2. METHODS

The purpose of this section is to present the methods used for data collection and analysis. All field notes are maintained in notebooks and duplicate copies (photocopies or electronic scans) exist for all field notes. Digital data is backed up and stored off-site.

2.1. OVERALL GOAL

The goal of the OWEB-funded research was to describe the changes in morphology of the Sandy River between 2007 and 2010 and to collect sediment transport measurements which would help explain the changes. The locations and data collected were chosen to fit into the larger effort described in section 1.2 above.

2.2. SITE SELECTION

Several sites on the river were chosen at which to measure changes in the bed. These sites were measured in the summer while the river discharge was low. Minimal sediment transport was occurring and much of the river was accessible. These summer-time measurements were of the 'sediment at rest', and comparisons of the same measures from year to year provided the annual changes. To explain how the changes occurred, measures were also needed of the 'sediment in motion'. These measurements of bedload and suspended load transport were made during the winter high-flow season at locations above and below the 'sediment at rest' reaches.

2.2.1. 'AT REST' REACHES

In the spring of 2007 four reaches of interest were designated by the JHU/NCED team (section 1.3.1 above) (Figure 8). Several factors played a role in the site selection including:

- predicted deposition by Stillwater Sciences (2000b) (Figure 6),
- evidence of past deposition – bars & islands,
- accessibility – either public lands or cooperative landowners,
- geomorphic heterogeneity – Since one goal of this research was to observe how different bedforms (pools, lateral bars, medial bars, point bars, etc…) respond to increases in sediment supply, reaches were favored that showed a variety of bedforms.

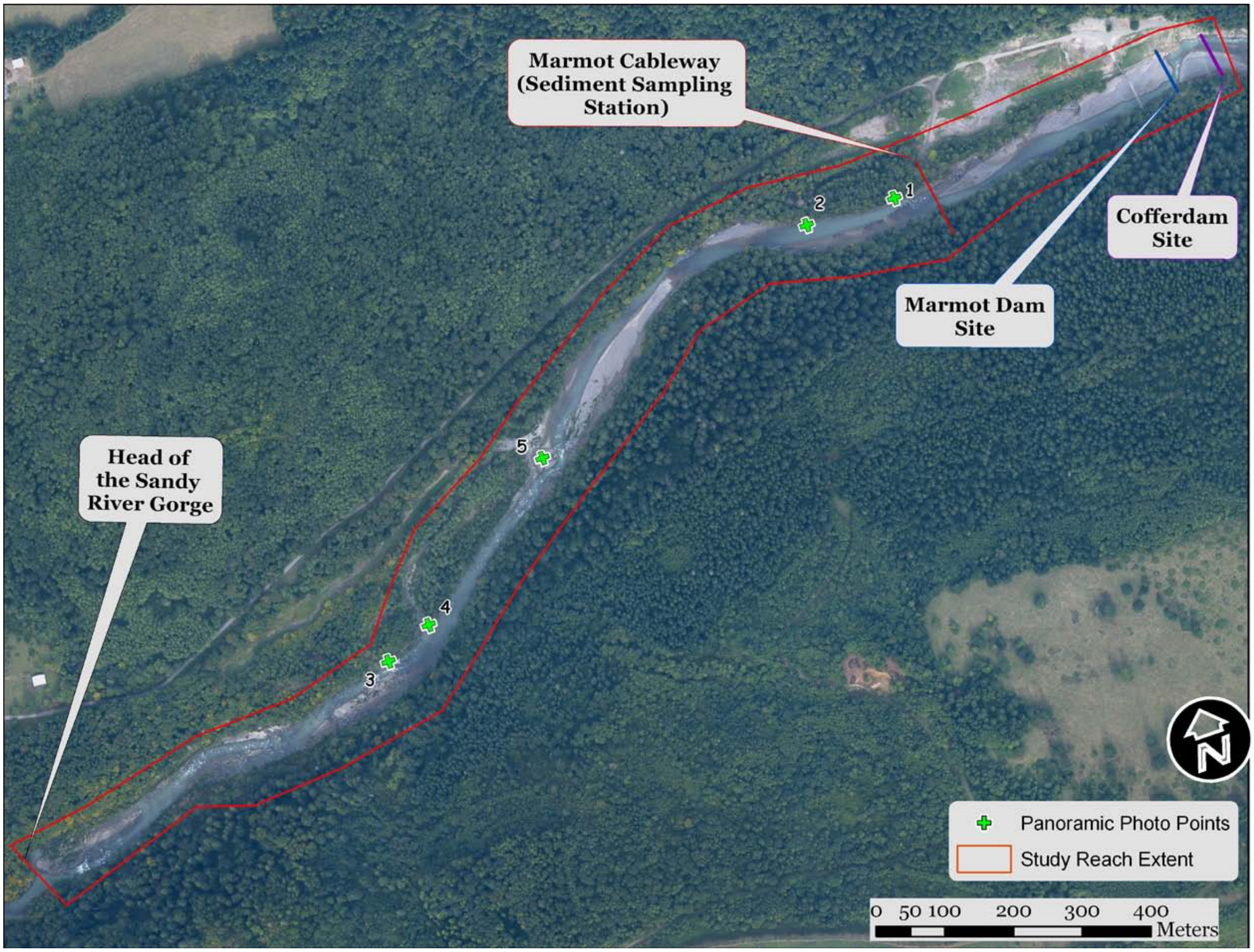


Figure 9 – Overview of Dam Reach (panoramic photo points shown in green; locations of dam and cofferdam noted)

2.2.1.1. DAM AREA

Our upstream-most monitoring reach was located in the immediate vicinity of the dam site (RK 49.2 – 46.0 [RM 30.6 – 28.6]) (Figure 9). Since this portion of the monitoring effort targeted deposition, the upstream limit of this reach was the location of the cofferdam. For 2.2 km (1.4 mi) below the dam, the river flows through an alluvial reach. At the end of the alluvial reach is the head of a 6.9 km-long (4.3 mi) bedrock gorge. The wetted width in the alluvial reach at low flows is ≈16-40 m (50-140 ft). The floodplains, islands, and bars occupy the rest of the valley bottom width of ≈120-140 m (400-460 ft). This reach was predicted to receive the bulk of the sediment deposition, receiving between 1 and 4 m (3.2 – 13 ft) of average deposition (Downs et al, 2009).

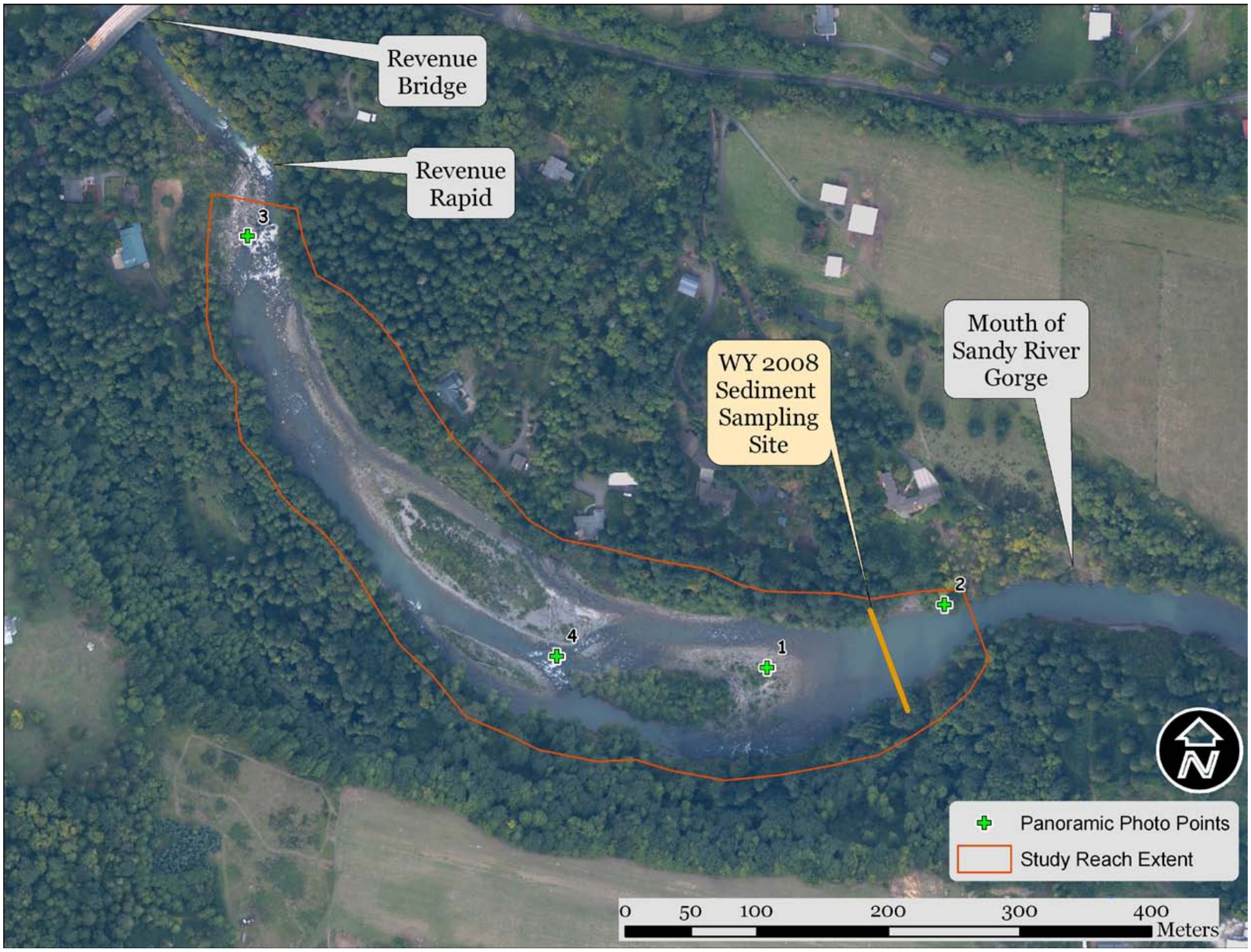


Figure 10 – Overview of Revenue Reach (panoramic photo points shown in green)

