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Assessment of Pool Depth Changes in the Trinity River between Lewiston Dam and the North Fork Trinity River

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Abstract

The Trinity River Restoration Program implements a variety of rehabilitation actions on the Trinity River downstream from Lewiston Dam. These actions, which include mechanical channel reconfiguration, gravel additions, and high-flow releases from Lewiston Dam, have the potential to affect the depth and morphology of the stream. Local stakeholders have expressed concern that some of these activities could result in the filling of some of the deep pools used as holding habitat by adult salmonids. This report documents the results of an assessment of whether widespread changes in pool depths are indeed occurring, and if so, where and why they are occurring. Depth changes are evaluated over two different time periods: Recent changes in pool geometry are assessed by comparing bed elevations acquired at 139 locations with sonar in 2009, 2010, and 2011, whereas depth changes spanning multiple decades at 13 locations are evaluated with a review of historical records.

Result of the recent sonar measurements indicates that the depths of most pools and deep runs increased between 2009 and 2011. Of 139 locations considered in this study, slightly more than half increased in depth over the study period. Significant depth decreases were observed in relatively few locations. In many cases, however, those decreases appear to be linked to recent rehabilitation actions. In particular, terrace lowering at channel rehabilitation projects sites was found to be associated with moderate to large depth decreases in about 12 distinct pool locations. Gravel additions alone, on the other hand, appear to have relatively little impact on pool depths. Of nine pools located within a few channel widths downstream from gravel additions but not adjacent to an area of terrace lowering, depth decreases were observed in just two locations. Neither terrace lowering nor gravel addition appears to have much effect on pool depths in more remote downstream reaches. A review of historical pool depth data indicates that the combination of higher flow releases from Lewiston Dam and reduced delivery of fine sediment from tributary watersheds has resulted in an increase in the depths of most natural pools in the Trinity River since the mid-20th Century.

Introduction

The Trinity River Restoration Program (TRRP) implements the fisheries restoration activities prescribed in the Trinity River Mainstem Fishery Record of Decision (ROD) issued by the U.S. Department of the Interior (USDOI 2000). These activities include numerous mechanical rehabilitation projects on the mainstem Trinity River between Lewiston Dam and the North Fork Trinity River and a coarse sediment augmentation program intended to increase the supply of gravel and small-to-medium cobble to the river downstream from Lewiston Dam. At present, TRRP has completed about half the mechanical rehabilitation projects called for in the ROD, and has been adding variable quantities of coarse sediment to the river on a near-annual basis since 2006. For brevity, the coarse sediment added to the river is hereafter referred to simply as gravel.

Various public stakeholders have long expressed concerns that gravel additions to the river could result in the filling of some of the deep pools used as holding habitat by adult salmonids. Concern over the potential for pool filling intensified in late 2010 when a perception became widespread among local fishermen that holes and runs were filling with sediment throughout the river. TRRP responded to this public input by eliminating mobile gravel placements from its 2012 channel rehabilitation projects and suspending high-flow gravel augmentations during the 2012 spring flow release. In addition, TRRP responded to the stakeholder concerns by initiating data collection efforts to support an evaluation of whether widespread changes in pool depths are indeed occurring, where they are occurring, and why. This report documents the results of those evaluations as of the end of 2012.

Pools are thought to provide holding habitat for adult salmon and steelhead (Wampler 1986; Nakamoto 1994), and their primary significance to the Trinity River is ecological. However, the scope of this report is limited to an investigation of physical changes in pool depths and geometries and the relationship of those changes to various management actions. The ecological functioning and habitat values of pools are not considered, as those topics are being addressed separately by TRRP fisheries experts. The basic objective of this report is to provide Program managers and scientists with timely physical information that can support scientific synthesis and adaptive management.

Changes in pool depths, as well as other aspects of channel morphology, can occur over a variety of time scales that potentially range from seasonal fluctuations to long-term adjustments that can persist for decades or centuries. The focus of this report is on changes that occurred over a 2.5-year period between the late fall of 2009 and the early spring of 2012. In addition to being the most recent time frame that can be evaluated, it includes the flow release of 2011, which is the maximum restoration flow that can be released from Lewiston Dam. Inclusion of the 2011 release is of particular interest because it provides insight into the potential for large restoration flows to maintain pool depths in the future. However, this report also summarizes what is known about how pool depths have evolved over the five decades since closure of Lewiston and Trinity Dams. Although this longer-term analysis is limited to 13 pools, it provides valuable context for assessing the significance of more recent changes.

Study Area

The Trinity River is a large gravel-bed stream in northern California. Flow in the river has been regulated since 1960 by two dams located near Lewiston, California, about 60 miles downstream from the river's source in the Scott Mountains and Trinity Alps. Trinity Dam, the more upstream of the two dams, impounds Trinity Reservoir, which stores up to about 2.4 million acre-feet of water for irrigation and power generation. Lewiston Dam is a smaller structure downstream from Trinity Dam used to regulate flow releases into the Trinity River and trans-basin diversions to the California's Central Valley. The study area considered in this report extends from Lewiston Dam, the more downstream of the two dams, to the confluence with the North Fork Trinity River (Figure 1), a distance of about 40 river miles.

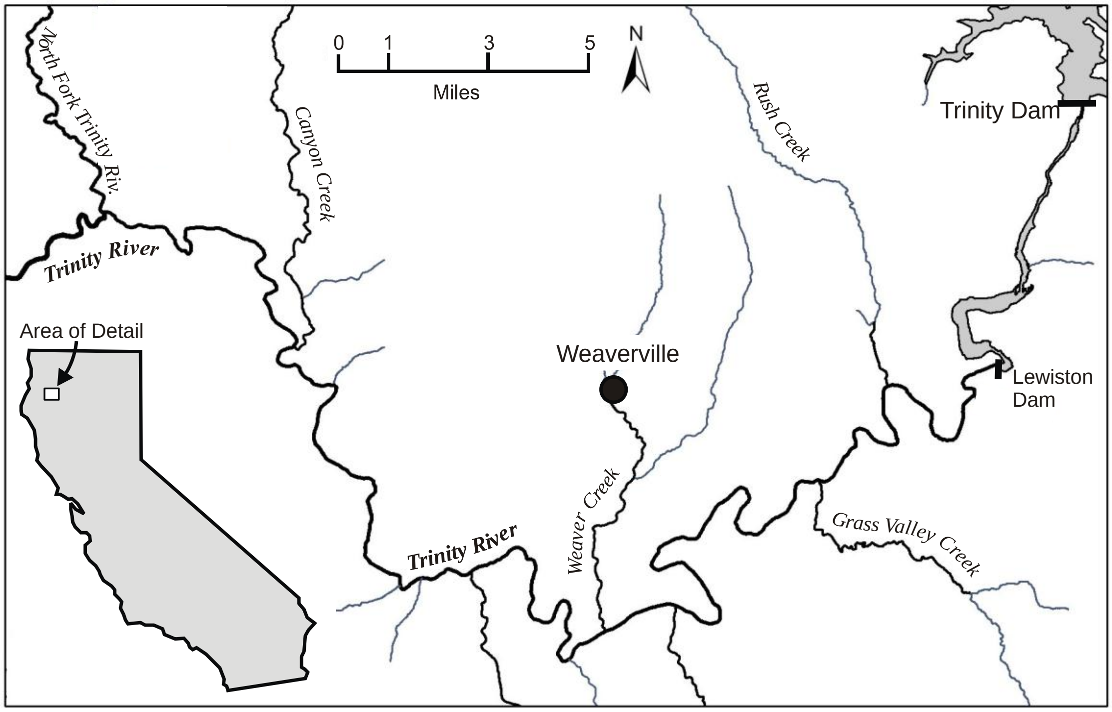

Figure 1: Location of the study area between Lewiston Dam and the North Fork Trinity River.

Stream flow in the study area is currently managed as prescribed in the ROD. Flood magnitudes are attained during annual spring flow releases with peaks ranging from 1500 to 11000 ft^3/s, depending on inflows to Trinity Reservoir. The prescribed flow regime is structured so that release peaks are expected to equal or exceed 6000 ft^3/s in 60% of the years. A constant baseflow discharge of 450 ft^3/s is released from the dam through most of the summer months. Tributary inflows are usually negligible in the summer and fall, but can be significant in the downstream half of the study area in the winter and spring. Detailed descriptions of the study area and TRRP management can be found in the Trinity River Flow Evaluation Study Final Report (USFW and HVT 1999) and numerous other documents available on TRRP's Online Data Portal (http://odp.trrp.net/).

The active channel width in the study area generally ranges between about 100 to 160 ft, and depths during the summer baseflow period range from less than 1 ft over riffle crests to more than 20 ft in the deepest pools. Runs, slowly-flowing areas of intermediate depth (Kennard et al. 2006), typically range between about 2 to 5 ft in depth at baseflow. This analyses presented in this report are focused on relatively deep portions of the river, i.e., pools and some of the deeper runs. For descriptive purposes, the depths of particular pools are sometimes characterized by the following qualitative terms: moderately deep (6 to 10 ft), deep (10 to 15 ft), and very deep (15 to 20+ ft).

Data and Analysis Methods

This report evaluates changes in pool depths over two different time periods using distinctly different data sources and analysis methods. Recent changes in pool geometry at nearly 140 locations in the Trinity River are assessed by comparing bed elevations acquired by sonar in 2009, 2010, and 2011, whereas depth changes spanning multiple decades at a handful of locations are evaluated with a review of various historical records. Only those data and methods pertaining to the quantitative analysis of recent changes are discussed in this section. Information sources pertaining to the assessment of longer-term pool changes are cited in a later section.

Sonar Data Collection

Most of the sonar data used for the evaluation presented in this report were collected over a 2.5-year period beginning in late 2009 and ending in the spring of 2012. For the purposes of this report, these data are sorted so as to represent three different “geomorphic years.” The start of a new geomorphic year (GY) on the Trinity River is herein defined to coincide with the rise to the peak of the annual spring flow release, which typically occurs in late April or early May. The concept of a geomorphic year is analogous to the water year concept used in hydrological studies, in that the beginning of the year is shifted to better correspond to natural breaks in the phenomenon being considered. In the case of the Trinity River geomorphic year, the spring flow release is the dominant geomorphic event responsible for shaping channel characteristics through most of the TRRP domain. Thus, the channel geometry formed during a particular flow release peak usually persists through the remainder of the geomorphic year until it is altered by the next release peak. Although winter storm events have the potential to produce geomorphically significant flows in the downstream half of the study area, these events present no difficulty for this study because data for all geomorphic years assessed were acquired prior to any winter floods.

Sonar data representing channel conditions in GY2009 were collected over about a 3-month period spanning November 2009 through mid-January 2010. The original purpose of this data collection effort was to support development of a new system-wide terrain model that was being developed with terrestrial and bathymetric LiDAR flown in early April 2009. The bathymetric LiDAR used in that effort was later found to be unreliable in water deeper than about 3 ft, so in the fall of 2009 Graham Matthews and Associates (GMA) was engaged to conduct bathymetric sonar surveys in as many relatively deep areas of the river as possible prior to the onset of the winter storm season. Collection was performed with a single 200-kHz Sonarmite sonar transducer mounted on a jet boat or raft. These survey-grade transducers are capable of operating in as little as 1 ft of water and have a single-ping root mean square (RMS) accuracy of ±0.08 ft. The position of the transducer was recorded in real time with a Trimble R8 RTK-GPS rover mounted directly overhead. This effort resulted in the acquisition of patches of bed elevation data in more than 160 locations scattered throughout the 40-mile TRRP domain.

A second set of bed elevations, representing GY2010, was collected via sonar in the late spring and early summer of 2010 and in the winter of 2011, prior to the 2011 flow release. These data were collected specifically to support this pool change analysis, so particular pools were identified for survey. By this time GMA had upgraded their sonar collection methods to include simultaneous collection with two transducers with overhead GPS rovers, so these surveys resulted in much higher data density than the 2009 surveys. This effort resulted in the acquisition of bed elevation data in 59 patches.

GY2011 bed elevation data were acquired via sonar in the late spring and early summer of 2011 and in the early winter of 2012, prior to the 2012 flow release. GMA was initially asked to survey a large number of deep areas to support this pool change analysis. This survey effort was later expanded to include nearly complete bathymetric coverage to support the development of a new system-wide terrain model that is currently under development. GMA had again upgraded their sonar collection methods, and for the 2012 data collection deployed a Ross Laboratories 875-3 portable sweep system with the capacity to simultaneously record sonar from up to seven transducers. In addition to GPS positioning and heading, the system incorporates pitch and roll sensors to correct for boat attitude. This final data set is therefore extraordinarily dense and covers a large area. A subset of 119 bed elevation patches was extracted from this very large data set for use in this pool change analysis. Examples of the topographic point densities and distributions obtained within local patches in the different years of the study are shown in Figure 2.

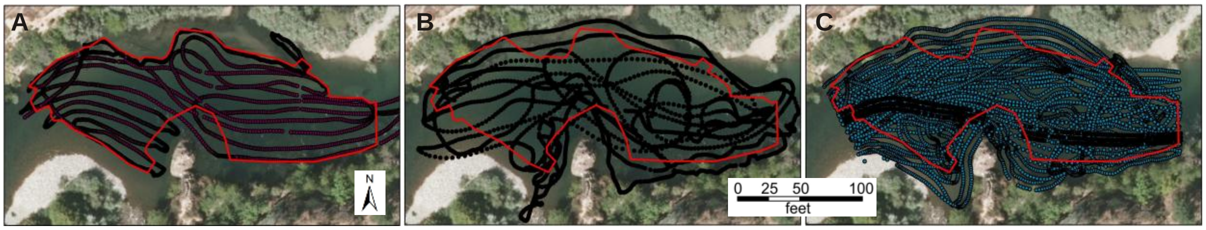

Figure 2: Examples of elevation point distributions obtained in a) 2009, b) 2010, and c) 2011. The red polygon indicates a local area in which overlapping data from all three years can be compared.

All bed elevations were determined as the GPS height minus the sonar depth and antenna height above the transducer, and referenced to a vertical datum based on NAVD88 Geoid09. GPS rovers were corrected in real time using the nearest of 12 control points that are dispersed through the river corridor. Eleven of the control points are 1st- or 2nd-order points established by the National Geodetic Survey (NGS) or the California Department of Water Resources (DWR), and one was established by GMA using the NGS's Online Position User Service (OPUS). The same control point was used for all repeat surveys at a given location.

A fourth set of bed elevations was used at one location only, that being a high-flow injection location known as the Sawmill burner hole. That hole is known to have filled following a high-flow injection performed during the 2009 spring release (Gaeuman 2011). Because the hole was already filled when the GY2009 sonar surveys were conducted, the three primary data sets described above do not document that change. However, bed elevation data had been collected at the Sawmill site both before and after the 2008 flow release to evaluate the effects of a 2008 high-flow injection (Gaeuman 2011). The post-release data collected at the Sawmill site in 2008 are used herein so that the effects of 2009 management actions at that location can be included in this assessment of pool changes. Those data were collected by the California Department of Water Resources with a single boat-mounted sonar transducer and methods similar to those used in the collection of the GY2009 data.

Sonar Data Reduction

Polygons corresponding to the sonar patches for each of the three geomorphic years were created by on-screen digitizing. Care was taken to place polygon boundaries just within the extents defined by the topographic data points so as to eliminate any extrapolation beyond the actual data extents. Polygons defining the extents of topographic data for the different years were then intersected by overlaying the polygon layers in a GIS. The result was 139 polygons in which data available from different years overlap completely. These include 90 polygons in which data from two of the years can be compared (2009-2010, 2009-2011, or 2010-2011), and 49 polygons in which all three years can be compared, for a total of 237 comparisons. All but a few of the polygons encompass areas of relatively deep water, and an informal classification assigns most of them to one of the following pool types: hole, trough, convergence, backwater, or pool (Table 1). These classes were defined for informational purposes only, and were not used in the interpretation of depth change results.

Polygon Type	Qualitative Description
Hole	Very deep area, usually located adjacent to a bedrock obstruction that forces an abrupt change in flow direction. Holes are often roughly circular in footprint and may include areas of strong eddy circulation.
Trough	Moderately deep area, usually located adjacent to bedrock or a bank underlain by bedrock. Often located along the outsides of bends. Troughs lengths are several times greater than their widths.
Convergence	Small, moderately deep area in an area of converging flow, such as the run-out of a steep riffle. Convergences differ from troughs in that they are relatively short and are often located near the center of the channel.
Backwater	Moderately deep to deep area with low-velocity flow. Pool-like character is largely due to the presence of a large downstream hydraulic control.
Pool	A generic term for moderately deep to deep areas that are not otherwise classified. Includes the pools associated with riffle-pool sequences and relatively deep runs.

Table 1: Polygon classifications used in this report.

No attempt was made to delineate the boundaries of what is or is not considered to be within the “pool” proper. Instead, depth characteristics are assessed over whatever portions of the channel that happens to fall within the region of overlapping data. Where possible, the polygon locations were assigned commonly-used names or names corresponding to nearby landmarks. Otherwise, they were named according to their river mile location. The locations of all 139 polygons are displayed on aerial photograph basemaps in Appendix A. Sequential identification numbers shown on the maps cross reference those locations to Appendix B, which provides polygon names, river mile locations, the years surveyed, and a brief description of each location.

Comparisons between the pool geometries observed in different years were achieved by gridding the topographic data in ArcMap 10.1 using the kriging algorithm with 3-ft pixel resolution and other parameters at their default settings. Grids for different years at a given polygon location were co-registered by assigning a common analysis extent for each grid operation. A nominal baseflow water surface elevation assigned to each polygon area was then used to compute water depth for each grid pixel. It is important to understand that the water surface elevation used to assign depths are not strictly linked to an exact discharge, nor should they be interpreted as actual water surface elevations over all points in a given grid. The nominal baseflow water surface elevation assigned to a given polygon serves only as a common datum from which ground elevations for all available years can be subtracted to yield a depth metric that approximates the water depth at a relatively low discharge. The fact that the nominal depth may deviate slightly from the actual depth at a given grid pixel by a small amount is immaterial to the analysis.

Once pixel-by-pixel depths have been computed for all years and all polygon locations according to the method described above, they are exported to text format and processed with a Perl script to compute cumulative depth-frequency plots of pool depths and summary statistics such as mean depth, the standard deviation of depths, and depth quantiles. Cumulative depth-frequency curves efficiently summarize the depth characteristics of a given pool at a given time by graphically representing the fraction of the area where water depths exceed a given value. For example, Figure 3 indicates that 50% of a hypothetical pool area is approximately 6 ft deep or deeper, 25% is 7 ft deep or deeper, and 10% is 8 ft deep or deeper. In other words, the median pool depth is 6 ft, the 75th percentile depth is 7 ft, and the 90th percentile depth is 8 ft. Consideration of the full distribution of depths makes it possible to assess multiple aspects of pool geometry, such pool shape and changes in the spatial extent of deep water.

In four locations, sonar surveys in one of the years surveyed yielded sparse or uneven distributions of points that were inadequate for producing meaningful grids. These lower quality surveys, which correspond to locations where turbulent flows with entrained bubbles interfere with the sonar acquisition, were conducted at the Diversion Pool (polygon 1), Cemetery Hole (polygon 12), and Sheridan (polygon 111) in 2009, and at Chop Tree (polygon 85) in 2011. For these locations, topographic changes relative to the year with the sparse data are evaluated with a point-by-point comparison with survey data from another year. Such a comparison is accomplished by performing a spatial join between a GIS layer containing the sparse survey data and another layer containing the survey points collected in the year they are being compared to. This operation links each of the sparse survey points to the nearest survey point from the other year, and facilitates the creation of a new attribute table that contains the difference in elevation between the linked points, as well as the distance between them. New attribute tables created in this manner were then filtered to remove pairs of points separated by a distance greater than 2 ft. The statistics of the elevation differences between the remaining near-by points provide some indication as to whether bed elevations in the area have changed.

Because the Diversion Pool and Chop Tree were surveyed in 2009 and 2011 only, the point-by-point comparisons provide the only quantitative information for assessing changes over the study period at those sites. Sheridan and Cemetery Hole were survey in all three years, so grid-based comparisons between 2010 and 2011 are available for both of those sites. However, quantitative evaluation of changes between 2009 and 2010 at those sites has special significance for this pool study because qualitative observations suggest that both of those locations aggraded during that time frame. Point-by-point comparisons are needed to objectively validate and document those observations.

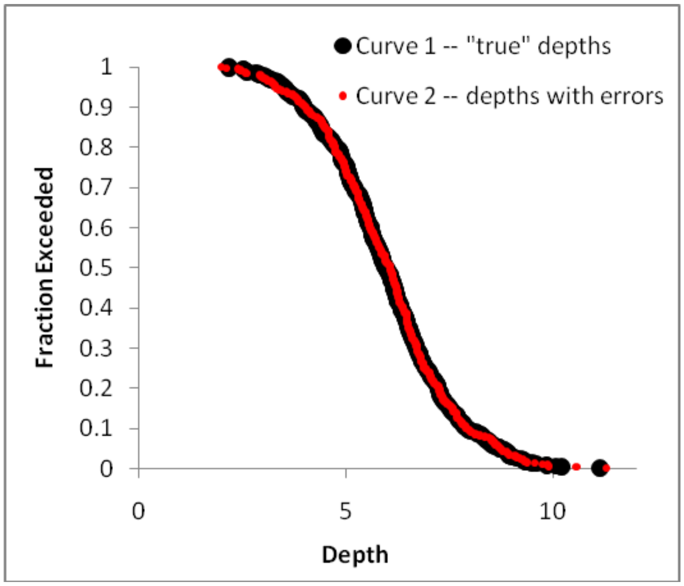

Figure 3: Cumulative depth-frequency curves for a hypothetical pool. Curve 2 with added errors demonstrates the minimal effect of measurement errors on the form of the curve.

Error Propagation

Three types of error contribute to the uncertainty in bed elevations acquired by boat-mounted sonar and the elevation changes derived from them. These are 1) survey errors associated with sonar imprecision, GPS error, and boat motions, 2) interpolation errors that arise when point elevations are gridded, and 3) systematic bias in the elevation data. Survey and interpolation errors are considered first.

As noted above, random error due to transducer accuracy is estimated to be less than 0.1 ft, whereas survey-grade GPS errors are considered to be on the order of 0.03 ft. However, boat-mounted sonar is also subject to errors due to boat motions, such as pitch, roll, and wave action. The magnitude of all combined errors was assessed with a nearest neighbor analysis in which 126 pairs of independent sonar-derived elevations surveyed on different dates within the same geomorphic year and located within 0.2 ft of one another were compared (GMA 2012). The mean difference in the elevations recorded for the paired points was found to be 0.017 ft with a standard deviation of 0.25 ft, including any actual elevation differences between the two locations. The single-ping sonar precision is therefore taken to be ±0.3 ft. These errors are assumed to be independent and randomly distributed.

Quantifying the magnitudes of the interpolation errors associated with grid generation is more challenging because they depend on the density and spatial distribution of the point data, as well as on the slope and complexity of the ground surface, both of which are spatially variable. In particular, the role of point density in error generation is difficult to evaluate for survey data collected with boat-mounted sonar because the survey points tend to be distributed along track lines defined by the direction of boat movement. As a consequence, the data distribution is highly anisotropic. That is, the distance between track lines may be orders of magnitude larger than the point spacing along the track lines. Thus, standard measures of point density, such as points per unit area, are poor indicators of the distances over which interpolation will be performed. Gaeuman (2013) developed a method for estimating the effective point density of anisotropic point distributions as part of an analysis of geomorphic responses to channel rehabilitation and gravel injection. That analysis suggests that the total uncertainty in grid elevations generated from these data is on the order of 0.4 ft.

The actual magnitude of the random errors associated with the surveys, however, has little bearing on the results presented in this report. This is because the reported depth statistics are based on a large number of individual grid depths for which the individual errors are independent random variables. The expected error over multiple random and independent measurements is defined by the standard error of the estimate, which is equal to the magnitude of the individual errors divided by $n^{0.5}$, where n is the number of independent points on which the estimate is based (Hamilton 1990). For example, if 500 points with individual uncertainties of 0.4 ft are used to estimate the mean elevation of a region, the standard error of the estimate is $0.4/500^{0.5}$, or about 0.018 ft. The minimal impact of these errors on the results of the analysis methods employed in this report can be demonstrated with a numerical experiment illustrated in Figure 3. Curve 1 is a cumulative depth-frequency curve for a hypothetical pool with a depth distribution generated by randomly selecting 500 depths from a normal probability distribution with a mean of 6 ft and a standard deviation of 1.5 ft. Curve 2 is a cumulative depth-frequency curve for the same pool, but with an error term drawn from a normal probability distribution with a mean of zero and a standard deviation of 0.4 ft added to each depth value. It is clear that the added error terms cancel and result in no detectable difference in the shapes of the two curves. Consequently, statistics describing the depth distribution are insensitive to the errors. In the example of Figure 3, the mean depth of curve 1 is 5.996 ft, whereas the mean depth of curve 2 is 6.004 ft.

However, the data may also be subject to systematic bias between different surveys. Bias is expressed by a non-zero expected error that persists regardless of the number of samples collected. Possible sources of survey bias include various errors associated with equipment dimensions or set-up, such as imperfect measurement of GPS antenna offsets, as well as issues with instrument calibration or parameterization. Because bias applies uniformly to the entire survey, it is propagated directly to any estimated of elevation change between two surveys. As noted above, a comparison of surveys from two different dates conducted by GMA yielded a mean difference of 0.017 ft. An independent comparison of several hundred paired elevations collected by GMA on two other survey dates suggests an error bias of about 0.04 ft (Gaeuman 2013). Biases of these magnitudes are negligible with respect to the analyses presented in this report.

Results of Sonar Comparisons

Grid-based Comparisons

Summary depth statistics observed at all 139 polygon for all years in which grids were generated are presented in Appendix C. Appendix D displays the cumulative depth-frequency curves for the 137 of those locations where inter-annual comparisons are possible. Changes in the median, 75th-percentile, and 90th-percentile depths between different geomorphic years are tabulated in Appendix E.

It is evident from the graphs in Appendix D that depth changes were negligible in many locations (for example, #119, Junction City Hole), whereas substantial aggradation or degradation occurred at a relatively few number of sites. Overall, median depth changes exceeding 15% of the original depth occurred at one time or another in 53, or 39%, of the 137 polygons (Table 2). Of the polygons that underwent median depth changes exceeding that threshold, depths increased in 31 polygons and depths decreased in 22 polygons.

ID	Name	RM	%Δ in 50th 2009-2011	%Δ in 50th 2009-2010	%Δ in 50th 2010-2011
4	Lower New Bridge	110.94	31.3		
6	Lower B2	110.63	15.6		
10	Upper Cemetery Run	109.5	-15.9	-0.6	-15.4
15	Sawmill FM2	109.13			76.1
16	Sawmill Burner	109	-42.6	-49.4	13.3
17	Lower Burner 1	108.93	33.5	9.8	21.5
20	RM108.7	108.7			20.8
22	RM107.55	107.55	44.9		
23	Salt Flat 1	106.85	-122.5		
24	Salt Flat 2	106.8	-43.3		
26	Lower Gold Bar	106.5	22.2	9.3	11.8
34	Lowden FM	104.95			16.9
35	Lowden FP Convergence	104.65	15.4	7.0	7.8
36	Wellock Pool	104.3	-81.4	2.7	-81.9

Table 2, continued on next page

Continued from previous page

37	Little Tree 1	104.07	-30.5		
38	Little Tree 2	104.07			-30.5
39	Trinity House	104			-29.3
44	Stott Hole	102.5	-17.9		
45	Stott Trough	102.45	-19.9		
47	RM102.1	102.1	-15.2		
51	Crosby	101.05			16.8
59	RM99.45	99.45	26.8	3.1	23.0
62	RM98.7	98.7	33.8		
67	RM98.1	98.1	18.7		
71	299 Bridge	94.1	-20.3		
72	Goodyears	93.15	-77.0		
74	Lower Bend	92.93	-10.0	5.9	-15.0
76	Alcatraz	92.3	-32.9	8.4	-38.2
77	Upper Steiner	92.24	-17.1	8.3	-23.5
80	Jumping Rock	91.75	-34.9		
84	Picnic Table	91.05	31.4	28.4	2.3
86	Dump Hole	90.75	22.2	28.5	-4.9
87	Center Pin	89.75	57.7	45.8	8.2
88	Goat Hole	89.45	13.5	17.8	-3.7
90	Dutton	89.15	43.1	34.6	6.3
92	RM88.65	88.65	34.3		
93	RM88.24	88.24	20.6		
95	RM88.07	88.07	19.9		
96	Browns 1	87.98	26.1		
97	Browns 2	87.93	31.8		
98	Browns 3	87.85	20.5		
99	RM87.8	87.8	26.7		
101	RM87.6	87.6	24.6		
104	Upper Evans Bar	85	-22.3		
109	Eds	82.3	-21.0		
115	Lower Sky Ranch	80.45	-29.7		
124	Upper Conner 2	77.75	17.7	0.4	17.2
125	Upper Conner 3	77.67	11.8	-3.3	15.6
126	McCartneys	77.1	-14.0	1.7	-15.5
129	Upper Bigfoot	75.8	-14.0	4.0	-17.3
135	Lower Elkhorn	73.5	16.0		
136	Screw Trap	73.3	17.9		
137	Pear Tree	73.05	4.7	-9.2	15.3

Table 2: Depth changes in excess of 15% of the original 50th-percentile depth. Positive figures indicate depth increases and negative figures indicate depth decreases. Shading indicates polygons with net depth increases. Figures enclosed by boxes indicate the year when the majority of net change occurred in polygons for which individual year changes are available.

Longitudinal Distribution of Depth Changes

Plots of changes in depth statistic versus longitudinal position in the river system reveal clear spatial differences in the propensity for polygon depths to increase or decrease. Seven river segments with different characteristics in polygon behavior can be identified from the spatial pattern of depth changes between 2009 and 2011 (Figure 4). These segments are (Figure 5):

1. Segment 1, from RM 112 to about RM 104.5, includes all polygons between Lewiston Dam and the downstream end of the Lowden Ranch rehabilitation site. No consistent tendency for polygon fill or scour is apparent in this segment. Instead, polygons that have filled markedly are mixed in with polygons that deepened in what appears to be, at first glance, a random fashion. Nonetheless, consideration of the individual locations later will reveal order in the distribution of these changes.

2. Segment 2 extends from the upstream boundary of the Trinity House Gulch rehabilitation site to about RM 101.5 near the middle of the Poker Bar residential subdivision. This 3-mile-long segment is characterized by consistent depth decreases.

3. Segment 3 begins just downstream of Society Pool in the Poker Bar subdivision and extends to the mouth of Indian Creek at about RM 95.5. Polygon depths show consistent increases through this 6-mile stretch of river.

4. Segment 4 begins at RM 94.2 just upstream from Weaver Creek and the Highway 299 bridge over the Trinity River and extends 3 miles downstream to RM 91.2. The majority of the polygons in the DC segment show fill. No sonar surveys were conducted in the approximately 1 mile of river between the end of the LPB segment and the beginning of the DC segment.

5. Segment 5 covers approximately 4 miles of river beginning downstream from RM 91.2 and extending through most of the Browns Creek Canyon to at least RM 87.5. Depth increases predominate in this segment. No sonar surveys were conducted in the most downstream 1.8 miles of the canyon between RMs 87.5 and 85.8.

6. Depth decreases dominate change in segment 6, which begins at RM 85.8 near the downstream end of the Browns Creek Canyon and extends to the Dutch Creek Bridge in Junction City (~RM 79.7).

7. Segment 7 begins at the Dutch Creek Bridge and extends to the mouth of the North Fork Trinity River. This segment lacks a clear tendency toward either deposition or scour, but polygons showing depth increases outnumber those showing decreases by about a 2 to 1 ratio.

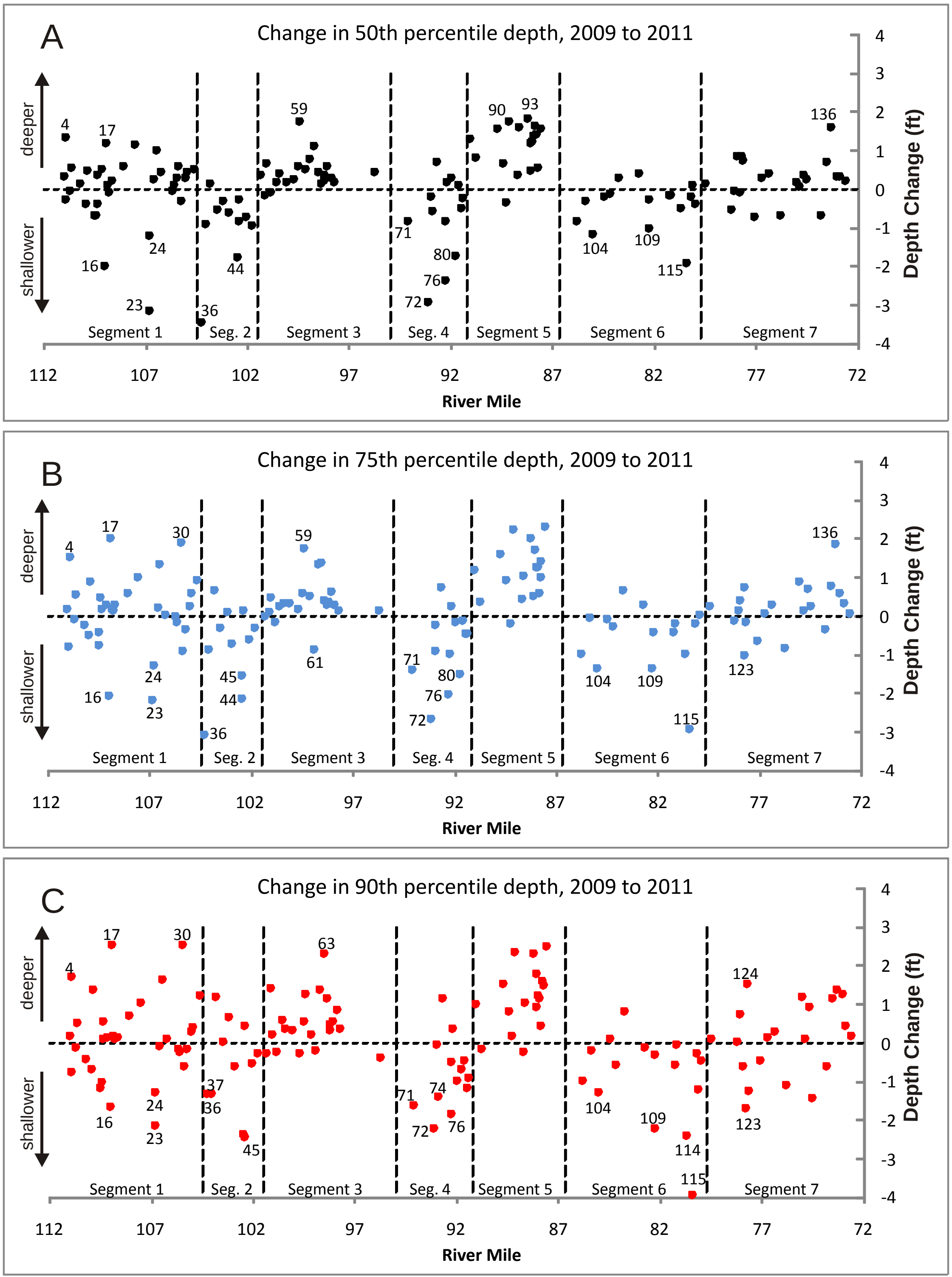

Figure 4: Changes in the a) 50th-percentile, b) 75th-percentile, and c) 90th-percentile depths as determined from grid-based comparisons for all polygons in the study. Numbers near points correspond to the IDs in Table 2. Changes are from 2009 through 2011 where 2009 data is available, or for from 2010 through 2011 where 2009 data is not available.

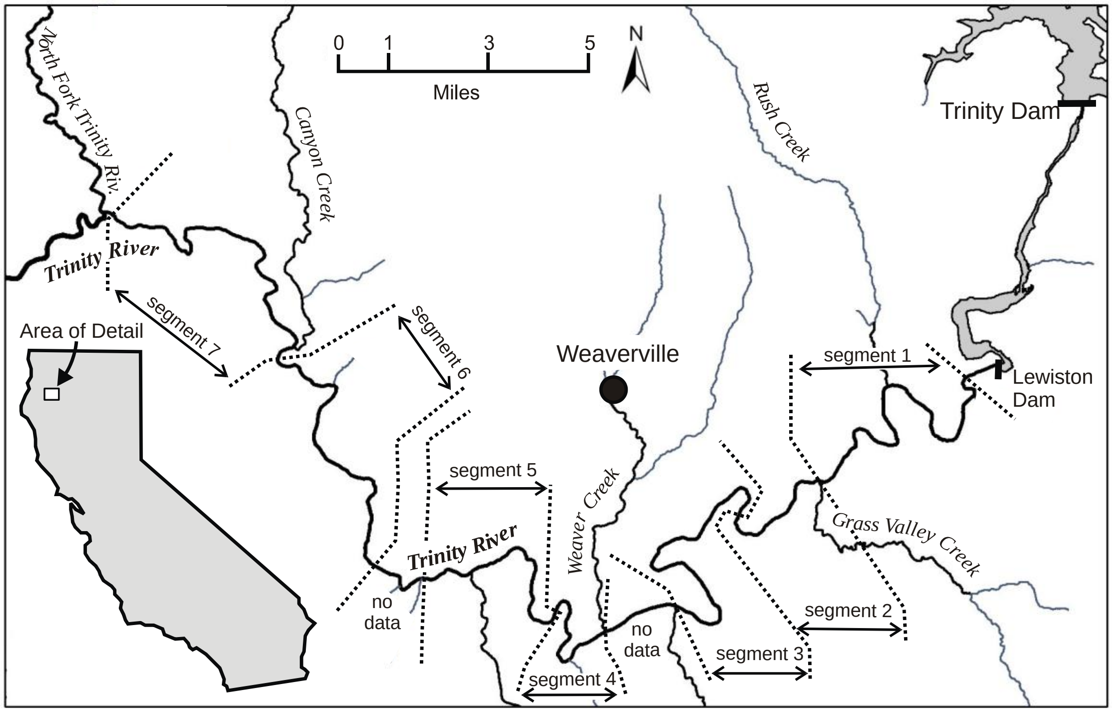

Figure 5: Map of the study area showing boundaries of the seven river segments defined by different depth-change trends.

Timing of Depth Changes

The changes shown in Figure 4 are net changes over the full 2009-2011 study period (or 2008-2011 in the case of the Sawmill Burner polygon). At locations where 2010 surveys were performed it is possible to constrain the timing of depth changes to having occurred either during the 2011 spring flow release or during an earlier spring release. Instances where changes relative to GY2010 conditions constitute the bulk of the net change measured over the study period are indicated on Table 2. With the exception of Sawmill Burner, where the median depth had decreased by nearly 50% prior to the 2011 flow release, all depth decreases greater than 15% occurred mostly or entirely during the 2011 release. This result requires careful interpretation, as it is largely an artifact of the choice of 2010 sonar survey locations, many of which were selected to monitor depth changes near recently-constructed rehabilitation projects.

Figure 6 provides a more comprehensive view of the timing of depth changes by displaying percent changes in median depths for all possible comparisons with the GY2010 data, including 47 2009-2010 comparisons and 61 2010-2011 comparisons. In addition to showing that most of the large depth decreases occurred in the later time period, as noted above, the graph makes it clear that the largest depth decreases are concentrated at the upstream end of segment 2 and near the middle of segment 4. Other notable temporal differences include a cluster of polygons in segment 5 that underwent relatively large depths increases in 2009-2010 but changed little in 2010-2011.

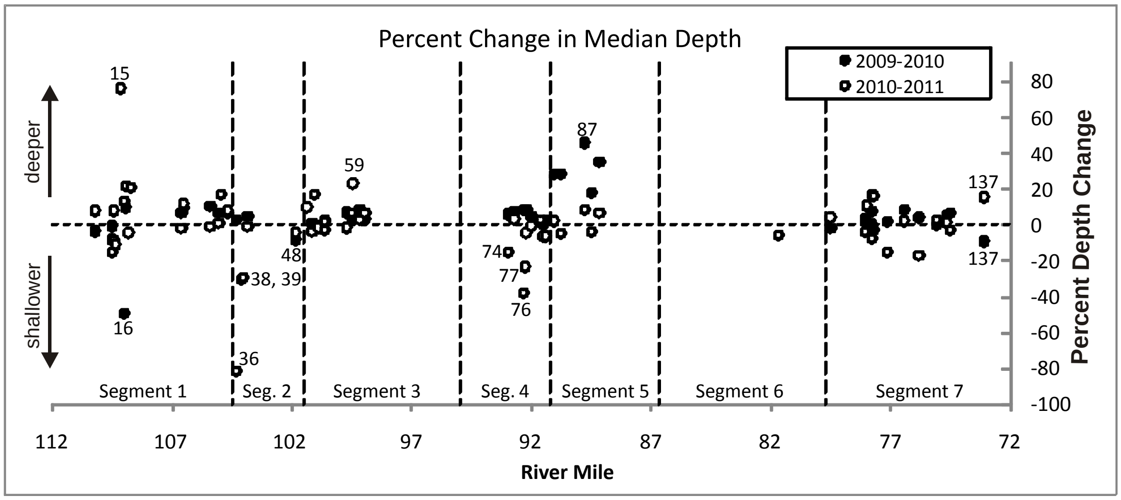

Figure 6: Percent depth changes in 2009-2010 and in 2010-2011 for polygons in which 2010 data was collected. Numbers near points correspond to the IDs in Table 2.

Point-by-point Comparisons

Point-by-point comparisons at Diversion Pool and at Chop Tree suggest that depths increases between 2009 and 2011 at both locations. At Diversion Pool, 1175 pairs of matched points showed a mean decrease in bed elevation (increase in depth) of 0.7 ft. These point pairs are distributed relatively evenly over much of the pool area, although points are entirely absent in the center of the pool where a tongue of turbulent, high-velocity flow prevented sonar data collection (Figure 7). At Chop Tree, a very sparse distribution of just 374 point pairs suggests bed elevations in the area decreased by an average of 1.22 ft (Figure 8).

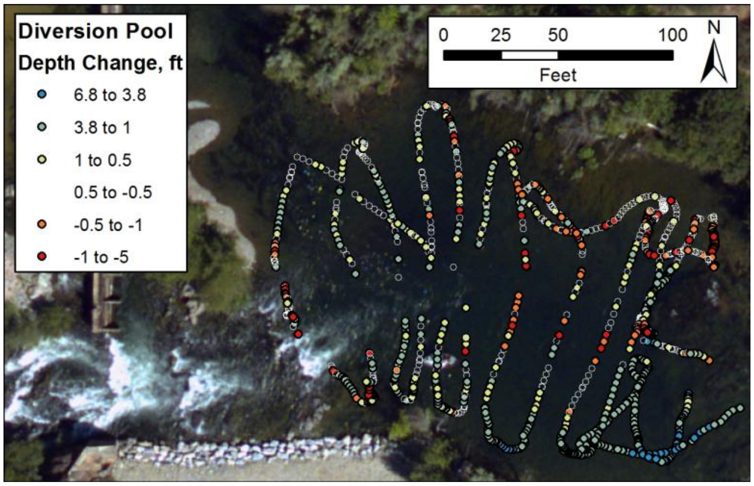

Figure 7: Point-by-point depth comparison at the Diversion Pool (RM 111.15).

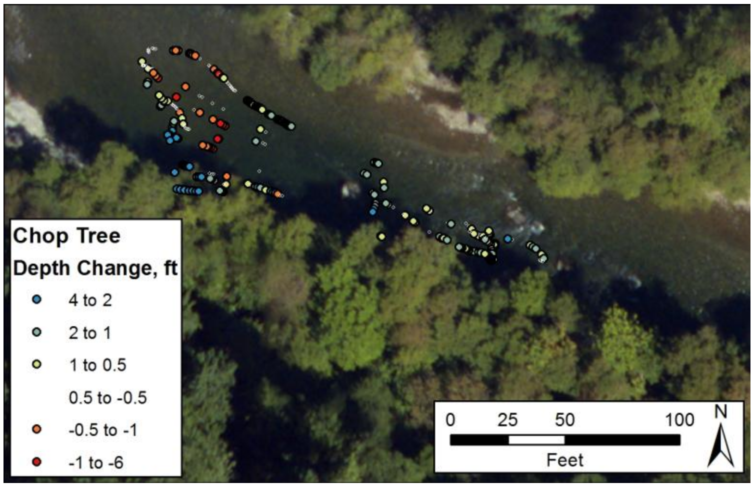

Figure 8: Point-by-point depth comparison at Chop Tree (RM 90.9).

The point comparisons at Cemetery Hole and at Sheridan lend some support to qualitative observation suggesting that both of those pools may have aggraded during 2009-2010. Elevation changes for 555 point pairs distributed over the central part of Cemetery Hole show a mean increase in bed elevation of 0.55 ft (Figure 9), whereas 22544 point pairs within the Sheridan polygon indicate a mean bed elevation increase of 0.59 ft (Figure 10). The paired points in the Sheridan polygon, however, are mostly located along the pool margin and in the tailout downstream, and so are poor indicators of bed level changes in the deeper areas along the left bank.

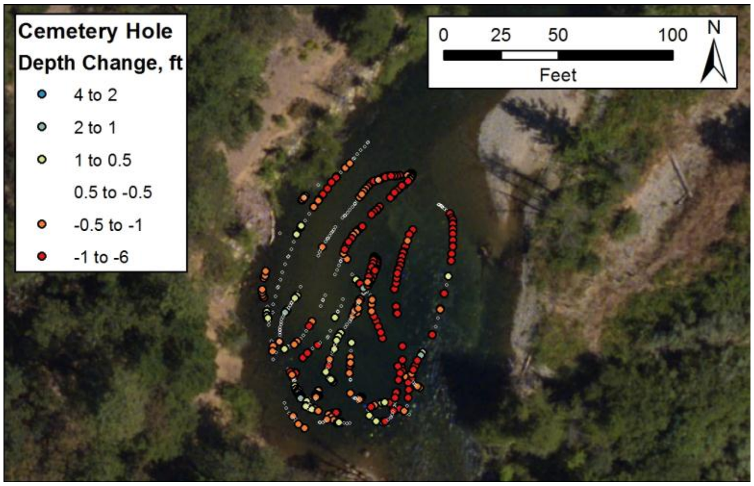

Figure 9: Point-by-point depth comparison at Cemetery Hole (RM 109.43).

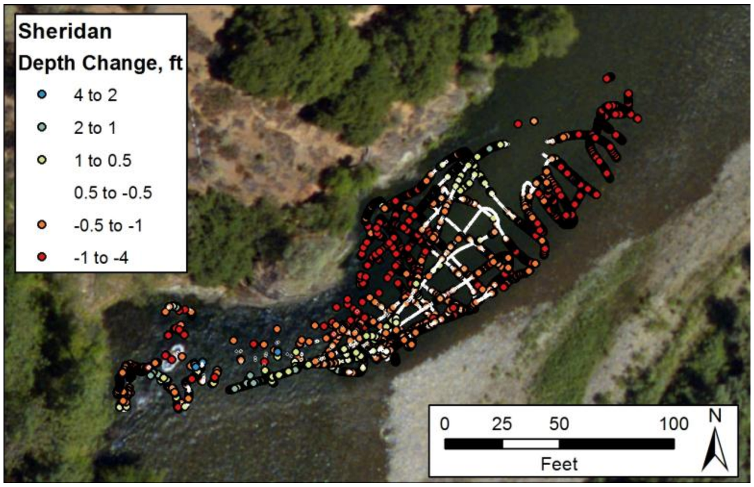

Figure 10: Point-by-point depth comparison at Sheridan (RM 81.65).

Relationship between Large Depth Changes and Recent Rehabilitation Actions

As of the summer of 2011, TRRP had implemented mechanical rehabilitation projects at 15 locations between Lewiston Dam and the North Fork Trinity River (Table 3). These projects have included a range of possible construction activities, including floodplain lowering, vegetation removal, side-channel excavation, and in-channel placement of gravel. It is hypothesized that all of these activities have the potential to encourage deposition in pools and other relatively deep parts of the channel.

Of the 15 mechanical projects identified in Table 3, nine were completed after the 2008 spring flow release. That release is significant because WY2008 was a normal water year with a spring release magnitude (6470 ft^3/s at Lewiston) capable of modifying bed topography. Thus, any geomorphic adjustments triggered by mechanical rehabilitation actions prior to that release were already well underway by the time the 2099 sonar surveys were conducted. By contrast, WY2009 was a dry year with a relatively small spring release (4630 ft^3/s at Lewiston) capable of generating relatively little geomorphic change, so the geomorphic effects of mechanical alterations completed in GY2008 may have remained largely dormant until 2010 flow release. Consequently, geomorphic responses to the rehabilitation projects completed in 2008 can potentially be captured by comparisons between the 2009 sonar and data from later years.

TRRP has also implemented high-flow gravel injections at four locations since GY2008, beginning with injections of 670 and 1670 yd^3 of gravel, respectively, at the Sawmill Burner Hole and the Diversion Pool during the 2008 spring flow release. Table 4 provides a more complete accounting of TRRP gravel injections since the current program began operations in 2002.

	Sites Constructed Before 2008	GY	RM	Primary Actions	Cut (yd^3)	Gravel (yd^3)
	Hocker Flat	2005	78.0	Terrace lowering, vegetation removal.	93400	0
	Conner Creek	2006	77.0	Terrace lowering, vegetation removal.	19400	0
	Valdor Gulch	2006	74.8	Terrace lowering, vegetation removal.	38900	0
	Elkhorn	2006	73.7	Terrace lowering, vegetation removal.	22500	0
	Pear Tree	2006	72.9	Terrace lowering, vegetation removal.	9900	0
	Indian Creek	2007	93.9	Terrace lowering and side channel construction.	77800	0
#	Sites Constructed 2008-2011					
1	Sven Olbertson[1]	2008	111.2	Side channel construction.	10800	0
2	Deadwood Creek[1]	2008	110.46	Side channel construction, gravel placement.	1700	1100
3	Cableway[1]	2008	110.18	Gravel placement, side channel enhancement.	600	5100
4	Hoadley Gulch[1]	2008	109.8	Terrace lowering, side channel construction, gravel placement.	5000	1500
5	Sawmill[1]	2009	108.88	Terrace lowering, side channel enhancement, gravel placement.	88000	5000
6	Dark Gulch[1]	2008	105.5	Terrace lowering, side channel construction, gravel placement.	39000	3000
7	Lowden Ranch[1]	2010	104.4	Terrace lowering, channel realignment, side channel construction, island construction.	104200	4600*
8	Trinity House Gulch	2010	104.0	Terrace lowering, side channel construction, gravel placement.	37100	3500
9	Reading Creek	2010	92.2	Terrace lowering, side channel construction, gravel placement.	66900	5900
Gravel Placed in the Study Area, 2008 – 2011						29700
Gravel Placed in Segment 1, 2008 – 2011						20300

Table 3: TRRP channel rehabilitation projects. GY = geomorphic year completed, RM = the river mile at the downstream boundary of the site. The heading "Gravel" refers to mobile gravel intended to augment the gravel supply to downstream reaches. [1]Denotes locations within river segment 1. *This quantity includes about 2900 yd^3 of gravel associated with channel realignment that was mobilized during the 2011 flow release (Gaeuman 2013).

