SEDIMENT SOURCE ASCRIPTION OF FOREST ROADS IN THE UPPER LITTLE TENNESSEE RIVER BASIN

by

SETH EDWARD YOUNGER

(Under the Direction of David S. Leigh)

ABSTRACT

The purpose of this project was to better understand if geochemical fingerprinting could determine sediment provenance for catchments with and without USDA Forest Service Roads. Sediment source ascription is valuable because sediment is one of the most important non-point source pollutants affecting surface waters in the southeastern United States. Gravel roads represent surfaces of geologically fresh material, rich in weatherable minerals, some of which are preserved in transport, and distinguishable in sediment deposits. Sediment samples were collected from sources of active erosion as well as within the channel near watershed outlets. Analysis for 33 elements, along with statistical separation allowed provenance to be determined for roads and stream banks. Discriminant analysis shows that road sediment is differentiated by P, Mo, and Na. Bank sediment can be distinguished by Pb. Road sources accounted for 39 to 61% of bedload sediment and the remainder was from banks.

INDEX WORDS: geochemical, fingerprinting, geomorphology, sedimentation, erosion, bank erosion, Southern Blue Ridge Mountains

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CHAPTER 1

INTRODUCTION AND BACKGROUND

Geochemical sediment fingerprinting is a widely applied technique using unique signatures such as chemistry or color for determining the proportion of depositional sediment at watershed outlets that was produced by sources in a watershed (Yu and Oldfield, 1989; Walling et al., 1993; Collins et al., 2010). In this study geochemical fingerprinting was used to determine sediment provenance for catchments with and without gravel roads in forested watersheds of the Southern Blue Ridge Mountains (SBRM). This information is valuable because sediment is labeled as one of the most important non-point source pollutants affecting streams and water bodies in the southeastern United States (Neary et al., 1989; Simons, 1993; Miller et al., 2005). The influx of fine sediment (<2 mm) in streams degrades biotic health by transporting pollutants (Scott et al., 2002; Clinton, 2006). In addition, this sediment exacerbates reservoir infilling, which is a costly resource management problem (Oblinger, 2003). The ability to trace the sources of fine sediment is a valuable contribution to watershed management because it identifies areas that need mediation, and it allows for existing management practices to be evaluated.

There is an existing body of knowledge characterizing erosion from unsealed forest roads based on physical measurements. This study adds to the existing information on unsealed roads as current sediment sources and the ability to evaluate them using methods other than direct measurement or empirical models. The primary objectives of this study are to determine if Forest Service roads have unique geochemical signatures in sediment from other sediment sources, and to use those signatures along with available discharge and sediment rating data to develop an annual sediment budget. Sediment budgets allow for erosion rates from each watershed component to be determined.

Chapter 2 addresses the ability of sedimnet source ascription to determine sediment provenance from road and non road sources. The results are combined with available discharge and suspended sediment measurements to develop a sediment budget which is compared to the existing body of knowledge in the region. Chapter 3 highlights the major findings of this project.

CHAPTER 2

SEDIMENT SOURCE ASCRIPTION OF FOREST ROADS IN THE UPPER LITTLE TENNESSEE RIVER BASIN, USA

[1] Younger, S.E., Leigh, D.S. To be submitted to *Environmental Monitoring and Assessment*

Abstract

The purpose of this project was to develop an understanding of the ability of geochemical fingerprinting to indicate sediment provenance for catchments within and outside United States Department of Agriculture (USDA) Forest Service Roads in the Southern Blue Ridge Mountains. Sediment source ascription is valuable because sediment is one of the most important non-point source pollutants affecting surface waters in the southeastern United States (USEPA, 2000), especially in western North Carolina (Simons, 1993). Gravel roads, like the USDA Forest Service roads, represent surfaces of geologically fresh material, rich in weatherable minerals, some of which are preserved in transport and distinguishable in sediment deposits. In order to characterize the chemistry of source and depositional material, sediment samples were collected from areas of active erosion as well as within the channel near watershed outlets. Analysis of 33 elements, along with statistical separation allowed provenance to be determined for roads and stream banks. Road sediment could be distinguished with the greatest accuracy using P, Mo, and Na as tracers. Bank sediment was most distinguishable by Pb. Road sources accounted for 39 to 61% of bedload sediment. For Ball Creek that equaled 39.65 tonnes/yr (61.29%), assuming total sediment export was similar to that of the 2011 water year when sediment-rating data was collected and discharge was measured.

Introduction and Literature Review

Geochemical fingerprinting was investigated as a means to determine sediment provenance for catchments with and without gravel roads in forested watersheds of the Southern Blue Ridge Mountains (SBRM). Geochemical sediment fingerprinting correlates sediment contained in depositional areas, such as bedload or floodplain deposits, with a source area in a watershed by identifying unique chemical signatures (Yu and Oldfield, 1989; Walling et al., 1993; Collins et al., 2010). The list of properties that can be utilized for fingerprinting includes color, chemical properties, base cations, organic and inorganic constituents, magnetic properties, and radioactive isotopes (Krishnappan et al., 2009). Sediment fingerprinting has been used to answer many resource conservation questions related to natural and human-induced erosion sources including erosion from agriculture practices (Collins et al., 2010), and contribution of total sediment load by using differences in geology (Gingele and De Deckker, 2005).

Sediment source ascription is valuable because sediment is labeled as one of the most important non-point source pollutants affecting streams and water bodies in the southeastern United States (Neary et al., 1989; Simons, 1993; Miller et al., 2005). The influx of fine sediment (<2 mm) in streams degrades biotic health by transporting pollutants including nitrogen, phosphorus, trace metals, pesticides, and herbicides (Scott et al., 2002; Clinton, 2006). In addition, reservoir sedimentation is an ongoing problem for Lake Fontona, North Carolina, and other reservoirs in the Upper Little Tennessee Basin (Neary et al., 1989; Oblinger, 2003). The ability to trace the sources of fine sediment is a valuable contribution to watershed management because it identifies areas that need mediation, and it allows for existing management practices to be evaluated. One source of fine sediment that needs to be studied more intensively is unsealed roads.

In the SBRM, most roads are paved except on USDA Forest Service and private land where access roads are not traveled enough to justify paving. Sediment production by (USDA) Forest Service roads in the SBRM is a resource conservation issue that has been studied since the 1970s, but is still of interest as roads age (Swift, 1985). Depending on topography, ditch topology, and proximity to channels, some sediment from road surfaces and ditches will reach streams (Reid and Dunne, 1984). Roads have been shown to contribute large proportions of sediment to streams and are often the major source of soil erosion in forested land (Patric, 1976). This is particularly true of unpaved roads that have permeable surfaces sensitive to moisture changes, traffic (Reid, 1984), and disturbance by maintenance activities (Swift, 1984a). The earliest development in road construction was an effort to reduce the length of slope that water could travel using broad based dips at close intervals along the road grade to route water off the road onto the forest floor.

Studies of forest road erosion at the Coweeta Experimental Watershed measured erosion directly before and after vegetation and gravel surfacing were completed to illustrate their effectiveness (Swift, 1984a; Swift, 1984b). Erosion was measured separately from the three road components (cut banks, road beds, and fill slopes) by isolating them with berms covered in plastic sheeting. Erosion was measured using drop inlets and broad based dips to collect flow from the road bed, and metal troughs to collect flow from cut and fill slopes (Swift, 1984b). Findings were that sediment production from cut and fill roads was the greatest during post-construction, logging equipment passage, and vegetation establishment at an average of 3.88 tonnes/hectare/yr. After vegetation was established on cut and fill banks and gravel was applied to the road surface erosion rates were greatly reduced to an average of 0.857 tonnes/hectare/yr for the entire road surface (Swift, 1984b, 1985).

These early studies at the Coweeta Experimental Watershed and elsewhere in the SBRM led to development of improved construction methods and mitigation approaches to reduce the connection of road sediment to streams (Swift, 1984a; Swift, 1984b; Riedel and Vose, 2002). Among the most important findings were that stabilization of slopes, and establishment of natural vegetation, significantly reduced cut bank erosion. In addition, use of larger diameter gravel at a sufficient depth (15-20cm) reduced erosion of the road surface (Swift, 1984a). Road design and retrofit improvements include, vegetated buffer strips, ditch turn outs to the forest floor, cross draining culverts routing to the forest floor, and ditch sediment traps that were all designed to trap sediment near its source and before it could reach stream channels (Swift 1984a, Swift 1984b). As a result of these improvements and cut bank stabilization over time, it was expected that current erosion rates would be much less than those observed historically. Geochemical fingerprinting combined with sediment budgeting offers the opportunity to determine current erosion rates. Relatively few geochemical fingerprinting studies focus on unsealed forest roads, and only one study is known in the SBRM (Miller et al., 2005).

Miller (2005) studied historic sedimentation in the Fairfield Lake basin, North Carolina (impounded in 1890) using chemical fingerprinting to determine the provenance of lacustrine sediment. The study found that road construction, deforestation, and development were the primary sources through history. The findings were consistent with landcover modification in the basin, which included an increased number of homes and roads. Additionally, research on mineral weathering rates indicates that the soils from forested watersheds are much more depleted of weatherable minerals than unweathered gneiss or granite gravel of the road surface (Velbel and Price, 2007). This suggests that if forest roads in the SBRM are contributing sediment to streams it should be chemically identifiable.

Outside of the SBRM some studies exist that illustrate the ability to fingerprint road sediment at watershed outlets based on geochemical properties. A geochemical fingerprinting study on the North Fork of the Broad River, GA found that unpaved roads and construction sites contributed 23 to 30 percent of the suspended sediment load collected during high flow events (Mukundan et al., 2010). In Victoria, Australia geochemical and radiometric tracer properties were employed to determine that unsealed roads contributed 20 to 60 times more sediment than undisturbed forest and approximately 10 times more than harvested forest areas on a per unit area basis (Motha et al., 2003). A study in Chichester State Forest, New South Wales, Australia relied on soil color as a tracer for road fill sediment that was transported as part of a mass movement event (Erskine, 2013). They found that the fill sediment had been confined to a few hundred meters of a zero order channel and had not reached the nearby stream in significant quantity. In addition, studies have illustrated that traffic related materials including lead from gasoline prior to 1968 (Sutherland et al., 2003), platinum group metals (Rauch et al., 2000), and tire tread particles (Unice et al., 2012) are present in road sediments, but these properties have been underutilized for sediment fingerprinting purposes. Because there are very few fingerprinting studies that traced sediment from gravel roads, and only one in the SBRM we believe this research has important implications for watershed scale sediment budget construction.

Project Objectives

The purpose of this project was to identify all of the eroding components of forested watersheds associated with USDA Forest Service roads and to determine if they could be statistically separated based on chemistry. Sediment sources were sampled with each soil horizon collected separately. Assuming success, a sediment budget would be constructed based on the sediment fingerprinting results, existing streamflow, and total suspended solids data for the 2011 water year. The sediment budget would allow for comparison of erosion rates from forest service roads to other parts of the basin, and to historic road erosion rates in the region.

The specific objectives were as follows:

1. Determine if USDA Forest Service gravel roads and road cuts have a unique geochemical signature compared to other components of the watershed (hillslopes and stream channels).

2. Analyze the geochemical signature of bedload and suspended sediment from forested watersheds with and without USDA Forest Service roads to determine the contribution of Forest service roads to bedload and suspended load sediment contained at the outlet of each watershed, according to methods described by (Collins et al., 1997).

3. Compare the results of a geochemically-derived sediment budget to modeled results of the Revised Universal Soil Loss Equation version 2 (RUSLE2) (Renard, 1991).

The hypotheses were that forest service roads would have more Ca, Mg, and Na due to the fresh mineralogical nature of gneiss and granitic road gravels. These elements would allow road-derived sediments to be differentiated from other sources in the basin (Velbel, 1989). Streambank sediment from naturally weathered saprolite hillslopes sampled by horizon would allow for comparison. A and E horizons were expected to be more depleted of weatherable minerals than road gravel, B Horizons were expected to contain more clay and iron oxides than road surfaces. Of the sediment collected from the watershed outlet, it was expected that a significant proportion would be from the road surface and ditch margins. Estimates of sediment export from sediment fingerprinting were expected to be similar to those derived from the RUSLE model, thus providing a consensus for modeled values of sediment sources.

Methods

Study Area

Two watershed pairs were chosen wherin each pair represented National Forest with and without USDA Forest Service roads (Figure 2.1). Ball Creek contains one of the pairs and was included in the study because streamflow and suspended sediment data available from a concurrent study would allow for construction of a sediment budget. Ball Creek is a 7.22 square kilometer watershed within the Coweeta Experimental Forest of Otto, North Carolina. It is representative of a typical forested watershed in the region with USDA Forest Service roads. Landcover consists of 99.50% forest, 0.01% grass, and 0.49% gravel road. The forest is predominantly hardwood with laurel and rhododendron understory, evergreen stands are scattered throughout the basin. Ball Creek has a weir, which acts as a bedload sediment trap, except when overtopped by extremely high flow. Paired sub-basins within Ball Creek are Lick Branch and Reynolds Branch. Lick Branch is 0.4 square kilometers and is 100% forested. Reynolds branch is 0.59 square kilometers and is 98.4% forested and 1.6% gravel road. On average the roads within Reynolds Branch are much steeper than those in Ball Creek and there are three locations where part of the road surface drains to streams by directly connected ditches (Figure 2.2).

Darnell Creek is a 13.3 square kilometer basin within the Chattahoochee National Forest of Rabun County Georgia. Within the Darnell Creek watershed paired sub-basins are Ramey Creek and Hoojah Branch. Ramey Creek has a 2.10 square kilometer drainage area and is nearly 100% forested aside from a small field and a 1km trail that is primarily grass. Hoojah Branch is 1.95 square kilometers with 99.75% forest and 0.25% forest road.

Geologically all of the study basins are in the Coweeta group, which is comprised of metasedimentary and metaigneous rocks, overlying the Tallulah Falls Formation. The group is composed of three formations; Persimmon Creek Gneiss is the oldest, overlain by the Coleman River Formation, which is overlain by the Ridgepole Mountain Formation. The Persimmon Creek Gneiss is massive feldspar-quartz-peltic schist. The Coleman River Formation is comprised of metasandstone, mafic poor gneiss and peltic schist. The Ridgepole Mountain Formation has lithologic variation, but is dominated by biotite garnet schist, and impure to clean quartzite (Hatcher, 1979).

Field Methods

Fieldwork was completed between September 23rd and October 30th 2011. Sediment source categories included a surface organic-rich A horizon on the stream bank, a subsurface non-organic stream bank horizon, the road surface and road ditches. Road cutbank erosion was not present in the study watersheds due to leaf litter cover and stabilization by vegetation. A target sample size of ten composite samples for each source in each watershed was chosen to ensure sample power. Composite samples incorporated at least three nearby subsamples, each sample location was photographed (Appendix A). All sediment was collected using a Polyvinyl chloride (PVC) trowel to prevent metal contamination and it was cleaned between samples to prevent carryover. Road sediment was collected from gravel material of the road surface, and material in adjacent ditches that had already been transported and deposited a short distance from the eroded road surface. Stream bank samples were collected to represent the dominant surface and subsurface horizons, which in most cases consisted of a surface O and A horizon and a subsurface E and/or B horizon. Bed samples were collected along a fifty-meter length of the stream channel upstream from each basin outlet. For Ball Creek it was assumed that the upland samples collected in the paired subbasins was representative of Ball Creek as a whole and those samples would be used in fingerprinting Ball Creek bed sediment for the entire basin.

Suspended sediment was collected from the watersheds with roads (Ball Creek, Hoojah Branch and Ramey Creek) from February 23rd to April 30th 2012 using a time integrating sampler (Figure 2.3). The sampler works as a settling tank by allowing a 4 mm diameter stream of inflow into a ~100 mm diameter PVC tube, and a 4 mm outflow. The decrease in flow as a result of the limited flow stream allows settling of a representative sample of suspended sediment (Phillips et al., 2000). The sampler was suspended above the base flow water level (Figure 2.4) to collect sediment when baseflow was exceeded. Sediment was collected from the sampler by sealing the outlet, removing the threaded cap from the inlet end and pouring the water and sediment solution into a plastic container for transportation to the lab. The sediment was allowed to settle, excess water was siphoned off, and the remainder of the moisture was removed by evaporation. Suspended sediment was not collected from watersheds without roads.

Laboratory Methods

Sample preparation was carried out at the University of Georgia Geomorphology Lab. Sediment samples were oven dried at 60° C and dry sieved to <0.25 mm. One-gram samples were crushed, bagged, and shipped to a private commercial laboratory (ALS Chemex) for analysis of 33 elements (Table 2.2). Near-total element decomposition was performed using a 4 acid digest (HCl, HNO_3, HF, $HClO_4$) and elemental concentrations were determined by inductively coupled mass spectroscopy. Ten replicate road samples from Reynolds Branch and five GXR6 (United States Geological Survey) standard samples were distributed throughout the batch to ensure reliability and consistency of results (Table B2). Phi scale particle size analysis by sieving was conducted for road sediment in order to understand the amount of road sediment susceptible to transport by sheet flow over the road surface. Organic carbon content was measured by loss on ignition (LOI). Samples were placed in a 550°C muffle furnace for 4 hours to combust organics (Heiri et al., 2001).

Data Analysis

Of the 33 elements Ag, Bi, Cd, Sb, Tl, U, and W were removed because all or the majority of the samples had concentrations near or below detection limits. The remaining 25 elements were divided by Aluminum (Al), to normalize the chemical data and make them more useful for comparisons. Al is a commonly used conservative element for geochemical normalization, and it helps to account for grain size variation, because most clays contain abundant Al as aluminosilicate clay minerals (Horowitz et al. 1988; Windom et al. 1989; Horowitz 1991; Covelli and Fontolan 1997).

Fingerprint selection for each watershed was performed using the two-stage procedure developed by Collins et al. (1997). The first step employed the Kruskal-Wallis rank sum test, a non-parametric procedure for detecting differences in populations, to compute the H statistic for each element in each watershed. Only the elements that were significantly different with a p-value less then 0.05 made it to stage two of the procedure (Table 2.3). In other words, the H statistic indicates that the sediment source classes are significantly different if they have p-values <0.05. The Kruskal-Wallis test does not indicate how the source categories are different, and that was determined based on stage two of the procedure, stepwise discriminant analysis. Although discriminant analysis assumes a normal distribution the results are still reliable if nonnormality is due to skewness rather than outliers in the data (Tabachnick and Fidell,1996). To confirm that outliers did not affect the distributions density curves were examined for each variable before proceeding with discriminant analysis. Stepwise discriminant analysis based on the minimization of Wilks' lambda was used to identify the smallest group of variables that could discriminate the sources. Variables satisfying the partial F ratio and tolerance level are added in order of their explanatory power. Stepwise discriminate analysis is complete when all source samples are correctly classified, or when adding variables fails to improve sample discrimination. Elements that pass both stages of selection become the tracer sets, which are all of the variables used to determine source area contributions for each watershed. The explanatory power of each individual tracer is quantified by the percentage of each source category predicted correctly. The mean of each fingerprint property for each source category provides additional information on the variations among source categories.

To model sediment source area contributions a mixing model was implemented to determine the proportion of sediment delivered to each watershed outlet from each source. The model was originally developed by Yu and Oldfield (1989) and later modified by Collins et al. (1997). The model requires that each upland sediment source contribute some sediment to the downstream mixture. The objective of the model is to assign all downstream sediment to one of the upland sources while minimizing the relative error between the tracer values in the source and deposition samples (Collins et al., 1997; Miller, 2005). The model equation was solved using the Quadratic programming package in the Optimization Toolbox for MATLAB®.

Sediment Budget

Ball Creek Weir 9 discharge for the 2011 water year was available from an existing study at Coweeta (Figure 2.5, Appendix D). That study used an ISCO™ sampler to collect stage and suspended sediment measurements during storm flow events. Water discharge was derived from a stage-discharge relationship, based on direct discharge measurements with a flow meter at various stages, and a sediment-rating curve was developed from the suspended sediment observations (Figure 2.5) in the form of a power function ($Qs = aQ^b$).

Where: Qs = suspended sediment load

Q = water discharge (m^3s^{-1})

a and b are regression coefficients

a = 0.2385 b = 0.701 $R^2 = 0.2733$

Those existing data were used to estimate total sediment exports for the 2011 water year and combined with the results of the mixing model to create a sediment budget. The budget allows denudation rates to be computed, which are analyzed in the context of existing literature in the region.

Sand Mineralogy

To help evaluate the results of chemical source separation Ball Creek sand mineralogy was classified visually into parent material rock and mineral classes (Lucas et al., 1978). The parent material classes included monomineralic garnet, mafics, quartz, and rock fragments of mica/biotite rich rocks or quartz/feldspar rich rock fragments. Sand grains 1-2 mm in size were cleaned with a sodium metaphosphate solution (50 g/L), separated by wet sieving, and dried. Photographs of approximately 300 grains per sample were taken at 10X magnification and counts were taken of the number of grains in each class. Rather than counting manually, grains were identified in a Geographic Information System (GIS) using a separate point for each grain. A geodatabase feature class with the five grain classes as subtypes helped streamline the data entry and provides a permanent record (Appendix C). Percentages for each sample and each class were calculated and summarized. In general Quartz/feldspar rocks should indicate road sediment while mica/biotite rocks indicate sediment from natural parts of the basin, which in this case is bank sediment.

Modeling Erosion with RUSLE2

RUSLE2 was used to simulate erosion for Ball Creek watershed as an independent estimate of soil loss. RUSLE2 is an empirical soil erosion model that leverages physically meaningful input data that are widely available or can be computed (Renard, 1991). The RUSLE2 factors are R, K, LS, C, and P. The R factor is a rainfall factor based on average annual rainfall. The assumption is that when other factors are constant storm losses from rainfall are proportional to the product of the total kinetic energy of the storm (E) times its maximum 30-minute intensity (I). The K factor represents susceptibility of soil to erosion and the rate of runoff, as measured under the standard unit plot condition. The LS factor is a combination of slope length L and slope steepness S. The C factor is a cover management factor and is used to represent the land management conditions. The P factor reflects the impact of support practices such as contour plowing for agriculture, or ditch turnouts for forest roads, represented as the ratio of soil loss with management practices to soil loss without management.

Data sources include a Digital Elevation Model (DEM) with a one-meter cell size, which was derived from a Light Detection and Ranging (LiDAR) dataset (http://lidar.cr.usgs.gov/, 2007). Length slope factor was calculated using the *LS-TOOL*, an open source visual basic program that uses a DEM to produce slope, slope length, and the LS factor (Zhang et al., 2013). Landcover data from the 2006 National Landcover Dataset was modified to include the road and cut/fill surfaces by digitizing them from a combination of the 2007 North Carolina Floodplain Mapping Program orthoimagery, (http://www.mrlc.gov/nlcd2006.php, http://www.ncfloodmaps.com/) and a slope map produced from the DEM. The R factor was obtained from the USDA Isoerodent maps of the United States (Renard et al., 1997). The K-factor was derived from the National Resources Conservation Service Soil Survey Geographic database (SSURGO). Road soils were reclassified to 0.24 a K-Factor representing gravelly loam. The RUSLE2 equation (R * K * L * C * P) was computed using ArcGIS 10.1 Raster Calculator.

Results

Particle size data for road sediment (Table E1) show that on average 72-92% of road sediment is <2mm, which could be transported by overland flow on the roadbed surface. An average of 6.12- 13.75% is <63μm, which could be transported in suspension if it reaches the stream channel.

The Kruskal-Wallis rank sum test results indicate which elements are significantly different among the source classes in each watershed and those were passed on to stage two of the selection process (Table 2.3). The elements that passed stage two make up the tracer set for each watershed, which is all of the elements that are used to separate the downstream sediment into the upland source categories (Table 2.4). For Ball Creek 13 elements passed stage one and went on to stage two. After stage two the tracer set for Ball Creek consisted of As, Na, P, S, Sr, Zn and LOI. Forest roads were classified with the greatest accuracy based on P, S and Na which occur in relatively high concentrations in the geologically fresh road gravel. Bank sediment was classified with the greatest accuracy based on LOI from organic rich A horizons, Na classified approximately half of bank samples correctly (Table 2.6). Those factors along with the combined differences in the tracer sets allow the mixing model to determine source contributions.

Fingerprinting of bedload sediment in Ball Creek sourced 94.61% from roads and 5.39% from banks (Figure 2.10). For three of the ten Ball Creek bed samples and all of the suspended sediment samples the model was unable to reach a solution. For the bed samples this is because the samples were collected at different points along a transect and some areas likely had high bias in particle size even though depositional areas were targeted. For suspended sediment it is most likely because of a particle size bias between the 0.25mm upland samples and suspended sediment, which is likely made up of finer fractions. For Lick Branch the Kruskal-Whallis test showed that the two bank classes were not significantly different for any of the tracer properties. For Reynolds Branch nine elements passed stage one of statistical selection. After stage two the tracer set for the watershed consisted of Na, P, and LOI. Na and P did a good job of classifying road sediment and LOI performed well at classifying bank sediment. Fingerprinting results were 92.31% from roads and 7.69% from banks, however the model could not reach a solution for two of the bed sediment samples or the suspended sediment sample.

For Hoojah Branch 14 elements passed stage one of selection and after stage two the tracer set consisted of Ba, Be, Cu, K, Mo, Na P, S, Sr, and LOI. Roads samples were classified with the greatest accuracy by Sr, Mo and LOI. Banks were most distinguishable by LOI and S. Bedload sediment was made up of 80.90% road sediment and 19.1% bank sediment (Figure 2.10). One suspended sediment sample and three vertical accretion samples were collected but the model was able to reach a solution for only one of the vertical accretion samples, which was

62.07% from roads and 37.93% from banks. Ramey Creek tracers were reduced to 12 elements after stage one of statistical selection, only Be survived stage two. The mixing model was unable to reach a solution for any of the ten bedload samples from Ramey Creek, it is not clear why.

Stepwise discriminant analysis was rerun excluding LOI because it was suspected that LOI is not conservative in bedload sediment. Without LOI the tracer set for Ball Creek consisted of P, Pb, S, Zn, Sr, Ca, Sc, Mn, As, Na, Ni, and Mg. Forest roads were classified with the greatest accuracy based on P, S and Na. Bank sediment was classified with the greatest accuracy based on Pb, Na classified approximately half of bank samples correctly (Table 2.6).

Fingerprinting of bedload sediment in Ball Creek without using LOI sourced 61.29% from roads and 39.65% from banks (Figure 2.11). For one of the ten Ball Creek bed samples and the suspended sediment sample the model was unable to reach a solution. For Reynolds Branch after stage two without using LOI the tracer set for the included P, Pb, Na, As, Mg, and Sr. Na and P did a good job of classifying road sediment and Pb performed well at classifying bank sediment. Fingerprinting results were 39.19% from roads and 60.81% from banks, however the model could not reach a solution for the suspended sediment sample.

For Hoojah Branch after stage two without using LOI the tracer set included Mo, Sr, Pb, Ba, K, Be, Cu, Na, P, and S. Roads samples were classified with the greatest accuracy by Mo, and Sr. Banks were most distinguishable by Be and Cu. Bedload sediment was made up of 58.98% road sediment and 41.02% bank sediment (Figure 2.11). One suspended sediment sample and three vertical accretion samples were collected but the model was able to reach a solution for only one of the vertical accretion samples, which was 59.91% from roads and 40.09% from banks. Sediment fingerprinting based on tracer selection excluding LOI are considered to be more realistic for these watersheds so those values are reported in the sediment budget below, both sets of values are compared (Table 2.15)

Sand mineralogy counts were summarized for Ball Creek bed sediment, Reynolds Branch road and bed sediment, and Lick Branch bed sediment to show variation among road versus non-road watersheds (Figure 2.11). The garnet and mafic classes were not dominant nor did they have significant differences among the watersheds so they are ignored (Table 2.12). Road sediment is most dominant in quartz/feldpsar rock fragments with an average of 65.09% the next most common is quartz at 20.17% and mica/biotite was 13.37%. Reynolds Branch bed mineralogy was 21.65% quartz/feldspar rock fragments, 48.17% quartz and 29.37% mica/biotite. Assuming all of the grains containing feldspar came from roads indicates that Reynolds Branch bed sediment contains at least 21% road sediment and Ball Creek contains at least 40% road sediment. Uncertainty lies in the proportion of monomineralic quartz bed sediment that is from roads. This may be resolved by evaluating the mineralogy of bank sediment.

Based on the rating curve, sediment discharge for the 2011 water year data was 64.69 tonnes/yr. RUSLE2 estimated erosion at 133.49 tonnes/yr for the Ball Creek basin. Assuming a sediment delivery ratio of 0.57, computed by the WEPP model (Flanagan et al., 1995), total sediment export would be 76.09 tonnes. The difference is that RUSLE2 predicts a very small amount of erosion over the entire basin when it reality the majority of erosion is confined to the road, stream banks, and the channel. The average erosion rate RUSLE2 predicted from forest roads was 1.10 tonnes/hectare/yr, for the forest floor 0.18 tonne/hectare/yr, and for the banks and channel 0.08 tonne/hectare/yr (Table 2.13).

Based on the sediment budget and sediment fingerprinting without LOI 25.04 tonnes of stream bank sediment is exported. Taking that amount and distributing it over the total bank area is more complicated, mostly because it is difficult to know the erodible bank height for the entire stream length. Based on work by (Rogers and Leigh, in press) 60cm is estimated. Combining the bank height with a total stream length in Ball Creek of 27560.82 meters and soil bulk density of 1.3 g/cm^3 (Price et al., 2010) yields a lateral migration rate of 0.0559 cm/yr. This is a low migration rate based on research in the region (Harden 2009, Rhoads et al., 2009).

Taking the total exported sediment load from the basin and fractionating the percentage of erosion estimated from roads yields a value of 39.65 tonnes, or 10.99 tonnes/hectare. Assuming a soil density of 1.73 g/cm^3 (Helvey and Kochenderfer, 1989) yields a denudation rate of 0.635 mm/year for the entire road area in Ball Creek watershed. It is important to note that the entire road surface does not contribute sediment to streams. Due to the effectiveness of road design only small proportions of the road surface are connected to streams, which means that those parts of the road have much higher denudation rates.

Ball Creek's total annual sediment export of 64.69 tonnes is equal to 0.088 tonnes/hectare, which is within the 0.15 tonnes/hectare average erosion rate observed by existing studies of forested basins in the SBRM (Simons, 1993). It is important to note that the R^2 for the sediment-rating curve was low at only 0.2733. However, this is the best available estimate and the total exported sediment load is a reasonable value for this type of basin.

Discussion

In the selected study watersheds of the SBRM forest road sediment is distinguishable from bank sediment based on chemistry. This is fitting with existing research in the region and the Coweeta Experimental Watershed, which found that naturally weathered saprolite has much lower concentrations of weatherable minerals (Velbel, 1993; Velbel and Price, 2007). However, there were limitations to the number and type of identified erosional sources that could be geochemically discriminated. For watersheds with roads the mixing model could separate bank sediment from road sediment but could not separate the two bank horizons from each other. This could be because downstream sediment is dominated by one of the bank horizons, or because three sediment sources create too many degrees of freedom for the model to determine a solution.

Source ascription of bedload sediment from watersheds with roads was successful. However, ascription of suspended sediment was unsuccessful and ascription of vertical accretion sediment was only successful for one sample in Hoojah Branch. The reason is unclear, but is likely because of particle size variation between the <0.25mm fraction that was analyzed from source categories and the suspended sediment which should be dominated by finer fractions. Solutions would be use of the 63μm fraction for all chemical analysis, or to collect a larger sample with which to perform full particle size analysis and correction. Suspended sediment was not collected from watersheds with only bank sources but it is likely that suspended sediment would be more successful for discriminating bank sources of sediment.

For Lick Branch the two bank sediment classes were not significantly different, which has several possible explanations. One is that the sample sizes of the bank classes are too small, because only two locations with active bank erosion were identified in the watershed. The second most likely explanation is that the majority of the sediment came from the A horizon soil and very little if any sediment from the B-horizon sources reached the watershed outlet. This is partially supported by the LOI values for Lick Branch sediment, which on average are nearly twice as high as Reynolds Branch and Ball Creek. The third and least likely scenario is that there was a third unknown sediment source that was not identified. For whatever reason, chemical fingerprinting was not possible for Lick Branch watershed.

For Hoojah Branch fingerprinting results show that roads produce only a slightly smaller proportion of sediment than Ball Creek even though there is less road area in the basin. It appears this is the case due to the close proximity of the road to the watershed outlet and because a road crossing upstream from the outlet contributes sediment directly to the stream. In addition, the culvert passing under the road crossing is elevated above the streambed acting as a bedload sediment trap.

Ramey Creek fingerprinting efforts were unsuccessful and only one of the elements survived stage two of the selection process. It is difficult to understand the exact reasons; it is most likely complex erosion and depositional patterns and or particle size variation. Another possibility is a chemically different bank source exists in the basin that was not identified in the sampling campaign. This is possible based on the poor fit in the mixing space between the source and bed samples. Based on field observation it appeared that the majority of sediment was from the subsurface banks because the channels have much more erosion and lateral migration than in Ball Creek. This was evident by the wider channels, vertical cut banks, undercuts, and fresh exposed tree roots.

Mineral classification results for Ball Creek show that a significant proportion of bed sediment is from roads but the values are lower than those from chemical fingerprinting. Mineralogy for Reynolds Branch and Ball Creek suggests that at least 21-60% of sediment is from road sources. This shows that road sediment is a source to be concerned about even though the mineralogy estimates are low. Because quartz and feldspar are difficult to differentiate visually the method would be improved by staining the feldspar grains.

Historical research in the Coweeta Creek basin directly measuring soil loss from roads found the erosion rate for road beds after graveling averaged 1.14 tonnes/hectare (Swift, 1984b). Swift (1984a) observed that stabilization of slopes and establishment of vegetation significantly reduced erosion rates for cut banks and gravel surfacing reduced erosion from the road bed in most cases. In addition development of techniques to manage and trap sediment near its source using filter strips allowed sediment delivery rates to be reduced even where erosion was occurring (Swift, 1986). Better management features in Ball Creek including filter strips and sediment traps (Figure 2.12) should mean that erosion rates have decreased from historic levels. However, the fingerprinting results don't support this for Ball Creek. However, the cutbanks that were observed in Reynolds Branch were stable and either covered in leaf liter or vegetated thus not contributing sediment, which confirms historical findings (Swift, 1985).

RUSLE2 cumulative results at the watershed scale provide a similar estimate to the sediment-rating-curve derived estimates, but with a high bias. RUSLE2 did not do a good job at predicting erosion rates from forest roads. However, RUSLE2 has not been designed or heavily tested in predicting surface erosion from forest roads, which means management factors are difficult to define. For the purposes of this research management factors were assumed to be similar to those for bare ground. Ditch routing is also not accounted for by RUSLE2, so in some cases erosion from roads is expected to be underestimated and vice versa. Still the cumulative results from the model are generally fitting with the sediment-rating-curve derived estimates of total sediment export. This shows that it may be possible to create sediment budgets in watersheds without available flow data by using the annual sediment export rates from a model like RUSLE2 to determine the total erosion from a basin along with fingerprinting methods to determine the amount from individual sources. Since this comparison is only available for a single watershed further study is needed to understand the reliability.

Because chemical data was only collected at a single point in time this study was not able to draw conclusions about the seasonal variations in erosion and sedimentation. However, the results should be representative of average annual conditions in the SBRM. Much more sediment is eroded and transported during high flow conditions. In addition bank erosion increases during the winter season when freeze thaw processes occur and loosen the bank sediment.

Bedload sediment was collected near the watershed outlet, which means that variability along the channels in unknown, although higher concentrations of road sediment near ditch to stream connections is expected. The abundance of cobble near watershed outlets suggests that high flow events have the power to mobilize bedload material, which should create a reliable average for the watershed at the outlet. In addition the roads have existed in the basins since deforestation in the early 1900's and have been contributing sediment all of that time, which means that bedload sediment from roads could have accumulated in the channels in higher concentrations than the proportion produced on an annual basis. Due to the potential transport power of these mountain streams at high flow this is not expected to be a dominating factor. LOI did a good job at discriminating upland sources but it was not a good tracer for determining bedload sediment sources due to organic matter being exported more rapidly than non-organic bedload sediment.

Conclusion

Sediment source ascription successfully differentiated forest road sediment from bank sediment. This is a promising finding because it may be possible to detect the same road signatures downstream in the Little Tennessee River and in Lake Emory. The technique has some limitations including, site specific fingerprints, cost associated with fingerprint establishment, difficulty in sampling remote sources, and the need for particle size and organic matter correction. In addition the sensitivity to non-conservative tracers such as LOI is very high so care must be taken to exclude them. Still the technique has value to managers because source identification is a key step in the mitigation process.

This research gives an interesting look back at historical research in the Coweeta Experimental Forest and shows that, careful road management, establishment of vegetation and gravel, along with natural stabilization over time significantly reduces erosion from forest road cut and fill banks. Ball Creek did not have any unstable cut banks except near the watershed divide so the ability to distinguish these sources in watersheds where they do contribute sediment to streams is unclear. It is unclear why the roadbed erosion rate is so much higher than suggested by historical research, which measured erosion directly. It is safe to assume that road segments near streams, especially those with direct connections, are greater contributors per unit area than the average rate.

Further study is required to understand how far downstream road sediment can be detected. It is possible that signatures are detectable in higher order streams; on the other hand it's possible that other sources in the basin have similar signatures. For example many private driveways exist in the Little Tennessee River Basin and it is safe to assume that their signatures are indistinguishable from forest road signatures. Nonetheless, general discrimination of gravel road sources may be possible.

Future study should use the finest possible particle fraction and collect large enough samples for particle size and organic matter correction. With these considerations sediment fingerprinting is a valuable technique for environmental monitoring and assessment purposes.

A significant downside to chemical fingerprinting is the cost of chemical analysis. Each sample costs approximately twenty dollars, which means that sampling multiple sources for many watersheds may not be feasible. This makes it important to conduct statistical power analysis as part of the sample design to ensure that sample sizes are not too small. Alternative methods including mineralogical source separation could provide valuable information, especially if feldspar staining is used. However, further investigation is needed to better understand it applicability.