2.2.1.2. *REVENUE BRIDGE AREA*

The second study reach (RK 39.1 – 38.4 [RM 24.3 – 23.9]) lies immediately below the 6.9 km-long (4.3 mi) bedrock gorge, in which the river and valley are confined to 30-40 m (100-130 ft) wide. In the Revenue Bridge study reach, the river expands to as much as 70 m (230 ft) as the valley expands to nearly 300 m (980 ft) (Figure 10). Both the existence of bedforms such as mid-channel bars / islands and the Stillwater Sciences report suggest that this reach would receive deposition. The Revenue Bridge reach is short, bounded at the top by the gorge and at the lower end by Revenue Rapid.

Figure 11 – Overview of Cedar Creek Reach (panoramic photo points shown in green)

2.2.1.3. *CEDAR CREEK AREA*

The third reach is located approximately three kilometers below the Revenue Bridge / Revenue Rapid area. The river between the Cedar Creek reach and the Revenue Bridge reach consists of an alluvial channel with occasional bedrock outcrops. The study reach contains the confluence of Cedar Creek with the Sandy River at RK 35.6 – 34.3 (RM 22.1-21.3) and included a unique 180 degree bend in the river (Figure 11). The reach average values of deposition from the Stillwater Sciences predictions were minimal; however there was evidence of historic deposition in the form of point bars, mid-channel islands, and lateral bars. The reach is popular with fishermen and they reported channel change (pool filling) associated with a large storm in November 2006, indicating the reach may exhibit channel change following high flows. Between summers of 2009 and 2010, there appeared to be no significant change in the river morphology of the Cedar Creek reach and it was dropped from the monitoring plan for the summer of 2010.

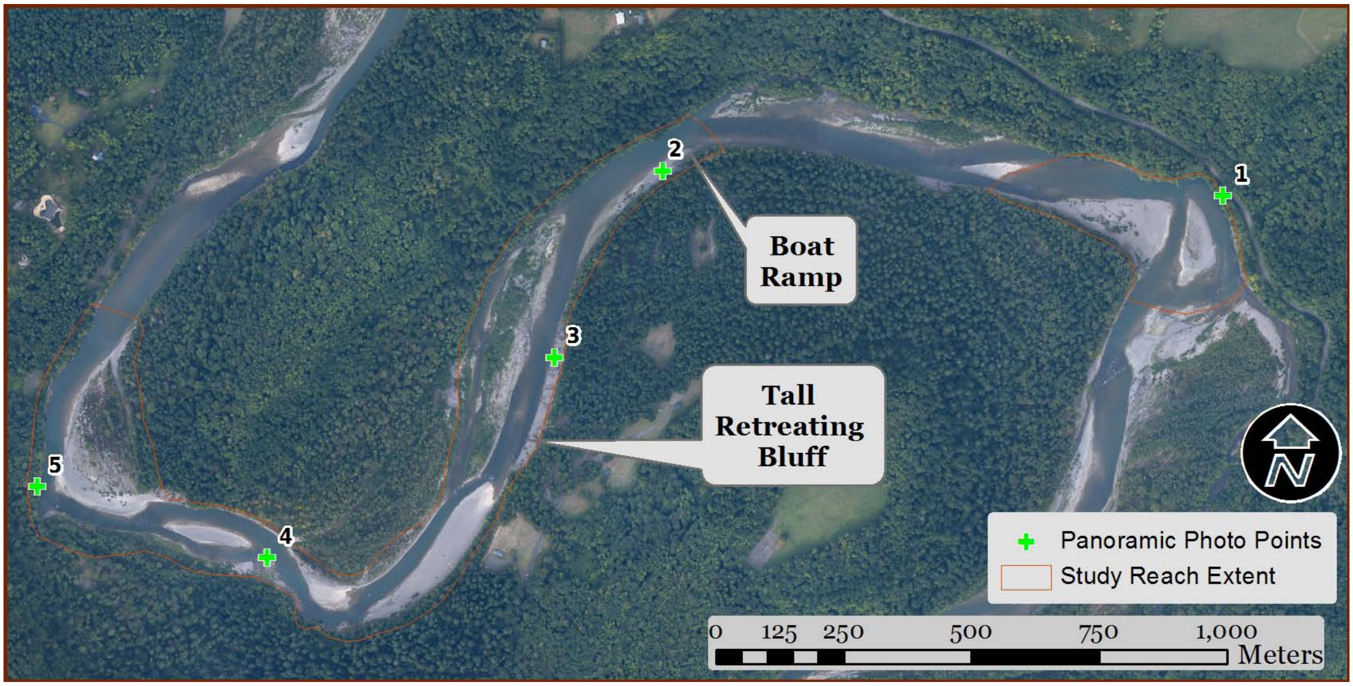


Figure 12 – Overview of Oxbow Reach (panoramic photo points shown in green)

2.2.1.4. *OXBOW PARK AREA*

The final downstream reach is contained within Oxbow Park (RK 20.1 – 16.8 [RM 12.5 – 10.4]) (Figure 12). The park area is lower gradient (Figure 7) and the deposits are sandier, providing a different geomorphic setting than the steeper, coarser Cedar Creek area. The upstream limit of this reach is the confluence of Gordon Creek. Following the storm in November 2006, there were significant changes to the morphology of the river at the Gordon Creek confluence. The Oxbow Park area was included to examine differences in depositional patterns in a dynamic and lower gradient reach. Observations prior to starting the field work in the summer of 2008 indicated only minor changes to the river morphology in the Oxbow Park Area. Consequently only a small portion at the upstream end of the reach was measured in the summer of 2009, and the reach was skipped entirely in the summer of 2010 allowing the dedication of additional resources to upper reaches which saw more change.

2.2.2. *'IN MOTION' SITES*

The sediment responsible for geomorphic change was transported by the river, primarily during isolated high-flow events during the late fall, winter, and spring. Measuring sediment transport above and below the 'at rest' reaches facilitates comparisons between measured changes in stored sediment volume and rates of sediment transport into and out of the reach. During Water Year 2008, the USGS and GMA occupied several sampling sites along the river (Major et al, 2008; GMA, 2008). For the 2008-2010 winter seasons (Water Years 2009 and 2010), only the JHU/NCED/GMA sampling crew made sediment transport measurements. A combination of landowner access problems in the Revenue Bridge area (Figure 13), where the measurements were made the previous year, and the need for a more robust data collection effort in the vicinity of Sleepy Hollow (USGS gauge 14136500) led the team to concentrate the sampling effort for 2008-2009 at Sleepy Hollow (Figure 8). There had been very few good measurements of sediment transport into the reservoir / dam area and therefore describing the upstream flux of sediment into the study reach was considered a priority. With a good estimate of the upstream sediment input from the WY2009 effort (Podolak and Pittman, 2010), the sediment transport focus was shifted downstream for the winter of 2009-2010. Access issues prevented reoccupying the sampling site from 2007-2008, however a suitable site 1.4 km (0.9 mi) downstream was selected (Figure 13).