	Gravel Augmentations before 2008	GY	Augmentation Type	Quantity (yd^3)
	Cableway Gravel (RM 110.4)	2003	Low flow placement	2000
	Hatchery Gravel (RM 111.8)	2006-2007	Low flow placement	5950
	Gravel Augmentations 2008-2011			
A	Diversion Pool (RM 111.15)	2008	High-flow injection	1670
A	Diversion Pool (RM 111.15)	2009	High-flow injection	670
A	Diversion Pool (RM 111.15)	2010	High-flow injection	1580
A	Diversion Pool (RM 111.15)	2011	High-flow injection	3270
B	Sawmill Burner (RM 109.0)	2008	High-flow injection	670
B	Sawmill Burner (RM 109.0)	2009	High-flow injection	1670
C	Lowden R-3 (RM 104.95)	2011	High-flow injection	2050
D	GVC Delta (RM 104.35)	2011	High-flow injection	1530
Gravel Injected 2008 – 2011 (all in Segment 1)				13100

Table 4: TRRP gravel augmentations. GY = geomorphic year completed. All augmentation sites are located within river segment 1. Gravel placement at the Hatchery was completed over two construction seasons.

Figure 11 illustrates the spatial relationship between the TRRP rehabilitation actions implemented from GY2008 through GY2011 and the percent change in depth in the subset of polygons where depth decreases were detected. Locations where the percent decrease in depth is large tend to coincide with restoration activities. This correspondence is most obvious in the near lack of locations where depth decreases were detected in Segments 3, 5, and 7, where no recent rehabilitation activities have been implemented. Depth decreases in Segment 6, also a segment with no recent rehabilitation activities, are mostly modest in magnitude, and a check of Figure 4 indicates that depth decreases in that segment are accompanied by a similar number of locations showing comparable depth increases. By contrast, Segments 1, 2, and 4 all include locations with large relative depth decreases in close proximity to rehabilitation actions.

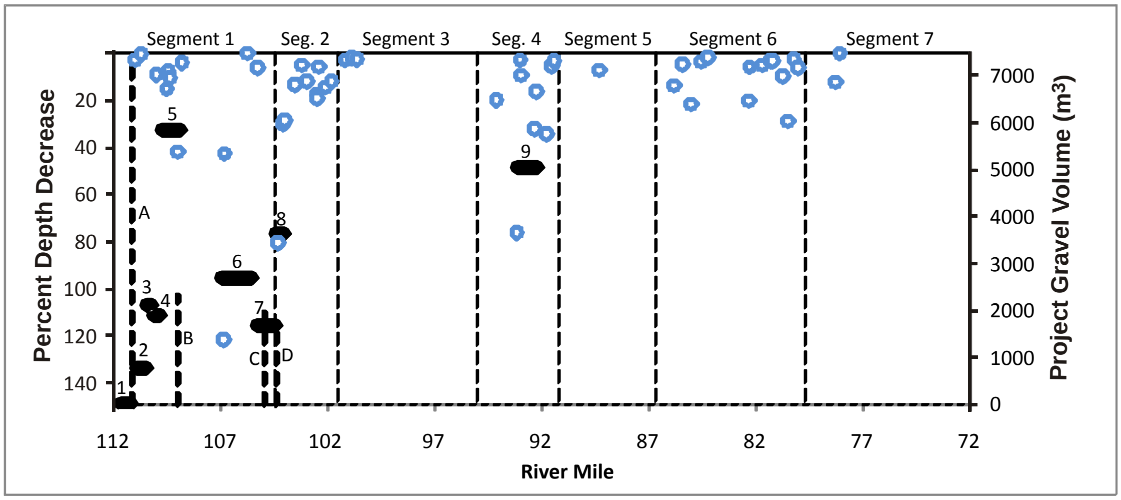

Figure 11: Relationship between TRRP rehabilitation actions and depth decreases in 2009-2011 (or 2010-2011 if no 2009 data is available). Percent decreases in polygon median depths are shown by blue circles (polygons with depth increases are not shown). The vertical positions of dashed lines (gravel injections) and horizontal bars (channel rehabilitation projects) indicate to the total quantity of gravel added at each site. The widths of the bars indicate the longitudinal extents of each project. Letters and numbers labeling the actions correspond to those given in Tables 3 and 4.

Closer examination of Figure 11 reveals that some rehabilitation actions appear to be more closely associated with local depth decreases than others. Most notably, no large depth decreases were detected in the immediate vicinity of the most upstream gravel injection point (Diversion Pool) or the most upstream three rehabilitation sites (Sven Olbertson, Deadwood Creek, and the Cableway). Likewise, the next rehabilitation site downstream, Hoadley Gulch, overlaps with polygons showing only relatively small depth decreases. However, a much larger percent depth decrease of 43% appears at RM109, which is adjacent to the Sawmill gravel injection point and within the Sawmill rehabilitation site. Aggradation at that location, which is referred to herein as the Sawmill Burner hole, during the 2009 spring flow release has been previously documented (Gaeuman 2011).

Several other polygons with large percent depth decreases appear within the boundaries of three out of the four most downstream rehabilitation sites shown on Figure 11. Of those four rehabilitation sites, only the Lowden site contains no locations with anomalously large percent depth decreases. However, an 81% decrease in median depth was measured in Wellock Pool (RM 104.3), which is located on the boundary between the Lowden and Trinity House Gulch rehabilitation sites and immediately downstream from a gravel injection point. Finally, several relatively large depth decreases, including one location where median depth decreased by 77%, were detected within the Reading Creek rehabilitation site. Depth changes near the locations plotted on Figure 11 are discussed on a site by site basis below.

Sven Olbertson Rehabilitation Site:

Constructed in 2008, the Sven Olbertson project (Appendix A, Map 1) involved the development of an extensive side channel complex. Virtually no work was performed on the main channel. No bed elevation data were collected within the boundaries of this site for this study, but qualitative observation suggests that the depths of mainstem pools and runs have not changed significantly in recent years.

Diversion Pool Gravel Injection:

More gravel has been injected into the Trinity River at the Diversion Pool (Appendix A, Map 1) than at all other high-flow gravel injection locations combined. Recent gravel additions at the Diversion Pool include high-flow injections of 1670 yd^3 during the 2008 spring flow release, followed by injections of 670, 1580, and 3270 yd^3 during the releases of 2009, 2010, and 2011. As previously noted, the recent topographic data indicate that the pool deepened slightly between 2009 and 2011. Gaeuman (2011) presented a comparison of topographic data collected via sonar before and after the 2008 spring release indicating that depths in the pool changed little in that year as well.

The next pools downstream from the Diversion Pool injection point are the Deadwood pool (polygon #2) and a large pool beneath the New Lewiston Bridge (Appendix A, Map 1), which in this study is separated into separate polygons (#3 and #4) upstream and downstream from the bridge (the separation is due to the fact that the lack of GPS reception under the bridge prevented sonar acquisition there). Graph 2 of Appendix D shows that depths in the Deadwood pool showed almost no change between 2009 and 2011. Graphs 3 and 4 (Appendix D) indicate that the deeper parts of polygon 3 upstream from the bridge became somewhat shallower after 2009 (change in the 75th-percentile depth = -0.78 ft), while polygon 4 downstream of the bridge deepened by about 1.5 ft over the majority of the depth distribution. As these two polygons are similar in size, the pool under the bridge got deeper overall, indicating that neither the Deadwood pool nor the New Lewiston Bridge pool have accumulated the gravel injected at the Diversion Pool.

Almost immediately downstream from the tailout of the New Bridge pool, the river encounters a major hydraulic control in the form of a large mid-channel island that splits the flow into two distinct channels characterized by nearly continuous riffles and rapids for a distance of about 750 ft. At the downstream end of the island, those riffles converge into a long trough and backwater pool that is split into polygons #5 and #6, called the Upper and Lower B-2 pools. Depth-frequency curves for Upper B2 show no depth change since 2009 and the curves for Lower B2 show a general deepening by about 0.5 ft. These data show that gravel injected at the Diversion Pool is not stored in any of the pools located within about a half a mile downstream. Given these results, it is natural to ask what can be said about where the gravel did go.

Repeat aerial imagery, as well as field observation, shows that a significant quantity of gravel was deposited along the left channel margin and in the left overbank area immediately downstream from the Diverison Pool between 2009 and 2011. The magnitude of the deposition can be estimated by comparing the 2009 terrestrial LiDAR with an August 2011 ground survey. That survey, which was conducted with a total station and hand-held rod, consists of more than 200 points placed along topographic breaks so as to effectively represent the irregular topography in the areas covered by fresh sub-aerial gravel deposits.

Topographic differencing within the area where reliable information exists for both years indicates that 2870 yd^3 of gravel deposited between the two survey dates, for an average deposit thickness in the area of 2.25 ft (Figure 12). Additional gravel deposits in some more thickly vegetation portions of the overbank area were not surveyed for practical reasons. It is assumed that these additional deposits justify rounding the estimated sub-aerial deposition up to 3000 yd^3. About 5500 yd^3 was injected at the Diversion Pool just upstream during the same period, so the measured sub-aerial deposition accounts for 55% of all the injected material.

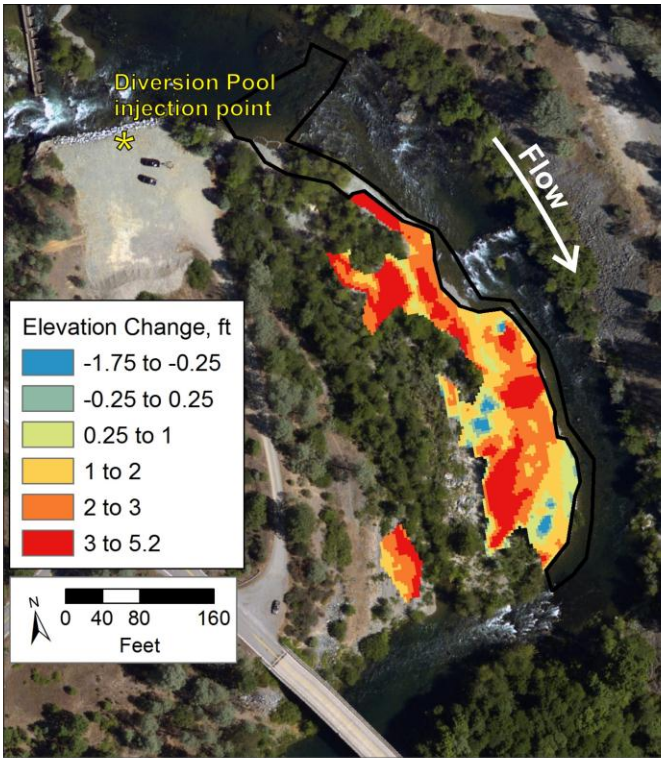

Figure 12: Changes in bar elevations between 2009 and 2011 surveys. The area of submerged deposition discussed in the text is outlined in black.

Extensive gravel deposits along the submerged portion of the bar and in the pool tailout area were also observed. However, insufficient data is available to accurately estimate the volume of those deposits. Although the 2011 survey included submerged portions of the bar as much as was practical, no reliable 2009 data exists within the wetted channel because swift, turbulent flow and numerous boulders preclude the collection of sonar data through most of that reach. The significance of the submerged deposition was assessed by defining the footprint of the area where gravel appears to have deposited and evaluating the potential thickness of those deposits. That area was found to cover about 2060 yd^2 (Figure 12), which implies that an average deposit thickness of just 1.2 ft in the submerged area would accommodate all of the remaining 2500 yd^3 of injected gravel not accounted for in the sub-aerial deposits. Considering that the sub-aerial deposits are more than twice that thickness, this depth of deposition seems entirely plausible. It is therefore concluded that the available data indicate a high likelihood that virtually all of the gravel injected at the Diversion Pool is stored upstream from the New Lewiston Bridge

Deadwood Creek Rehabilitation Site:

The Deadwood Creek project, located immediately upstream from the Upper and Lower B2 pools (Appendix A, Map 1), was constructed in 2008. It involved the excavation of a short side channel and placement of a small gravel bar. With a total cut of 1700 yd^3 and a total fill volume of 1100 yd^3, it is the smallest project implemented by TRRP to date. The lack of fill in the B2 pools noted above suggests that most of the gravel placed at the site has either remained upstream from the pools or was transported though them.

Cableway Rehabilitation Site:

The Cableway Rehabilitation project (Appendix A, Map 2) was also constructed in 2008. The primary action at the site was the addition of 5100 yd^3 of gravel in the form of four constructed lateral bars in a straight reach upstream from the Old Lewiston Bridge (Figure 13). Excavation was limited to enlarging the entrance to an existing side channel and removal of some grade control structures, and totaled less than 600 yd^3.

Three of the four gravel bars placed in the Cableway reach were significantly eroded by GY2011. In particular, the most downstream bar located along the left bank just upstream from the Old Bridge and adjacent to the Old Bridge analysis polygon (#7) was completely removed. As illustrated in Graph 7 of Appendix D, the deeper parts the Old Bridge polygon filled by approximately 1 ft between 2009 and 2010, suggesting that gravel from the adjacent bar or upstream bars had spread into the thalweg. By 2011 the deepest part of the Old Bridge polygon was only slightly deeper than in 2010, whereas the shallower half of the area had deepened by up to 0.5 ft. This pattern of change indicates a trend toward the development of a more planar bed in the local area.

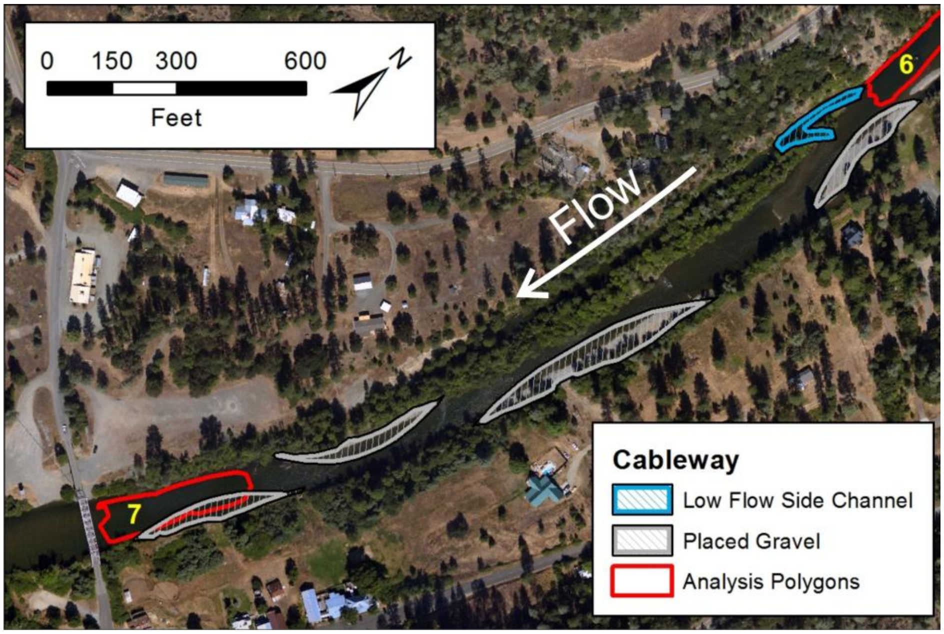

Figure 13: Design elements at the Cableway site (2011 photo).

Hoadley Gulch Rehabilitation Site:

Another 2008 project, Hoadley Gulch is located immediately downstream from the Old Lewiston Bridge (Appendix A, Map 2). Activities at Hoadley Gulch included the excavation of a side channel, terrace lowering, and placement of 1 gravel bar (Figure 14). The constructed gravel bar, which totaled 1500 yd^3 of gravel fill, was placed on the right bank near the apex of a channel bend to the right. Lowering of the terrace construction of a side channel in the overbank area adjacent to the bar required about 5000 yd^3 of cut. A relatively deep trough located along the left bank opposite the placed bar is designated in this report as polygon 8#, Hoadley Bar. Substantial fill in the shallower parts of that polygon between 2009 and 2011 may indicate that some of the placed gravel sloughed into the trough (Appendix D, graph 8). Relatively little fill was detected in the deeper portion of the Hoadley bar polygon, which is situated close to the left bank.

The trough along the left bank extends downstream well beyond the bar placement location. That portion of the trough is designated separately as polygon #9, Hoadley Pool. It can be seen on Graph 9 of Appendix D that depths increased in Hoadley Pool between 2009 and 2011, suggesting that the effect of the gravel addition is limited to the immediate vicinity of the placed bar. It is worth noting here that the different directions of depth change observed in polygons #8 and #9 also corresponds to differences in the how the Hoadley Gulch project altered channel conveyance. Side channel construction and terrace lowering totaling 5000 yd^3 of cut was implemented adjacent to and upstream from Hoadly Bar (Figure 14), whereas no changes were made to the channel and floodplain adjacent to Hoadley Pool.

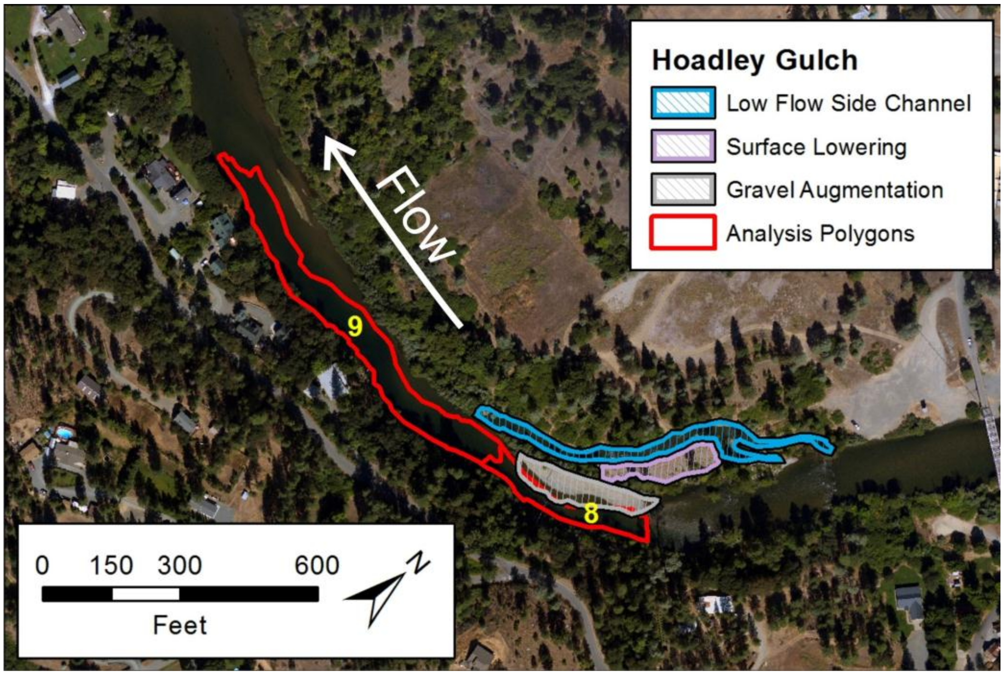

Figure 14: Design elements at the Hoadley Gulch site (2011 photo).

<u>Sawmill Rehabilitation Site and Sawmill Burner Gravel Injection:</u>

The Sawmill Rehabilitation is a large project constructed in 2009. It extends from the entrance of an existing side channel near the downstream end of polygon #9 to just beyond the Sawmill Burner gravel injection location 0.85 miles downstream (Appendix A, Map 3). Mechanical alterations at the Sawmill site included the addition of 5850 yd^3 of gravel in the form of three constructed gravel bars and extensive floodplain lowering and channel expansion totaling 88000 yd^3 of cut.

The most upstream gravel placement was a small bar placed along the left bank upstream from polygon #10, Upper Cemetery Run (Figure 15). Although no depth changes were recorded at that location the first year after construction, depths decreased by about 1 ft throughout the polygon during the 2011 flow release (Appendix D, graph 10). The fact that the placed bar is visible in 2010 aerial photographs but had been completely removed by 2011 supports an interpretation of the depth changes in polygon #10 as being directly caused by movement of the placed gravel into the run. The 2011 flow release also produced fill in portions of polygon #11, Upper Cemetery Pool (Appendix D, graph 11), located about 200 ft farther downstream. Decreased depths in relatively shallow portions of that polygon (for example, the 20th percentile depth decrease from about 6 ft in 2010 to about 2.5 ft in 2011) indicate that the extent of deep water in the pool contracted even though the maximum depth remained constant. Cemetery Hole itself, polygon #12, shows no evidence of fill during the 2011 release (Appendix D, graph 12). Although the topographic data collected in the hole in 2009 do not support a grid-based analysis of change, point-by-point comparison of the 2009 sonar with 2010 data do provide a means for assessing depth changes resulting from the 2010 release. As described in a previous section, that comparison suggests that Cemetery Hole may have aggraded by an average of about 0.5 ft that year (Figure 9).

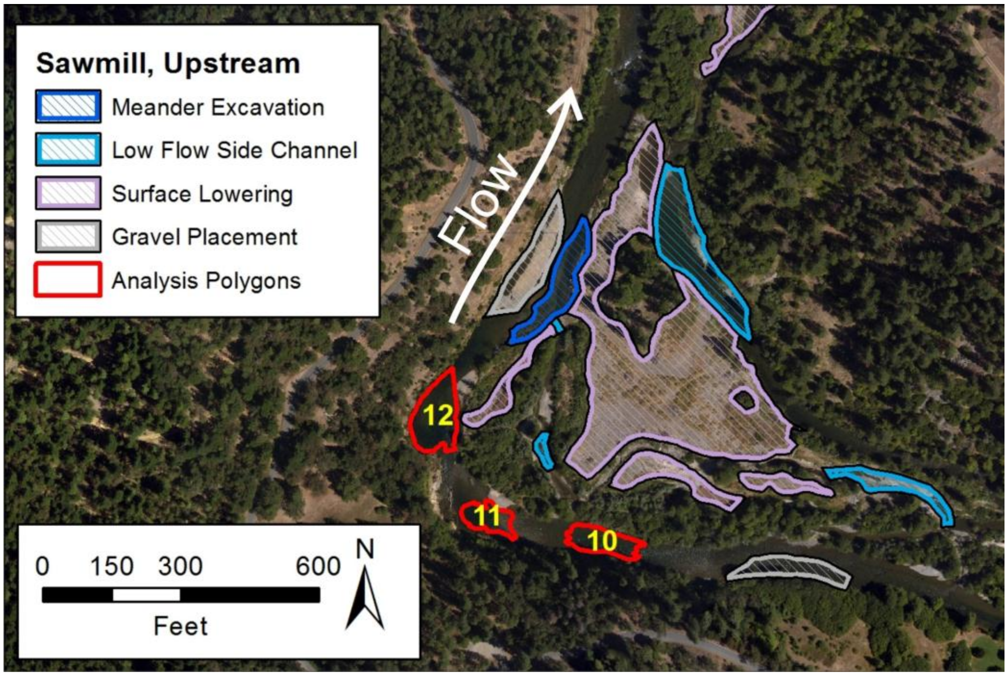

Figure 15: Design elements at the upstream end of the Sawmill site (2011 photo).

In addition to the upstream gravel placement, lowering of the terrace on the inside of the sharp bend to the right in the upstream part of the Sawmill project area may have contributed to the depth decreases detected in Upper Cemetery Run, Upper Cemetery Pool, and Cemetery Hole. At its widest point near the apex of the bend, the surface was lowered by between 6 and 16 ft over a distance of at least 150 ft (Figure 15). It was observed during the ensuing 2010 spring flow release that a large proportion of the flood flow was conveyed across that lowered surface, thereby bypassing the bend and the polygons it contains. That observation was confirmed on May 5, 2010 when Graham Mathews and Associates measured main channel flow upstream from the bend apex using an acoustic Doppler current profiler mounted on a jet boat. Those measurements showed that the main channel was conveying only about 3600 ft^3/s when the total discharge in the river was 6400 ft^3/s.

The largest depth decrease observed at the Sawmill site occurred in polygon #16, the Sawmill Burner Hole (Appendix D, graph 16). Prior to being filled, that was the location of a deep hole at the base of bedrock cliff on river right where the channel makes a bend to the left (Appendix A, Map 3, Figure 16). The high terrace and bedrock on the left bank made the Sawmill Burner a convenient location for injecting gravel into the stream during peak flow events. Injections of about 700 yd^3 into the hole in 2000 and again in 2008 were successful, in that high flows cleared the gravel from the hole and distributed it downstream. However, an injection of about 1700 yd^3 into the hole during the 2009 dry year flow release did not transport the gravel out of the hole. More significantly, subsequent flow releases have also failed to clear the gravel from the hole.

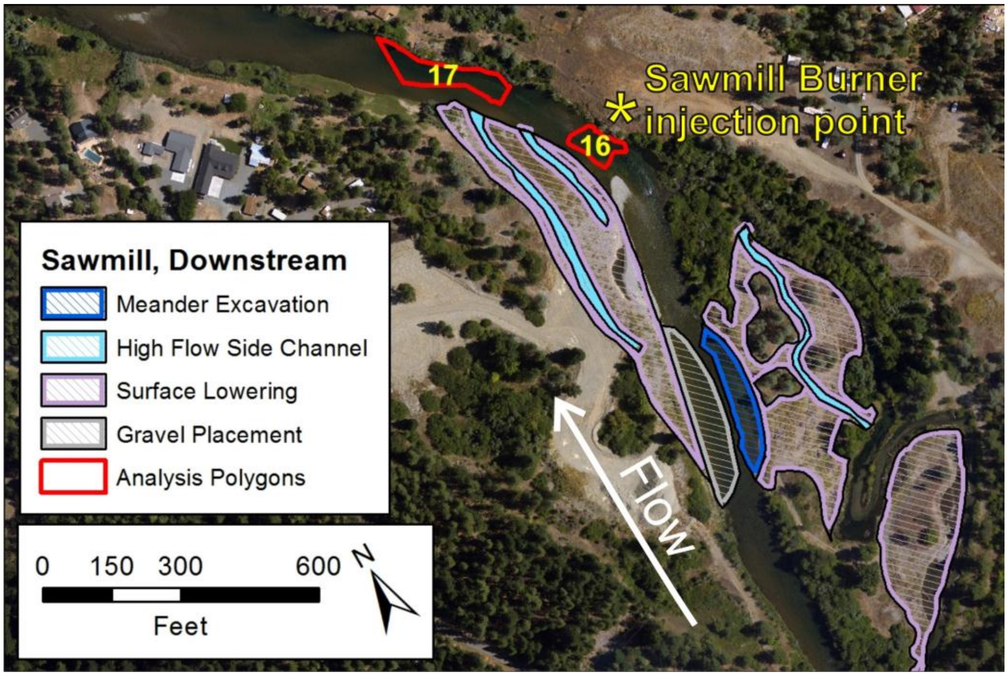

Figure 16: Design elements at the downstream end of the Sawmill site (2011 photo).

The failure of the 2009 flood to clear the Sawmill Burner Hole was partially due to the fact that 2009 was a dry year, and the flow release peak of 4630 ft^3/s at Lewiston was relatively low. By comparison, the 2008 release that successfully cleared the hole the previous year peaked at 6890 ft^3/s. But the failure of the 2010 and 2011 releases to mobilize the gravel requires explanation, because both releases exceeded the 2008 release. The 2010 release peaked at 7480 ft^3/s, whereas the 2011 peak of 12300 ft^3/s was the largest restoration flow ever released from Lewiston Dam.

The inability of these large releases to mobilize gravel in the Sawmill Burner Hole is probably due to changes in channel geometry near the hole associated with the Sawmill Rehabilitation project. As noted above, the project included extensive terrace and floodplain lowering at several locations within the site. A significant portion of that activity took place on the left side of the river opposite the Sawmill Burner Hole where the existing terrace was lowered by as much as 6 ft in places to create a low floodplain-like surface with a high-flow chute channel (Figure 16). Increased flood conveyance over this lowered surface allows a significant portion of the flow to cut across the inside of the bend, thereby reducing shear stresses and sediment transport capacities in the Sawmill Burner Hole. Interestingly, polygons located immediately downstream from the area of terrace lowering have either become deeper in recent years or have not changed (Appendix D, graphs 17-20).

Dark Gulch Rehabilitation Site:

The Dark Gulch project (Appendix A, Maps 5 and 6) was constructed in 2008. Although the project site spans a long stretch of river (1.5 miles), total cut and fill quantities were relatively small. Gravel placements at five locations scattered through the site totaled about

3000 yd^3, and the total excavation associated with the project was about 39000 yd^3. The majority of the total cut (22600 yd^3) took place at a single location near the upstream end of the site where a swath of the left overbank area up to 300 wide was lowered by between 2 and 5 ft (Figure 17). Although the resulting floodplain-like surface and low-flow side channel was designed to flood at a flow near 6000 ft^3/s, a field visit during the 2009 flow release showed that the surface was fully inundated under about 1 ft of water at a flow of about 4500 ft^3/s.

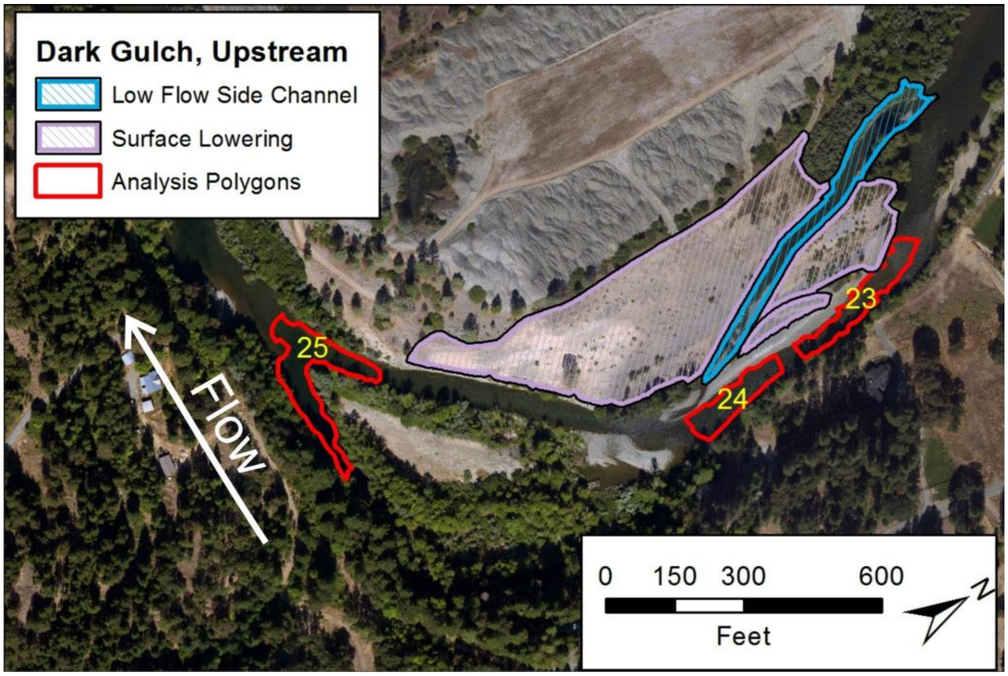

Figure 17: Design elements at the upstream end of the Dark Gulch site (2011 photo).

Polygon #23 (Salt Flat 1) and polygon #24 (Salt Flat 2) are located immediately adjacent to this lowered surface. Those polygons encompassed relatively deep runs prior to construction of the Dark Gulch project, but mostly filled after construction (Appendix D, graphs 23 and 24). By contrast, five other polygons located within the Dark Gulch site boundaries (Appendix D, graphs 25-29) but far from the lowered area show either no depth change or slight deepening.

Lowden Ranch Rehabilitation Site and Gravel Injection:

Constructed in 2010, the Lowden Ranch Rehabilitation project (Appendix A, Maps 6 and 7) included a constructed side channel, a constructed meander bend, two constructed islands, and terrace lowering to create a new floodplain (Figure 18). The project differed substantially from any other TRRP project in two respects. First, the design included a gravel bar that was to be dynamically constructed by injecting gravel upstream rather than by mechanical placement. Secondly, the overbank areas were maintained at relatively high elevations to keep stream power concentrated in the channel, even at high stages. Although a large terrace area on the left side of the river was lowered to produce a new floodplain, the new surface was designed to convey little or no flow until discharges exceed 7000 ft^3/s.

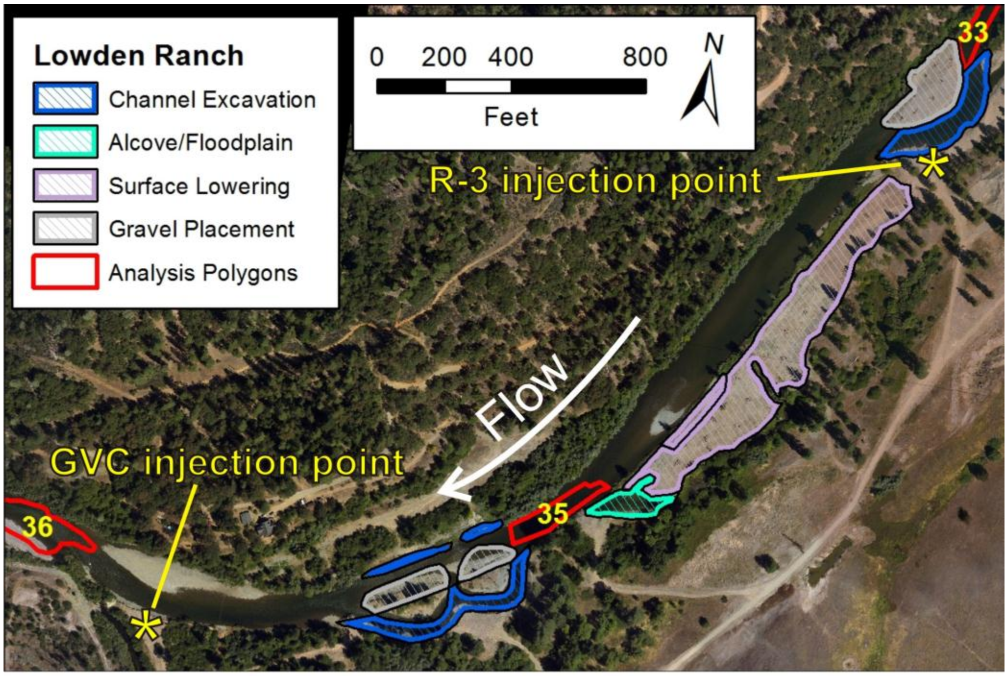

Figure 18: Design elements in the central and downstream part of the Lowden Ranch site (2011 photo).

Two gravel injections were performed in conjunction with the Lowden Ranch project. The first of these, the GVC Delta injection, was implemented prior to site construction during the 2010 high-flow release. The Lowden Ranch site design had originally called for 1500 yd^3 of gravel to be placed along the left bank just upstream from the mouth of Grass Valley Creek (GVC) near the downstream end of the site. As project design documents indicated that the gravel was primarily intended to supply downstream reaches, it was decided that introducing the gravel by injection during a high-flow event would be logistically preferable to mechanically placing it in the channel during site construction. A high terrace surface composed of delta deposits from Grass Valley Creek providing easy access to the channel, allowing loaders to push 1530 yd^3 of gravel into the channel during the release. Most of the injected gravel deposited as a fluvially-sculpted bar along the left bank at the injection location (Gaeuman 2011).

The second injection was performed during the 2011 flow release, when 2050 yd^3 of gravel was injected from the left bank near the downstream end of the constructed meander bend. The location of that injection is referred to herein as the Lowden R-3 injection point, after the feature identifier used for the meander excavation in the project design documents. Gaeuman (2013) presents a detailed analysis of the topographic changes observed within the Lowden Ranch site during the 2011 flow release. In summary, both the heights of bars and the depths of pools increased, resulting in a general increase in bed relief through the site. Of the three polygons presented in this report that are located within the Lowden site, two show modest deepening and 1 shows virtually no change (Appendix D, graphs 33-35).

Erosion during the 2011 release was particularly intense near the downstream end of the Lowden Ranch site, where a large quantity of gravel was mobilized from several sources. A large proportion of the gravel used to construct a pair of islands was mobilized, as well as virtually the entire gravel bar created by the GVC Delta injection in 2010. In addition, the high terrace along a section of the left bank more than 400 ft long retreated up to 50 ft, introducing an estimated 4300 yd^3 of gravelly alluvium into the channel from bank erosion alone. Gaeuman (2013) reported that the estimated gravel load transported past the downstream boundary of the Lowden Ranch site during the 2011 exceeded 8500 yd^3. A large share of that gravel deposited immediately downstream in an area that is partially covered by polygon #36, Wellock Pool. A large proportion of Wellock Pool aggraded by 3 ft or more, such that more than 40% of the pool area, which was entirely submerged in 2010, had been converted to an emergent bar by 2011 (Appendix D, graph 36). Topographic differencing indicates that approximately 5250 yd^3 of gravel deposited in and around the Wellock Pool polygon during the 2011 flow release.

Trinity House Gulch Rehabilitation Site:

The Trinity House Gulch project, which is located immediately downstream from the Lowden Ranch site (Appendix A, Map 7), was also constructed in 2010. Construction at the Trinity House Gulch site included lowering of a large terrace on river right, excavation of a baseflow side channel through the lowered area, addition of 3500 yd^3 of gravel in the form of three in-channel bars, and bank excavation to create a low-amplitude meander bend (Figure 19). Despite being in the same section of river as the Lowden site, and experiencing exactly the same flow conditions, Trinity House Gulch had a radically different response to the 2011 flow release. Channel responses within the Lowden site included both erosion and deposition, but erosion was the more dominant process, particularly in the most downstream third of the site. By contrast, changes within the Trinity House Gulch site were almost exclusively depositional.

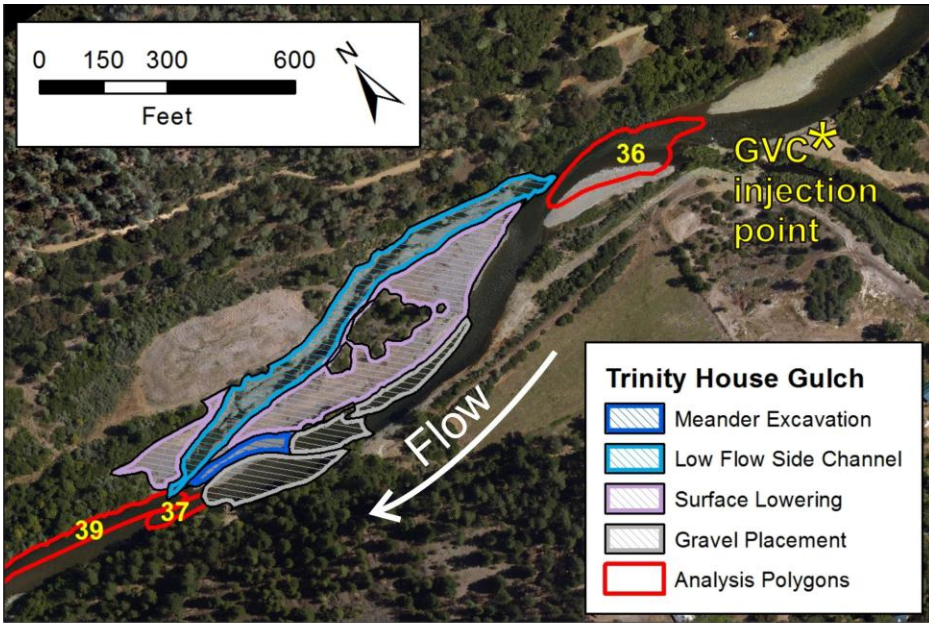

Figure 19: Design elements in Trinity House Gulch site (2011 photo).

As described above, the transition from an erosion-dominated reach to a depositional reach occurs at Wellock Pool, which is located between the Lowden Ranch and Trinity House Gulch sites. It appears that activities at both rehabilitation sites, as well as past dredging, contributed to the massive deposition observed at that location. The fact that the Lowden site delivered a large gravel flux to the Wellock Pool area has already been described. However, terrace lowering and side channel construction at Trinity House Gulch may have also encouraged deposition in Wellock Pool, even though most of the pool is slightly upstream from those features. The proposed mechanism is as follows: Excavation at the upstream end of the terrace area resulted in the removal of the existing vegetation, leaving the right bank in the vicinity of the side channel entrance susceptible to erosion. The result was bank retreat of up to 50 ft in the tailout area of the pool during the 2011 flow release, which provided additional space for bar and riffle deposition. In the end, the pool tailout area was converted into a large diagonal riffle encompassing the bar in Wellock Pool on the left and extending onto the upstream portion of the lowered terrace surface (Figure 20). Finally, Wellock Pool was created by mechanical dredging in 1984 and maintained to some extent by re-excavation as late as 1995 (Gaeuman 2010). It is interesting to note that, prior to dredging, the bar configuration in the area was similar to the post 2011 release condition (Figure 20). It appears that the pre-release pool morphology was incompatible with the local geomorphic setting, making its eventual filling inevitable.

Significant deposition was also observed at other locations in and immediately downstream from the Trinity House Gulch site. Polygons #37 and #38, Little Tree 1 and Little Tree 2, both show depth decreases of 30% or more over a large proportion of their areas (Appendix D, graphs 37 and 38). Little Tree 1 encompasses a larger area than Little Tree 2, but is limited to a comparison between 2009 and 2011 data. Little Tree 2, however, provides clear evidence that the depth changes in the area occurred after construction of the Trinity House Gulch project in 2010. The construction feature that contributed to fill in the Little Tree area was a constructed meander and point bar immediately upstream. The point bar, which was located along the left bank following construction, was completely eroded and the material was evidently transported into the deeper areas immediately downstream during the 2011 flow release (Figure 20).

Although the constructed bar upstream from Little Tree was removed during the release, deposition was widespread throughout the rest of the reach. It is likely that lowering of the adjacent terrace contributed to deposition in the reach. In particular, the excavated area in the right bank that defines the constructed meander bend adjacent to the lowered terrace area completely refilled with gravel (Figure 19). Polygon #39, Trinity House, which is located just downstream from the lowered area, also aggraded, although to a much lesser degree (Appendix D, graph 39).

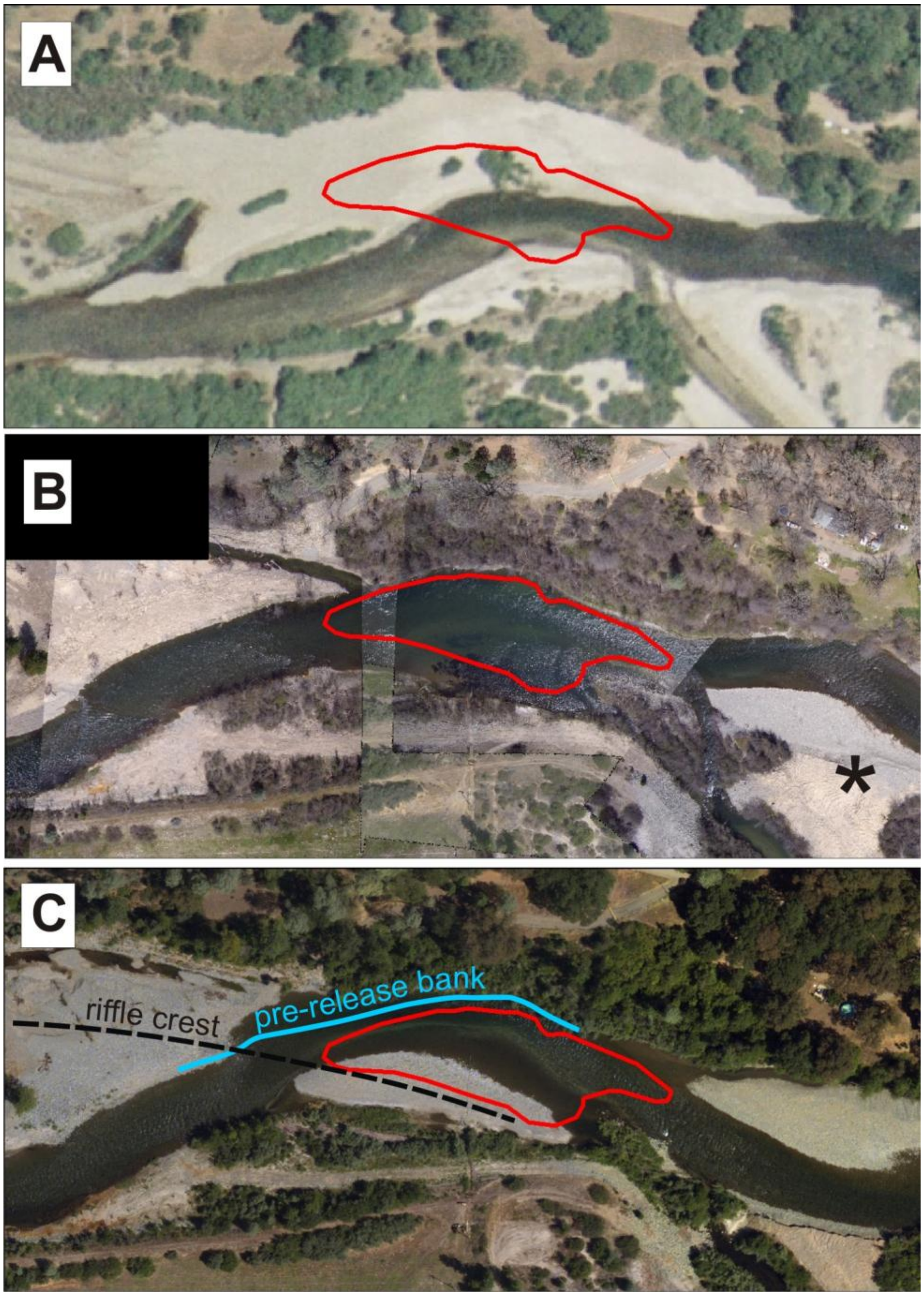

Figure 20: Wellock Pool area in a) 1980, prior to dredging, b) the as-built condition in April 2011 before the spring release, and c) after the 2011 flow release. Fill in Wellock Pool was associated with erosion of the right bank and deposition of a large diagonal riffle that extends from the pool onto the lowered terrace surface. The * in panel b indicates the location of the GVC Delta gravel injection.

Reading Creek Rehabilitation Site:

The Reading Creek project site is located about 19 miles downstream from Lewiston Dam, near the town of Douglas City (Appendix A, Map 16). The project included 5900 yd^3 of in-channel gravel placement, and terrace and side channel excavation totaling about 66900 yd^3. Three of the five depth analysis polygons located within the Reading Creek project reach show moderate to large decreases in depth (Appendix D, graphs 72, 74, and 76). All three of those polygons, Goodyears (#72), Lower Bend (#74), and Alcatraz (#76), are located adjacent to terrace or floodplain areas that were lowered during project construction. None of those polygons, however, are located in close proximity to a gravel addition. The majority of the added gravel was placed in the straight reach downstream from polygon #75, Painted Rock (Appendix A, Map 16).

Excavation at the site included lowering of a swath of the left-side terrace about 200 ft wide at the downstream end of the site by several feet (Figure 21). The excavation was particularly large near the downstream end of the terrace, where the surface was lower by 6 to at least 10 ft over a width of about 100 ft. That surface conveyed a large portion of the 2011 flood flow, thereby bypassing a sharp turn with a bedrock protrusion on the right bank and causing Alcatraz, a large hole located at the base of the bedrock, to lose 3 ft of depth over a large portion of its area. A similar result ensued from the excavation of a high-flow channel about 50 ft wide in the right overbank area at the upstream boundary of the project work area (Figure 22). That excavation extends about 1000 ft from the upstream site boundary through the apex of a sharp bend, thereby allowing a portion of flood flows to bypass both the Goodyears and Lower Bend polygons. However, a third polygon in the same area bypassed by the high-flow channel, Upper Bend (#73), did not aggrade.

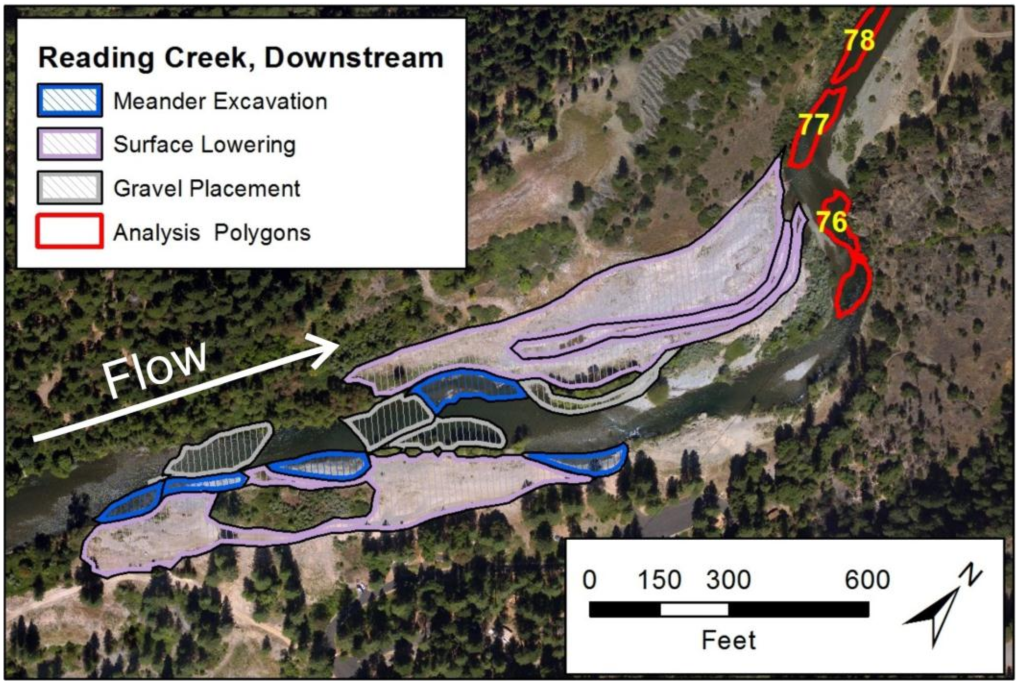

Figure 21: Design elements at the downstream end of the Reading Creek site (2011 photo).

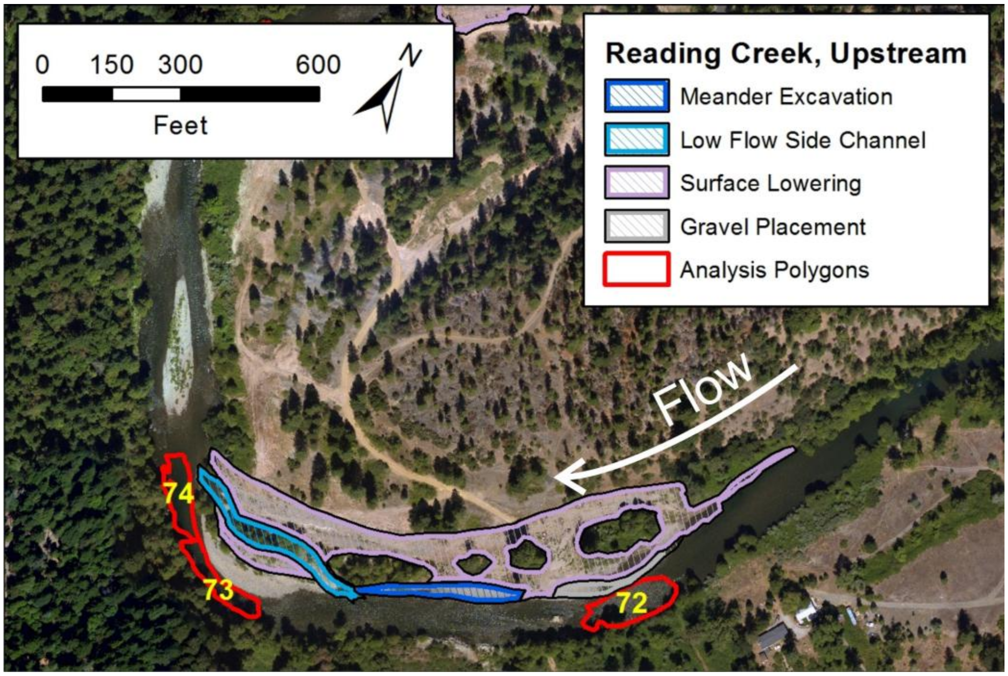

Figure 22: Design elements at the upstream end of the Reading Creek site (2011 photo).

