this study, the highest mean drift density on any sampling date was less than 25 individuals/m^3, and the mean for all sample dates was 7.6 individuals/m^3.

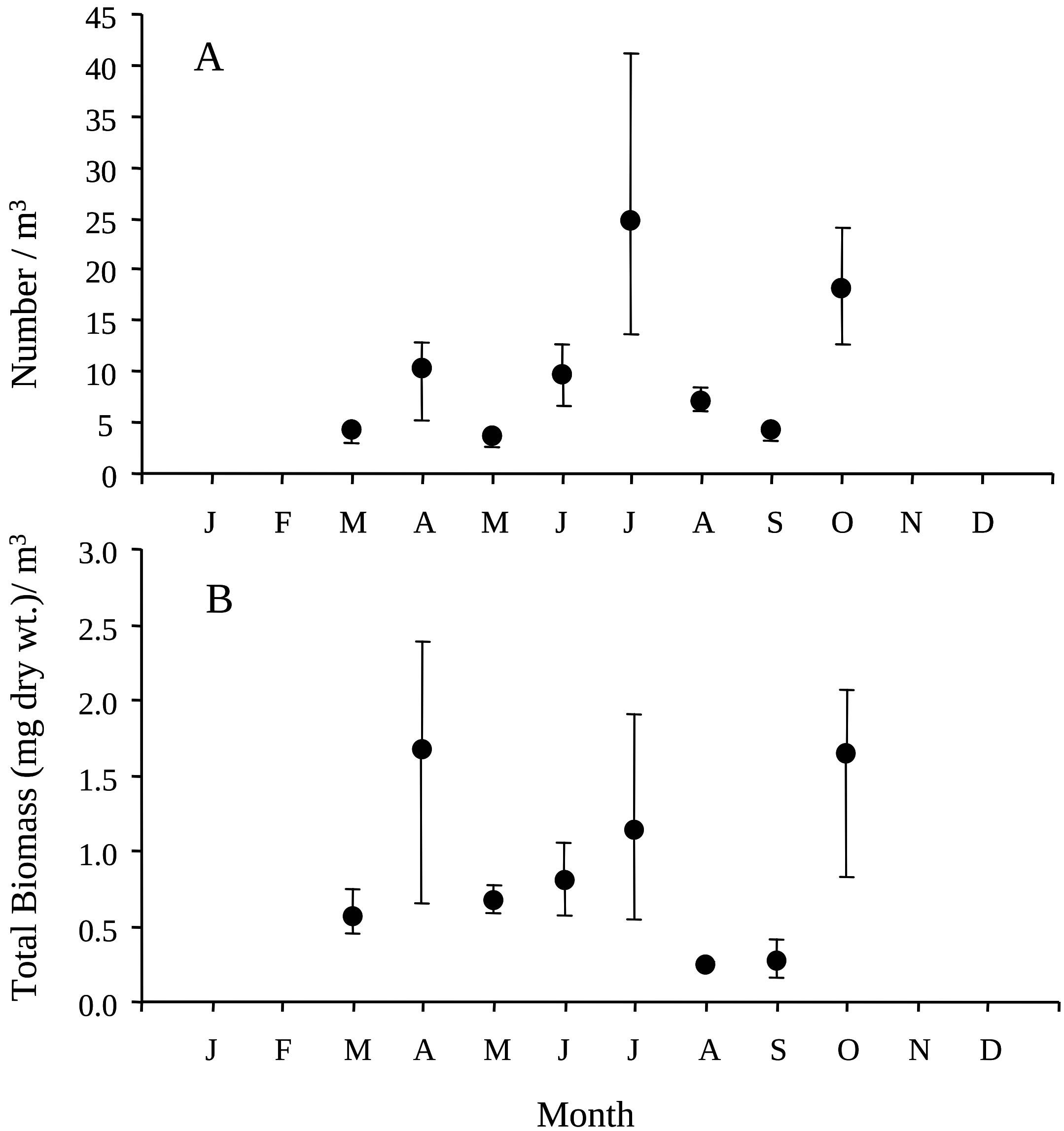

Figure 4. Monthly invertebrate density (A), and total biomass (B) in the drift from March to October, 2006. Vertical bars represent the range of values measured.