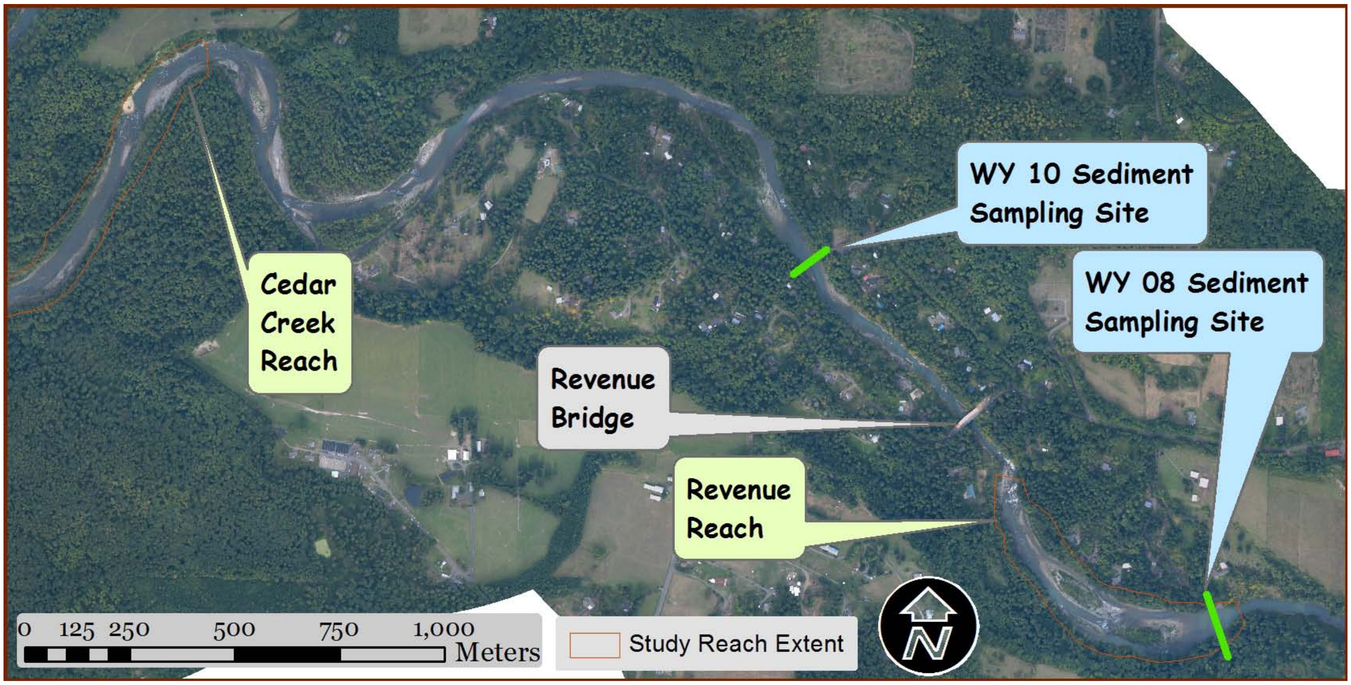


Figure 13 – Overview of the WY 2008 and WY2010 Sediment Sampling Sites in relation to the Revenue and Cedar Creek Reaches

2.3. SEDIMENT AT REST (SUMMER)

The data collection effort for the 'at rest' reaches took place during July 2008, July - August 2009, August - September 2010, and September 2011. Documenting change required repeating the same measurements using the same protocols as the previous years.

Figure 14 – Surveying Setups. Total station (left), RTK GPS (center), and cataraft–based RTK GPS tied to depth sounder (right).

2.3.1. *SURVEY*

Describing changes in the form of the river bed from one year to the next relied on detailed topographic surveys of the entire bed for each year. Non-bathymetric LiDAR was available for 2006, 2007, and 2008, and as a result the survey focused on collecting topographic data near and below the summertime waterline. LiDAR topography was used for the higher elevations.

2.3.1.1. Collection Methods

Topographic survey data were collected using a variety of methods (Figure 14):

- The lower two reaches (Oxbow and Cedar Creek - Figure 15, Figure 17) were surveyed by hand using a total station (Topcon APL-1A or Sokkia SET2110) using conventional methods of mapping breaks in grade and significant features (water edge, bar top, etc…). In areas of uniform topography, a grid pattern (approximately $10m^2$) was utilized. Detailed, monumented cross section surveys supplemented topographic surveys.
- Deep pools and riffles in the Oxbow reach were surveyed using a depth sounder integrated with an RTK GPS (Fig 14). Equipment was mounted to a 4.8m (16 ft) cataraft which traversed the rivers, mapping features > 0.43m (1.4 ft) in depth.
- In the Dam reach, GMA adopted the DEA protocol of cross section spaced approximately every 10 meters. These data were used to fill in the gaps between the DEA surveys (Figure 19), though our sections were not monumented and large boulders were not mapped. In areas of less topographic variation (such as the downstream-most bar), breaklines were utilized in lieu of cross sections.

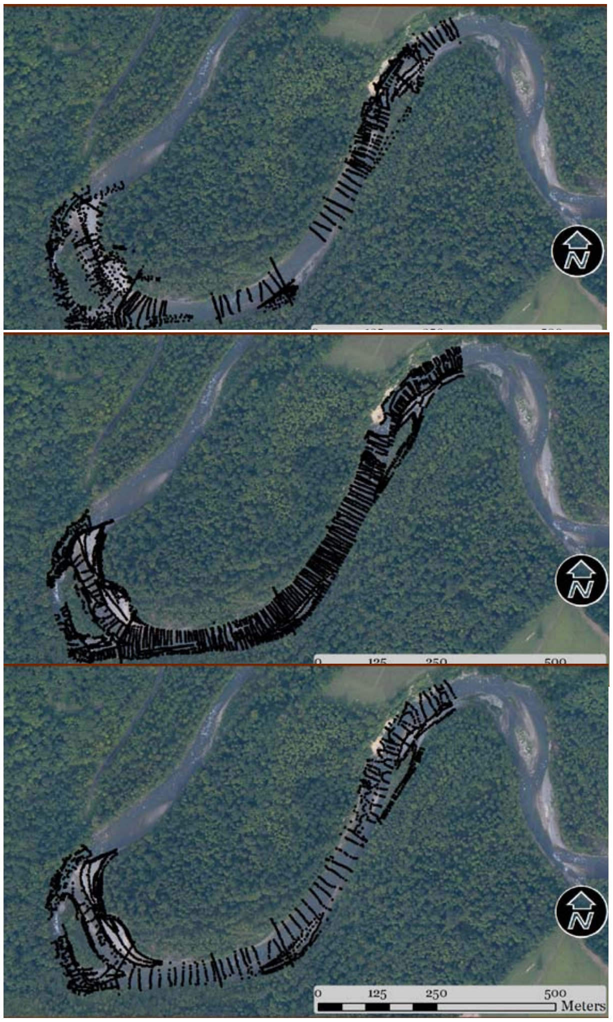


Figure 15 – Survey Points for Cedar Creek Reach From top to bottom: 2007, 2008, 2009.

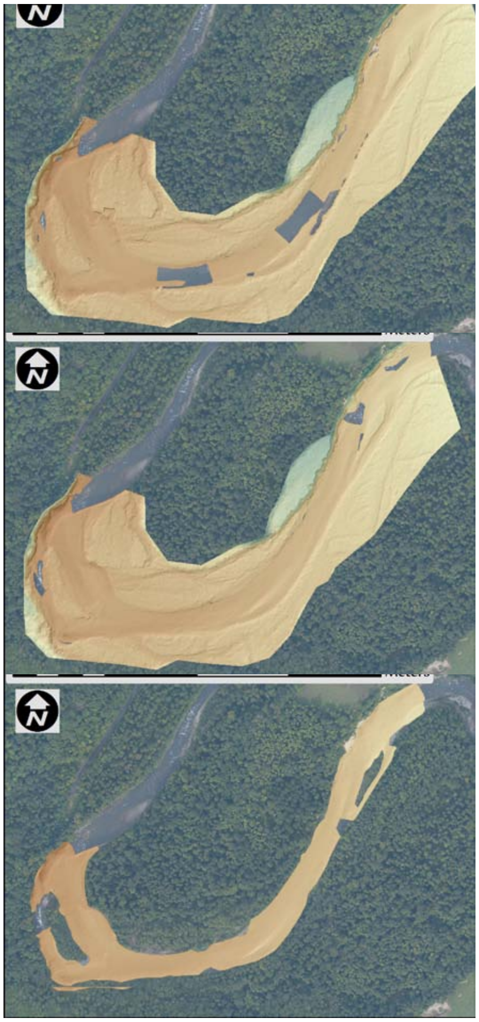


Figure 16 – DEM generated from survey & LiDAR for Cedar Creek Reach. From top to bottom: 2007, 2008, 2009.