2009-2011 Depth Changes in the Absence of Rehabilitation Actions

The previous section identified 12 polygons in which decreases in depth between 2009 and 2011 appear to be directly linked to one or more rehabilitation actions at or immediately upstream from the polygon locations. Those 12 polygons are #7 Old Bridge, #8 Hoadley Bar, #10 Upper Cemetery Run, #11 Upper Cemetery Pool, #16 Sawmill Burner, #23 Salt Flat 1, #24 Salt Flat 2, #36 Wellock Pool, #37 Little Tree, #72 Goodyears, #74 Lower Bend, and #76 Alcatraz. This section focuses on the remaining polygons for which depth changes are not clearly linked to a rehabilitation action.

Figure 23 displays the longitudinal distribution of 75th-percentile depth changes from 2009 to 2011, excluding the 12 polygons that have been linked to specific rehabilitation actions. This depth percentile is used as an index of overall change in this section, but the reader is encouraged to refer to Figure 4 or Appendix D for a more comprehensive view of the changes. It can be seen that, once the localized effects of a few identified rehabilitation actions have been taken into account, the number of polygons indicating large depth decreases (e.g. more than 1.5 ft) are roughly balanced by the number showing large depth increases, whereas 65% of the all depth changes plotted in Figure 23 are positive (i.e., deeper). The changes shown on Figure 23 are considered by river segment below, with special attention to some of the larger changes.

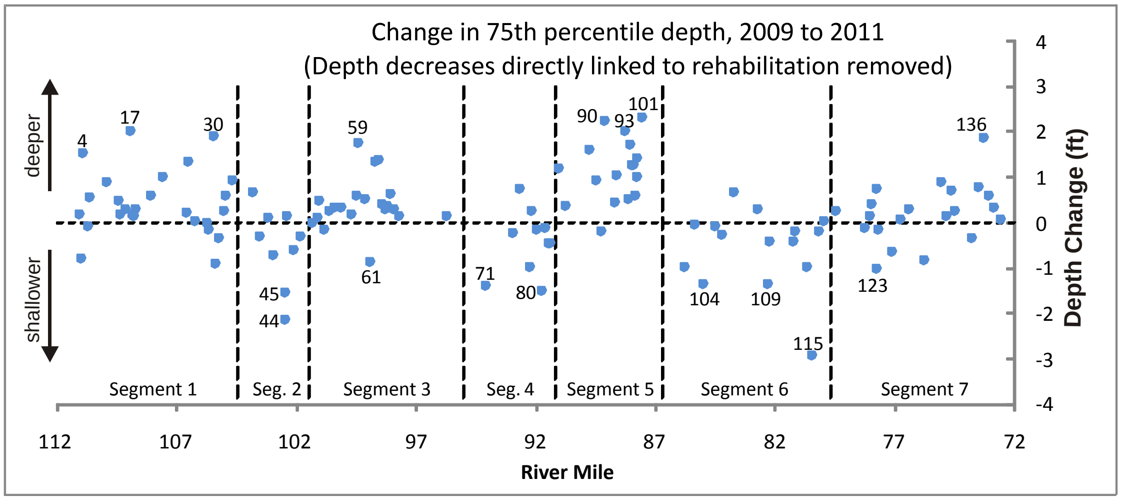

Figure 23: Changes in the 75th-percentile depths for polygons that are not immediately adjacent to the rehabilitation actions, as described in the preceding text. Numbers near points correspond to the IDs in Table 2.

Segment 1: Lewiston through Lowden Ranch

Excluding polygons located immediately adjacent to identified rehabilitation actions, 20 of 26 polygons in segment 1 show increases in 75th-percentile depth and no polygons show depth decreases exceeding 1 ft. All large depth changes in the segment are positive, the three largest being Below New Bridge (#4), Lower Burner 1 (#17), and Upper Bucktail Pool (#30). This bias toward increasing depth is of particular interest in segment 1 because 78% of all gravel augmentation activities from 2008 through 2011, i.e., 68% of the low-flow gravel placements associated with channel rehabilitation and 100% of the high-flow injections, took place within this segment (see Tables 3 and 4).

Among the polygons showing large depth increases in segment 1, the changes at Below New Bridge were already discussed in the context of the Diversion Pool gravel injection site. Depths in the Lower Burner 1 polygon show a persistent trend toward deepening since 2009, with most of the increase occurring during the 2011 flow release (Appendix D, graph 17). These changes could be interpreted as the reestablishment of prior depths after transient filling associated with the gravel additions at the Sawmill Burner injection point in 2008 and 2009. Apparently, Lower Burner 1 is located far enough downstream from the lowered terrace on the opposite bank that high flows re-converging into the channel can entrain the excess gravel. Indeed, the 2011 release also produced slight deepening in the Sawmill Burner polygon itself, although that area remains far from its 2008 depth.

Depth increases at the Upper Bucktail Pool after 2009 were greatest in the deepest parts of the pool, with depth increases steadily grew from about zero at the 50th-percentile depth to nearly 5 ft at the maximum depth (Appendix D, graph 30). This pool is located immediately downstream from the Bucktail Bridge, a location where bridge-induced scour has been identified as a cause for concern. Trinity County is currently preparing designs and seeking funds to replace that bridge with a longer span.

Segment 2: Trinity House Gulch through Upper Poker Bar

Decreases in the 75th percentile depth were observed in six of the nine polygons in segment 2 that are not directly associated with a rehabilitation action. The most notable changes are depth decreases of around 2 ft in adjacent polygons #44, Stott Hole, and #45, Stott Trough. Depth decreases at Stott Hole are relatively uniform over the entire polygon area (Appendix D, graph 44), whereas the decreases at Stott Trough were greatest in the deepest parts of the trough (Appendix D, graph 45).

The cause of depth losses in the two Stott polygons is unclear. No other nearby polygons underwent large depth decreases, although there does appears to be a general tendency toward decreasing depth in the segment, particularly for median depths (see Figure 4a). It is plausible depth decreases in segment 2 could be related to the downstream propagation of gravel placed at the Lowden Ranch and Trinity House Gulch rehabilitation sites, but the data lack the temporal resolution to thoroughly evaluate that possibility. Data allowing the total 2009-2011 change to be parsed into individual years is available only at polygon #48, Society Pool, which corresponds to the most downstream location in segment 2 shown on Figure 23. Those data show that Society Pool had begun to fill in 2010, prior to large-scale gravel placement or injection at the upstream rehabilitation sites (Appendix D, graph 48).

Another possible explanation for the slight filling observed in the segment 2 is an increase in the local sediment loading from bank erosion. Downstream from the Trinity House Gulch rehabilitation site, segment 2 enters the the Poker Bar subdivision, where residential development extends for about 1.4 miles along the right river bank upstream from Stott Hole (Appendix A, maps 8 and 9). Many of those residential parcels include grassy lawns or other managed vegetation that is less resistant to erosion than natural riparian cover, and the TRRP office has fielded numerous complaints of bank erosion from residents in the area. The potential magnitude of sediment inputs from these residential banks has not been assessed.

Segment 3: Lower Poker Bar to Indian Creek

Depth changes in segment 3 are predominantly positive, with 19 of 21 polygons showing depth increases. In general, the increases become progressively larger with distance from the Poker Bar subdivision. The largest increases are found within the undeveloped canyon reach between the Poker Bar area and residential developments along Steel Bridge Road, with the maximum occurring at polygon #59, Upper Steel Bridge (Appendix D, graph 59). Little overall change was detected at Steel Bridge itself (Polygon #61), despite the decrease in the 75th-percentile depth indicated for that location in Figure 23. As shown in Graph 61 of Appendix D, depth decreases at Steel Bridge were restricted to a narrow band of the depth distribution centered on the 75th-percentile depth, while most other depth percentiles remained constant or increased.

Segment 4: Highway 299 Bridge to RM 91.2

No clear trends emerge from the segment 4 polygons that remain after rehabilitation actions at the Reading Creek rehabilitation site have been taken into account (Figure 23). In part, this is due to a lack of data between the mouth of Indian Creek and the Reading Creek rehabilitation site. Only polygon #71, Highway 299 Bridge, lies within that 2-mile stretch of river. That polygon shows depth decreases across the full range of depths between 2009 and 2011, with the largest decreases near the 90th-percentile depth approaching 2 ft (Appendix D, graph 71). It is hypothesized that fill at this location may be related to the recent entrainment and downstream transport of excess gravel stored in the reach downstream from Indian Creek. The most recent sediment budget for the mainstem Trinity River downstream from Lewiston Dam indicates that decades of low flows since flow regulation began in 1960 have allowed large quantities of tributary-derived sediments to accumulate in this area (Gaeuman and Krause 2011).

The largest decrease in the 75th-percentile depth observed in segment 4 is at polygon #80, Jumping Rock. However, closer inspection reveals that the apparent pool filling may be an artifact of polygon location, in which the area being considered extends into an area with a developing bar. Figure 24 shows a comparison between bed elevation grids for Jumping Rock in 2009 and in 2011. Deposition in the polygon after 2009 was concentrated at its downstream end and along its left edge where a new bar had developed. At the same time, the depth and extent of the pool at the base of the bedrock outcrop in the upstream portion of the polygon changed little. The bar-like quality of the depositional area is evident in the figure by the riffled water surface visible at the downstream end of the polygon, and by the 2011 cumulative depth-frequency curve indicating a minimum baseflow water depth of less than 1 ft.

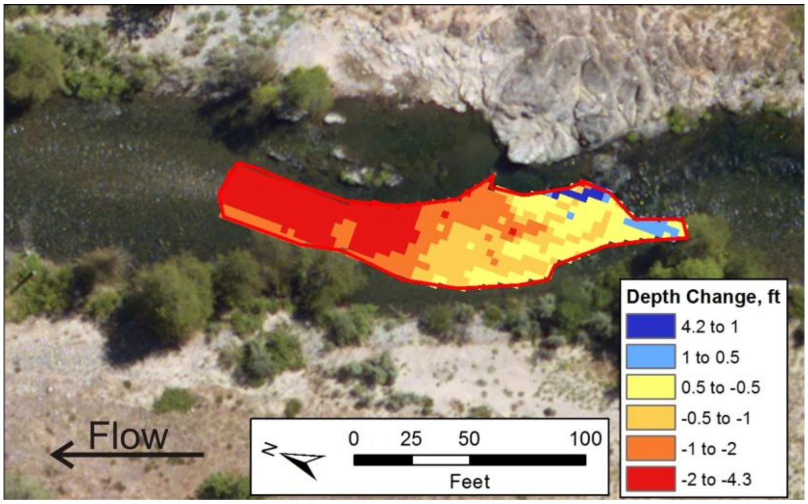

Figure 24: Depth changes in the Jumping Rock polygon (#80) show bar formation at the downstream end of the polygon during between 2009 and 2011.

The cumulative depth-frequency plot for Jumping Rock is characterized by large decreases in the depths of relatively shallow area, increased depth or little change in the depths of the deeper areas, and an overall decrease in the slope of the curve. In general, these types of changes are indicative of bar growth in a portion of the polygon. Several other polygons in the study area show similar characteristics, including #32 (RM105.25), #41 (RM103.5), #46 (Stott Convergence), #91 (RM88.7), and #120 (RM78.25); see the graphs in Appendix D. It can be argued that the increased local bed relief in these polygons represents an increase in habitat complexity and overall habitat value.

Segment 5: RM 91.2 to RM 87.5 (Browns Creek Canyon)

Segment 5 spans a bedrock-confined section of river commonly referred to as the Browns Creek Canyon or simply as “the Canyon”. Like much of segment 3, channel widths and lateral sediment inputs in segment 5 are constrained by bedrock banks. Accordingly, depth changes in this segment are heavily dominated by increases, with 16 of 17 shown in Figure 23 increasing in depth during the study period. In addition, a point-by-point comparison of 2009 and 2011 data yielded an estimated depth increase of about 1.2 ft for the Chop Tree polygon, which is also located within the segment but is not shown on the graph. Some of the largest depth increases were recorded in polygon #90 (Dutton), #93 (RM88.24), and #101 (RM87.6).

Segment 6: RM 86 to Dutch Creek Bridge

Segment 6 begins at approximately RM 86 where the canyon walls begin to recede and the river gradually enters a relatively broad semi-alluvial valley. This river segment appears to be prone to aggradation, with 13 of the 16 polygons in the segment showing a decrease in 75th-percentile depth (Figure 23). Of those, five lost at least 1 ft of depth. In addition, the Sheridan polygon, which is not shown on the graph, is estimated to have lost about 0.6 ft in depth on the basis of a point-by-point comparison of 2009 and 2010 data.

Contrary to some of the depth decreases in other river segments, which might be interpreted in terms of bar development, the decreases observed in segment 6 are generally concentrated in the deepest portions of the polygons. Thus, many of the changes in segment 6 can be accurately described in terms of pool filling. For example, the three largest 75th-percentile depth decreases in the segment tend to be largest in relatively deep part of the polygons. Polygon #104, Upper Evans Bar, shows fill by about 1.3’ over a range of depth from about the 50th to about the 95th percentiles (Appendix D, graph 104). Polygon #109, Eds, shows progressively larger depth decreases with increasing depth, with the maximum decrease of about 3 ft occurring near the 100th-percentile depth (Appendix D, graph 109). Depths in polygon #115, Lower Sky Ranch, also decreased over nearly the full range of depths, but showed a maximum decrease of about 4 ft at the 90th percentile depth (Appendix D, graph 115).

These depth decreases do not appear to be related to rehabilitation activities, as this segment is 7 to 12 miles downstream from the upstream nearest rehabilitation action. Moreover, the net erosion observed in segment 5 provides further evidence that upstream gravel additions have little or no impact on the quantity of gravel delivered to the upstream boundary of segment 6. The cause of widespread depth decreases in segment 6 is currently unknown. Given that segment 6 spans a relative alluvial section of the river, increased sediment inputs from bank erosion under the ROD flow regime is a possible contributing factor. Future monitoring of bank erosion and channel widths could help to evaluate that possibility, and continued bed elevation monitoring is needed to determine whether the 2009-2011 changes represent a long-term trend or a transient fluctuation.

Segment 7: Dutch Creek Bridge to the North Fork Trinity River

Depth changes in segment 7 are biased toward net degradation, with 15 of 21 polygons showing 75th-percentile depth increases between 2009 and 2011 (Figure 23). In general, the changes are relatively small, with only two of the 21 polygons showing depth change in excess of 1 ft. The largest negative depth change of 1.02 ft at polygon #123, Upper Conner 1, only barely exceeds that threshold. On the positive side, polygon #36, Screw Trap, stands out with a depth increase of nearly 2 ft over the majority of its depth range (Appendix D, graph 136).

Historical Trends in Pool Depths

This section documents how the maximum depths 13 pools have changed over the last 5 decades. Historical maximum depth information was compiled by reviewing a collection of 25 technical reports, contract specifications, and bathymetric surveys (see Appendix F for tabular data and references). Depth data exist for some of these pools extends as far back as 1963. Most of the data come from early restoration efforts that dredged pools to remove sediment, primarily sand. These dredged pools were also called sediment control pools.

Flow regulation of the Trinity River started in November 1960 and coincided with high upland sediment production rates associated with timber harvest in the Upper Middle Trinity River Watershed (Figure 25). The combination of mainstem flow regulation and elevated tributary sediment supply from logging and road building caused significant accumulations of sand in Trinity River, filling pools, smothering spawning areas, and causing riparian encroachment and channel narrowing (Department of Water Resources, 1970; Rogers, 1972). Photographs of sand accumulation in the Trinity River are shown in Figure 26.

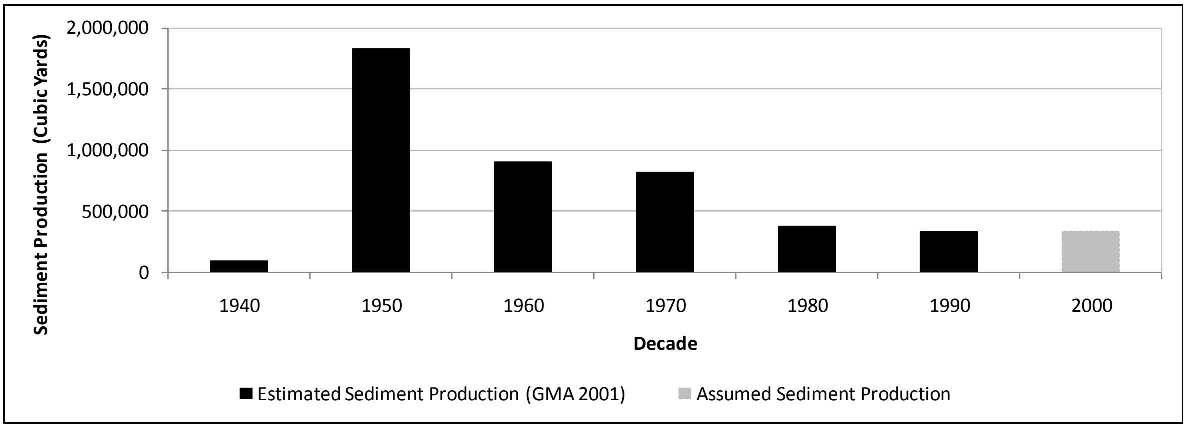

Figure 25: Sediment production in the Upper Middle Trinity River watershed (GMA 2001).

Figure 26: Sand accumulation in the Trinity River downstream from the Old Lewiston Bridge in August 1999 (left) and downstream from Grass Valley Creek in 1989 (right).

Sand accumulation was observed for 30 miles downstream of Lewiston Dam (Trinity River Taskforce, 1978). The largest accumulations of sand occurred in the 8-mile stretch downstream of Grass Valley Creek (Department of Water Resources, 1970). LaFaunce (1968) estimated that sand accumulation eliminated 80% of the spawning habitat in the first two miles below Grass Valley Creek and that 50% of the spawning habitat was lost over the next 6 miles. According to Brown (1994), un-cited documents from the 1970's reported sand deposits 2 to 4 ft thick covering riffles and runs downstream of Grass Valley Creek. Nelson (1987) states: "Most of the deep pools (formerly 10 to 20 ft deep) between Grass Valley Creek (RM 104.3) and Steel Bridge (RM 99.0) gradually filled with sand, reducing pool depths to 3 to 6 ft and greatly reducing pool area."

Restoring spawning and adult holding habitat lost due to sand accumulation was the major focus of early restoration efforts on the Trinity River in the 1970's and 1980's. Pool dredging was one of the primary methods used to control sand accumulation. Dredge operations with suction dredges, excavators, and draglines removed 221100 yd^3 of sediment from Trinity River pools between 1976 and 1991 (Figure 27, Table 5). Existing pools were dredged to remove sand and were often enlarged to more efficiently trap sand for subsequent removal via repeat dredging. In the Lewiston area, dredging was also used to create sediment traps by dredging new pools where none previously existed (e.g. Old Lewiston Bridge Pool at RM 110.1). A typical sediment control pool was excavated to be about 300 to 500 ft long and 10 to 15 ft deep.

Dredge records exist for 16 pools, and historical data quantifying maximum pool depths are available for 13 pools (Table 5). All but one of these pools was dredged at some point. Fourteen of the 16 pools correspond to the locations of polygons defined for the 2009-2011 depth change analyses presented above. The 13 pools with historic depth data are grouped into three general types: bedrock pools that form naturally adjacent to bedrock outcrops, natural pools that existed in alluvial areas prior to dredge operations, and constructed pools that were dredged in areas where no pool existed prior to dredging. Since the early 1990's when pool dredging stopped, bedrock pools have gradually deepened, natural pools have stabilized at a depth slightly shallower the typical dredge depth, and constructed pool have filled.

Figure 27: Suction dredging in Stott Hole in 1977 (left). The area occupied by the sand bars on the right side of the photograph is currently about 20 ft deep. Right: Pool dredging with an excavator.

Name	Approximate Location	Pool Type	Historical Depth Available	Times Dredged	Sediment Dredged (yd^3)
New Bridge	Polygons 3, 4	Natural	Yes	5	10000
B2	Polygons 5, 6	Constructed	Yes	2	10000
Old Lewiston Bridge	110.13*	Constructed	Yes	5	37600
Upper Cemetery	Polygon 11	Bedrock	No	1	1800
Cemetery Hole	Polygon 12	Bedrock	Yes	4	4600
Baxter	107.45**	Constructed	Yes	1	5600
Bucktail Hole	Polygon 31	Bedrock	Yes	2	6700
Wellock Pool	Polygon 36	Constructed	Yes	3	47200
SP	Polygon 40	Natural	Yes	7	46100
Ponderosa	Polygon 40	Natural	Yes	2	10800
Tom Lang	Polygon 42	Natural	Yes	1	7600
Stott Hole	Polygon 44	Bedrock	Yes	5	19000
Society Pool	Polygon 48	Natural	Yes	1	10800
Montana	Polygon 49	Natural	No	1	4000
Snell	Polygon 50	Natural	No	1	300
Upper Steel Bridge	Polygon 59	Bedrock	Yes	0	0
Total					221100

Table 5: Pools with historical depth data summarized in this report (modified from Krause 2012). *The historical dredge pool at Old Lewiston Bridge was located just downstream from the Old Lewiston Bridge, whereas the Old Bridge polygon (#7) is located just upstream from the bridge. **The dredged Baxter pool is located about 1000 ft downstream from the mouth of Rush Creek near polygon #22.

Bedrock Pools

The deepest pools on the river are forced by bedrock. There are four bedrock pools with historic depth data available: Cemetery Hole, Bucktail Hole, Stott Hole, and Upper Steel Bridge. Stott Hole has the longest record of pool depth data of any pool on the Trinity River. At 22 ft deep, Stott Hole is one of the deepest pools on the river. Stott Hole experienced some of worst impacts from high sand loads following flow regulation because it is located two miles below Grass Valley Creek. For these reasons, Stott Hole tells the clearest and most dramatic story of sand infilling and habitat loss on the river. By 1963, just a few years after flow regulation, Stott Hole was only 10 ft deep, having lost over half of its depth due to sand infilling. By 1966, the pool had completely filled with sand reducing the water depth to just a few inches (LaFaunce, 1968). The water depth increased to 1 ft after elevated winter releases in 1967 (LaFaunce, 1968). Stott Hole was dredged five times between 1976 and 1991, removing 19,000 yd^3 of sediment (Krause, 2012). Maximum depth in the pool gradually increased after dredging stopped in 1991, presumably because upland sediment production diminished and flow releases to the river have increased (Figure 28).

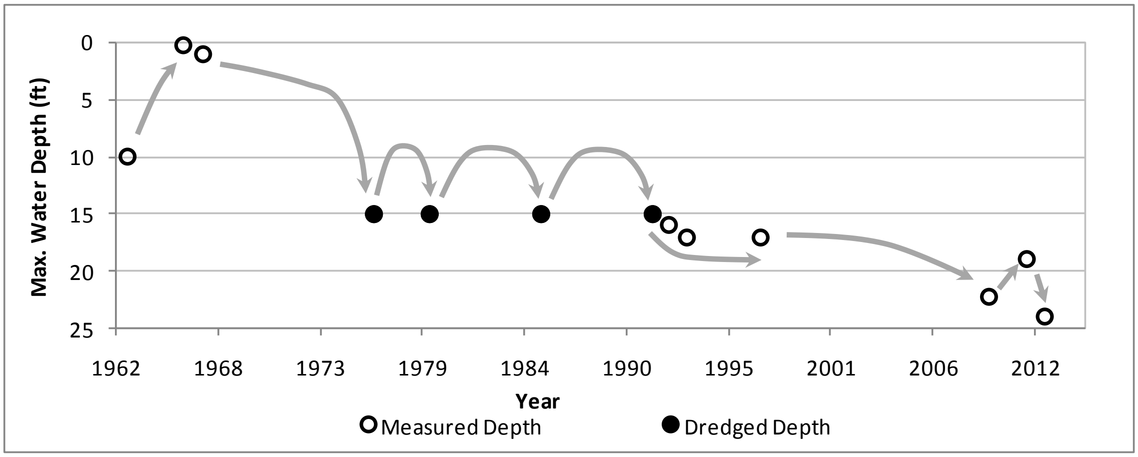

Figure 28: Maximum depths in Stott Hole since 1963.

The other bedrock pools with historic data follow a similar trend as Stott Hole: sand infilling following flow regulation (Nelson 1987), repeated dredging (Krause 2012), then stabilization or gradual deepening since the early 1990s (Figure 29).

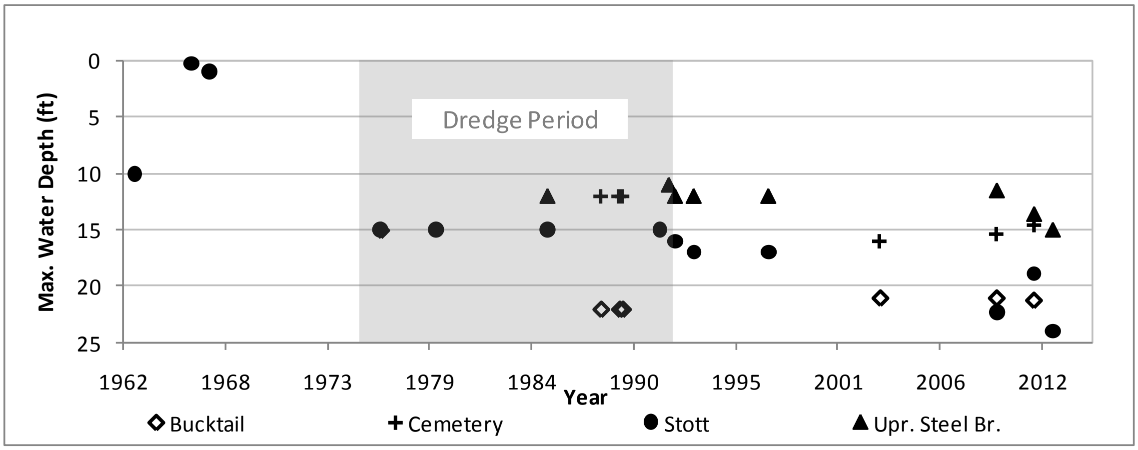

Figure 29: Maximum depth trend for bedrock holes since 1963.

Natural Pools

Historic depths are known for five natural pools: New Bridge, SP, Ponderosa, Society, and Tom Lang. All of these natural pools were dredged. Except for the New Bridge, all are located downstream from Grass Valley Creek and were dredged to remove sand. The New Bridge pool was dredged to provide a coarse sediment supply for gravel augmentation projects.

Natural Pools below Grass Valley Creek

SP pool provides a good example of the long term depth trend of natural pools downstream from Grass Valley Creek (Figure 30). SP pool is located immediately downstream of Grass Valley Creek, so it experienced very high sand loading and intensive dredging. From 1977 to 1987, SP pool was dredged five times. The total quantity of sediment removed (46100 yd^3) is the most dredged from any natural or bedrock pool. The initial dredging in 1976 removed 9,000 yd^3 of sediment (Krause, 2012). The first winter storms after the initial dredging completely filled the pool with sediment (Trinity River Taskforce, 1979). An annual cycle of dredge and fill continued through 1987, when the construction of sediment detention ponds on Grass Valley Creek eliminated the need for continued dredging at SP pool. The maximum depth of SP pool has remained stable at between 8 to 10 ft since 1991.

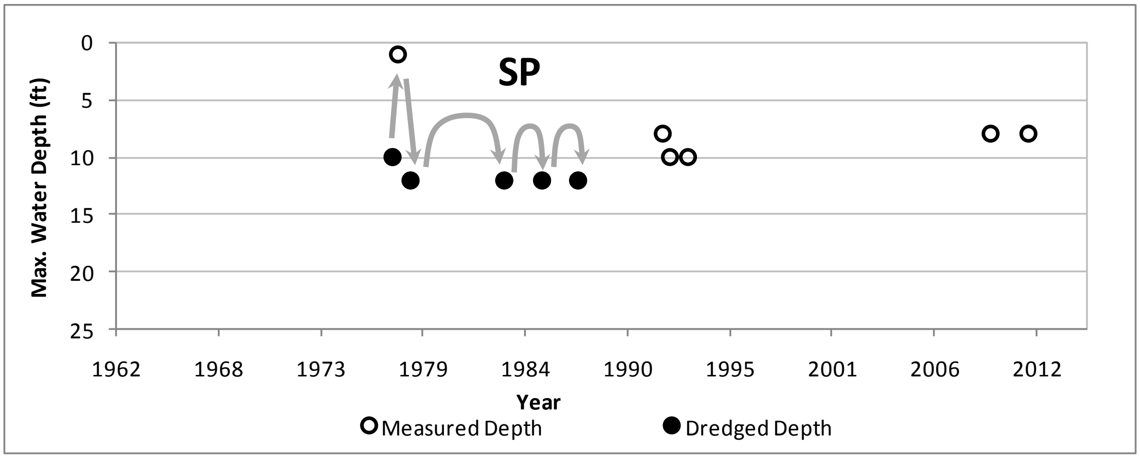

Figure 30: Maximum depths of SP Pool since 1976.

Like SP pool, the depth of the other natural pools below Grass Valley Creek has stabilized since dredging ended in the early 1990's. The stable depth of these pools is equal to, or slightly shallower than, the typical dredge depth (Figure 31). The depth of these pools prior to dredging is not known. Most of these pools have scoured slightly deeper in response to high flows since 2006.

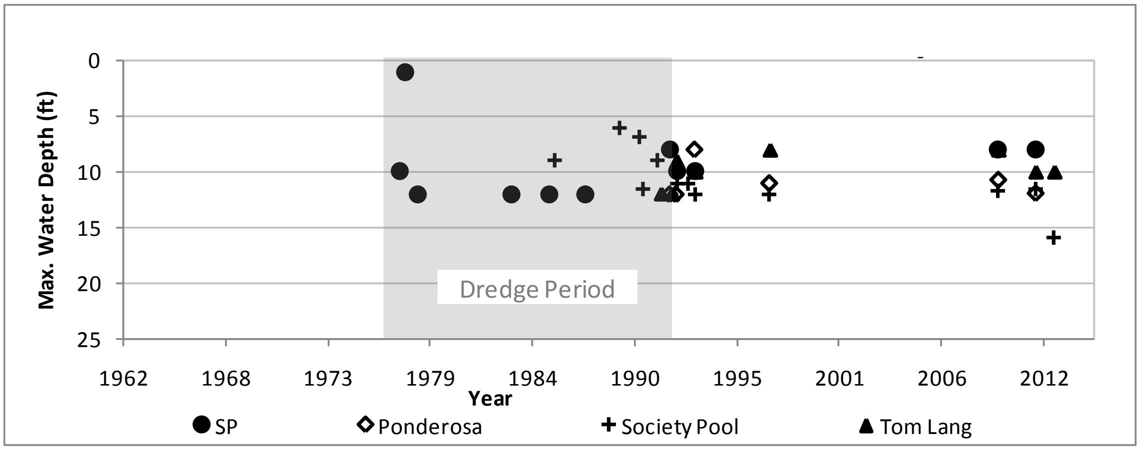

Figure 31: Maximum depth trend for natural pools downstream from Grass Valley Creek.

New Bridge Pool

Like the natural pools below Grass Valley Creek, the maximum depth at New Bridge Pool (Figure 32) follows a cycle of dredge and fill followed by a relatively stable depth after dredging stopped. Unlike the natural pools below Grass Valley Creek, the stable maximum depth of New Bridge pool appears to have decreased by 3 to 4 ft since the late 1990s.

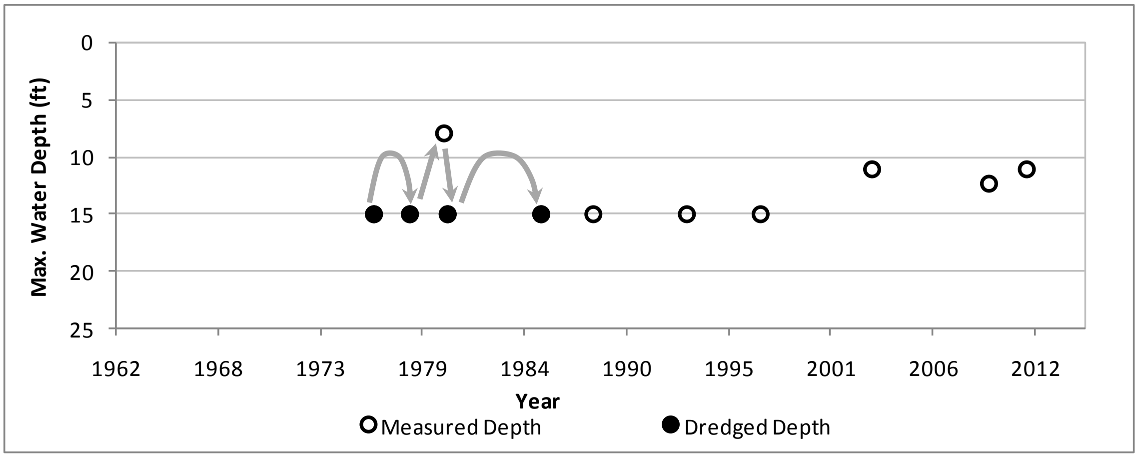

Figure 32: Maximum depths of New Bridge Pool since 1976.

Constructed Pools

The pools described in the previous sections were natural pools that were dredged to remove fine sediment from the river. Four other sediment control pools were constructed by dredging depressions in the river bed where no pool, or a much smaller pool, previously existed. These constructed sediment control pools have gradually filled since dredging operations stopped (Figure 33). The contemporary eight foot depth of B2 pool is created by a small, local scour pocket behind a piece of bedrock. This local scour pocket is not representative of the fate of the larger sediment control pool constructed at B2 which has completely filled in.

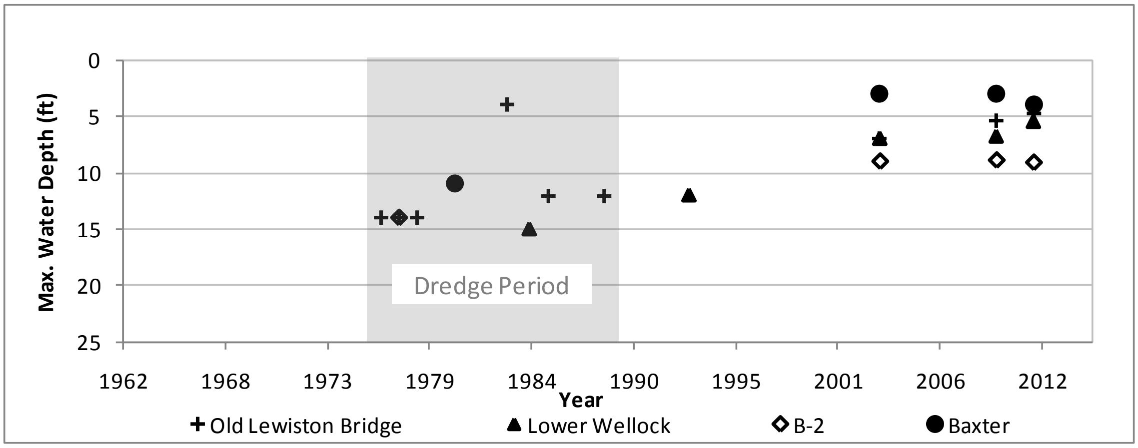

Figure 33: Maximum depth trend for constructed pools.

Discussion and Conclusion

The depths of most pools and deep runs in the Trinity River between Lewiston Dam and the North Fork Trinity River increased between 2009 and 2011. Of 139 polygons considered in this study, 75 to 82 (54-59%) increased in depth over the study period, depending on the depth metric considered. In most cases, the magnitudes of the depth changes were modest (on the order of 1 ft or less) regardless of the direction of change. Depth increases were more frequent than decreases in four of seven river segments defined for this study. Of about 36.5 river miles over which data for evaluating depth changes are available, the segments with more depth increases span 24.5 miles, or 67% of the study area. Segments in which depth decreases predominate are a 3-mile stretch of river near the Poker Bar residential subdivision (segment 2), a 3-mile stretch downstream from Douglas City (segment 4), and a 6-mile stretch downstream from Junction City (segment 6).

However, large localized depth decreases were observed in several locations. In many cases, those decreases appear to be linked to recent rehabilitation actions. In particular, the data demonstrate that the lowering of large overbank areas to elevations below the ordinary flood stage can result in aggradation in the adjacent channel. Seven locations where the effects of recent terrace lowering can be assessed with adjacent analysis polygons have been identified. Those locations are adjacent to: 1) the Hoadley Gulch side channel (Figure 14), 2) Cemetery Hole in the upper part of the Sawmill site (Figure 15), 3) the Sawmill Burner Hole (Figure 16), 4) the Salt Flat polygons within the Dark Gulch site (Figure 17), 5) the Trinity House Gulch side channel (Figure 19), 6) the high-flow channel in the upper Reading Creek site (Figure 22), and 7) Alcatraz in the lower Reading Creek site (Figure 21). Of 13 analysis polygons located adjacent to these areas, 12 showed depth decreases during the study period (Table 6). Only Upper Bend (#74) maintained its pre-project depth in a location adjacent to a lowered terrace. Two additional polygons (#13 and #14) located near the lowered terrace area in the upper Sawmill site increased slightly in depth between 2010 and 2011, but they are excluded from further consideration because they cover areas where the original bed geometry was highly altered by channel realignment, bar construction, and the placement of large wood structures during the 2009 construction of the Sawmill project.

Treatment	Major Fill	Minor to Moderate Fill	No Fill
Gravel Only	None	7, 39	2, 3-4*, 5, 6, 9, 17, Lowden site
Lowering Only	23, 24, 72, 76	74, 12[1]	74
Gravel and Lowering	16, 36, 37[2]	8, 10, 11	None

Table 6: Relationship between the magnitude of polygon fill and proximity to rehabilitation actions. *Polygons 3 and 4 are considered together. [1]Fill in polygon #12 is based on point-by-point comparisons rather than grid-based analysis. [2]This polygon is co-located with polygon 38. [3]The lack of fill in polygons #13 and #14 is likely an artifact of in-channel construction that altered the bed topography prior to data collection.

Gravel additions, on the other hand, have a more nuanced relationship to depth changes. Of 16 locations identified within a few channel widths downstream from a gravel addition, half show no evidence of fill (Table 6). Moreover, of the eight that did experience depth decreases, six are also located adjacent to a lowered terrace area. Of nine areas identified in Table 6 as being near upstream gravel additions but not adjacent to lowered terraces, two underwent minor to moderate fill whereas seven either maintained depth or increased in depth. The two locations where gravel additions alone appear to have promoted pool aggradation (polygons #7, Old Bridge, and #39, Trinity House) are located where gravel was placed adjacent to or immediately upstream from the polygon locations. There is little evidence to suggest that gravel additions have had any effect on pool depths more than a few channel widths downstream from the gravel placement locations. To the contrary, depth increases were found to be more common than decreases over most of the study area, and long reaches of river with consistently increasing pool depths show that, if a wedge of deposition exists, it has not propagated far.

The preponderance of aggradation in areas where the bankfull channel has been artificially widened highlights the sensitivity of gravel transport to comparatively small variations in the fluid forces that drive it. It is well known that bedload transport in gravel-bed rivers takes place under hydraulic conditions that are very close to the threshold of particle entrainment (Parker 1979; Andrews 1983, Lisle et al. 2000). Transport rates scale as a non-linear function of shear stress or unit stream power, in which small changes in the fluid forcing corresponds to rather large changes in the transport rate (Ferguson and Church 2009). As a result, bedload transport in natural streams is a very uneven process. Different reaches of the same stream can have very different sediment transport capacities and sediment storage characteristics, depending on the local channel geometry. Sediment that readily passes through one reach with little interaction can potentially trigger major aggradation and channel metamorphosis in the next reach downstream (Wathen and Hoey 1998). The existence of these so-called "transport reaches" and "response reaches" has long been recognized in the geomorphic literature at a variety of scales (Schumm 1977). These considerations provide a context for understanding the relative significance of gravel addition and terrace lowering in the Trinity River.

The results presented here show that gravel additions alone have had little effect on the depths of downstream pools in areas where the sediment transport capacity of the channel has been maintained. For example, the reaches downstream from the Diversion Pool gravel injection site (the most heavily used gravel injection location in the study area) and the Lowden R-3 injection point both show net scour over downstream distances exceeding 0.5

miles. Any excess gravel mobilized from these injection locations was either transmitted downstream or contributed to local increases in bar heights and bed relief.

However, any gravel that may be propagating downstream is likely to deposit when it encounters lower shear stresses and decreased transport capacity. Although zones of low shear stress can arise naturally through a variety of mechanisms, mechanical channel expansions in the form of terrace lowering or pool dredging appear to account for a substantial proportion of those zones in the study area. Major depth decreases in absolute and/or relative terms in Wellock Pool (#36), Alcatraz (#76), Salt Flat 1 (#23), and Salt Flat 2 (#24), as well as the persistence of injected gravel in Sawmill Burner (#16), are perhaps the prime examples of locations where channel expansions have resulted in bed aggradation. Upstream gravel additions may increase the magnitude of deposition realized at locations such as these, but they are by no means required for deposition to occur. Decreased depths were observed in nearly all polygons adjacent to channel expansions regardless of their proximity to upstream gravel augmentations, suggesting that even natural background bedload transport rates can be sufficient cause for pool aggradation in those areas.

An investigation into pool dynamics over a time scale spanning up to five decades suggests that pools in the Trinity River may be generally deeper now than in most of the second half of the 20th Century. Historical data on pool depths is mainly available only where pools were dredged in the first few decades following closure of Lewiston and Trinity Dams. Those data show that repeated dredging was necessary to maintain pool depths from the early 1960s to the early 1990s, after which dredge activities ceased. Naturally-formed pools have since maintained depths similar to or greater than the dredged depths. However, the depths of pools that were dredged in unnatural locations where hydraulics are not suitable for pool formation or maintenance have, on average, decreased to about half their maximum dredged depths.

The results summarized above should not be interpreted as evidence that naturally-formed pools will necessarily pass whatever gravel load is delivered to them from upstream, provided the channel has not be artificially widened. There is undoubtedly some magnitude of gravel influx that will produce aggradation even in natural pools that have undergone no mechanical alteration, and very large sediment loads have been shown to be associated with pool filling and reduced bed relief (Lisle 1982; Yarnell 2006). Continued monitoring is needed to detect if, when, and where gravel additions have altered pool depth and other aspects of channel geometry.

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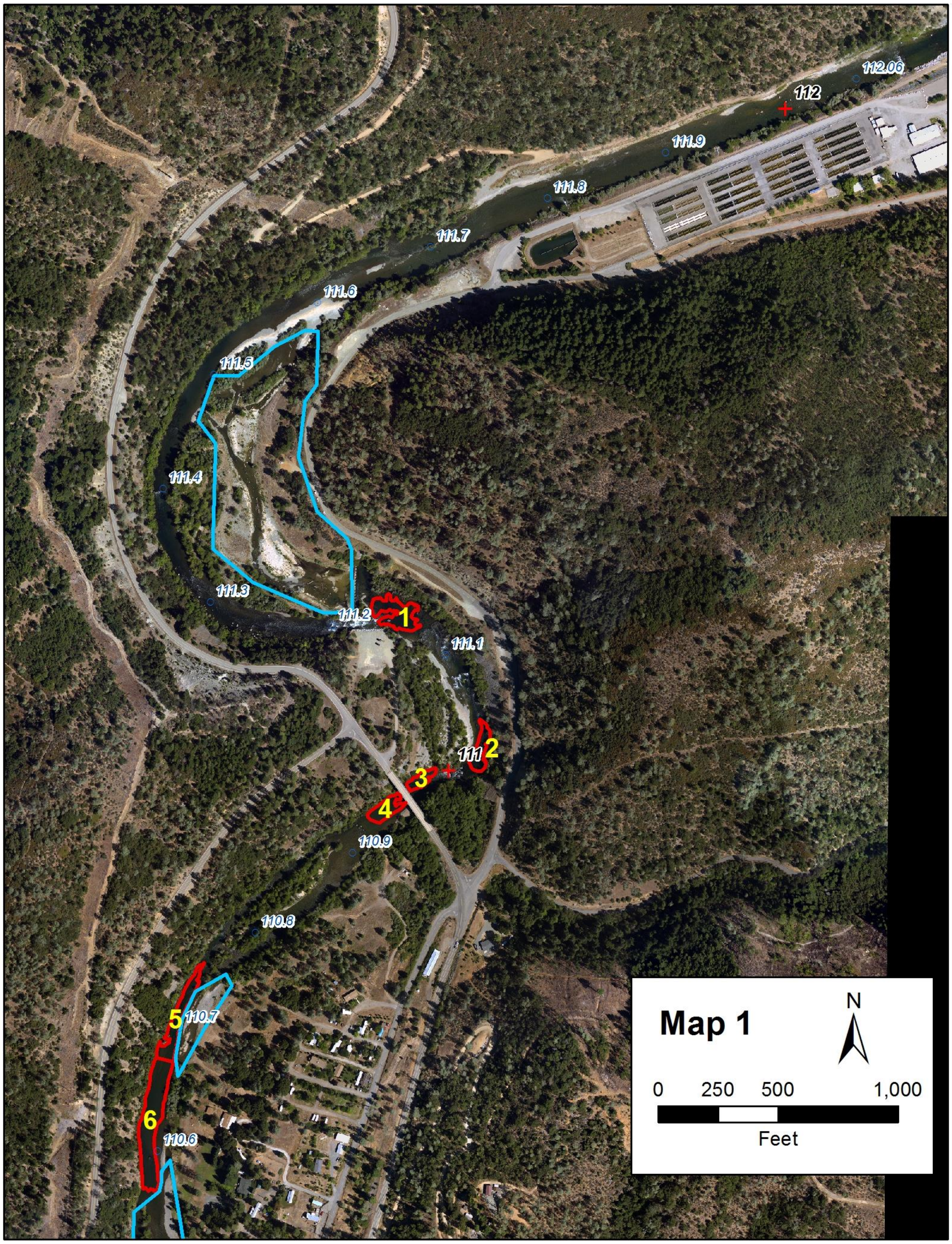
APPENDIX A