Table 2.1. Slope, drainage area, and geologic makeup of the study watersheds.

Name	Mean Slope %	Area km^2	Geologic formation/type
Ball Creek	24.72	7.22	Coleman River Fm., Persimmon Crk Gneiss, Ridgepole Mt.
Lick Branch	25.35	0.40	Persimmon Crk Gneiss & Coleman River Fm.
Reynolds Branch	26.51	0.59	Coleman River Fm.
Hoojah Branch	21.37	1.95	biotite gneiss
Ramey Creek	18.67	2.10	biotite gneiss

Table 2.2. Chemical tracer properties and analysis ranges in parts per million unless otherwise noted.

Element	Symbol	Analysis Range (ppm)	Group
Aluminum	Al	0.01%-50%	Poor Metal
Antimony	Sb	5-10,000	Poor metal
Arsenic	As	5-10,000	Non-metal
Barium	Ba	10-10,000	Alkaline Earth
Beryllium	Be	0.5-1,000	Alkaline Earth
Bismuth	Bi	2-10,000	Poor Metal
Cadmium	Cd	0.5-1,000	Transition Metal
Calcium	Ca	0.01%-50%	Alkaline Earth
Chromium	Cr	1-10,000	Transition Metal
Cobalt	Co	1-10,000	Transition Metal
Copper	Cu	1-10,000	Transition Metal
Gallium	Ga	1-10,000	Poor Metal
Iron	Fe	0.01%-50%	Transition Metal
Lanthanum	La	10-10,000	Rare Earth
Lead	Pb	2-10,000	Poor Metal
Magnesium	Mg	0.01%-50%	Alkaline Earth
Manganese	Mn	5-100,000	Transition Metal
Molybdenum	Mo	1-10,000	Transition Metal
Nickel	Ni	1-10,000	Transition Metal
Phosphorus	P	10-10,000	Non-metals
Potassium	K	0.01%-10%	Alkali Metal
Scandium	Sc	1-10,000	Transition Metal
Silver	Ag	0.5-100	Transition Metal
Sodium	Na	0.01%-10%	Alkali Metal
Strontium	Sr	1-10,000	Alkaline Earth
Sulfur	S	0.01%-10%	Non-metal
Thallium	Tl	10-10,000	Poor Metals
Thorium	Th	20-10,000	Rare Earth
Titanium	Ti	0.01%-10%	Transition Metal
Tungsten	W	10-10,000	Transition Metal
Uranium	U	10-10,000	Rare Earth
Vanadium	V	1-10,000	Transition Metal
Zink	Zn	2-10,000	Transition Metal

Table 2.3. Kruskal-Wallis rank sum test results by watershed.
* Denotes significant p value at <0.05.

		Ball Creek			Lick Branch		Reynolds Branch		
Element	**Symbol**	**Chi-Sq**		**p-value**	**Chi-Sq**	**p-value**	**Chi-Sq**		**p-value**
Arsenic	As	9.152	*	0.010	4.714	0.194	9.680	*	0.008
Barium	Ba	0.402		0.818	3.571	0.312	1.739		0.419
Beryllium	Be	0.692		0.708	3.143	0.370	0.096		0.953
Calcium	Ca	16.618	*	<.0001	3.571	0.312	9.620	*	0.008
Cobalt	Co	0.904		0.636	0.143	0.986	0.275		0.872
Chromium	Cr	4.932		0.085	3.571	0.312	2.211		0.331
Copper	Cu	0.732		0.694	3.571	0.312	1.556		0.459
Iron	Fe	5.803		0.055	4.714	0.194	3.776		0.151
Gallium	Ga	1.674		0.433	3.857	0.277	1.196		0.550
Potassium	K	0.359		0.836	3.571	0.312	1.019		0.601
Lanthanum	La	0.672		0.715	2.143	0.543	0.731		0.694
Magnesium	Mg	16.670	*	<.0001	2.143	0.543	9.620	*	0.008
Manganese	Mn	7.571	*	0.023	2.143	0.543	2.924		0.232
Molybdenum	Mo	1.397		0.497	3.857	0.277	5.819		0.055
Sodium	Na	16.618	*	<.0001	3.571	0.312	9.620	*	0.008
Nickel	Ni	6.732	*	0.035	2.429	0.488	2.291		0.318
Phosphorus	P	11.741	*	0.003	4.286	0.232	6.011	*	0.050
Lead	Pb	16.674	*	<.0001	4.714	0.194	9.680	*	0.008
Sulfur	S	8.441	*	0.015	4.286	0.232	4.416		0.110
Scandium	Sc	13.407	*	0.001	1.286	0.733	7.796	*	0.020
Strontium	Sr	16.670	*	<.0001	3.571	0.312	9.600	*	0.008
Thorium	Th	0.599		0.741	3.857	0.277	1.419		0.492
Titanium	Ti	0.232		0.891	4.286	0.232	0.176		0.916
Vanadium	V	0.403		0.817	4.286	0.232	0.339		0.844
Zink	Zn	7.577	*	0.023	3.857	0.277	5.420		0.067
Loss On Ignition	LOI	17.025	*	<.0001	2.400	0.123	9.680	*	<.0001

	Hoojah Branch			Ramey Creek		
Element	**Chi-Sq**		**p-value**	**Chi-Sq**		**p-value**
As	10.316	*	0.035	2.173		0.337
Ba	18.230	*	0.001	3.456		0.178
Be	11.114	*	0.025	15.619	*	<.0001
Ca	33.541	*	<.0001	19.357	*	<.0001
Co	7.609		0.107	0.808		0.668
Cr	6.448		0.168	19.448	*	<.0001
Cu	24.348	*	<.0001	15.030	*	0.001
Fe	2.080		0.721	3.579		0.167
Ga	1.848		0.764	1.089		0.580
K	25.058	*	<.0001	20.105	*	<.0001
La	4.780		0.311	6.320		0.042
Mg	2.680		0.613	18.715	*	<.0001
Mn	7.401		0.116	4.625		0.099
Mo	26.242	*	<.0001	2.526		0.283
Na	27.032	*	<.0001	16.187	*	<.0001
Ni	16.161	*	0.003	5.872		0.053
P	15.934	*	0.003	1.541		0.463
Pb	12.616	*	0.013	0.403		0.818
S	22.789	*	<.0001	9.813	*	0.007
Sc	4.113		0.391	17.477	*	<.0001
Sr	33.912	*	<.0001	19.405	*	<.0001
Th	4.129		0.389	3.533		0.171
Ti	4.033		0.402	17.129	*	<.0001
V	2.670		0.614	15.890	*	<.0001
Zn	9.813		0.044	3.796		0.150
LOI	36.186	*	<.0001	2.286		0.136

Table 2.4. Stepwise discriminant analysis used for the second step of tracer selection. Cumulative percent classified correctly for roads, ditches, and two bank categories including LOI.

# of tracers	Tracer	Wilks' Lambda	Partial Lambda	F	R^2	% classified correctly	Cumulative % classified correctly
				Ball Creek			
1	LOI	0.008	0.167	29.931	0.316	85%	85%
2	P	0.003	0.435	7.791	0.657	64%	100%
3	Na	0.002	0.676	2.872	0.946	69%	100%
4	As	0.002	0.717	2.368	0.129	40%	100%
5	Zn	0.003	0.544	5.030	0.787	34%	100%
6	Sr	0.002	0.662	3.065	0.965	61%	100%
7	S	0.002	0.674	2.906	0.530	40%	100%
				Reynolds Branch			
1	LOI	0.073	0.060	94.776	0.358	85%	85%
2	P	0.018	0.244	18.604	0.570	50%	100%
3	Na	0.007	0.659	3.105	0.673	60%	100%
				Hoojah Branch			
1	Mo	0.020	0.185	45.634	0.470	50%	75%
2	Sr	0.008	0.484	11.006	0.933	60%	67.5%
3	LOI	0.005	0.772	3.045	0.168	70%	80%
4	Cu	0.005	0.739	3.648	0.746	50%	82.5%
5	P	0.005	0.676	4.943	0.712	50%	92.5%
6	Na	0.005	0.729	3.850	0.949	50%	92.5%
7	K	0.007	0.513	9.804	0.883	50%	87.5%
8	Ba	0.005	0.669	5.120	0.873	50%	90.5%
9	S	0.005	0.803	2.528	0.548	50%	95%
10	Be	0.004	0.834	2.057	0.784	50%	95%
				Ramey Creek			
1	Be	0.855	0.910	1.679	0.011	60%	60%

Table 2.5. Stepwise discriminant analysis used for the second step of tracer selection. Cumulative percent classified correctly for roads, ditches, and two bank categories excluding LOI.

# of tracers		Wilks' Lambda	Partial Lambda	F	R^2	% classified correctly	Cumulative % classified correctly
			Ball Creek				
1	P	0.001	0.535	3.770	0.764	63.75%	63.75%
2	Pb	0.001	0.791	1.143	0.794	71.25%	95.00%
3	S	0.001	0.609	2.787	0.679	42.50%	95.00%
4	Zn	0.002	0.185	19.151	0.962	33.75%	95.00%
5	Sr	0.002	0.221	15.301	0.993	61.25%	95.00%
6	Ca	0.001	0.818	0.967	0.987	66.25%	95.00%
7	Sc	0.001	0.337	8.524	0.984	46.25%	95.00%
8	Mn	0.002	0.200	17.342	0.967	40.00%	95.00%
9	As	0.001	0.444	5.421	0.695	40.00%	95.00%
10	Na	0.001	0.618	2.676	0.987	68.75%	95.00%
11	Ni	0.001	0.704	1.823	0.957	40.00%	95.00%
12	Mg	0.001	0.810	1.016	0.978	63.75%	95.00%
			Reynolds Branch				
1	P	0.062	0.430	6.622	0.826	47.50%	47.50%
2	Pb	0.030	0.880	0.683	0.827	77.50%	100.00%
3	Na	0.032	0.820	1.100	0.968	62.50%	100.00%
4	As	0.033	0.796	1.284	0.461	30.00%	100.00%
5	Mg	0.045	0.592	3.441	0.848	57.50%	100.00%
6	Sr	0.036	0.739	1.765	0.966	55.00%	100.00%
			Hoojah Branch				
1	Mo	0.016	0.160	47.185	0.540	75.00%	75.00%
2	Sr	0.004	0.607	5.822	0.946	55.00%	67.50%
3	Pb	0.004	0.630	5.278	0.820	35.00%	90.00%
4	Ba	0.004	0.620	5.510	0.926	52.50%	95.00%
5	K	0.006	0.465	10.356	0.911	47.50%	95.00%
6	Be	0.003	0.816	2.027	0.852	50.00%	95.00%
7	Cu	0.003	0.808	2.137	0.809	60.00%	95.00%
8	Na	0.004	0.736	3.226	0.960	47.50%	95.00%
9	P	0.003	0.795	2.315	0.833	42.50%	95.00%
10	S	0.003	0.800	2.248	0.599	52.50%	95.00%
			Ramey Creek				
1	Be	0.855	0.910	1.679	0.011	60%	60%

Table 2.6. Discriminant analysis percent classified correctly for each tracer and source.

Watershed	Source	P	Pb	S	Zn	Sr	Ca	Sc	Mn	As	Na	Ni	Mg	LOI
Ball	Bank A	0%	100%	0%	25%	50%	50%	25%	0%	50%	50%	0%	50%	100%
	Bank A	75%	75%	0%	0%	75%	75%	50%	50%	0%	75%	50%	75%	100%
	Ditch	80%	60%	100%	60%	60%	50%	60%	50%	10%	60%	40%	60%	50%
	Road	100%	50%	70%	50%	60%	90%	50%	60%	100%	90%	70%	70%	90%

		P	Pb	Na	As	Mg	Sr	LOI
Reynolds	Bank A	0%	100%	50%	0%	50%	50%	100%
	Bank A	0%	100%	50%	0%	50%	50%	100%
	Ditch	90%	60%	60%	20%	60%	60%	50%
	Road	100%	50%	90%	100%	70%	60%	90%

		Mo	Sr	Pb	Ba	K	Be	Cu	Na	P	S	LOI
Hoojah	Bank A	70%	50%	60%	80%	70%	80%	70%	50%	20%	60%	60%
	Bank A	50%	40%	10%	30%	40%	40%	70%	30%	70%	50%	80%
	Ditch	80%	60%	40%	30%	20%	60%	70%	70%	0%	70%	60%
	Road	100%	70%	30%	70%	60%	20%	30%	40%	80%	30%	60%

	Source	Be
Ramey	Bank A	70%
	Bank B	50%

Table 2.7. Summary statistics of normalized chemical tracers for Ball Creek. Each tracer was divided by Aluminum except Aluminum which is in parts per million and LOI which is in percent.

	Reynolds Road			Reynolds Ditches		
	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
	n=10			n=10		
Al	753.80	760.50	36.77	658.40	666.50	69.17
As	0.00332	0.00329	0.00016	0.00453	0.00375	0.00259
Ba	0.62853	0.61896	0.12538	0.69614	0.66923	0.18151
Be	0.00170	0.00168	0.00037	0.00154	0.00157	0.00022
Ca	0.26268	0.25586	0.02906	0.18930	0.18131	0.08617
Co	0.01929	0.01949	0.00424	0.02147	0.02031	0.00663
Cr	0.09298	0.09045	0.02199	0.10065	0.09528	0.02840
Cu	0.05568	0.05057	0.02386	0.03151	0.02996	0.01109
Fe	0.80583	0.83336	0.15945	0.91514	0.87457	0.31200
Ga	0.02527	0.02613	0.00443	0.02409	0.02692	0.00676
K	0.00173	0.00156	0.00054	0.00190	0.00178	0.00061
La	0.08526	0.08614	0.02024	0.04593	0.04226	0.01781
Mg	0.17424	0.17595	0.04083	0.14506	0.14076	0.02682
Mn	1.49005	1.51672	0.35487	1.32366	1.30256	0.49373
Mo	0.00245	0.00263	0.00136	0.00077	0.00075	0.00009
Na	0.25584	0.25285	0.02914	0.18786	0.16642	0.08063
Ni	0.02497	0.02435	0.00440	0.02717	0.02600	0.01216
P	1.58668	1.54195	0.18894	0.83706	0.88036	0.24463
Pb	0.01703	0.01796	0.00360	0.01485	0.01374	0.00372
S	0.00439	0.00459	0.00183	0.00174	0.00151	0.00068
Sc	0.02473	0.02437	0.00583	0.02432	0.02281	0.00531
Sr	0.37352	0.38577	0.07391	0.27752	0.25265	0.10848
Th	0.02925	0.02706	0.00864	0.01841	0.01525	0.00664
Ti	0.10283	0.10117	0.02737	0.12300	0.10065	0.07143
V	0.14003	0.14377	0.02795	0.16854	0.16124	0.06206
Zn	0.13665	0.13099	0.02566	0.12402	0.12600	0.02405
LOI%	0.927	0.91	0.36751	1.454	1.13	0.86258

	Reynolds Bed			Ball Bed		
	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
	n=10			n=10		
Al	619.80	605.50	136.84	3385.60	432.50	9351.41
As	0.00576	0.00427	0.00321	0.00609	0.00587	0.00330
Ba	0.95842	0.95960	0.14802	0.56739	0.60073	0.21091
Be	0.00171	0.00170	0.00030	0.00196	0.00217	0.00068
Ca	0.10875	0.10913	0.10427	0.29258	0.32263	0.09396
Co	0.02140	0.02085	0.00661	0.02602	0.02858	0.00926
Cr	0.09269	0.09180	0.02349	0.23249	0.25703	0.09626
Cu	0.03570	0.03225	0.00997	0.01953	0.02096	0.00706
Fe	0.79515	0.80275	0.25907	1.27208	1.36910	0.64364
Ga	0.03238	0.03304	0.00527	0.02557	0.02405	0.01215
K	0.00262	0.00262	0.00047	0.00158	0.00170	0.00057
La	0.04487	0.04725	0.01469	0.04012	0.03373	0.02346
Mg	0.09219	0.09248	0.04906	0.18241	0.20164	0.06378
Mn	1.00546	1.02469	0.54936	2.03043	2.17040	1.02272
Mo	0.00155	0.00084	0.00023	0.00406	0.00450	0.00141
Na	0.13154	0.13322	0.09646	0.19782	0.15685	0.13003
Ni	0.03290	0.03123	0.01239	0.04207	0.04579	0.01502
P	0.59717	0.60256	0.23337	0.35640	0.37528	0.13793
Pb	0.03155	0.02313	0.00714	0.02068	0.02266	0.00807
S	0.00192	0.00169	0.00087	0.00639	0.00117	0.01649
Sc	0.01984	0.02013	0.00559	0.03774	0.04160	0.01542
Sr	0.22177	0.22476	0.12929	0.24922	0.27514	0.08868
Th	0.01619	0.01652	0.00541	0.02359	0.02312	0.01168
Ti	0.15193	0.14937	0.05227	0.22584	0.23640	0.12578
V	0.18446	0.18461	0.04582	0.29655	0.31589	0.14933
Zn	0.12040	0.12034	0.02149	0.10803	0.12313	0.04052
LOI%	3.71	3.71	5.44	1.41	1.44	0.39

	Lick Bed		
	Mean	Median	Std. Dev.
	n=10		
Al	524.70	530.00	33.76
As	0.00595	0.00487	0.00256
Ba	0.97033	0.95964	0.03923
Be	0.00193	0.00189	0.00014
Ca	0.08960	0.08926	0.00430
Co	0.02536	0.02549	0.00294
Cr	0.10790	0.10349	0.01306
Cu	0.03784	0.03855	0.00456
Fe	0.96884	0.91058	0.17192
Ga	0.02478	0.02014	0.00906
K	0.00266	0.00263	0.00012
La	0.06648	0.06584	0.00703
Mg	0.09097	0.09246	0.00488
Mn	1.21900	1.20624	0.27200
Mo	0.00133	0.00103	0.00049
Na	0.09775	0.09511	0.00686
Ni	0.03867	0.03771	0.00314
P	0.54284	0.55507	0.07547
Pb	0.02907	0.02991	0.00394
S	0.00304	0.00353	0.00095
Sc	0.02290	0.02263	0.00192
Sr	0.17510	0.17484	0.00818
Th	0.02648	0.02070	0.00894
Ti	0.20109	0.19196	0.03774
V	0.23261	0.21783	0.03874
Zn	0.12843	0.13116	0.00689
LOI%	5.48	5.06	1.90

	Bank A			Bank B		
	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
		n=5			n=5	
Al	870.80	874.00	54.26	920.60	918.00	57.45
As	0.00645	0.00294	0.00502	0.00272	0.00272	0.00018
Ba	0.69408	0.67138	0.11042	0.70731	0.64270	0.13272
Be	0.00153	0.00163	0.00043	0.00152	0.00163	0.00038
Ca	0.02777	0.02941	0.01578	0.01884	0.01743	0.01369
Co	0.02181	0.02321	0.00621	0.02390	0.02243	0.00805
Cr	0.07824	0.07780	0.00317	0.07435	0.07440	0.00676
Cu	0.03461	0.03504	0.00480	0.04104	0.03670	0.00985
Fe	0.65360	0.62662	0.06880	0.62847	0.61613	0.02723
Ga	0.02304	0.02288	0.00143	0.02592	0.02407	0.00467
K	0.00187	0.00183	0.00026	0.00197	0.00174	0.00035
La	0.05485	0.05656	0.00637	0.05884	0.06116	0.01058
Mg	0.05209	0.05882	0.01719	0.06966	0.07612	0.02163
Mn	0.92964	0.83980	0.59988	0.71725	0.74414	0.42924
Mo	0.00104	0.00114	0.00027	0.00088	0.00102	0.00032
Na	0.04052	0.04412	0.01824	0.03140	0.02723	0.01845
Ni	0.03479	0.03586	0.00698	0.04187	0.04077	0.01267
P	0.69337	0.65217	0.07850	0.47510	0.45752	0.09058
Pb	0.02986	0.02954	0.00201	0.02381	0.02407	0.00205
S	0.00297	0.00316	0.00051	0.00109	0.00109	0.00007
Sc	0.01633	0.01688	0.00190	0.01643	0.01634	0.00163
Sr	0.08136	0.08966	0.02481	0.06808	0.06427	0.02802
Th	0.02068	0.02262	0.00517	0.02180	0.02179	0.00142
Ti	0.09301	0.09725	0.01524	0.09095	0.09190	0.00772
V	0.14098	0.14723	0.01428	0.13881	0.13452	0.00857
Zn	0.10030	0.10338	0.01259	0.10808	0.11213	0.01424
LOI%	13.99	14.44	1.73	7.55	6.95	1.26

Table 2.8. Summary statistics of normalized chemical tracers for Hoojah Branch. Each tracer was divided by Aluminum except Aluminum which is in parts per million and LOI which is in percent.

	Hoojah Ditches			Hoojah Road		
	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
	n=10			n=10		
Al	589.30000	596.50000	89.41545	610.10000	656.50000	102.38213
As	0.00508	0.00422	0.00238	0.00421	0.00381	0.00078
Ba	0.90028	0.90777	0.14831	0.96293	0.98377	0.21703
Be	0.00216	0.00218	0.00041	0.00200	0.00202	0.00047
Ca	0.19519	0.19618	0.08036	0.17302	0.15091	0.05241
Co	0.01454	0.01143	0.00613	0.01724	0.01860	0.00499
Cr	0.05914	0.04946	0.03726	0.06399	0.06240	0.02825
Cu	0.01760	0.01469	0.00659	0.02382	0.01818	0.01775
Fe	0.49828	0.49222	0.21415	0.61794	0.56987	0.24770
Ga	0.02510	0.02516	0.00674	0.02743	0.02865	0.00508
K	0.00241	0.00262	0.00037	0.00245	0.00259	0.00054
La	0.12384	0.09012	0.10927	0.28656	0.22029	0.20257
Mg	0.07735	0.06847	0.03678	0.08761	0.08324	0.04932
Mn	0.72137	0.60789	0.32751	0.91615	0.80775	0.46801
Mo	0.00087	0.00084	0.00014	0.00358	0.00305	0.00106
Na	0.21242	0.21590	0.07747	0.17370	0.17860	0.08667
Ni	0.02399	0.01626	0.01384	0.02256	0.02442	0.00746
P	0.93398	0.77317	0.34745	1.29077	1.30867	0.30620
Pb	0.02793	0.02924	0.00333	0.03298	0.03303	0.00789
S	0.00164	0.00141	0.00115	0.00201	0.00152	0.00131
Sc	0.01307	0.01257	0.00436	0.01526	0.01487	0.00711
Sr	0.38735	0.40225	0.11195	0.35146	0.32917	0.07787
Th	0.04641	0.03373	0.03677	0.10141	0.08361	0.07106
Ti	0.06841	0.06275	0.03435	0.09464	0.09099	0.03366
V	0.10739	0.11303	0.05068	0.13132	0.12397	0.04797
Zn	0.08806	0.08084	0.02837	0.10353	0.10631	0.02981
LOI%	1.88	1.47	0.90	2.11	2.02	0.54

	Hoojah Bank A			Hoojah Bank B		
	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
		n=10			n=10	
Al	766.10000	750.50000	100.99774	827.40000	797.50000	200.53828
As	0.00565	0.00647	0.00187	0.00389	0.00354	0.00220
Ba	0.68414	0.67289	0.06019	0.77489	0.77108	0.18744
Be	0.00171	0.00170	0.00015	0.00186	0.00185	0.00031
Ca	0.03979	0.03775	0.01740	0.04196	0.03182	0.02918
Co	0.02043	0.01810	0.00741	0.02360	0.01981	0.01041
Cr	0.07309	0.07498	0.00955	0.07247	0.07351	0.01388
Cu	0.03814	0.03664	0.00419	0.03879	0.04031	0.00958
Fe	0.54520	0.54784	0.05399	0.57198	0.52142	0.20516
Ga	0.02649	0.02665	0.00330	0.02491	0.02716	0.00501
K	0.00165	0.00164	0.00020	0.00174	0.00180	0.00032
La	0.19001	0.16656	0.10012	0.19018	0.16748	0.14749
Mg	0.07647	0.07410	0.01436	0.07699	0.08111	0.01842
Mn	0.54819	0.56170	0.16089	0.63741	0.55595	0.24070
Mo	0.00066	0.00067	0.00008	0.00064	0.00063	0.00015
Na	0.04417	0.04471	0.01577	0.04625	0.03763	0.02326
Ni	0.03432	0.03323	0.00670	0.03593	0.03463	0.00842
P	0.82088	0.87770	0.15489	0.72385	0.70009	0.24179
Pb	0.03474	0.03561	0.00429	0.02870	0.02758	0.00399
S	0.00407	0.00415	0.00098	0.00261	0.00272	0.00078
Sc	0.01530	0.01574	0.00228	0.01604	0.01630	0.00263
Sr	0.10085	0.10492	0.03022	0.10726	0.09548	0.04908
Th	0.06597	0.05330	0.03694	0.06836	0.05583	0.05455
Ti	0.07342	0.07633	0.00910	0.07455	0.07847	0.01551
V	0.11874	0.12267	0.01483	0.11957	0.12262	0.02060
Zn	0.11649	0.11118	0.01452	0.11962	0.11287	0.01987
LOI%	12.72	12.14	4.33	8.66	8.18	1.94

	Hoojah Bed		
	Mean	Median	Std. Dev.
	n=10		
Al	664.70000	496.00000	56.95817
As	0.00518	0.00504	0.00072
Ba	0.80805	1.08258	0.04185
Be	0.00195	0.00198	0.00009
Ca	0.12447	0.13163	0.02018
Co	0.01659	0.02136	0.00276
Cr	0.06596	0.07732	0.00918
Cu	0.02737	0.02661	0.00223
Fe	0.52429	0.64180	0.10630
Ga	0.02622	0.02016	0.00288
K	0.00209	0.00269	0.00013
La	0.16275	0.22495	0.09951
Mg	0.07682	0.09957	0.00867
Mn	0.64380	0.88729	0.17372
Mo	0.00089	0.00147	0.00073
Na	0.13700	0.14089	0.01459
Ni	0.02799	0.03266	0.00245
P	0.91274	0.66667	0.15225
Pb	0.03152	0.03142	0.00357
S	0.00277	0.00111	0.00124
Sc	0.01404	0.01665	0.00144
Sr	0.25846	0.27411	0.02614
Th	0.05813	0.08787	0.03405
Ti	0.07203	0.10273	0.02385
V	0.11409	0.14486	0.02964
Zn	0.10144	0.11451	0.00953
LOI%	6.69	2.53	0.59

Table 2.9. Summary Statistics of normalized chemical tracers for Ramey Creek. Each tracer was divided by Aluminum except Aluminum which is in parts per million and LOI which is in percent.

	Bank A			Bank B		
	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
	n=10			n=10		
Al	790.10000	787.50000	59.38097	801.40000	815.50000	99.40735
As	0.00485	0.00337	0.00224	0.00428	0.00330	0.00214
Ba	0.57208	0.55899	0.06530	0.61340	0.63433	0.09347
Be	0.00148	0.00147	0.00021	0.00165	0.00157	0.00037
Ca	0.08600	0.06425	0.06632	0.08362	0.07458	0.04890
Co	0.01334	0.01227	0.00428	0.01313	0.01385	0.00397
Cr	0.08315	0.07925	0.01342	0.08654	0.08041	0.01488
Cu	0.03751	0.03465	0.01224	0.03553	0.03579	0.00796
Fe	0.55508	0.50745	0.16259	0.59110	0.54537	0.18467
Ga	0.02544	0.02540	0.00192	0.02589	0.02520	0.00496
K	0.00139	0.00145	0.00015	0.00147	0.00151	0.00022
La	0.17801	0.13907	0.08646	0.71411	0.30011	0.94129
Mg	0.08503	0.06704	0.04718	0.08145	0.07718	0.02930
Mn	0.55949	0.41421	0.53131	0.52175	0.45068	0.29912
Mo	0.00085	0.00063	0.00069	0.00091	0.00061	0.00067
Na	0.06259	0.06613	0.02710	0.08157	0.07050	0.04235
Ni	0.03122	0.03052	0.00614	0.03528	0.03385	0.00652
P	0.78676	0.75829	0.33018	1.44466	0.91450	1.23221
Pb	0.03138	0.03282	0.00590	0.03493	0.03035	0.01024
S	0.00344	0.00316	0.00111	0.00282	0.00264	0.00105
Sc	0.01784	0.01641	0.00563	0.01700	0.01610	0.00257
Sr	0.15482	0.13766	0.05935	0.16489	0.15629	0.07459
Th	0.06538	0.05158	0.03475	0.26266	0.11085	0.34457
Ti	0.08267	0.07735	0.01307	0.09328	0.07842	0.03064
V	0.13170	0.13031	0.00790	0.14940	0.14127	0.03476
Zn	0.09839	0.09619	0.02346	0.09991	0.10043	0.01400
LOI%	10.70839	9.82474	2.84416	8.26160	7.42798	3.38424

	Outlet		
	Mean	Median	Std. Dev.
	n=10		
Al	486.20000	485.00000	44.38168
As	0.00518	0.00516	0.00047
Ba	0.83058	0.82752	0.03832
Be	0.00216	0.00217	0.00005
Ca	0.17004	0.16100	0.02522
Co	0.01912	0.01919	0.00196
Cr	0.09386	0.09027	0.01325
Cu	0.03147	0.03113	0.00176
Fe	0.70419	0.61418	0.18401
Ga	0.02072	0.02062	0.00190
K	0.00175	0.00174	0.00009
La	0.85017	0.65956	0.48831
Mg	0.09207	0.09187	0.00223
Mn	0.98581	0.90104	0.24191
Mo	0.00311	0.00301	0.00113
Na	0.14473	0.14462	0.01349
Ni	0.03555	0.03525	0.00077
P	1.41139	1.16601	0.61490
Pb	0.03975	0.03811	0.00674
S	0.00207	0.00206	0.00019
Sc	0.01735	0.01662	0.00189
Sr	0.29896	0.29395	0.02507
Th	0.31693	0.24409	0.18614
Ti	0.13804	0.11237	0.05543
V	0.18394	0.15757	0.05827
Zn	0.10687	0.10668	0.00801
LOI%	4.13169	4.44850	0.94881

Table 2.10. Mixing model results by watershed and sample with LOI as a tracer.

	Ball Creek		Reynolds Branch		Hoojah Branch	
Source	Road	Banks	Road	Bank	Road	Banks
Mean	94.61%	5.39%	92.31%	7.69%	80.90%	19.10%
Std. Dev.	3.16%	3.16%	3.44%	3.44%	7.90%	7.90%
1	95.33%	4.67%	93.24%	6.76%	75.49%	24.51%
2	NaN	NaN	NaN	NaN	78.73%	21.27%
3	92.85%	7.15%	90.73%	9.27%	73.83%	26.17%
4	88.44%	11.56%	84.23%	15.77%	83.35%	16.65%
5	97.57%	2.43%	93.81%	6.19%	74.02%	25.98%
6	96.95%	3.05%	94.46%	5.54%	99.36%	0.64%
7	NaN	NaN	NaN	NaN	NaN	NaN
8	93.09%	6.91%	92.61%	7.39%	84.44%	15.56%
9	98.03%	1.97%	96.63%	3.37%	78.01%	21.99%
10	NaN	NaN	92.80%	7.20%	NaN	NaN

Table 2.11. Mixing model results by watershed and sample without LOI as a tracer.

	Ball Creek		Reynolds Branch		Hoojah Branch	
Source	Road	Banks	Road	Banks	Road	Banks
Mean	61.29%	38.71%	39.19%	60.81%	58.98%	41.02%
Std. Dev.	21.20%	21.20%	4.73%	4.73%	14.01%	14.01%
1	60.13%	39.87%	34.57%	65.43%	44.84%	55.16%
2	74.57%	25.43%	47.81%	52.19%	50.60%	49.40%
3	69.80%	30.20%	44.93%	55.07%	53.83%	46.17%
4	77.80%	22.20%	41.11%	58.89%	38.99%	61.01%
5	95.75%	4.25%	35.04%	64.96%	50.53%	49.47%
6	56.18%	43.82%	30.81%	69.19%	73.08%	26.92%
7	20.34%	79.66%	39.34%	60.66%	82.24%	17.76%
8	36.17%	63.83%	40.44%	59.56%	57.70%	42.30%
9	60.90%	39.10%	37.87%	62.13%	57.76%	42.24%
10	NaN	NaN	39.98%	60.02%	80.26%	19.74%

Table 2.12. Mineralogy means and standard deviations.

Reynolds Road					
	garnet	mafic	quartz	mica/biotite	quartz/feldspar
Mean	0.98%	0.39%	20.17%	13.37%	65.09%
SD	0.60%	1.07%	8.92%	4.82%	8.68%

Reynolds Bed					
	garnet	mafic	quartz	mica/biotite	quartz/feldspar
Mean	0.81%	0.00%	48.17%	29.37%	21.65%
SD	0.84%	0.00%	5.09%	2.67%	4.58%

Lick bed					
	garnet	mafic	quartz	mica/biotite	quartz/feldspar
Mean	0.32%	0.08%	48.70%	39.26%	11.63%
SD	0.53%	0.16%	8.39%	7.37%	5.05%

Ball Bed					
	garnet	mafic	quartz	mica/biotite	quartz/feldspar
Mean	1.72%	1.25%	34.73%	20.93%	41.37%
SD	1.47%	1.06%	9.37%	6.00%	10.36%

Table 2.13. RUSLE2 zonal statistics for total erosion from each source type in tonnes/hectare/yr.

	Road Surface	**Forest**	**Stream**
Min	0.0001	0.0001	0.0001
Max	12.2985	8.7847	4.3923
Mean	1.1008	0.1807	0.0810
Std. Dev.	2.3778	0.2861	0.1829
Total tonnes	3.8978	129.4003	0.1988
% of Total	2.92%	96.93%	0.15%

Table 2.14. RUSLE2 zonal statistics for Reynolds Branch (roads) vs. Lick Branch (no roads) in tonnes/hectare/yr.

	Reynolds Branch	**Lick Branch**
Min	0.0001171	0.0003699
Max	12.2985392	2.0343447
Mean	0.1992141	0.2054027
Std. Dev.	0.4535187	0.3173019

Table 2.15. RUSLE2 sediment export compared to source ascription sediment export.

Source	%	Tonnes/yr	Tonnes/hectare/yr
		With LOI	
Roads	94.61	60.52	16.8
Banks	5.39	4.14	
		Without LOI	
Roads	61.29	39.65	10.99
Banks	38.71	25.04	
		RUSLE	
Roads	0.02	2.22	0.63
Banks	0.001	0.12	0.05
Forest	0.96	73.76	0.1

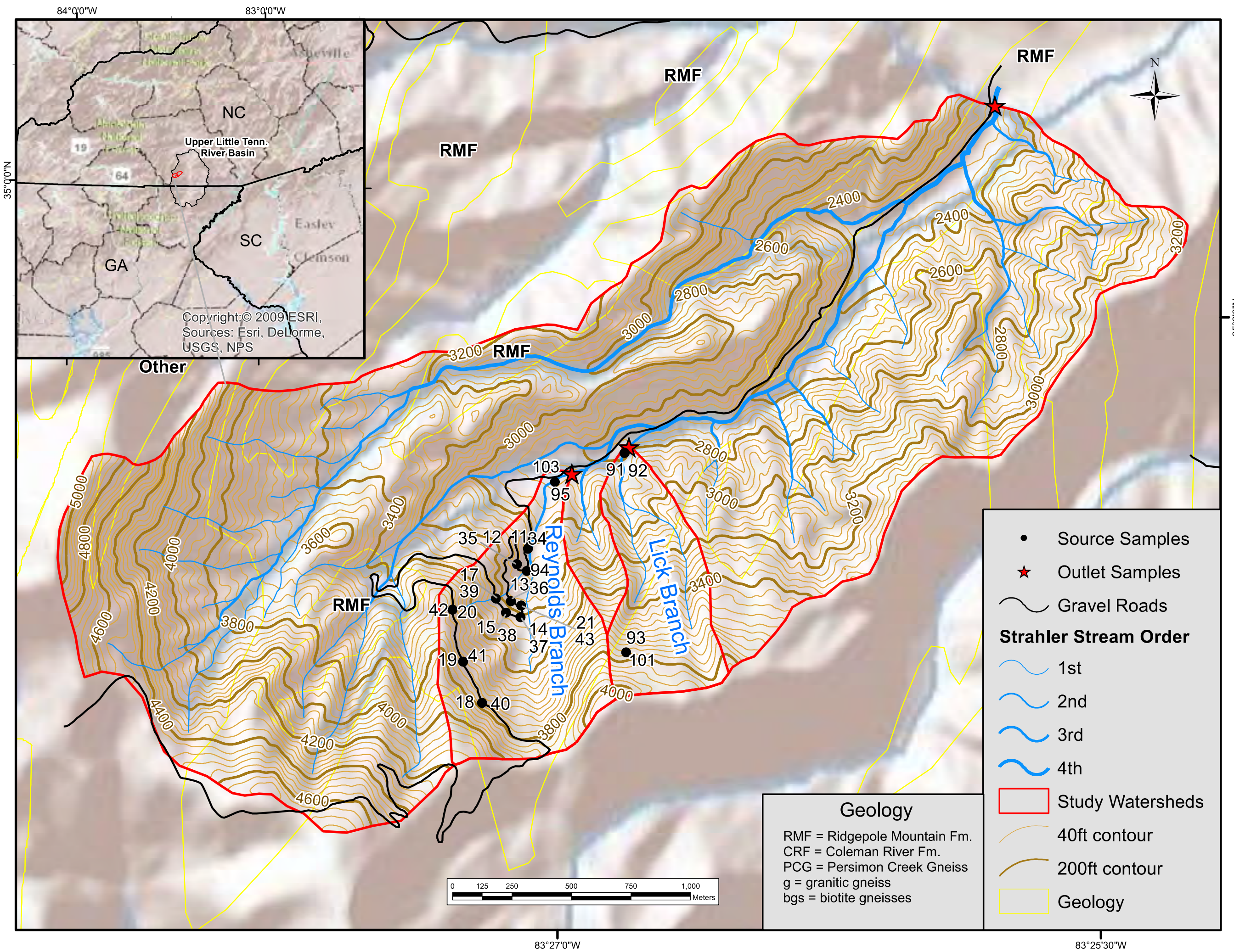

Figure 2.1. Map of Ball Creek - Upper Little Tennessee River Basin, Western North Carolina. **Data sources**: Elevation- USGS Click LiDAR, Geology- Hatcher (1979) Coweeta Group, Roads- LiDAR, 2007 NC Floodplain Mapping program orthophotography and field verification, Shaded relief- ArcGIS Online.