In 2005, total drift biomass ranged between approximately 0.25 and 3.00 mg dry weight/m^3 (Figure 3B, Appendix Table 2), and monthly biomass fluctuations closely followed patterns of drift density, with one notable exception. Whereas drift density in October 2005 was only slightly higher than in September, invertebrate biomass per unit of stream volume was considerably higher than the previous month. This result occurred because the absolute biomass of invertebrates drifting down the channel remained relatively unchanged from September to October while the discharge volume declined dramatically. In 2006, drift biomass patterns also followed drift density patterns (Figure 4B, Appendix Table 3), and biomass ranged between approximately 0.15 and 2.4 mg dry weight/m^3. A comparison of summer drift biomass between 2005 and 2006 shows differing patterns, with a July peak in biomass being present in 2006 but absent in 2005. However, average March to October biomass was slightly higher in 2005 (1.08 mg dry weight/m^3) than in 2006 (0.87 mg dry weight/m^3). Comparisons of my drift biomass results to those of other studies will be particularly tenuous, because the method used to preserve samples can substantially alter invertebrate dry weights (Wiederholm and Eriksson 1977). For this reason, I strongly recommend that samples collected in the summer of 2008 also be preserved in isopropyl alcohol so that comparisons to these baseline data remain valid. However, I note that the drift biomass measured in this study is comparable to those measured by Sagar and Glova (1992) in a glacial-fed coldwater stream.

The “OTHER” taxonomic group comprised the highest 2005 annual drift biomass (about 31.6%) followed by Adult Dipteran (19.5%), Ephemeroptera (15.8%), Dipteran Larvae (14.9%), Trichoptera (10.3%), and Plecoptera (7.3%). Terrestrial insects contributed a large portion to the OTHER taxonomic group in 2005 and 2006, especially in mid-summer when the OTHER group comprised a larger portion of the drifting biomass (Figure 4, Appendix Table 2). In October 2005, when drift biomass was high, ADULT DIPTERANS comprised a larger portion of the drift biomass than in any month except May. Comparisons of the 2005 and 2006 March through October time periods show only small changes in the average taxonomic composition, with Dipterans accounting for a greater biomass in 2006 samples (Table 1). The comparatively low biomass of taxa generally considered to be intolerant to habitat degradation (e.g., Ephemeroptera, Tricoptera, and Plecoptera) may signal poor water quality in lower Taneum Creek. By comparison, in a highly productive coastal stream Ephemeroptera accounted for the greatest drift biomass (30.3%), followed by Coleoptera (25.1%), Plecoptera (16.6%), and Trichoptera (14.5%; Benke et al. 1991).

In 2005, the EPT ratio peaked in spring at 0.78, then declined about 28.0% in the summer season to its lowest point of the year (0.61; Figure 5). Among all seasons, the average EPT ratio was 0.70. The ratio was much lower in spring of 2006 (0.20), due mostly to a large Dipteran larvae biomass (78.6 mg dry weight/m^3) present in one sample collected in April. Thus the low EPT ratio in the spring of 2006 may be an aberration. The EPT ratio in the summer of 2006 (0.64) was similar to the 2005 summer measurement (0.61).