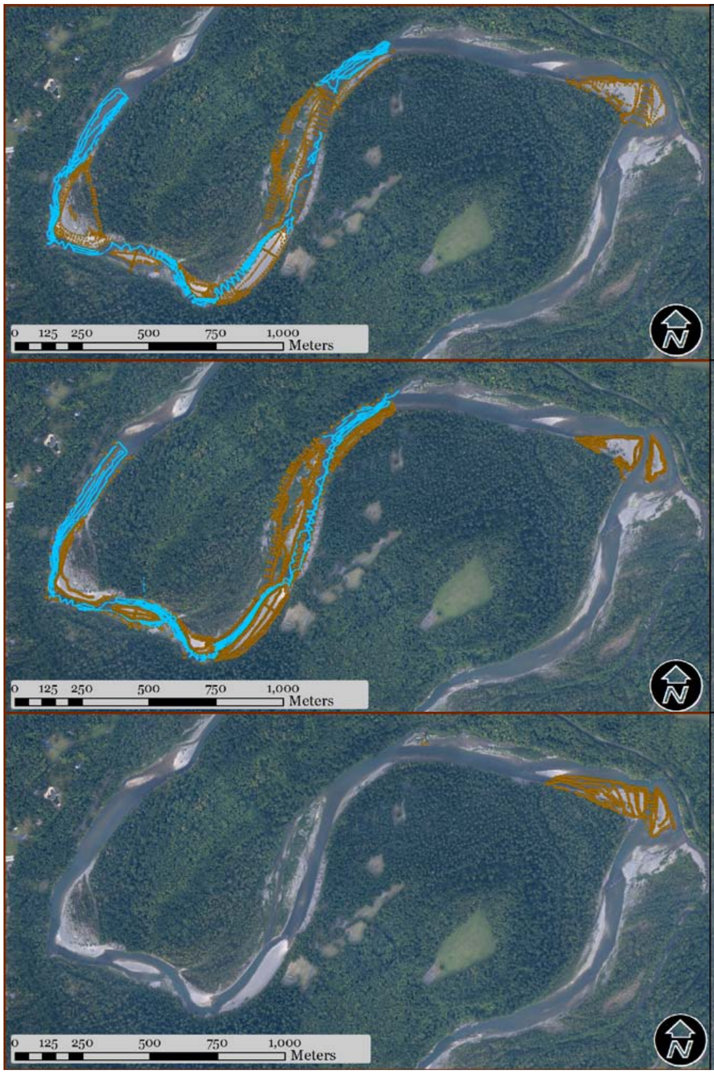


Figure 17 – Survey Points for Oxbow Reach (brown points were taken with the total station, blue were taken with a GPS/depth sounder combination). From top to bottom: 2007, 2008, 2009.

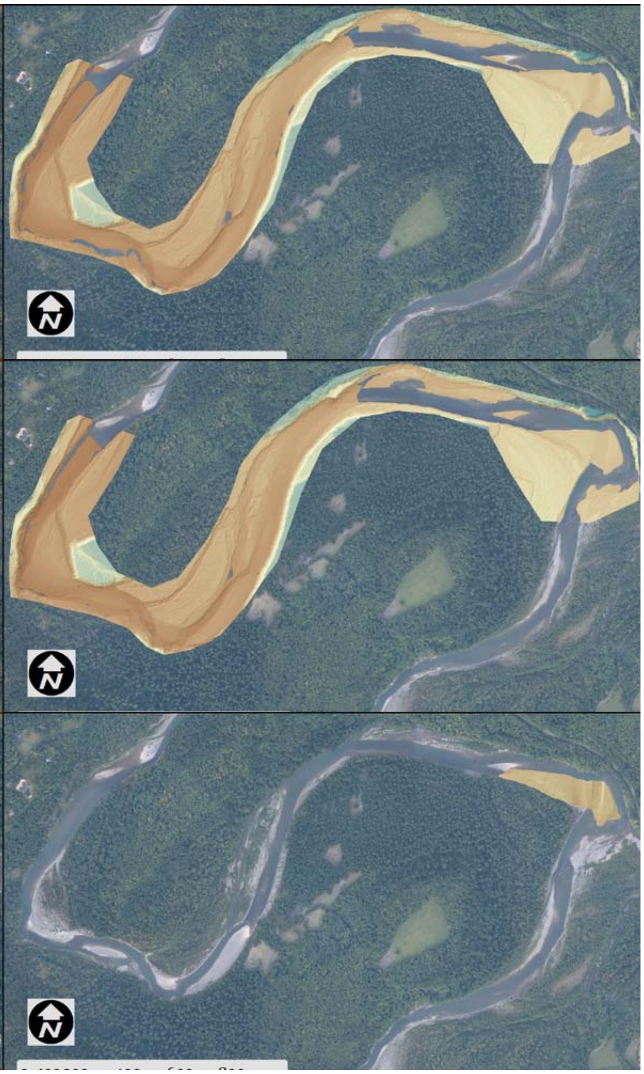
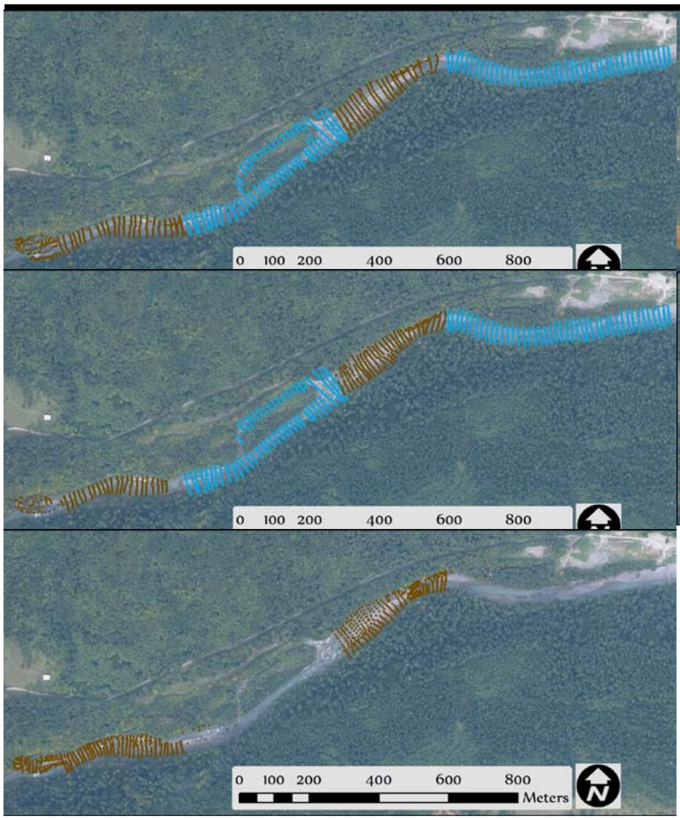


Figure 18 – DEM generated from survey & LiDAR for Oxbow Reach. From top to bottom: 2007, 2008, 2009.

Many of the coarser riffles were punctuated by large numbers of extremely large particles (>1m). Such particles were not defined by the surveys and we assume that in coarse riffles our surveys will only detect change >0.5 m.

2.3.1.2. PROCESSING METHODS

Survey control coordinates were obtained from DEA. The survey data (x,y,z coordinates) from the total station data collectors were downloaded daily from the survey instruments using Sokkia Prolink Version 1.15 and TDS Survey Link software. The raw coordinate and elevation data was then exported as a text file. The points from all the survey sources were post-processed together using ESRI's ArcGIS software. Breaklines were created using common survey points types as vertices and the points were interpolated into a digital elevation model using the TIN (triangular irregular network) creation tool. In order to compare changes from year to year, TINs were converted to ESRI Grids. Figure 16, Figure 18 and Figure 20 show the grids combined with the LiDAR derived DEMs to form a digital representation of elevations throughout the reaches. In these three figures the extent of the DEMs are larger in 2007 and 2008 than in 2009 and 2010 due to the lack of LiDAR for 2009 and 2010. All the



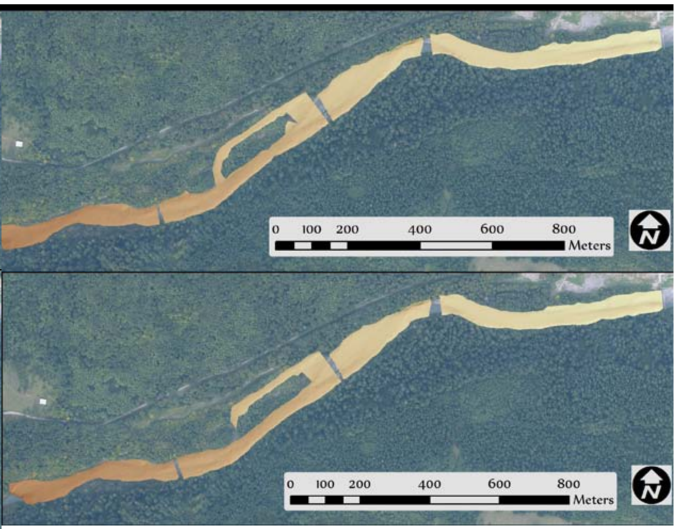


Figure 20 – DEM generated from survey & LiDAR for Dam Reach. From top to bottom: 2009, 2010.

Figure 19 – Survey Points for the Dam Reach Brown points were collected by GMA to augment the points collected by DEA for PGE – blue points. From top to bottom: 2009, 2010, 2011. ***At the time of this writing, the 2011 DEA survey has been conducted, but the data is not yet available.***

Grid DEMs were projected into the NAD 1983 Oregon North State Plane (feet) coordinate system and resampled to ensure identical (1 m^2 [1.2 yd^2]) cell size and cell alignment. Annual changes in elevation were computed using the Geomorphic Change Detection software (available for download at: http://www.joewheaton.org/Home/research/software/GCD). The details of this change detection algorithm are available in Wheaton et al (2010). This method provides a more robust measure of change than those described in Podolak and Pittman (2010) through an incorporation of a fuzzy-inference system to produce a spatially varying threshold of detection using point density and local terrain slope. The effect of this improvement over the spatially uniform detection threshold used in Podolak and Pittman (2010) is a better treatment of uncertainty in both the elevation models and their difference, which results in a more accurate depiction of annual change. The annual changes were computed using a spatially variable uncertainty based on the point density and surface slope, which were combined into an uncertainty value with a Fuzzy Inference System. The computed annual differences are evaluated against the uncertainty values to filter out areas (at a .9 confidence level) where computed changes are likely not real due to uncertainty. A second filter was applied using a sloping datum computed from the 2008 LiDAR-derived water surface. For each reach, the maximum water surface elevation (relative to the sloping datum) was determined from field observations (Dam reach: 3 m; Revenue Reach: 2.4 m; Cedar Creek Reach: 2 m; Oxbow Reach: 2.4 m). Elevation changes which occurred above those elevations were assessed not be fluvial and were filtered out of the computations.