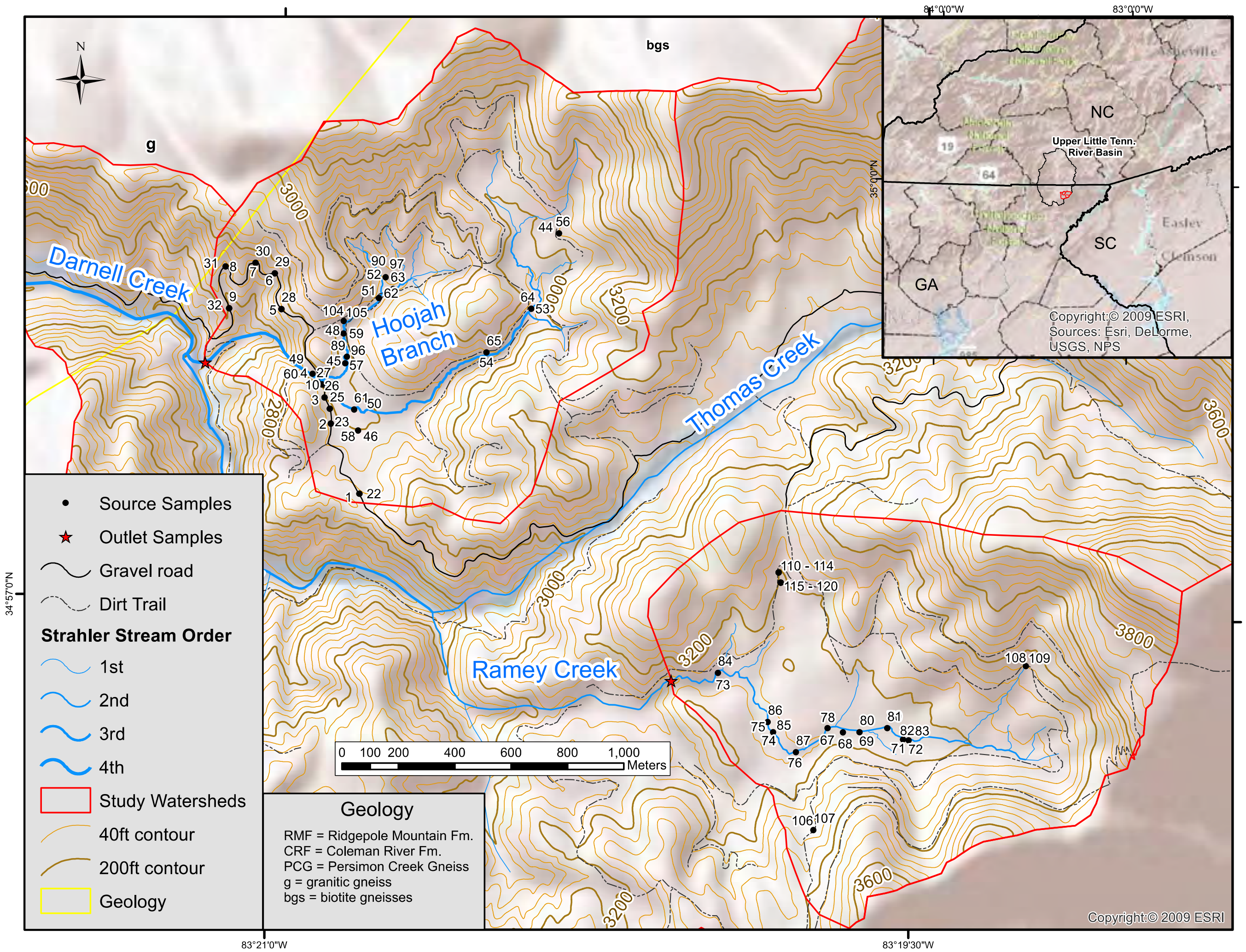

Figure 2.2. Map of paired watersheds in Darnell Creek - Upper Little Tennessee River Basin, Western North Carolina. **Data sources**: Elevation- USGS Click LiDAR, Geology- Hatcher (1979) Coweeta Group, Roads- LiDAR, orthophotography and field verification, Shaded relief- ArcGIS Online.

Figure 2.3. Photograph of road ditch sediment entering Reynolds Branch.

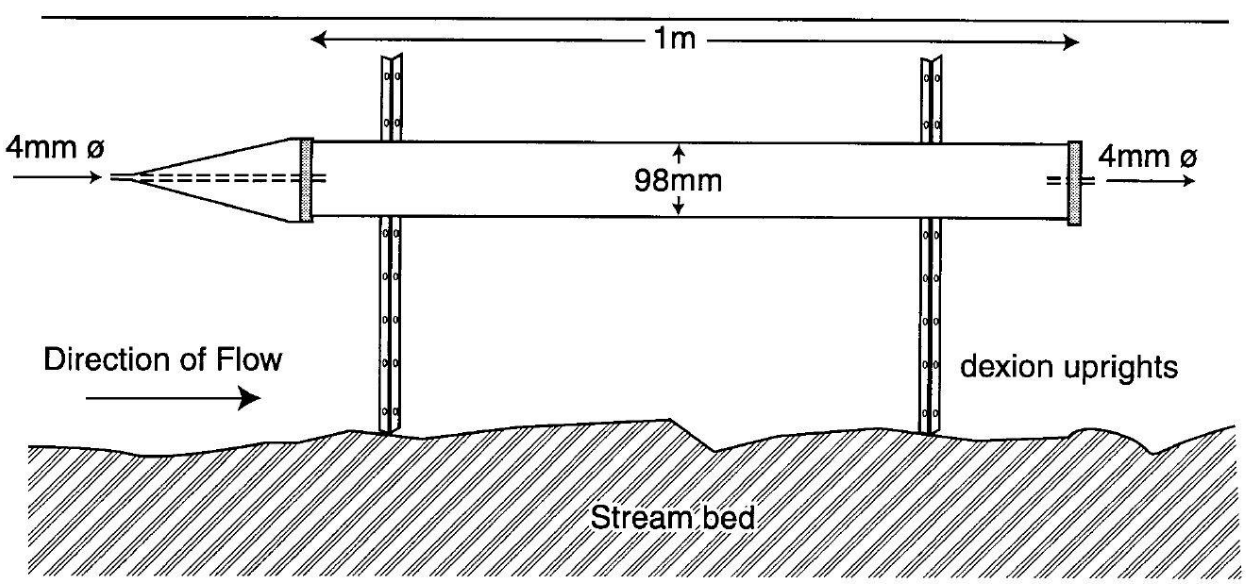

Figure 2.4. Time integrating suspended sediment sampler from Phillips et al. (2000).

Figure 2.5. Suspended Sediment Sampler installed in Ball Creek above baseflow.

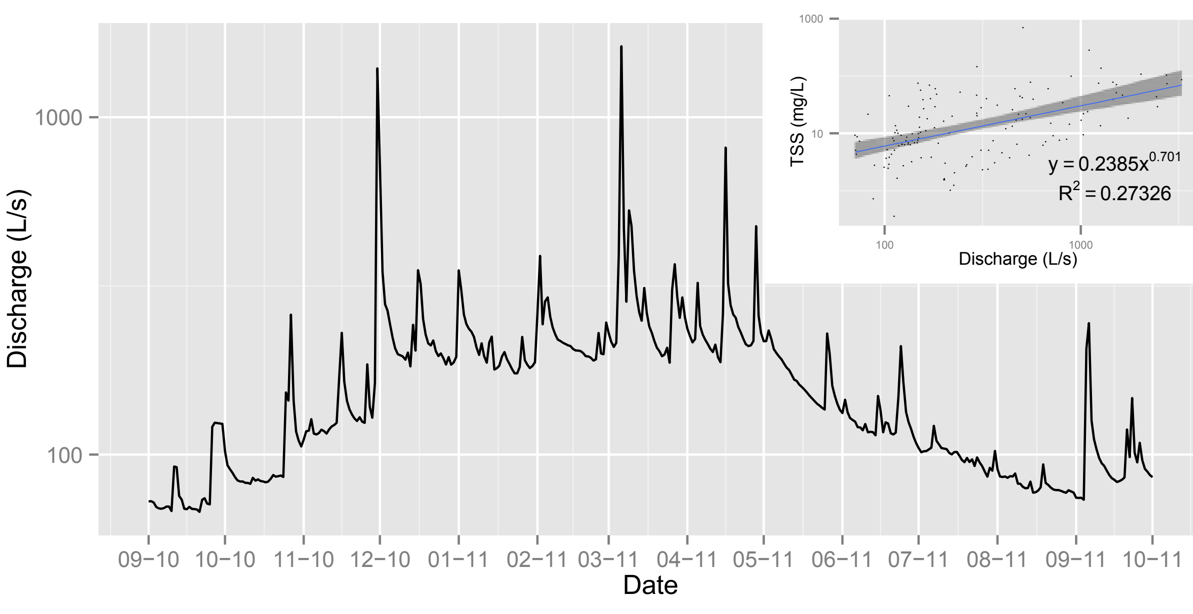

Figure 2.6. Ball Creek daily discharge data for the 2011 water year and suspended sediment measurements used to compute the sediment-rating curve.

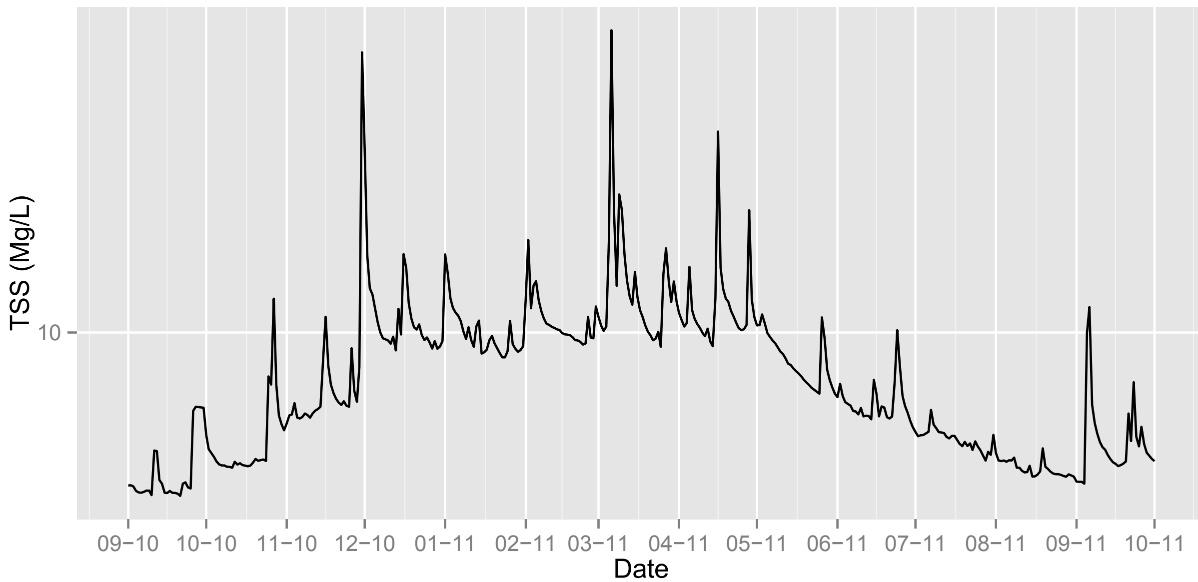

Figure 2.7. Ball creek daily average total suspended solids estimated using a rating curve model.

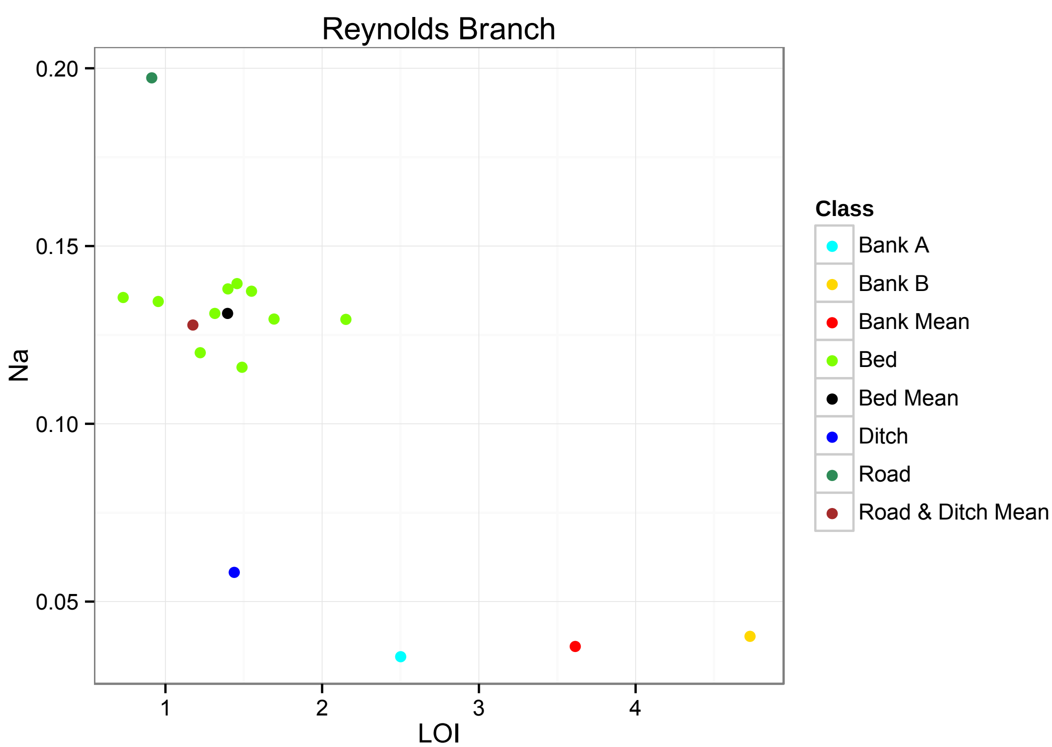

Figure 2.8. Scatterplot of Reynolds Branch LOI vs. Na.

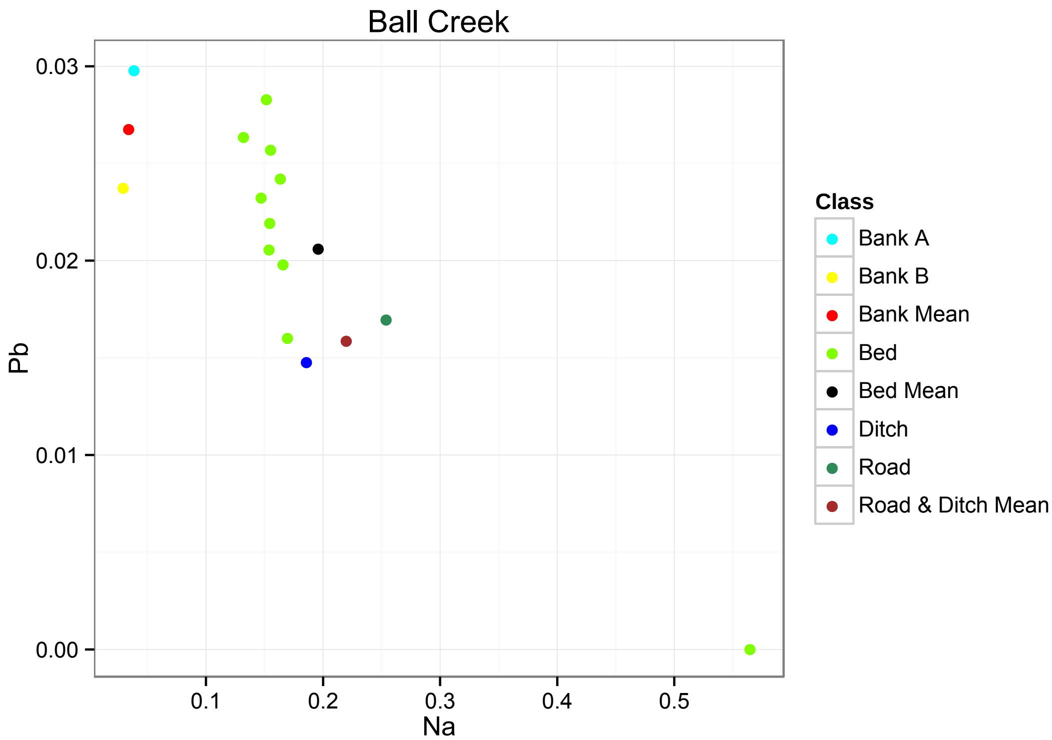

Figure 2.9. Scatterplot of Ball Creek Na vs. Pb.

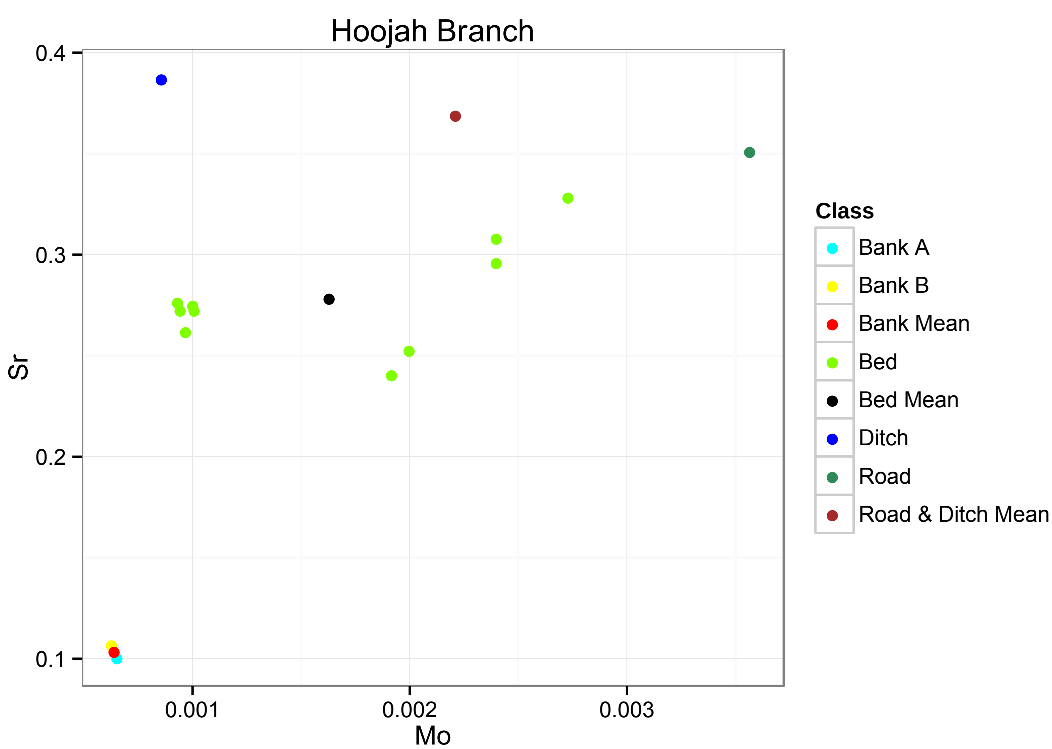

Figure 2.10. Scatterplot of Hoojah Branch Mo vs.Sr.

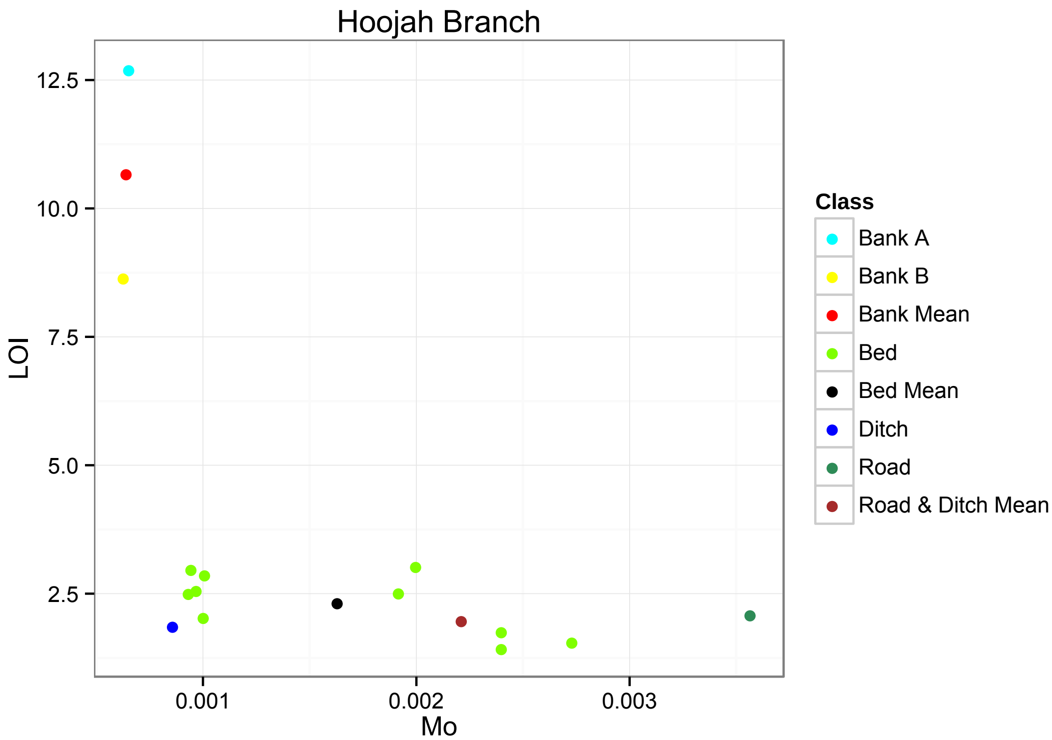

Figure 2.11. Scatterplot of Hoojah Mo vs. LOI.

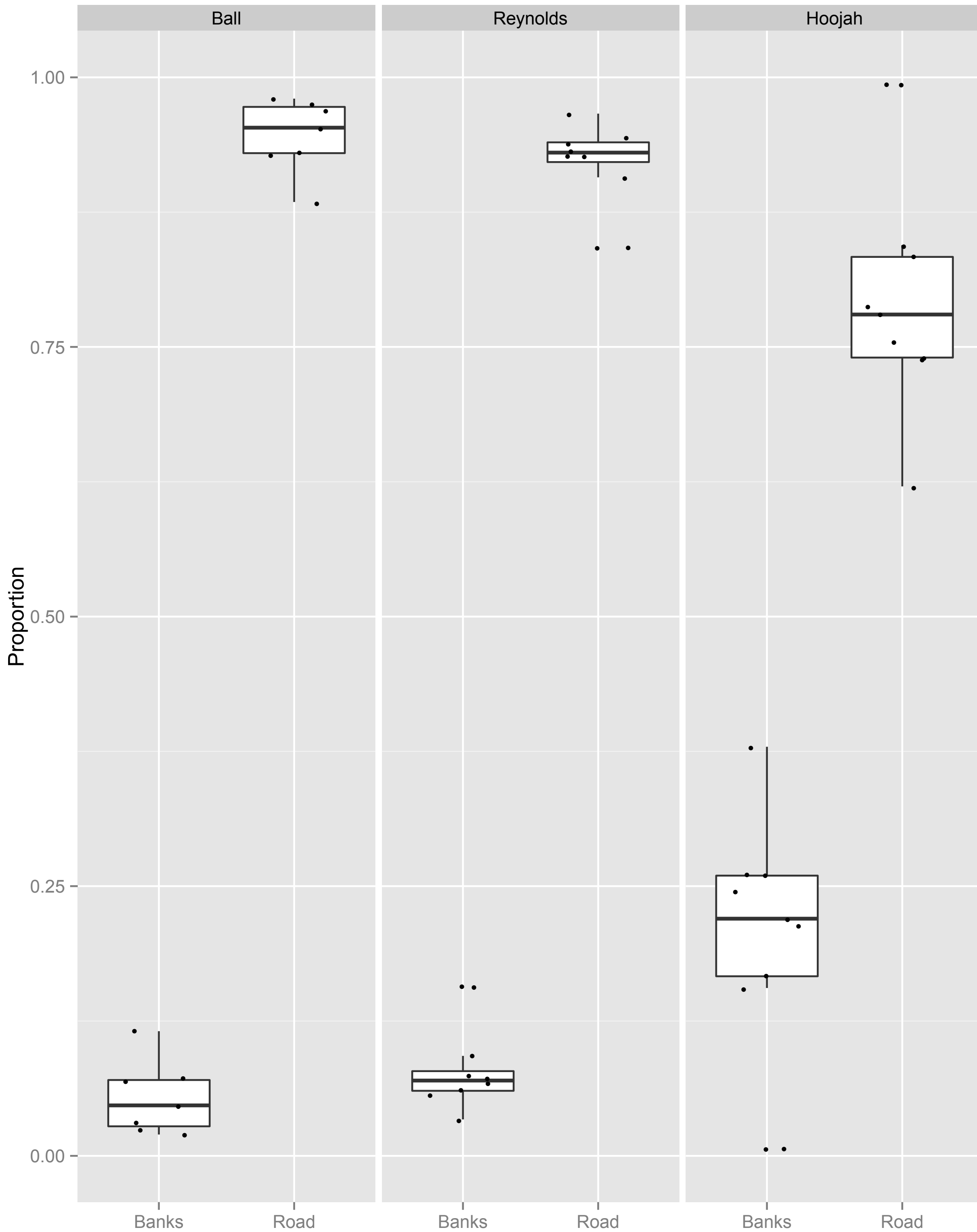

Figure 2.12. Sediment fingerprinting results for each fingerprinted source in each watershed with LOI included.

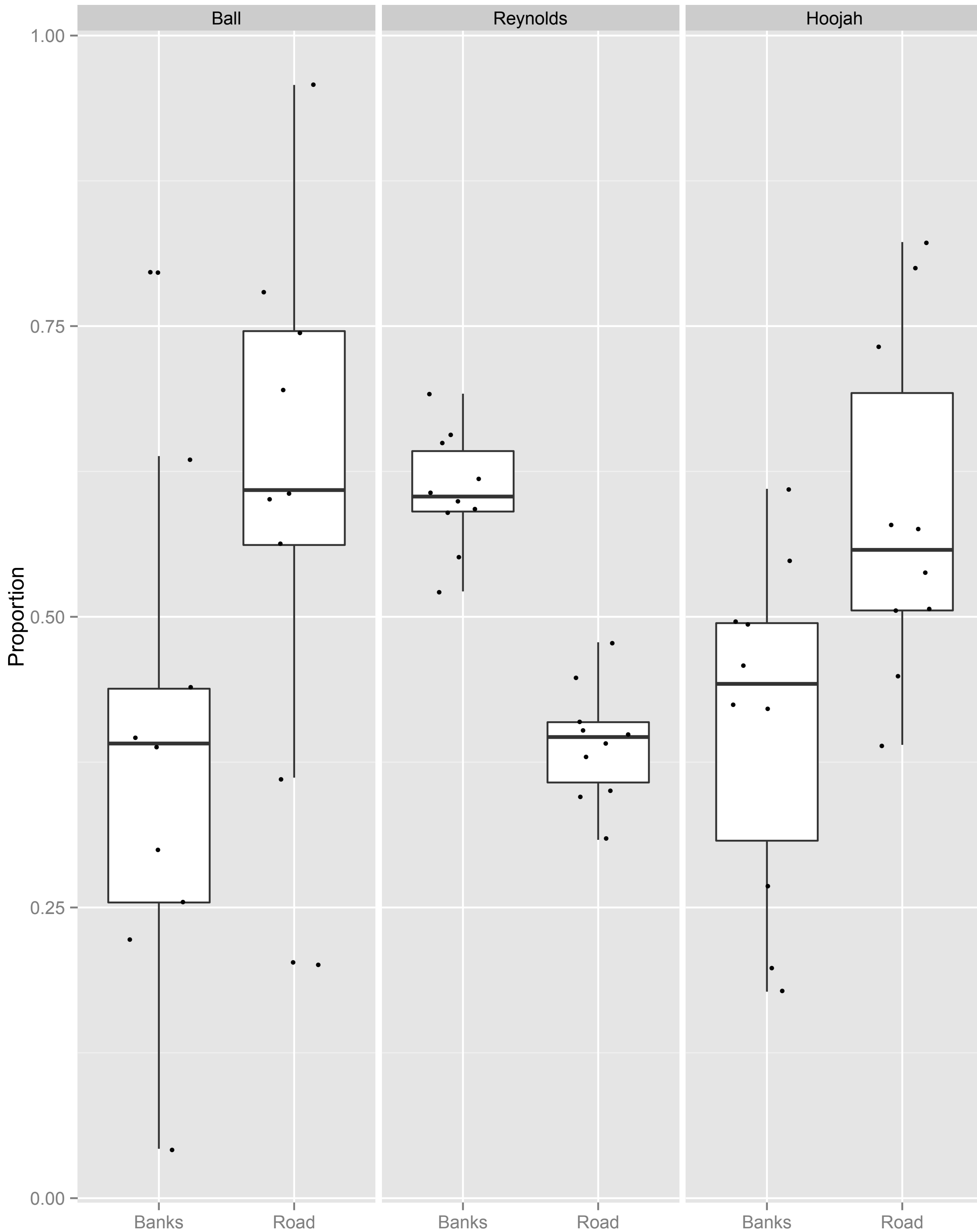

Figure 2.13. Sediment fingerprinting results for each fingerprinted source in each watershed without LOI included.

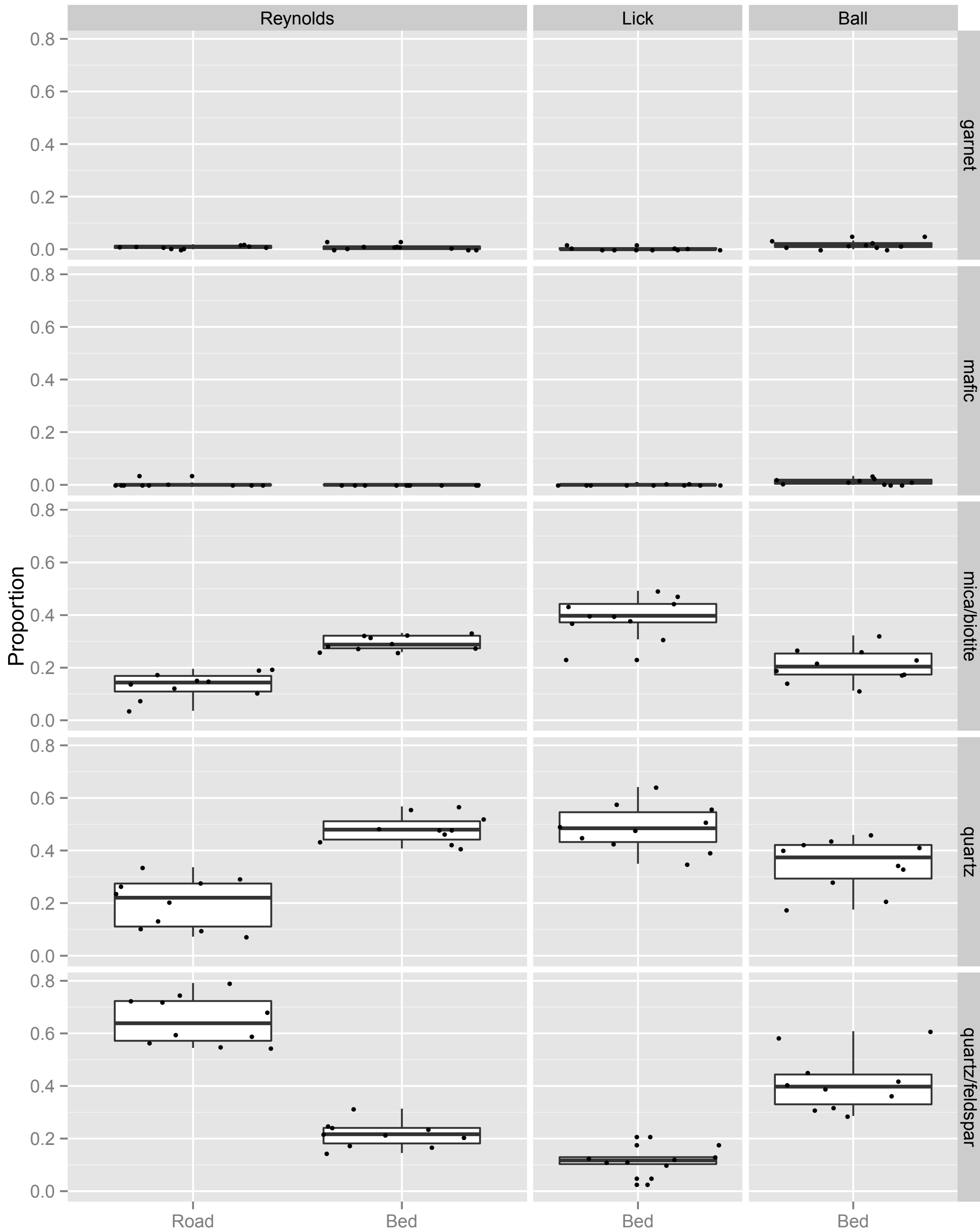

Figure 2.14. Proportions of 1-2 mm sediment grains by grain class and sediment source.

Figure 2.15. Photograph of a roadside sediment trap in Ball Creek Watershed that was recently cleaned out.

CHAPTER 3

CONCLUSION

Variation between Forest Road sediment and stream bank sediment was evaluated and sediment source ascription was implemented to differentiate the proportions they delivered to watershed outlets. This finding shows that sediment source ascription is a useful technique for evaluating the impact of forest roads on stream sediment loads. Further study is required to understand if road sediment can be detected farther downstream in sediment traps including Lake Emory and Fontana. It is possible that signatures are detectable downstream but an alternative possibility is that other sources in the basin including private driveways have similar signatures. In that case general discrimination of gravel road sources should still be possible. With these considerations sediment fingerprinting is a valuable technique for environmental monitoring and assessment purposes relating to unsealed roads in this region. However, a barrier to implementing chemical fingerprinting is the cost of establishing chemical tracers. Using the 33 tracer elements this study relied on, each sample costs approximately twenty dollars, which means that sampling multiple sources for many watersheds may not be feasible. Alternative methods including mineralogical source separation could provide valuable information, especially if feldspar staining is used. Further investigation is needed to better understand the applicability of such techniques.

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APPENDIX A

SAMPLE LOCATION PHOTOGRAPHS

Figure A1. Lick Branch Bank samples 91 & 98.

Figure A2. Lick Branch Bank samples 92 & 99.

Figure A3. Lick Branch Bed samples 143 - 153.

Figure A4. Lick Branch Bed samples 143 - 153 upstream.

Figure A5. Lick Branch Bed samples 143 - 153 downstream.

Figure A6. Reynolds Branch Bank samples 94 & 102.

Figure A7. Reynolds Branch Bank samples 95 & 103.

Figure A8. Reynolds Branch Bed sample 154 - 164 downstream.

Figure A9. Reynolds Branch Bed samples 154 - 164 upstream.

Figure A10. Ball Creek Bed Samples 165 - 175.

Figure A11. Hoojah Branch Bank samples 44 & 56.

Figure A12. Hoojah Branch Bank samples 45 & 57.

Figure A13. Hoojah Branch Bank samples 46 & 58.

Figure A14. Hoojah Branch Bank samples 48 & 59.

Figure A15. Hoojah Branch Bank samples 49 & 60.

Figure A16. Hoojah Branch Bank samples 50 & 61.

Figure A17. Hoojah Branch Bank samples 51 & 52.

Figure A18. Hoojah Branch Bank samples 52 & 63.

Figure A19. Hoojah Branch Bank samples 53 & 64.

Figure A20. Hoojah Branch Bank samples 54 & 65.

Figure A21. Hoojah Branch Bed samples 121 - 131.

Figure A22. Ramey Creek Bank samples 67 & 78.

Figure A23. Ramey Creek Bank samples 68 & 79.

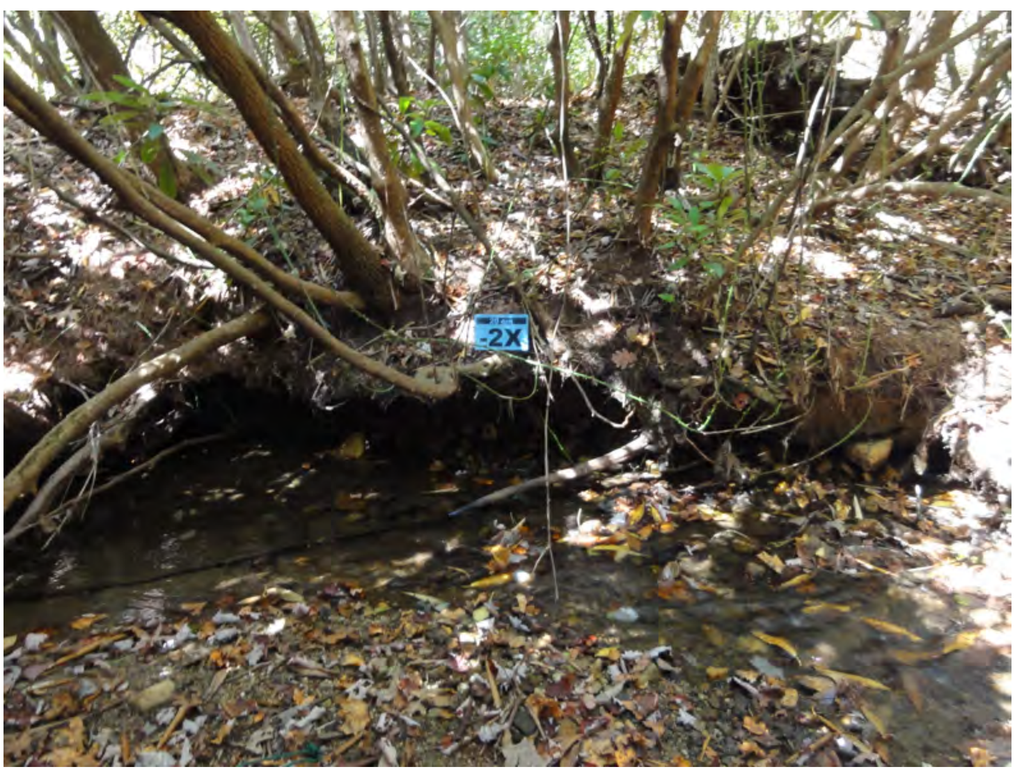

Figure A24. Ramey Creek Bank samples 69 & 80.