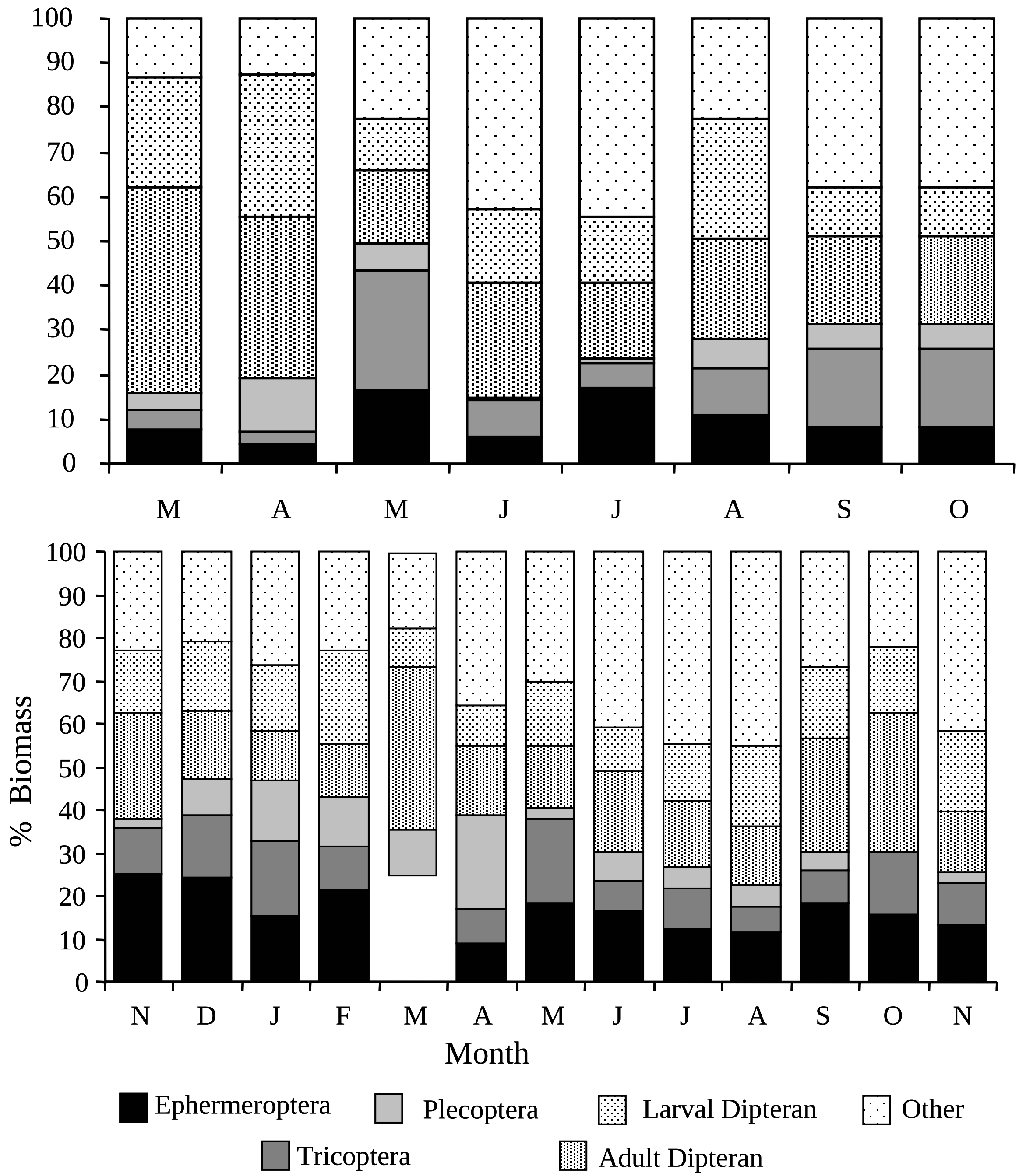

Figure 4. Average invertebrate biomass percentages, by month, for each taxonomic group from March to October 2006 (top panel) and November 2004 to November 2005. The May 2005 Ephemeroptera and Tricoptera collections were inadvertently dried together, so individual biomasses for these two taxonomic groups are not available.

Table 1. Average percent taxonomic composition of invertebrate biomass collected from March through October in 2005 and 2006

Taxonomic Group	% Composition 2005	2006
Ephemeroptera	12.7	9.8
Tricoptera	8.9	11.7
Plecoptera	7.0	5.2
Adult Dipterans	21.9	25.5
Dipteran Larvae	13.4	18.5
Other	32.9	29.3