Locations of analysis polygon and rehabilitation actions implemented since 2008 are shown on 2011 aerial photographs. Analysis polygons are shown with red outlines and are labeled in yellow with numbers that increase from upstream to downstream. Smaller blue or black numbers with white edges indicate River Mile locations in 0.1-mile increments. The approximate limit of riverine mechanical alterations at recent rehabilitation sites is shown with blue outlines. Non-riverine activity areas, including upland spoils, contractor use areas, access roads, and off-channel wetlands may extend beyond the boundaries shown.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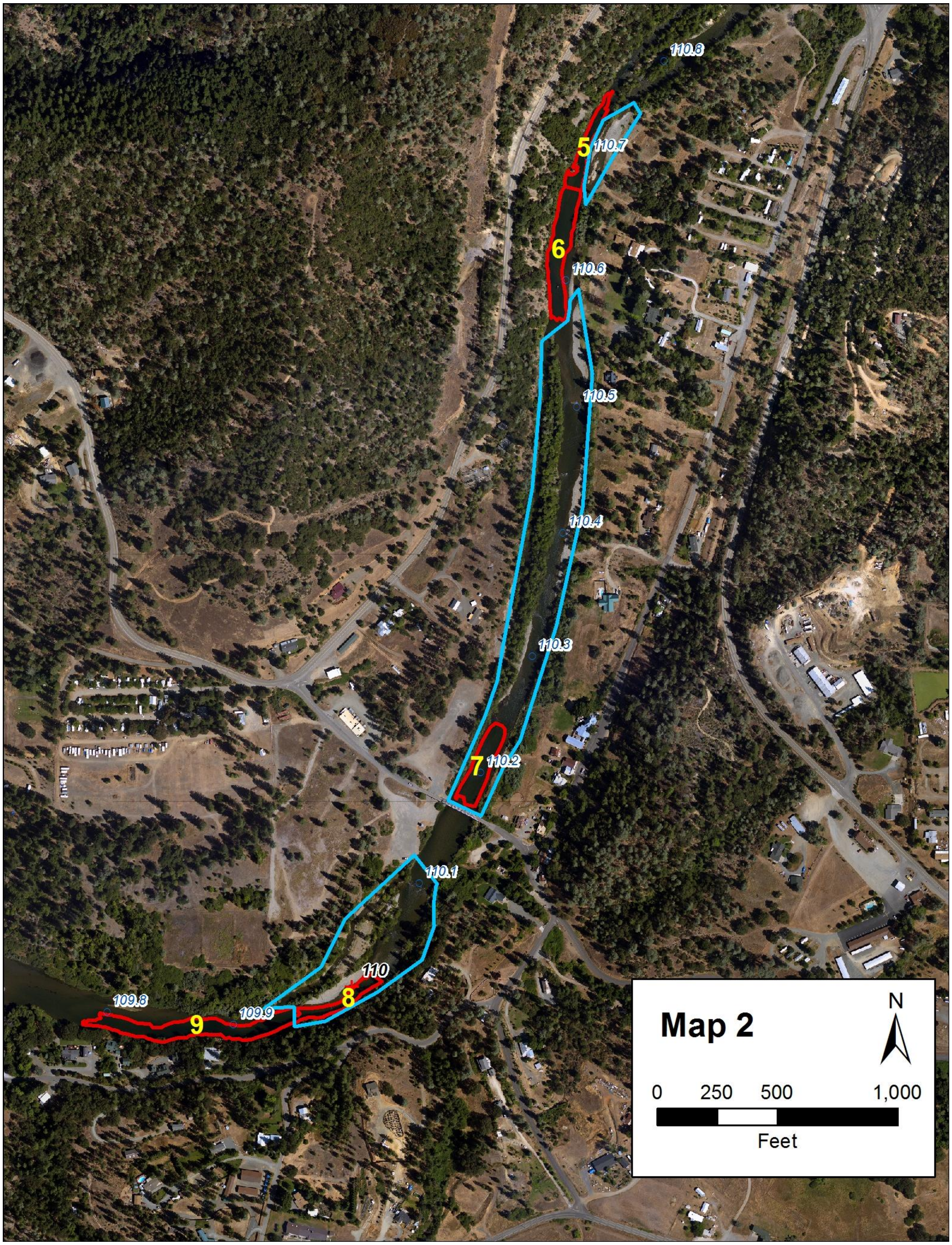
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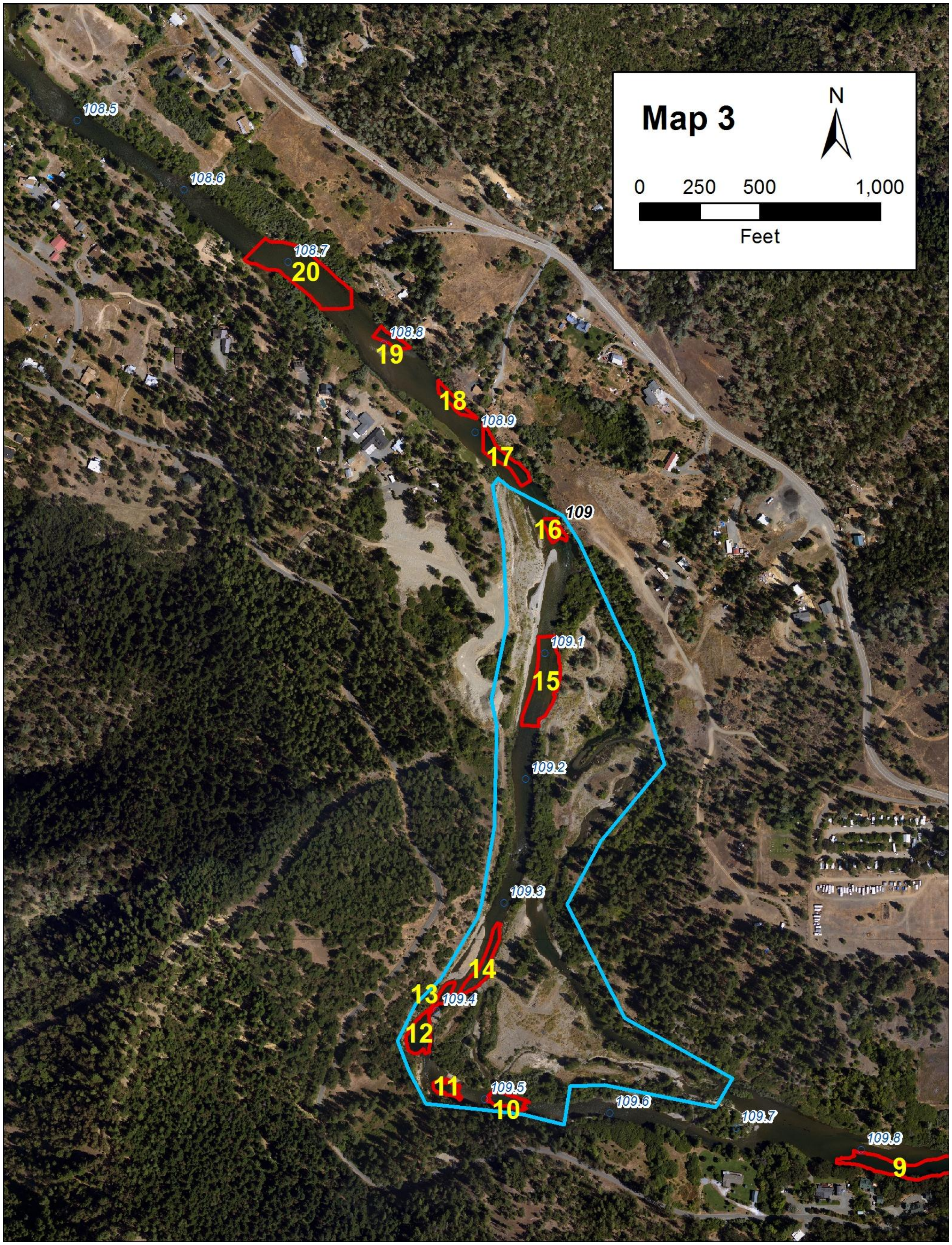
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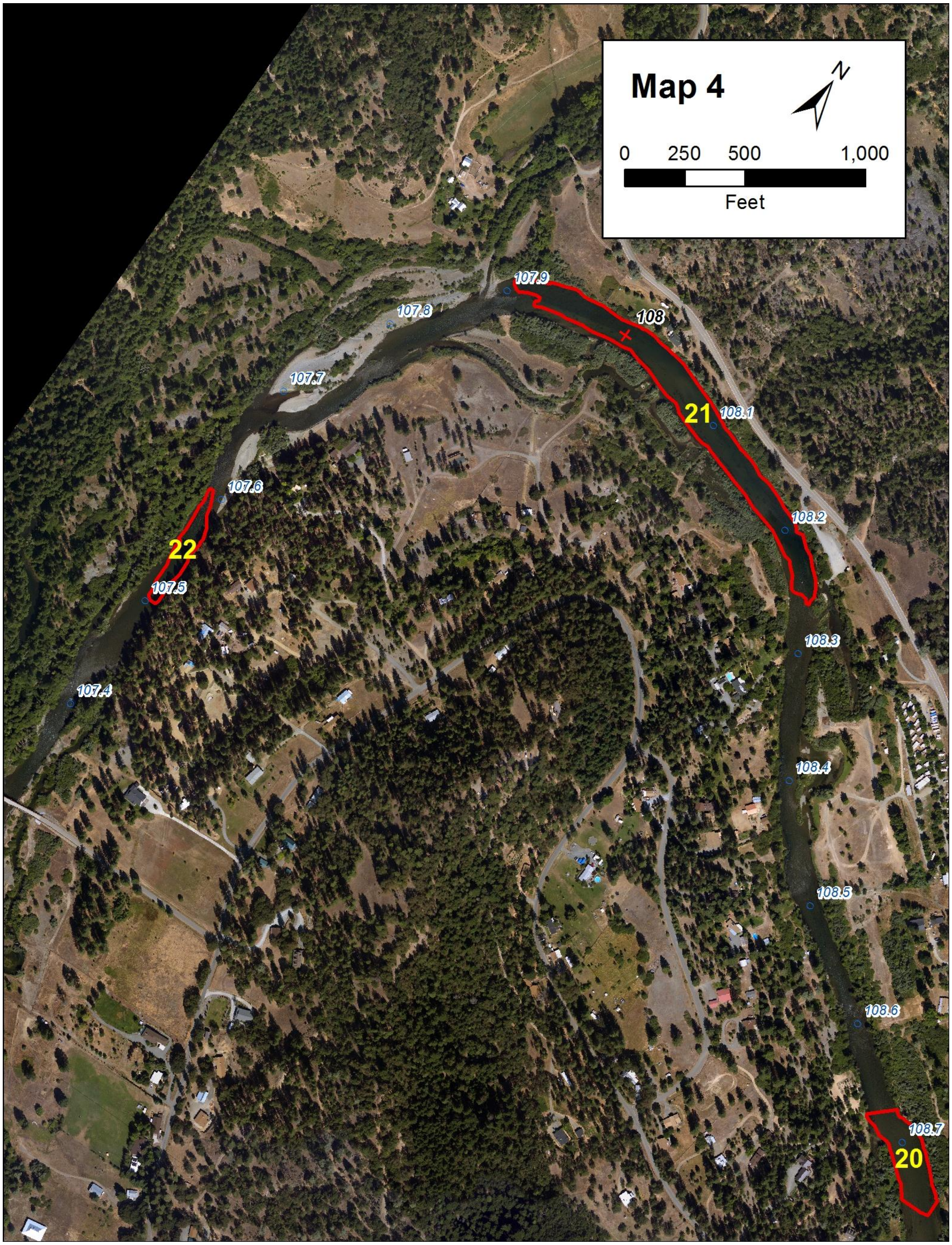
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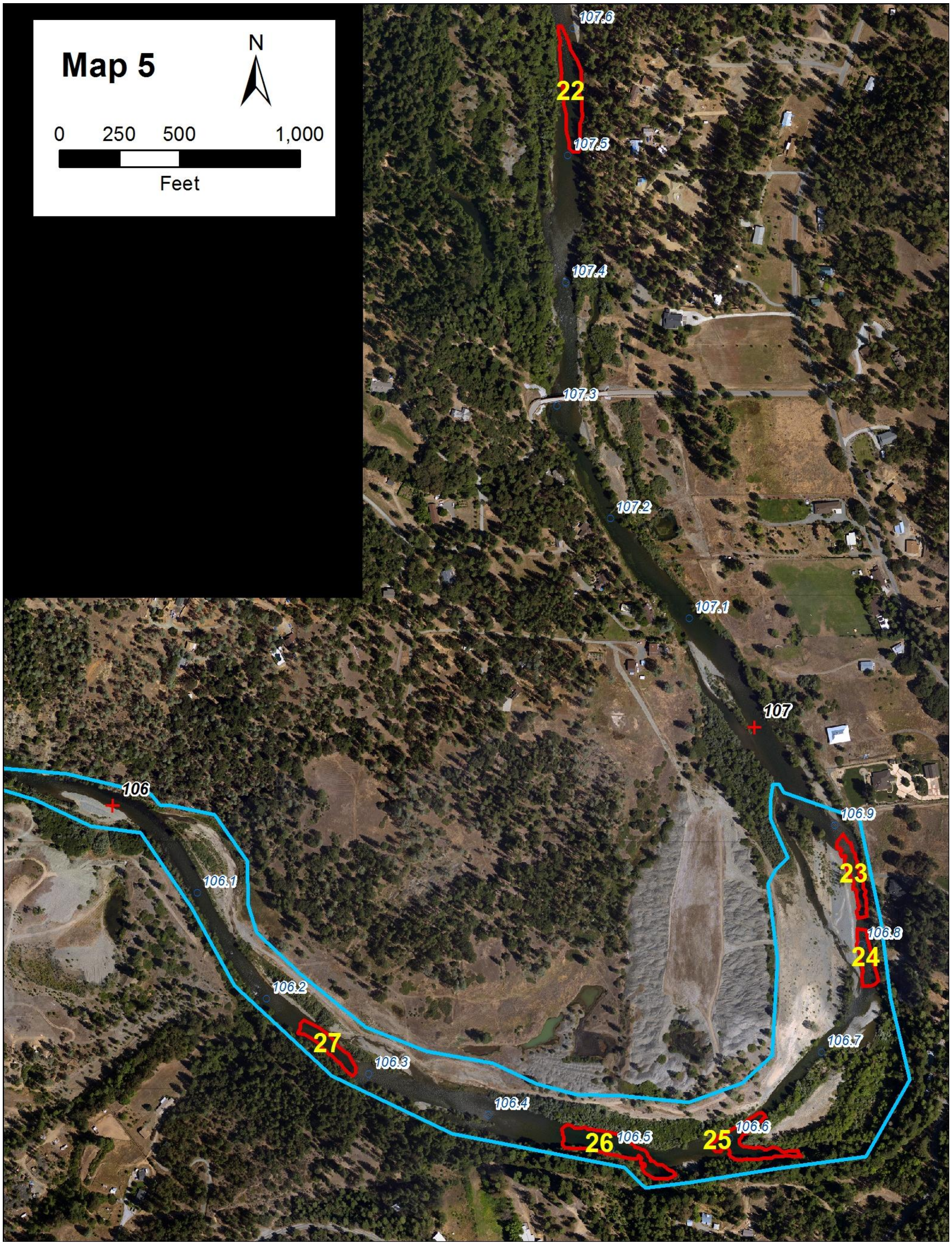
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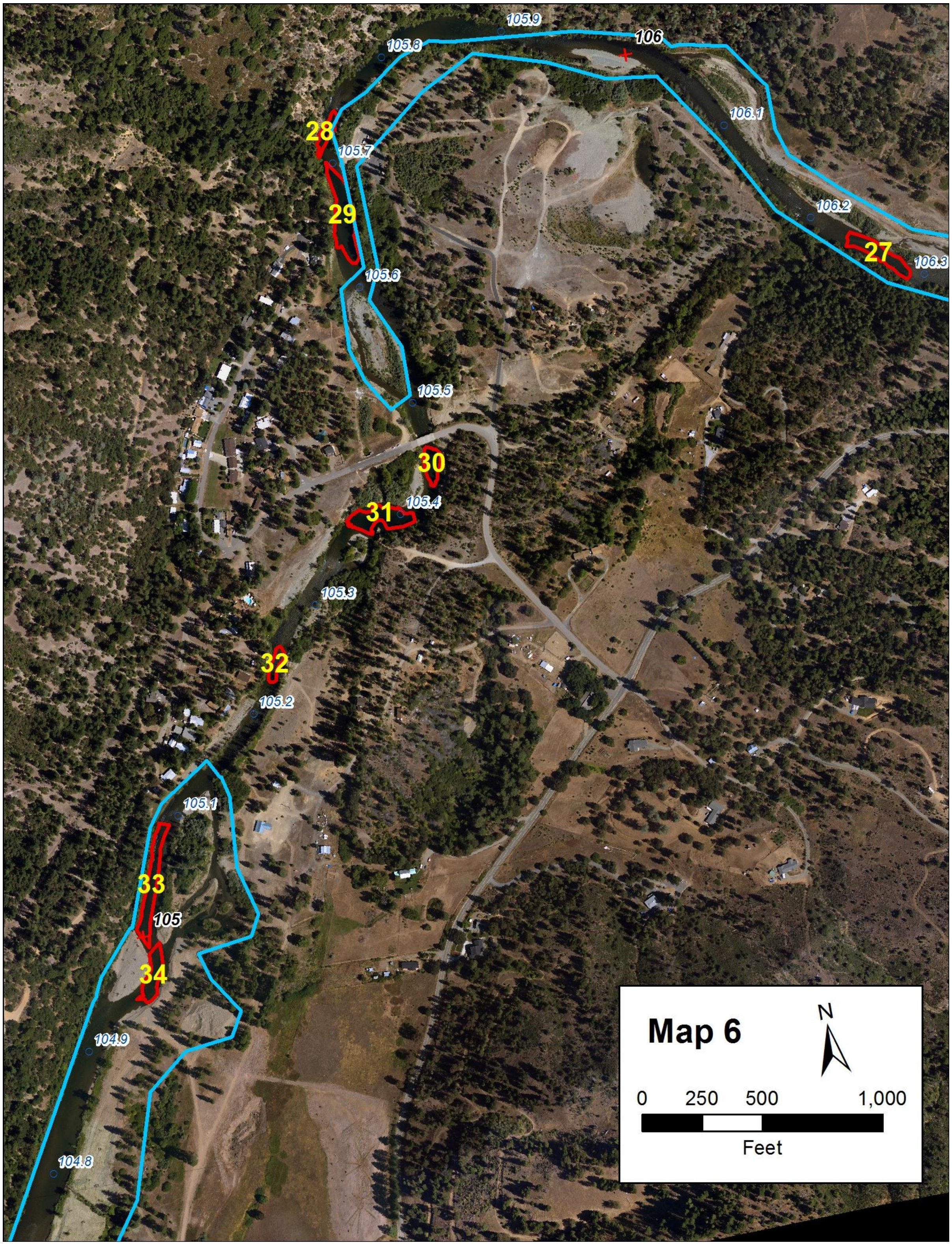
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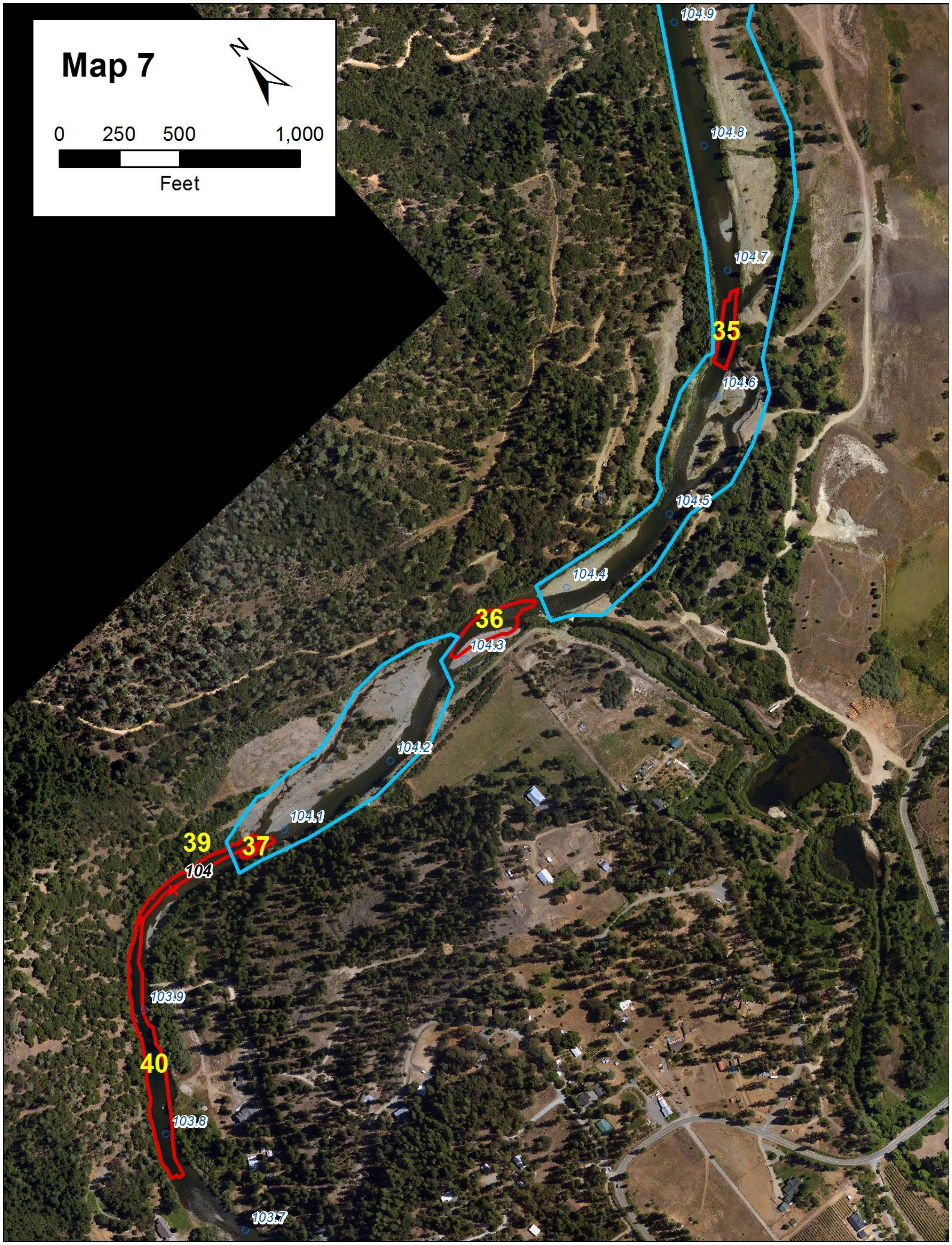
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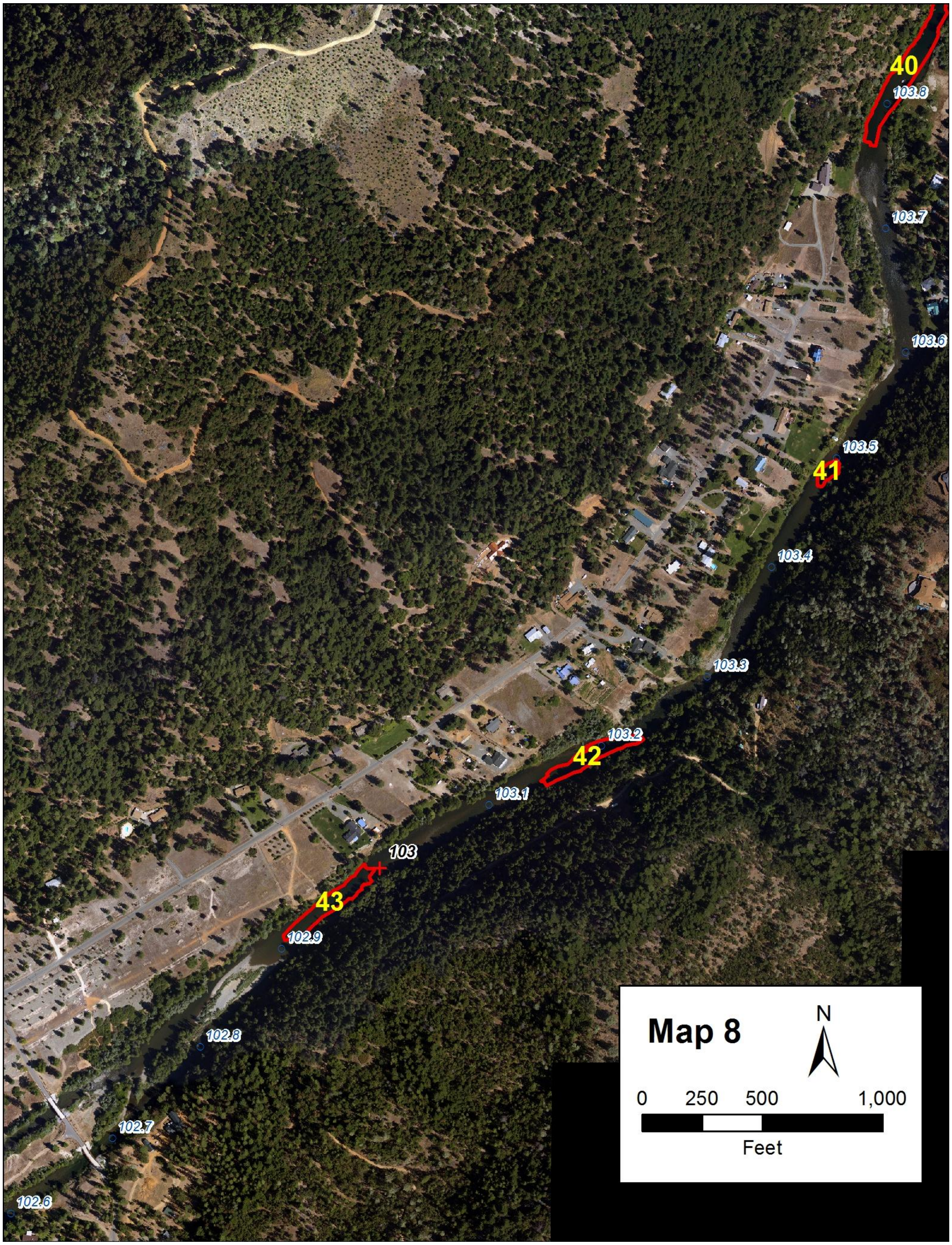
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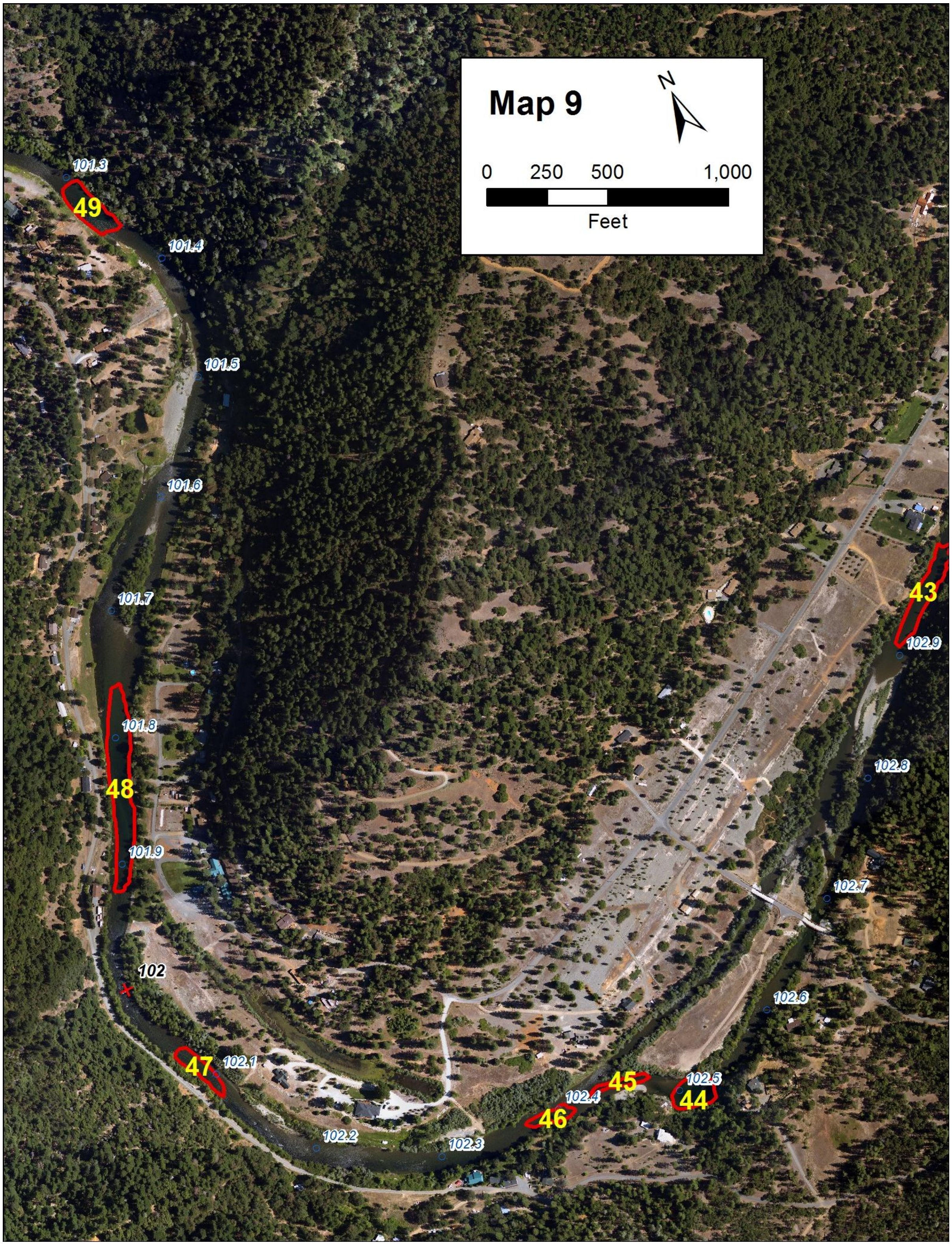
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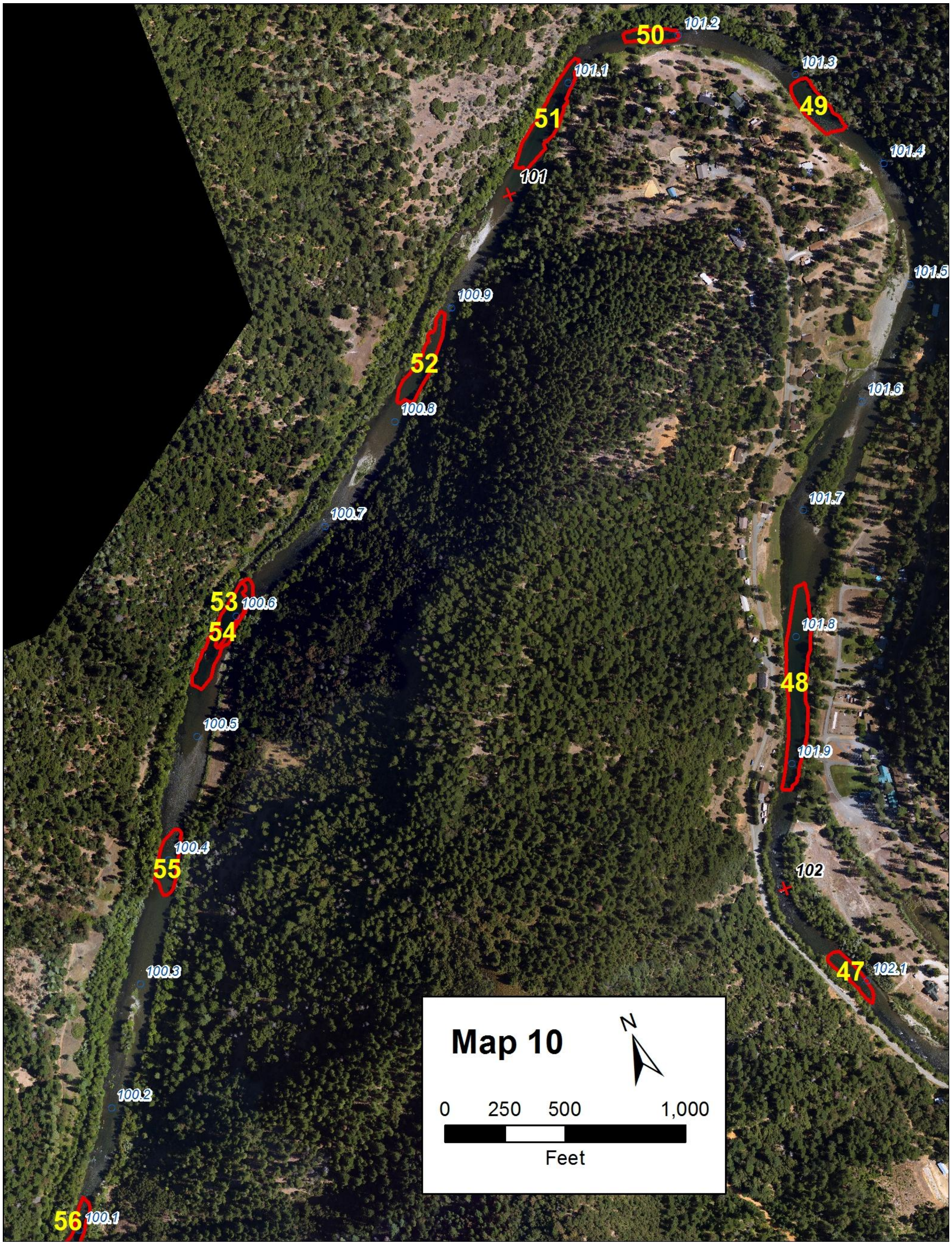
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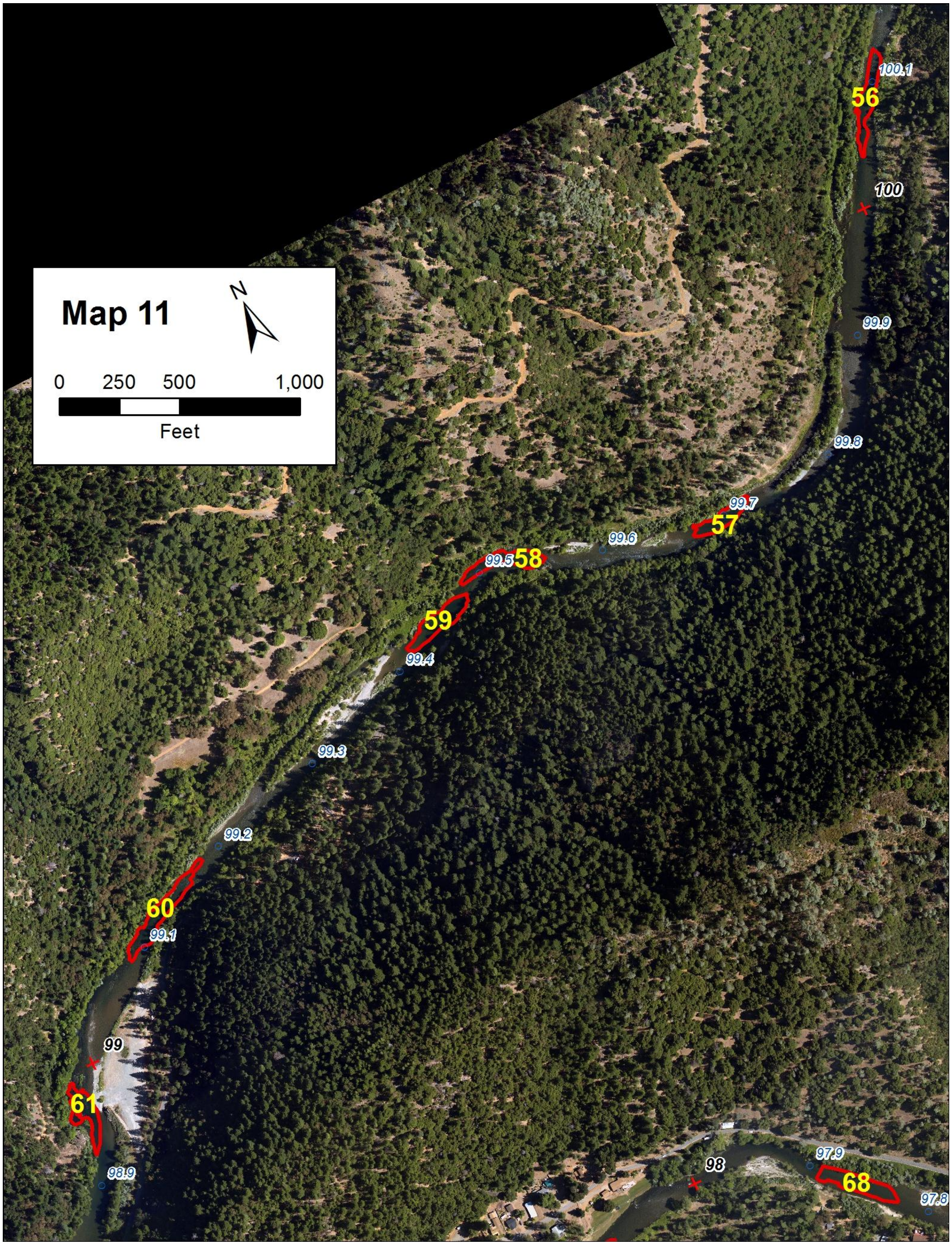
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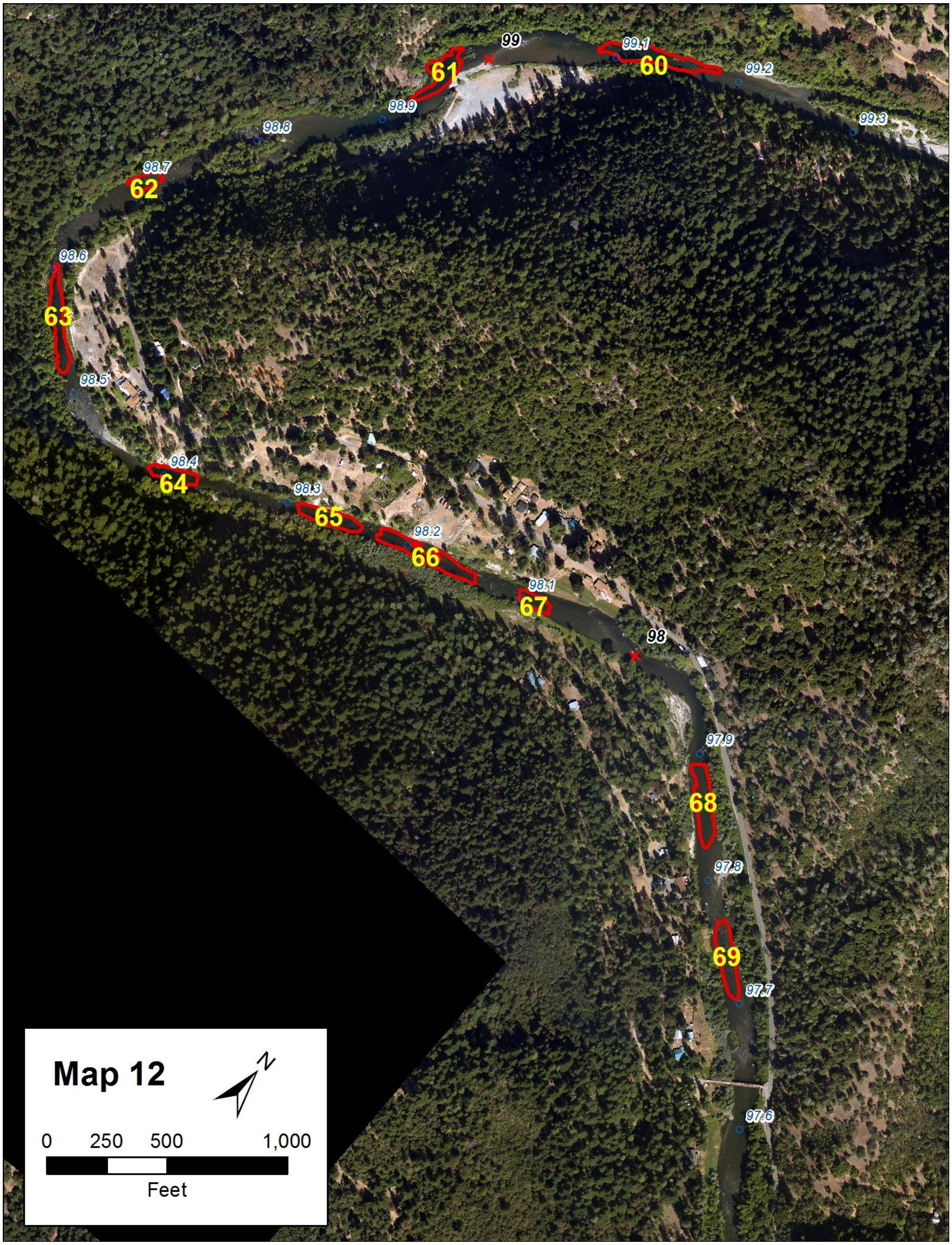
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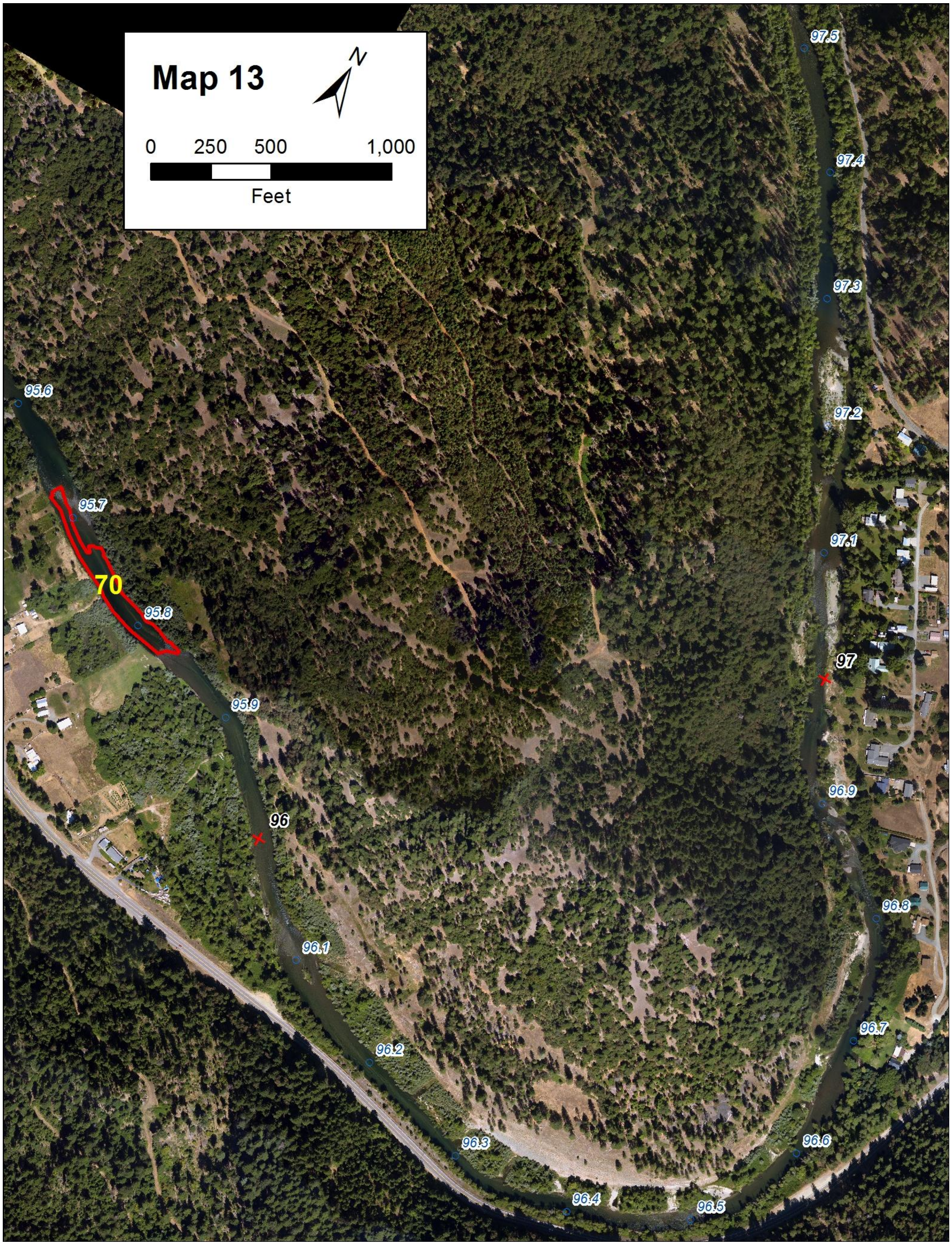