Figure A25. Ramey Creek Bank samples 70 & 81.

Figure A26. Ramey Creek Bank samples 71 & 82.

Figure A27. Ramey Creek Bank samples 72 & 83.

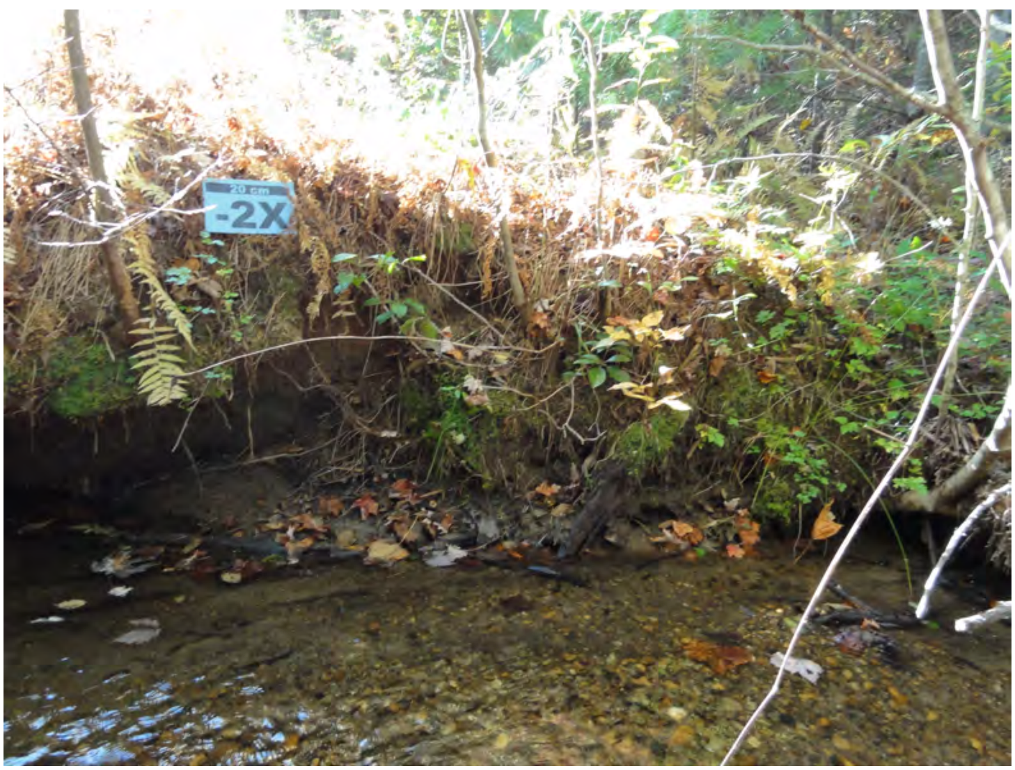

Figure A28. Ramey Creek Bank samples 73 & 84.

Figure A29. Ramey Creek Bank samples 74 & 85.

Figure A30. Ramey Creek Bank samples 75 & 86.

Figure A31. Ramey Creek Bank samples 76 & 87.

Figure A32. Ramey Creek Bed samples 132 - 142.

APPENDIX B

CHEMICAL DATA

Table B1. Element concentrations in PPM or percent.

Sample	X UTM	Y UTM	Watershed	Class	Ag ppm	Al %	As ppm	Ba ppm	Be ppm
1	285724.9799	3870394.925	Hoojah Branch	Road	<0.5	5.42	<5	450	1.3
2	285623.655	3870643.673	Hoojah Branch	Road	<0.5	4.89	<5	550	0.8
3	285620.0339	3870696.206	Hoojah Branch	Road	<0.5	5.05	<5	500	0.8
4	285592.5488	3870782.419	Hoojah Branch	Road	<0.5	4.44	<5	560	0.7
5	285448.344	3871049.554	Hoojah Branch	Road	<0.5	5.57	<5	630	1.1
6	285425.2171	3871176.148	Hoojah Branch	Road	<0.5	6.65	<5	650	1.6
7	285356.6114	3871213.225	Hoojah Branch	Road	<0.5	6.52	<5	510	1.7
8	285250.5917	3871200.622	Hoojah Branch	Road	<0.5	7.31	<5	620	1.8
9	285262.7271	3871052.215	Hoojah Branch	Road	<0.5	6.81	<5	720	1.4
10	285601.4961	3870735.947	Hoojah Branch	Road	<0.5	6.61	<5	640	1.6
11	276364.6772	3880294.562	Reynolds Branch	Road	<0.5	7.16	<5	350	0.9
12	276318.9877	3880228.896	Reynolds Branch	Road	<0.5	7.68	<5	550	1.6
13	276293.1415	3880074.01	Reynolds Branch	Road	<0.5	8.03	<5	420	1
14	276334.0934	3880006.7	Reynolds Branch	Road	<0.5	7.67	<5	410	1.5
15	276272.8554	3880025.756	Reynolds Branch	Road	<0.5	7.14	<5	450	1
17	276230.244	3880085.308	Reynolds Branch	Road	<0.5	7.57	<5	460	1.1
18	276171.8451	3879647.237	Reynolds Branch	Road	<0.5	7.64	<5	690	1.8
19	276092.7668	3879820.404	Reynolds Branch	Road	<0.5	7.05	<5	490	1.3
20	276048.5138	3880038.356	Reynolds Branch	Road	<0.5	7.32	<5	490	1.2

21	276336.2702	3880055.399	Reynolds Branch	Road	<0.5	8.12	<5	420	1.4
22	285724.9799	3870394.925	Hoojah Branch	Road Ditch	<0.5	5.9	<5	500	1.3
23	285623.655	3870643.673	Hoojah Branch	Road Ditch	<0.5	4.34	<5	370	0.9
25	285620.0339	3870696.206	Hoojah Branch	Road Ditch	<0.5	4.75	<5	410	0.8
26	285601.4961	3870735.947	Hoojah Branch	Road Ditch	<0.5	7.33	<5	860	1
27	285592.5488	3870782.419	Hoojah Branch	Road Ditch	<0.5	5.43	<5	520	1.1
28	285448.344	3871049.554	Hoojah Branch	Road Ditch	<0.5	6.3	<5	600	1.6
29	285425.2171	3871176.148	Hoojah Branch	Road Ditch	<0.5	6.89	<5	510	1.5
30	285356.6114	3871213.225	Hoojah Branch	Road Ditch	<0.5	5.96	<5	380	1.6
31	285250.5917	3871200.622	Hoojah Branch	Road Ditch	<0.5	5.97	<5	600	1.3
32	285262.7271	3871052.215	Hoojah Branch	Road Ditch	<0.5	6.06	7	590	1.6
34	276364.6772	3880294.562	Reynolds Branch	Road Ditch	<0.5	6.6	<5	340	1
35	276318.9877	3880228.896	Reynolds Branch	Road Ditch	<0.5	7.4	<5	660	1.2
36	276293.1415	3880074.01	Reynolds Branch	Road Ditch	<0.5	6.82	<5	300	0.9
37	276334.0934	3880006.7	Reynolds Branch	Road Ditch	<0.5	7.46	<5	410	1.3
38	276272.8554	3880025.756	Reynolds Branch	Road Ditch	<0.5	6.5	<5	480	0.8
39	276230.244	3880085.308	Reynolds Branch	Road Ditch	<0.5	6	<5	360	0.8
40	276171.8451	3879647.237	Reynolds Branch	Road Ditch	<0.5	6.73	<5	650	1.1
41	276092.7668	3879820.404	Reynolds Branch	Road Ditch	<0.5	6.39	<5	530	1.1
42	276048.5138	3880038.356	Reynolds Branch	Road Ditch	<0.5	5.06	6	430	0.7
43	276336.2702	3880055.399	Reynolds Branch	Road Ditch	<0.5	6.88	<5	400	1.3
44	286433.8569	3871317.947	Hoojah Branch	Bank A	<0.5	9.55	6	580	1.5
45	285674.7137	3870857.386	Hoojah Branch	Bank A	<0.5	7.61	6	520	1.2
46	285720.282	3870618.8	Hoojah Branch	Bank A	<0.5	7.63	<5	530	1.3
48	285668.9696	3870962.961	Hoojah Branch	Bank A	<0.5	7.51	5	500	1.2
49	285558.7055	3870820.156	Hoojah Branch	Bank A	<0.5	6.98	<5	510	1.2
50	285706.5015	3870693.486	Hoojah Branch	Bank A	<0.5	6.16	<5	510	1.1
51	285794.3647	3871088.763	Hoojah Branch	Bank A	<0.5	7.5	<5	510	1.3
52	285845.3733	3871120.862	Hoojah Branch	Bank A	<0.5	7.42	5	480	1.2
53	286335.3114	3871050.553	Hoojah Branch	Bank A	<0.5	7.04	5	460	1.2
54	286176.3453	3870895.563	Hoojah Branch	Bank A	<0.5	9.21	7	600	1.9

56	286433.8569	3871317.947	Hoojah Branch	Bank B	<0.5	10.8	<5	690	2
57	285674.7137	3870857.386	Hoojah Branch	Bank B	<0.5	6.98	<5	550	1.3
58	285720.282	3870618.8	Hoojah Branch	Bank B	<0.5	5.87	<5	500	1.2
59	285668.9696	3870962.961	Hoojah Branch	Bank B	<0.5	8.79	<5	1070	1.1
60	285558.7055	3870820.156	Hoojah Branch	Bank B	<0.5	9.99	<5	640	1.7
61	285706.5015	3870693.486	Hoojah Branch	Bank B	<0.5	5.94	<5	510	1.1
62	285794.3647	3871088.763	Hoojah Branch	Bank B	<0.5	6.71	<5	550	1.6
63	285845.3733	3871120.862	Hoojah Branch	Bank B	<0.5	7.16	<5	540	1.3
64	286335.3114	3871050.553	Hoojah Branch	Bank B	<0.5	9.2	9	540	1.5
65	286176.3453	3870895.563	Hoojah Branch	Bank B	<0.5	11.3	<5	670	2.5
67	287386	3869564	Ramey Creek	Bank A	<0.5	7.88	<5	490	1.2
68	287441	3869549	Ramey Creek	Bank A	<0.5	7.7	<5	450	1.2
69	287500	3869550	Ramey Creek	Bank A	<0.5	8.12	<5	450	0.9
70	287598	3869564	Ramey Creek	Bank A	<0.5	7.94	6	420	1.3
71	287654	3869524	Ramey Creek	Bank A	<0.5	6.98	6	350	1
72	287674	3869521	Ramey Creek	Bank A	<0.5	8.87	6	500	1.2
73	286997	3869760	Ramey Creek	Bank A	<0.5	7.81	<5	550	1.4
74	287193	3869550	Ramey Creek	Bank A	<0.5	8.66	<5	480	1.3
75	287174	3869586	Ramey Creek	Bank A	<0.5	8.17	<5	530	1.4
76	287274	3869479	Ramey Creek	Bank A	<0.5	7.6	5	450	1.1
78	287386	3869564	Ramey Creek	Bank B	<0.5	8.12	<5	620	1.8
79	287441	3869549	Ramey Creek	Bank B	<0.5	8.88	<5	580	1.5
80	287500	3869550	Ramey Creek	Bank B	<0.5	9.62	5	420	1
81	287598	3869564	Ramey Creek	Bank B	<0.5	8.19	<5	430	1.1
82	287654	3869524	Ramey Creek	Bank B	<0.5	7.76	<5	410	1.2
83	287674	3869521	Ramey Creek	Bank B	<0.5	8.28	<5	530	1.8
84	286997	3869760	Ramey Creek	Bank B	<0.5	7.41	<5	460	1.1
85	287193	3869550	Ramey Creek	Bank B	<0.5	6.94	<5	480	1.1
86	287174	3869586	Ramey Creek	Bank B	<0.5	8.75	5	550	1.7
87	287274	3869479	Ramey Creek	Bank B	<0.5	6.19	6	400	0.9
89	285680.7403	3870880.553	Hoojah Branch	Bank A	<0.5	8.83	6	580	1.2

90	285818.0267	3871162.57	Hoojah Branch	Bank A	<0.5	9.73	<5	720	1.4
91	276778	3880693	Lick Branch	Bank A	<0.5	8.74	11	490	1.1
92	276779	3880715	Lick Branch	Bank A	<0.5	7.99	9	520	1.3
93	276777	3879859	Lick Branch	Slide A	<0.5	9.48	<5	690	1.7
94	276360	3880201	Reynolds Branch	Bank A	<0.5	8.84	<5	760	1.8
95	276492	3880547	Reynolds Branch	Bank A	<0.5	8.49	<5	570	0.8
96	285680.7403	3870880.553	Hoojah Branch	Bank B	<0.5	9.65	<5	620	1.4
97	285818.0267	3871162.57	Hoojah Branch	Bank B	<0.5	9.19	<5	670	1.6
98	276778	3880693	Lick Branch	Bank B	<0.5	9.14	<5	540	1.2
99	276779	3880715	Lick Branch	Bank B	<0.5	8.31	<5	500	1.4
101	276777	3879859	Lick Branch	Slide B	<0.5	9.81	<5	820	1.6
102	276360	3880201	Reynolds Branch	Bank B	<0.5	9.59	<5	830	1.9
103	276492	3880547	Reynolds Branch	Bank B	<0.5	9.18	<5	590	0.9
104	285669.0986	3871007.353	Hoojah Branch	Trail erosion A	<0.5	9.59	<5	980	1.7
105	285669.0986	3871007.353	Hoojah Branch	Trail erosion B	<0.5	11.55	6	620	1
106	287336	3869203	Ramey Creek	Trail erosion A	<0.5	9.64	<5	590	1.5
107	287336	3869203	Ramey Creek	Trail erosion B	<0.5	6.81	<5	420	1.2
108	288090	3869784	Ramey Creek	Trail erosion A	<0.5	10.55	<5	780	1.7
109	288090	3869784	Ramey Creek	Trail erosion B	<0.5	10	<5	620	1.3
110	287213	3870116	Ramey Creek	Gully	<0.5	11.8	5	650	1.3
111	287213	3870116	Ramey Creek	Gully	<0.5	11.2	<5	650	1.2
112	287213	3870116	Ramey Creek	Gully	<0.5	10.95	8	640	1.3
113	287213	3870116	Ramey Creek	Gully	<0.5	11.2	5	670	1.4
114	287213	3870116	Ramey Creek	Gully	<0.5	11.05	5	540	1
115	287220	3870080	Ramey Creek	Gully	<0.5	10.8	5	540	1
117	287220	3870080	Ramey Creek	Gully	<0.5	11.65	<5	620	1.3
118	287220	3870080	Ramey Creek	Gully	<0.5	11.9	<5	640	1.3
119	287220	3870080	Ramey Creek	Gully	<0.5	12	<5	660	1.3
120	287220	3870080	Ramey Creek	Gully	<0.5	11.9	<5	660	1.3
121	285280.398	3870953.228	Hoojah Branch	Bed	<0.5	5.11	<5	570	1
122	285280.398	3870953.228	Hoojah Branch	Bed	<0.5	5.31	<5	580	1.1

123	285280.398	3870953.228	Hoojah Branch	Bed	<0.5	5.24	<5	560	1
124	285280.398	3870953.228	Hoojah Branch	Bed	<0.5	4.94	<5	530	1
126	285280.398	3870953.228	Hoojah Branch	Bed	<0.5	4.91	<5	520	1
127	285239.9802	3870944.19	Hoojah Branch	Bed	<0.5	4.15	<5	440	0.8
128	285239.9802	3870944.19	Hoojah Branch	Bed	<0.5	3.65	<5	380	0.8
129	285239.9802	3870944.19	Hoojah Branch	Bed	<0.5	5.19	<5	600	1
130	285239.9802	3870944.19	Hoojah Branch	Bed	<0.5	4.98	<5	580	1
131	285239.9802	3870944.19	Hoojah Branch	Bed	<0.5	4.15	<5	460	0.8
132	286774	3869693	Ramey Creek	Bed	<0.5	5.1	<5	420	1.1
133	286774	3869693	Ramey Creek	Bed	0.8	5.17	<5	440	1.1
135	286774	3869693	Ramey Creek	Bed	0.6	5.43	<5	480	1.2
136	286774	3869693	Ramey Creek	Bed	0.6	5.52	<5	480	1.2
137	286774	3869693	Ramey Creek	Bed	<0.5	4.8	<5	420	1
138	286821	3869715	Ramey Creek	Bed	0.5	4.28	<5	330	0.9
139	286821	3869715	Ramey Creek	Bed	0.8	4.57	<5	380	1
140	286821	3869715	Ramey Creek	Bed	1	4.26	<5	340	0.9
141	286821	3869715	Ramey Creek	Bed	1.2	4.9	<5	390	1.1
142	286821	3869715	Ramey Creek	Bed	1.7	4.59	<5	370	1
143	276787	3880734	Lick Branch	Bed	<0.5	5.35	<5	510	1
144	276787	3880734	Lick Branch	Bed	<0.5	4.82	<5	450	0.9
145	276787	3880734	Lick Branch	Bed	<0.5	5.35	6	510	1
146	276787	3880734	Lick Branch	Bed	<0.5	5.76	<5	570	1.1
147	276787	3880734	Lick Branch	Bed	<0.5	5.58	<5	540	1.1
148	276787	3880734	Lick Branch	Bed	<0.5	5.59	<5	540	1
150	276787	3880734	Lick Branch	Bed	<0.5	4.84	5	510	1.1
151	276787	3880734	Lick Branch	Bed	<0.5	5.02	<5	510	1
152	276787	3880734	Lick Branch	Bed	<0.5	5.25	<5	490	1
153	276787	3880734	Lick Branch	Bed	<0.5	4.91	<5	460	0.9
154	276390	3880592	Reynolds Branch	Bed	<0.5	5.86	<5	550	1
155	276390	3880592	Reynolds Branch	Bed	<0.5	6.47	<5	600	1.1
156	276390	3880592	Reynolds Branch	Bed	<0.5	6.31	5	600	1.1

158	276390	3880592	Reynolds Branch	Bed	<0.5	9.31	312	1270	1
159	276390	3880592	Reynolds Branch	Bed	<0.5	6.16	5	590	1.1
160	276390	3880592	Reynolds Branch	Bed	<0.5	5.93	<5	580	1
161	276390	3880592	Reynolds Branch	Bed	<0.5	5.93	5	570	1
162	276390	3880592	Reynolds Branch	Bed	<0.5	5.95	<5	570	1
163	276390	3880592	Reynolds Branch	Bed	<0.5	6.39	<5	620	1.1
164	276390	3880592	Reynolds Branch	Bed	<0.5	7.13	6	690	1.2
165	278317.9468	3882082.094	Ball Creek	Bed	<0.5	4.53	<5	320	1
167	278325.9902	3882097.863	Ball Creek	Bed	<0.5	3.88	<5	210	0.8
168	278322.0744	3882087.491	Ball Creek	Bed	<0.5	4.29	<5	250	0.9
169	278312.6551	3882076.484	Ball Creek	Bed	<0.5	4.23	<5	260	0.9
170	278303.9768	3882072.463	Ball Creek	Bed	<0.5	3.73	<5	200	0.8
171	278318.5818	3882081.776	Ball Creek	Bed	<0.5	4.36	6	300	1
172	278326.6252	3882097.545	Ball Creek	Bed	<0.5	4.09	<5	240	0.9
173	278322.7094	3882087.174	Ball Creek	Bed	<0.5	4.92	<5	350	1.1
174	278313.2901	3882076.167	Ball Creek	Bed	<0.5	4.53	<5	320	1
175	278304.6118	3882072.145	Ball Creek	Bed	<0.5	4.47	<5	300	1
176	276390	3880592	Reynolds Branch	Suspended sed	<0.5	8.85	<5	800	1.8
177	278317.9468	3882082.094	Ball Creek	Suspended sed	<0.5	7.25	<5	610	2
178	285239.9802	3870944.19	Hoojah Branch	Suspended sed	<0.5	9.13	<5	760	2.2
179	276390	3880592	Reynolds Branch	Bed	<0.5	5.44	5	470	0.9
180	278317.9468	3882082.094	Ball Creek	Vertical Accretion	<0.5	3.93	<5	210	0.7
181	278317.9468	3882082.094	Ball Creek	Vertical Accretion	<0.5	3.66	<5	190	0.6
182	278317.9468	3882082.094	Ball Creek	Vertical Accretion	<0.5	4.23	<5	230	0.7
183	285239.9802	3870944.19	Hoojah Branch	Vertical Accretion	<0.5	4.27	<5	460	0.9
184	285239.9802	3870944.19	Hoojah Branch	Vertical Accretion	<0.5	4.17	<5	450	0.8
185	285239.9802	3870944.19	Hoojah Branch	Vertical Accretion	<0.5	4.22	<5	470	0.9

Sample	**X UTM**	**Y UTM**	**Watershed**	**Class**	**Cd ppm**	**Co ppm**	**Cr ppm**	**Cu ppm**	**Fe %**
1	285724.9799	3870394.925	Hoojah Branch	Road	<0.5	12	68	13	3.28

2	285623.655	3870643.673	Hoojah Branch	Road	<0.5	6	13	6	1.36
3	285620.0339	3870696.206	Hoojah Branch	Road	<0.5	7	19	5	1.89
4	285592.5488	3870782.419	Hoojah Branch	Road	<0.5	9	42	6	4.63
5	285448.344	3871049.554	Hoojah Branch	Road	<0.5	12	37	10	3.11
6	285425.2171	3871176.148	Hoojah Branch	Road	<0.5	12	34	14	3.53
7	285356.6114	3871213.225	Hoojah Branch	Road	<0.5	5	25	12	2.98
8	285250.5917	3871200.622	Hoojah Branch	Road	<0.5	14	44	19	4.25
9	285262.7271	3871052.215	Hoojah Branch	Road	<0.5	10	44	12	4.41
10	285601.4961	3870735.947	Hoojah Branch	Road	<0.5	14	54	20	4.65
11	276364.6772	3880294.562	Reynolds Branch	Road	<0.5	17	85	51	7.2
12	276318.9877	3880228.896	Reynolds Branch	Road	<0.5	11	55	37	5
13	276293.1415	3880074.01	Reynolds Branch	Road	<0.5	19	87	80	6.47
14	276334.0934	3880006.7	Reynolds Branch	Road	<0.5	14	61	29	5.04
15	276272.8554	3880025.756	Reynolds Branch	Road	<0.5	16	81	50	6.76
17	276230.244	3880085.308	Reynolds Branch	Road	0.5	18	89	59	7.06
18	276171.8451	3879647.237	Reynolds Branch	Road	<0.5	9	39	14	3.84
19	276092.7668	3879820.404	Reynolds Branch	Road	<0.5	14	63	28	6.07
20	276048.5138	3880038.356	Reynolds Branch	Road	<0.5	14	67	30	6.68
21	276336.2702	3880055.399	Reynolds Branch	Road	<0.5	13	72	43	6.36
22	285724.9799	3870394.925	Hoojah Branch	Road Ditch	<0.5	15	72	18	3.47
23	285623.655	3870643.673	Hoojah Branch	Road Ditch	<0.5	4	10	6	1.23
25	285620.0339	3870696.206	Hoojah Branch	Road Ditch	<0.5	4	11	4	1.07
26	285601.4961	3870735.947	Hoojah Branch	Road Ditch	<0.5	14	29	10	3.06
27	285592.5488	3870782.419	Hoojah Branch	Road Ditch	<0.5	12	69	11	5.24
28	285448.344	3871049.554	Hoojah Branch	Road Ditch	<0.5	8	21	9	1.98
29	285425.2171	3871176.148	Hoojah Branch	Road Ditch	<0.5	7	39	15	4.44
30	285356.6114	3871213.225	Hoojah Branch	Road Ditch	<0.5	6	31	9	3.34
31	285250.5917	3871200.622	Hoojah Branch	Road Ditch	<0.5	6	28	8	3.03
32	285262.7271	3871052.215	Hoojah Branch	Road Ditch	<0.5	11	41	15	2.89
34	276364.6772	3880294.562	Reynolds Branch	Road Ditch	<0.5	12	63	24	5.75
35	276318.9877	3880228.896	Reynolds Branch	Road Ditch	<0.5	18	57	37	4.7

36	276293.1415	3880074.01	Reynolds Branch	Road Ditch	<0.5	11	73	17	6.85
37	276334.0934	3880006.7	Reynolds Branch	Road Ditch	<0.5	12	50	13	4.45
38	276272.8554	3880025.756	Reynolds Branch	Road Ditch	<0.5	16	98	25	9.59
39	276230.244	3880085.308	Reynolds Branch	Road Ditch	<0.5	11	72	21	5.93
40	276171.8451	3879647.237	Reynolds Branch	Road Ditch	<0.5	15	64	15	5.2
41	276092.7668	3879820.404	Reynolds Branch	Road Ditch	<0.5	23	59	14	5.61
42	276048.5138	3880038.356	Reynolds Branch	Road Ditch	<0.5	13	69	23	6.97
43	276336.2702	3880055.399	Reynolds Branch	Road Ditch	<0.5	9	45	16	3.8
44	286433.8569	3871317.947	Hoojah Branch	Bank A	<0.5	17	47	46	4.32
45	285674.7137	3870857.386	Hoojah Branch	Bank A	<0.5	14	52	27	3.8
46	285720.282	3870618.8	Hoojah Branch	Bank A	<0.5	13	60	29	4.27
48	285668.9696	3870962.961	Hoojah Branch	Bank A	<0.5	11	53	27	3.86
49	285558.7055	3870820.156	Hoojah Branch	Bank A	<0.5	15	52	24	3.68
50	285706.5015	3870693.486	Hoojah Branch	Bank A	<0.5	14	49	23	3.65
51	285794.3647	3871088.763	Hoojah Branch	Bank A	<0.5	18	56	31	4.19
52	285845.3733	3871120.862	Hoojah Branch	Bank A	<0.5	10	56	26	4.03
53	286335.3114	3871050.553	Hoojah Branch	Bank A	<0.5	11	53	25	3.89
54	286176.3453	3870895.563	Hoojah Branch	Bank A	<0.5	36	78	37	6.01
56	286433.8569	3871317.947	Hoojah Branch	Bank B	<0.5	26	53	59	4.78
57	285674.7137	3870857.386	Hoojah Branch	Bank B	<0.5	14	50	28	3.72
58	285720.282	3870618.8	Hoojah Branch	Bank B	<0.5	9	44	17	2.67
59	285668.9696	3870962.961	Hoojah Branch	Bank B	<0.5	13	43	19	3.54
60	285558.7055	3870820.156	Hoojah Branch	Bank B	<0.5	19	72	41	4.8
61	285706.5015	3870693.486	Hoojah Branch	Bank B	<0.5	10	47	18	3.53
62	285794.3647	3871088.763	Hoojah Branch	Bank B	<0.5	24	59	30	7.5
63	285845.3733	3871120.862	Hoojah Branch	Bank B	<0.5	14	63	29	3.77
64	286335.3114	3871050.553	Hoojah Branch	Bank B	<0.5	21	65	36	4.75
65	286176.3453	3870895.563	Hoojah Branch	Bank B	<0.5	54	93	53	7.36
67	287386	3869564	Ramey Creek	Bank A	<0.5	11	64	29	4.32
68	287441	3869549	Ramey Creek	Bank A	<0.5	9	58	26	3.73
69	287500	3869550	Ramey Creek	Bank A	<0.5	7	60	24	4.14

70	287598	3869564	Ramey Creek	Bank A	<0.5	8	60	25	4.01
71	287654	3869524	Ramey Creek	Bank A	<0.5	7	57	21	3.86
72	287674	3869521	Ramey Creek	Bank A	<0.5	13	81	28	3.79
73	286997	3869760	Ramey Creek	Bank A	<0.5	12	60	28	3.85
74	287193	3869550	Ramey Creek	Bank A	<0.5	11	69	33	4.26
75	287174	3869586	Ramey Creek	Bank A	<0.5	12	65	31	4.25
76	287274	3869479	Ramey Creek	Bank A	<0.5	9	60	27	4.26
78	287386	3869564	Ramey Creek	Bank B	<0.5	12	61	30	3.44
79	287441	3869549	Ramey Creek	Bank B	<0.5	10	67	32	3.64
80	287500	3869550	Ramey Creek	Bank B	<0.5	6	74	30	3.73
81	287598	3869564	Ramey Creek	Bank B	<0.5	7	61	28	4.28
82	287654	3869524	Ramey Creek	Bank B	<0.5	13	93	29	6.3
83	287674	3869521	Ramey Creek	Bank B	<0.5	16	65	21	7.32
84	286997	3869760	Ramey Creek	Bank B	<0.5	8	61	27	4.21
85	287193	3869550	Ramey Creek	Bank B	<0.5	11	61	19	3.36
86	287174	3869586	Ramey Creek	Bank B	<0.5	13	80	48	5.22
87	287274	3869479	Ramey Creek	Bank B	<0.5	8	64	22	5.09
89	285680.7403	3870880.553	Hoojah Branch	Bank A	<0.5	15	55	21	4.12
90	285818.0267	3871162.57	Hoojah Branch	Bank A	<0.5	17	44	40	4.39
91	276778	3880693	Lick Branch	Bank A	<0.5	16	68	35	5.71
92	276779	3880715	Lick Branch	Bank A	<0.5	21	65	28	6.16
93	276777	3879859	Lick Branch	Bank A	<0.5	22	70	35	5.64
94	276360	3880201	Reynolds Branch	Bank A	<0.5	25	68	30	5.5
95	276492	3880547	Reynolds Branch	Bank A	<0.5	11	69	23	5.32
96	285680.7403	3870880.553	Hoojah Branch	Bank B	<0.5	17	58	26	4.45
97	285818.0267	3871162.57	Hoojah Branch	Bank B	<0.5	21	54	39	4.54
98	276778	3880693	Lick Branch	Bank B	<0.5	15	68	41	5.55
99	276779	3880715	Lick Branch	Bank B	<0.5	30	54	47	5.12
101	276777	3879859	Lick Branch	Road Landslide	<0.5	22	70	36	5.93
102	276360	3880201	Reynolds Branch	bank B	<0.5	26	75	33	6.38
103	276492	3880547	Reynolds Branch	bank B	<0.5	16	76	30	5.96

104	285669.0986	3871007.353	Hoojah Branch	Trail erosion A	<0.5	15	36	21	3.71
105	285669.0986	3871007.353	Hoojah Branch	Trail erosion B	<0.5	11	60	47	5.6
106	287336	3869203	Ramey Creek	Trail erosion A	<0.5	15	80	47	5.8
107	287336	3869203	Ramey Creek	Trail erosion B	<0.5	9	57	23	4.48
108	288090	3869784	Ramey Creek	Trail erosion A	<0.5	29	54	60	4.82
109	288090	3869784	Ramey Creek	Trail erosion B	<0.5	19	84	40	5.09
110	287213	3870116	Ramey Creek	Gully	<0.5	16	70	73	5.79
111	287213	3870116	Ramey Creek	Gully	<0.5	14	68	70	5.7
112	287213	3870116	Ramey Creek	Gully	<0.5	16	70	64	5.75
113	287213	3870116	Ramey Creek	Gully	<0.5	17	73	66	5.8
114	287213	3870116	Ramey Creek	Gully	<0.5	8	67	51	4.12
115	287220	3870080	Ramey Creek	Gully	<0.5	8	64	50	4.1
117	287220	3870080	Ramey Creek	Gully	<0.5	14	68	68	5.61
118	287220	3870080	Ramey Creek	Gully	<0.5	14	71	72	5.8
119	287220	3870080	Ramey Creek	Gully	<0.5	14	73	72	5.77
120	287220	3870080	Ramey Creek	Gully	<0.5	15	70	71	5.78
121	285280.398	3870953.228	Hoojah Branch	Bed	<0.5	11	35	13	2.82
122	285280.398	3870953.228	Hoojah Branch	Bed	<0.5	10	39	14	3.1
123	285280.398	3870953.228	Hoojah Branch	Bed	<0.5	9	40	14	3.38
124	285280.398	3870953.228	Hoojah Branch	Bed	<0.5	9	35	13	2.71
126	285280.398	3870953.228	Hoojah Branch	Bed	<0.5	8	32	12	2.53
127	285239.9802	3870944.19	Hoojah Branch	Bed	<0.5	10	37	12	3.31
128	285239.9802	3870944.19	Hoojah Branch	Bed	<0.5	8	33	11	2.89
129	285239.9802	3870944.19	Hoojah Branch	Bed	<0.5	11	46	16	3.7
130	285239.9802	3870944.19	Hoojah Branch	Bed	<0.5	11	39	15	3.18
131	285239.9802	3870944.19	Hoojah Branch	Bed	<0.5	10	35	11	3.18
132	286774	3869693	Ramey Creek	Bed	<0.5	10	48	15	2.95
133	286774	3869693	Ramey Creek	Bed	<0.5	9	43	16	3.21
135	286774	3869693	Ramey Creek	Bed	<0.5	10	46	17	3.21
136	286774	3869693	Ramey Creek	Bed	<0.5	11	46	18	3.26
137	286774	3869693	Ramey Creek	Bed	<0.5	8	41	14	2.68

138	286821	3869715	Ramey Creek	Bed	<0.5	7	37	13	2.6
139	286821	3869715	Ramey Creek	Bed	<0.5	10	43	15	3.31
140	286821	3869715	Ramey Creek	Bed	<0.5	8	43	13	3.59
141	286821	3869715	Ramey Creek	Bed	<0.5	10	49	16	3.8
142	286821	3869715	Ramey Creek	Bed	<0.5	10	58	16	5.29
143	276787	3880734	Lick Branch	Bed	<0.5	14	65	21	6.18
144	276787	3880734	Lick Branch	Bed	<0.5	15	64	18	6.23
145	276787	3880734	Lick Branch	Bed	<0.5	15	65	21	6.21
146	276787	3880734	Lick Branch	Bed	<0.5	15	57	24	5.12
147	276787	3880734	Lick Branch	Bed	<0.5	14	59	26	5.27
148	276787	3880734	Lick Branch	Bed	<0.5	13	52	18	4.5
150	276787	3880734	Lick Branch	Bed	<0.5	12	49	19	3.98
151	276787	3880734	Lick Branch	Bed	<0.5	13	54	19	4.68
152	276787	3880734	Lick Branch	Bed	<0.5	12	53	17	4.58
153	276787	3880734	Lick Branch	Bed	<0.5	10	47	16	4
154	276390	3880592	Reynolds Branch	Bed	<0.5	13	50	17	4.36
155	276390	3880592	Reynolds Branch	Bed	<0.5	13	58	24	4.93
156	276390	3880592	Reynolds Branch	Bed	<0.5	13	64	23	5.37
158	276390	3880592	Reynolds Branch	Bed	<0.5	12	78	63	5.31
159	276390	3880592	Reynolds Branch	Bed	<0.5	13	57	20	5
160	276390	3880592	Reynolds Branch	Bed	<0.5	12	54	18	4.73
161	276390	3880592	Reynolds Branch	Bed	<0.5	12	59	19	5.18
162	276390	3880592	Reynolds Branch	Bed	<0.5	13	58	18	5.09
163	276390	3880592	Reynolds Branch	Bed	<0.5	16	58	37	4.82
164	276390	3880592	Reynolds Branch	Bed	<0.5	17	68	29	5.76
165	278317.9468	3882082.094	Ball Creek	Bed	<0.5	11	78	10	3.33
167	278325.9902	3882097.863	Ball Creek	Bed	<0.5	12	132	8	8.2
168	278322.0744	3882087.491	Ball Creek	Bed	<0.5	13	126	10	7.9
169	278312.6551	3882076.484	Ball Creek	Bed	<0.5	12	116	9	6.02
170	278303.9768	3882072.463	Ball Creek	Bed	<0.5	11	109	7	5.93
171	278318.5818	3882081.776	Ball Creek	Bed	<0.5	12	100	9	4.32

172	278326.6252	3882097.545	Ball Creek	Bed	<0.5	13	119	9	7.74
173	278322.7094	3882087.174	Ball Creek	Bed	<0.5	14	118	13	6.47
174	278313.2901	3882076.167	Ball Creek	Bed	<0.5	13	87	9	3.7
175	278304.6118	3882072.145	Ball Creek	Bed	<0.5	12	99	10	4.62
176	276390	3880592	Reynolds Branch	Suspended sed	<0.5	31	68	74	5.09
177	278317.9468	3882082.094	Ball Creek	Suspended sed	<0.5	25	105	46	4.27
178	285239.9802	3870944.19	Hoojah Branch	Suspended sed	<0.5	25	71	43	4.69
179	276390	3880592	Reynolds Branch	Bed	<0.5	12	77	15	7.37
180	278317.9468	3882082.094	Ball Creek	Vertical Accretion	<0.5	16	156	10	13.25
181	278317.9468	3882082.094	Ball Creek	Vertical Accretion	<0.5	18	185	11	17.1
182	278317.9468	3882082.094	Ball Creek	Vertical Accretion	<0.5	14	155	8	11.25
183	285239.9802	3870944.19	Hoojah Branch	Vertical Accretion	<0.5	9	34	10	2.53
184	285239.9802	3870944.19	Hoojah Branch	Vertical Accretion	<0.5	8	45	10	3.69
185	285239.9802	3870944.19	Hoojah Branch	Vertical Accretion	<0.5	7	34	10	2.45