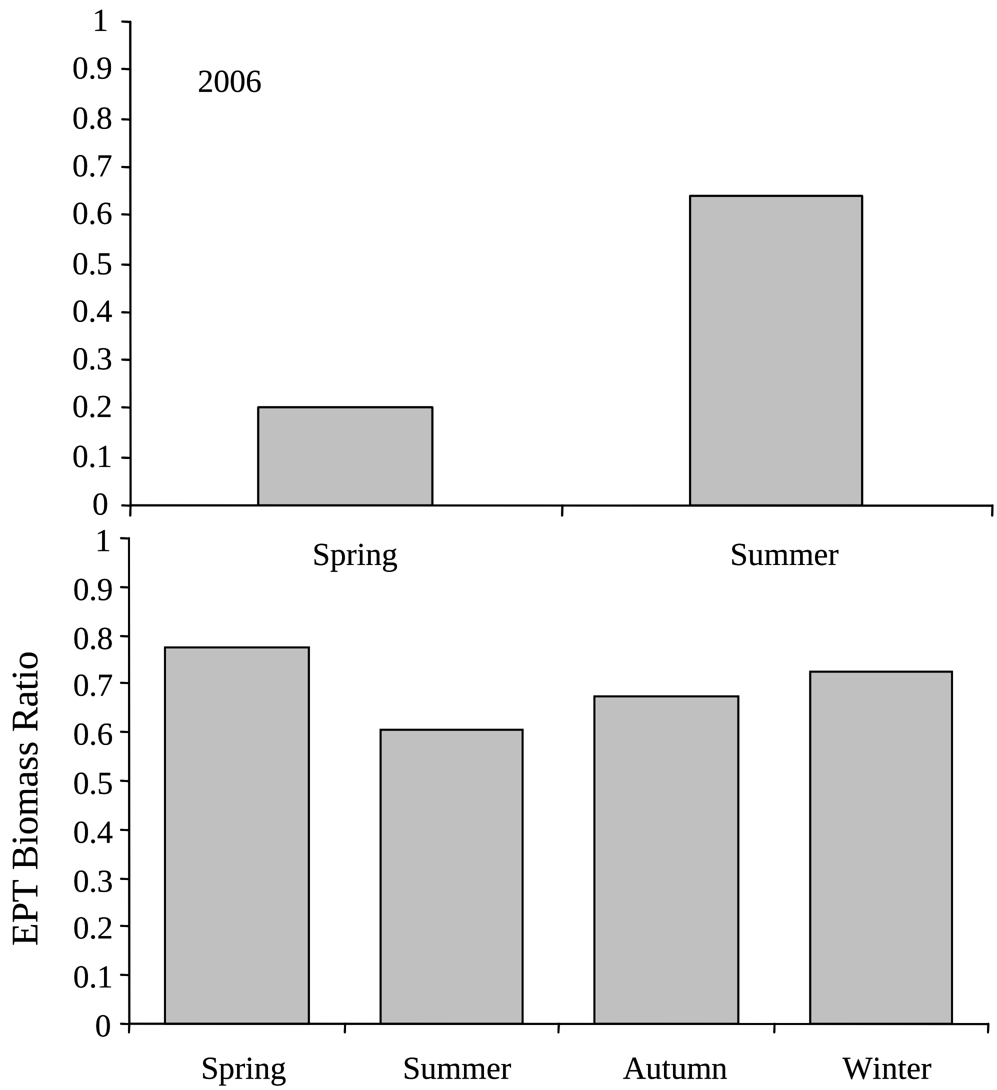

Figure 5. Seasonal EPT biomass ratios for 2005 and 2006 (top panel) for invertebrates collected in Taneum Creek.

A key question is whether the drift biomass measured in this study is sufficient to support the feeding demand of a salmonid population in lower Taneum Creek. A serious attempt to answer this question, using bioenergetics modeling, also requires knowing the abundance of invertebrate-feeding fishes in the study reach, and a quantitative description of their diets and growth patterns. Although such data were not collected for this study, inferences can be drawn from existing publications to better understand the feeding-demand to food-supply relationship. For example, in a series of experiments to measure the energetics of brown trout, Elliot (1976) reported that a 50 gram fish requires about 1,250 calories/day to maintain body weight when water temperatures range between 15 and 20°C; typical mid-summer temperatures in Taneum Creek. Assuming that Taneum Creek invertebrates have an average energy value of 4.5 calories/milligram of dry biomass, a 50 gram brown trout would therefore need to filter all the invertebrates from about 93 to 555 m^3 (assuming an invertebrate drift biomass of 0.50-3.00 mg/m^3) . Similarly, at a 15°C water temperature Brett and Higgs (1970) showed that fingerling sockeye would need to consume about 1.2% of its body mass each day to maintain weight. Thus a 5 gram sockeye would require 60 milligrams/day or the invertebrate biomass found in 30 to 120 m^3 of Taneum Creek water. Such comparisons of drift biomass to salmonid feeding demand might help to understand these results, although a more exhaustive literature search than was possible for this study may also assist in establishing a biological context to interpret this data.

In summary, restoration of Taneum Creek’s salmon and steelhead populations require improvements to seasonal flow regimes, and a better understanding of the relation between flow and food-web dynamics. In this study to understand baseline invertebrate drift conditions, I found differing patterns of invertebrate drift densities during the March to October time periods of 2005 and 2006, probably as a result of differing flow regimes. Monthly drift biomass patterns also varied between the two years, but the difference in average monthly biomass for the two time periods was only 24%. When compared with drift data collected in the two years immediately following the winter water-right purchase (i.e., March to October of 2008 and 2009), this study will help to understand how fluctuating winter flows influence invertebrate food abundance for fish.