2.3.2. GRAIN SIZE

It was expected that not only would the form of the river bed change, but that the texture (grain size distribution) would also change. While the survey provided a measurement of the shape of the river bed, bars, and banks, a measurement of the grain size was made for all of the survey areas to assign a texture to the entire surveyed surface.

2.3.2.1. COLLECTION METHODS

Before measuring the grain size of the bed, the surface was mapped into distinct textural patches, or facies (Buffington and Montgomery, 1999). The facies were identified by the presence and relative abundance of grain size classes (sand, gravel, cobble, and boulder). The facies were mapped in the field using the ArcPad software from ESRI on a Trimble Juno (Figure 21, Figure 22, Figure 23, and Figure 24).

After classifying all exposed bars, lightly vegetated islands, and shallow submerged areas of sediment into distinct facies, pebble counts were made of the each facies. Grains were selected for measurement by laying out several 100-meter fiberglass tapes in a manner that they were evenly distributed throughout the facies (Figure 25). At fixed intervals on the tapes, the grains that were under a mark on the tape were picked up and measured using a gravelometer (a metal plate with square openings of 2, 4, 5.6, 8, 11.25, 16, 22.5, 32, 45, 64, 90, and 128 mm) (Figure 26). For grains larger than 128mm, the intermediate axis was measured. For nearly all the pebble counts three 100-meter tapes were used and grains were measured every meter. For few large facies more than three tapes were used, and similarly for several small or homogeneous facies either fewer than 3 tapes were used or the interval was decreased. In any case, the spacing of the tapes and measurement intervals were selected to avoid measuring the same grain twice.

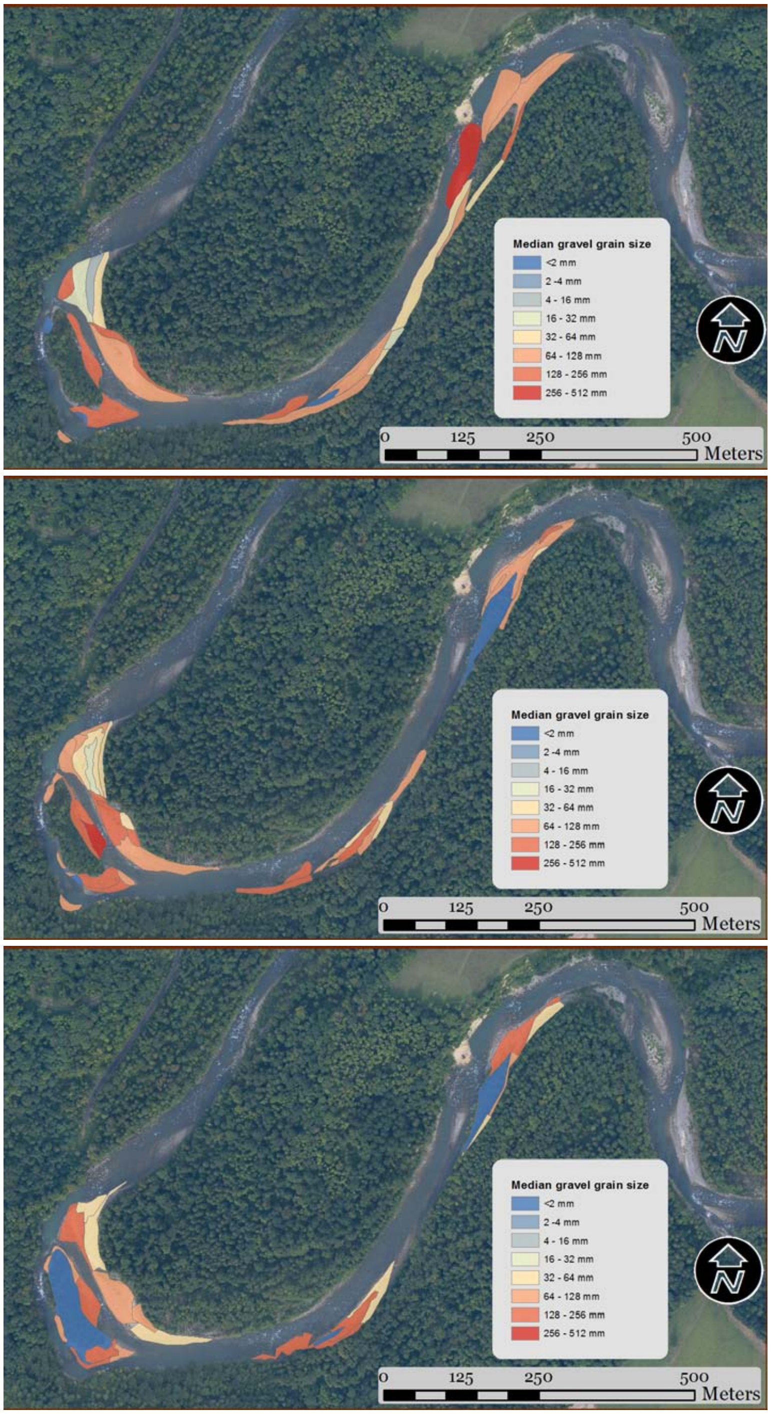


Figure 21 – Facies in Cedar Creek Reach (colored by median gravel grain size) Top to bottom: 2007, 2008, 2009

In addition to collecting surface grain size over all of our study reaches, in 2009 we chose to measure the subsurface grain size of the newly deposited sediment downstream of the dam site (Figure 27). At eight locations we excavated by hand an average of 1350 kg (1.5 tons) of sediment by digging a pit approximately 1 m (3.3 ft) in diameter and 1 m (3.3 ft) deep (Figure 28). The upper layer (defined as all the sediment down to the elevation of the largest grain visible on the surface) was segregated and

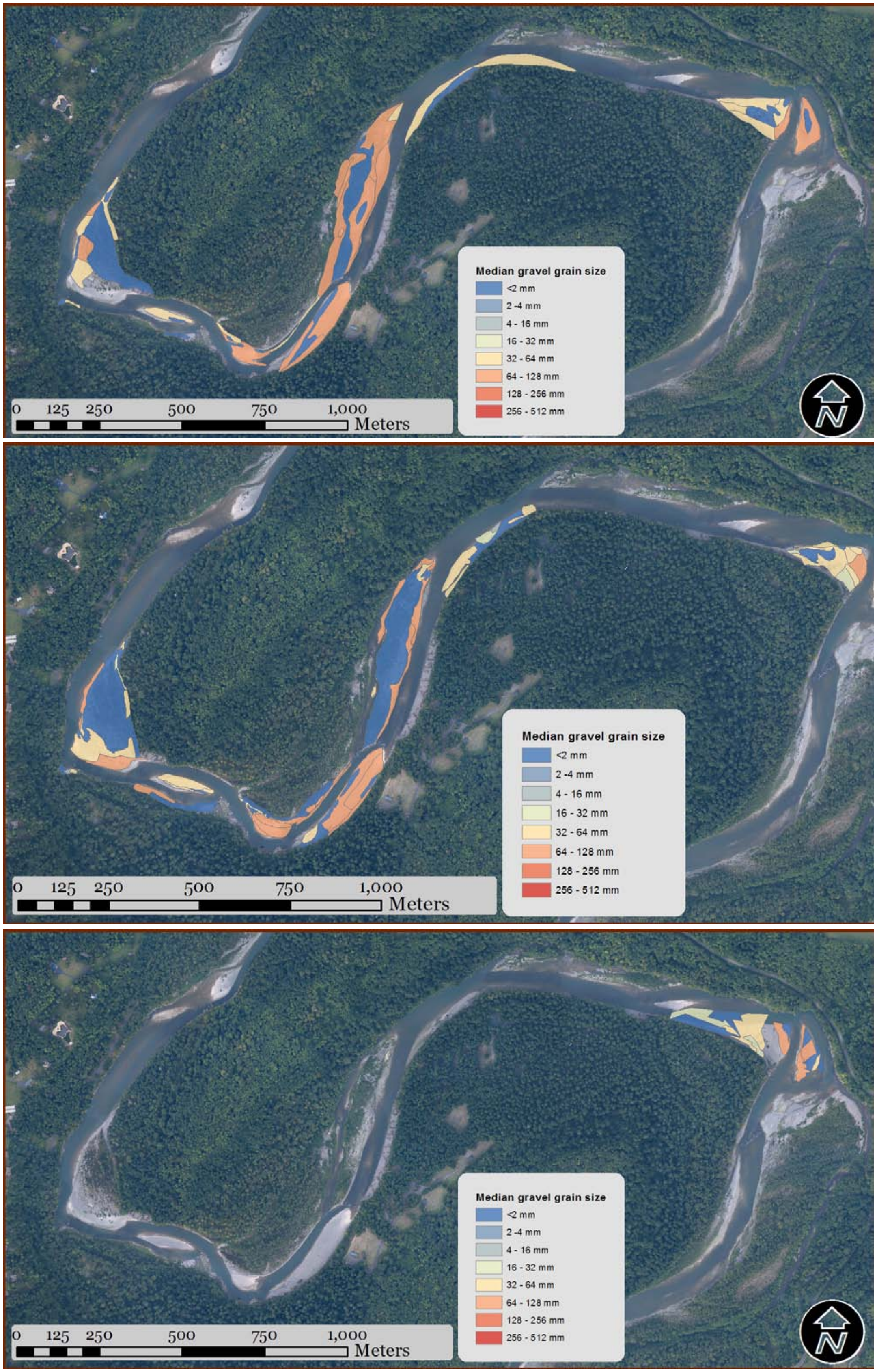


Figure 22 – Facies in Oxbow Reach (colored by median gravel grain size). Top to bottom: 2007, 2008, 2009

processed separately to compare against the subsurface sample and the surface pebble count. The bulk sampling effort is also detailed in DiLeonardo et al (2009), and Keith et al (2009).