Sample	X UTM	Y UTM	Watershed	Class	La ppm	Mg %	Mn ppm	Mo ppm	Na %
1	285724.9799	3870394.925	Hoojah Branch	Road	270	0.6	510	2	1.04
2	285623.655	3870643.673	Hoojah Branch	Road	150	0.18	201	3	0.6
3	285620.0339	3870696.206	Hoojah Branch	Road	230	0.23	253	2	0.68
4	285592.5488	3870782.419	Hoojah Branch	Road	350	0.27	587	2	0.57
5	285448.344	3871049.554	Hoojah Branch	Road	70	0.6	434	2	0.9
6	285425.2171	3871176.148	Hoojah Branch	Road	140	0.57	564	2	1.45
7	285356.6114	3871213.225	Hoojah Branch	Road	150	0.34	546	2	2.16
8	285250.5917	3871200.622	Hoojah Branch	Road	150	0.7	576	2	1.43
9	285262.7271	3871052.215	Hoojah Branch	Road	180	0.55	536	2	1.56
10	285601.4961	3870735.947	Hoojah Branch	Road	120	0.67	547	2	1.41
11	276364.6772	3880294.562	Reynolds Branch	Road	70	1.5	1475	2	1.69
12	276318.9877	3880228.896	Reynolds Branch	Road	70	1.07	926	3	2.2
13	276293.1415	3880074.01	Reynolds Branch	Road	70	2.04	1335	3	2.13
14	276334.0934	3880006.7	Reynolds Branch	Road	50	1.32	1060	2	2.2

15	276272.8554	3880025.756	Reynolds Branch	Road	80	1.37	1240	3	1.65
17	276230.244	3880085.308	Reynolds Branch	Road	90	1.42	1365	2	1.62
18	276171.8451	3879647.237	Reynolds Branch	Road	50	0.85	636	2	2.22
19	276092.7668	3879820.404	Reynolds Branch	Road	60	1.14	1075	<1	1.6
20	276048.5138	3880038.356	Reynolds Branch	Road	50	0.99	867	<1	1.76
21	276336.2702	3880055.399	Reynolds Branch	Road	50	1.46	1225	<1	2.28
22	285724.9799	3870394.925	Hoojah Branch	Road Ditch	50	0.86	484	<1	0.58
23	285623.655	3870643.673	Hoojah Branch	Road Ditch	50	0.17	197	<1	0.9
25	285620.0339	3870696.206	Hoojah Branch	Road Ditch	20	0.17	149	<1	0.8
26	285601.4961	3870735.947	Hoojah Branch	Road Ditch	70	0.46	404	<1	0.59
27	285592.5488	3870782.419	Hoojah Branch	Road Ditch	140	0.71	687	<1	1.12
28	285448.344	3871049.554	Hoojah Branch	Road Ditch	20	0.43	264	<1	1.77
29	285425.2171	3871176.148	Hoojah Branch	Road Ditch	260	0.48	711	<1	1.88
30	285356.6114	3871213.225	Hoojah Branch	Road Ditch	60	0.32	681	<1	1.81
31	285250.5917	3871200.622	Hoojah Branch	Road Ditch	50	0.41	382	<1	1.68
32	285262.7271	3871052.215	Hoojah Branch	Road Ditch	30	0.6	349	<1	1.36
34	276364.6772	3880294.562	Reynolds Branch	Road Ditch	50	1.06	1085	<1	1.62
35	276318.9877	3880228.896	Reynolds Branch	Road Ditch	30	0.86	554	<1	0.8
36	276293.1415	3880074.01	Reynolds Branch	Road Ditch	30	1.32	1290	<1	1.69
37	276334.0934	3880006.7	Reynolds Branch	Road Ditch	20	1.07	811	<1	2.2
38	276272.8554	3880025.756	Reynolds Branch	Road Ditch	50	1.1	1340	<1	0.71
39	276230.244	3880085.308	Reynolds Branch	Road Ditch	30	0.99	1015	<1	1.25
40	276171.8451	3879647.237	Reynolds Branch	Road Ditch	20	0.72	509	<1	0.77
41	276092.7668	3879820.404	Reynolds Branch	Road Ditch	30	0.85	970	<1	0.78
42	276048.5138	3880038.356	Reynolds Branch	Road Ditch	20	0.63	421	<1	0.63
43	276336.2702	3880055.399	Reynolds Branch	Road Ditch	20	0.95	692	<1	2.09
44	286433.8569	3871317.947	Hoojah Branch	Bank A	70	0.61	307	<1	0.24
45	285674.7137	3870857.386	Hoojah Branch	Bank A	110	0.55	439	<1	0.22
46	285720.282	3870618.8	Hoojah Branch	Bank A	120	0.6	417	<1	0.43
48	285668.9696	3870962.961	Hoojah Branch	Bank A	120	0.4	277	<1	0.28
49	285558.7055	3870820.156	Hoojah Branch	Bank A	130	0.53	460	<1	0.43

50	285706.5015	3870693.486	Hoojah Branch	Bank A	160	0.57	508	<1	0.31
51	285794.3647	3871088.763	Hoojah Branch	Bank A	130	0.64	516	<1	0.16
52	285845.3733	3871120.862	Hoojah Branch	Bank A	210	0.52	313	<1	0.46
53	286335.3114	3871050.553	Hoojah Branch	Bank A	280	0.49	301	<1	0.42
54	286176.3453	3870895.563	Hoojah Branch	Bank A	60	0.95	596	<1	0.36
56	286433.8569	3871317.947	Hoojah Branch	Bank B	60	0.71	748	<1	0.39
57	285674.7137	3870857.386	Hoojah Branch	Bank B	120	0.58	387	<1	0.28
58	285720.282	3870618.8	Hoojah Branch	Bank B	270	0.51	336	<1	0.53
59	285668.9696	3870962.961	Hoojah Branch	Bank B	80	0.38	490	<1	0.33
60	285558.7055	3870820.156	Hoojah Branch	Bank B	70	0.58	380	<1	0.24
61	285706.5015	3870693.486	Hoojah Branch	Bank B	250	0.47	527	<1	0.5
62	285794.3647	3871088.763	Hoojah Branch	Bank B	160	0.65	807	<1	0.23
63	285845.3733	3871120.862	Hoojah Branch	Bank B	140	0.63	331	<1	0.27
64	286335.3114	3871050.553	Hoojah Branch	Bank B	150	0.61	482	<1	0.5
65	286176.3453	3870895.563	Hoojah Branch	Bank B	40	1.16	611	<1	0.27
67	287386	3869564	Ramey Creek	Bank A	140	0.53	362	<1	0.48
68	287441	3869549	Ramey Creek	Bank A	110	0.49	348	<1	0.5
69	287500	3869550	Ramey Creek	Bank A	90	0.48	225	<1	0.32
70	287598	3869564	Ramey Creek	Bank A	220	0.46	274	<1	0.71
71	287654	3869524	Ramey Creek	Bank A	180	0.41	320	<1	0.63
72	287674	3869521	Ramey Creek	Bank A	120	1.05	373	<1	0.81
73	286997	3869760	Ramey Creek	Bank A	100	0.58	305	<1	0.53
74	287193	3869550	Ramey Creek	Bank A	80	0.58	266	<1	0.5
75	287174	3869586	Ramey Creek	Bank A	160	0.61	389	<1	0.55
76	287274	3869479	Ramey Creek	Bank A	260	0.51	310	<1	0.42
78	287386	3869564	Ramey Creek	Bank B	120	0.65	367	<1	0.79
79	287441	3869549	Ramey Creek	Bank B	90	0.58	269	<1	0.51
80	287500	3869550	Ramey Creek	Bank B	110	0.37	168	<1	0.18
81	287598	3869564	Ramey Creek	Bank B	160	0.43	311	<1	0.48
82	287654	3869524	Ramey Creek	Bank B	2110	1.09	954	2	1.15
83	287674	3869521	Ramey Creek	Bank B	450	0.74	580	<1	1.17

84	286997	3869760	Ramey Creek	Bank B	300	0.52	333	<1	0.4
85	287193	3869550	Ramey Creek	Bank B	500	0.78	354	<1	0.77
86	287174	3869586	Ramey Creek	Bank B	40	0.8	278	<1	0.41
87	287274	3869479	Ramey Creek	Bank B	1330	0.46	434	1	0.51
89	285680.7403	3870880.553	Hoojah Branch	Bank A	60	0.56	469	<1	0.26
90	285818.0267	3871162.57	Hoojah Branch	Bank A	90	0.53	417	<1	0.17
91	276778	3880693	Lick Branch	Bank A	50	0.3	337	1	0.16
92	276779	3880715	Lick Branch	Bank A	40	0.47	671	1	0.5
93	276777	3879859	Lick Branch	Bank A	60	0.63	1505	1	0.49
94	276360	3880201	Reynolds Branch	Bank A	50	0.6	1335	<1	0.39
95	276492	3880547	Reynolds Branch	Bank A	40	0.28	276	1	0.22
96	285680.7403	3870880.553	Hoojah Branch	Bank B	60	0.6	611	<1	0.26
97	285818.0267	3871162.57	Hoojah Branch	Bank B	100	0.63	510	1	0.17
98	276778	3880693	Lick Branch	Bank B	50	0.53	259	1	0.13
99	276779	3880715	Lick Branch	Bank B	60	0.76	732	1	0.12
101	276777	3879859	Lick Branch	Road Landslide	60	0.83	730	1	0.46
102	276360	3880201	Reynolds Branch	bank B	60	0.73	1280	<1	0.52
103	276492	3880547	Reynolds Branch	bank B	40	0.35	315	<1	0.25
104	285669.0986	3871007.353	Hoojah Branch	Trail erosion A	50	0.63	551	1	1.67
105	285669.0986	3871007.353	Hoojah Branch	Trail erosion B	40	0.43	427	2	0.36
106	287336	3869203	Ramey Creek	Trail erosion A	100	0.83	461	1	0.91
107	287336	3869203	Ramey Creek	Trail erosion B	230	0.54	469	<1	1.34
108	288090	3869784	Ramey Creek	Trail erosion A	120	0.81	555	<1	0.29
109	288090	3869784	Ramey Creek	Trail erosion B	160	0.92	353	<1	0.54
110	287213	3870116	Ramey Creek	Gully	120	0.45	559	<1	0.1
111	287213	3870116	Ramey Creek	Gully	200	0.43	600	1	0.09
112	287213	3870116	Ramey Creek	Gully	330	0.5	797	1	0.13
113	287213	3870116	Ramey Creek	Gully	140	0.54	893	1	0.13
114	287213	3870116	Ramey Creek	Gully	100	0.3	414	1	0.1
115	287220	3870080	Ramey Creek	Gully	110	0.3	404	1	0.1
117	287220	3870080	Ramey Creek	Gully	140	0.39	872	1	0.1

118	287220	3870080	Ramey Creek	Gully	70	0.4	956	1	0.1
119	287220	3870080	Ramey Creek	Gully	90	0.39	797	<1	0.1
120	287220	3870080	Ramey Creek	Gully	30	0.39	865	1	0.1
121	285280.398	3870953.228	Hoojah Branch	Bed	40	0.53	385	<1	0.7
122	285280.398	3870953.228	Hoojah Branch	Bed	80	0.52	416	<1	0.75
123	285280.398	3870953.228	Hoojah Branch	Bed	120	0.5	483	<1	0.72
124	285280.398	3870953.228	Hoojah Branch	Bed	30	0.5	397	<1	0.71
126	285280.398	3870953.228	Hoojah Branch	Bed	70	0.45	368	<1	0.69
127	285239.9802	3870944.19	Hoojah Branch	Bed	140	0.39	474	1	0.65
128	285239.9802	3870944.19	Hoojah Branch	Bed	120	0.34	454	1	0.63
129	285239.9802	3870944.19	Hoojah Branch	Bed	160	0.62	476	1	0.64
130	285239.9802	3870944.19	Hoojah Branch	Bed	110	0.55	427	1	0.64
131	285239.9802	3870944.19	Hoojah Branch	Bed	100	0.42	447	1	0.65
132	286774	3869693	Ramey Creek	Bed	210	0.47	446	1	0.76
133	286774	3869693	Ramey Creek	Bed	380	0.47	427	2	0.76
135	286774	3869693	Ramey Creek	Bed	310	0.52	442	2	0.77
136	286774	3869693	Ramey Creek	Bed	310	0.51	465	1	0.72
137	286774	3869693	Ramey Creek	Bed	200	0.43	370	1	0.73
138	286821	3869715	Ramey Creek	Bed	250	0.39	397	1	0.72
139	286821	3869715	Ramey Creek	Bed	370	0.42	455	1	0.65
140	286821	3869715	Ramey Creek	Bed	540	0.38	512	2	0.68
141	286821	3869715	Ramey Creek	Bed	580	0.45	508	2	0.65
142	286821	3869715	Ramey Creek	Bed	900	0.44	720	2	0.57
143	276787	3880734	Lick Branch	Bed	30	0.52	696	1	0.5
144	276787	3880734	Lick Branch	Bed	30	0.44	725	1	0.5
145	276787	3880734	Lick Branch	Bed	40	0.51	703	1	0.49
146	276787	3880734	Lick Branch	Bed	40	0.54	875	1	0.52
147	276787	3880734	Lick Branch	Bed	40	0.48	912	<1	0.53
148	276787	3880734	Lick Branch	Bed	40	0.47	497	<1	0.51
150	276787	3880734	Lick Branch	Bed	30	0.46	451	<1	0.53
151	276787	3880734	Lick Branch	Bed	30	0.47	558	<1	0.51

152	276787	3880734	Lick Branch	Bed	40	0.44	531	<1	0.5
153	276787	3880734	Lick Branch	Bed	30	0.44	478	<1	0.52
154	276390	3880592	Reynolds Branch	Bed	20	0.5	568	<1	0.82
155	276390	3880592	Reynolds Branch	Bed	30	0.59	658	<1	0.88
156	276390	3880592	Reynolds Branch	Bed	30	0.58	654	<1	0.82
158	276390	3880592	Reynolds Branch	Bed	<10	0.52	988	<1	0.09
159	276390	3880592	Reynolds Branch	Bed	30	0.57	630	<1	0.8
160	276390	3880592	Reynolds Branch	Bed	30	0.55	573	<1	0.78
161	276390	3880592	Reynolds Branch	Bed	20	0.56	616	<1	0.8
162	276390	3880592	Reynolds Branch	Bed	30	0.55	621	<1	0.82
163	276390	3880592	Reynolds Branch	Bed	30	0.6	660	3	0.77
164	276390	3880592	Reynolds Branch	Bed	40	0.69	732	3	0.83
165	278317.9468	3882082.094	Ball Creek	Bed	10	0.78	524	2	0.75
167	278325.9902	3882097.863	Ball Creek	Bed	20	0.88	1365	2	0.61
168	278322.0744	3882087.491	Ball Creek	Bed	20	0.87	1230	2	0.64
169	278312.6551	3882076.484	Ball Creek	Bed	20	0.92	985	2	0.65
170	278303.9768	3882072.463	Ball Creek	Bed	10	0.79	962	2	0.64
171	278318.5818	3882081.776	Ball Creek	Bed	10	0.87	728	2	0.68
172	278326.6252	3882097.545	Ball Creek	Bed	40	0.82	1155	1	0.64
173	278322.7094	3882087.174	Ball Creek	Bed	20	1.01	990	2	0.66
174	278313.2901	3882076.167	Ball Creek	Bed	10	0.82	611	2	0.76
175	278304.6118	3882072.145	Ball Creek	Bed	20	0.88	702	2	0.72
176	276390	3880592	Reynolds Branch	Suspended sed	60	1.08	1065	1	0.69
177	278317.9468	3882082.094	Ball Creek	Suspended sed	50	0.87	1290	2	0.36
178	285239.9802	3870944.19	Hoojah Branch	Suspended sed	40	0.86	976	1	0.32
179	276390	3880592	Reynolds Branch	Bed	40	0.51	861	<1	0.85
180	278317.9468	3882082.094	Ball Creek	Vertical Accretion	30	0.74	1675	<1	0.55
181	278317.9468	3882082.094	Ball Creek	Vertical Accretion	80	0.67	2000	<1	0.48
182	278317.9468	3882082.094	Ball Creek	Vertical Accretion	50	0.89	1620	<1	0.6
183	285239.9802	3870944.19	Hoojah Branch	Vertical Accretion	160	0.4	384	<1	0.63
184	285239.9802	3870944.19	Hoojah Branch	Vertical Accretion	500	0.42	545	1	0.6

Sample	X UTM	Y UTM	Watershed	Class	Pb ppm	S %	Sb ppm	Sc ppm	Sr ppm
185	285239.9802	3870944.19	Hoojah Branch	Vertical Accretion	160	0.4	393	<1	0.63
1	285724.9799	3870394.925	Hoojah Branch	Road	17	0.02	<5	8	223
2	285623.655	3870643.673	Hoojah Branch	Road	19	0.01	<5	4	148
3	285620.0339	3870696.206	Hoojah Branch	Road	20	0.01	<5	5	149
4	285592.5488	3870782.419	Hoojah Branch	Road	21	0.01	<5	7	152
5	285448.344	3871049.554	Hoojah Branch	Road	18	<0.01	<5	9	160
6	285425.2171	3871176.148	Hoojah Branch	Road	19	0.01	<5	9	255
7	285356.6114	3871213.225	Hoojah Branch	Road	22	0.01	<5	6	360
8	285250.5917	3871200.622	Hoojah Branch	Road	21	0.01	<5	11	231
9	285262.7271	3871052.215	Hoojah Branch	Road	23	0.01	<5	10	253
10	285601.4961	3870735.947	Hoojah Branch	Road	19	0.01	<5	11	235
11	276364.6772	3880294.562	Reynolds Branch	Road	13	0.04	<5	24	221
12	276318.9877	3880228.896	Reynolds Branch	Road	15	0.02	<5	15	336
13	276293.1415	3880074.01	Reynolds Branch	Road	10	0.03	<5	23	258
14	276334.0934	3880006.7	Reynolds Branch	Road	10	0.04	<5	18	330
15	276272.8554	3880025.756	Reynolds Branch	Road	14	0.05	<5	21	215
17	276230.244	3880085.308	Reynolds Branch	Road	14	0.05	<5	22	197
18	276171.8451	3879647.237	Reynolds Branch	Road	18	0.02	<5	10	375
19	276092.7668	3879820.404	Reynolds Branch	Road	10	0.03	<5	17	255
20	276048.5138	3880038.356	Reynolds Branch	Road	13	0.01	<5	16	300
21	276336.2702	3880055.399	Reynolds Branch	Road	11	0.04	<5	20	336
22	285724.9799	3870394.925	Hoojah Branch	Road Ditch	13	0.01	<5	11	117
23	285623.655	3870643.673	Hoojah Branch	Road Ditch	13	0.02	<5	3	190
25	285620.0339	3870696.206	Hoojah Branch	Road Ditch	12	0.01	<5	4	166
26	285601.4961	3870735.947	Hoojah Branch	Road Ditch	22	0.01	<5	10	160
27	285592.5488	3870782.419	Hoojah Branch	Road Ditch	17	0.01	<5	11	204
28	285448.344	3871049.554	Hoojah Branch	Road Ditch	16	<0.01	<5	6	294
29	285425.2171	3871176.148	Hoojah Branch	Road Ditch	22	0.01	<5	8	340

30	285356.6114	3871213.225	Hoojah Branch	Road Ditch	17	<0.01	<5	8	324
31	285250.5917	3871200.622	Hoojah Branch	Road Ditch	18	<0.01	<5	7	256
32	285262.7271	3871052.215	Hoojah Branch	Road Ditch	15	<0.01	<5	10	219
34	276364.6772	3880294.562	Reynolds Branch	Road Ditch	9	0.02	<5	18	226
35	276318.9877	3880228.896	Reynolds Branch	Road Ditch	15	0.01	<5	14	126
36	276293.1415	3880074.01	Reynolds Branch	Road Ditch	7	0.02	<5	21	225
37	276334.0934	3880006.7	Reynolds Branch	Road Ditch	9	0.01	<5	15	329
38	276272.8554	3880025.756	Reynolds Branch	Road Ditch	11	0.01	<5	21	102
39	276230.244	3880085.308	Reynolds Branch	Road Ditch	7	0.01	<5	18	168
40	276171.8451	3879647.237	Reynolds Branch	Road Ditch	12	0.01	<5	13	122
41	276092.7668	3879820.404	Reynolds Branch	Road Ditch	13	0.01	<5	14	129
42	276048.5138	3880038.356	Reynolds Branch	Road Ditch	7	<0.01	<5	12	114
43	276336.2702	3880055.399	Reynolds Branch	Road Ditch	8	0.01	<5	13	307
44	286433.8569	3871317.947	Hoojah Branch	Bank A	31	0.03	<5	11	58
45	285674.7137	3870857.386	Hoojah Branch	Bank A	29	0.04	<5	11	61
46	285720.282	3870618.8	Hoojah Branch	Bank A	28	0.04	<5	12	90
48	285668.9696	3870962.961	Hoojah Branch	Bank A	31	0.04	<5	9	69
49	285558.7055	3870820.156	Hoojah Branch	Bank A	23	0.03	<5	11	92
50	285706.5015	3870693.486	Hoojah Branch	Bank A	22	0.02	<5	10	73
51	285794.3647	3871088.763	Hoojah Branch	Bank A	27	0.02	<5	12	51
52	285845.3733	3871120.862	Hoojah Branch	Bank A	25	0.03	<5	12	101
53	286335.3114	3871050.553	Hoojah Branch	Bank A	25	0.03	<5	11	95
54	286176.3453	3870895.563	Hoojah Branch	Bank A	23	0.03	<5	18	63
56	286433.8569	3871317.947	Hoojah Branch	Bank B	26	0.03	<5	13	76
57	285674.7137	3870857.386	Hoojah Branch	Bank B	19	0.02	<5	11	67
58	285720.282	3870618.8	Hoojah Branch	Bank B	21	0.01	<5	10	114
59	285668.9696	3870962.961	Hoojah Branch	Bank B	29	0.02	<5	11	101
60	285558.7055	3870820.156	Hoojah Branch	Bank B	30	0.02	<5	14	67
61	285706.5015	3870693.486	Hoojah Branch	Bank B	19	0.01	<5	10	112
62	285794.3647	3871088.763	Hoojah Branch	Bank B	18	0.02	<5	13	60
63	285845.3733	3871120.862	Hoojah Branch	Bank B	20	0.02	<5	13	68

64	286335.3114	3871050.553	Hoojah Branch	Bank B	25	0.04	<5	14	103
65	286176.3453	3870895.563	Hoojah Branch	Bank B	26	0.03	<5	22	51
67	287386	3869564	Ramey Creek	Bank A	30	0.03	<5	13	100
68	287441	3869549	Ramey Creek	Bank A	27	0.03	<5	12	104
69	287500	3869550	Ramey Creek	Bank A	29	0.03	<5	12	74
70	287598	3869564	Ramey Creek	Bank A	26	0.02	<5	12	135
71	287654	3869524	Ramey Creek	Bank A	27	0.02	<5	10	121
72	287674	3869521	Ramey Creek	Bank A	24	0.02	<5	16	137
73	286997	3869760	Ramey Creek	Bank A	21	0.02	<5	13	107
74	287193	3869550	Ramey Creek	Bank A	28	0.03	<5	14	102
75	287174	3869586	Ramey Creek	Bank A	28	0.04	<5	14	113
76	287274	3869479	Ramey Creek	Bank A	25	0.02	<5	13	93
78	287386	3869564	Ramey Creek	Bank B	23	0.04	<5	13	153
79	287441	3869549	Ramey Creek	Bank B	26	0.03	<5	14	109
80	287500	3869550	Ramey Creek	Bank B	26	0.02	<5	13	54
81	287598	3869564	Ramey Creek	Bank B	24	0.02	<5	13	101
82	287654	3869524	Ramey Creek	Bank B	44	0.02	<5	18	224
83	287674	3869521	Ramey Creek	Bank B	26	0.03	<5	14	210
84	286997	3869760	Ramey Creek	Bank B	25	0.02	<5	12	92
85	287193	3869550	Ramey Creek	Bank B	25	0.01	<5	13	135
86	287174	3869586	Ramey Creek	Bank B	24	0.03	<5	14	75
87	287274	3869479	Ramey Creek	Bank B	31	0.01	<5	11	131
89	285680.7403	3870880.553	Hoojah Branch	Bank A	32	0.02	<5	13	70
90	285818.0267	3871162.57	Hoojah Branch	Bank A	90	0.03	<5	12	79
91	276778	3880693	Lick Branch	Bank A	29	0.03	<5	12	40
92	276779	3880715	Lick Branch	Bank A	24	0.02	<5	15	89
93	276777	3879859	Lick Branch	Bank A	28	0.03	<5	16	85
94	276360	3880201	Reynolds Branch	Bank A	25	0.03	<5	15	80
95	276492	3880547	Reynolds Branch	Bank A	24	0.02	<5	13	59
96	285680.7403	3870880.553	Hoojah Branch	Bank B	31	0.01	<5	14	71
97	285818.0267	3871162.57	Hoojah Branch	Bank B	31	0.02	<5	13	65

98	276778	3880693	Lick Branch	Bank B	22	0.01	<5	14	38
99	276779	3880715	Lick Branch	Bank B	17	0.01	<5	12	37
101	276777	3879859	Lick Branch	Road Landslide	24	0.01	<5	18	79
102	276360	3880201	Reynolds Branch	bank B	25	0.01	<5	17	105
103	276492	3880547	Reynolds Branch	bank B	22	0.01	<5	15	59
104	285669.0986	3871007.353	Hoojah Branch	Trail erosion A	33	<0.01	<5	12	280
105	285669.0986	3871007.353	Hoojah Branch	Trail erosion B	43	0.02	<5	15	88
106	287336	3869203	Ramey Creek	Trail erosion A	31	0.01	<5	15	142
107	287336	3869203	Ramey Creek	Trail erosion B	20	<0.01	<5	10	209
108	288090	3869784	Ramey Creek	Trail erosion A	43	0.01	<5	17	98
109	288090	3869784	Ramey Creek	Trail erosion B	31	0.01	<5	17	98
110	287213	3870116	Ramey Creek	Gully	36	0.02	<5	16	53
111	287213	3870116	Ramey Creek	Gully	35	0.02	<5	15	55
112	287213	3870116	Ramey Creek	Gully	35	0.02	<5	16	59
113	287213	3870116	Ramey Creek	Gully	34	0.02	<5	16	55
114	287213	3870116	Ramey Creek	Gully	35	0.02	<5	14	49
115	287220	3870080	Ramey Creek	Gully	35	0.02	<5	14	50
117	287220	3870080	Ramey Creek	Gully	37	0.03	<5	16	50
118	287220	3870080	Ramey Creek	Gully	36	0.03	<5	15	50
119	287220	3870080	Ramey Creek	Gully	40	0.03	<5	15	52
120	287220	3870080	Ramey Creek	Gully	38	0.03	<5	15	50
121	285280.398	3870953.228	Hoojah Branch	Bed	14	<0.01	<5	8	134
122	285280.398	3870953.228	Hoojah Branch	Bed	17	<0.01	<5	8	147
123	285280.398	3870953.228	Hoojah Branch	Bed	15	<0.01	<5	9	143
124	285280.398	3870953.228	Hoojah Branch	Bed	15	<0.01	<5	8	136
126	285280.398	3870953.228	Hoojah Branch	Bed	15	<0.01	<5	7	134
127	285239.9802	3870944.19	Hoojah Branch	Bed	16	0.02	<5	7	128
128	285239.9802	3870944.19	Hoojah Branch	Bed	13	0.01	<5	6	120
129	285239.9802	3870944.19	Hoojah Branch	Bed	16	0.01	5	10	125
130	285239.9802	3870944.19	Hoojah Branch	Bed	17	0.01	5	9	126
131	285239.9802	3870944.19	Hoojah Branch	Bed	15	<0.01	<5	7	123

132	286774	3869693	Ramey Creek	Bed	18	0.01	<5	8	146
133	286774	3869693	Ramey Creek	Bed	19	0.01	5	8	151
135	286774	3869693	Ramey Creek	Bed	20	0.01	5	9	150
136	286774	3869693	Ramey Creek	Bed	19	0.01	<5	9	143
137	286774	3869693	Ramey Creek	Bed	16	0.01	5	8	142
138	286821	3869715	Ramey Creek	Bed	17	0.01	<5	7	141
139	286821	3869715	Ramey Creek	Bed	18	0.01	5	8	141
140	286821	3869715	Ramey Creek	Bed	18	0.01	6	8	146
141	286821	3869715	Ramey Creek	Bed	21	0.01	7	9	140
142	286821	3869715	Ramey Creek	Bed	26	0.01	7	10	144
143	276787	3880734	Lick Branch	Bed	16	0.01	10	13	87
144	276787	3880734	Lick Branch	Bed	13	0.01	7	13	85
145	276787	3880734	Lick Branch	Bed	16	0.01	7	13	89
146	276787	3880734	Lick Branch	Bed	19	0.02	7	12	103
147	276787	3880734	Lick Branch	Bed	20	0.02	<5	13	103
148	276787	3880734	Lick Branch	Bed	13	0.02	<5	12	93
150	276787	3880734	Lick Branch	Bed	15	0.02	<5	10	89
151	276787	3880734	Lick Branch	Bed	12	0.02	<5	11	87
152	276787	3880734	Lick Branch	Bed	16	0.02	<5	12	91
153	276787	3880734	Lick Branch	Bed	13	0.01	<5	11	91
154	276390	3880592	Reynolds Branch	Bed	14	0.01	<5	11	134
155	276390	3880592	Reynolds Branch	Bed	13	0.01	<5	13	148
156	276390	3880592	Reynolds Branch	Bed	11	0.01	<5	13	140
158	276390	3880592	Reynolds Branch	Bed	89	0.01	5	23	38
159	276390	3880592	Reynolds Branch	Bed	14	0.01	<5	12	136
160	276390	3880592	Reynolds Branch	Bed	66	0.01	<5	12	130
161	276390	3880592	Reynolds Branch	Bed	15	0.01	<5	12	135
162	276390	3880592	Reynolds Branch	Bed	14	0.01	<5	12	138
163	276390	3880592	Reynolds Branch	Bed	17	0.02	<5	13	131
164	276390	3880592	Reynolds Branch	Bed	16	0.02	<5	14	146
165	278317.9468	3882082.094	Ball Creek	Bed	11	<0.01	<5	13	128

167	278325.9902	3882097.863	Ball Creek	Bed	10	<0.01	<5	21	104
168	278322.0744	3882087.491	Ball Creek	Bed	10	<0.01	<5	21	118
169	278312.6551	3882076.484	Ball Creek	Bed	12	<0.01	<5	18	116
170	278303.9768	3882072.463	Ball Creek	Bed	6	<0.01	<5	17	112
171	278318.5818	3882081.776	Ball Creek	Bed	9	<0.01	<5	16	120
172	278326.6252	3882097.545	Ball Creek	Bed	9	<0.01	<5	20	117
173	278322.7094	3882087.174	Ball Creek	Bed	13	<0.01	<5	20	121
174	278313.2901	3882076.167	Ball Creek	Bed	9	<0.01	<5	14	129
175	278304.6118	3882072.145	Ball Creek	Bed	8	<0.01	<5	16	125
176	276390	3880592	Reynolds Branch	Suspended sed	25	0.07	<5	15	141
177	278317.9468	3882082.094	Ball Creek	Suspended sed	21	0.1	<5	13	121
178	285239.9802	3870944.19	Hoojah Branch	Suspended sed	28	0.07	<5	15	120
179	276390	3880592	Reynolds Branch	Bed	9	0.01	<5	14	138
180	278317.9468	3882082.094	Ball Creek	Vertical Accretion	8	<0.01	6	25	112
181	278317.9468	3882082.094	Ball Creek	Vertical Accretion	9	<0.01	<5	27	101
182	278317.9468	3882082.094	Ball Creek	Vertical Accretion	9	<0.01	<5	26	120
183	285239.9802	3870944.19	Hoojah Branch	Vertical Accretion	13	0.01	<5	7	128
184	285239.9802	3870944.19	Hoojah Branch	Vertical Accretion	18	0.01	<5	8	135
185	285239.9802	3870944.19	Hoojah Branch	Vertical Accretion	15	0.01	<5	7	130

Sample	**X UTM**	**Y UTM**	**Watershed**	**Class**	**Tl ppm**	**U ppm**	**V ppm**	**W ppm**	**Zn ppm**
1	285724.9799	3870394.925	Hoojah Branch	Road	<10	<10	75	<10	62
2	285623.655	3870643.673	Hoojah Branch	Road	<10	<10	28	<10	29
3	285620.0339	3870696.206	Hoojah Branch	Road	10	<10	43	10	37
4	285592.5488	3870782.419	Hoojah Branch	Road	<10	<10	100	<10	49
5	285448.344	3871049.554	Hoojah Branch	Road	<10	<10	68	<10	70
6	285425.2171	3871176.148	Hoojah Branch	Road	<10	<10	74	<10	68
7	285356.6114	3871213.225	Hoojah Branch	Road	<10	<10	67	<10	45
8	285250.5917	3871200.622	Hoojah Branch	Road	<10	<10	92	<10	83
9	285262.7271	3871052.215	Hoojah Branch	Road	<10	<10	101	<10	68

10	285601.4961	3870735.947	Hoojah Branch	Road	<10	<10	109	<10	83
11	276364.6772	3880294.562	Reynolds Branch	Road	<10	10	122	<10	112
12	276318.9877	3880228.896	Reynolds Branch	Road	<10	10	84	<10	95
13	276293.1415	3880074.01	Reynolds Branch	Road	<10	10	117	<10	140
14	276334.0934	3880006.7	Reynolds Branch	Road	<10	10	88	<10	94
15	276272.8554	3880025.756	Reynolds Branch	Road	<10	<10	122	<10	110
17	276230.244	3880085.308	Reynolds Branch	Road	<10	<10	122	<10	127
18	276171.8451	3879647.237	Reynolds Branch	Road	<10	10	70	<10	82
19	276092.7668	3879820.404	Reynolds Branch	Road	<10	<10	100	<10	97
20	276048.5138	3880038.356	Reynolds Branch	Road	<10	<10	121	<10	72
21	276336.2702	3880055.399	Reynolds Branch	Road	<10	<10	105	<10	101
22	285724.9799	3870394.925	Hoojah Branch	Road Ditch	<10	<10	75	<10	84
23	285623.655	3870643.673	Hoojah Branch	Road Ditch	<10	<10	23	<10	25
25	285620.0339	3870696.206	Hoojah Branch	Road Ditch	<10	<10	22	<10	27
26	285601.4961	3870735.947	Hoojah Branch	Road Ditch	<10	<10	60	<10	80
27	285592.5488	3870782.419	Hoojah Branch	Road Ditch	<10	<10	119	<10	61
28	285448.344	3871049.554	Hoojah Branch	Road Ditch	<10	<10	41	<10	47
29	285425.2171	3871176.148	Hoojah Branch	Road Ditch	<10	<10	95	<10	56
30	285356.6114	3871213.225	Hoojah Branch	Road Ditch	<10	<10	70	<10	36
31	285250.5917	3871200.622	Hoojah Branch	Road Ditch	<10	<10	66	<10	48
32	285262.7271	3871052.215	Hoojah Branch	Road Ditch	<10	<10	70	<10	64
34	276364.6772	3880294.562	Reynolds Branch	Road Ditch	<10	<10	94	<10	81
35	276318.9877	3880228.896	Reynolds Branch	Road Ditch	<10	<10	93	<10	98
36	276293.1415	3880074.01	Reynolds Branch	Road Ditch	<10	<10	110	<10	80
37	276334.0934	3880006.7	Reynolds Branch	Road Ditch	<10	<10	77	<10	69
38	276272.8554	3880025.756	Reynolds Branch	Road Ditch	<10	<10	174	<10	101
39	276230.244	3880085.308	Reynolds Branch	Road Ditch	<10	<10	100	<10	78
40	276171.8451	3879647.237	Reynolds Branch	Road Ditch	<10	<10	115	<10	87
41	276092.7668	3879820.404	Reynolds Branch	Road Ditch	<10	<10	103	<10	105
42	276048.5138	3880038.356	Reynolds Branch	Road Ditch	<10	<10	144	<10	53
43	276336.2702	3880055.399	Reynolds Branch	Road Ditch	<10	<10	70	<10	63

44	286433.8569	3871317.947	Hoojah Branch	Bank A	<10	<10	87	<10	107
45	285674.7137	3870857.386	Hoojah Branch	Bank A	<10	<10	81	<10	89
46	285720.282	3870618.8	Hoojah Branch	Bank A	<10	<10	97	<10	83
48	285668.9696	3870962.961	Hoojah Branch	Bank A	<10	<10	79	<10	72
49	285558.7055	3870820.156	Hoojah Branch	Bank A	<10	<10	84	<10	77
50	285706.5015	3870693.486	Hoojah Branch	Bank A	<10	<10	77	<10	79
51	285794.3647	3871088.763	Hoojah Branch	Bank A	<10	<10	87	<10	102
52	285845.3733	3871120.862	Hoojah Branch	Bank A	<10	<10	93	<10	79
53	286335.3114	3871050.553	Hoojah Branch	Bank A	<10	<10	89	<10	76
54	286176.3453	3870895.563	Hoojah Branch	Bank A	<10	<10	133	<10	131
56	286433.8569	3871317.947	Hoojah Branch	Bank B	<10	<10	96	<10	118
57	285674.7137	3870857.386	Hoojah Branch	Bank B	<10	<10	82	<10	91
58	285720.282	3870618.8	Hoojah Branch	Bank B	<10	<10	75	<10	64
59	285668.9696	3870962.961	Hoojah Branch	Bank B	<10	<10	79	<10	82
60	285558.7055	3870820.156	Hoojah Branch	Bank B	<10	<10	101	<10	100
61	285706.5015	3870693.486	Hoojah Branch	Bank B	<10	<10	83	<10	65
62	285794.3647	3871088.763	Hoojah Branch	Bank B	<10	<10	93	<10	94
63	285845.3733	3871120.862	Hoojah Branch	Bank B	<10	<10	93	<10	93
64	286335.3114	3871050.553	Hoojah Branch	Bank B	<10	<10	107	<10	107
65	286176.3453	3870895.563	Hoojah Branch	Bank B	<10	<10	165	<10	179
67	287386	3869564	Ramey Creek	Bank A	<10	<10	103	<10	74
68	287441	3869549	Ramey Creek	Bank A	<10	<10	94	<10	67
69	287500	3869550	Ramey Creek	Bank A	<10	<10	105	<10	68
70	287598	3869564	Ramey Creek	Bank A	<10	<10	104	<10	61
71	287654	3869524	Ramey Creek	Bank A	<10	<10	98	<10	52
72	287674	3869521	Ramey Creek	Bank A	<10	<10	115	<10	91
73	286997	3869760	Ramey Creek	Bank A	<10	<10	96	<10	85
74	287193	3869550	Ramey Creek	Bank A	<10	<10	108	<10	88
75	287174	3869586	Ramey Creek	Bank A	<10	<10	107	<10	83
76	287274	3869479	Ramey Creek	Bank A	<10	<10	108	<10	69
78	287386	3869564	Ramey Creek	Bank B	<10	<10	95	<10	89