Literature Cited

Benke, A.C., Parsons, K.A., and S.M. Dhar. 1991. Population and Community Patterns of Invertebrate Drift in an Unregulated Coastal Plain River. Canadian Journal of Fisheries and Aquatic Sciences 48(5):811-823.

Brittain, J.E. and T.J. Eikeland. 1988. Invertebrate drift – A review. Hydrobiologia 166:77-93.

Brett, J.R. and D.A. Higgs. 1970. Effect of Temperature on the rate of gastric digestion in fingerling sockeye salmon, Oncorhynchus nerka. Journal of the Fisheries Research Board of Canada 27:1767-1779.

Collier, K.J. and J.M. Quinn. 2003. Land-use influences macroinvertebrate community response following a pulse disturbance. Freshwater Biology 48:1462-1481.

Elliott, J.M. 1976. The Energetics of Feeding, Metabolism and Growth of Brown Trout (Salmo trutta L.) in Relation to Body Weight, Water Temperature and Ration Size. Journal of Animal Ecology 45(3):923-948.

Forest Service. 1995. Watershed analysis, Taneum/Manastash Watershed. Cle Elum Ranger District, Wenatchee National Forest.

Hieber, M., Robinson, C.T., and U. Uehlinger. 2003. Seasonal and diel patterns of invertebrate drift in different alpine stream types. Freshwater Biology 48:1078-1092.

Martin, M.D., R.S. Brown, D.R. Barton, and G. Power. 2000. Abundance of stream invertebrates in winter: seasonal changes and effects of river ice. Canadian Field Naturalist 115(1):68-74.

Post, J. R., and E. A. Parkinson. 2001. Energy allocation strategy in young fish: allometry and survival. Ecology 82:1040–1051.

Resh, V.H. and G. Grodhaus. 1983. Aquatic insects in urban environments. Pages 247-276 *In* Urban Entomology: Interdisciplinary Perspectives. G.W. Frankie and C.S. Koehler,editors. Praeger Publishers, New York.

Sagar, P.M. and G.J. Glova. 1992. Invertebrate drift in a large, braided New Zealand river. Freshwater Biology 27:405-416.

Weiderholm, T. and L. Eriksson. 1977. Effects of alcohol preservation on the weight of some benthic invertebrates. Zoon 5:29-31.

Appendix Table 1. Mean monthly (Nov. 2004 – Nov. 2005) macroinvertebrate densities (number/100 m^3) by taxonomic group in Taneum Creek. Ranges are shown in parentheses for taxonomic groups appearing in more than one sample during monthly collections.

	Taxonomic Group					
Month	Ephemeroptera	Tricoptera	Plecoptera	Adult Dipteran	Larval Dipteran	Other
Nov.	73.1 (56.3-104.1)	11.6 (3.1-22.4)	0.5 (0.0-2.0)	87.8 (46.9-156.9)	17.6 (8.6-20.8)	81.3 (56.3-130.4)
Dec.	42.4 (39.6-47.2)	12.1 (11.3-13.2)	1.2 (0.0-2.6)	14.3 (4.7-31.1)	23.6 (16.0-37.1)	30.6 (5.6-50.4)
Jan.	54.5 (33.1-66.7)	51.2 (45.0-58.3)	6.1 (3.9-10.5)	5.6 (2.3-7.9)	24.6 (19.8-31.6)	36.3 (30.4-41.0)
Feb.	67.5 (60.2-79.2)	15.1 (6.8-26.9)	18.7 (16.4-21.9)	9.5 (3.9-16.4)	90.3 (73.2-118.2)	22.4 (10.8-37.3)
March	406.5 (104.2-942.9)	27.2 (8.6-55.4)	47.0 (15.2-92.4)	375.1 (92.4-553.0)	60.6 (32.5-92.4)	36.5 (0.0-72.5)
April	147.2 (77.4-210.6)	28.2 (15.3-42.1)	20.9 (13.6-25.6)	445.9 (423.9-476.2)	251.5 (184.3-360.7)	746.6 (660.6-882.0)
May	134.1 (108.2-173.1)	21.9 (15.7-31.6)	1.0 (0.0-3.0)	371.2 (236.0-463.4)	266.5 (236.9-302.9)	323.1 (251.8-405.5)
June	113.2 (51.7-181.8)	11.4 (6.7-14.2)	5.2 (4.4-6.1)	267.9 (154.4-337.1)	134.0 (86.5-195.1)	291.4 (181.5-443.6)
July	59.4 (41.4-72.5)	10.0 (6.1-13.8)	6.8 (5.3-9.2)	190.9 (151.3-230.6)	143.7 (112.7-188.9)	231.4 (192.4-268.6)
Aug	61.8 (50.5-77.8)	11.2 (7.5-14.8)	6.1 (5.0-11.4)	137.7 (109.8-170.5)	241.5 (135.1-380.2)	120.3 (89.6-139.7)
Sept	50.1 (26.0-70.7)	5.5 (1.7-8.3)	0.9 (0.0-1.7)	133.3 (88.6-159.4)	107.7 (94.4-125.4)	72.6 (47.9-88.3)
Oct	48.9 (28.2-75.9)	25.7 (0.0-48.8)	0.0	225.6 (56.5-360.2)	99.5 (56.5-128.2)	107.8 (84.8-140.9)
Nov.	17.5 (11.0-26.3)	4.6 (2.7-9.8)	1.5 (0.0-3.2)	8.8 (2.9-14.7)	17.2 (8.8-23.6)	16.4 (11.8-23.6)