2.3.2.2. *Processing Methods*

For the pebble counts each grain was classified into a size bin with the following breaks: 1m, 512mm, 256mm, 180mm, 128mm, 90mm, 64mm, 45mm, 32mm, 22.5mm, 16mm, 11.25mm, 8mm, and 2mm. A cumulative frequency distribution was computed for each facies, and from the distribution the fraction of sand [f_s] (grains less than 2 mm) as well as the median grain size of the gravel fraction [D_{50g}] (for grains greater than or equal to 2 mm) were calculated.

Facies delineation is a subjective decision – looking at the same bar, reasonable people can disagree how many facies exist. Therefore, for year-on-year change, individual facies were not the unit of comparison, but rather bars as a whole served as the unit. Facies were digitized as polygons in ArcGIS and their area was calculated. Values of the f_s and D_{50g} for each bar were computed as an areal weighted average using the f_s and D_{50g} for the constituent facies. Finally, since several bars had large higher-elevation surfaces which would not be inundated except for the very high and infrequent discharges, a further analysis was conducted. To avoid potentially subtle grain size changes on the portions of the bars which had been inundated from being overshadowed by the unchanging grain sizes in uninundated areas, portions of the facies were censored. Using the surfaces created with the surveys (section 2.3.1) and the LiDAR, water surfaces were created 1,2,3,4, and 5 feet higher than the water surface at the time of the LiDAR measurements. Year-on-year change of the f_s and D_{50g} for each bar was then evaluated using an areal weighted average, not of the total area for each facies, but instead using the area inundated at various stages.

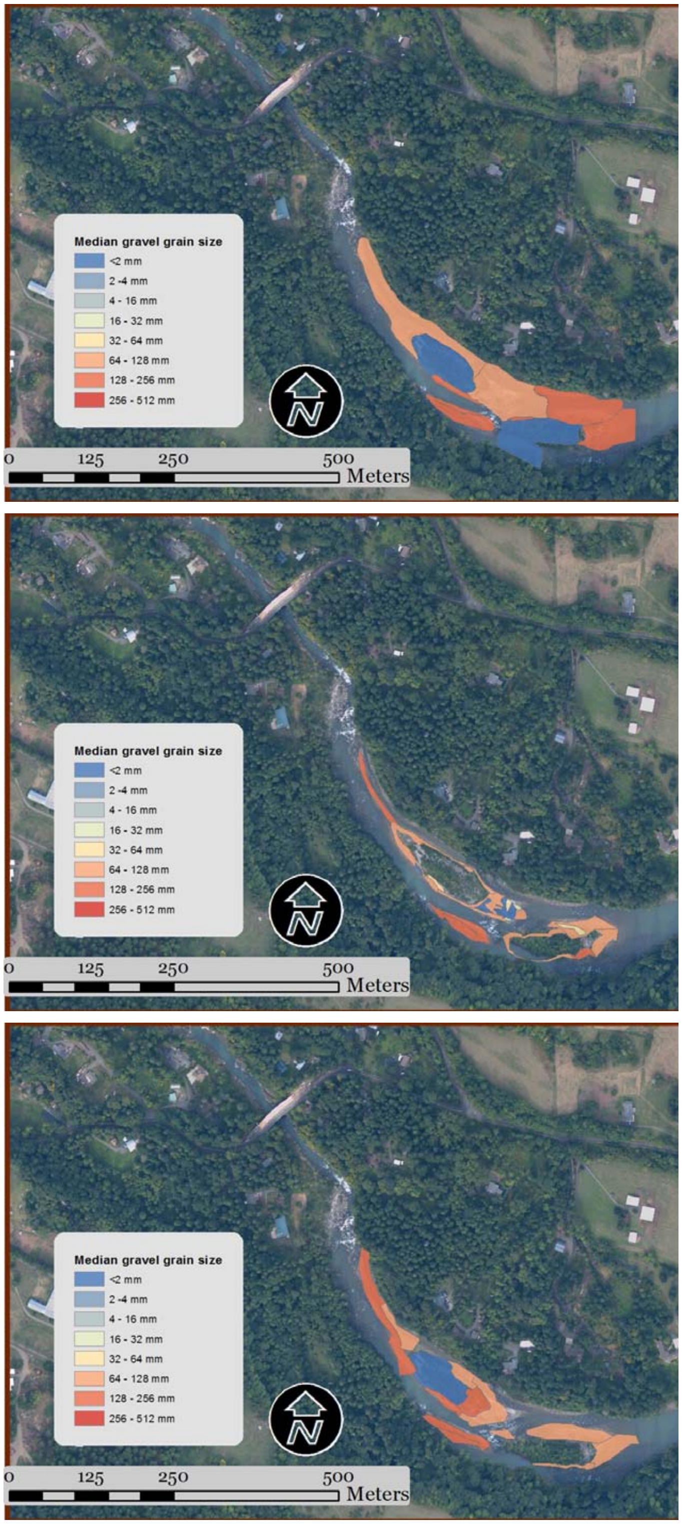


Figure 23 – Facies in the Revenue Reach (colored by median gravel grain size). Top to bottom: 2007, 2008, 2009

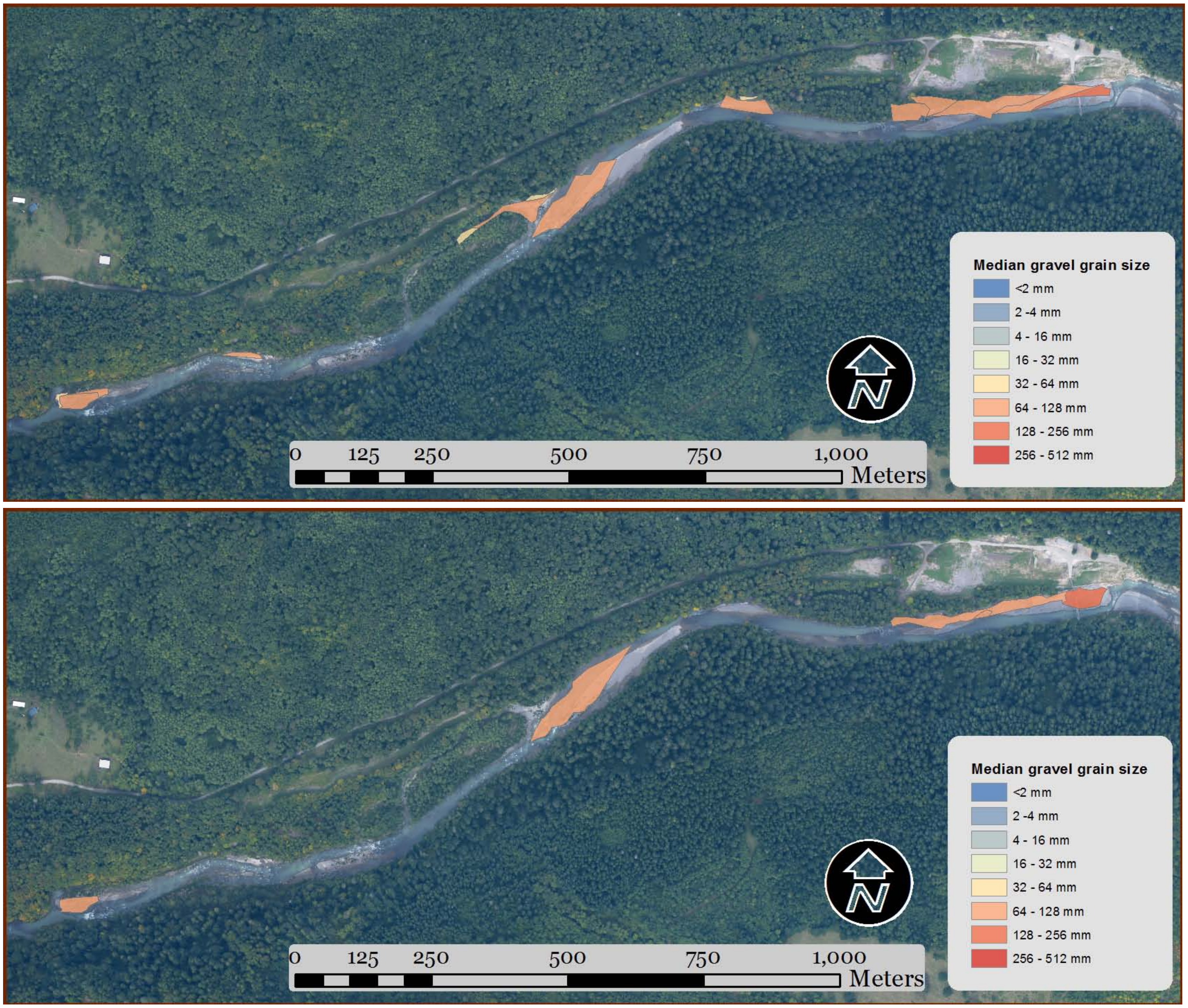


Figure 24 – Facies in the Dam Reach(colored by median grain size). Top to bottom: 2009, 2010