79	287441	3869549	Ramey Creek	Bank B	<10	<10	103	<10	91
80	287500	3869550	Ramey Creek	Bank B	<10	<10	119	<10	77
81	287598	3869564	Ramey Creek	Bank B	<10	<10	107	<10	67
82	287654	3869524	Ramey Creek	Bank B	<10	<10	169	<10	87
83	287674	3869521	Ramey Creek	Bank B	<10	<10	130	<10	74
84	286997	3869760	Ramey Creek	Bank B	<10	<10	109	<10	72
85	287193	3869550	Ramey Creek	Bank B	<10	<10	94	<10	71
86	287174	3869586	Ramey Creek	Bank B	<10	<10	129	<10	110
87	287274	3869479	Ramey Creek	Bank B	<10	<10	125	<10	61
89	285680.7403	3870880.553	Hoojah Branch	Bank A	<10	<10	96	<10	123
90	285818.0267	3871162.57	Hoojah Branch	Bank A	<10	<10	69	<10	99
91	276778	3880693	Lick Branch	Bank A	10	<10	129	<10	119
92	276779	3880715	Lick Branch	Bank A	10	<10	126	<10	93
93	276777	3879859	Lick Branch	Bank A	<10	<10	117	<10	75
94	276360	3880201	Reynolds Branch	Bank A	<10	<10	114	<10	98
95	276492	3880547	Reynolds Branch	Bank A	<10	<10	125	<10	102
96	285680.7403	3870880.553	Hoojah Branch	Bank B	10	<10	100	<10	70
97	285818.0267	3871162.57	Hoojah Branch	Bank B	<10	<10	83	<10	110
98	276778	3880693	Lick Branch	Bank B	<10	<10	133	<10	113
99	276779	3880715	Lick Branch	Bank B	<10	<10	109	<10	99
101	276777	3879859	Lick Branch	Road Landslide	<10	<10	130	<10	100
102	276360	3880201	Reynolds Branch	Bank B	10	<10	129	<10	110
103	276492	3880547	Reynolds Branch	Bank B	<10	<10	138	<10	111
104	285669.0986	3871007.353	Hoojah Branch	Trail erosion A	<10	<10	68	<10	77
105	285669.0986	3871007.353	Hoojah Branch	Trail erosion B	<10	<10	113	<10	85
106	287336	3869203	Ramey Creek	Trail erosion A	<10	<10	130	<10	85
107	287336	3869203	Ramey Creek	Trail erosion B	<10	<10	101	<10	108
108	288090	3869784	Ramey Creek	Trail erosion A	<10	<10	107	<10	62
109	288090	3869784	Ramey Creek	Trail erosion B	<10	<10	112	<10	123
110	287213	3870116	Ramey Creek	Gully	<10	<10	131	<10	112
111	287213	3870116	Ramey Creek	Gully	<10	<10	132	<10	104

112	287213	3870116	Ramey Creek	Gully	<10	<10	131	<10	99
113	287213	3870116	Ramey Creek	Gully	<10	<10	133	<10	108
114	287213	3870116	Ramey Creek	Gully	<10	<10	133	<10	115
115	287220	3870080	Ramey Creek	Gully	<10	<10	128	<10	78
117	287220	3870080	Ramey Creek	Gully	10	<10	129	<10	76
118	287220	3870080	Ramey Creek	Gully	<10	<10	135	<10	99
119	287220	3870080	Ramey Creek	Gully	<10	<10	134	<10	105
120	287220	3870080	Ramey Creek	Gully	<10	<10	135	<10	104
121	285280.398	3870953.228	Hoojah Branch	Bed	<10	<10	59	<10	104
122	285280.398	3870953.228	Hoojah Branch	Bed	<10	<10	66	<10	60
123	285280.398	3870953.228	Hoojah Branch	Bed	<10	<10	75	<10	60
124	285280.398	3870953.228	Hoojah Branch	Bed	<10	<10	57	<10	59
126	285280.398	3870953.228	Hoojah Branch	Bed	<10	<10	54	<10	56
127	285239.9802	3870944.19	Hoojah Branch	Bed	<10	<10	78	<10	52
128	285239.9802	3870944.19	Hoojah Branch	Bed	<10	<10	67	<10	53
129	285239.9802	3870944.19	Hoojah Branch	Bed	<10	<10	83	<10	41
130	285239.9802	3870944.19	Hoojah Branch	Bed	<10	<10	73	<10	71
131	285239.9802	3870944.19	Hoojah Branch	Bed	<10	<10	73	<10	64
132	286774	3869693	Ramey Creek	Bed	<10	<10	72	<10	48
133	286774	3869693	Ramey Creek	Bed	<10	<10	82	<10	53
135	286774	3869693	Ramey Creek	Bed	<10	<10	79	<10	56
136	286774	3869693	Ramey Creek	Bed	<10	<10	80	<10	60
137	286774	3869693	Ramey Creek	Bed	<10	<10	67	<10	62
138	286821	3869715	Ramey Creek	Bed	<10	<10	67	<10	48
139	286821	3869715	Ramey Creek	Bed	<10	<10	88	<10	40
140	286821	3869715	Ramey Creek	Bed	<10	<10	97	<10	48
141	286821	3869715	Ramey Creek	Bed	<10	<10	102	<10	43
142	286821	3869715	Ramey Creek	Bed	<10	<10	149	<10	55
143	276787	3880734	Lick Branch	Bed	<10	<10	145	<10	56
144	276787	3880734	Lick Branch	Bed	<10	<10	149	<10	72
145	276787	3880734	Lick Branch	Bed	<10	<10	145	<10	63

146	276787	3880734	Lick Branch	Bed	<10	<10	118	<10	70
147	276787	3880734	Lick Branch	Bed	<10	<10	123	<10	76
148	276787	3880734	Lick Branch	Bed	<10	<10	108	<10	75
150	276787	3880734	Lick Branch	Bed	<10	<10	100	<10	67
151	276787	3880734	Lick Branch	Bed	<10	<10	119	<10	65
152	276787	3880734	Lick Branch	Bed	<10	<10	113	<10	66
153	276787	3880734	Lick Branch	Bed	<10	<10	97	<10	62
154	276390	3880592	Reynolds Branch	Bed	<10	<10	101	<10	58
155	276390	3880592	Reynolds Branch	Bed	<10	<10	113	<10	66
156	276390	3880592	Reynolds Branch	Bed	<10	<10	125	<10	78
158	276390	3880592	Reynolds Branch	Bed	<10	<10	181	<10	77
159	276390	3880592	Reynolds Branch	Bed	<10	<10	117	<10	124
160	276390	3880592	Reynolds Branch	Bed	<10	<10	110	<10	74
161	276390	3880592	Reynolds Branch	Bed	<10	<10	122	<10	68
162	276390	3880592	Reynolds Branch	Bed	<10	<10	118	<10	72
163	276390	3880592	Reynolds Branch	Bed	<10	<10	110	<10	70
164	276390	3880592	Reynolds Branch	Bed	<10	<10	131	<10	85
165	278317.9468	3882082.094	Ball Creek	Bed	<10	<10	79	<10	92
167	278325.9902	3882097.863	Ball Creek	Bed	<10	<10	194	<10	44
168	278322.0744	3882087.491	Ball Creek	Bed	<10	<10	183	<10	54
169	278312.6551	3882076.484	Ball Creek	Bed	<10	<10	140	<10	56
170	278303.9768	3882072.463	Ball Creek	Bed	<10	<10	138	<10	52
171	278318.5818	3882081.776	Ball Creek	Bed	<10	<10	101	<10	46
172	278326.6252	3882097.545	Ball Creek	Bed	<10	<10	178	<10	47
173	278322.7094	3882087.174	Ball Creek	Bed	<10	<10	148	<10	54
174	278313.2901	3882076.167	Ball Creek	Bed	<10	<10	88	<10	63
175	278304.6118	3882072.145	Ball Creek	Bed	<10	<10	109	<10	45
176	276390	3880592	Reynolds Branch	Suspended sed	<10	<10	110	10	49
177	278317.9468	3882082.094	Ball Creek	Suspended sed	<10	<10	90	<10	157
178	285239.9802	3870944.19	Hoojah Branch	Suspended sed	<10	<10	95	<10	151
179	276390	3880592	Reynolds Branch	Bed	<10	<10	174	<10	69

180	278317.9468	3882082.094	Ball Creek	Vertical Accretion	10	<10	320	<10	69
181	278317.9468	3882082.094	Ball Creek	Vertical Accretion	20	<10	426	<10	84
182	278317.9468	3882082.094	Ball Creek	Vertical Accretion	10	<10	269	<10	63
183	285239.9802	3870944.19	Hoojah Branch	Vertical Accretion	<10	<10	61	<10	46
184	285239.9802	3870944.19	Hoojah Branch	Vertical Accretion	<10	<10	93	<10	47
185	285239.9802	3870944.19	Hoojah Branch	Vertical Accretion	<10	<10	58	<10	43

Table B2. Replicate samples.

SAMPLE	Type	Ag ppm	Al %	As ppm	Ba ppm	Be ppm	Bi ppm	Ca %	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe %	Ga ppm	K %	La ppm
16	Replicate	<0.5	6.44	<5	610	1.6	<2	1.18	<0.5	12	55	20	4.93	20	1.74	160
24	GXR6	<0.5	10.4	347	1380	1.1	<2	0.18	<0.5	12	82	67	5.85	20	1.77	10
33	Replicate	<0.5	6.7	<5	630	1.7	<2	1.23	<0.5	12	58	19	5.08	20	1.86	130
47	Replicate	<0.5	6.63	<5	620	1.6	<2	1.17	<0.5	14	55	19	4.92	20	1.82	120
55	GXR6	<0.5	9.98	324	1340	1	<2	0.18	<0.5	11	76	64	5.57	20	1.69	10
66	Replicate	<0.5	6.81	<5	630	1.7	<2	1.26	<0.5	12	57	21	5.14	20	1.88	130
77	Replicate	<0.5	6.56	<5	610	1.6	<2	1.18	<0.5	11	52	19	4.8	20	1.84	110
88	GXR6	<0.5	7.86	321	1220	1	<2	0.14	<0.5	11	79	64	5.19	20	1.6	<10
100	Replicate	<0.5	6.51	<5	600	1.6	2	1.2	<0.5	12	51	19	4.82	20	1.85	130
116	Replicate	<0.5	6.83	<5	630	1.6	<2	1.24	<0.5	13	56	20	5.1	20	1.94	150
125	GXR6	<0.5	9.25	317	1260	1	<2	0.16	<0.5	12	78	64	5.32	20	1.7	<10
134	Replicate	<0.5	6.53	<5	610	1.6	<2	1.22	<0.5	13	54	27	5.03	20	1.81	140
149	Replicate	<0.5	6.44	<5	590	1.6	<2	1.14	<0.5	11	53	19	4.82	20	1.78	120
157	GXR6	<0.5	9.31	312	1270	1	<2	0.16	<0.5	12	78	63	5.31	20	1.63	<10
166	Replicate	<0.5	6.16	5	580	1.5	<2	1.11	<0.5	13	53	18	4.83	20	1.69	120

SAMPLE	Type	Mg %	Mn ppm	Mo ppm	Na %	Ni ppm	P ppm	Pb ppm	S %	Sb ppm	Sc ppm	Sr ppm	Th ppm	Ti %	Tl ppm	U ppm
16	Replicate	0.63	547	3	1.43	20	1000	20	0.01	<5	11	240	60	0.77	<10	<10
24	GXR6	0.58	1090	<1	0.09	20	410	100	0.01	<5	26	42	<20	0.5	<10	<10
33	Replicate	0.64	535	<1	1.48	18	880	17	0.01	<5	11	255	50	0.72	<10	<10

47	Replicate	0.63	539	2	1.42	20	930	21	<0.01	<5	11	245	50	0.71	<10	<10
55	GXR6	0.56	1035	1	0.08	20	390	93	0.01	<5	25	41	<20	0.47	<10	<10
66	Replicate	0.66	538	<1	1.51	19	890	19	0.01	<5	11	258	50	0.73	<10	<10
77	Replicate	0.63	504	<1	1.43	18	830	15	0.01	<5	11	243	40	0.68	<10	<10
88	GXR6	0.42	968	1	0.08	21	350	90	0.01	5	18	33	<20	0.46	<10	<10
100	Replicate	0.62	542	<1	1.46	18	900	18	<0.01	<5	11	249	50	0.7	<10	<10
116	Replicate	0.66	573	<1	1.49	19	920	19	<0.01	<5	12	259	60	0.73	<10	<10
125	GXR6	0.5	1005	2	0.08	20	370	91	<0.01	<5	22	37	<20	0.46	<10	<10
134	Replicate	0.64	513	1	1.46	20	830	17	0.01	5	11	252	50	0.73	<10	<10
149	Replicate	0.62	533	<1	1.41	18	870	19	0.01	<5	11	246	50	0.72	<10	<10
157	GXR6	0.52	988	<1	0.09	20	370	89	0.01	5	23	38	<20	0.47	<10	<10
166	Replicate	0.58	519	2	1.35	18	890	18	<0.01	<5	11	235	50	0.71	<10	<10

SAMPLE	**Type**	**V ppm**	**W ppm**	**Zn ppm**
16	Replicate	118	<10	78
24	GXR6	193	<10	133
33	Replicate	119	<10	79
47	Replicate	115	<10	80
55	GXR6	185	<10	127
66	Replicate	123	<10	80
77	Replicate	113	<10	78
88	GXR6	184	<10	123
100	Replicate	113	<10	75
116	Replicate	116	<10	80
125	GXR6	181	<10	125
134	Replicate	117	<10	79
149	Replicate	112	<10	76
157	GXR6	181	<10	124
166	Replicate	115	<10	74

APPENDIX C

MINERAL PHOTOGRAPHS

Reynolds Branch Road without Symbology

Figure C1. Reynolds Branch road #11 without symbology.

Figure C2. Reynolds Branch road #12 without symbology.

Figure C3. Reynolds Branch road #13 without symbology.

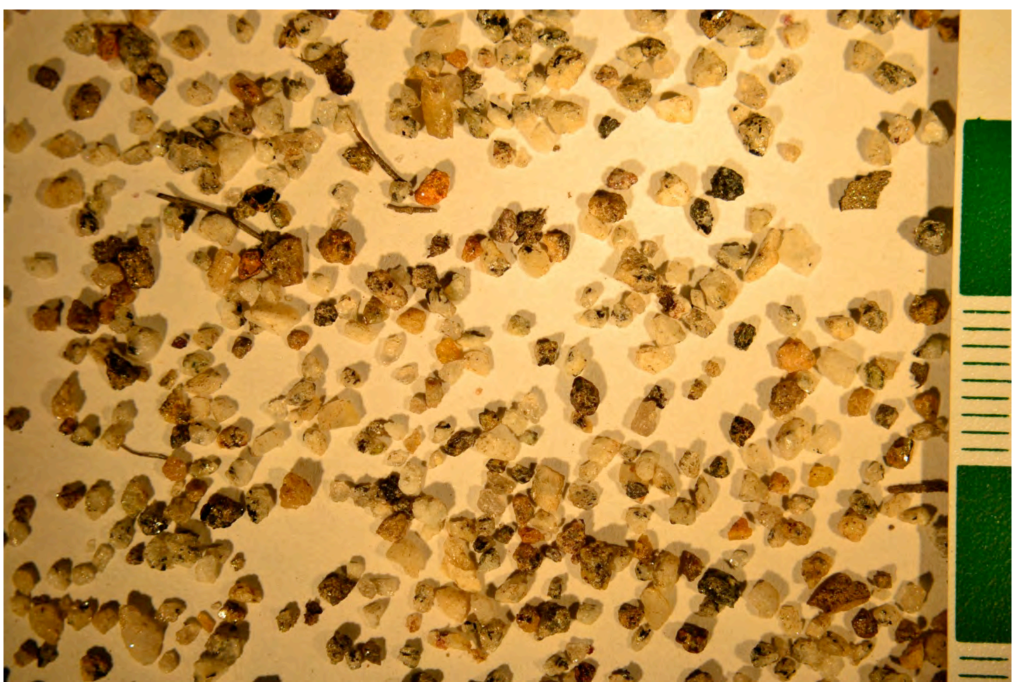

Figure C4. Reynolds Branch road #14 without symbology.

Figure C5. Reynolds Branch road #15 without symbology.

Figure C6. Reynolds Branch road #17 without symbology.

Figure C7. Reynolds Branch road #18 without symbology.

Figure C8. Reynolds Branch road #19 without symbology.

Figure C9. Reynolds Branch road #20 without symbology.

Figure C10. Reynolds Branch road #21 without symbology.

Reynolds Branch road with Symbology

GrainClass

- ★ Garnet
- + Mafic
- × Mica/Biotite rich Rock
- ▲ Quartz
- ■ Quartz/Feldspar rich Rock

Figure C11. Legend showing mineral class symbology.

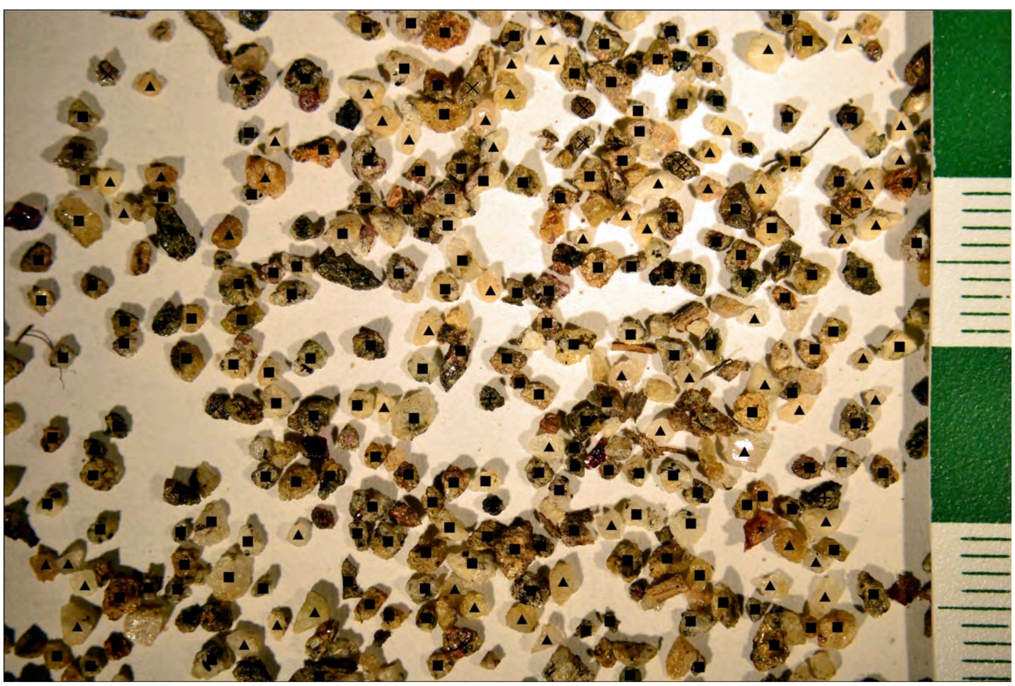

Figure C12. Reynolds Branch road #11 with symbology.

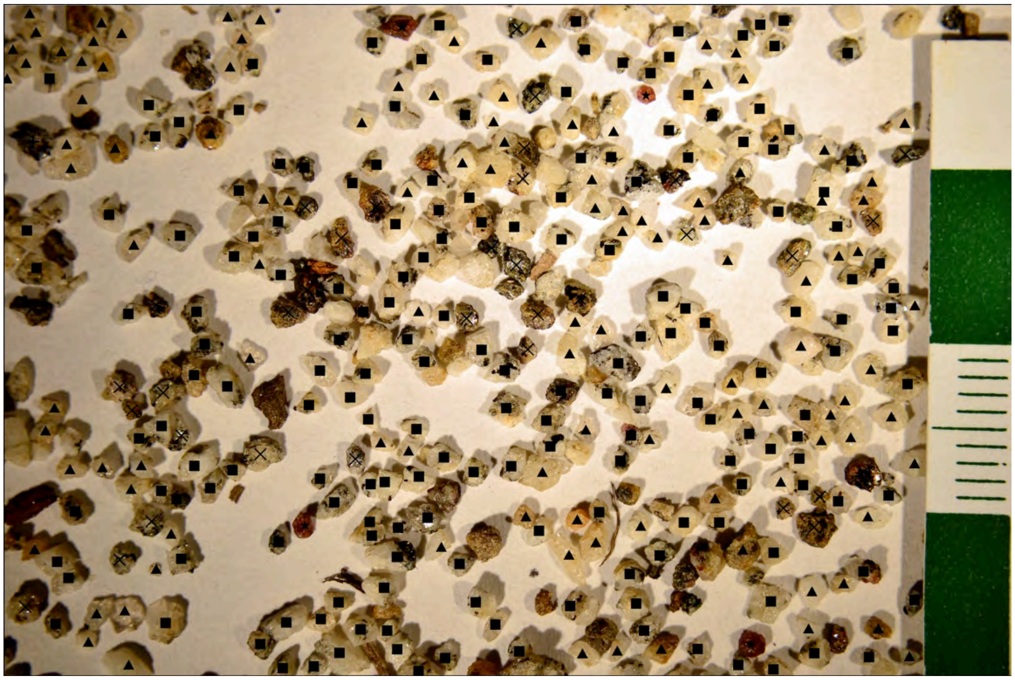

Figure C13. Reynolds Branch road #12 with symbology.

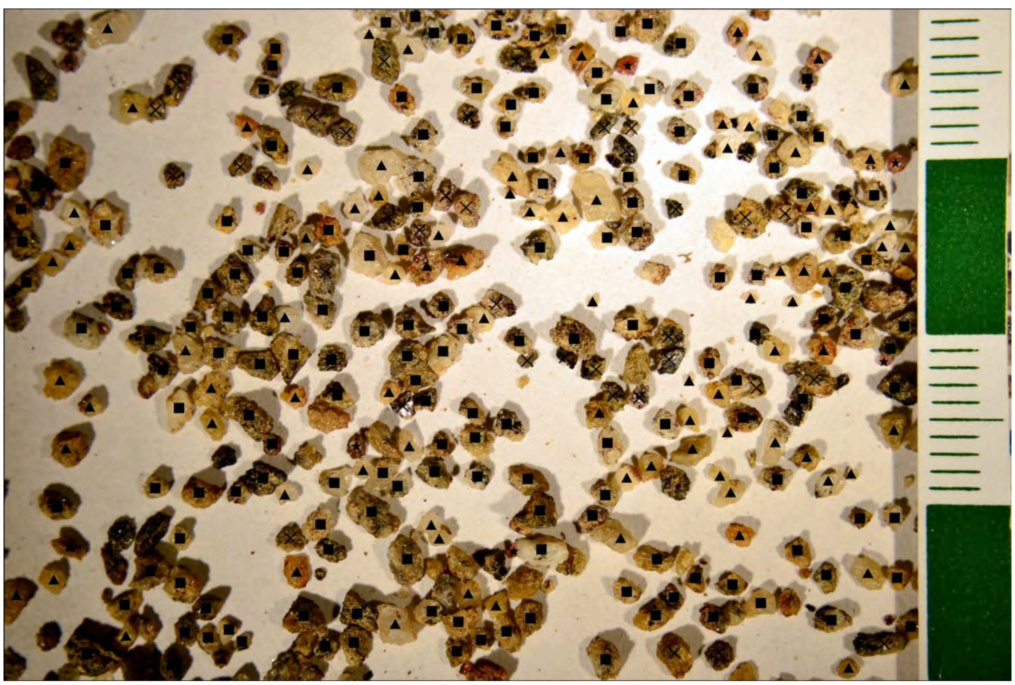

Figure C14. Reynolds Branch road #13 with symbology.

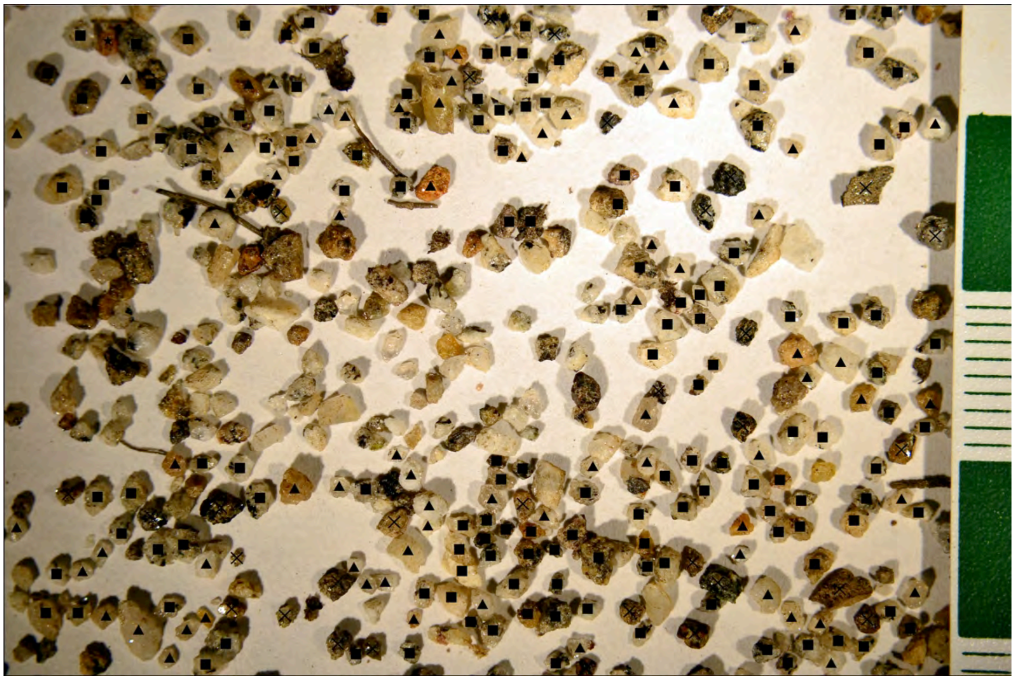

Figure C15. Reynolds Branch road #14 with symbology.

Figure C16. Reynolds Branch road #15 with symbology.

Figure C17. Reynolds Branch road #17 with symbology.

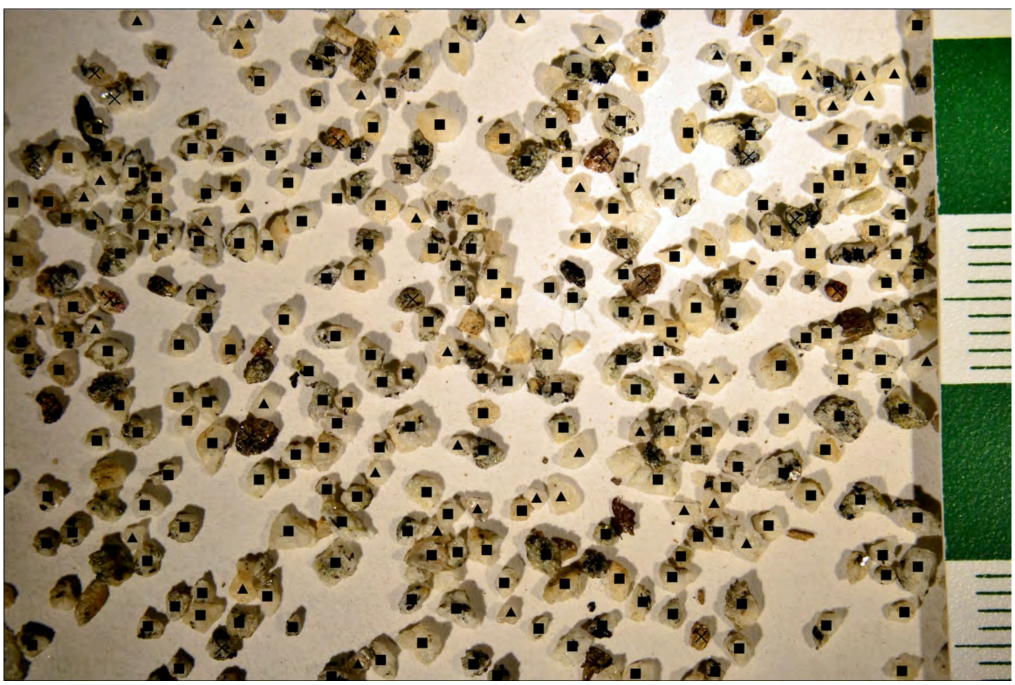

Figure C18. Reynolds Branch road #18 with symbology.

Figure C19. Reynolds Branch road #19 with symbology.

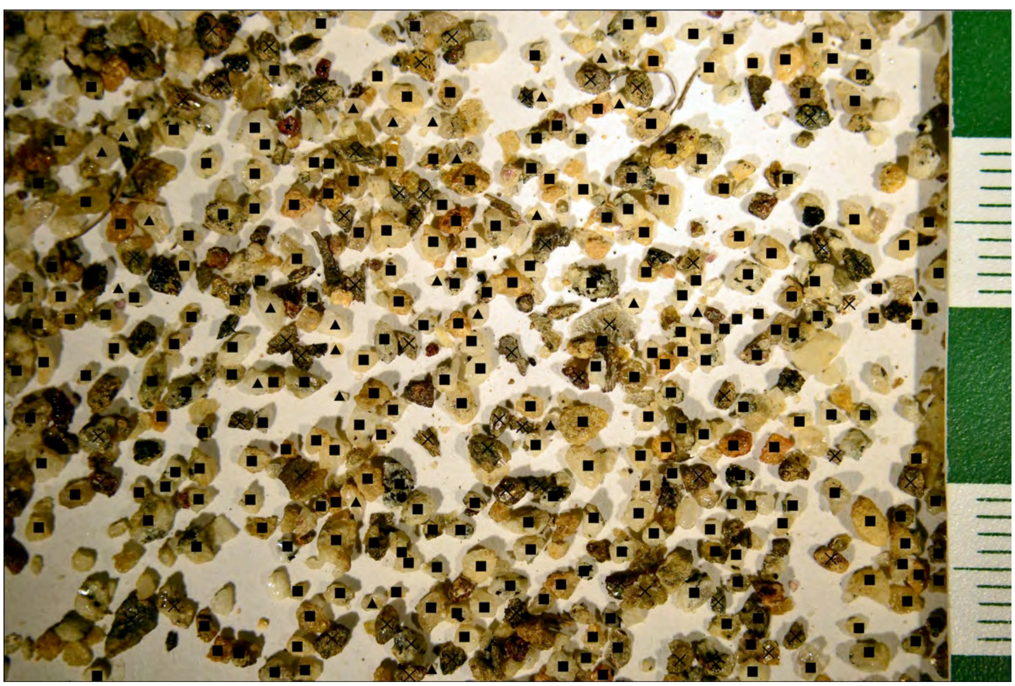

Figure C20. Reynolds Branch road #20 with symbology.

Figure C21. Reynolds Branch road #21 with symbology.

Reynolds Branch outlet without Symbology

Figure C22. Reynolds Branch outlet #154 without symbology.

Figure C23. Reynolds Branch outlet #155 without symbology.

Figure C24. Reynolds Branch outlet #156 without symbology.

Figure C25. Reynolds Branch outlet #158 without symbology.

Figure C26. Reynolds Branch outlet #159 without symbology.

Figure C27. Reynolds Branch outlet #160 without symbology.

Figure C28. Reynolds Branch outlet #161 without symbology.

Figure C29. Reynolds Branch outlet #162 without symbology.

Figure C30. Reynolds Branch outlet #163 without symbology.

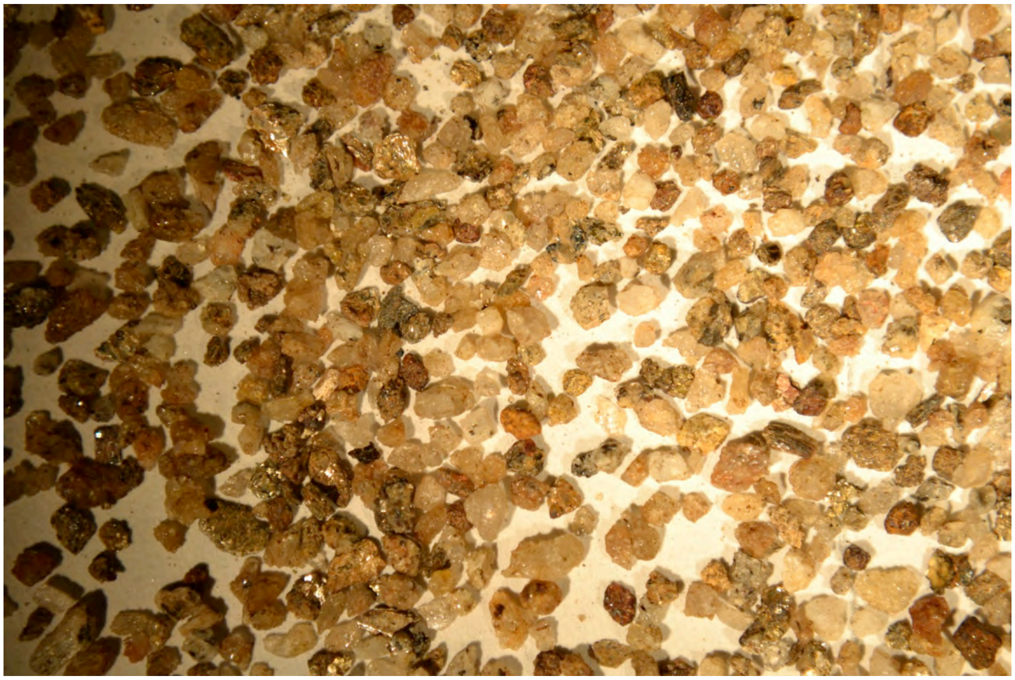

Figure C31. Reynolds Branch outlet #164 without symbology.

Reynolds Branch outlet with Symbology

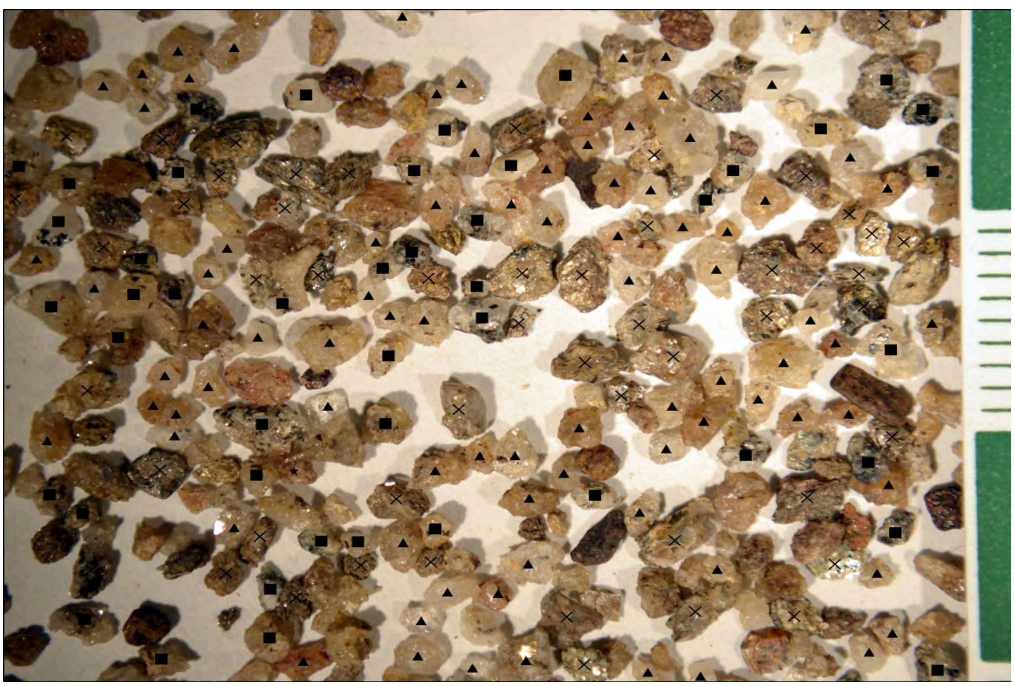

Figure C32. Reynolds Branch outlet #154 with symbology.