Appendix Table 2. Mean monthly (Nov. 2004 – Nov. 2005) macroinvertebrate biomass (mg dry weight/m^3) by taxonomic group in Taneum Creek. Ranges are shown in parentheses for taxonomic groups appearing in more than one sample during monthly collections.

Month	Ephemeroptera	Tricoptera	Plecoptera	Adult Dipteran	Larval Dipteran	Other
Nov.	1.88 (0.68-4.85)	0.65 (0.38-0.96)	0.24	1.11 (0.87-1.37)	0.56 (0.28-1.03)	0.91 (0.38-1.04)
Dec.	0.62 (0.50-0.77)	0.48 (0.31-0.69)	0.50	0.51 (0.32-0.66)	0.66 (0.32-1.27)	0.58 (0.44-0.80)
Jan.	0.60 (0.58-0.62)	0.68 (0.56-0.85)	0.55 (0.46-0.72)	0.45 (0.40-0.50)	0.61 (0.39-0.85)	1.03 (0.62-1.72)
Feb.	0.83 (0.73-1.02)	0.42 (0.25-0.73)	0.44 (0.34-0.63)	0.49 (0.32-0.70)	0.84 (0.79-0.88)	1.00 (0.32-2.32)
March	0.93	0.64	2.37 (0.39 5.92)	3.36 (2.11-4.25)	1.72 (0.41-4.07)	1.48
April	1.81 (1.60-2.05)	1.48 (1.05-2.35)	4.04 (0.36-10.90)	3.19 (3.01-3.50)	1.84 (1.64-1.94)	7.32 (4.65-8.77)
May	2.05 (1.55-2.60)	1.96 (0.63-4.21)	0.50	1.60 (1.45-1.81)	1.59 (1.34-2.00)	3.26 (1.97-4.74)
June	1.51 (0.42-2.62)	0.54 (0.29-0.89)	0.53 (0.35-0.80)	1.52 (0.83-2.13)	0.92 (0.32-1.60)	3.39 (1.67-5.63)
July	0.76 (0.57-0.85)	0.54 (0.45-0.63)	0.32 (0.10-0.46)	0.88 (0.76-0.98)	0.80 (0.52-0.99)	2.63 (2.49-2.91)
Aug.	0.74 (0.39-1.13)	0.39 (0.25-0.59)	0.33 (0.21-0.41)	0.90 (0.69-1.19)	1.22 (0.52-1.79)	2.85 (1.15-5.32)
Sept.	0.67 (0.63-0.70)	0.28 (0.19-0.38)	0.15 (0.06-0.21)	1.01 (0.68-1.17)	0.61 (0.56-0.64)	0.99 (0.73-1.34)
Oct.	2.88 (1.95-4.24)	3.24 (1.46-5.94)	0.0	3.77 (0.28-7.88)	4.05 (1.68-8.77)	5.10 (2.32-9.90)
Nov.	0.63 (0.50-0.79)	0.50 (0.25-0.82)	0.24	0.64 (0.46-0.74)	0.93 (0.55-1.45)	1.93 (0.72-4.74)

Appendix Table 3. Mean monthly (March – Oct. 2006) macroinvertebrate densities (number/100 m^3) by taxonomic group in Taneum Creek. Ranges are shown in parentheses for taxonomic groups appearing in more than one sample during monthly collections.