The processing of the bulk samples was done in the field (Figure 28). The total weight of all sediment was recorded and the grains were segregated by size using gravelometers and sieves. Clasts larger than 64mm were individually weighed with a hanging scale. Grains smaller than 64 mm, were collected in buckets and weighed in size classes (32–64 mm, 16–32 mm, 8–16 mm, <8 mm). It was assessed that the size distribution of the grains less than 8mm was relatively similar among all the pits. In the interest of time, only a single sample less than 8mm was processed into 4-8 mm, 2-4 mm, and <2 mm size classes. The distribution of these small size classes was applied to the mass of the <8mm sample for all the other pits.

2.3.3. *PHOTOS*

In addition to the survey data capturing the shape of the surface each year and the grain size data characterizing the texture of the surface, repeated photographs were taken at monumented photopoints at least once per year. Nineteen locations were chosen throughout the four study reaches (Figures 9, 10, 11, & 12). The locations were selected for their views of the reach, ability to be reoccupied for

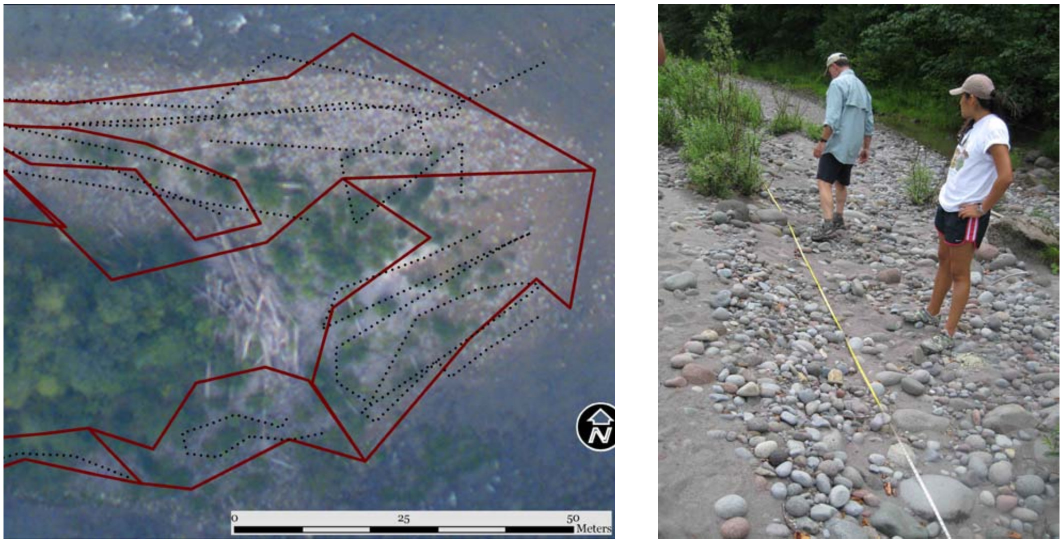


Figure 25 – Record of pebble counts in Revenue Reach. Dots (left) show 1m spacing along recorded locations of measuring tapes (right).

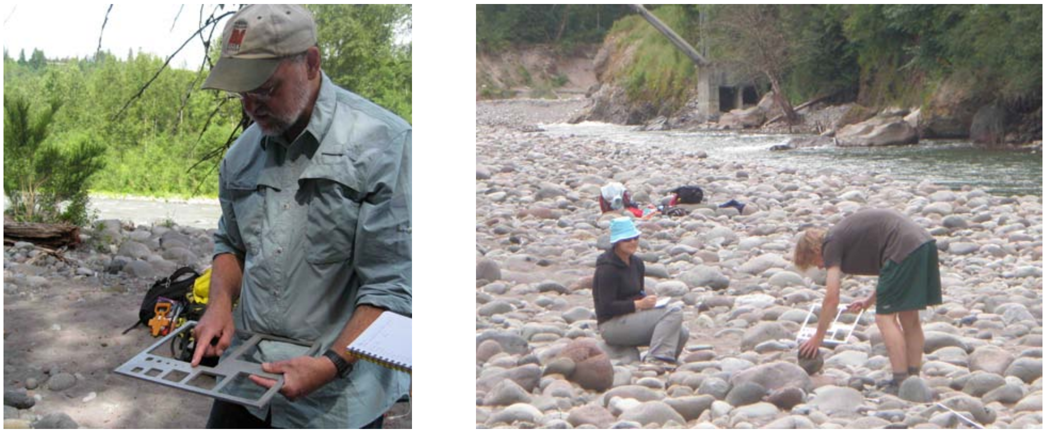


Figure 26 – Gravelometer (demonstrated by Dr. Peter Wilcock, JHU [left]), in use by Jessica Roark and Kiernan Folz Donahue [right]

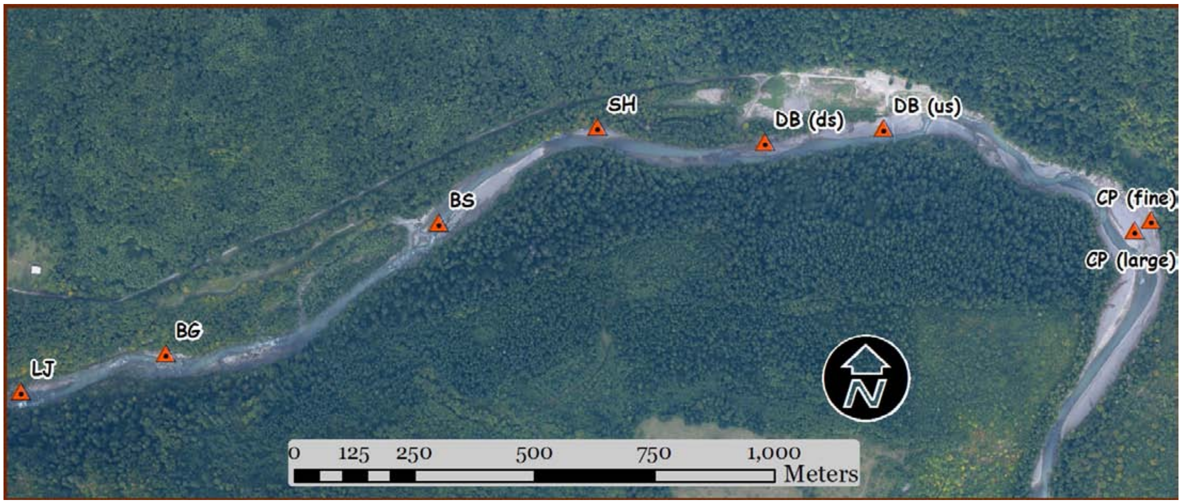


Figure 27 – Locations of 2009 bulk samples in the dam reach

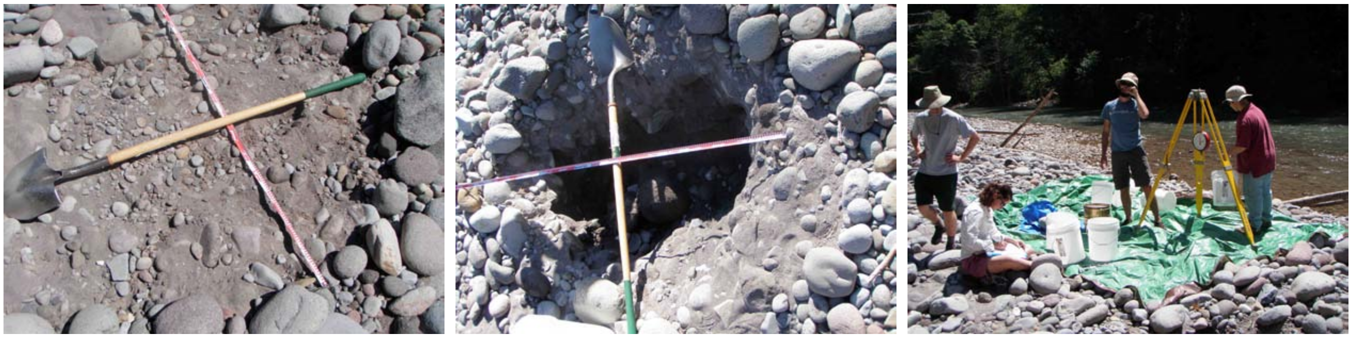


Figure 28 – Bulk Sampling. [left to right] Pre–excavation. Post–excavation. The sorting and weighing setup for field processing.

multiple years, and accessibility during times of high discharge. Where practical the locations were surveyed using a total station, and where this was infeasible, the photo points were located using a handheld GPS receiver (Garmin Legend HCx). Photographs were taken with a handheld digital camera (Cannon Powershot S200 Digital Elph with 2.0 megapixels) at a 1600 x 1200 resolution. To keep the panning motion level, the photographs were made from the top of a survey rod at a fixed height keeping the bubble level centered while panning the camera. Between 7 and 18 photographs were taken per panorama at each location. The photo points were reoccupied each summer (July 2009, and August 2010) and opportunistically throughout the winters. The photographs were stitched together (Figures 56, 71, 72, 73, and 74) into a single image using Adobe Photoshop CS4.