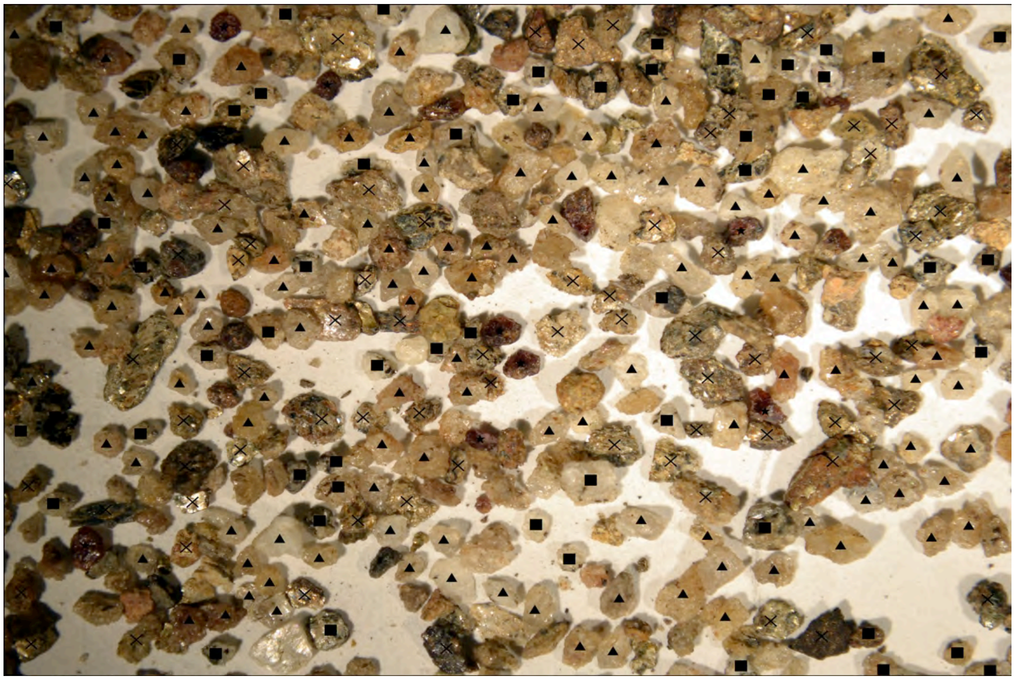

Figure 33. Reynolds Branch outlet #155 with symbology.

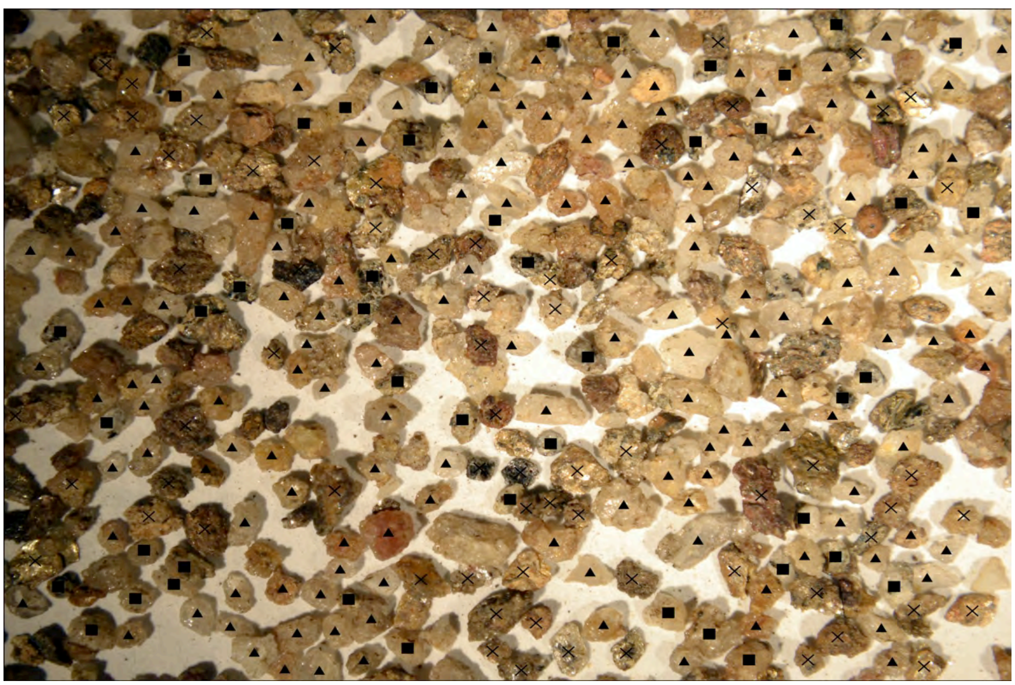

Figure C34. Reynolds Branch outlet #156 with symbology.

Figure C35. Reynolds Branch outlet #158 with symbology.

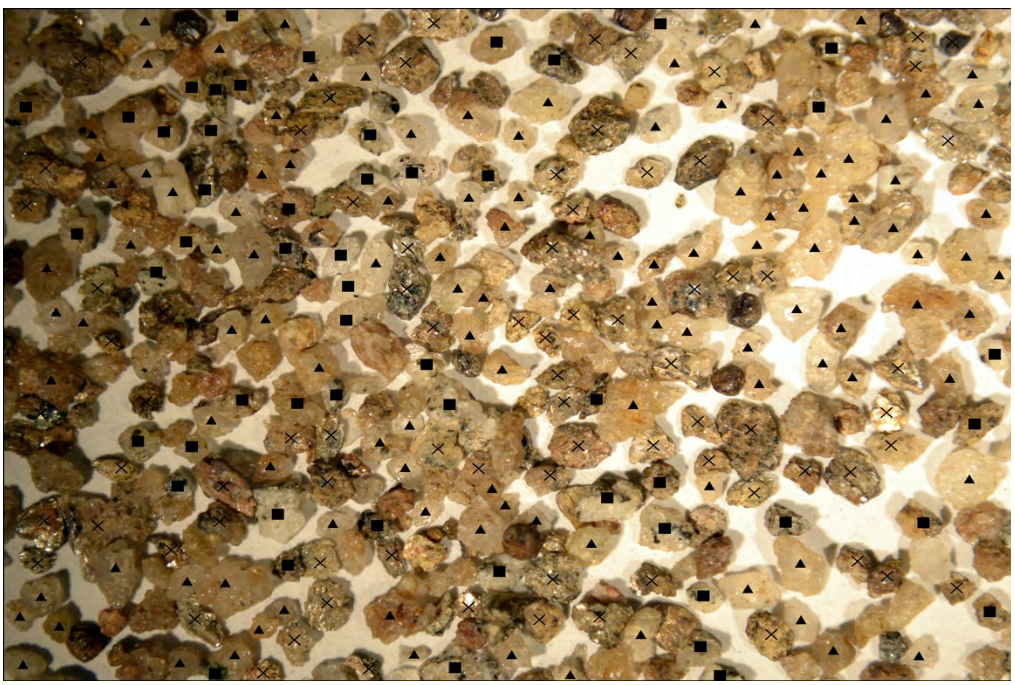

Figure C36. Reynolds Branch outlet #159 with symbology.

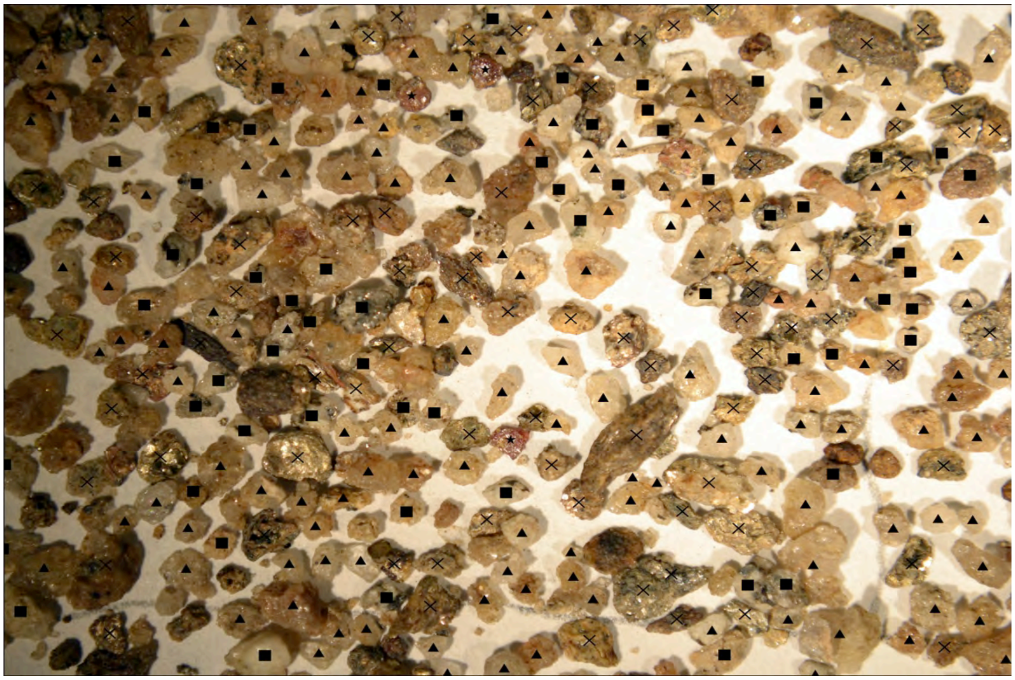

Figure C37. Reynolds Branch outlet #160 with symbology.

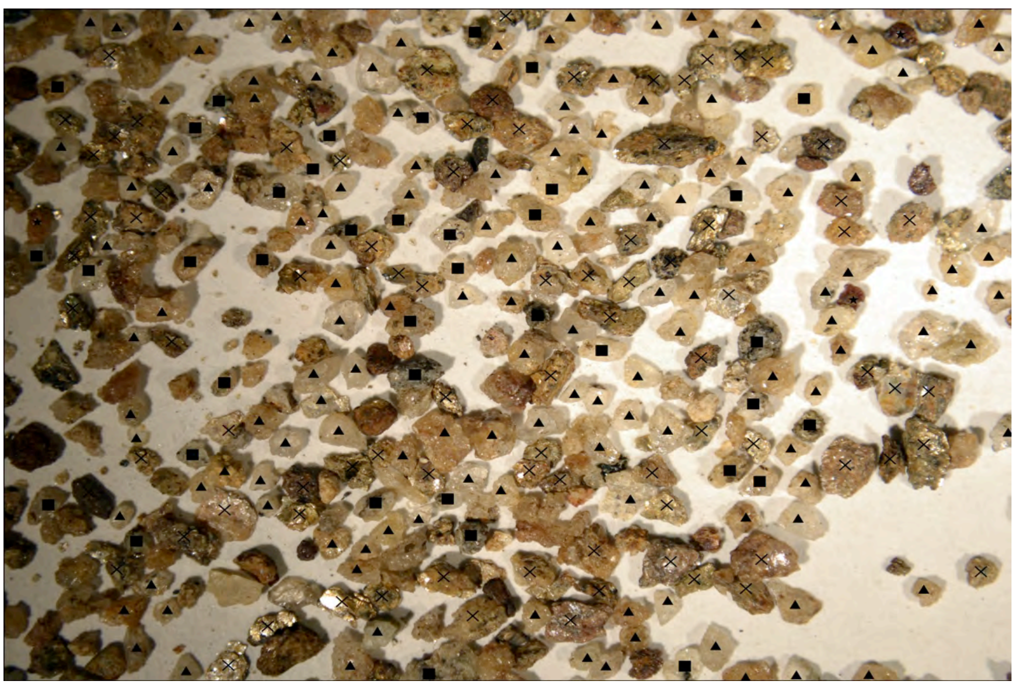

Figure C38. Reynolds Branch outlet #161 with symbology.

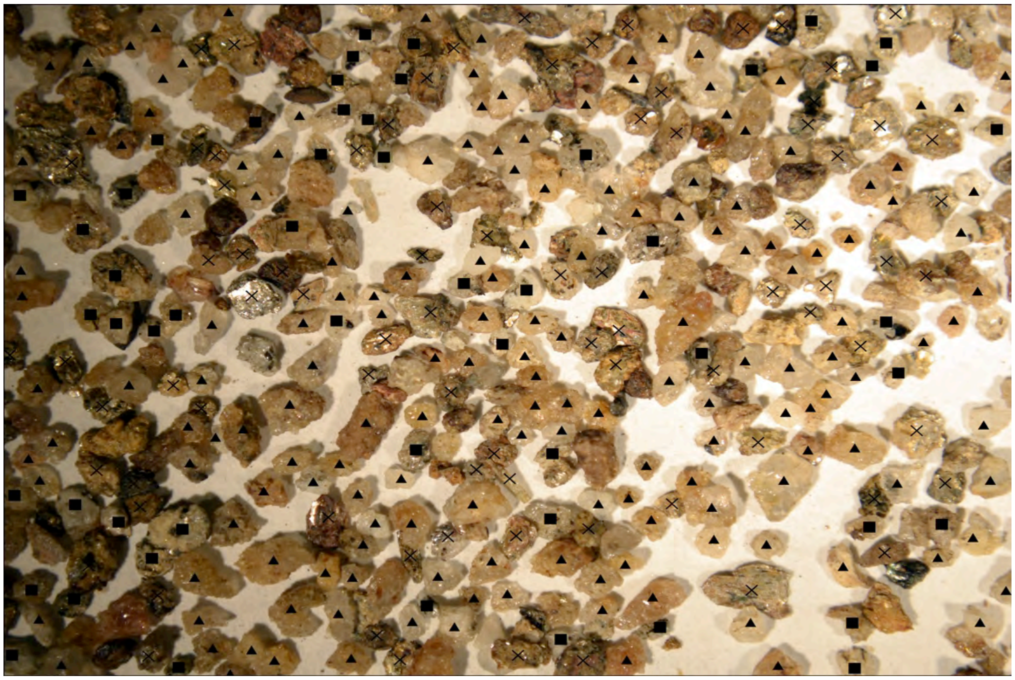

Figure C39. Reynolds Branch outlet #162 with symbology.

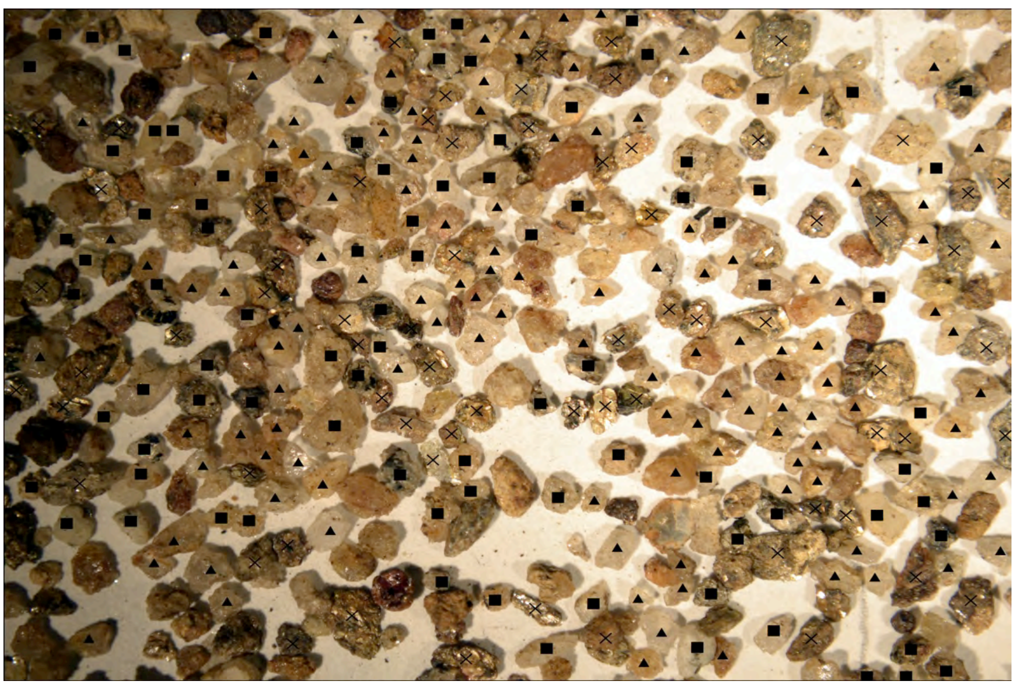

Figure C40. Reynolds Branch outlet #163 with symbology.

Figure C41. Reynolds Branch outlet #164 with symbology.

Lick Branch outlet without Symbology

Figure C42. Lick Branch outlet #143 without symbology.

Figure C43. Lick Branch outlet #144 without symbology.

Figure C44. Lick Branch outlet #145 without symbology.

Figure C45. Lick Branch outlet #146 without symbology.

Figure C46. Lick Branch outlet #147 without symbology.

Figure C47. Lick Branch outlet #148 without symbology.

Figure C48. Lick Branch outlet #150 without symbology.

Figure C49. Lick Branch outlet #151 without symbology.

Figure C50. Lick Branch outlet #152 without symbology.

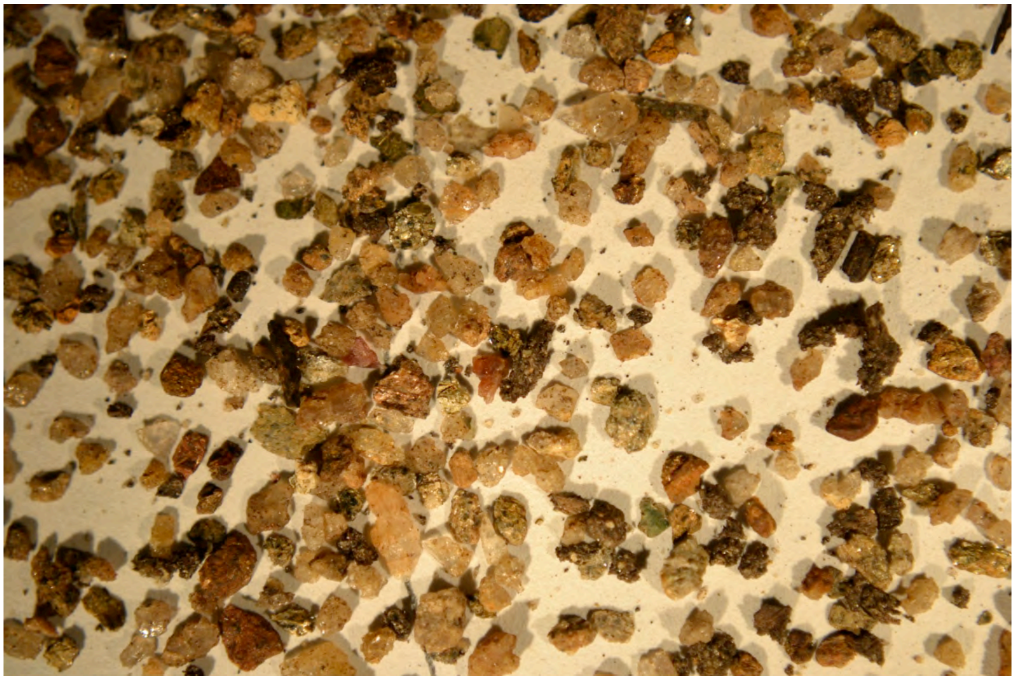

Figure C51. Lick Branch outlet #153 without symbology.

Lick Branch outlet with Symbology

Figure C52. Lick Branch outlet #143 with symbology.

Figure C53. Lick Branch outlet #144 with symbology.

Figure C54. Lick Branch outlet #145 with symbology.

Figure C55. Lick Branch outlet #146 with symbology.

Figure C56. Lick Branch outlet #147 with symbology.

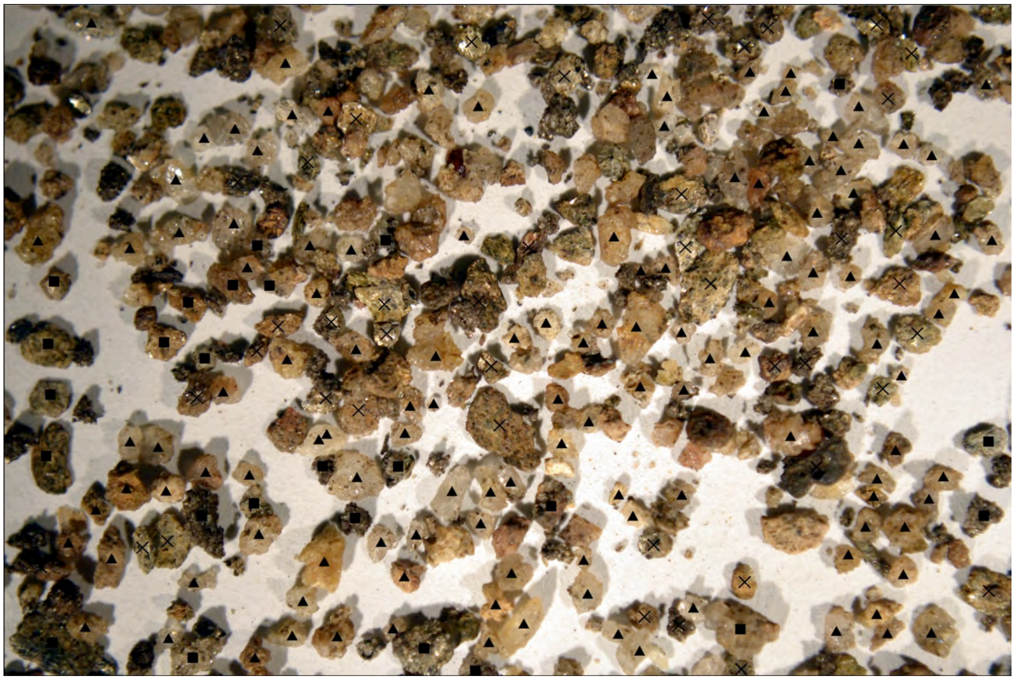

Figure C57. Lick Branch outlet #148 with symbology.

Figure C58. Lick Branch outlet #150 with symbology.

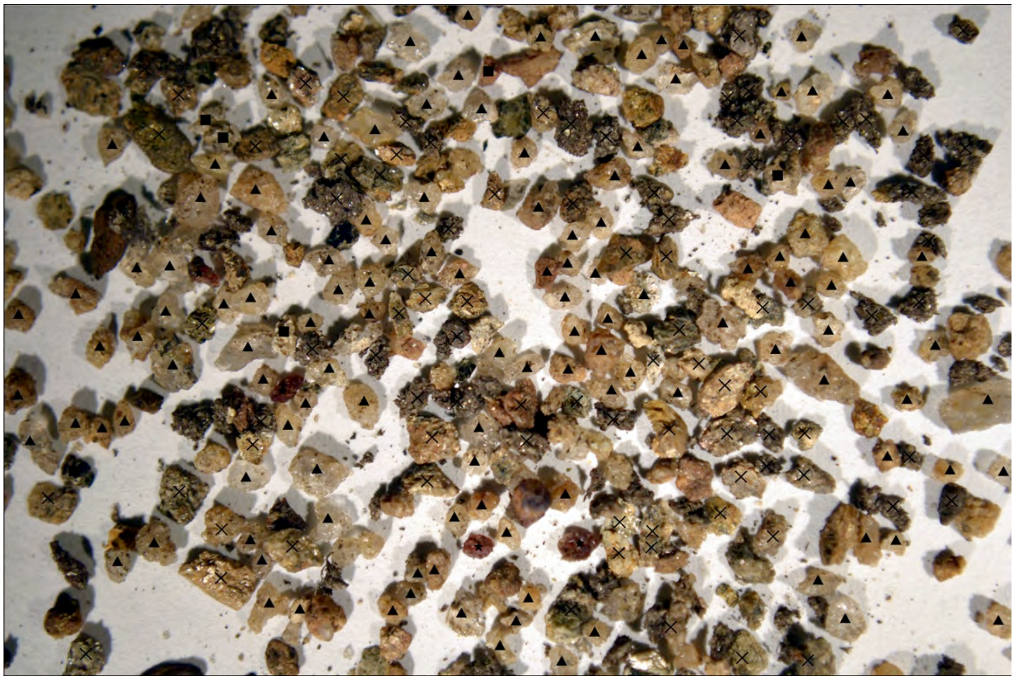

Figure C59. Lick Branch outlet #151 with symbology.

Figure C60. Lick Branch outlet #152 with symbology.

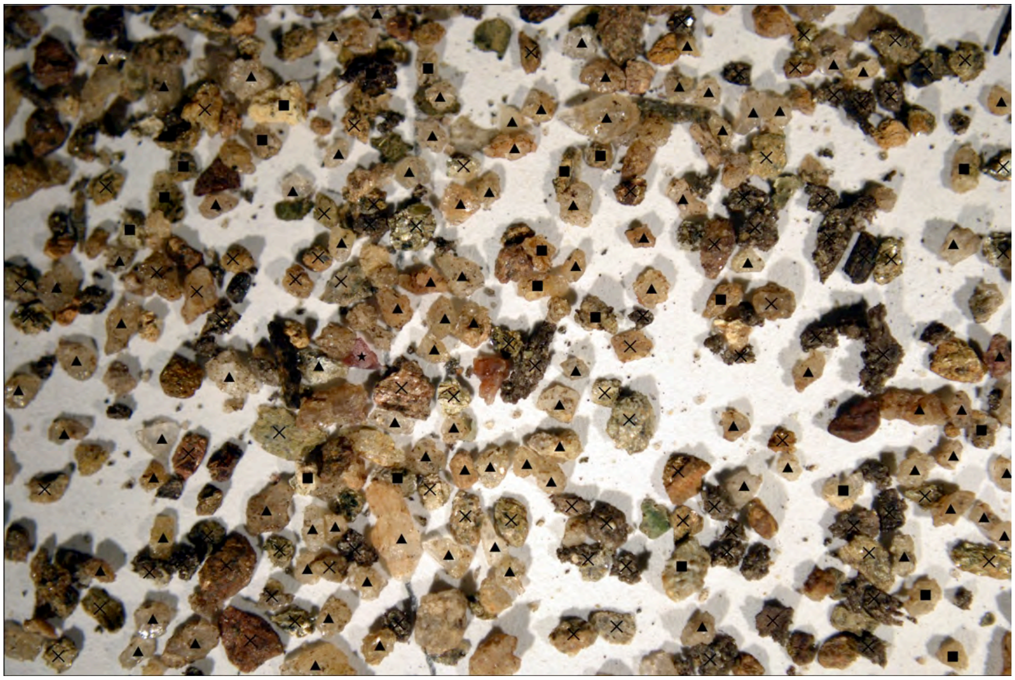

Figure C61. Lick Branch outlet #153 with symbology.

Ball Creek outlet without Symbology

Figure C62. Ball Creek outlet #167 without symbology.

Figure C63. Ball Creek outlet #172 without symbology.

Figure C64. Ball Creek outlet #173 without symbology.

Figure C65. Ball Creek outlet #168 without symbology.

Figure C66. Ball Creek outlet #171 without symbology.

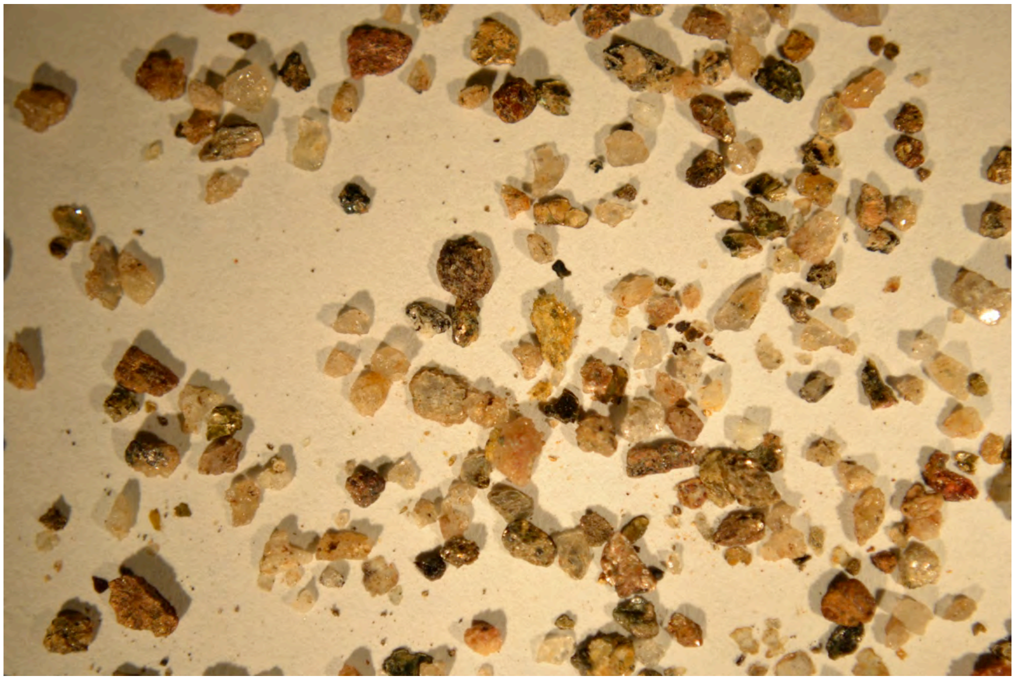

Figure C67. Ball Creek outlet #165 without symbology.

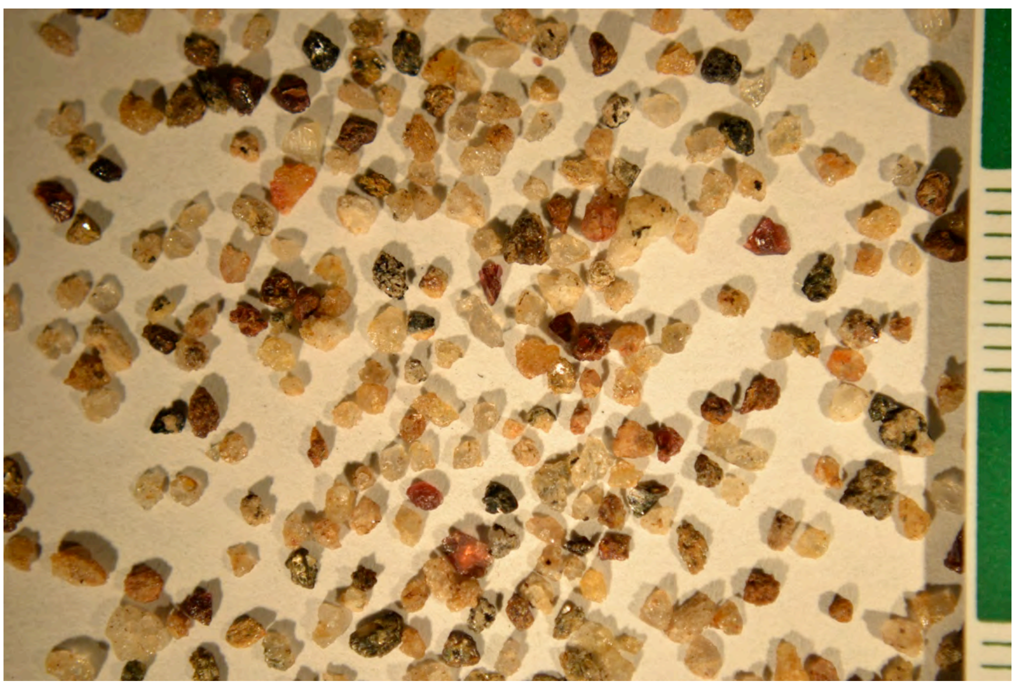

Figure C68. Ball Creek outlet #169 without symbology.

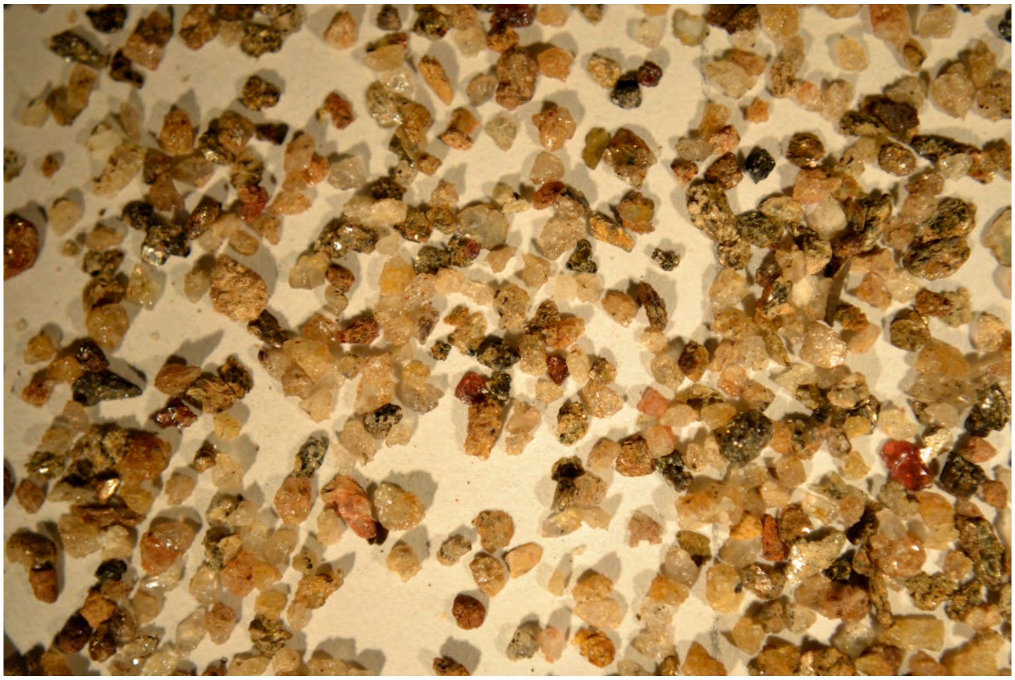

Figure C69. Ball Creek outlet #174 without symbology.

Figure C70. Ball Creek outlet #175 without symbology.

Figure C71. Ball Creek outlet #170 without symbology.

Ball Creek outlet with Symbology

Figure C72. Ball Creek outlet #167 with symbology.

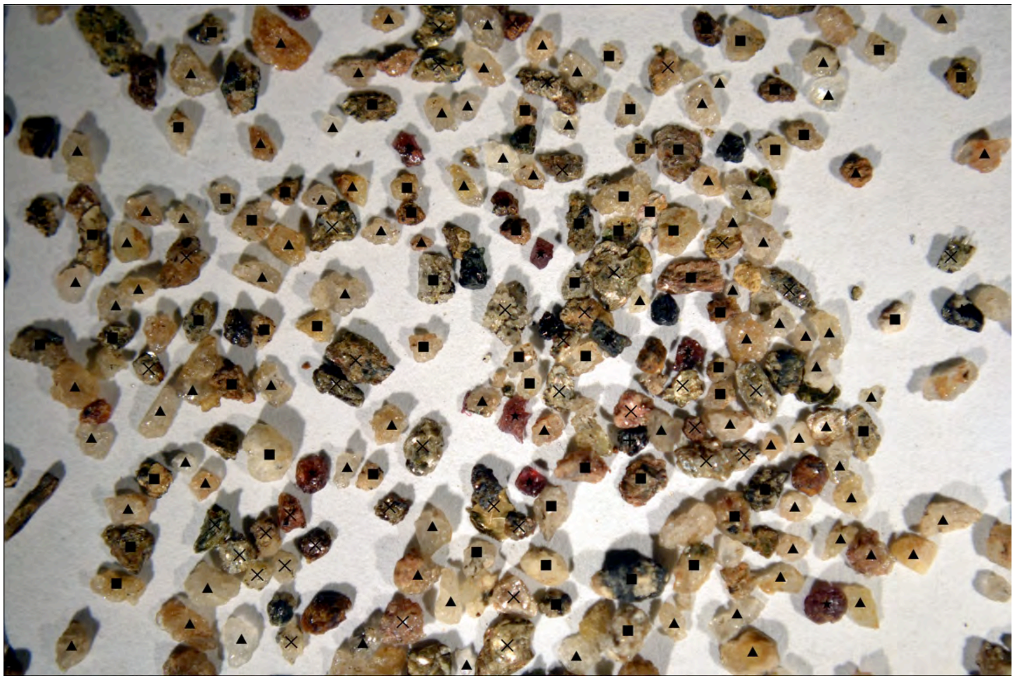

Figure C73. Ball Creek outlet #172 with symbology.

Figure C74. Ball Creek outlet #173 with symbology.

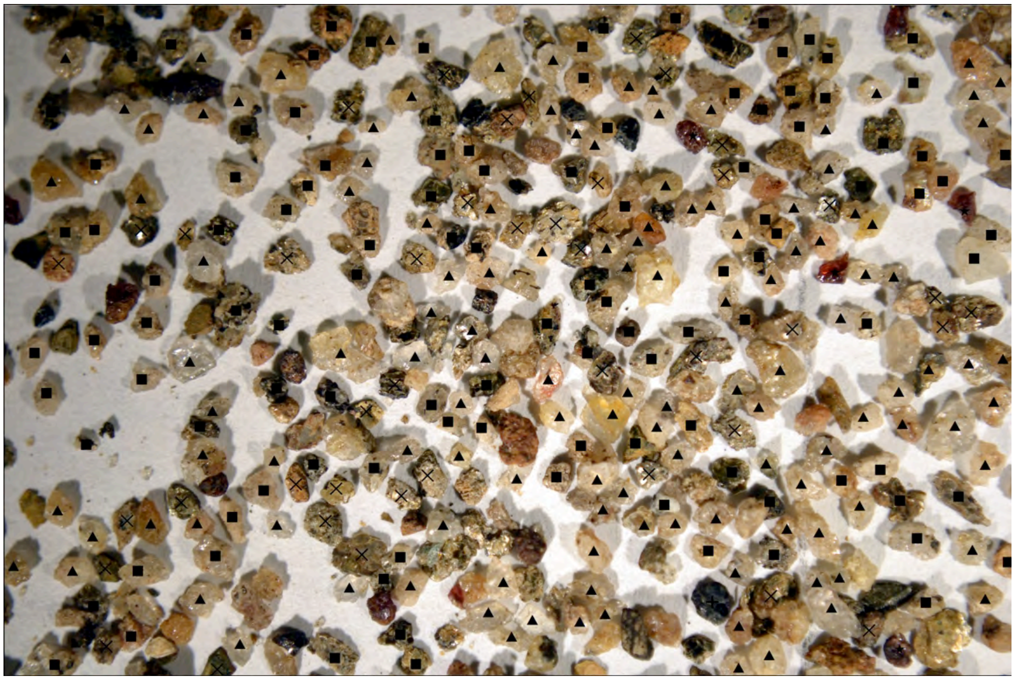

Figure C75. Ball Creek outlet #168 with symbology.