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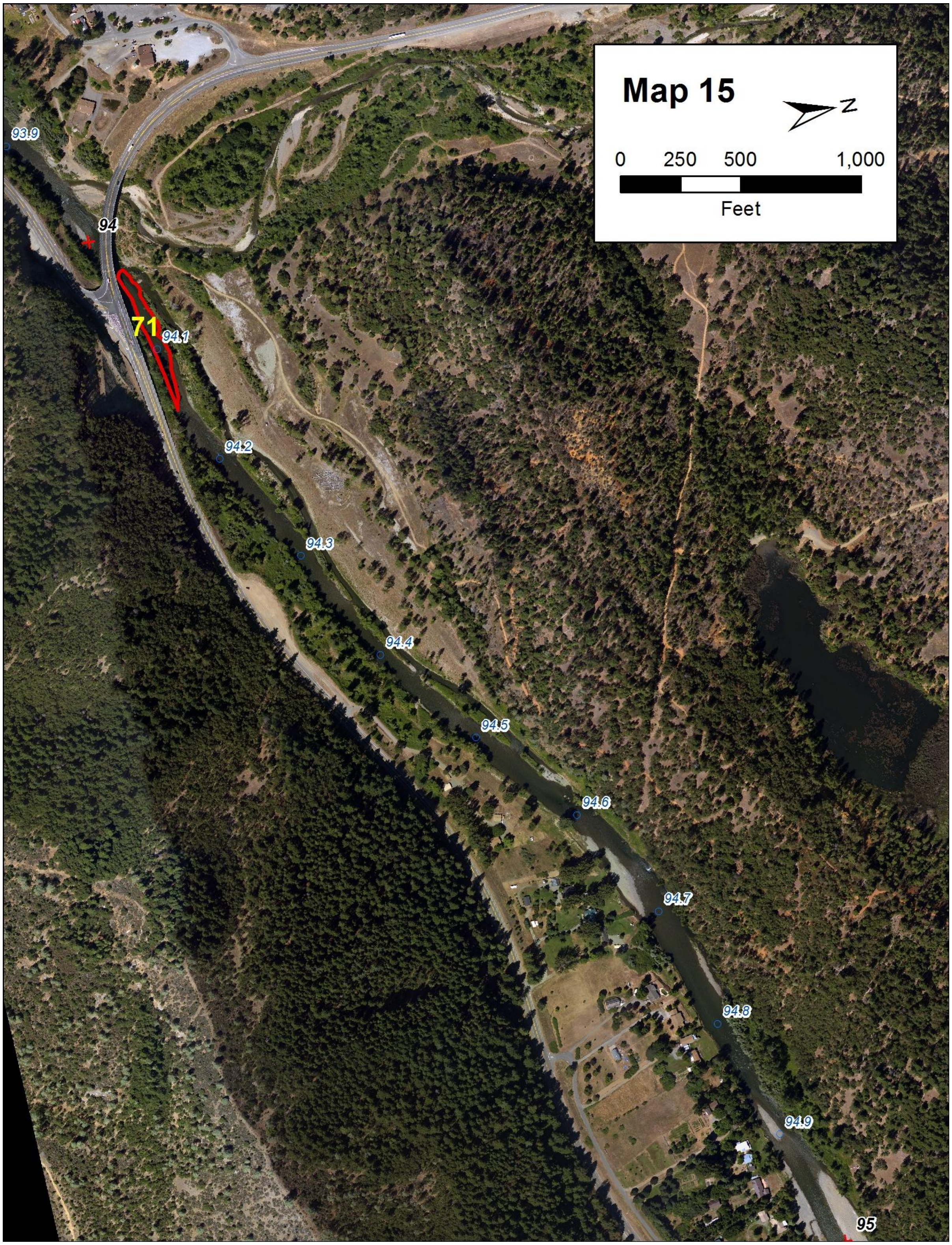
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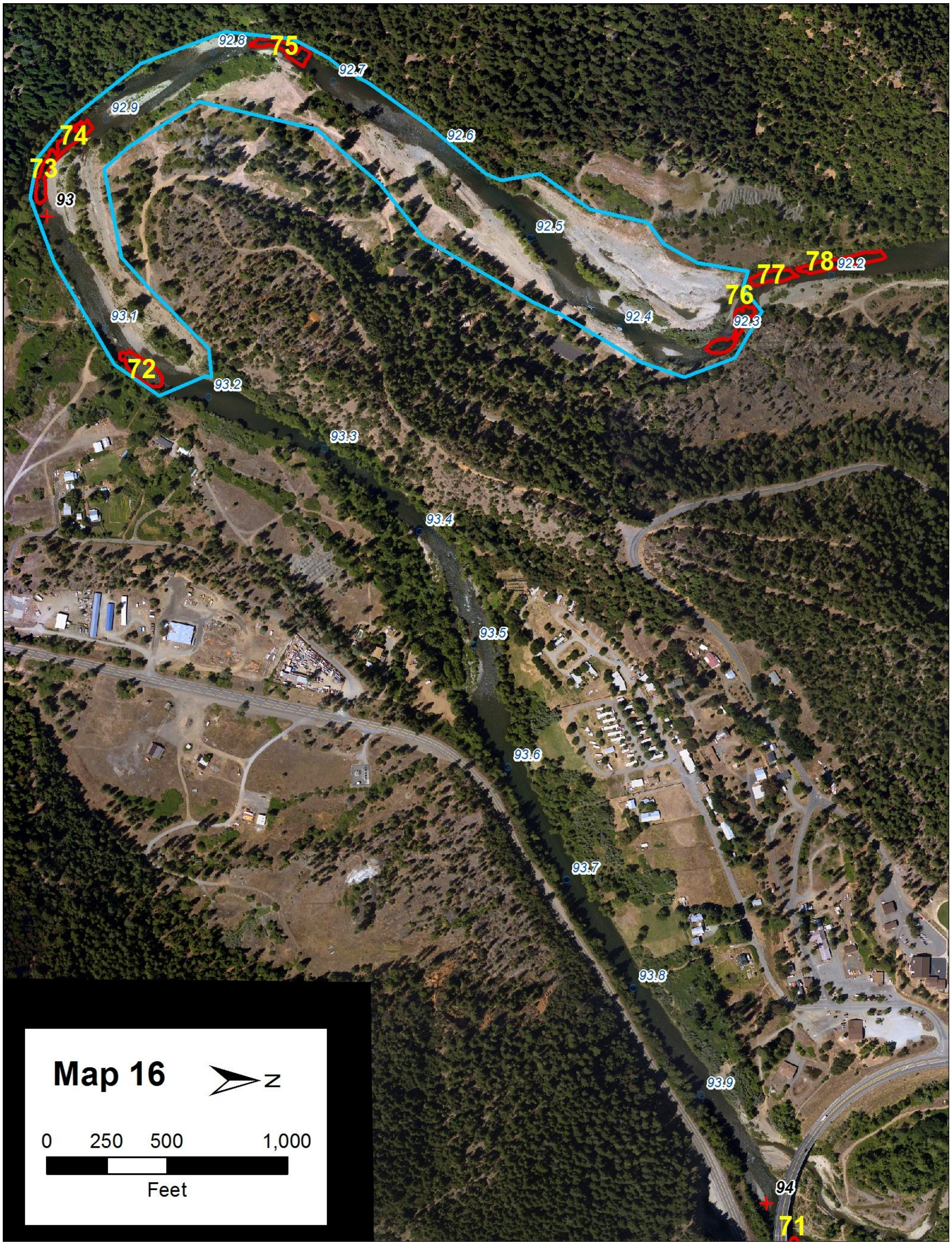
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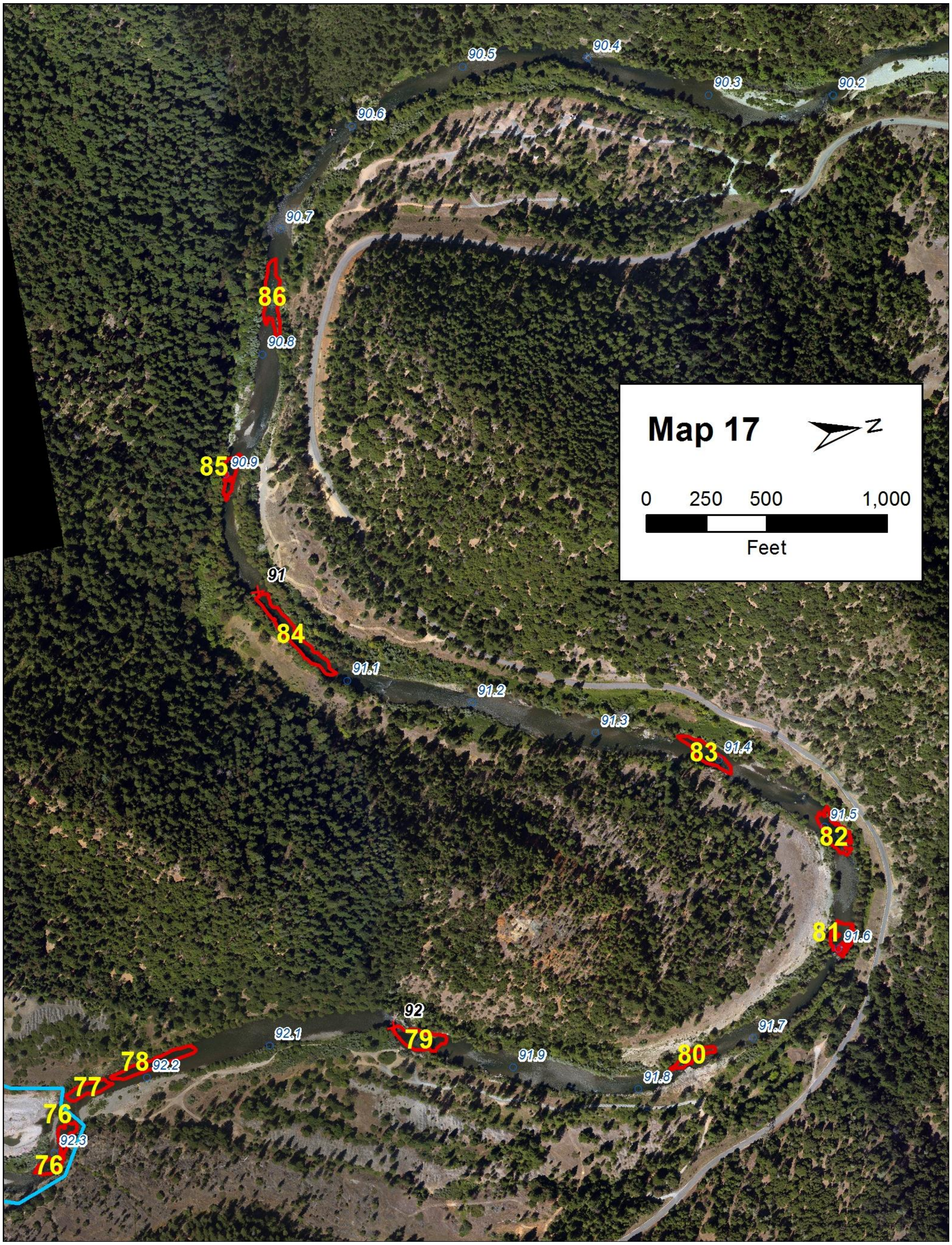
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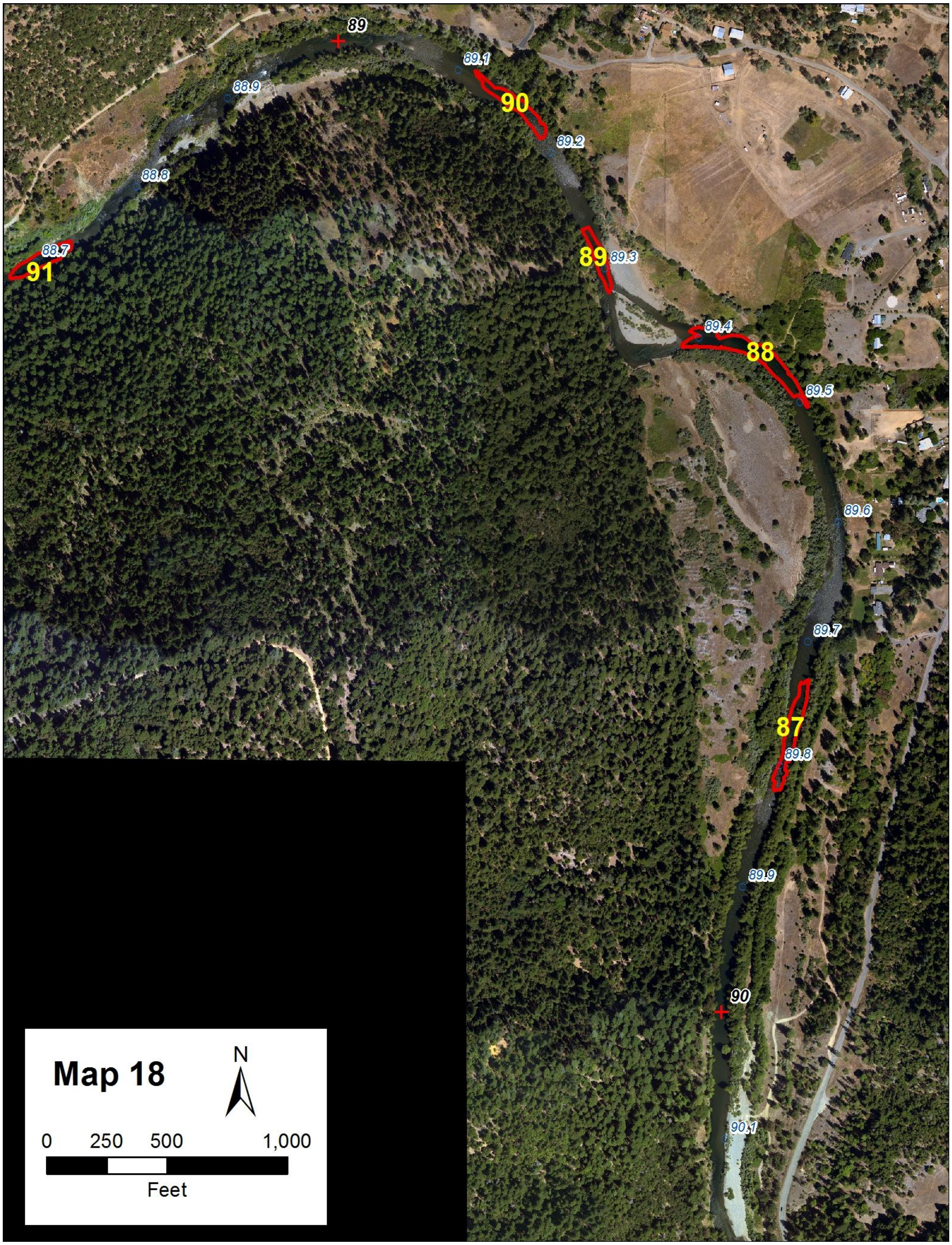
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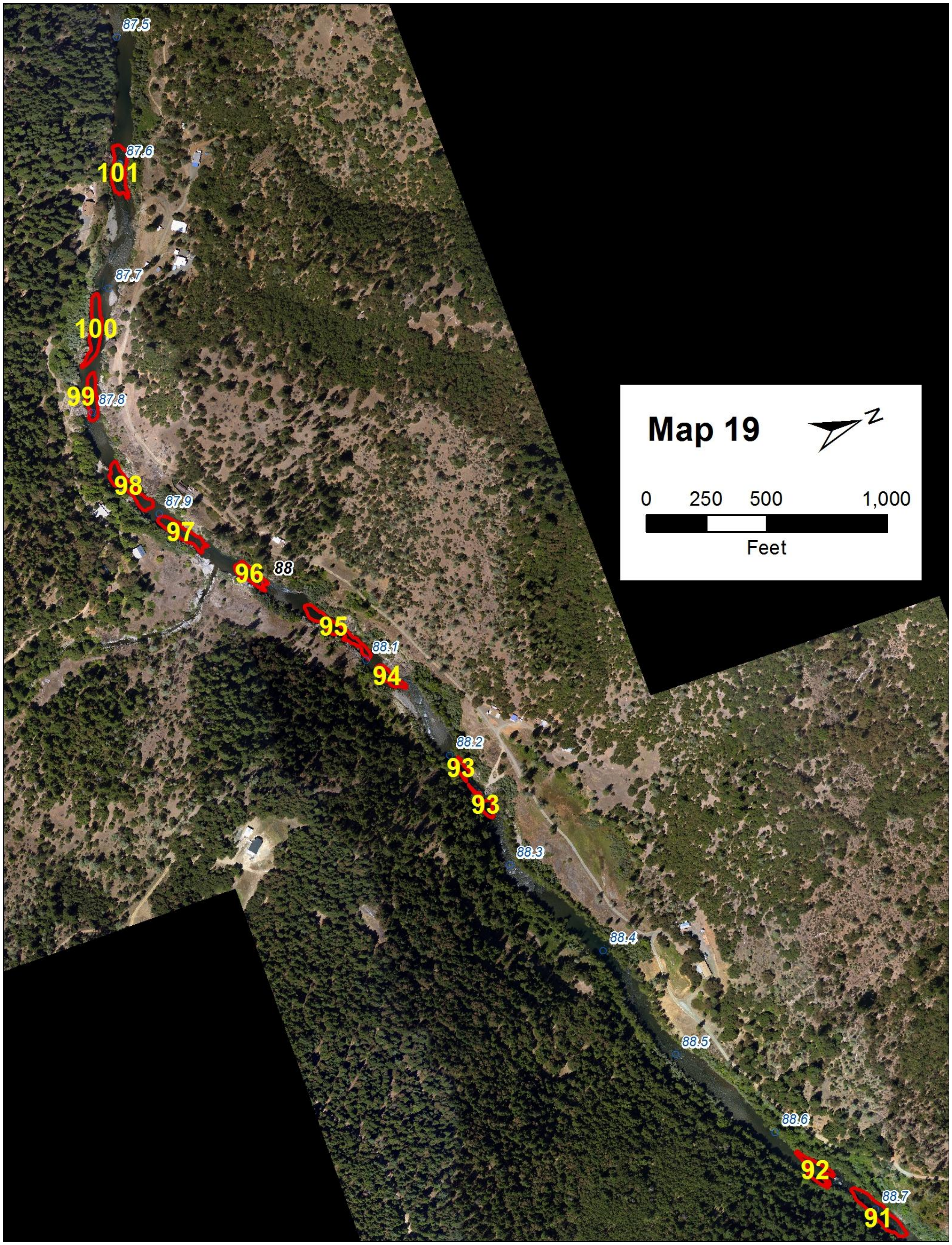
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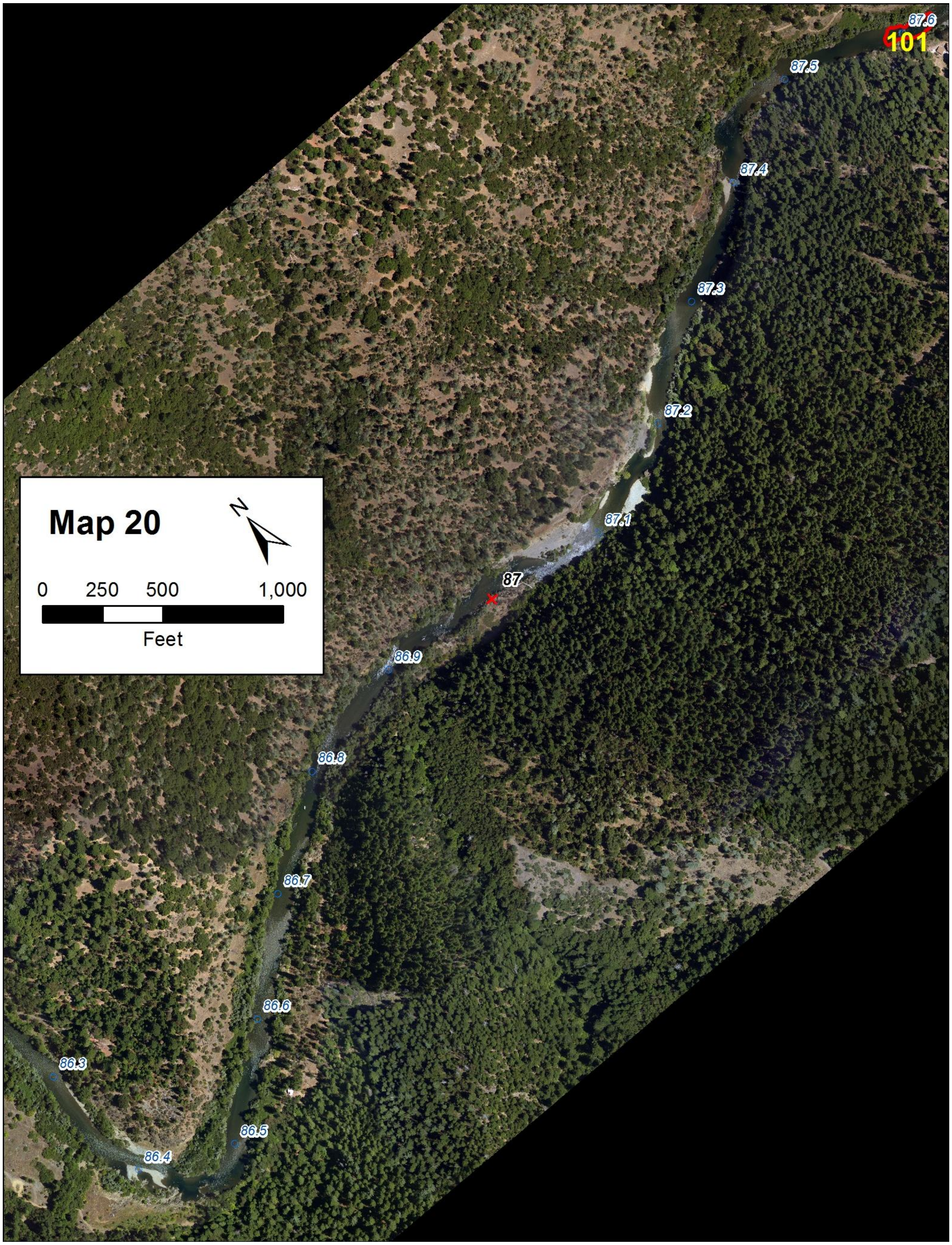
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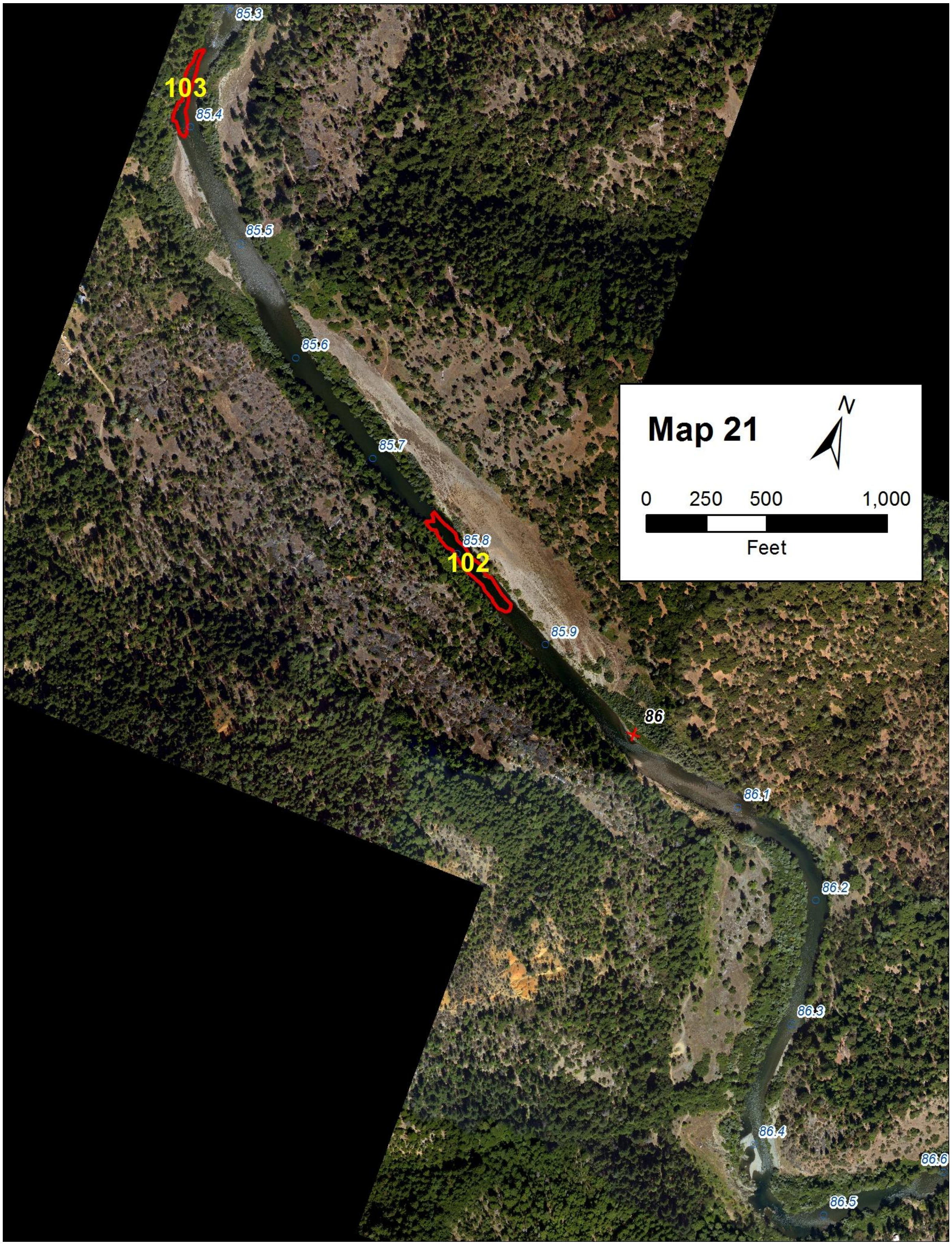
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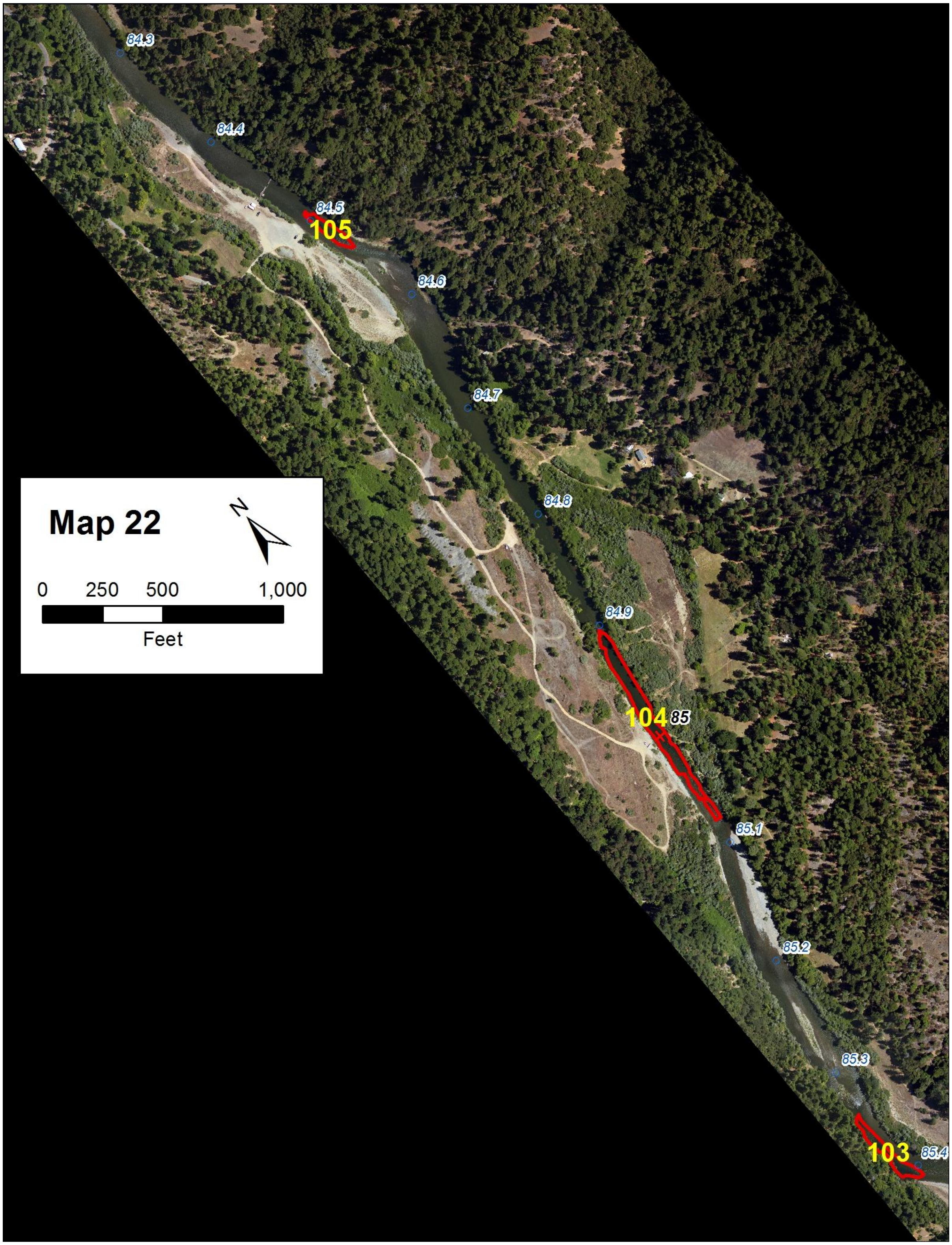
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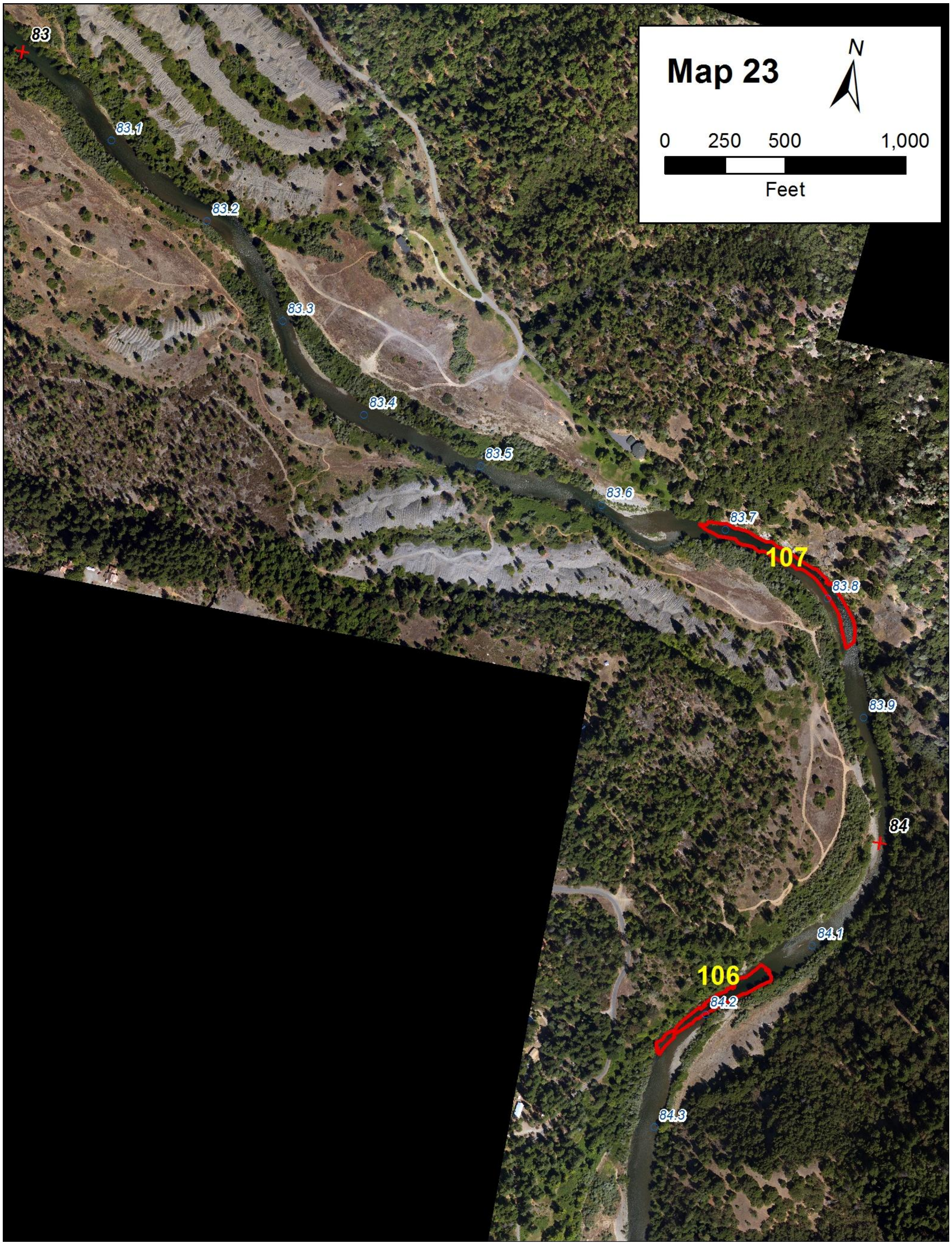
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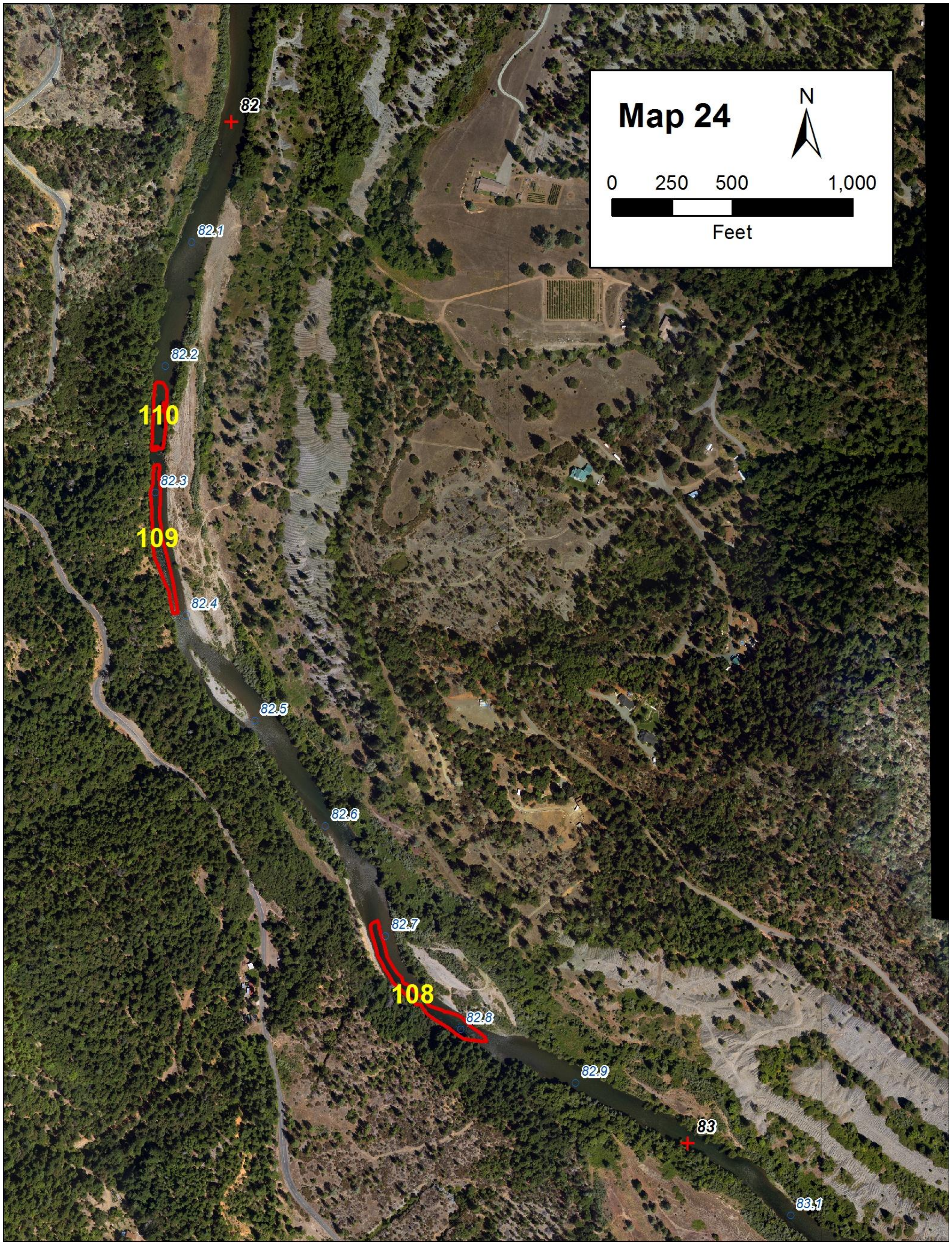
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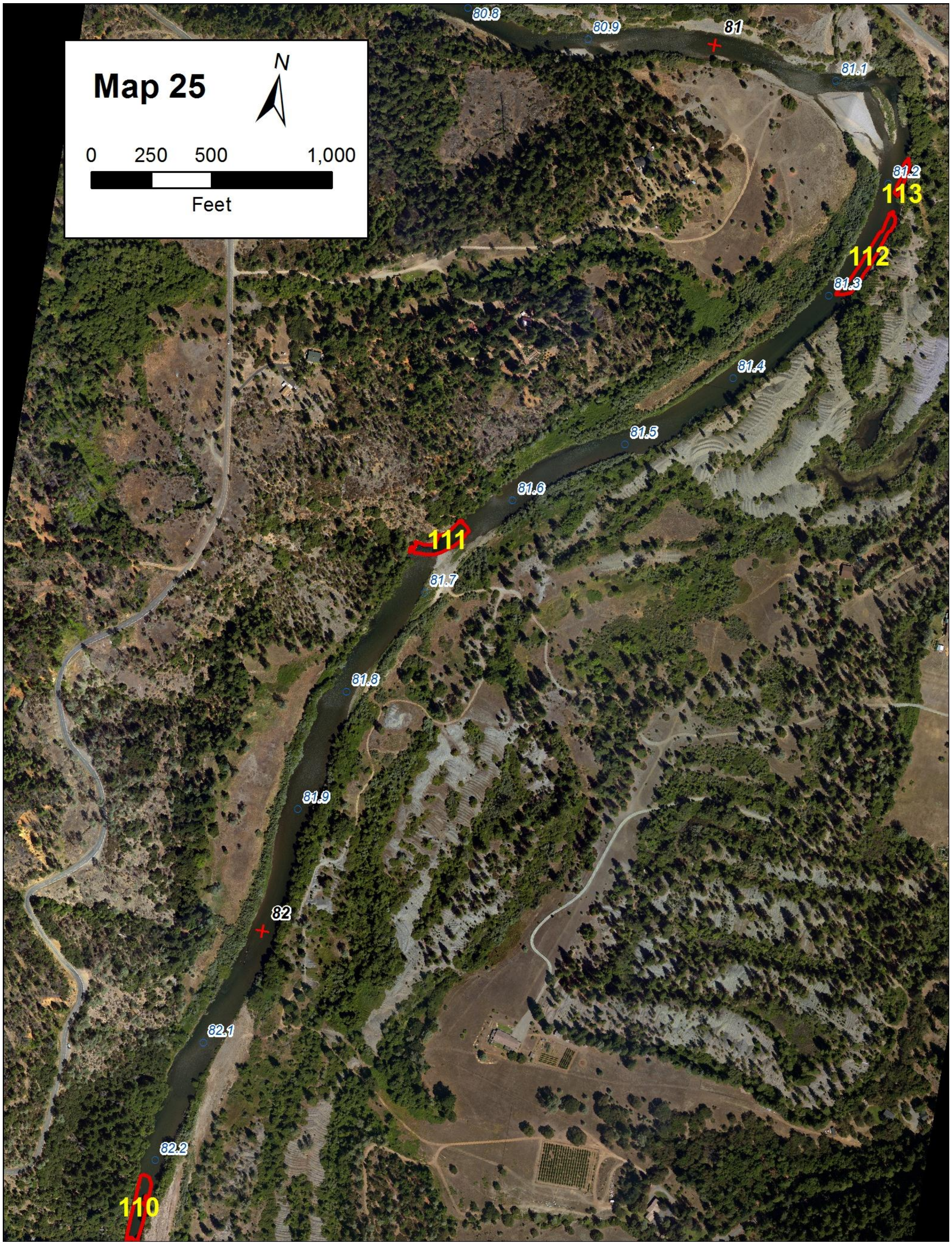
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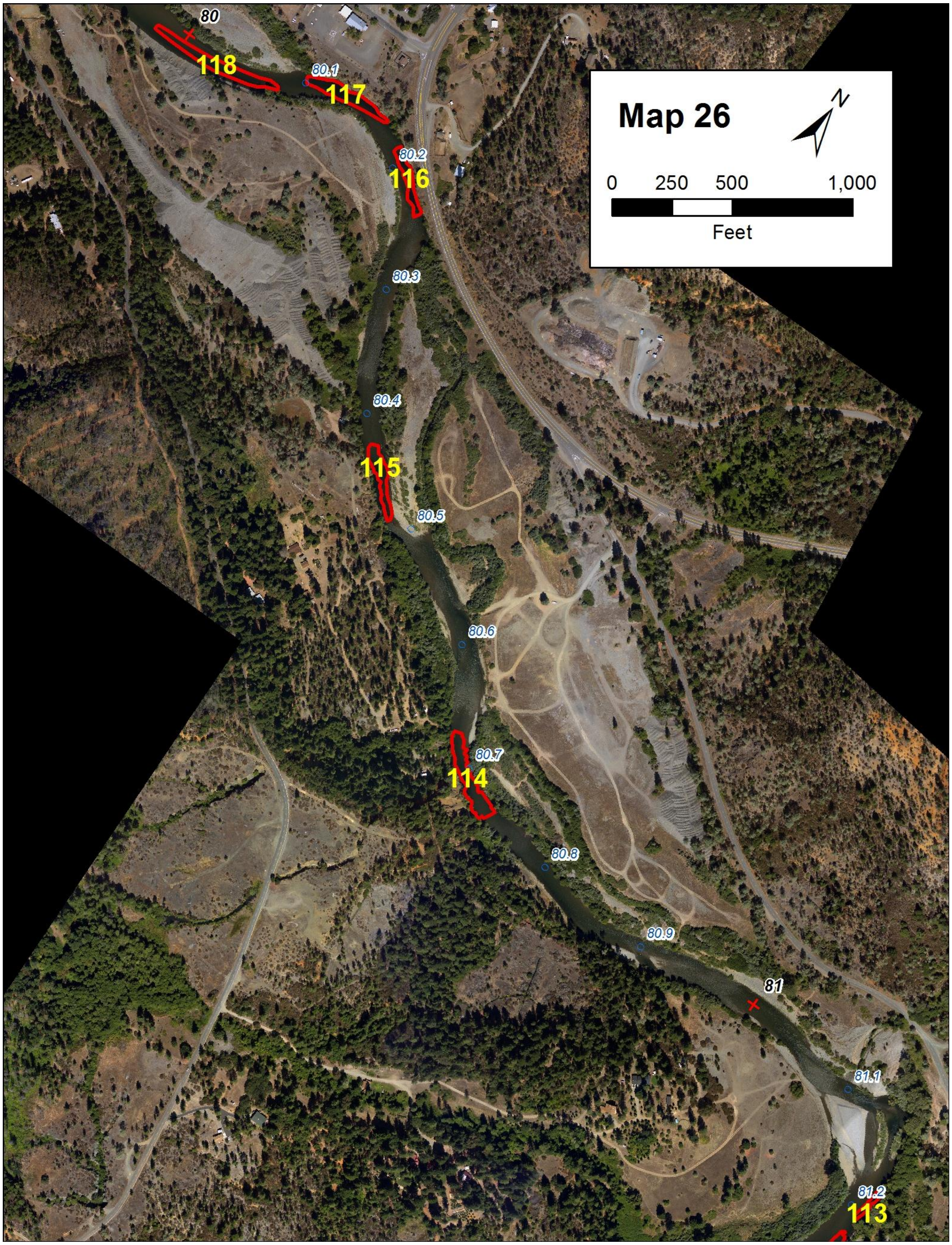
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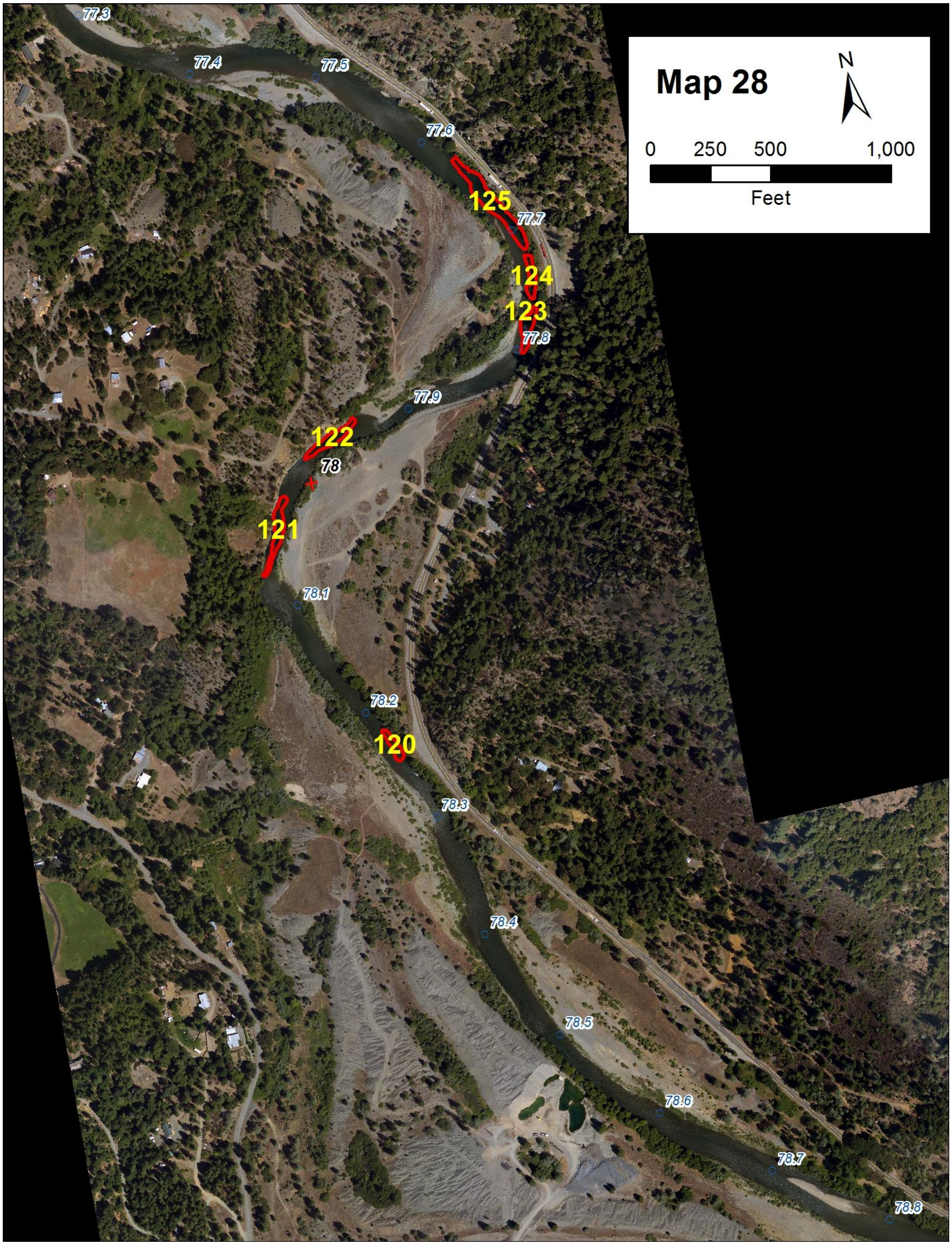
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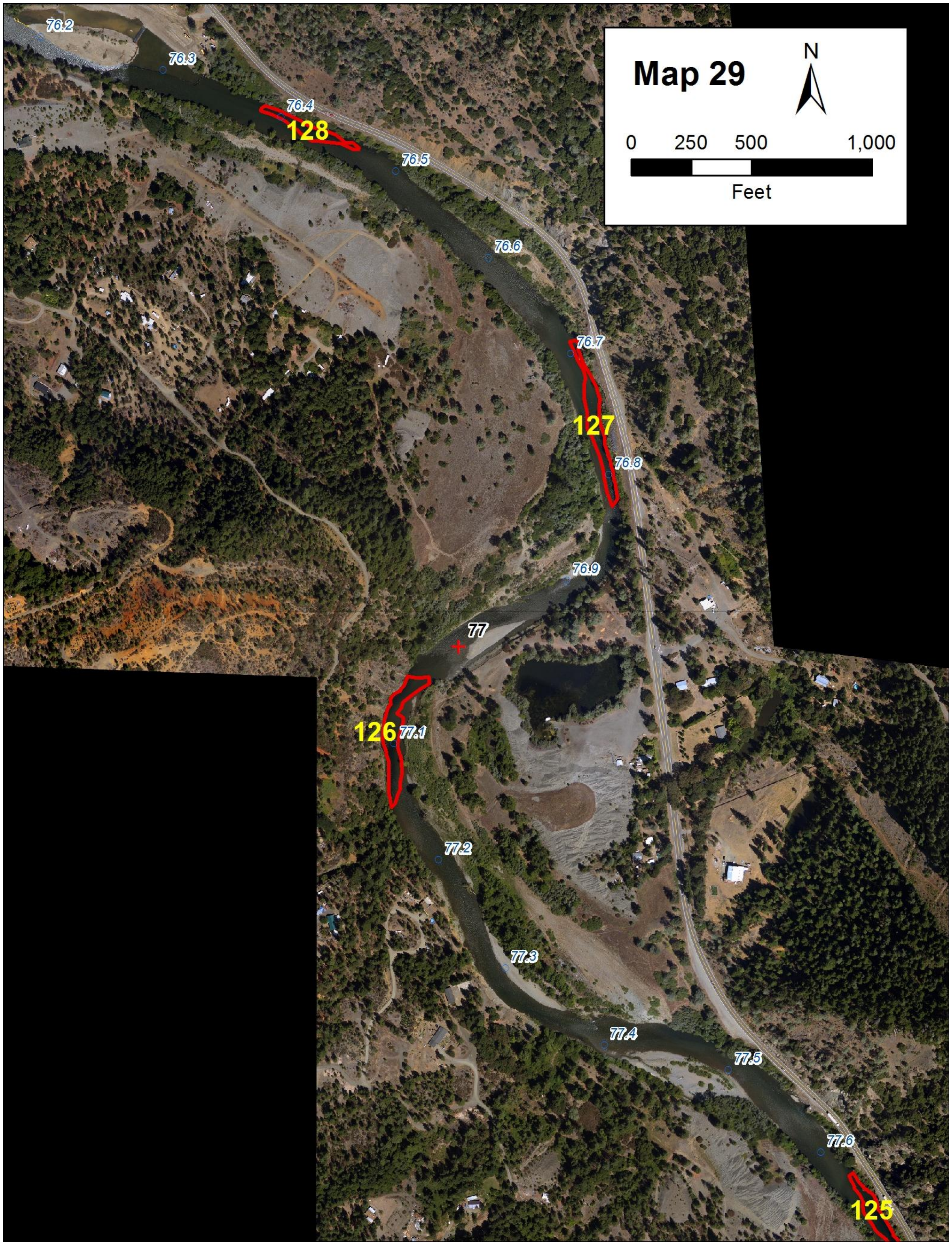
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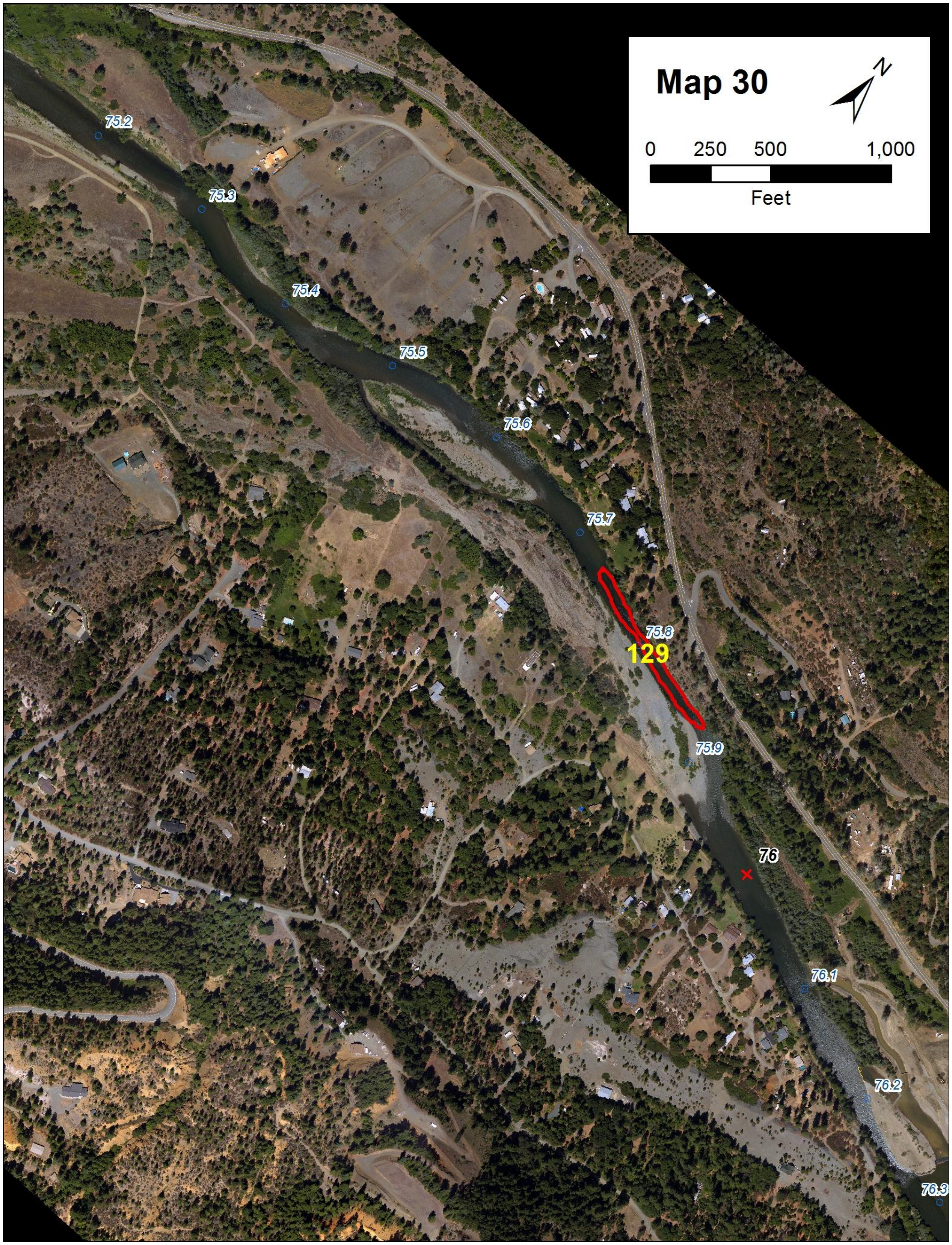
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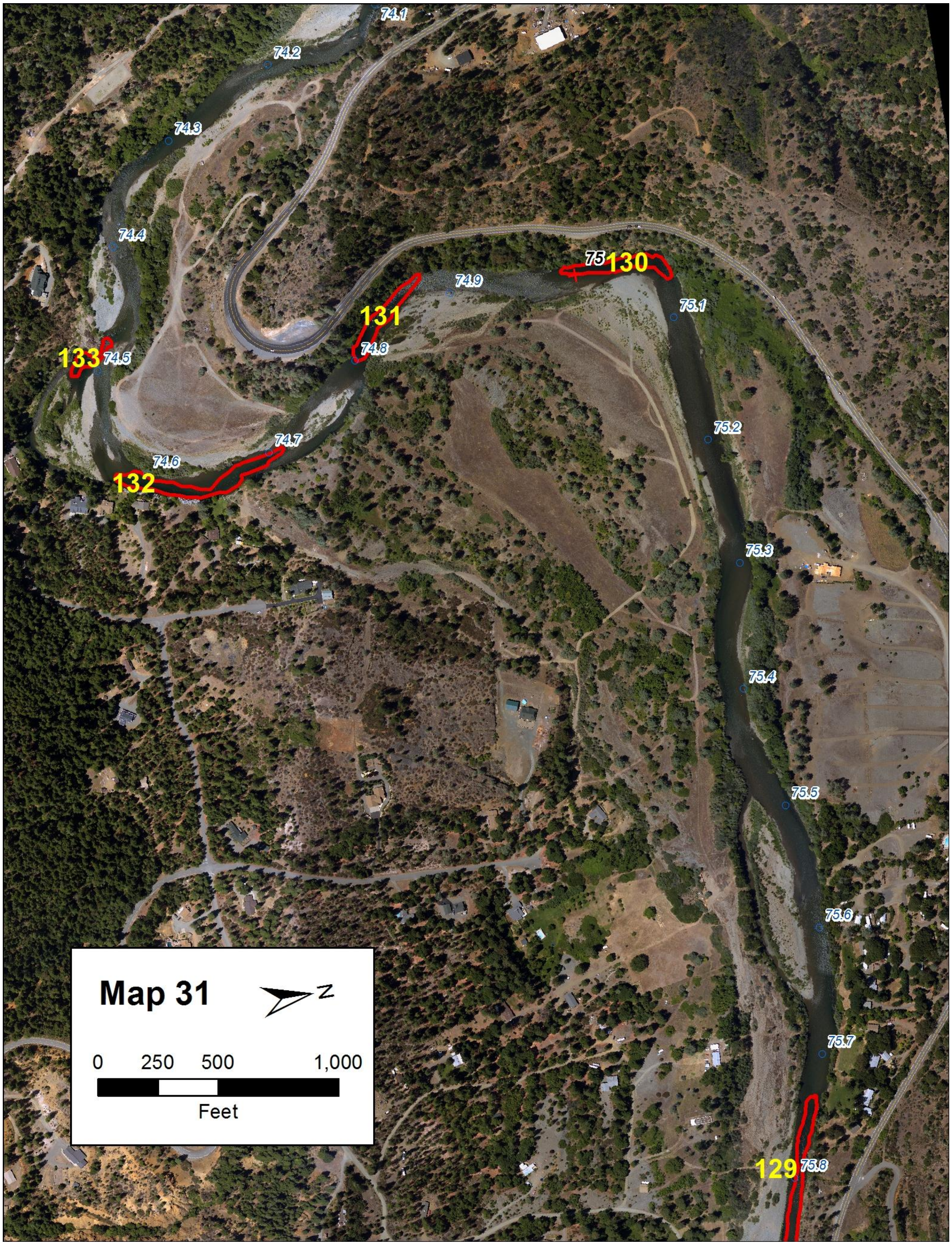
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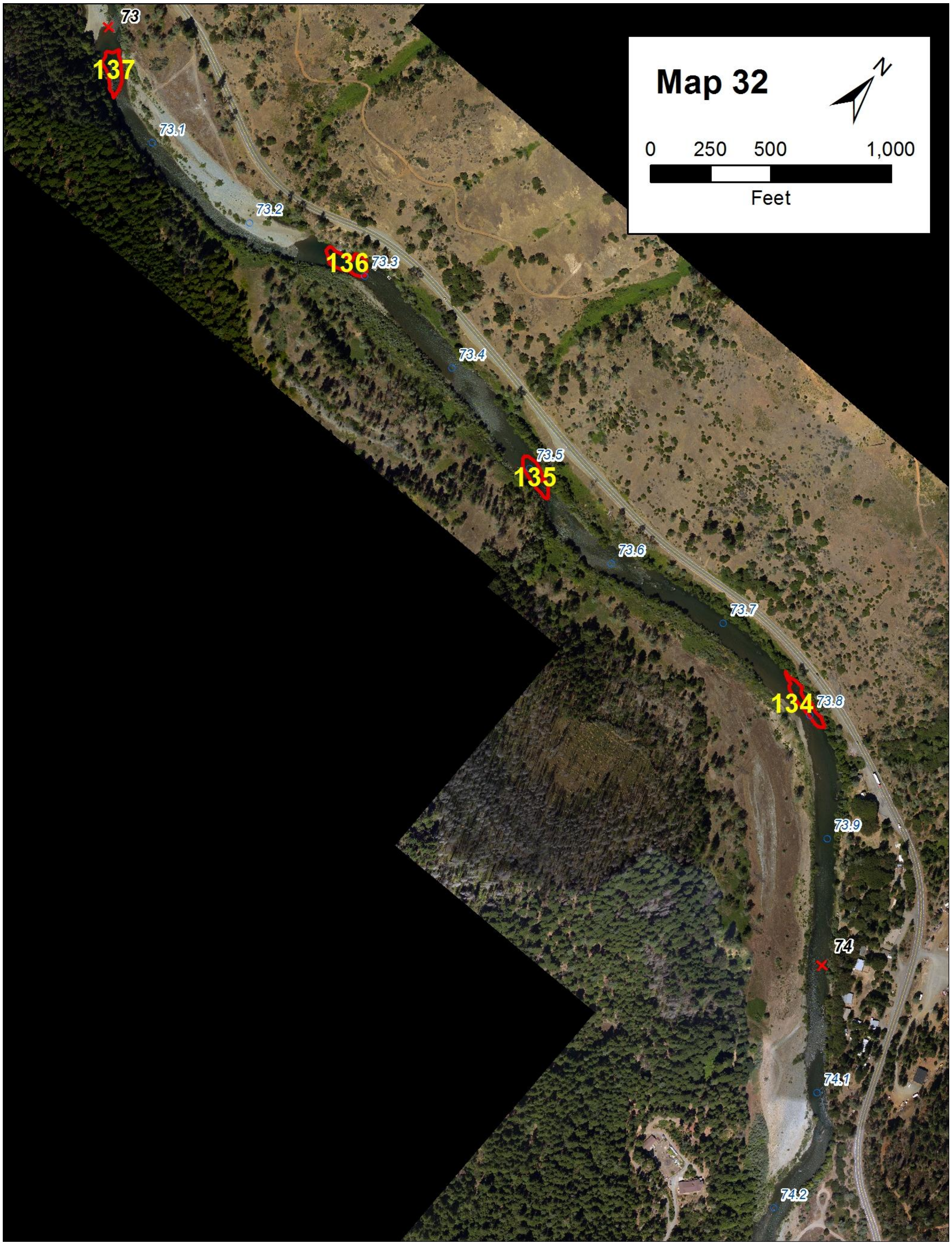
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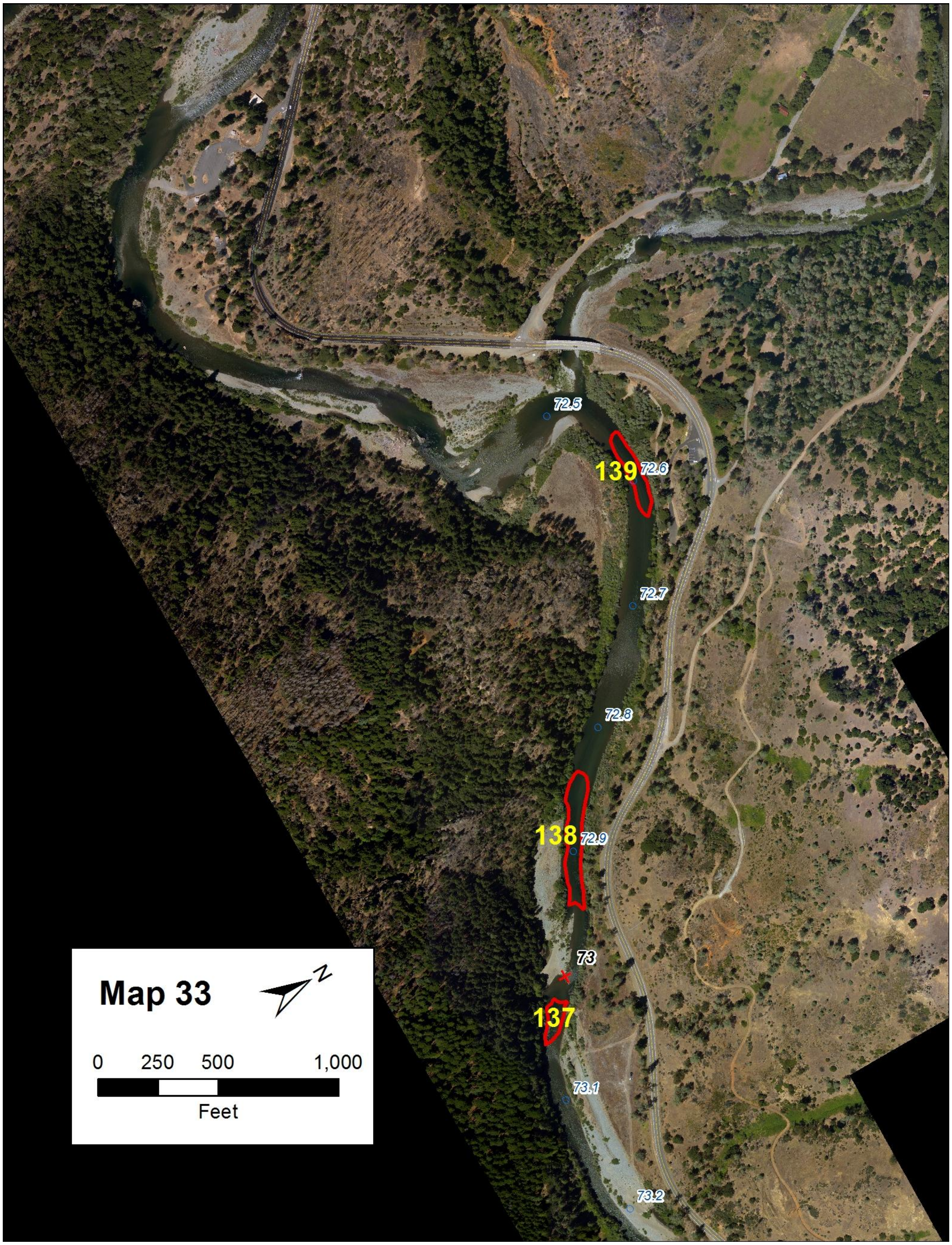
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Map 33
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APPENDIX B