2.4. SEDIMENT IN MOTION (WINTER)

WY2008 sediment sampling efforts aimed to measure the sediment downstream of the Marmot Dam site. The USGS maintained a sampling site 400 meters downstream of the dam and our sampling site measured sediment passing the Sandy River gorge and entering a reach above Revenue Bridge with the potential to experience significant deposition.

WY2009 sediment sampling efforts focused on developing the dataset initiated by the USGS at the Brightwood (Sleepy Hollow) Bridge above the reservoir in WY2008. The sampling section was located on the downstream side of the Brightwood Bridge (E. Barlow Trail Road bridge over the Sandy River, near the intersection with E. Sleepy Hollow Dr). Data collected in WY2008 were inadequate to compute sediment loads into the reservoir reach. Under the assumption that sediment transport as a function of discharge would be similar in WY2009, the bedload and suspended load relationships were expanded and developed to compute sediment loads into the reservoir reach in WY2008. This computation (for the previous year), filled a critical gap in the sediment budget. WY2009 was also computed for Brightwood using the GMA 2009 data (though peak flows were three times greater than flows measured during sampling). No data were collected in the vicinity of Revenue Bridge in WY 2009 and loads were not computed for this site.

WY2010 sediment sampling efforts focused on the sampling location below Revenue Bridge under the assumption that transport rates measured here would be comparable to those measured just above Revenue Bridge (thus facilitating the sediment budget approach using the same boundaries). The WY2009 sediment transport rates from Brightwood were used to generate WY2010 loads using the WY2010 hydrograph from the USGS near Marmot.

2.4.1. Streamflow

In WY2008 a temporary stream gaging station was constructed near the GMA Revenue sampling site to support sediment transport monitoring efforts. A Global Water Level Loggers series #WL-15-15 datalogger was encased in flexible armored conduit and a locked steel box, secured to the stream bank. Global Water Level Loggers are of a pressure transducer type, utilizing a silicon diaphragm, and have a 4.5 meter (15 foot) range. Recording interval was set to 15 minutes and the gage was serviced and downloaded every 1-2 months. A local stage reference was established and surveyed to existing elevation control. Gage height records were checked against observed stage heights and adjusted to compensate for drift as necessary. Any error was distributed over the period of record between known (observed) gage heights. All stage references were surveyed to locally established benchmarks using an auto level. All discharge measurements were performed during high flow sampling events, therefore no wading measurements were collected. High flow measurements were taken from a cataraft attached to a cableway, which has been specially modified for sediment and discharge data collection (Figure 29). A platform is securely affixed to very stiff, inflatable plastic tubes, a tower and modified USGS roller system connects the raft to the ¼ inch cable, and a crane assembly facilitates the use of various reels, winches and power drive assists.

Figure 29 – Sediment sampling from the cataraft on a cableway platform (left) with the TR2 Bedload Sampler (right).

Streamflow data were collected at the Brightwood gage by the USGS continuously in WY2008 and part of WY2009 (USGS 14136500) [total length of the published record: 1 October 2007 – 12 September 2008]. The stage-discharge rating was verified and expanded by GMA during the January 2009 storms with two discharge measurements taken from the bridge.

In WY2010, GMA built a temporary streamgage at the site from just downstream from Revenue Bridge which a continuous discharge record could be developed if necessary. Two Global WL-15-15 pressure tranducer/data collection platforms recorded stage at 15 minute intervals. Three stage references were surveyed in at the gaging section -- as were three more upstream to serve as a water surface slope measurement section. Crest stage recorders were installed along the gaging section to validate peak flow elevations. Low flow measurements were collected by wading at the hydraulic control for the gaging section.

For all years discharge measurements followed standard USGS protocol and utilized a Price AA current meter, 100c sounding weight and a B-reel. In WY2009 this setup was deployed from a trailer mounted crane and (Figure 30) in WY2008 and 2010 it was deployed from a cataraft. Measurements typically contained at least 25 verticals at 0.6 depth.

2.4.2. *SUSPENDED SEDIMENT SAMPLING*

Depth-integrated suspended sediment sampling was performed using a US D-74 Depth-Integrating Suspended Sediment Sampler (cable-deployed from a bridge using a trailer-mounted crane in WY2009, cable-deployed from a cataraft-mounted crane in WY2008 and WY2010) with a 3/16 inch nozzle. Standard methods, as developed by the USGS and described in Edwards and Glysson (1998), were generally used for sampling. For each sample, the location, date/time, stage, number of verticals, distance between verticals, bottle #, and whether a field replicate was taken, were recorded. Suspended sediment concentrations were measured in the GMA sediment lab in Weaverville, California following USGS and ASTM D-3977 protocols. Samples were analyzed for concentrations at greater and less than 0.063mm. All sample data are stored together in Excel workbooks.

During WY2008 single-vertical, depth-integrated SSC samples were collected with each full cross section sample as a type of “box sample.” The single point-sample correlations with full cross section samples can be very strong and can provide a viable alternative to sampling off of a cableway during a winter storm, as a single person can quickly and safely collect samples.

2.4.3. *BEDLOAD SAMPLING*

A 15.2 x 30.5cm TR-2 bedload sampler (Figure 29**)** was lowered from the same crane assembly described in the methods for discharge and suspended sediment measurements. Standard methods, as developed by the USGS and described in Edwards and Glysson (1998), were used. For the WY2009 bridge-based sampling a stay-line was utilized to prevent the sampler from being swept too far downstream.

Figure 30 – Bridge crane sampling setup.

Beginning and end stations, sample interval, sample duration, start time and end time, beginning and end gage height, and pass number were recorded. All bedload sample data are stored together in Excel workbooks. Bedload samples were processed at the GMA coarse sediment lab in Arcata, California. Processing involves sieving and computing the percent retained in each sieve class as determined by weight. These data are entered into Excel spreadsheets for subsequent conversion to the cumulative percentage finer (by weight) than the corresponding sieve size.

2.4.4. *COMPUTATIONS*

2.4.4.1. *WATER DISCHARGE*

GMA computed continuous streamflow records for the temporary gaging station at the site above Revenue Bridge. Streamflow computations for annual records were also completed by the USGS for WY2008. Gage malfunction precluded the development of the entire WY2009 record at Brightwood (USGS 14136500). Streamflow computations for annual records were completed by the USGS (#14137002) for WY2010 and records were not computed from the GMA gage data.

2.4.4.2. *CONTINUOUS SEDIMENT DISCHARGE*

Utilizing the annual streamflow record and the sample data, partial annual loads were computed for suspended sediment and bedload. Suspended sediment loads were computed using continuous discharge (Q, cms or cfs) as an index of continuous suspended sediment concentration (SSC). Equations were developed utilizing discharge as the independent variable, and concentration (in two size classes: greater and less than 0.063 mm) as the dependent variable in the form SSC = aQb. Continuous SSC (mg/l) was computed using the gauging record (Q, cms or cfs) and the appropriate equation for each 15 minute period in the gauging record. The corresponding discharge for each period was used to compute the continuous loads (SSC x Q (in cfs) x 0.0027, in tons/day) which were then summed for the entire period of record.

Bedload discharge was computed in similar fashion as was suspended sediment discharge. Loads were computed for the Sandy River corresponding to the following size classes: < 2mm, 2-8mm and > 8mm. Bedload transport is spatially and temporally much more variable than suspended sediment transport and at present water discharge is the most practical surrogate available to estimate loads continuously. Bedload sampling is far more labor, equipment and time intensive than suspended sediment sampling, consequently bedload transport relationships are usually based on far fewer observations than are suspended sediment transport relationships. Therefore, since (1) fewer samples typically describe the bedload-discharge relationship, (2) bedload is computed using discharge as a surrogate, and (3) bedload transport is poorly described by discharge (due to the aforementioned temporal and spatial variability in bedload transport in both sampling and seasonal time-scales), bedload transport estimates have greater uncertainty associated than do suspended sediment load estimates.