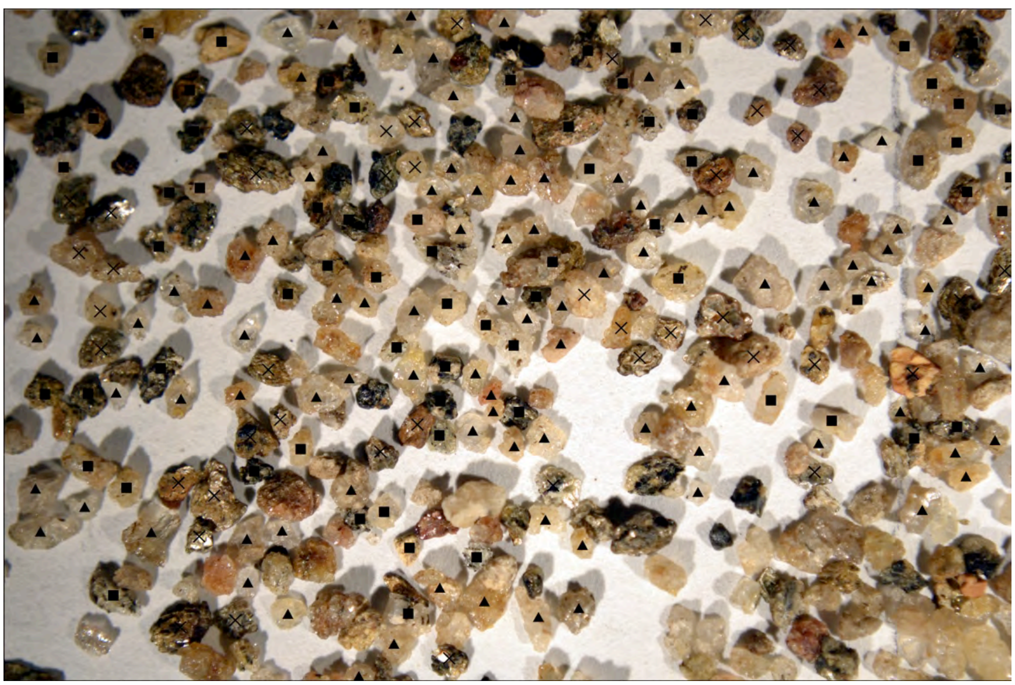

Figure C76. Ball Creek outlet #171 with symbology.

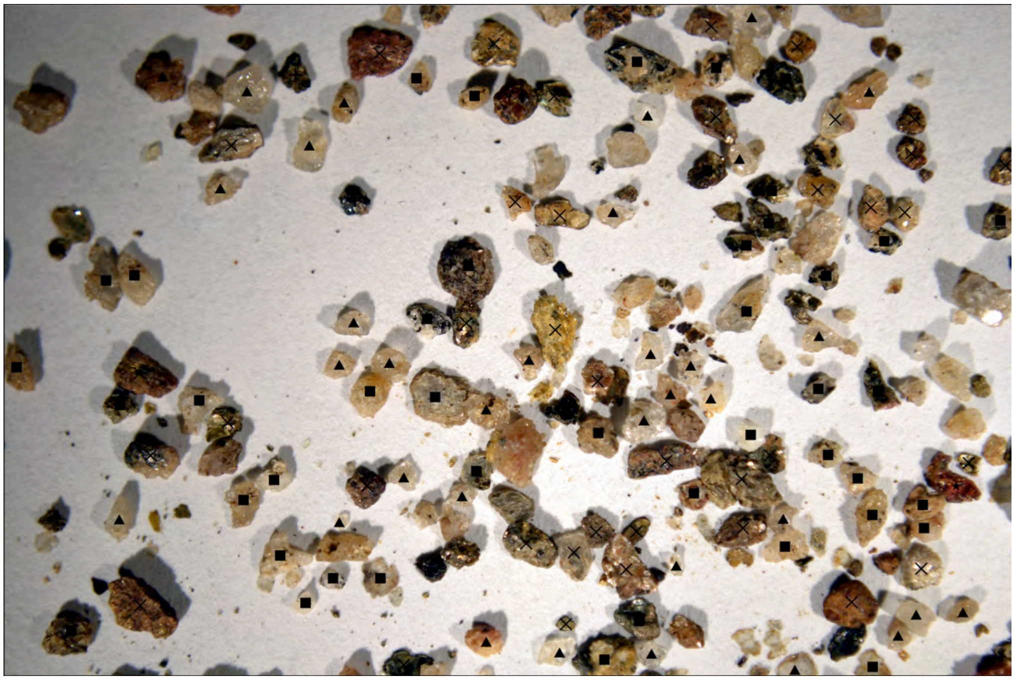

Figure C77. Ball Creek outlet #165 with symbology.

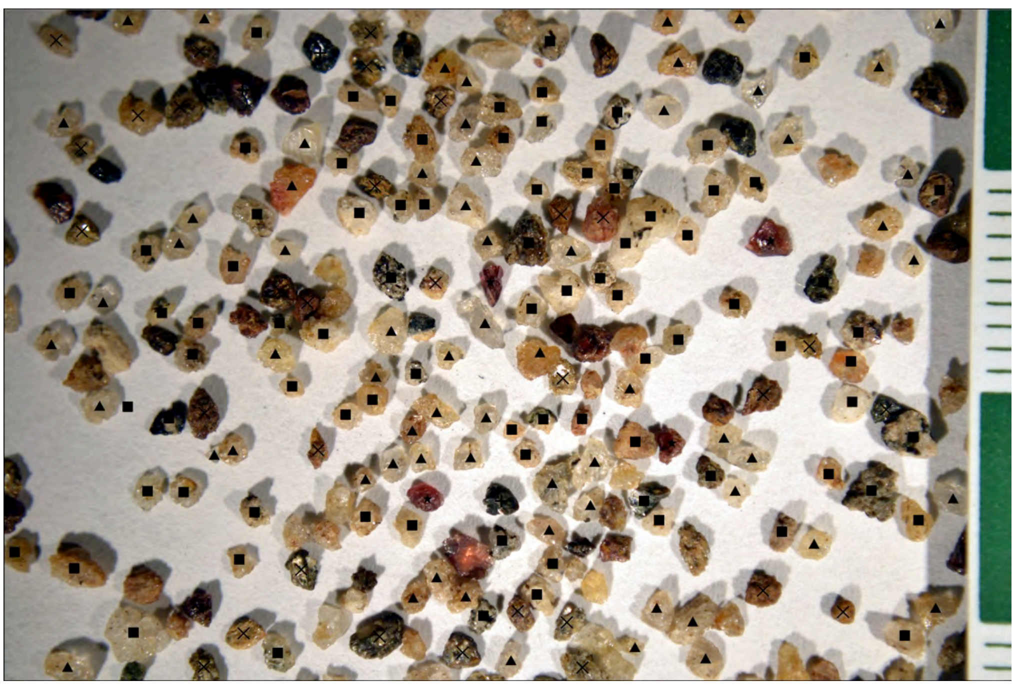

Figure C78. Ball Creek outlet #169 with symbology.

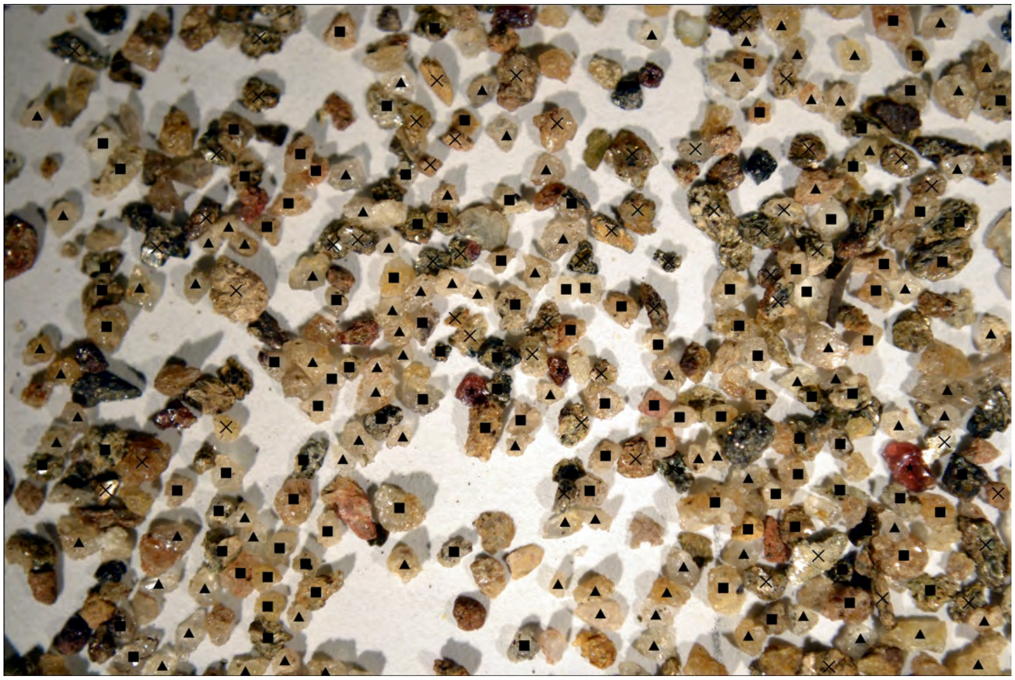

Figure C79. Ball Creek outlet #174 with symbology.

Figure C80. Ball Creek outlet #175 with symbology.

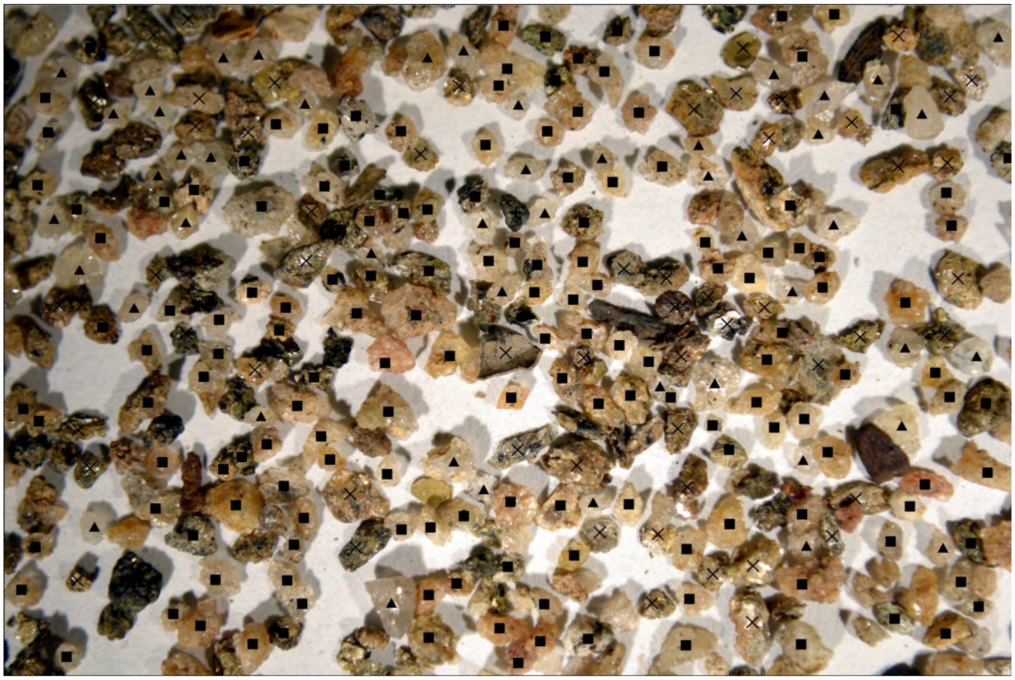

Figure C81. Ball Creek outlet #170 with symbology.

APPENDIX D

SEDIMENT RATING AND DISCHARGE DATA

Table D1. Total suspended solid data collected at Ball Creek weir 9 for the 2011 water year.

Date / Time	Stage (mm)	Discharge (L/s)	TSS
9/26/10 9:00	266.7	115.7151545	11.5446
9/26/10 9:30	264.3	113.869335	13.7815
9/26/10 10:00	261.8	111.9779085	7.5167
9/26/10 10:30	259.6	110.3394592	8.3667
9/26/10 11:00	263.5	113.2606281	10.3577
9/26/10 11:30	268.8	117.3547744	10.1983
9/26/10 12:00	274.3	121.759965	9.4
9/26/10 12:30	286.9	132.4852882	30.0833
9/26/10 13:00	308.4	153.0128044	56.9636
9/26/10 13:30	323.8	169.6439123	69.8
9/26/10 14:00	334.2	181.8862709	60.68
9/26/10 14:30	336.4	184.5871309	48.42
9/26/10 15:31	333.6	181.157	29.4118
9/26/10 16:31	320.1	165.490	18.1188
9/26/10 17:31	306.4	150.976	12.9421
9/26/10 18:31	293.9	138.847	9.9504
9/26/10 19:31	284.2	130.110	8.6667
9/26/10 20:31	276.1	123.237	6.4923
9/26/10 21:31	270.2	118.461	6.1818
9/26/10 22:31	262.7	112.655	5.1692
9/26/10 23:31	257.3	108.652	4.4154
9/27/10 0:31	253.5	105.921	3.9237
9/27/10 1:31	249.9	103.397	5.2462
9/27/10 2:31	248.2	102.226	3.7714
10/25/10 3:30	225.3	87.68506658	0.733
10/25/10 4:15	227.4	88.9275156	2.8
10/25/10 5:00	244.7	99.85624547	2.633
10/25/10 5:45	251.5	104.5109245	2.5
10/25/10 6:30	253	105.5665549	2.933
10/25/10 7:15	325.7	171.8172834	40.9
10/25/10 8:00	377.5	243.1045521	53.3

10/25/10 8:45	406.7	295.6367801	47.16
10/25/10 9:30	423.7	331.3024176	40.7
10/25/10 10:15	407.1	296.4301493	22.7
10/25/10 11:46	358.5	214.046	10.23333
10/25/10 13:15	339.7	188.7138047	6.8
10/25/10 14:45	327	173.3203483	3.933
10/25/10 16:15	309.4	154.0414322	3.833
10/25/10 17:45	292.7	137.7350079	3.267
10/25/10 19:15	278.1	124.8997738	2.767
10/25/10 20:45	267.2	116.1034503	1.667
10/25/10 22:16	262.1	112.203	0.36667
11/29/10 23:00	473.9	463.7620542	60.444
11/30/10 0:00	486.7	505.2895374	41.978
11/30/10 1:00	479.8	482.4617324	22.088
11/30/10 2:00	475.7	469.3888862	17.03
11/30/10 3:00	486.7	505.2895374	18.099
11/30/10 4:00	505.8	574.2711126	40.26
11/30/10 5:00	532.1	684.9265502	61.319
11/30/10 6:00	572.2	896.0369101	101.778
11/30/10 7:00	624.7	1273.764039	139.475
11/30/10 8:00	620.5	1238.419943	76.885
11/30/10 9:00	645.6	1465.221356	80
11/30/10 10:00	651.6	1525.323208	51.868
11/30/10 12:01	594.1	1037.648	22.28
11/30/10 14:01	569.2	878.206	14.56666667
11/30/10 16:01	646.0	1469.153	39.91666667
11/30/10 18:01	694.9	2038.708	109.04
11/30/10 20:01	740.3	2763.495	74.7
11/30/10 22:01	723.5	2469.304	29.5
12/1/10 0:01	672.4	1753.417	18.65
12/1/10 2:01	623.7	1265.258	13.78512397
12/1/10 4:01	593.6	1034.177	9.516666667
12/1/10 6:01	564.4	850.413	7.95
12/1/10 8:01	541.0	727.011	9.180952381
12/1/10 10:01	527.5	664.139	7.229508197
2/28/11 14:30	349.2	201.1159498	1.569
2/28/11 15:00	350.2	202.4679508	1.567
2/28/11 15:30	350.1	202.3323427	1.653
2/28/11 16:00	351.5	204.239149	3.074
2/28/11 17:00	407.3	296.8276319	20.567
2/28/11 18:00	443.1	377.2890507	31.443
2/28/11 19:00	469.3	449.6869196	26.083
2/28/11 20:00	457.9	416.6187798	12.067

2/28/11 21:00	435.5	358.5584211	7.471
2/28/11 22:00	414.3	311.0804643	5.16
2/28/11 23:00	398.9	280.5835682	4
3/1/11 0:00	389.3	263.1045828	2.867
3/1/11 7:43	367.8	227.808	2.08333
3/5/11 7:01	360.4	216.788	1.03333
3/5/11 9:01	366.6	225.983	1.26667
3/5/11 11:01	387.7	260.299	2.71250
3/5/11 13:01	427.6	340.073	5.13750
3/5/11 15:01	469.1	449.085	13.34211
3/5/11 17:01	493.3	528.135	22.14286
3/5/11 19:01	500.7	554.980	18.89032
3/5/11 21:01	536.9	707.312	15.40260
3/5/11 23:01	557.8	813.627	34.86000
3/6/11 1:01	601.3	1088.931	24.14000
3/6/11 3:01	651.8	1527.369	71.64000
3/6/11 5:01	721.7	2439.703	44.36364
3/6/11 7:01	765.9	3280.567	87.35556
3/6/11 9:01	739.5	2747.968	105.77070
3/6/11 13:01	662.2	1637.328	47.07595
3/6/11 17:01	589.9	1008.815	17.08176
3/6/11 21:01	551.8	781.630	7.73418
3/7/11 1:01	523.1	644.971	6.29814
3/7/11 5:01	498.7	547.765	4.22642
3/7/11 9:01	477.3	474.337	6.58278
3/7/11 13:01	464.4	435.111	3.82781
3/7/11 17:02	451.1	398.064	4.65806
3/7/11 21:02	438.4	365.637	3.11409
3/8/11 1:02	426.3	337.203	2.41060
3/8/11 5:02	417.0	316.659	2.34437
9/4/11 21:00	193.3	70.7640856	9.455
9/4/11 23:00	194.3	71.23979683	5.147
9/5/11 1:00	195.5	71.8148735	4.42
9/5/11 3:00	196.9	72.49166621	8.781
9/5/11 5:00	201.3	74.66053255	7.403
9/5/11 7:00	216	82.38814922	21.779
9/5/11 9:00	253.5	105.9207959	46.315
9/5/11 11:00	303.8	148.3688802	76.054
9/5/11 13:00	312.5	157.2743302	39.469
9/5/11 15:00	313.7	158.5439127	27.167
9/5/11 17:00	306.4	150.9761091	19.403
9/5/11 19:00	487.9	509.3684405	701.862
9/5/11 21:00	407.2	296.628824	148.029

9/5/11 23:00	603.9	1108.066193	285.667
9/6/11 1:00	482.5	491.2688856	45.045
9/6/11 3:00	501	556.0963699	78.944
9/6/11 5:00	414.6	311.7063649	28.245
9/6/11 7:00	363.8	221.7834835	20.028
9/6/11 8:00	348.8	200.5776807	16.404
9/6/11 10:00	332.7	180.0674686	12.822
9/6/11 12:00	317.5	162.6322646	11.155
9/6/11 14:00	308.6	153.2179789	10.529
9/6/11 16:00	304.6	149.1662725	10.047
9/6/11 18:00	302.7	147.2794211	7.007
9/6/11 20:00	304.9	149.4663982	8.471
9/6/11 22:00	303.7	148.2695063	7.674
9/7/11 0:00	297.8	142.5227458	7.015
9/7/11 2:00	293.7	138.6609308	7.518
9/7/11 4:00	290.3	135.5379407	6.378
9/7/11 6:00	286.4	132.042205	6.58
9/7/11 6:30	286.6	132.219	7.015151515
9/7/11 8:30	282.7	128.809	7.517730496
9/7/11 10:30	280.3	126.754	6.378378378
9/7/11 12:30	275.7	122.907	6.580152672

Table D2. ISCO derived daily discharge data collected at Ball Creek weir 9 for the 2011 water year.

Date	Flow (L/s)	Date	Flow (L/s)	Date	Flow (L/s)
9/1/2010	72.64	1/12/2011	187.20	5/23/2011	139.67
9/2/2010	72.71	1/13/2011	214.94	5/24/2011	137.75
9/3/2010	72.11	1/14/2011	223.68	5/25/2011	135.95
9/4/2010	69.93	1/15/2011	178.73	5/26/2011	228.61
9/5/2010	69.29	1/16/2011	180.38	5/27/2011	199.08
9/6/2010	69.13	1/17/2011	183.37	5/28/2011	159.96
9/7/2010	69.46	1/18/2011	195.57	5/29/2011	149.45
9/8/2010	70.14	1/19/2011	201.37	5/30/2011	141.73
9/9/2010	70.11	1/20/2011	191.66	5/31/2011	135.75
9/10/2010	68.03	1/21/2011	185.31	6/1/2011	132.76
9/11/2010	92.23	1/22/2011	179.14	6/2/2011	145.34
9/12/2010	91.81	1/23/2011	174.16	6/3/2011	133.61
9/13/2010	75.40	1/24/2011	174.20	6/4/2011	128.30
9/14/2010	73.47	1/25/2011	181.80	6/5/2011	126.64
9/15/2010	69.13	1/26/2011	223.31	6/6/2011	125.24

9/16/2010	68.91	1/27/2011	190.36	6/7/2011	120.67
9/17/2010	69.96	1/28/2011	184.76	6/8/2011	120.40
9/18/2010	69.02	1/29/2011	180.63	6/9/2011	118.03
9/19/2010	68.98	1/30/2011	183.09	6/10/2011	123.19
9/20/2010	68.73	1/31/2011	187.83	6/11/2011	116.41
9/21/2010	67.63	2/1/2011	261.79	6/12/2011	116.87
9/22/2010	73.51	2/2/2011	387.93	6/13/2011	116.60
9/23/2010	74.22	2/3/2011	243.25	6/14/2011	114.09
9/24/2010	71.61	2/4/2011	284.58	6/15/2011	149.28
9/25/2010	71.15	2/5/2011	292.47	6/16/2011	135.29
9/26/2010	120.80	2/6/2011	256.52	6/17/2011	116.41
9/27/2010	124.32	2/7/2011	238.31	6/18/2011	124.61
9/30/2010	123.42	2/8/2011	226.85	6/19/2011	123.61
10/1/2010	102.42	2/9/2011	219.09	6/20/2011	115.70
10/2/2010	93.03	2/10/2011	217.28	6/21/2011	114.69
10/3/2010	90.55	2/11/2011	214.39	6/22/2011	116.22
10/4/2010	88.18	2/12/2011	212.87	6/23/2011	147.89
10/5/2010	85.59	2/13/2011	210.83	6/24/2011	209.59
10/6/2010	83.80	2/14/2011	209.75	6/25/2011	164.23
10/7/2010	83.28	2/15/2011	205.63	6/26/2011	133.84
10/8/2010	83.29	2/16/2011	203.70	6/27/2011	124.97
10/9/2010	82.52	2/17/2011	203.38	6/28/2011	119.37
10/10/2010	82.45	2/18/2011	202.71	6/29/2011	112.80
10/11/2010	81.94	2/19/2011	199.86	6/30/2011	108.16
10/12/2010	85.37	2/20/2011	195.79	7/1/2011	104.70
10/13/2010	83.76	2/21/2011	195.43	7/2/2011	101.62
10/14/2010	84.52	2/22/2011	193.66	7/3/2011	102.35
10/15/2010	83.49	2/23/2011	189.91	7/4/2011	102.39
10/16/2010	83.22	2/24/2011	191.56	7/6/2011	104.80
10/17/2010	82.79	2/25/2011	229.31	7/7/2011	121.67
10/18/2010	83.20	2/26/2011	199.37	7/8/2011	109.95
10/19/2010	84.76	2/27/2011	198.39	7/9/2011	107.24
10/20/2010	87.05	2/28/2011	246.37	7/10/2011	104.55
10/21/2010	86.00	3/1/2011	229.32	7/11/2011	104.25
10/22/2010	86.33	3/2/2011	216.28	7/12/2011	103.85
10/23/2010	86.72	3/3/2011	208.58	7/13/2011	101.18
10/24/2010	85.84	3/4/2011	214.62	7/14/2011	100.09
10/25/2010	152.91	3/5/2011	391.02	7/15/2011	101.80
10/26/2010	144.57	3/6/2011	1622.98	7/16/2011	101.88
10/27/2010	259.82	3/7/2011	466.38	7/17/2011	99.19
10/28/2010	144.64	3/8/2011	283.87	7/18/2011	96.42
10/29/2010	117.07	3/9/2011	529.58	7/19/2011	94.91
10/30/2010	110.22	3/10/2011	476.48	7/20/2011	97.78

10/31/2010	105.80	3/11/2011	350.96	7/21/2011	95.08
11/1/2010	110.83	3/12/2011	294.75	7/22/2011	96.84
11/2/2010	117.17	3/13/2011	264.38	7/23/2011	92.54
11/3/2010	117.80	3/14/2011	249.39	7/24/2011	98.15
11/4/2010	127.41	3/15/2011	311.74	7/25/2011	94.74
11/5/2010	115.43	3/16/2011	263.01	7/26/2011	92.40
11/6/2010	114.70	3/17/2011	240.07	7/27/2011	89.11
11/7/2010	115.90	3/18/2011	229.00	7/28/2011	86.04
11/8/2010	118.62	3/19/2011	216.88	7/29/2011	91.31
11/9/2010	117.43	3/20/2011	207.56	7/30/2011	89.56
11/10/2010	115.34	3/21/2011	202.34	7/31/2011	102.56
11/11/2010	118.74	3/22/2011	195.62	8/1/2011	90.61
11/12/2010	121.12	3/23/2011	197.86	8/2/2011	86.15
11/13/2010	122.33	3/24/2011	207.24	8/3/2011	85.81
11/14/2010	124.29	3/25/2011	187.18	8/4/2011	86.13
11/15/2010	172.29	3/26/2011	307.97	8/5/2011	85.37
11/16/2010	229.63	3/27/2011	366.68	8/6/2011	86.29
11/17/2010	164.59	3/28/2011	294.09	8/7/2011	86.14
11/18/2010	144.50	3/29/2011	254.20	8/8/2011	87.86
11/19/2010	136.30	3/30/2011	292.29	8/9/2011	82.00
11/20/2010	131.25	3/31/2011	255.40	8/10/2011	81.93
11/21/2010	127.89	4/1/2011	236.15	8/11/2011	80.27
11/22/2010	125.83	4/2/2011	224.50	8/12/2011	79.42
11/23/2010	129.06	4/3/2011	214.92	8/13/2011	79.64
11/24/2010	125.14	4/4/2011	220.09	8/14/2011	83.13
11/25/2010	124.27	4/5/2011	323.07	8/15/2011	77.17
11/26/2010	185.19	4/6/2011	240.52	8/16/2011	77.33
11/27/2010	138.69	4/7/2011	226.80	8/17/2011	78.22
11/28/2010	128.65	4/8/2011	218.82	8/18/2011	79.98
11/29/2010	163.06	4/9/2011	212.82	8/19/2011	93.55
11/30/2010	1396.21	4/10/2011	205.81	8/20/2011	82.39
12/1/2010	720.24	4/11/2011	201.22	8/21/2011	81.29
12/2/2010	348.02	4/12/2011	211.78	8/22/2011	79.78
12/3/2010	279.01	4/13/2011	194.11	8/23/2011	78.81
12/4/2010	267.35	4/14/2011	187.87	8/24/2011	78.45
12/5/2010	242.56	4/15/2011	261.76	8/25/2011	78.46
12/6/2010	221.71	4/16/2011	812.74	8/26/2011	78.09
12/7/2010	206.63	4/17/2011	321.28	8/27/2011	77.48
12/8/2010	198.29	4/18/2011	277.35	8/28/2011	77.08
12/9/2010	196.93	4/19/2011	260.03	8/29/2011	78.37
12/10/2010	195.50	4/20/2011	254.44	8/30/2011	77.74
12/11/2010	191.06	4/21/2011	239.18	8/31/2011	77.14
12/12/2010	200.58	4/22/2011	229.96	9/1/2011	74.50

12/13/2010	182.52	4/23/2011	220.28	9/2/2011	74.45
12/14/2010	242.52	4/24/2011	212.35	9/3/2011	74.46
12/15/2010	203.40	4/25/2011	209.70	9/4/2011	73.51
12/16/2010	352.07	4/26/2011	210.95	9/5/2011	206.12
12/17/2010	320.30	4/27/2011	217.20	9/6/2011	245.33
12/18/2010	252.36	4/28/2011	475.16	9/7/2011	126.06
12/19/2010	226.96	4/29/2011	258.00	9/8/2011	111.07
12/20/2010	213.56	4/30/2011	229.20	9/9/2011	103.58
12/21/2010	210.65	5/1/2011	216.61	9/10/2011	97.65
12/22/2010	218.03	5/2/2011	217.02	9/11/2011	94.31
12/23/2010	202.49	5/3/2011	233.41	9/12/2011	92.60
12/24/2010	195.81	5/4/2011	219.90	9/13/2011	89.57
12/25/2010	199.51	5/5/2011	205.38	9/14/2011	87.01
12/26/2010	192.67	5/6/2011	200.17	9/15/2011	85.11
12/27/2010	184.96	5/7/2011	195.45	9/16/2011	84.20
12/28/2010	194.60	5/8/2011	191.70	9/17/2011	82.93
12/29/2010	184.75	5/9/2011	186.31	9/18/2011	83.45
12/30/2010	187.49	5/10/2011	181.14	9/19/2011	84.24
12/31/2010	194.82	5/11/2011	178.12	9/20/2011	85.54
1/1/2011	351.60	5/12/2011	172.81	9/21/2011	118.70
1/2/2011	308.34	5/13/2011	166.88	9/22/2011	98.32
1/3/2011	260.11	5/14/2011	165.35	9/23/2011	147.02
1/4/2011	243.81	5/15/2011	161.47	9/24/2011	101.28
1/5/2011	236.20	5/16/2011	158.75	9/25/2011	94.84
1/6/2011	231.22	5/17/2011	156.05	9/26/2011	108.42
1/7/2011	223.14	5/18/2011	152.97	9/27/2011	96.34
1/8/2011	207.87	5/19/2011	149.63	9/28/2011	90.70
1/9/2011	197.48	5/20/2011	146.84	9/29/2011	89.00
1/10/2011	213.85	5/21/2011	144.30	9/30/2011	87.04
1/11/2011	196.02	5/22/2011	141.58	10/1/2011	85.77

APPENDIX E

ROAD PARTICLE SIZE

Table E1. Phi scale particle size of road sediment.

	% of 20g	**Percentage of <2mm fraction**						
Size Classes	**>2mm**	**2 - 1 mm**	**1- 0.5 mm**	**0.5 - 0.25 mm**	**0.25 - 0.125 mm**	**0.125 mm -63µm**	**<63µm**	**>63µm**
Weight (Φ boundary)	**-1**	**0**	**1**	**2**	**3**	**4**	**4**	**4**
Reynolds Turnout 1	1.80	5.45	16.29	36.71	27.75	7.13	6.11	93.33
Reynolds Turnout 2	9.35	13.24	16.22	23.72	25.15	9.54	12.08	87.87
Reynolds Turnout 3	6.35	9.18	15.00	39.99	27.02	5.77	3.31	96.96
Reynolds Turnout 4	9.85	18.64	19.86	26.62	18.03	8.60	4.49	91.74
Reynolds Turnout 5	16.15	8.53	11.63	33.87	29.28	6.62	8.53	89.92
Reynolds Turnout 6	7.00	6.13	14.57	38.01	30.32	7.47	4.30	96.51
Reynolds Turnout 7	10.50	9.78	18.66	37.71	22.63	4.92	6.65	93.69
Reynolds Turnout 8	8.70	4.33	10.13	31.33	35.65	9.26	9.53	90.69
Reynolds Turnout 9	5.85	5.42	16.30	39.83	27.83	5.84	4.89	95.22
Reynolds Turnout 10	6.75	18.45	37.75	26.27	13.62	2.63	1.29	98.71
Mean	8.23	9.91	17.64	33.41	25.73	6.78	6.12	93.46
Median	7.85	8.86	16.25	35.29	27.38	6.87	5.50	93.51
Std. Dev.	3.55	4.98	7.24	5.75	5.99	2.01	3.03	3.27

Reynolds Road 1	13.00	8.05	5.75	15.86	34.31	13.74	22.30	77.70
Reynolds Road 2	43.35	10.68	8.03	14.47	24.10	12.27	27.80	69.55
Reynolds Road 3	36.70	10.19	7.82	18.88	25.04	12.16	26.86	74.09
Reynolds Road 4	35.40	11.76	10.60	19.27	26.55	9.60	21.59	77.79
Reynolds Road 5	28.05	11.19	7.99	17.51	27.87	13.06	21.96	77.62
Reynolds Road 6	22.60	9.30	8.72	20.41	29.13	10.08	19.96	77.65
Reynolds Road 7	29.20	12.43	11.51	18.79	22.53	11.72	22.03	76.98
Reynolds Road 8	24.95	6.86	7.59	20.72	31.25	12.26	22.32	78.68
Reynolds Road 9	23.70	9.70	10.62	26.15	27.92	9.24	15.60	83.62
Reynolds Road 10	19.30	8.86	10.78	22.80	25.59	11.71	17.91	79.74
Mean	27.63	9.90	8.94	19.49	27.43	11.58	21.83	77.34
Median	26.50	9.94	8.38	19.08	27.21	11.94	22.00	77.67
Std. Dev.	8.51	1.62	1.75	3.17	3.32	1.41	3.45	3.45
Hoojah Turnout 1	1.40	10.60	23.43	31.29	21.81	6.90	5.58	94.02
Hoojah Turnout 2	11.55	10.57	28.83	29.28	20.92	5.43	4.75	95.03
Hoojah Turnout 3	7.15	9.05	21.27	31.56	23.05	7.05	6.95	91.98
Hoojah Turnout 4	3.70	9.03	32.35	20.46	19.21	6.23	12.62	87.28
Hoojah Turnout 5	15.80	10.15	17.22	32.13	26.72	8.31	5.40	94.54
Hoojah Turnout 6	7.20	8.35	17.13	30.23	26.29	10.13	7.76	92.13
Hoojah Turnout 7	11.40	11.63	16.53	29.74	25.79	8.86	7.11	92.55
Hoojah Turnout 8	26.25	17.97	21.22	30.31	22.03	5.08	2.78	96.61
Hoojah Turnout 9	4.70	9.60	17.73	28.86	24.50	8.39	10.02	89.09
Hoojah Turnout 10	1.45	5.12	21.46	27.90	28.77	9.23	7.97	92.49
Mean	9.06	10.21	21.72	29.17	23.91	7.56	7.09	92.57
Median	7.18	9.88	21.25	29.98	23.77	7.68	7.03	92.52
Std. Dev.	7.24	3.08	5.01	3.15	2.84	1.60	2.64	2.63
Hoojah Road 1	35.15	9.48	12.41	26.06	29.07	9.33	12.03	86.35

Hoojah Road 2	3.30	4.50	16.24	28.23	28.13	8.95	13.34	86.04
Hoojah Road 3	28.30	10.11	21.13	29.22	22.52	7.95	9.14	90.93
Hoojah Road 4	25.45	13.01	20.52	31.25	22.67	6.77	4.56	94.23
Hoojah Road 5	26.85	10.94	17.29	32.47	23.58	7.04	8.13	91.32
Hoojah Road 6	22.60	20.03	9.17	21.32	26.03	6.91	17.12	83.46
Hoojah Road 7	24.30	12.42	11.56	21.14	25.76	11.43	16.45	82.30
Hoojah Road 8	34.65	8.19	12.32	22.42	23.95	9.95	23.03	76.82
Hoojah Road 9	17.75	9.12	12.64	23.89	26.75	8.75	18.72	81.16
Hoojah Road 10	11.70	9.29	15.18	25.25	24.80	9.57	15.01	84.09
Mean	23.01	10.71	14.85	26.12	25.33	8.66	13.75	85.67
Median	24.88	9.80	13.91	25.66	25.28	8.85	14.17	85.06
Std. Dev.	9.37	3.83	3.74	3.85	2.11	1.43	5.21	5.01

APPENDIX F

LOSS ON IGNITION AND LOI DATA

Table F1. Percent loss on ignition.

Sample	%LOI	Sample	%LOI	Sample
1	2.01	40	1.72	80
2	2.83	41	2.44	81
3	2.66	42	1.36	82
4	1.49	43	0.79	83
5	2.03	44	18.68	84
6	1.92	45	12.41	85
7	1.19	46	14.48	86
8	2.74	48	8.70	87
9	1.81	49	20.31	89
10	2.36	50	10.28	90
11	0.76	51	8.15	91
12	0.57	52	7.68	92
13	0.48	53	11.86	93
14	0.92	54	14.61	94
15	1.08	56	9.68	95
17	1.77	57	6.90	96
18	0.67	58	6.68	97
19	0.95	59	8.74	98
20	1.17	60	11.71	99
21	0.90	61	6.45	101
22	2.94	62	7.61	102
23	2.08	63	7.47	103
25	2.19	64	11.25	104
26	3.81	65	10.14	105
27	1.45	67	9.58	106
28	1.42	68	9.50	107
29	1.22	69	15.34	108
30	0.88	70	10.48	109
31	1.49	71	9.74	110
32	1.33	72	7.14	111
34	0.73	73	9.91	112
35	3.16	74	14.71	113
36	0.77	75	13.34	114

37	0.64	76	7.35	115
38	2.03	78	14.05	117
39	0.90	79	12.56	118

Sample	**%LOI**	**Sample**	**%LOI**
119	15.56	159	3.09
120	15.64	160	2.67
121	2.58	161	2.68
122	2.52	162	2.35
123	2.99	163	4.72
124	2.05	164	4.77
126	2.88	165	1.47
127	1.78	167	0.75
128	1.57	168	1.71
129	2.53	169	2.17
130	3.05	170	1.41
131	1.45	171	1.33
132	3.81	172	0.97
133	4.64	173	1.56
135	4.49	174	1.24
136	4.90	175	1.50
137	4.72		
138	3.28		
139	2.85		
140	2.66		
141	5.56		
142	4.41		
143	3.39		
144	3.21		
145	4.67		
146	8.78		
147	8.17		
148	6.95		
150	5.04		
151	5.42		
152	5.08		
153	4.13		
154	2.73		
155	4.94		
156	4.32		
158	4.81		