Names and descriptions of polygon locations.
Pool names in common use among local river users are shown in bold font.

Polygon 1, **Diversion Pool** (RM 111.15); surveyed 2009 (low resolution), 2011

Also known as the Weir Hole, this is a hole located immediately downstream from a partially-breached concrete dam. High-flow gravel injections were performed annually at this location from 2008 through 2011. Although sonar was obtained at this location in 2009 and 2011, turbulence and bubbles in the water column interfered with data collection. As a result, the 2009 data are of insufficient density to support gridding and evaluation of bed elevation changes at this location is limited to point-to-point comparisons.

Polygon 2, Deadwood Creek Pool (RM 111.03); surveyed 2009, 2011

The Deadwood Creek pool is located immediately upstream from the mouth of Deadwood Creek at RM 111.03.

Polygon 3, Above New Bridge (RM 110.97); surveyed 2009, 2011

This is the upstream half of a relatively long pool centered under the New Lewiston Bridge. The pool is divided in two because no data exist for the portion of the pool directly under the bridge.

Polygon 4, Below New Bridge (RM 110.94); surveyed 2009, 2011

This is the downstream half of the pool centered under the New Lewiston Bridge. This part of the pool has characteristics of a backwater pool.

Polygon 5, Upper B-2 (RM 110.7); surveyed 2009, 2011

This is a trough located adjacent to the Deadwood Creek rehabilitation project site. The Trinity River Task Force assigned the name “B-2” to a pool that was dredged in this general area in the late 1970s.

Polygon 6, Lower B-2 (RM 110.63); surveyed 2009, 2011

This is a backwater pool located in the upstream part of the Cableway rehabilitation project site. It is contiguous with the Upper B-2 trough and is also in the general area occupied by the B-2 pool dredged in the late 1970s.

Polygon 7, Old Bridge (RM 110.2); surveyed 2009, 2010, 2011

This is a convergence area at the downstream end of the Cableway rehabilitation project site and immediately upstream from the Old Lewiston Bridge. Construction of the Cableway project in 2008 included placement of a gravel bar along the left bank adjacent to the Old Bridge polygon, as well as placement of several other bars farther upstream within the project site.

Polygon 8, Hoadley Bar (RM 109.98); surveyed 2009, 2011

This polygon covers a trough along the outside of a bend directly opposite a constructed point bar placed in 2008 as part of the Hoadley Gulch rehabilitation project.

Polygon 9, Hoadley Pool (RM 109.9); surveyed 2009, 2011
This polygon covers a long trough that is contiguous with and downstream from the Hoadley Bar polygon.

Polygon 10, Upper Cemetery Run (RM 109.5); surveyed 2009, 2010, 2011
This is an area that has been identified as a steelhead run by local fishermen and classified as a trough for this report. In 2009 a gravel bar was placed along the left bank immediately upstream from this polygon as part of the Sawmill rehabilitation project.

Polygon 11, Upper Cemetery Pool (RM 109.47); surveyed 2009, 2010, 2011
This pool is located just upstream from the apex of a 90-degree bend where the river encounters bedrock along the left valley wall.

Polygon 12, **Cemetery Hole** (RM 109.43); surveyed 2009 (low resolution), 2010, 2011
This is the deep hole located at the apex of a 90-degree bend where the river encounters bedrock along the left valley wall. Sonar was collect in Cemetery Hole in 2009, 2010, and 2011, but the 2009 data are too sparse to support gridding. Evaluation of bed elevation changes between 2009 and 2010 is therefore limited to a point-to-point comparison. This limitation is particularly relevant to the issues being investigated in this report because pool depths at this location may have been impacted by construction of the Sawmill rehabilitation project in 2009.

Polygon 13, Below Cemetery (RM 109.39); surveyed 2010, 2011
This is a trough along the left valley wall immediately downstream from Cemetery Hole. Sonar was collected within this polygon in 2010 and 2011 only, limiting its value for evaluating the impacts of the 2009 Sawmill rehabilitation project.

Polygon 14, Sawmill Forced Meander 1 (RM 109.35); surveyed 2010, 2011
This pool polygon covers the constructed meander excavated into the right bank in the upstream half of the Sawmill rehabilitation project site. No pool was present at this location prior to project construction, but formation of a pool in the constructed bend and near a large wood structure was anticipated by the site designers.

Polygon 15, Sawmill Forced Meander 2 (RM 109.13); surveyed 2010, 2011
This pool polygon covers another constructed meander excavated into the right bank near the downstream end of the Sawmill rehabilitation project site. No pool was present at this location prior to project construction, but formation of a pool in the constructed bend was anticipated by the site designers.

Polygon 16, **Sawmill Burner** (RM 109); surveyed 2008, 2010, 2011
Sawmill Burner Hole is located at the apex of a sharp bend to the left where the river encounters bedrock along its right bank. The hole was used as a high-flow gravel injection point several times, most recently in 2008 and 2009. Gravel injected into the hole during the 2008 high-flow release cleared from the hole during the release, but gravel injected during the 2009 release did not. Failure for gravel to clear the hole in 2009 is hypothesized to be at least partially related to terrace and floodplain lowering on the opposite bank as part of the

Sawmill rehabilitation project. Sonar collected in 2009 is of no use for quantifying the magnitude of aggradation at this location because the hole was already filled when the 2009 sonar was collected. However, bed elevations in much of the Sawmill Burner Hole are captured by sonar collected as part of a special survey effort conducted in 2008. Thus, the comparisons presented for the Sawmill Burner Hole include data collected in 2008, 2010, and 2011. This is the only location discussed in this report in which sonar obtained prior to 2009 is utilized.

Polygon 17, Lower Burner 1 (RM 108.93); surveyed 2009, 2010, 2011
This polygon covers the more upstream of two short troughs along the right bank downstream from the Sawmill Burner Hole. This reach receives any augmented gravel that passes downstream from the Sawmill area.

Polygons 18, Lower Burner 2 (108.88); surveyed 2009, 2011
This polygon covers the more downstream of two short troughs along the right bank downstream from the Sawmill Burner Hole. This reach receives any augmented gravel that passes downstream from the Sawmill area.

Polygon 19, RM108.8; surveyed 2010, 2011
This polygon covers a trough along the right bank immediately downstream from a low-amplitude medial bar. This reach receives any augmented gravel that passes downstream from the Sawmill area.

Polygon 20, RM108.7; surveyed 2010, 2011
This polygon is classified as a baseflow backwater area. It is relatively shallow with a maximum depth of less than 3 ft, but is included in this analysis simply because 2010 and 2011 data are available to evaluate changes.

Polygon 21, **Rush Creek Pool** (RM 108.1); surveyed 2009, 2011
This is the large backwater pool upstream from the Rush Creek delta.

Polygon 22, RM107.55; surveyed 2009, 2011
This polygon covers a region of flow convergence between 2 riffles at the downstream end of the Rush Creek delta.

Polygon 23, Salt Flat 1 (RM106.85); surveyed 2009, 2011
This polygon covers the upstream part of what was a relatively deep run prior to construction of the Dark Gulch rehabilitation project in 2008. That rehabilitation project included substantial lowering of a terrace on river right at this location. It is classified as baseflow backwater zones for the purposes of this report.

Polygon 24, Salt Flat 2 (106.8); surveyed 2009, 2011
This polygon covers the upstream part of what was a relatively deep run prior to construction of the Dark Gulch rehabilitation project in 2008. That rehabilitation project included substantial lowering of a terrace on river right at this location. It is classified as baseflow backwater zones for the purposes of this report.

Polygon 25, Gold Bar (RM 106.6); surveyed 2009, 2010, 2011
The Gold Bar polygon encompasses a deep hole at the downstream end of Gold Bar.

Polygon 26, Lower Gold Bar Pool (RM 106.5); surveyed 2009, 2010, 2011
Lower Gold Bar is a large backwater pool.

Polygon 27, RM106.25; surveyed 2009, 2011
This pool is immediately downstream from an excavation into the right bank implemented as part of the Dark Gulch rehabilitation project in 2008.

Polygon 28, **Dirty Bird** (RM 105.72); surveyed 2009, 2011
Dirty Bird is a short trough located along the right bank where the bedrock valley wall forces the channel to curve sharply to the left. A portion of this unit could be considered a hole, but turbulence and aerated water in that area interfered with the collection of sonar data. That area was therefore excluded from this analysis.

Polygon 29, Bucktail Island Backwater (RM 105.65); surveyed 2009, 2011
This polygon is located immediately downstream from Dirty Bird and just upstream from a large bar in the backwater zone upstream from Bucktail Bridge.

Polygon 30, Upper Bucktail Pool (RM 105.45); surveyed 2009, 2011
Upper Bucktail Pool is immediately downstream from Bucktail Bridge where the channel encounters the valley wall and begins to curve to the right.

Polygon 31, **Bucktail Hole** (RM 105.4); surveyed 2009, 2010, 2011
Bucktail Hole is a deep hole where bedrock protrudes into the channel along the left valley wall, forcing sreamflow to the right.

Polygon 32, RM105.25; surveyed 2009, 2011
This polygon covers a small trough next to bedrock along the right bank.

Polygon 33, Upper Lowden (RM 105.05); surveyed 2009, 2010, 2011
This polygon spans a long trough next to bedrock along the right bank upstream from a forced meander constructed as part of the Lowden Ranch rehabilitation site in 2010.

Polygon 34, Lowden Forced Meander (RM 104.95); surveyed 2010, 2011
This pool polygon covers the upstream two-thirds of the forced meander constructed at the Lowden Ranch rehabilitation site in 2010. Site designers anticipated the potential for pool formation along the outside of the bend.

Polygon 35, Lowden Floodplain Convergence (RM 104.65); surveyed 2009, 2010, 2011
This area covered by this polygon is a region of flow convergence at the downstream end of a floodplain constructed at part of the Lowden Ranch rehabilitation project. Site designers anticipated the potential for scour in this area.

Polygon 36, **Wellock Pool** (RM 104.3); surveyed 2009, 2010, 2011
Wellock Pool is located immediately downstream from the Lowden Ranch rehabilitation site and at the upstream end of the Trinity House Gulch rehabilitation site, both of which were constructed in 2010. Wellock Pool itself was created by dredging in the late 1980s.

Polygons 37 and 38, Little Tree 1 and Little Tree 2 (RM 104.07); survey dates below
The area near these polygons has been identified as a steelhead run by local fishermen, and the area is considered a trough for purposes of this report. The Trinity House Gulch rehabilitation design included placement of a gravel bar along the left bank in the upstream portion of this trough. The impact of that placement, both where the gravel was placed in portions of the run immediately downstream, can be evaluated by sonar collected in 2010 and 2011. However, the 2010 sonar covers only about half of the area covered by the 2011 sonar. The remainder of that area can be compared against 2009 sonar, which covers a larger region than the 2010. Thus, 2 different polygons are used to assess changes at this location: Little Tree 1 includes the area where 2009 and 2011 data are available whereas Little Tree 2 includes the sub-area where 2010 and 2011 data are also available.

Polygon 39, Trinity House (RM 104); surveyed 2010, 2011
The Trinity House polygon encompasses a long trough along the right bank where the channel begins a curve to the left.

Polygon 40, **SP-Ponderosa** (RM 103.85); surveyed 2009, 2010, 2011
This polygon contains a continuation of the Trinity House trough that incorporates a pair of discrete pools (SP and Ponderosa Pools).

Polygon 41, RM103.5; surveyed 2009, 2011
This is a small pool located in the upstream part of the right-bank Poker Bar residential subdivision.

Polygon 42, **Tom Lang** (RM 103.2); surveyed 2009, 2011
Tom Lang pool is located near the middle of the right-bank Poker Bar residential subdivision.

Polygon 43, RM102.95; surveyed 2009, 2011
This is a backwater pool located upstream from the near the main Poker Bar Island.

Polygon 44, **Stott Hole** (RM 102.5); surveyed 2009, 2011
Stott Hole is a deep hole located where flow impinges on bedrock in the left valley wall at the downstream end of Poker Bar Island.

Polygon 45, Stott Trough (RM 102.45); surveyed 2009, 2011
This trough is located at a linear scour along the edge of Poker Bar Island just downstream from Stott Hole.

Polygon 46, Stott Convergence (RM 102.4); surveyed 2009, 2011
This is a moderately deep area where the channel branches around Poker Bar Island converge into a narrower channel.

Polygon 47, RM102.1; surveyed 2009, 2011
Polygon RM102.1 covers a trough along the left bank adjacent to Poker Bar Road.

Polygon 48, **Society Pool** (RM 101.8); surveyed 2009, 2010, 2011
Society Pool is a large backwater pool in the downstream reach of the greater Poker Bar area. A large wooded island at its downstream end controls hydraulics in the pool.

Polygon 49, **Montana** (RM 101.35); surveyed 2010, 2011
Montana Pool is located near the most downstream residences in the Poker Bar area.

Polygon 50, **Snell** (RM 101.15); surveyed 2009, 2010, 2011
Snell Pool is located at the mouth of China Gulch at the most downstream extent of the Poker Bar residential area.

Polygon 51, **Crosby** (RM 101.05); surveyed 2010, 2011
Crosby Pool is located at the beginning of a straight, narrow canyon reach immediately downstream from the Poker Bar area.

Polygon 52, RM100.85; surveyed 2009, 2010, 2011
Polygon RM100.85 covers a backwater pool between 2 riffles near the upstream end of the straight canyon reach between the Poker Bar area and the environmental study limits (ESL) for the potential Limekiln Gulch project.

Polygons 53 and 54, **Leos** 1 and **Leos** 2 (RM 100.6); survey dates below
Leos Pool occupies a mild bend in the straight canyon reach the Poker Bar area and the ESL for the potential Limekiln Gulch project. The Leos 2 polygon defines the extent of sonar data collected in 2010 and 2011, which cover most of the pool. The Leos 1 polygon, which is less than half the size of Leos 2, defines the extent of data collected in 2009. Thus Leos 1 allows for comparisons of bed elevation changes between all three years, whereas Leos 2 allow for comparison of 2010 and 2011 elevations over a wider area.

Polygon 55, Upper Limekiln (RM 100.4); surveyed 2009, 2011
This pool polygon is located near the upstream boundary of the ESL for the potential Limekiln Gulch rehabilitation project, just downstream from the site of feather edge project implemented in the 1990s.

Polygon 56, Limekiln Trough (RM 100.1); surveyed 2009, 2011
This trough is located near the center of the ESL for the potential Limekiln Gulch rehabilitation project.

Polygon 57, Lower Limekiln (RM 99.7); surveyed 2009, 2010, 2011
This pool polygon is located just downstream from the bend to the right and the island at the downstream end of the ESL for the potential Limekiln Gulch rehabilitation project.

Polygon 58, RM99.5; surveyed 2009, 2010, 2011
Polygon RM99.5 covers a trough along the right bank in a low-amplitude bend to the left.

Polygon 59, Upper Steel Bridge (RM 99.45); surveyed 2009, 2010, 2011
The Upper Steel Bridge polygon covers a backwater-controlled pool upstream from a large medial bar and flow split.

Polygon 60, RM99.15; surveyed 2009, 2010, 2011
Polygon RM99.15 covers a trough immediately upstream from the Steel Bridge boat launch.

Polygon 61, **Steel Bridge** (RM 98.95); surveyed 2009, 2010, 2011
This polygon includes a hole and trough at the Steel Bridge boat launch were the river encounters a bedrock protrusion on its left bank.

Polygon 62, RM98.7; surveyed 2009, 2011
Polygon RM98.7 is in an flow convergence area immediately downstream from the riffle and island that forms the hydraulic control for the Limekiln Gulch gaging station.

Polygon 63, Steel Bridge Day Use (RM 98.55); surveyed 2009, 2011
This polygon covers a trough near the apex of the 180-degree bend adjacent to the Steel Bridge Day Use areas.

Polygon 64, RM98.4; surveyed 2009, 2011
Polygon RM98.4 defines a pool area at the downstream exit from the 180-degree bend adjacent to the Steel Bridge Day Use areas.

Polygons 65, 66, and 67, RM98.27, RM98.2, and RM98.1; all surveyed 2009, 2011
These three pool polygons are adjacent to a series of homes along the left bank in a straight section of river.

Polygon 68, RM97.9; surveyed 2009, 2011
Polygon RM97.9 is a backwater-controlled pool just downstream from a 45-degree bend to the southwest.

Polygon 69, Biggers (RM 97.72); surveyed 2009, 2011
This polygon covers a trough in the approach to Biggers Bridge (also referred to as the Treadwell Bridge).

Polygon 70, Upper Indian Creek Backwater (RM 95.75); surveyed 2009, 2011
This polygon covers a portion of the backwater pool upstream from the Indian Creek delta.

Polygon 71, Highway 299 Bridge (RM 94.1); surveyed 2009, 2011

This polygon covers the backwater-controlled pool immediately upstream from the Highway 299 bridge over the Trinity River at Douglas City.

Polygon 72, Goodyears (RM 93.15); surveyed 2009, 2011

This polygon is located about 300 feet upstream from the mouth of Reading Creek at the beginning of a 180-degree bend. It is classified as a convergence area.

Polygon 73, **Upper Bend** (RM 92.97); surveyed 2009, 2011

This polygon covers the upstream half of a trough located at the apex of the 180-degree bend between the mouth of Reading Creek and the Douglas City Campground.

Polygon 74, **Lower Bend** (92.93); surveyed 2009, 2010, 2011

This polygon covers the downstream half of a trough located at the apex of the 180-degree bend between the mouth of Reading Creek and the Douglas City Campground.

Polygon 75, **Painted Rock** (RM 92.7); surveyed 2009, 2010, 2011

Painted Rock is a hole and associated trough near the exit of the 180-degree bend between the mouth of Reading Creek and the Douglas City Campground.

Polygon 76, **Alcatraz** (RM 92.3); surveyed 2009, 2010, 2011

This 2-part polygon covers a hole located at the base of a bedrock cliff on the river right just downstream from the Douglas City Campground.

Polygon 77, Upper Steiner (RM 92.24); surveyed 2009, 2010, 2011

This polygon covers a trough along the left bank at the upstream end of the historical Steiner Flat feathered edge project site.

Polygon 78, Steiner (RM 92.2); surveyed 2009, 2010, 2011

The Steiner polygon covers a trough along the left bank at the historical Steiner Flat feathered edge project site.

Polygon 79, Lower Steiner (RM 92); surveyed 2009, 2010, 2011

The Lower Steiner polygon covers a hole where a bedrock protrusion on river left forces the channel to jog to the right.

Polygon 80, Jumping Rock (RM 91.75); surveyed 2009, 2011

This polygon covers a trough adjacent to a popular swimming area among bedrock outcrops on the right bank.

Polygon 81, **X-factor** (RM 91.6); surveyed 2010, 2011

This hole is located along Steiner Flat Road among several in-channel mega-boulders or bedrock outcrops near the apex of a bend to the south-southwest.

Polygon 82, **Skeletor** (RM 91.5); surveyed 2009, 2010, 2011
Skeletor is a hole is located along Steiner Flat Road at the apex of a bend to the south-southwest.

Polygon 83, RM94.4; surveyed 2009, 2010, 2011
Polygon RM91.4 is a pool located along Steiner Flat Road near the upstream end of a straight section of channel trending toward the south-southwest.

Polygon 84, **Picnic Table** (RM 91.5); surveyed 2009, 2010, 2011
Picnic Table is a trough at the upstream end of a large-scale U-shaped bend in the valley.

Polygon 85, **Chop Tree** (RM 90.9); surveyed 2009, 2011 (low resolution)
Chop Tree is a trough located slightly upstream from the middle of a large-scale U-shaped bend in the valley. Sonar data from 2009 and 2011 exist for this location, but the 2011 data are of insufficient quality to support gridding, so evaluation of bed elevation changes at this location is limited to a point-to-point comparison.

Polygon 86, **Dump Hole** (RM 90.75); surveyed 2009, 2010, 2011
Dump Hole is a trough located slightly downstream from the middle of a large-scale U-shaped bend in the valley.

Polygon 87, **Center Pin** (RM 89.75); surveyed 2009, 2010, 2011
Center Pin is classified as a backwater pool. It is located in a straight section of channel just upstream from a residential area along the right bank.

Polygon 88, **Goat Hole** (RM 89.45); surveyed 2009, 2010, 2011
Goat Hole consists of a trough and with some very deep holes where bedrock along the right bank forces the river to the left.

Polygon 89, RM89.3; surveyed 2009, 2011
Polygon RM89.3 is a trough along the left bank at the base of the valley wall opposite the goat farm.

Polygon 90, Dutton (RM 89.15); surveyed 2009, 2010, 2011
This is a pool and trough located at the mouth of Dutton Creek.

Polygons 91 and 92, RM88.7 and RM88.65; both surveyed 2009, 2011
This pair of polygons covers a pool and a flow convergence area about 100 feet downstream. The 2 polygons are separated by a cluster of mega-boulders or bedrock outcrops in the center of the channel.

Polygon 93, RM88.24; surveyed 2009, 2011
This is a 2-part polygon covering portions of a pool surrounding bedrock outcrops along the right bank. The polygons exclude a substantial portion of the pool center, presumably because turbulence or bubbles prevented data collection in that area.

Polygons 94 and 95, RM88.12 and RM88.07; both surveyed 2009, 2011
These polygons cover 2 nearby pools in a 550-foot-long straight section of channel with large areas of bedrock exposed on both banks.

Polygon 96, Browns 1 (RM 87.98); surveyed 2009, 2011
This pool is located just upstream from the mouth of Browns Creek.

Polygons 97 and 98, Browns 2 and Browns 3 (RM 87.93 and 87.85); both surveyed 2009, 2011
These pools are located just downstream from the mouth of Browns Creek.

Polygons 99 and 100, RM87.8 and RM87.75; both surveyed 2009, 2011
These polygons covers two pool areas just upstream from the last residences accessible from the Douglas City end of the canyon.

Polygons 101, RM87.6; surveyed 2009, 2011
This polygon covers a pool area adjacent to the last residence accessible from the Douglas City end of the canyon.

Polygon 102, Dutch (RM 85.8); surveyed 2009, 2011
This is a backwater pool located in the center of the straight reach through the ESL for a potential Dutch Creek rehabilitation project.

Polygons 103, **Last Hole on the Left**; surveyed 2009, 2011
This is a trough along the left bank on the outside of the bend to the right near the downstream end of the ESL for the potential Dutch Creek rehabilitation project.

Polygon 104, Upper Evans Bar (RM 85); surveyed 2009, 2011
This is a backwater pool located near the most upstream end of the terrace flat that can be accessed by passenger vehicle from Dutch Creek Road.

Polygon 105, Evans Bar (RM 84.5); surveyed 2009, 2011
This is a convergence pool about 250 feet upstream from the Evans Bar fish counting weir location.

Polygon 106, RM84.2; surveyed 2009, 2011
Polygon RM84.2 covers a trough along the left bank about 1000 feet downstream from the Evans Bar fish counting weir location.

Polygon 107, RM83.75; surveyed 2009, 2011
Polygon RM83.75 covers a trough along the right bank just upstream from the round house at the end of Sky Ranch Road.

Polygon 108, **Icebox** (RM 82.75); surveyed 2009, 2011
This is a trough along the left valley wall near the downstream boundary of the ESL for the potential Chapman Ranch rehabilitation project.

Polygon 109, Eds (RM 82.3); surveyed 2009, 2011
This is a trough along the left valley wall immediately upstream from the mouth of Deep Gulch.

Polygon 110, Deep Gulch (RM 82.25); surveyed 2009, 2011
This pool is immediately upstream from the mouth of Deep Gulch.

Polygon 111, **Sheridan Hole** (RM 81.65); surveyed 2009 (low resolution), 2010, 2011
This polygon covers a trough along the left valley wall at the base of a bedrock cliff. Sonar data exists for all three years, but the 2009 data is too sparse to support gridding. Evaluation of bed elevation changes between 2009 and 2010 at this location is therefore limited to a point-to-point comparison. A deep hole at the upstream end of the trough is excluded due to lack of reliable sonar data in that area.

Polygons 112 and 113, Oregon 1 and Oregon 2 (RM 81.25 and 81.2); both surveyed 2009, 2011
These are two troughs along the right bank in the backwater pool upstream from the Oregon Gulch delta.

Polygons 114 and 115, Sky Ranch and Lower Sky Ranch (RM 80.7 and 80.45); both surveyed 2009, 2011
These two pools are located adjacent to the flat terrace area off Sky Ranch Road that is often used as a fire fighters camp and staging area during the wildfire season.

Polygons 116 and 117, UJC 1 and UJC 2 (RM 80.2 and 80.15); both surveyed 2009, 2011
These are troughs along the bedrock right bank adjacent Highway 299.

Polygons 118 UJC 3 (RM 80); surveyed 2009, 2011
This is a backwater-controlled pool at the base of a large tailing pile on the left bank about 1200 feet upstream from the Dutch Creek Bridge.

Polygon 119, **Junction City Hole** (RM 79.5); surveyed 2009, 2010, 2011
This hole is located where a bedrock protrusion forces the river to the right about 1200 feet downstream from the Dutch Creek Bridge.

Polygon 120, RM78.25; surveyed 2009, 2011
This is an area of converging flow near the downstream boundary of the Hocker Flat rehabilitation project site.

Polygons 121 and 122, JC Campground 1 and JC Campground 2 (RM 78.05 and 77.97); surveyed 2009, 2010, 2011
These are troughs along the left bank adjacent to the Junction City Campground boat launch area.

Polygons 123, 124, and 125, Upper Conner 1, Upper Conner 2, and Upper Conner 3 (RM 77.77, 77.75, and 77.67); all surveyed 2009, 2010, 2011
This series of three troughs is located about 1300 feet upstream from the mouth of Conner Creek along the bedrock right bank adjacent to Highway 299.

Polygon 126, **McCartneys** (RM 77.1); surveyed 2009, 2010, 2011
This pool is about 1200 feet downstream from the mouth of Conner Creek where the valley wall forces a curve to the right.

Polygon 127, RM76.75; surveyed 2009, 2011
This is a trough along the right bank adjacent to Highway 299 just upstream from where the highway begins to veer to the northwest.

Polygon 128, **Barbie** (RM 76.4); surveyed 2009, 2010, 2011
Barbie is a trough along the right bank adjacent to Highway 299 near the upstream boundary of the Wheel Gulch rehabilitation project site.

Polygon 129, **Upper Bigfoot** (RM 75.8); surveyed 2009, 2010, 2011
This polygon covers a long pool located slightly upstream from the Bigfoot Campground.

Polygon 130, Valdor (RM 75.05); surveyed 2009, 2010, 2011
Valdor is a hole located where the river encounters the valley wall and is forced to make a 90-degree turn to the left.

Polygon 131, Coopers Bar (RM 74.85); surveyed 2009, 2011
This polygon covers a pool located adjacent to Highway 299 where west-bound traffic approaches a tight U-shaped curve.

Polygon 132, **Rip-rap Hole** (RM 74.65); surveyed 2009, 2010, 2011
This is a long trough along the left bank where the river approaches the apex of a large U-shaped bend just upstream from the Lime Point boat launch.

Polygon 133, Lime Point (RM 74.5); surveyed 2009, 2010, 2011
This polygon covers a hole adjacent to a bedrock protuberance and a convergence area just downstream from the Lime Point boat launch.

Polygon 134 and 135, Elkhorn and Lower Elkhorn (RM 73.8 and 73.5); both surveyed 2009, 2011
Elkhorn is a trough is located on the left bank adjacent to Highway 299 where the highway curves to assume an east-west orientation. Lower Elkhorn is a trough located about 1400 feet farther downstream.

Polygon 136, Screw Trap (RM 73.3); surveyed 2009, 2011
This hole is immediately downstream from where rotary screw traps are used to estimate out-migrating smolt numbers.

Polygon 137, Pear Tree (RM 73.05); surveyed 2009, 2010, 2011
This pool is located immediately upstream from the last major riffle crossing before the confluence with the North Fork Trinity River.

Polygon 138, Lower Pear Tree (RM 72.9); surveyed 2009, 2011
This pool is located immediately downstream from the last major riffle crossing before the confluence with the North Fork Trinity River.

Polygon 139, Bagdad (RM 72.6); surveyed 2009, 2011
This polygon is located in the backwater pool upstream from the delta formed by the North Fork Trinity River.

APPENDIX C

Polygon depth statistics for all years with sufficient data for gridding.

No.	Name	Year	RM	Area	WSEL	Max_D	50P_D	75P_D	90P_D
1	Diversion Pool	2011	111.15	1864	1822.1	13.68	8.06	10.47	12.19
2	Deadwood Pool	2009	111.03	1004	1816.8	11.48	4.45	5.66	6.75
2	Deadwood Pool	2011	111.03	1004	1816.8	11.18	4.78	5.86	6.94
3	Above New Bridge	2009	110.97	585	1814	12.42	7.78	9.67	10.54
3	Above New Bridge	2011	110.97	585	1814	11.09	7.50	8.88	9.79
4	Below New Bridge	2009	110.94	945	1814	10.62	4.32	5.46	6.69
4	Below New Bridge	2011	110.94	945	1814	11.53	5.68	7.00	8.41
5	Upper B2	2009	110.7	1959	1807.8	8.92	4.85	5.74	6.58
5	Upper B2	2011	110.7	1936	1807.8	9.13	4.80	5.67	6.45
6	Lower B2	2009	110.63	4349	1807.8	6.21	3.56	4.07	4.70
6	Lower B2	2011	110.63	4339	1807.8	7.49	4.12	4.63	5.24
7	Old Bridge	2009	110.2	2962	1803	5.34	3.50	4.18	4.58
7	Old Bridge	2010	110.2	2962	1803	4.45	3.37	3.78	4.01
7	Old Bridge	2011	110.2	2964	1803	4.75	3.63	3.95	4.15
8	Hoadley Bar	2009	109.98	1781	1799.8	7.74	3.98	4.67	5.67
8	Hoadley Bar	2011	109.98	1781	1799.8	8.37	3.60	4.16	5.00
9	Hoadley Pool	2009	109.9	5905	1799.7	11.27	5.80	6.93	8.09
9	Hoadley Pool	2011	109.9	5905	1799.7	13.02	6.27	7.81	9.47
10	Upper Cemetery Run	2009	109.5	797	1795.5	8.30	4.26	5.27	6.66
10	Upper Cemetery Run	2010	109.5	799	1795.5	8.27	4.24	5.26	6.67
10	Upper Cemetery Run	2011	109.5	799	1795.5	7.00	3.59	4.54	5.50
11	Upper Cemetery Pool	2009	109.47	606	1795	12.14	7.53	9.46	11.10
11	Upper Cemetery Pool	2010	109.47	606	1795	11.97	7.48	9.31	10.19
11	Upper Cemetery Pool	2011	109.47	606	1795	12.29	6.86	9.05	10.09
12	Cemetery Hole	2010	109.43	1401	1793.9	15.38	5.64	8.99	11.25
12	Cemetery Hole	2011	109.43	1401	1793.9	14.57	5.17	8.71	10.60
13	Below Cemetery	2010	109.39	458	1793.74	7.24	4.77	5.89	6.44
13	Below Cemetery	2011	109.39	458	1793.74	8.06	5.15	6.37	6.98
14	Sawmill FM1	2010	109.35	1280	1793.3	6.11	3.48	4.14	5.01
14	Sawmill FM1	2011	109.35	1280	1793.3	6.56	3.09	4.31	5.13
15	Sawmill FM2	2010	109.13	3709	1789.1	3.45	0.70	1.57	2.23
15	Sawmill FM2	2011	109.13	3709	1789.1	3.15	1.24	1.86	2.38
16	Sawmill Burner	2008	109	626	1787.2	8.01	4.64	5.78	6.54
16	Sawmill Burner	2010	109	622	1787.2	6.20	2.35	3.08	4.30
16	Sawmill Burner	2011	109	622	1787.2	7.17	2.66	3.71	4.91
17	Lower Burner 1	2009	108.93	1448	1787.055	7.27	3.53	4.47	5.40
17	Lower Burner 1	2010	108.93	1448	1787.05	7.70	3.88	4.74	5.60
17	Lower Burner 1	2011	108.93	1448	1787.05	9.92	4.71	6.48	7.96
18	Lower Burner 2	2009	108.88	615	1787	6.08	3.53	4.46	5.20
18	Lower Burner 2	2011	108.88	615	1787	6.06	3.63	4.64	5.36
19	RM108.8	2010	108.8	597	1786.35	4.82	1.92	2.33	3.36
19	RM108.8	2011	108.8	597	1786.35	5.06	1.83	2.48	3.46
20	RM108.7	2010	108.7	6388	1786.1	2.71	0.98	1.27	1.58
20	RM108.7	2011	108.7	6388	1786.1	2.76	1.19	1.55	1.74
21	Rush Creek Pool	2009	108.1	22035	1781	10.21	4.03	5.29	6.66

21	Rush Creek Pool	2011	108.1	22035	1781	10.55	4.63	5.89	7.36
22	RM107.55	2009	107.55	3445	1774.6	3.86	2.54	2.98	3.23
22	RM107.55	2011	107.55	3445	1774.6	5.22	3.68	3.97	4.27
23	Salt Flat 1	2009	106.85	1606	1763.8	5.16	2.57	3.07	3.92
23	Salt Flat 1	2011	106.85	1606	1763.8	2.70	-0.58	0.91	1.77
24	Salt Flat 2	2009	106.8	1350	1763.8	3.67	2.80	3.20	3.38
24	Salt Flat 2	2011	106.8	1350	1763.8	2.33	1.59	1.92	2.10
25	Gold Bar	2009	106.6	2448	1760.7	12.07	6.02	8.27	9.79
25	Gold Bar	2010	106.6	2448	1760.7	12.12	6.40	8.38	9.92
25	Gold Bar	2011	106.6	2448	1760.7	11.49	6.26	8.49	9.72
26	Lower Gold Bar	2009	106.5	3796	1759.6	7.72	4.61	5.51	6.17
26	Lower Gold Bar	2010	106.5	3796	1759.6	8.41	5.04	5.96	7.09
26	Lower Gold Bar	2011	106.5	3796	1759.6	8.67	5.63	6.85	7.80
27	RM106.25	2009	106.25	1684	1756.3	7.34	3.83	4.70	5.59
27	RM106.25	2011	106.25	1684	1756.3	7.51	4.28	4.73	5.72
28	Dirty Bird	2009	105.72	633	1749.1	10.03	5.39	6.95	8.42
28	Dirty Bird	2011	105.72	633	1749.1	9.69	5.36	6.93	8.28
29	Bucktail Island	2009	105.65	2804	1749	7.80	4.82	5.92	6.58
29	Bucktail Island	2011	105.65	2804	1749	7.35	4.92	5.78	6.35
30	Upper Bucktail Pool	2009	105.45	874	1746.7	9.74	5.99	7.68	8.82
30	Upper Bucktail Pool	2011	105.45	874	1746.7	14.59	6.28	9.57	11.38
31	Bucktail Hole	2009	105.4	2059	1745.9	20.99	6.85	10.61	14.41
31	Bucktail Hole	2010	105.4	2059	1745.9	21.24	7.54	10.07	13.84
31	Bucktail Hole	2011	105.4	2059	1745.9	21.67	7.45	9.70	13.81
32	RM105.25	2009	105.25	557	1742.9	7.48	4.43	5.48	6.10
32	RM105.25	2011	105.25	557	1742.9	6.98	4.12	5.14	5.95
33	Upper Lowden	2009	105.05	2159	1741	6.13	3.85	4.53	5.00
33	Upper Lowden	2010	105.05	2159	1741	6.78	4.10	4.72	5.26
33	Upper Lowden	2011	105.05	2159	1741	6.83	4.14	4.77	5.28
34	Lowden FM	2010	104.95	1329	1740.95	5.08	2.73	3.28	3.91
34	Lowden FM	2011	104.95	1329	1740.95	5.79	3.19	3.87	4.33
35	Lowden FP	2009	104.65	1810	1739.1	4.32	3.49	3.74	3.89
35	Lowden FP	2010	104.65	1810	1739.1	4.56	3.74	4.05	4.21
35	Lowden FP	2011	104.65	1810	1739.1	6.32	4.03	4.69	5.12
36	Wellock Pool	2009	104.3	3286	1734.7	6.83	4.22	4.97	5.52
36	Wellock Pool	2010	104.3	3286	1734.7	7.07	4.33	5.07	5.76
36	Wellock Pool	2011	104.3	3286	1734.7	5.47	0.78	1.89	4.21
37	Little Tree 1	2009	104.07	988	1730.7	4.85	2.98	3.21	3.78
37	Little Tree 1	2011	104.07	988	1730.7	3.96	2.07	2.34	2.48
37	Little Tree 2	2010	104.07	779	1730.7	5.33	3.06	3.41	4.56
38	Little Tree 2	2011	104.07	779	1730.7	3.58	2.12	2.34	2.44
39	Trinity House	2010	104	3083	1730.3	7.03	2.67	3.94	4.73
39	Trinity House	2011	104	3083	1730.3	8.49	1.89	3.61	5.13
40	SP-Ponderosa	2009	103.85	7982	1728.8	10.65	4.49	5.76	7.11
40	SP-Ponderosa	2010	103.85	7982	1728.8	11.35	4.69	5.96	7.61
40	SP-Ponderosa	2011	103.85	7982	1728.8	11.97	4.64	6.42	8.29
41	RM103.5	2009	103.5	625	1723	5.62	3.65	4.54	5.05
41	RM103.5	2011	103.5	625	1723	6.05	3.14	4.24	5.10
42	Tom Lang	2009	103.2	2454	1719.7	7.98	5.41	6.18	6.98

42	Tom Lang	2011	103.2	2454	1719.7	10.06	5.10	6.27	7.64
43	RM102.95	2009	102.95	2957	1719	6.26	4.95	5.50	5.78
43	RM102.95	2011	102.95	2957	1719	6.02	4.33	4.77	5.17
44	Stott Hole	2009	102.5	2087	1714.1	22.30	9.81	13.67	17.73
44	Stott Hole	2011	102.5	2087	1714.1	18.95	8.05	11.54	15.36
45	Stott Trough	2009	102.45	668	1713.5	7.96	4.12	5.27	6.70
45	Stott Trough	2011	102.45	668	1713.5	5.57	3.30	3.75	4.27
46	Stott Convergence	2009	102.4	947	1713.45	5.07	4.18	4.44	4.62
46	Stott Convergence	2011	102.4	947	1713.45	5.69	3.90	4.57	5.07
47	RM102.1	2009	102.1	1477	1709.4	6.65	4.64	5.25	5.85
47	RM102.1	2011	102.1	1477	1709.4	6.56	3.94	4.64	5.32
48	Society Pool	2009	101.8	7059	1706.2	11.85	7.43	9.67	10.73
48	Society Pool	2010	101.8	7059	1706.2	11.65	6.81	8.98	10.06
48	Society Pool	2011	101.8	7059	1706.2	11.60	6.50	9.35	10.46
49	Montana	2010	101.35	2649	1697.4	10.65	3.72	5.82	7.95
49	Montana	2011	101.35	2649	1697.4	9.56	4.09	5.83	7.69
50	Snell	2009	101.15	1172	1695	9.04	4.71	6.12	7.26
50	Snell	2010	101.15	1172	1695	8.87	4.74	6.03	7.23
50	Snell	2011	101.15	1172	1695	10.41	4.55	6.23	8.69
51	Crosby	2010	101.05	3966	1694.1	9.62	3.89	5.70	7.37
51	Crosby	2011	101.05	3966	1694.1	9.32	4.54	6.17	7.61
52	RM100.85	2009	100.85	2546	1692.7	5.59	4.13	4.64	5.00
52	RM100.85	2010	100.85	2546	1692.7	6.26	4.10	4.63	5.00
52	RM100.85	2011	100.85	2546	1692.7	5.52	4.03	4.48	4.79
53	Leos 1	2009	100.6	2336	1689.1	7.78	4.13	5.67	6.50
53	Leos 1	2010	100.6	2336	1689.1	8.08	4.24	5.88	6.69
53	Leos 1	2011	100.6	2336	1689.1	8.74	4.31	5.93	7.09
54	Leos 2	2010	100.6	3801	1689.1	7.96	3.74	5.01	6.42
54	Leos 2	2011	100.6	3801	1689.1	8.73	3.62	5.08	6.42
55	Upper Limekiln	2009	100.4	2081	1688	4.34	3.45	3.79	3.97
55	Upper Limekiln	2011	100.4	2081	1688	4.79	3.84	4.12	4.33
56	Limekiln Trough	2009	100.1	1964	1682.8	7.64	4.23	4.68	5.25
56	Limekiln Trough	2011	100.1	1964	1682.8	8.65	4.41	5.00	5.58
57	Lower Limekiln	2009	99.7	1429	1677.2	11.49	4.87	6.77	9.26
57	Lower Limekiln	2010	99.7	1429	1677.2	10.99	5.22	6.93	8.73
57	Lower Limekiln	2011	99.7	1429	1677.2	10.64	5.14	6.97	8.98
58	RM99.5	2009	99.5	1873	1675.4	7.75	4.60	5.02	5.69
58	RM99.5	2010	99.5	1873	1675.4	8.30	4.88	5.32	5.91
58	RM99.5	2011	99.5	1873	1675.4	7.60	5.18	5.63	6.25
59	Upper Steel Bridge	2009	99.45	2147	1675.3	11.52	6.50	8.35	9.89
59	Upper Steel Bridge	2010	99.45	2147	1675.3	11.49	6.70	8.40	10.01
59	Upper Steel Bridge	2011	99.45	2147	1675.3	13.56	8.24	10.09	11.15
60	RM99.15	2009	99.15	2590	1671	7.84	4.52	6.08	7.04
60	RM99.15	2010	99.15	2590	1671	8.29	4.89	6.41	7.30
60	RM99.15	2011	99.15	2590	1671	8.13	5.03	6.61	7.26
61	Steel Bridge	2009	98.95	1725	1670.1	19.02	7.98	11.76	14.93
61	Steel Bridge	2010	98.95	1725	1670.1	21.25	8.24	12.15	14.87
61	Steel Bridge	2011	98.95	1725	1670.1	17.78	8.75	10.90	14.73
62	RM98.7	2009	98.7	804	1665.8	5.71	3.33	3.89	4.20

62	RM98.7	2011	98.7	804	1665.8	6.58	4.46	5.21	5.58
63	Steel Bridge Day Use	2009	98.55	2109	1663.8	13.11	4.24	5.64	8.55
63	Steel Bridge Day Use	2011	98.55	2108	1663.8	14.62	4.70	7.03	10.86
64	RM98.4	2009	98.4	1214	1660.7	15.27	7.44	10.49	12.54
64	RM98.4	2011	98.4	1213	1660.7	17.90	7.59	10.89	13.69
65	RM98.27	2009	98.27	1501	1659.21	6.53	4.03	4.88	5.35
65	RM98.27	2011	98.27	1501	1659.21	7.07	4.39	5.16	5.68
66	RM98.2	2009	98.2	2415	1658.8	6.88	3.92	4.94	5.39
66	RM98.2	2011	98.2	2415	1658.8	7.61	4.14	5.32	5.86
67	RM98.1	2009	98.1	737	1658.5	4.38	3.23	3.66	4.05
67	RM98.1	2011	98.1	737	1658.5	5.13	3.83	4.31	4.59
68	RM97.9	2009	97.9	2178	1655.4	5.40	3.70	4.22	4.48
68	RM97.9	2011	97.9	2178	1655.4	7.78	3.99	4.53	5.33
69	Biggers	2009	97.72	2003	1654.2	4.37	3.09	3.54	3.77
69	Biggers	2011	97.72	2003	1654.2	4.92	3.26	3.70	4.15
70	Upper Ind. Ck.	2009	95.75	5853	1638	9.18	4.57	5.83	7.26
70	Upper Ind. Ck.	2011	95.75	5852	1638	11.41	5.01	5.96	6.87
71	Highway 299 Bridge	2009	94.1	2874	1618.3	6.46	4.04	4.97	5.63
71	Highway 299 Bridge	2011	94.1	2873	1618.3	6.57	3.22	3.59	4.01
72	Goodyears	2009	93.15	1410	1606.2	5.71	3.79	4.44	4.90
72	Goodyears	2011	93.15	1410	1606.2	4.47	0.87	1.77	2.71
73	Upper Bend	2009	92.97	835	1604.7	9.27	5.55	6.85	7.72
73	Upper Bend	2011	92.97	834	1604.7	10.35	5.36	6.61	7.67
74	Lower Bend	2009	92.93	883	1604.5	10.97	5.78	7.36	9.34
74	Lower Bend	2010	92.93	883	1604.5	11.67	6.12	7.59	9.42
74	Lower Bend	2011	92.93	883	1604.5	11.37	5.20	6.46	7.94
75	Painted Rock	2009	92.7	1018	1599.7	12.89	6.77	8.98	10.13
75	Painted Rock	2010	92.7	1018	1599.7	13.37	7.25	8.85	10.16
75	Painted Rock	2011	92.7	1018	1599.7	14.19	7.47	9.71	11.29
76	Alcatraz	2009	92.3	1141	1592.12	15.59	7.11	9.01	10.96
76	Alcatraz	2010	92.3	1141	1592.12	15.82	7.71	9.47	10.75
76	Alcatraz	2011	92.3	1141	1592.12	11.79	4.77	7.00	9.13
77	Upper Steiner	2009	92.24	809	1591.4	9.18	4.79	5.98	6.70
77	Upper Steiner	2010	92.24	809	1591.4	8.73	5.19	6.48	7.27
77	Upper Steiner	2011	92.24	809	1591.4	8.10	3.97	5.02	6.22
78	Steiner	2009	92.2	1377	1591.4	6.34	4.71	5.31	5.62
78	Steiner	2010	92.2	1377	1591.4	6.63	5.11	5.67	5.97
78	Steiner	2011	92.2	1377	1591.4	6.83	4.88	5.57	5.98
79	Lower Steiner	2009	92	1453	1587.9	17.83	7.46	10.39	12.53
79	Lower Steiner	2010	92	1453	1587.9	19.08	7.81	10.50	12.50
79	Lower Steiner	2011	92	1453	1587.9	17.42	7.76	10.22	11.56
80	RM91.75	2009	91.75	618	1583.3	9.36	4.97	6.20	7.44
80	RM91.75	2011	91.75	618	1583.3	9.13	3.24	4.71	6.77
81	X Factor	2010	91.6	909	1582.3	10.86	4.84	6.14	7.92
81	X Factor	2011	91.6	909	1582.3	9.99	4.96	6.02	7.47
82	Skeletor	2009	91.5	1261	1580.3	14.54	7.50	9.78	11.98
82	Skeletor	2010	91.5	1261	1580.3	14.91	7.52	9.26	10.79
82	Skeletor	2011	91.5	1261	1580.3	14.52	7.03	9.32	10.81
83	RM91.4	2009	91.4	1198	1579	12.97	6.14	9.16	11.39