	Taxonomic Group					
Month	Ephemeroptera	Tricoptera	Plecoptera	Adult Dipteran	Larval Dipteran	Other
March	16.4 (13.5-20.2)	5.64 (2.29-9.15)	15.36 (11.4-18.3)	170.4 (74.7-226.4)	156.3 (129.3-185.2)	50.40 (32.21-70.89)
April	15.52 (9.4-20.6)	85.94 (64.5-108)	14.49 (11.3-16.5)	406.6 (144.8-629.9)	415.1 (251.9-561.3)	81.83 (37.8-108.9)
May	51.25 (34.3-64.8)	17.84 (9.25-29.4)	6.49 (4.63-9.95)	81.7 (44.7-107.7)	44.9 (34.8-53.8)	166.4 (129.4-203.6)
June	16.05 (8.2-23.6)	16.35 (11.8-23.6)	2.95 (0.0-11.8)	260.3 (197.0-389.5)	202.6 (131.3-247.9)	472.6 (320.1-613.8)
July	743.8 (470.0-1155)	62.29 (36.5-113)	12.62 (6.7-23.8)	399.6 (229.9-494.4)	585.7 (263.8-1000)	671.3 (324.8-1334)
Aug	51.61 (34.9-63.4)	83.56 (18.8-137)	10.43 (9.2-12.7)	186.7 (171.0-216.3)	190.8 (148.9-258.9)	183.9 (148.1-244.7)
Sept	23.53 (18.34-27.46)	16.12 (3.7-22.7)	5.12 (3.67-6.20)	157.3 (151.1-163.2)	111.2 (57.8-146.8)	112.7 (59.9-175.8)
Oct	82.99 (64.05-110.5)	80.98 (76.8-85.0)	0.80 (0.0-2.40)	1280.7 (546-1929)	79.7 (38.43-119.02)	283.1 (158.4-529.5)

Appendix Table 4. Mean monthly (March – Oct. 2006) macroinvertebrate biomass (mg dry weight/m^3) by taxonomic group in Taneum Creek. Ranges are shown in parentheses for taxonomic groups appearing in more than one sample during monthly collections.

Month	Ephemeroptera	Tricoptera	Plecoptera	Adult Dipteran	Larval Dipteran	Other
March	0.42 (0.12-0.85)	0.24 (0.18-0.32)	0.22 (0.18-0.41)	2.58 (1.27-4.23)	1.37 (1.03-1.53)	0.74 (0.54-1.05)
April	0.70 (0.60-0.80)	0.46 (0.33-0.62)	1.43 (0.17-3.79)	5.99 (1.29-8.45)	5.26 (3.54-6.87)	2.87 (0.49-6.81)
May	1.10 (0.83-1.57)	1.84 (0.04-4.63)	0.41 (0.20-0.69)	1.10 (0.55-1.39)	0.76 (0.55-1.03)	1.50 (0.80-2.08)
June	0.40 (0.25-0.49)	0.59 (0.08-1.18)	0.24	1.66 (0.99-2.36)	1.20 (0.74-2.01)	2.72 (2.12-3.07)
July	1.79 (1.35-2.26)	0.58 (0.37-0.83)	0.17 (0.04-0.42)	1.83 (1.08-2.74)	1.75 (0.64-3.22)	5.20 (1.93-9.59)
Aug.	0.27 (0.12-0.43)	0.26 (0.07-0.36)	0.15 (0.03-0.26)	0.56 (0.48-0.68)	0.64 (0.35-0.83)	0.55 (0.53-0.57)
Sept.	0.28 (0.14-0.40)	0.70 (0.05-1.83)	0.05 (0.02-0.22)	0.80 (0.56-1.04)	0.20 (0.15-0.25)	1.92 (0.70-3.89)
Oct.	0.81 (0.09-1.28)	0.12 (0.02-0.34)	0.0	3.94 (3.71-4.25)	0.38 (0.43-0.85)	11.0 (2.54-17.0)

Appendix Figure 1. Location of sampling sites in Taneum Creek, Kittitas County, Washington.