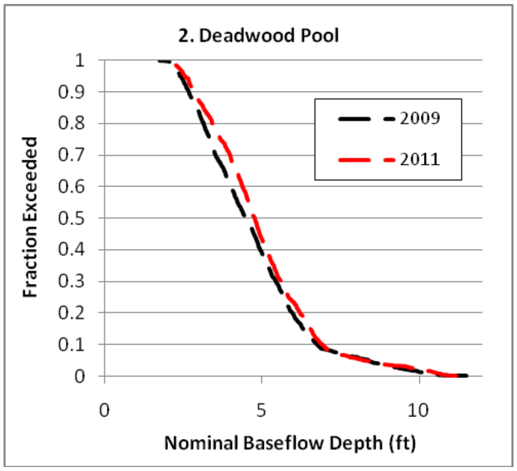
83	RM91.4	2010	91.4	1198	1579	12.85	6.30	9.42	10.86
83	RM91.4	2011	91.4	1198	1579	12.69	5.91	8.72	10.50
84	Picnic Table	2009	91.05	2116	1575.3	8.66	4.22	5.55	6.90
84	Picnic Table	2010	91.05	2116	1575.3	10.52	5.42	6.95	8.35
84	Picnic Table	2011	91.05	2116	1575.3	9.55	5.54	6.75	7.92
85	Chop Tree	2009	90.9	708	1572.6	9.22	4.51	5.56	6.90
86	Dump Hole	2009	90.75	1619	1571.4	10.20	3.77	5.52	7.40
86	Dump Hole	2010	90.75	1619	1571.4	10.57	4.84	6.34	8.12
86	Dump Hole	2011	90.75	1619	1571.4	10.01	4.61	5.88	7.23
87	Center Pin	2009	89.75	2130	1559	3.85	2.73	3.07	3.38
87	Center Pin	2010	89.75	2130	1559	4.84	3.98	4.23	4.60
87	Center Pin	2011	89.75	2130	1559	5.39	4.31	4.67	4.89
88	Goat Hole	2009	89.45	3563	1555.6	14.75	4.90	7.07	9.21
88	Goat Hole	2010	89.45	3563	1555.6	14.74	5.77	7.65	9.86
88	Goat Hole	2011	89.45	3563	1555.6	14.68	5.56	8.00	10.04
89	RM89.3	2009	89.3	1063	1553.2	9.16	4.31	6.10	6.98
89	RM89.3	2011	89.3	1063	1553.2	8.88	3.97	5.92	7.16
90	Dutton	2009	89.15	1625	1552.6	13.04	4.11	6.11	7.74
90	Dutton	2010	89.15	1625	1552.6	11.62	5.53	7.80	9.36
90	Dutton	2011	89.15	1625	1552.6	11.99	5.87	8.35	10.11
91	RM88.7	2009	88.7	1481	1540.5	8.26	4.25	5.00	6.30
91	RM88.7	2011	88.7	1481	1540.5	7.69	4.61	5.46	6.07
92	RM88.65	2009	88.65	792	1540.5	11.46	4.65	7.44	8.69
92	RM88.65	2011	88.65	792	1540.5	11.09	6.24	8.48	9.72
93	RM88.24	2009	88.24	645	1534	17.72	8.84	11.76	14.01
93	RM88.24	2011	88.24	645	1534	18.67	10.66	13.80	16.34
94	RM88.12	2009	88.12	468	1529.88	10.34	5.12	6.89	8.37
94	RM88.12	2011	88.12	468	1529.88	11.76	5.60	7.41	9.29
95	RM88.07	2009	88.07	1181	1529.8	11.33	5.98	7.09	9.34
95	RM88.07	2011	88.07	1179	1529.8	13.89	7.17	8.80	11.13
96	Browns 1	2009	87.98	708	1528.3	7.18	4.76	5.38	6.16
96	Browns 1	2011	87.98	708	1528.3	8.17	6.00	6.65	7.37
97	Browns 2	2009	87.93	1028	1528.1	8.34	4.40	5.45	6.12
97	Browns 2	2011	87.93	1028	1528.1	9.27	5.80	6.72	7.27
98	Browns 3	2009	87.85	1052	1528	13.23	8.04	11.02	11.98
98	Browns 3	2011	87.85	1050	1528	13.66	9.69	11.61	12.43
99	RM87.8	2009	87.8	766	1527.2	12.81	5.28	7.31	9.71
99	RM87.8	2011	87.8	766	1527.2	14.69	6.69	8.73	11.31
100	RM87.75	2009	87.75	1122	1527.1	16.45	6.65	10.58	12.71
100	RM87.75	2011	87.75	1121	1527.1	16.47	7.21	11.58	14.19
101	RM87.6	2009	87.6	1181	1525.9	11.06	6.43	8.48	9.32
101	RM87.6	2011	87.6	1181	1525.9	13.14	8.01	10.81	11.83
102	Dutch	2009	85.8	2863	1509.8	8.04	5.78	6.60	6.96
102	Dutch	2011	85.8	2863	1509.8	6.95	4.95	5.61	6.00
103	Last Hole on the Left	2009	85.38	1390	1506.3	10.67	5.56	6.97	8.44
103	Last Hole on the Left	2011	85.38	1389	1506.3	9.54	5.26	6.93	8.24
104	Upper Evans Bar	2009	85	4341	1500.6	8.01	5.20	5.93	6.31
104	Upper Evans Bar	2011	85	4341	1500.6	7.20	4.04	4.59	5.03
105	Evans Bar	2009	84.5	944	1496.3	6.18	4.64	5.32	5.71

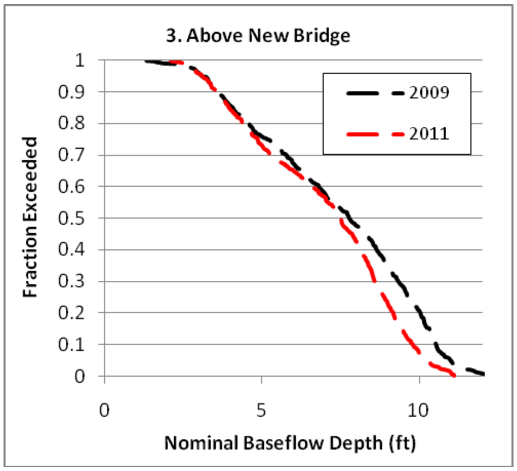
105	Evans Bar	2011	84.5	944	1496.3	6.85	4.45	5.26	5.83
106	RM84.2	2009	84.2	2663	1492.4	9.51	4.83	5.90	7.05
106	RM84.2	2011	84.2	2663	1492.4	8.58	4.71	5.65	6.47
107	RM83.75	2009	83.75	4058	1487.9	9.70	4.47	5.39	6.59
107	RM83.75	2011	83.75	4057	1487.9	10.94	4.78	6.05	7.40
108	Icebox	2009	82.75	3152	1480	8.28	4.34	5.28	6.29
108	Icebox	2011	82.75	3152	1480	7.94	4.75	5.57	6.18
109	Eds	2009	82.3	2360	1474.8	10.69	4.76	5.57	7.55
109	Eds	2011	82.3	2360	1474.8	7.71	3.76	4.22	5.33
110	RM82.25	2009	82.25	1508	1474.8	5.48	4.31	4.69	4.88
110	RM82.25	2011	82.25	1508	1474.8	5.54	4.03	4.29	4.56
111	Sheridan	2010	81.65	1441	1469.8	14.62	4.57	6.74	9.44
111	Sheridan	2011	81.65	1441	1469.8	12.54	4.31	7.35	9.97
112	Oregon 1	2009	81.25	1520	1467.7	6.86	4.22	4.87	5.39
112	Oregon 1	2011	81.25	1520	1467.7	5.85	4.05	4.44	4.83
113	Oregon 2	2009	81.2	351	1467.7	5.63	3.83	4.34	4.66
113	Oregon 2	2011	81.2	351	1467.7	5.94	3.68	4.16	4.62
114	Sky Ranch	2009	80.7	2190	1460.4	17.28	4.72	6.69	10.24
114	Sky Ranch	2011	80.7	2190	1460.4	14.17	4.23	5.70	7.85
115	Lower Sky Ranch	2009	80.45	1311	1456.3	15.98	6.50	9.05	11.88
115	Lower Sky Ranch	2011	80.45	1311	1456.3	11.32	4.57	6.14	7.94
116	UJC 1	2009	80.2	1018	1452.65	12.84	6.32	7.76	9.21
116	UJC 1	2011	80.2	1018	1452.65	12.50	6.12	7.56	8.93
117	UJC 2	2009	80.15	1757	1452.65	16.80	7.36	9.33	12.14
117	UJC 2	2011	80.15	1757	1452.65	14.83	7.48	9.15	10.96
118	UJC 3	2009	80	2275	1452.4	8.44	5.26	6.05	7.09
118	UJC 3	2011	80	2275	1452.4	7.56	4.90	6.08	6.63
119	Junction City Hole	2009	79.5	2022	1445.1	23.61	8.50	12.45	16.79
119	Junction City Hole	2010	79.5	2022	1445.1	23.04	8.31	11.87	16.24
119	Junction City Hole	2011	79.5	2022	1445.1	23.30	8.65	12.71	16.91
120	RM78.25	2009	78.25	450	1425.4	5.10	3.99	4.48	4.76
120	RM78.25	2011	78.25	449	1425.4	5.43	3.47	4.36	4.79
121	JC Campground 1	2009	78.05	949	1423.5	10.74	6.33	7.56	8.44
121	JC Campground 1	2010	78.05	949	1423.5	10.18	6.52	7.63	8.57
121	JC Campground 1	2011	78.05	949	1423.5	10.53	6.28	7.69	9.19
122	JC Campground 2	2009	77.97	861	1422.05	12.64	7.43	8.87	10.38
122	JC Campground 2	2010	77.97	861	1422.05	11.34	7.48	8.78	9.70
122	JC Campground 2	2011	77.97	861	1422.05	11.66	8.27	9.28	9.79
123	Upper Conner 1	2009	77.77	720	1420.2	14.85	6.64	9.92	12.57
123	Upper Conner 1	2010	77.77	720	1420.2	15.18	7.11	10.35	12.06
123	Upper Conner 1	2011	77.77	720	1420.2	12.88	6.55	8.91	10.88
124	Upper Conner 2	2009	77.75	563	1419.9	7.85	4.91	5.57	6.38
124	Upper Conner 2	2010	77.75	563	1419.9	8.57	4.93	5.59	6.86
124	Upper Conner 2	2011	77.75	563	1419.9	9.68	5.78	6.32	7.89
125	Upper Conner 3	2009	77.67	2305	1419.8	16.12	6.39	9.56	12.35
125	Upper Conner 3	2010	77.67	2305	1419.8	12.97	6.18	8.63	10.45
125	Upper Conner 3	2011	77.67	2305	1419.8	14.19	7.14	9.42	11.10
126	McCartneys	2009	77.1	3549	1411.6	14.73	5.14	7.11	9.77
126	McCartneys	2010	77.1	3549	1411.6	15.39	5.23	7.37	10.50

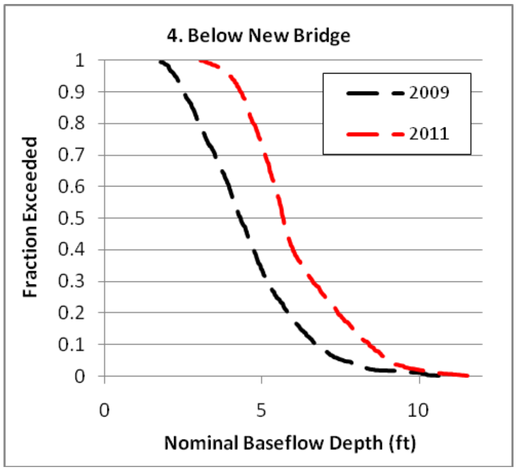
126	McCartneys	2011	77.1	3549	1411.6	13.40	4.42	6.47	9.31
127	RM76.75	2009	76.75	2999	1405.9	8.49	5.10	6.16	7.09
127	RM76.75	2011	76.75	2999	1405.9	8.80	5.39	6.22	7.23
128	Barbie	2009	76.4	1609	1402.6	6.25	4.02	4.65	5.18
128	Barbie	2010	76.4	1609	1402.6	6.65	4.35	4.89	5.58
128	Barbie	2011	76.4	1609	1402.6	6.65	4.44	4.95	5.47
129	Upper Bigfoot	2009	75.8	3322	1395.2	9.17	4.91	5.86	7.27
129	Upper Bigfoot	2010	75.8	3322	1395.2	8.85	5.10	5.94	7.10
129	Upper Bigfoot	2011	75.8	3322	1395.2	8.98	4.22	5.03	6.20
130	Valdor	2009	75.05	2237	1388.45	10.14	6.40	7.32	8.30
130	Valdor	2010	75.05	2237	1388.45	10.93	6.39	7.67	8.96
130	Valdor	2011	75.05	2237	1388.45	12.39	6.57	8.21	9.51
131	Coopers Bar	2009	74.85	2261	1385.6	14.40	6.66	8.63	10.26
131	Coopers Bar	2011	74.85	2261	1385.6	13.44	6.75	8.79	10.38
132	Rip Rap	2009	74.65	3719	1383.4	11.06	5.55	6.94	8.77
132	Rip Rap	2010	74.65	3719	1383.4	11.39	5.84	7.25	9.07
132	Rip Rap	2011	74.65	3719	1383.4	12.00	5.92	7.66	9.70
133	Lime Point	2009	74.5	863	1380.7	15.29	7.99	9.78	12.47
133	Lime Point	2010	74.5	863	1380.7	14.52	8.50	10.08	11.27
133	Lime Point	2011	74.5	863	1380.7	15.58	8.25	10.05	11.06
134	Elkhorn	2009	73.8	943	1370.9	9.20	5.23	6.12	7.17
134	Elkhorn	2011	73.8	943	1370.9	8.39	4.56	5.78	6.57
135	Lower Elkhorn	2009	73.5	950	1368.4	8.31	4.43	5.72	6.95
135	Lower Elkhorn	2011	73.5	949	1368.4	9.44	5.13	6.49	8.11
136	Screw Trap	2009	73.3	1205	1365.7	18.83	8.90	12.34	14.79
136	Screw Trap	2011	73.3	1204	1365.7	17.34	10.49	14.22	16.18
137	Pear Tree	2009	73.05	1093	1363.1	14.73	7.30	9.55	11.51
137	Pear Tree	2010	73.05	1093	1363.1	13.18	6.63	8.59	10.46
137	Pear Tree	2011	73.05	1093	1363.1	17.00	7.64	10.14	12.77
138	Lower Pear Tree	2009	72.9	3957	1362.55	7.44	5.33	5.92	6.39
138	Lower Pear Tree	2011	72.9	3957	1362.55	8.66	5.65	6.25	6.85
139	Bagdad	2009	72.6	2142	1361.1	7.12	4.51	5.25	5.76
139	Bagdad	2011	72.6	2142	1361.1	7.50	4.71	5.33	5.94

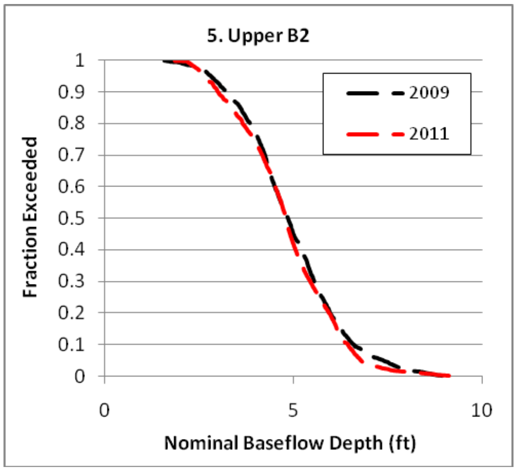
APPENDIX D

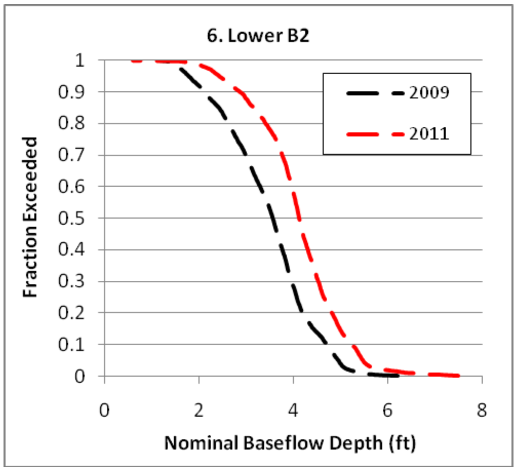
Cumulative depth-frequency curves.

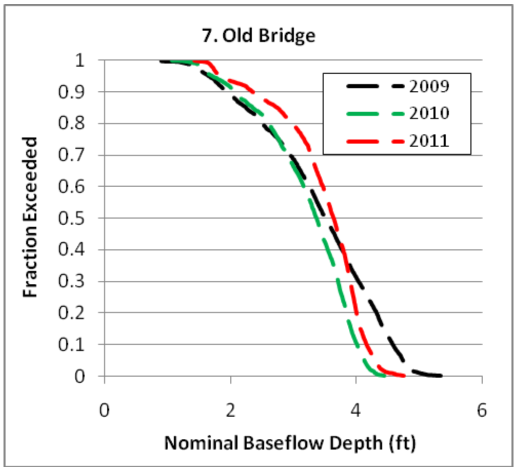


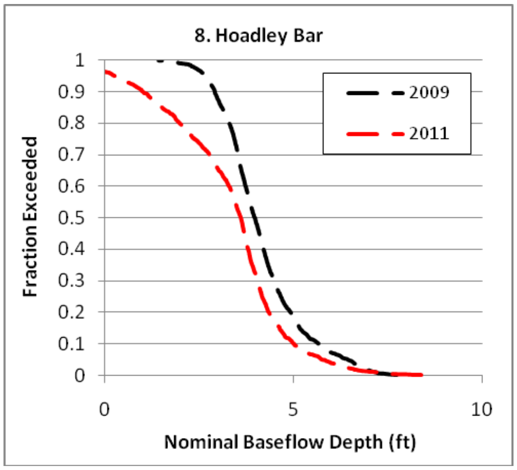


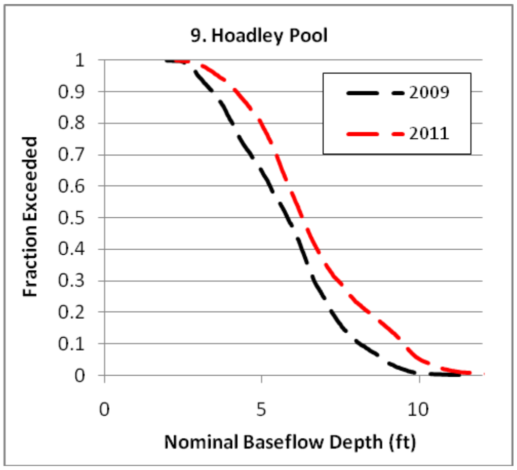









8. Hoadley Bar
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2009
2011


9. Hoadley Pool
Fraction Exceeded
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0.9
0.8
0.7
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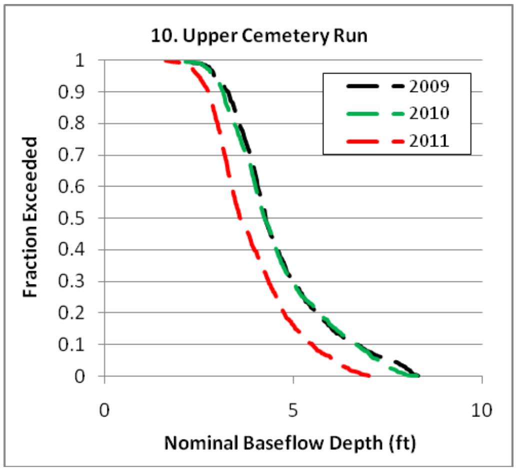
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2009
2011


10. Upper Cemetery Run
Fraction Exceeded
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0.7
0.6
0.5
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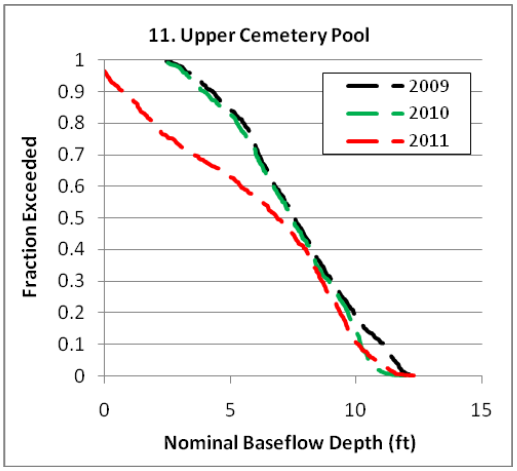
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2009
2010
2011


11. Upper Cemetery Pool
Fraction Exceeded
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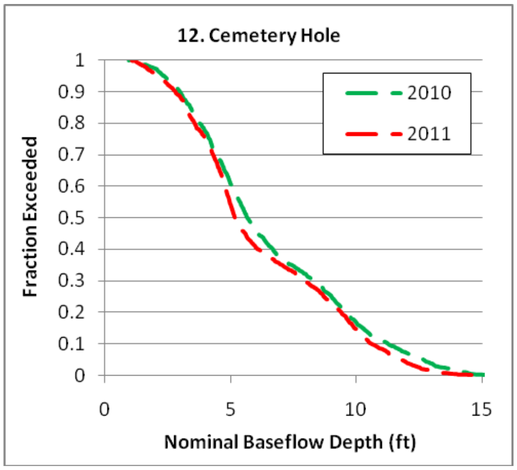
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
Nominal Baseflow Depth (ft)
2009
2010
2011


12. Cemetery Hole
Fraction Exceeded
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0.7
0.6
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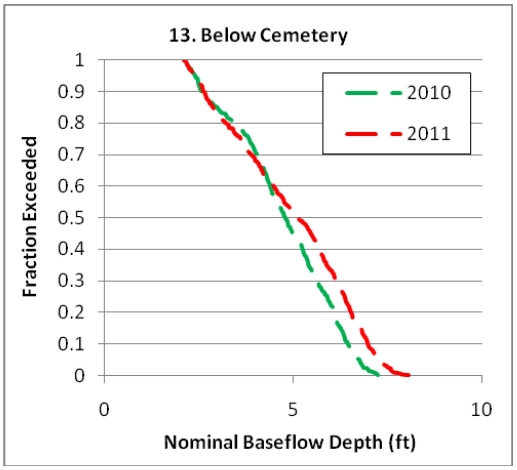
0.4
0.3
0.2
0.1
0
0
5
10
15
Nominal Baseflow Depth (ft)
2010
2011


13. Below Cemetery
Fraction Exceeded
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0.6
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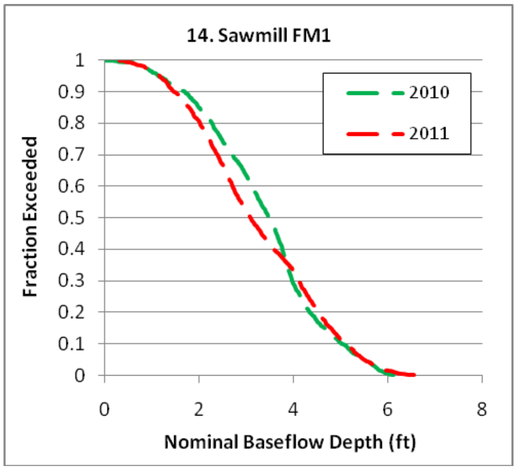
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2010
2011


14. Sawmill FM1
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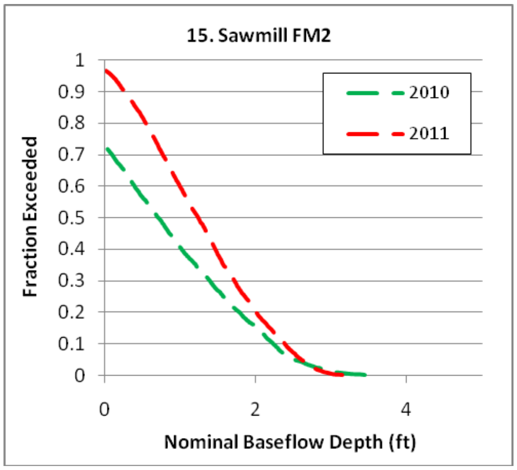
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
Nominal Baseflow Depth (ft)
2010
2011


15. Sawmill FM2
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0.7
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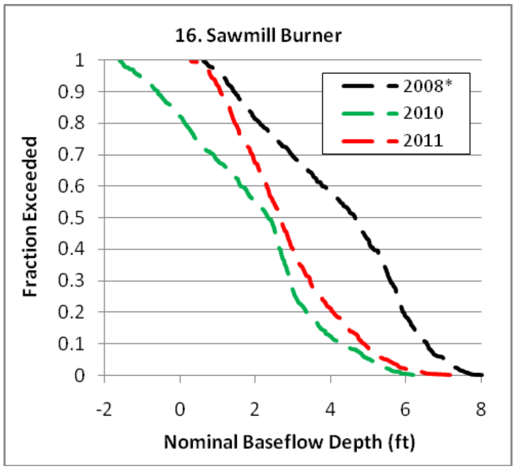
0.4
0.3
0.2
0.1
0
0
2
4
Nominal Baseflow Depth (ft)
2010
2011


16. Sawmill Burner
Fraction Exceeded
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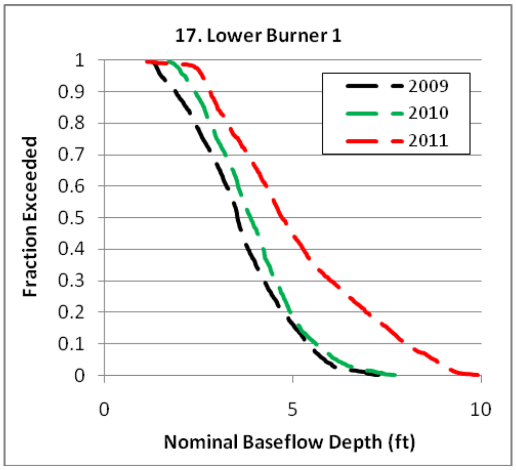
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-2
0
2
4
6
8
Nominal Baseflow Depth (ft)
2008*
2010
2011


17. Lower Burner 1
Fraction Exceeded
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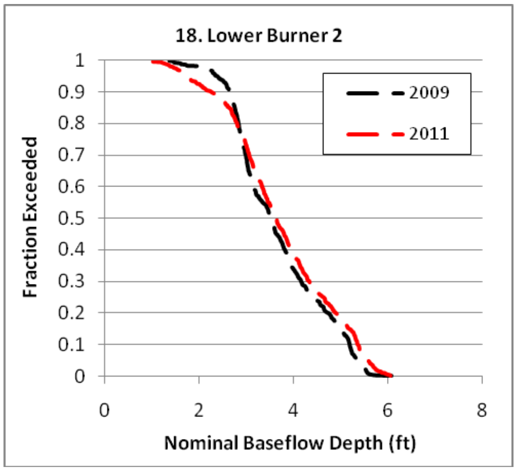
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2009
2010
2011


18. Lower Burner 2
Fraction Exceeded
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0.9
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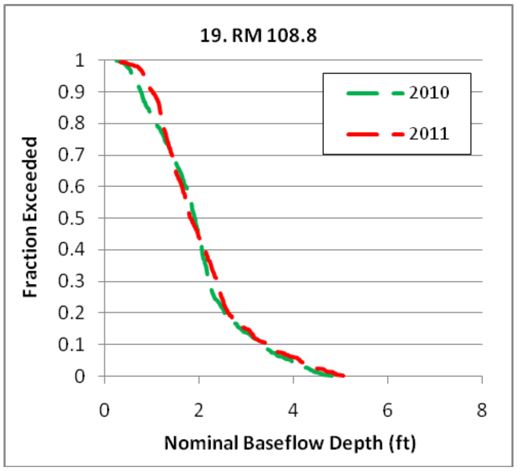
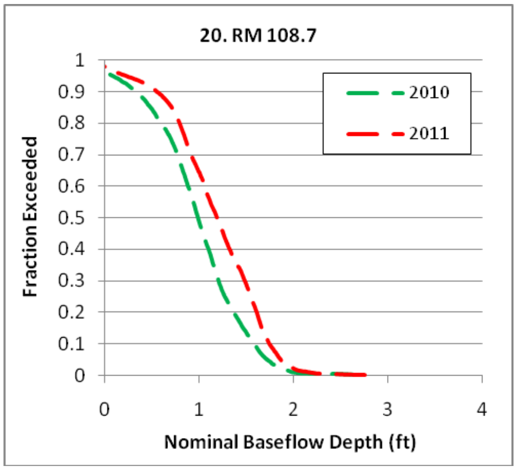
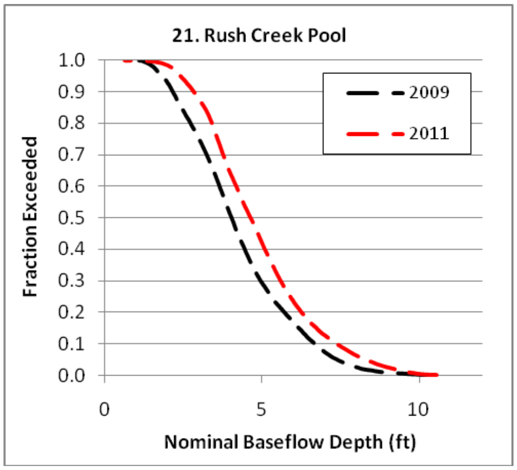
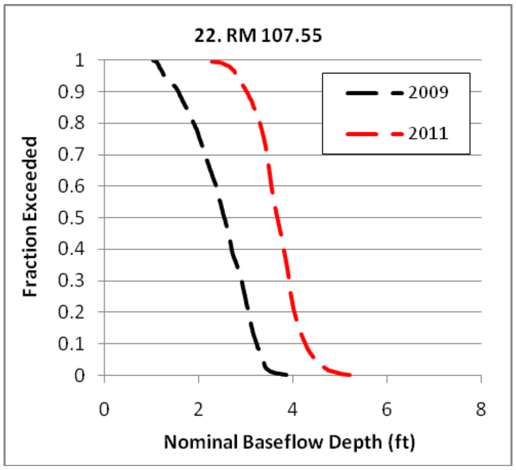
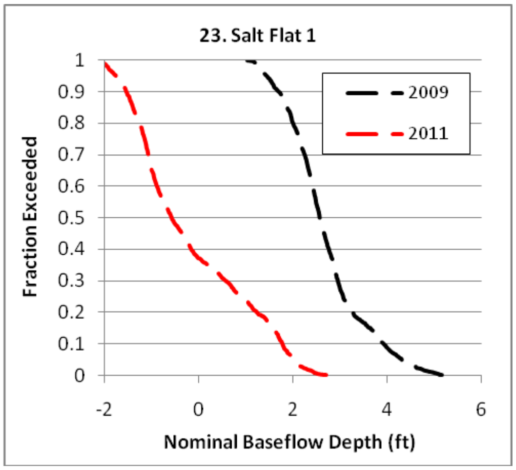
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
Nominal Baseflow Depth (ft)
2009
2011

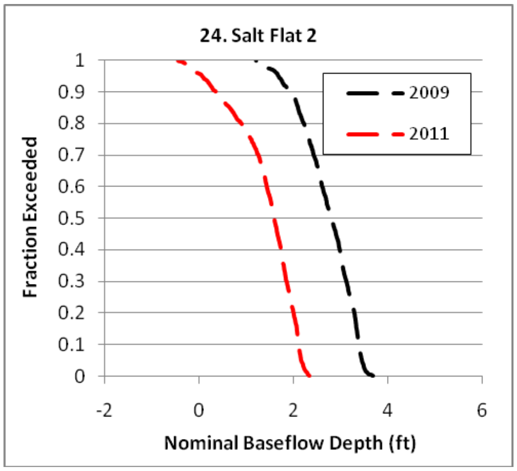

19. RM 108.8
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
Nominal Baseflow Depth (ft)
2010
2011

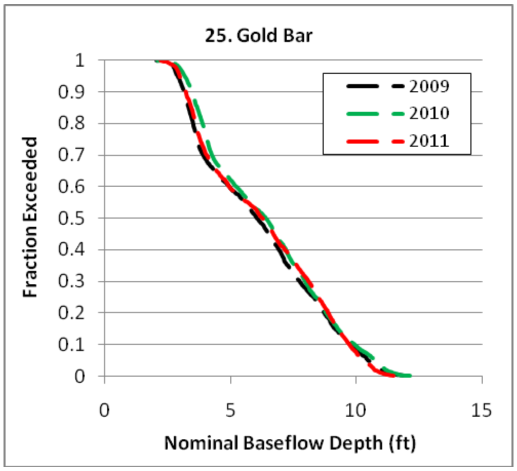

20. RM 108.7
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
Nominal Baseflow Depth (ft)
2010
2011

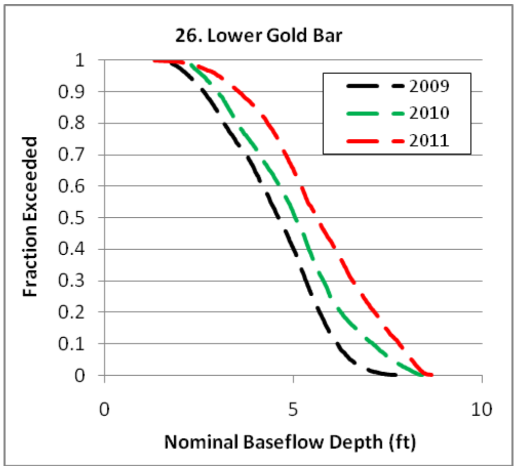

21. Rush Creek Pool
Fraction Exceeded
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
5
10
Nominal Baseflow Depth (ft)
2009
2011

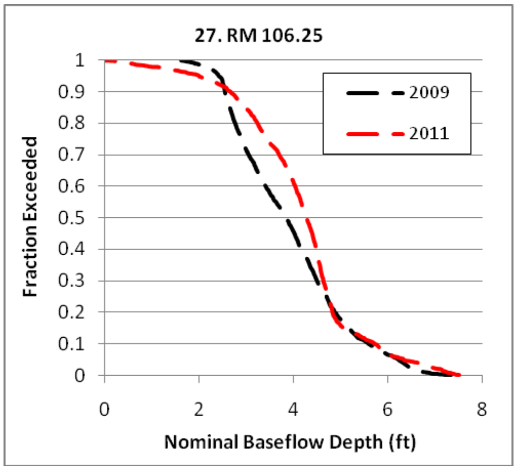

22. RM 107.55
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
Nominal Baseflow Depth (ft)
2009
2011

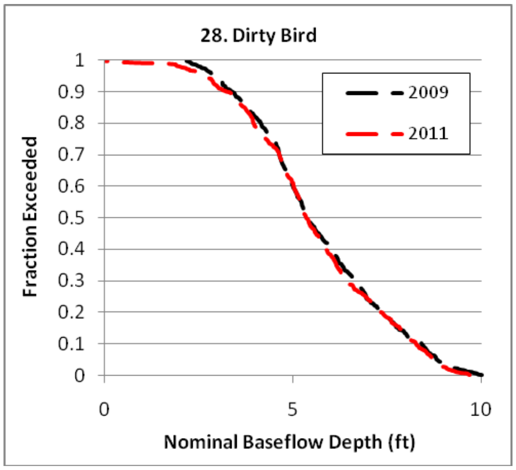

23. Salt Flat 1
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-2
0
2
4
6
Nominal Baseflow Depth (ft)
2009
2011

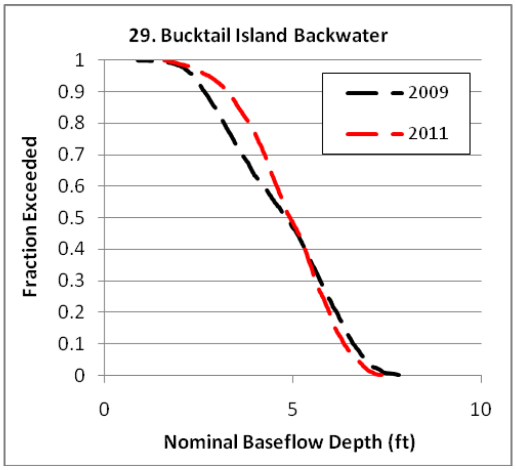

24. Salt Flat 2
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-2
0
2
4
6
Nominal Baseflow Depth (ft)
2009
2011

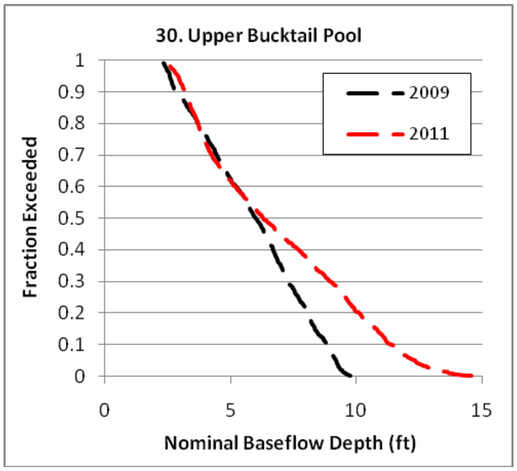

25. Gold Bar
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
Nominal Baseflow Depth (ft)
2009
2010
2011

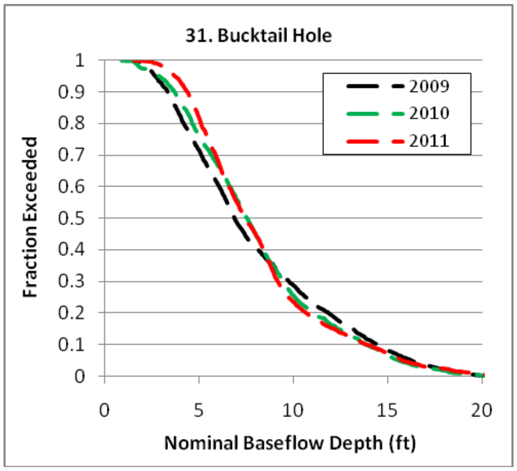

26. Lower Gold Bar

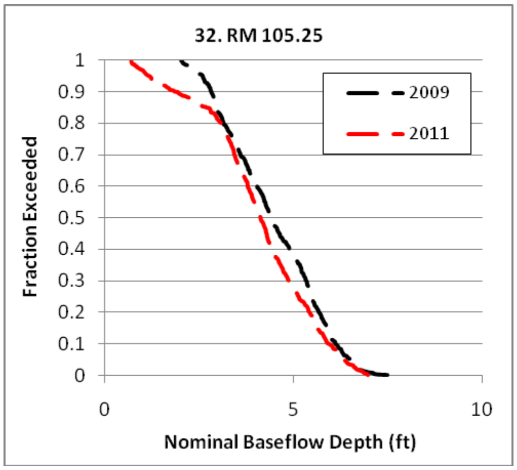

27. RM 106.25

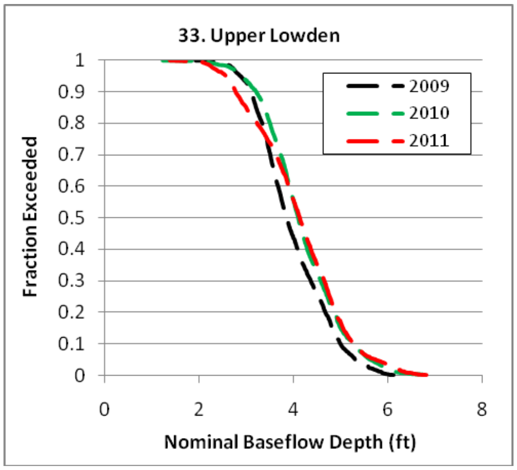

28. Dirty Bird

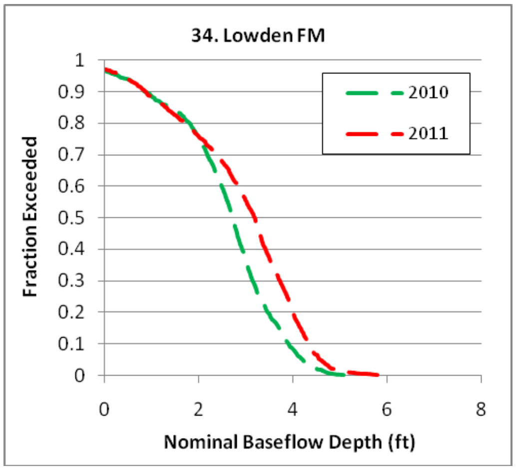

29. Bucktail Island Backwater

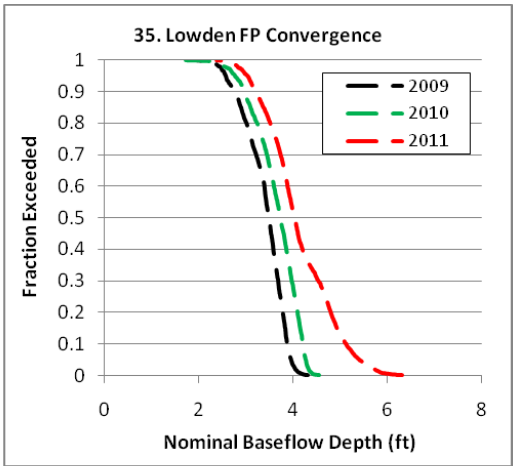

30. Upper Bucktail Pool

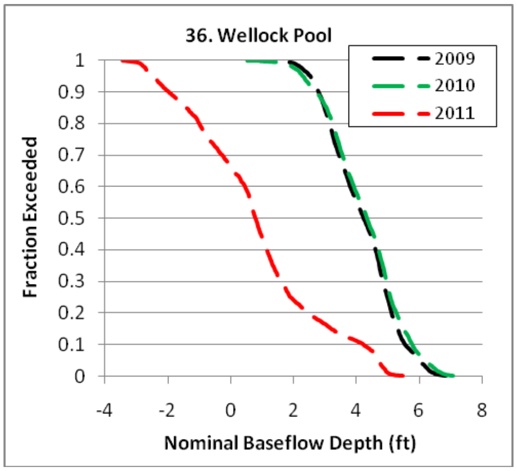

31. Bucktail Hole

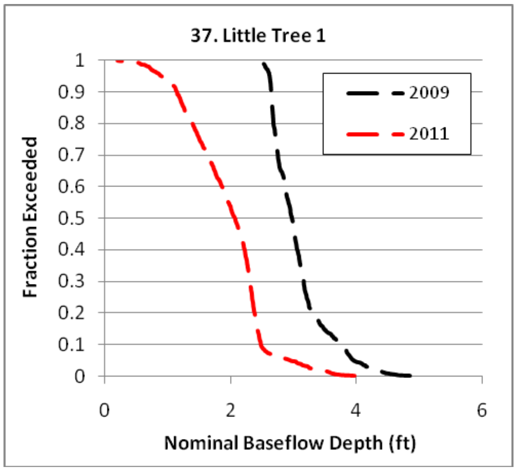

32. RM 105.25

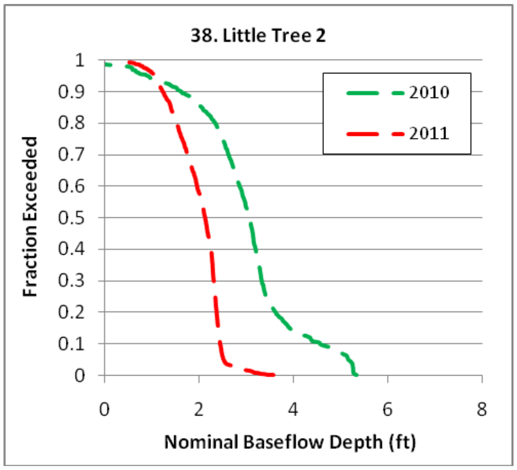

33. Upper Lowden

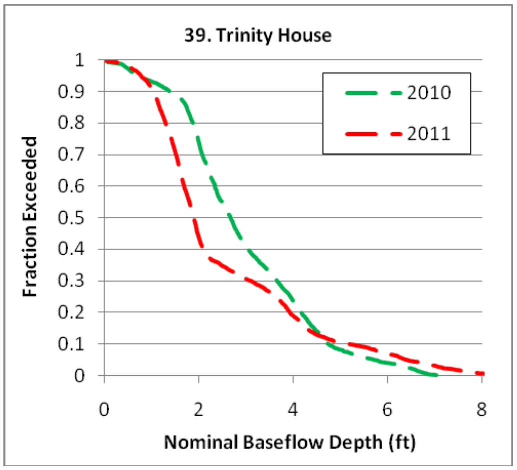

34. Lowden FM

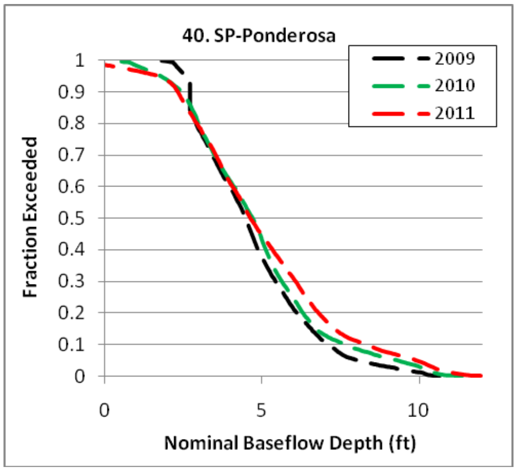

35. Lowden FP Convergence

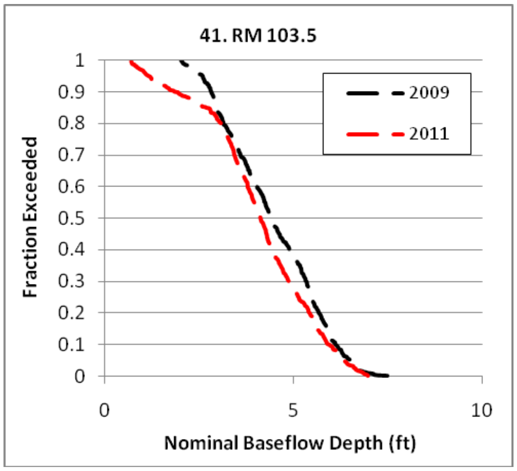

36. Wellock Pool

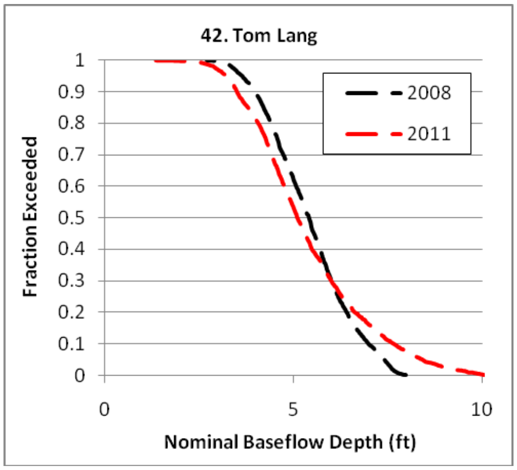

37. Little Tree 1

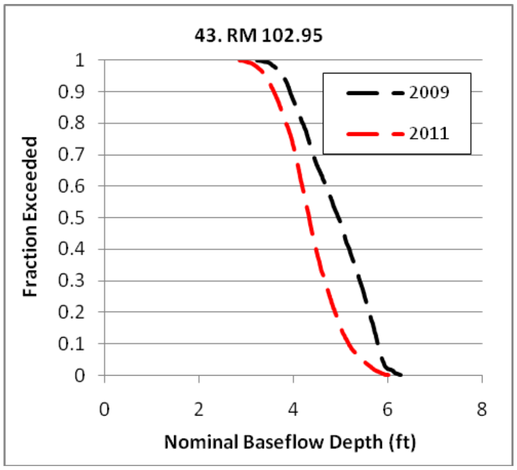

38. Little Tree 2
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
Nominal Baseflow Depth (ft)
2010
2011

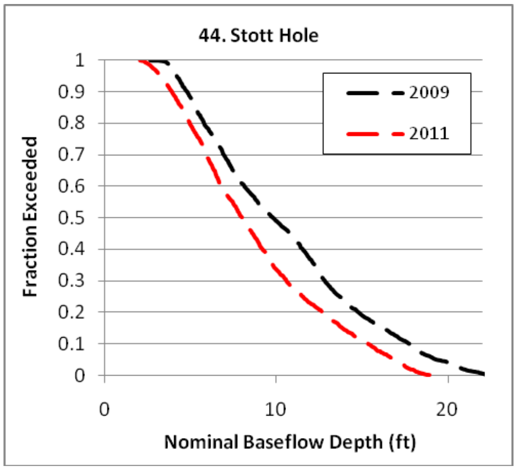

39. Trinity House
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
Nominal Baseflow Depth (ft)
2010
2011

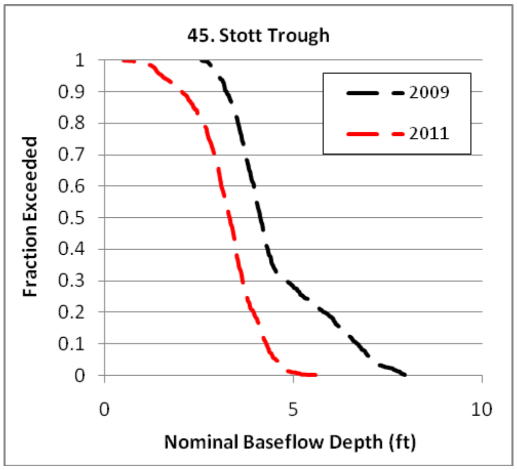

40. SP-Ponderosa
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2009
2010
2011

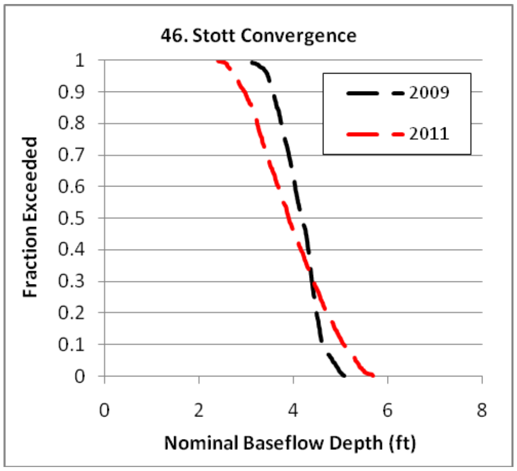

41. RM 103.5
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2009
2011

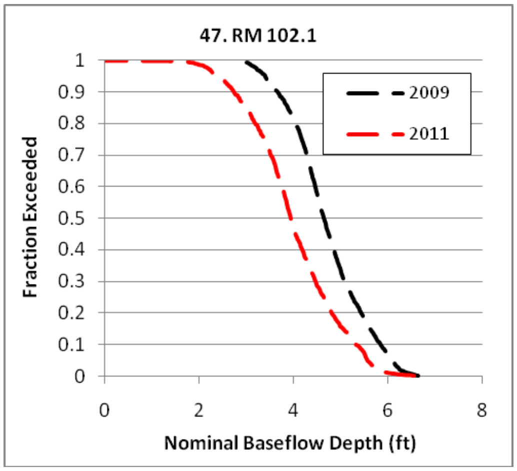

42. Tom Lang
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2008
2011

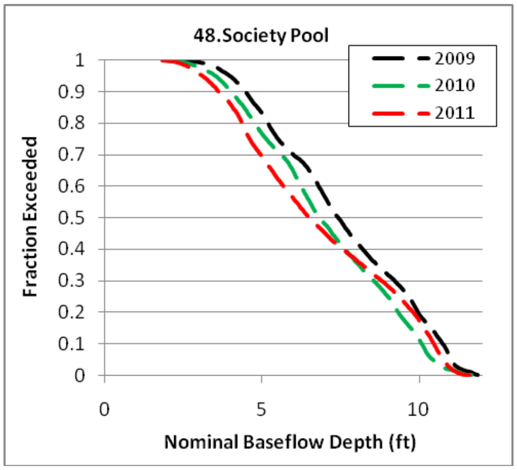

43. RM 102.95
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
Nominal Baseflow Depth (ft)
2009
2011

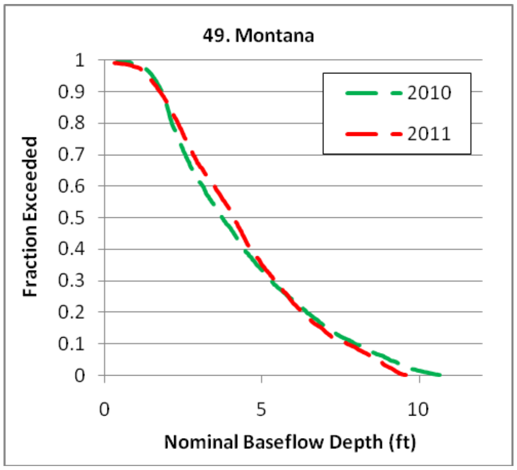

44. Stott Hole
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
Nominal Baseflow Depth (ft)
2009
2011


45. Stott Trough
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2009
2011


46. Stott Convergence
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
Nominal Baseflow Depth (ft)
2009
2011


47. RM 102.1
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
Nominal Baseflow Depth (ft)
2009
2011


48.Society Pool
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2009
2010
2011


49. Montana
Fraction Exceeded
1
0.9
0.8
0.7
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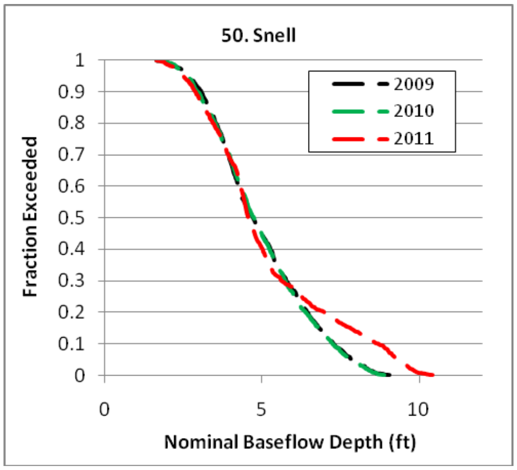
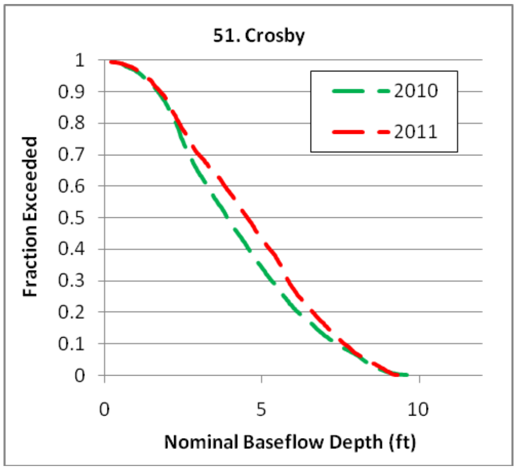
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2010
2011


50. Snell
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2009
2010
2011


51. Crosby
Fraction Exceeded
1
0.9
0.8
0.7
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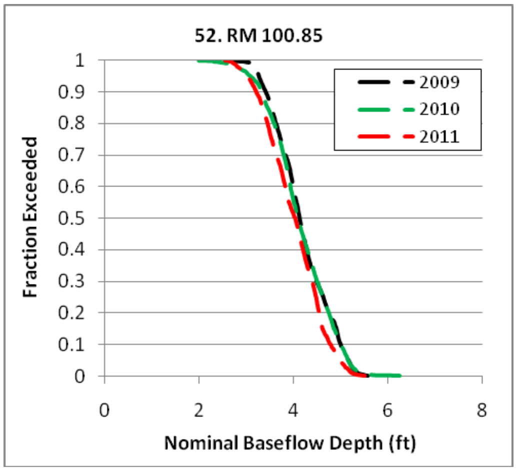
0.5
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2010
2011


52. RM 100.85
Fraction Exceeded
1
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0.8
0.7
0.6
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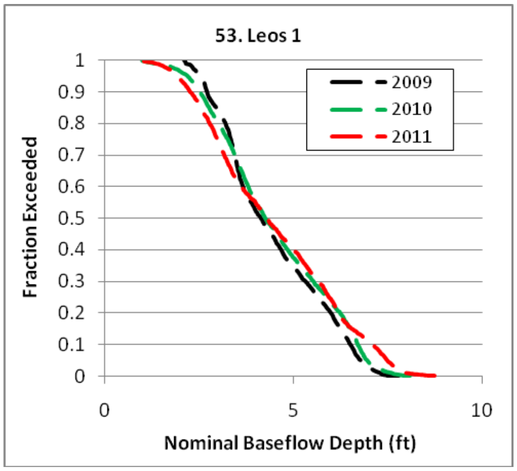
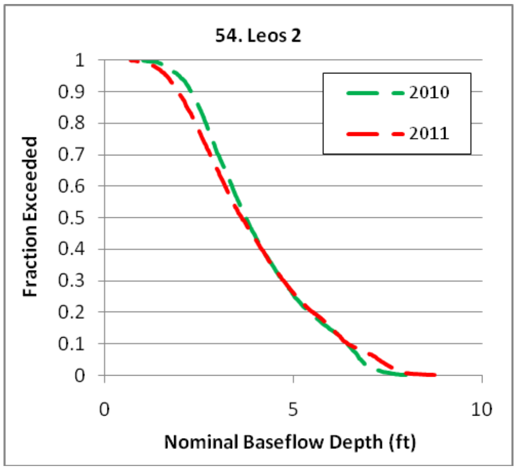
0.2
0.1
0
0
2
4
6
8
Nominal Baseflow Depth (ft)
2009
2010
2011


53. Leos 1
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2009
2010
2011


54. Leos 2
Fraction Exceeded
1
0.9
0.8
0.7
0.6
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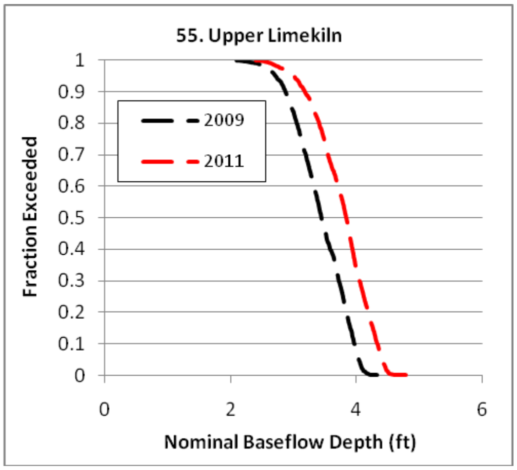
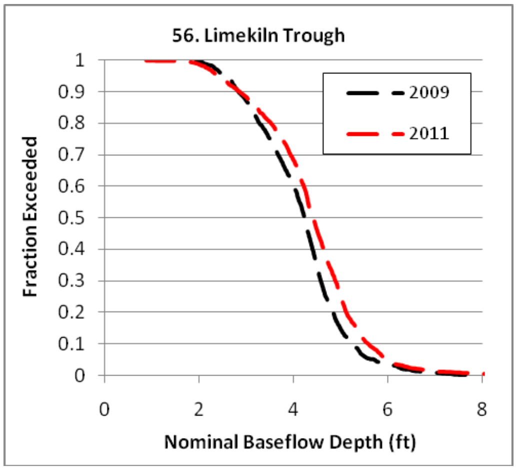
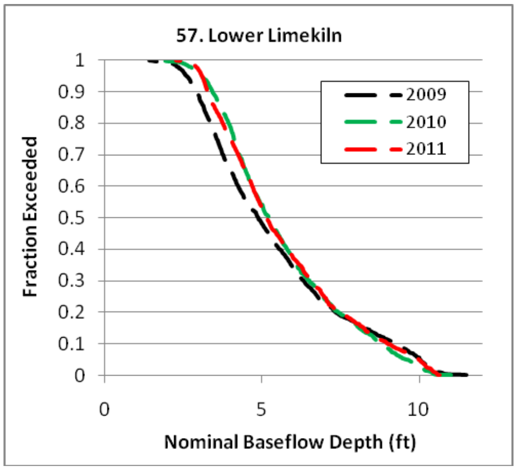
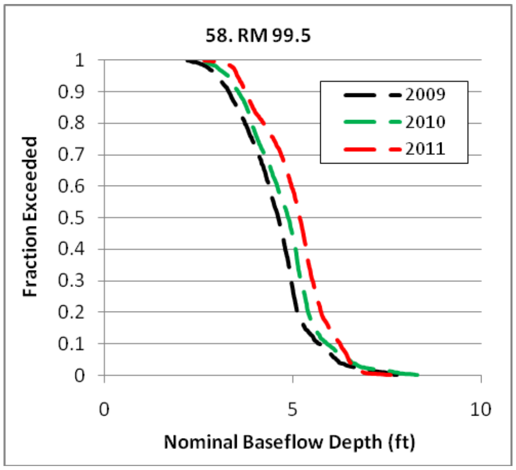
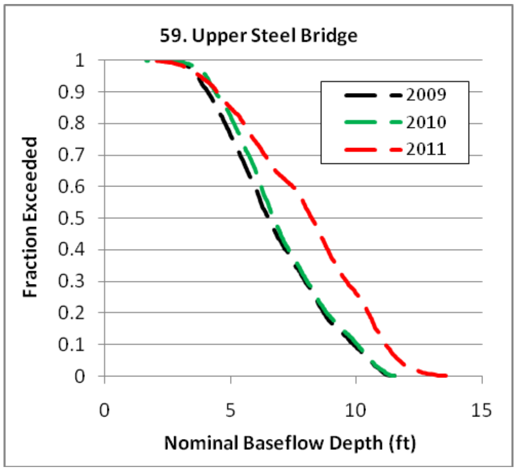
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2010
2011

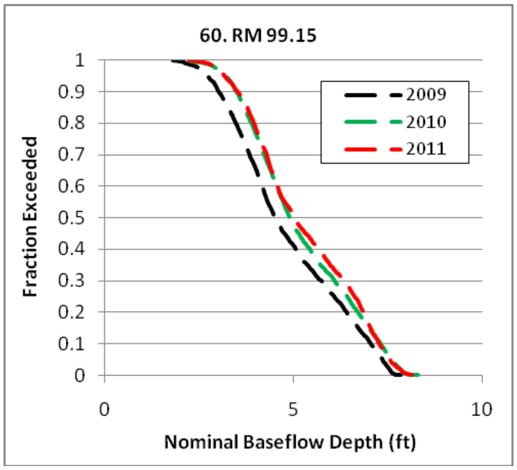

55. Upper Limekiln
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
Nominal Baseflow Depth (ft)
2009
2011

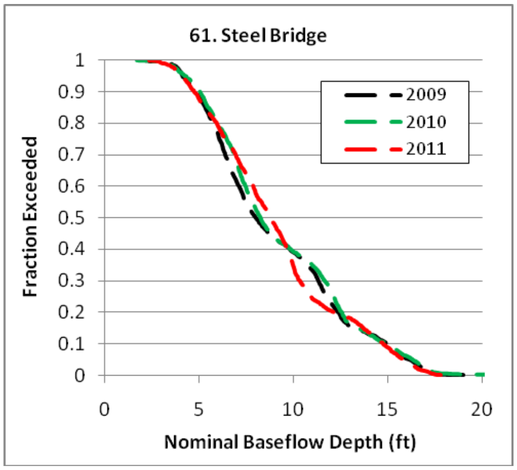

56. Limekiln Trough

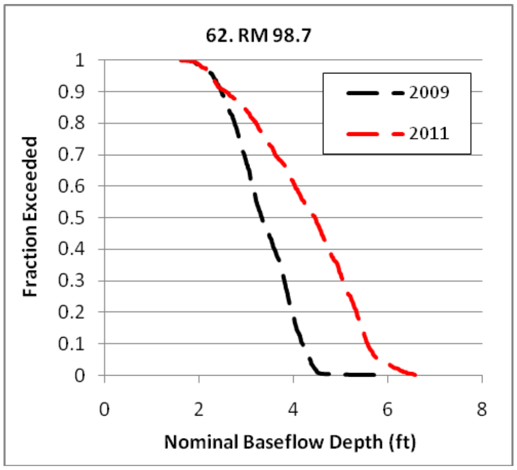

57. Lower Limekiln

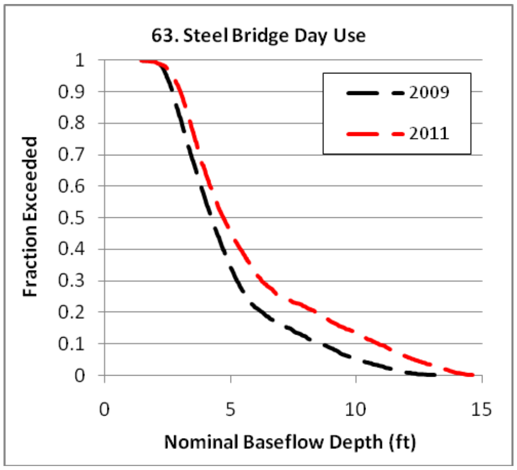

58. RM 99.5

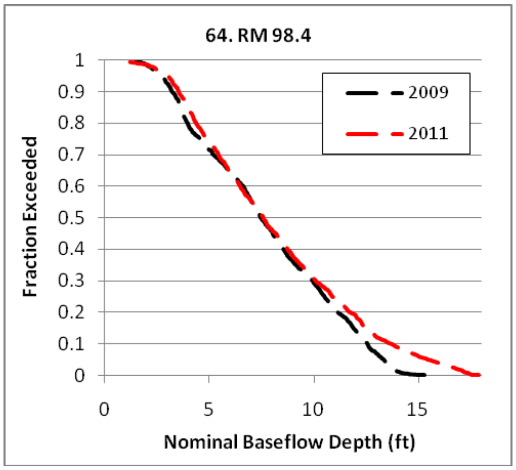

59. Upper Steel Bridge

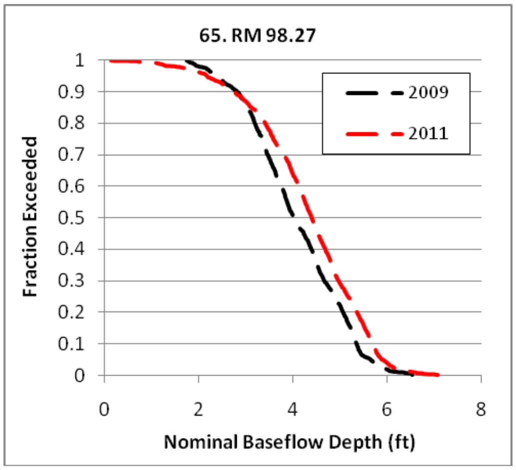

60. RM 99.15

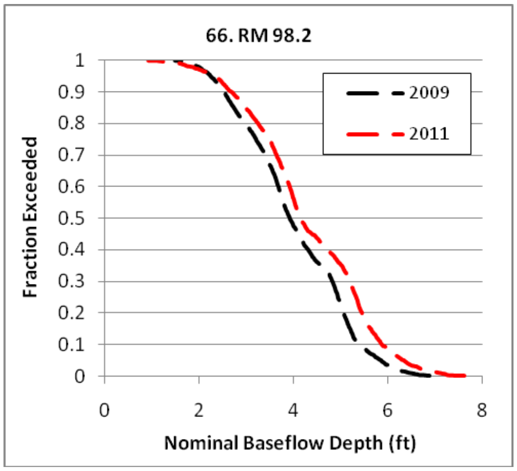

61. Steel Bridge

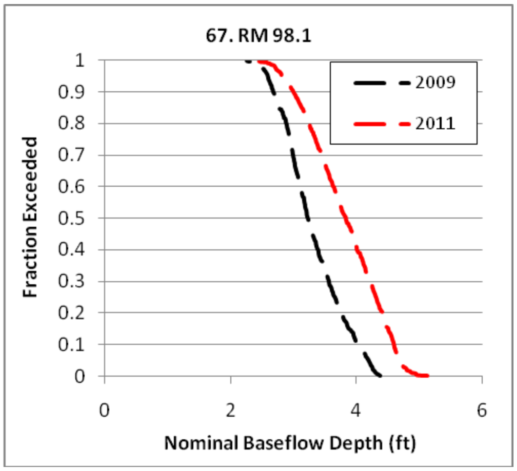

62. RM 98.7

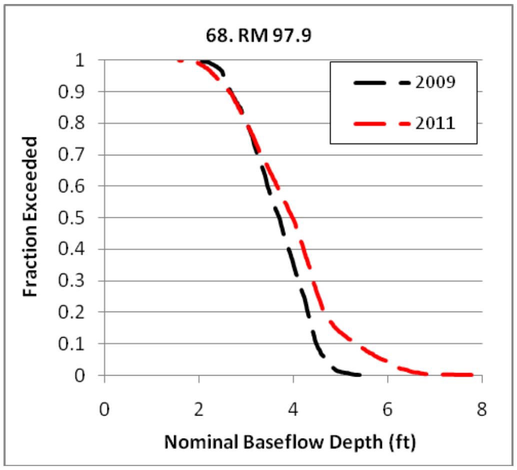

63. Steel Bridge Day Use

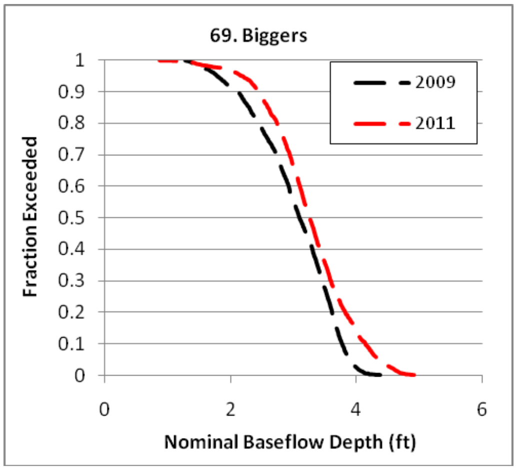

64. RM 98.4

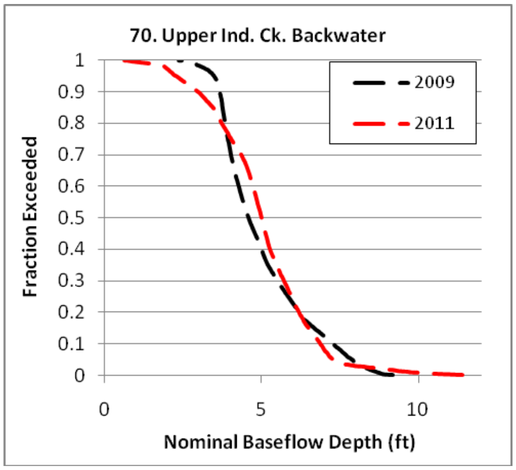

65. RM 98.27

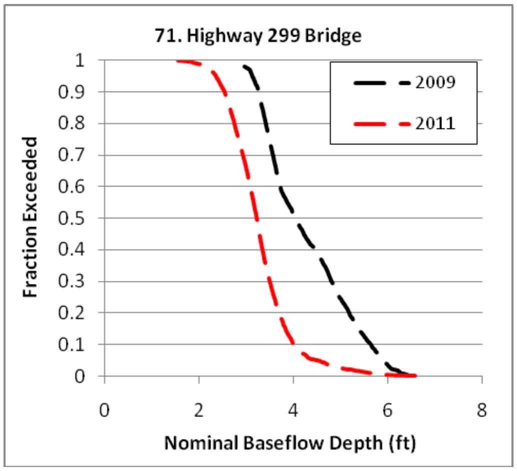

66. RM 98.2

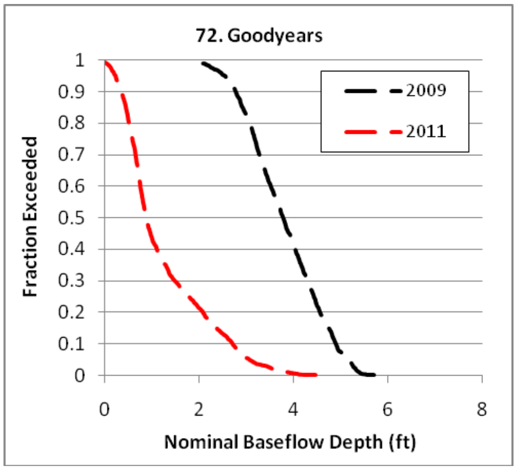

67. RM 98.1

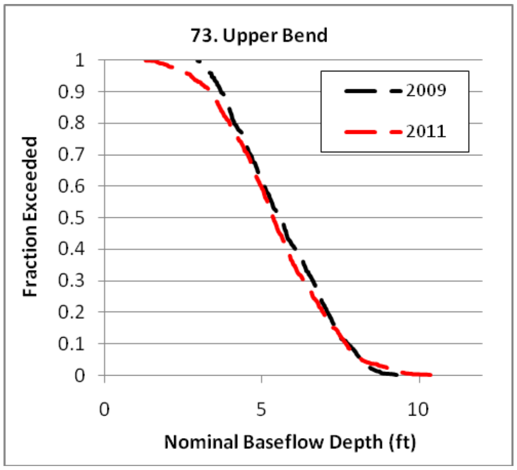

68. RM 97.9

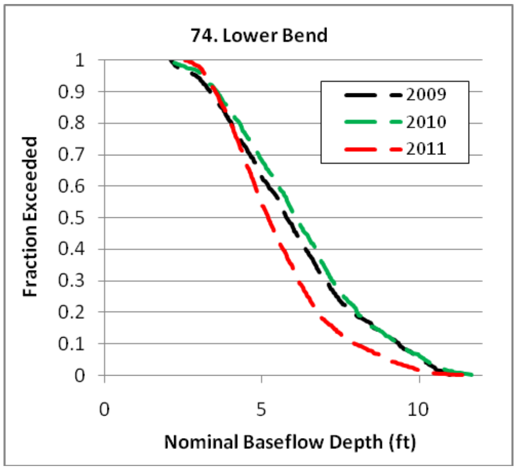

69. Biggers

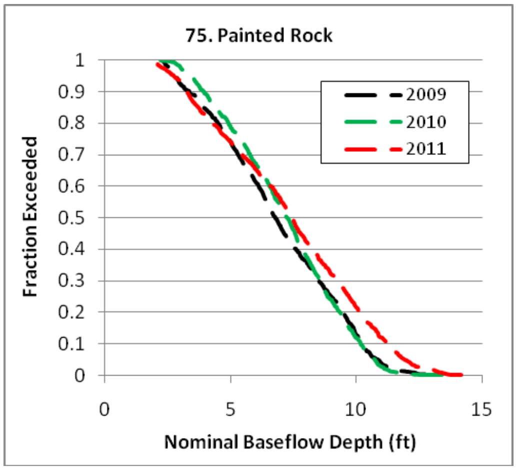

70. Upper Ind. Ck. Backwater

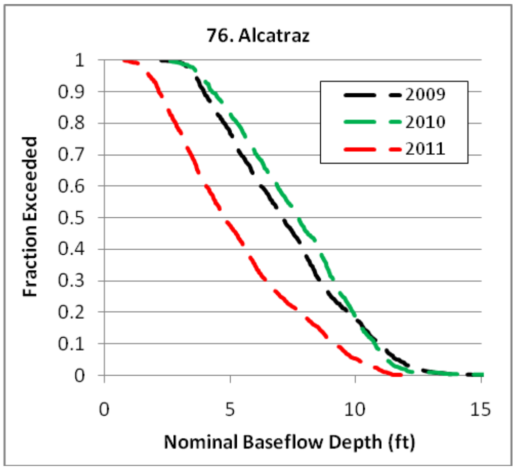

71. Highway 299 Bridge

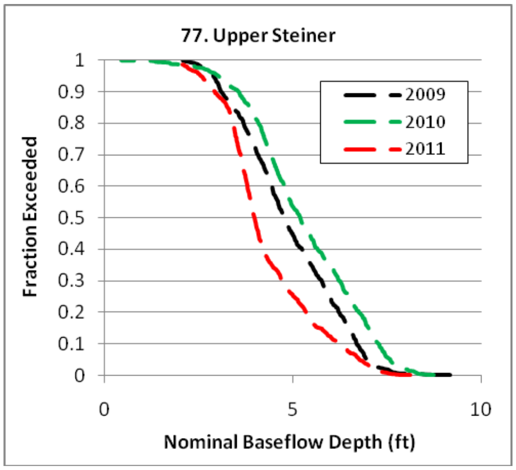

72. Goodyears

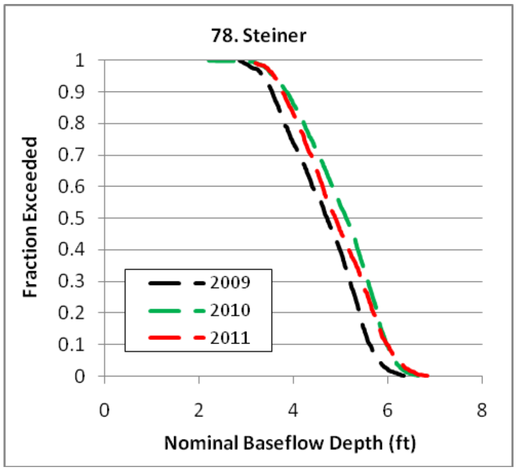

73. Upper Bend

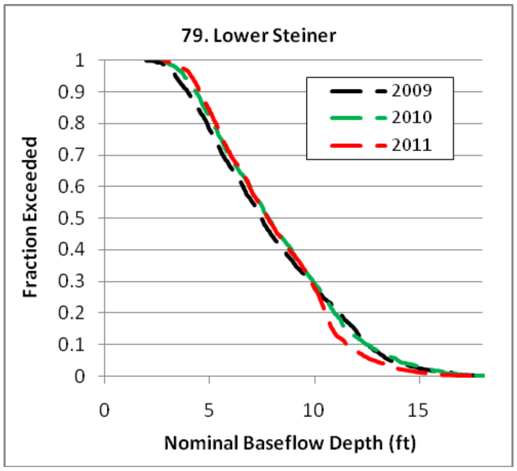

74. Lower Bend

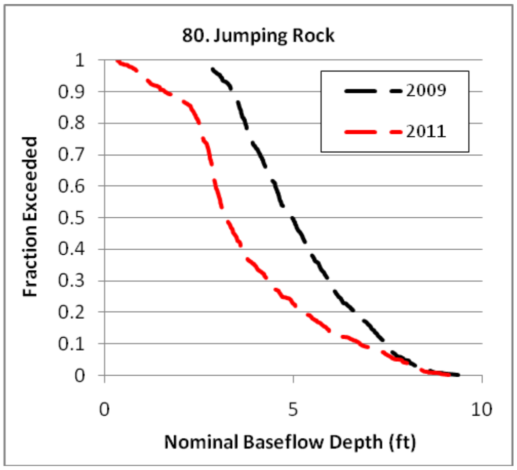

75. Painted Rock

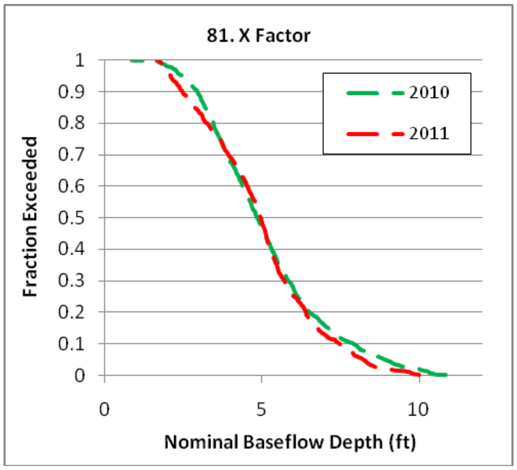

76. Alcatraz

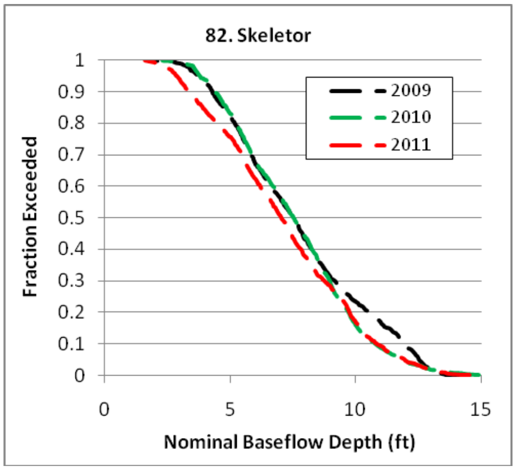

77. Upper Steiner

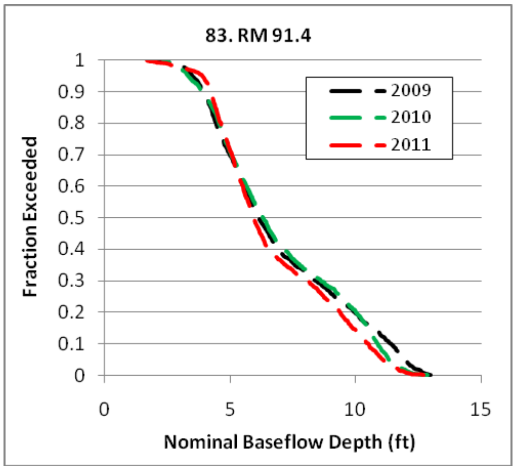

78. Steiner

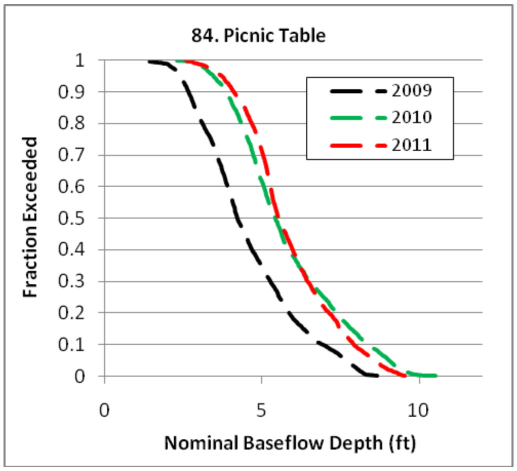

79. Lower Steiner

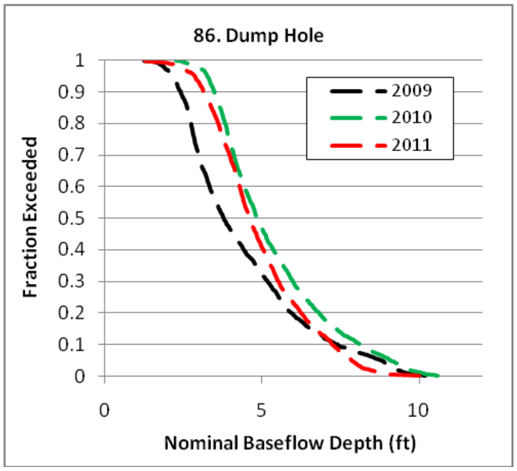

80. Jumping Rock
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2009
2011

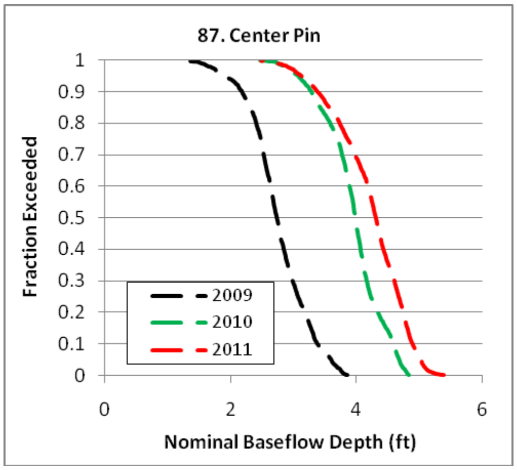

81. X Factor
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2010
2011

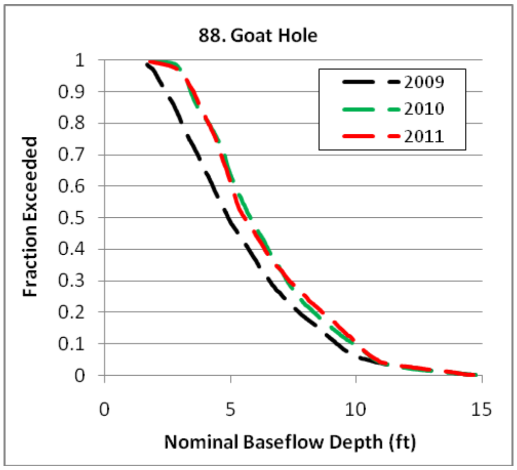

82. Skeletor
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
Nominal Baseflow Depth (ft)
2009
2010
2011

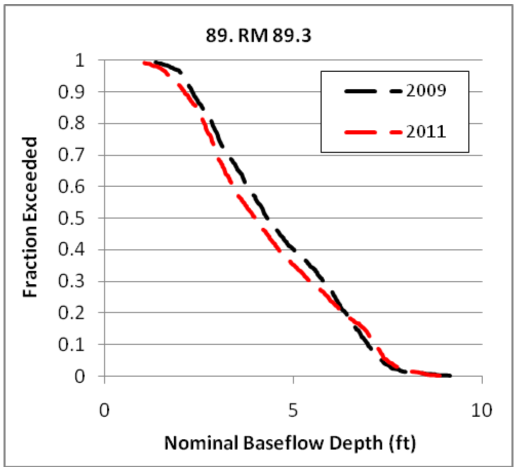

83. RM 91.4
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
Nominal Baseflow Depth (ft)
2009
2010
2011

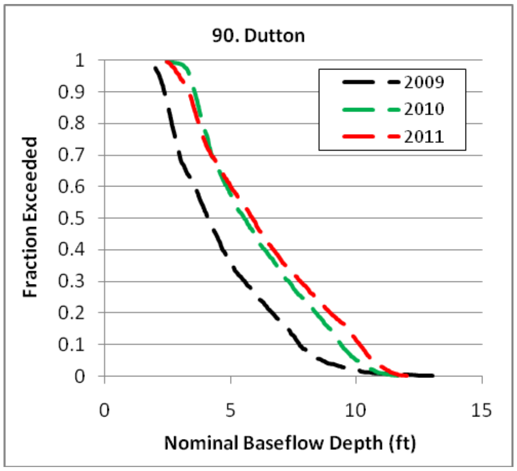

84. Picnic Table
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2009
2010
2011

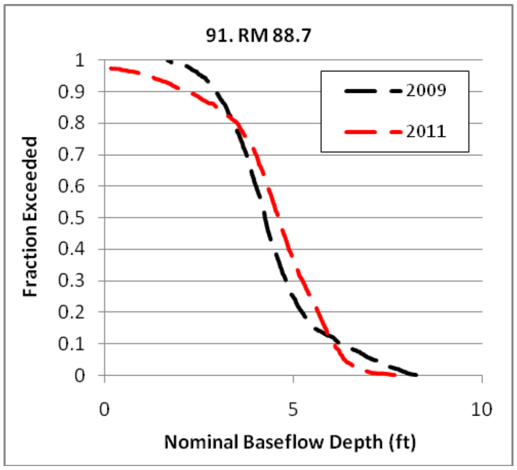

86. Dump Hole
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2009
2010
2011

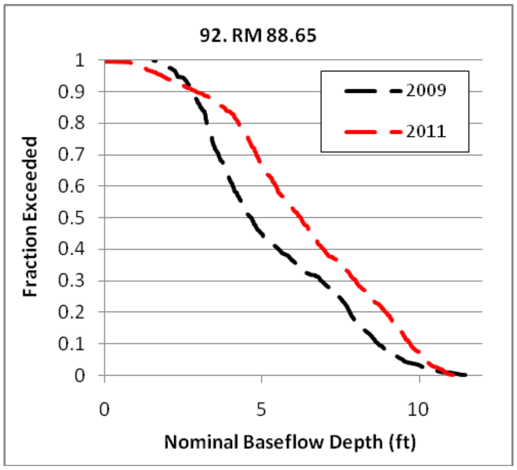

87. Center Pin
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
Nominal Baseflow Depth (ft)
2009
2010
2011

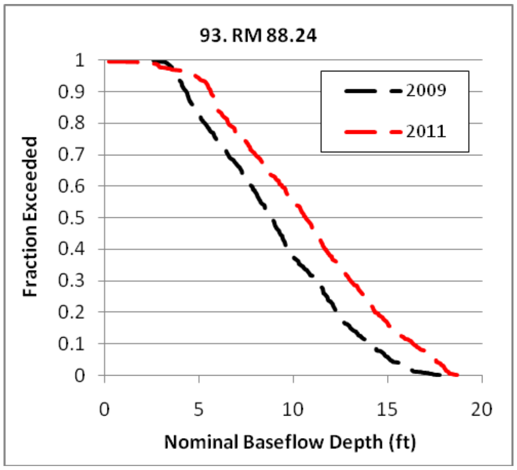

88. Goat Hole
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
Nominal Baseflow Depth (ft)
2009
2010
2011

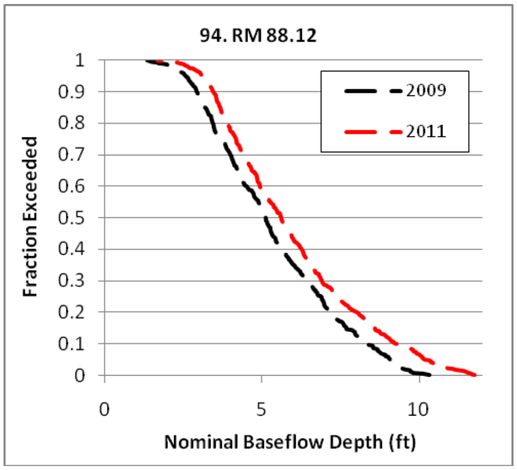

89. RM 89.3
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2009
2011

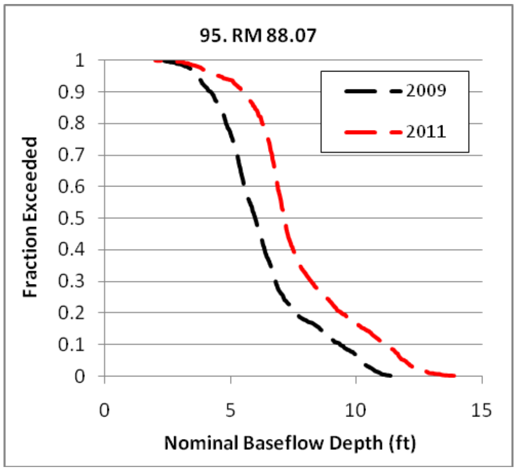

90. Dutton
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
Nominal Baseflow Depth (ft)
2009
2010
2011

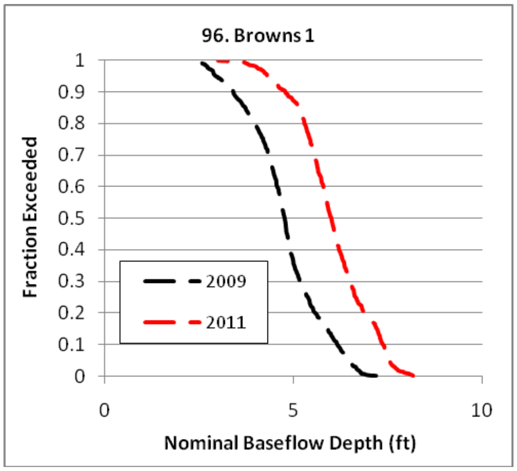

91. RM 88.7
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2009
2011

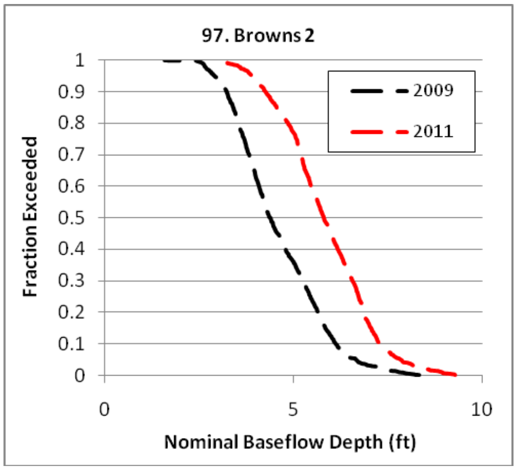

92. RM 88.65
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2009
2011

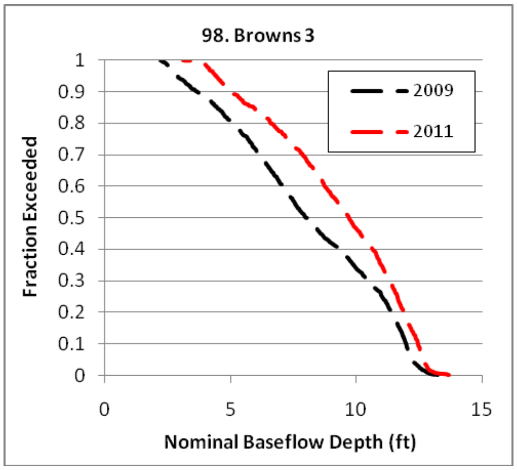

93. RM 88.24

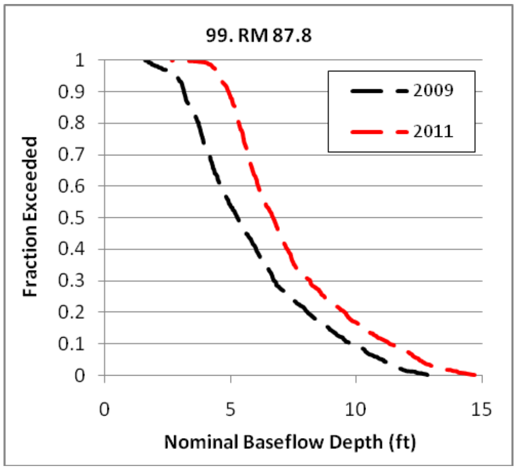

94. RM 88.12

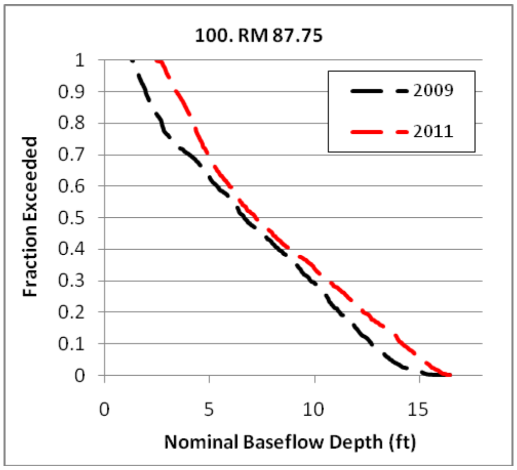

95. RM 88.07

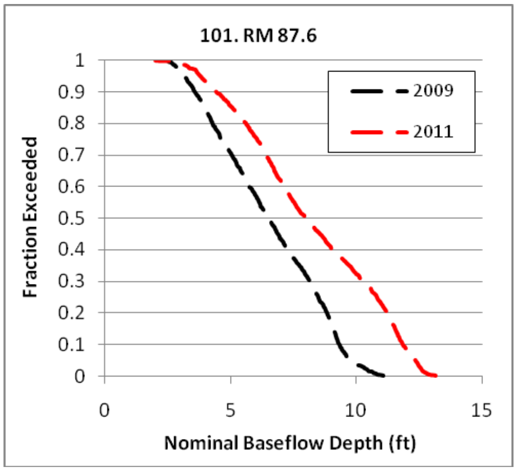

96. Browns 1

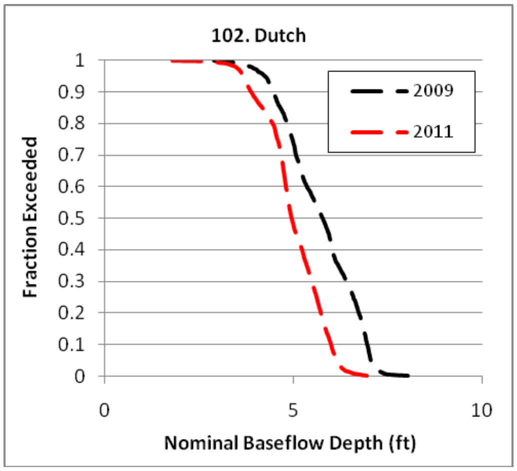

97. Browns 2

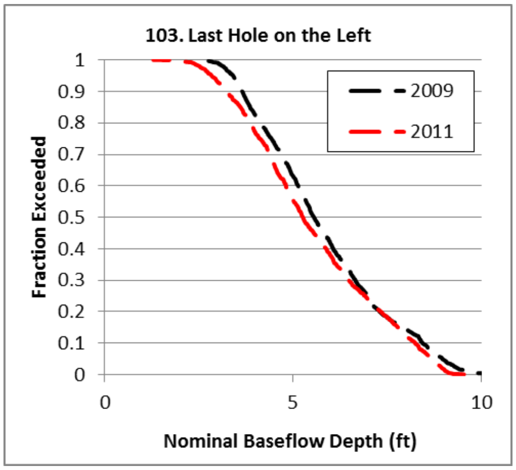

98. Browns 3

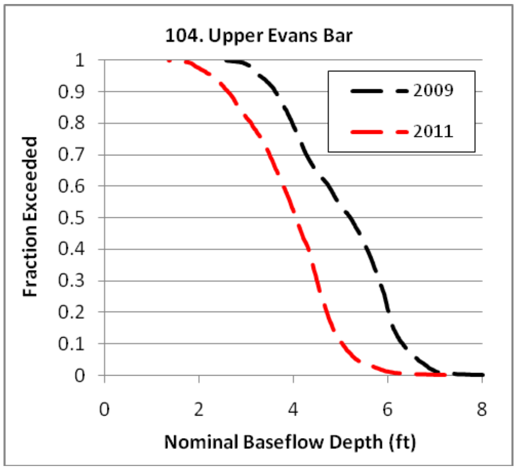

99. RM 87.8
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
Nominal Baseflow Depth (ft)
2009
2011

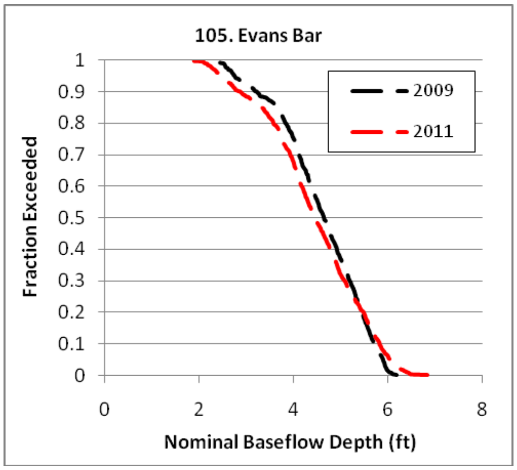

100. RM 87.75
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
Nominal Baseflow Depth (ft)
2009
2011

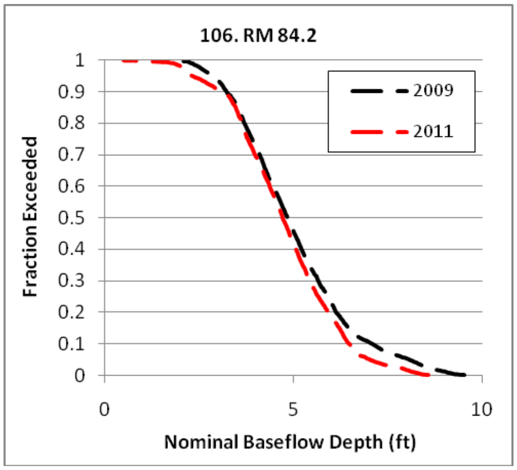

101. RM 87.6
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
Nominal Baseflow Depth (ft)
2009
2011

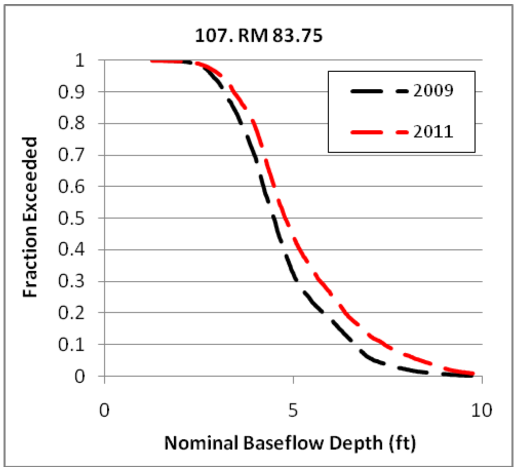

102. Dutch
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2009
2011

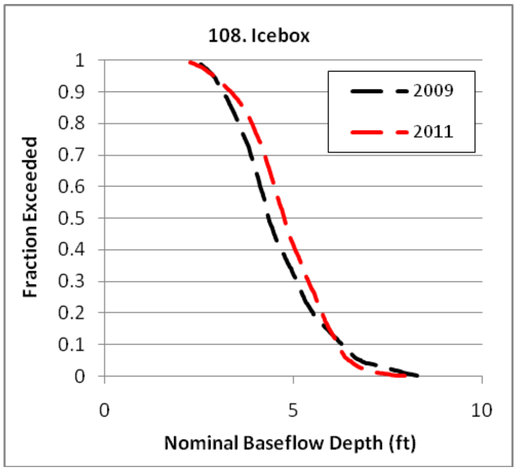

103. Last Hole on the Left
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2009
2011

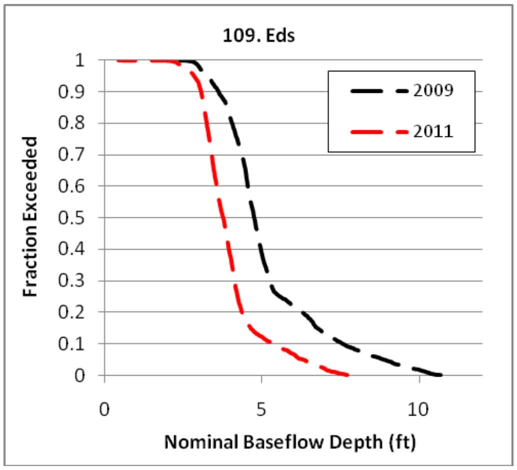

104. Upper Evans Bar
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
Nominal Baseflow Depth (ft)
2009
2011

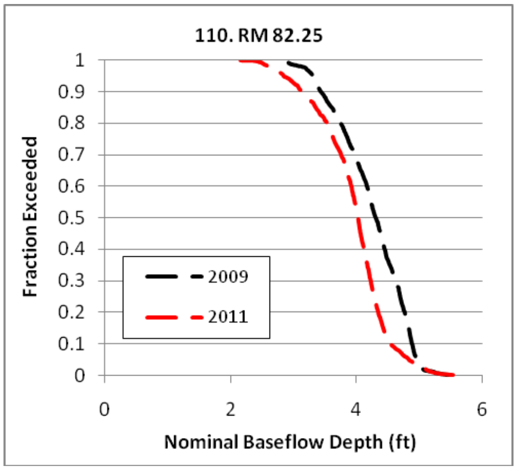

105. Evans Bar
Fraction Exceeded
Nominal Baseflow Depth (ft)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
2009
2011

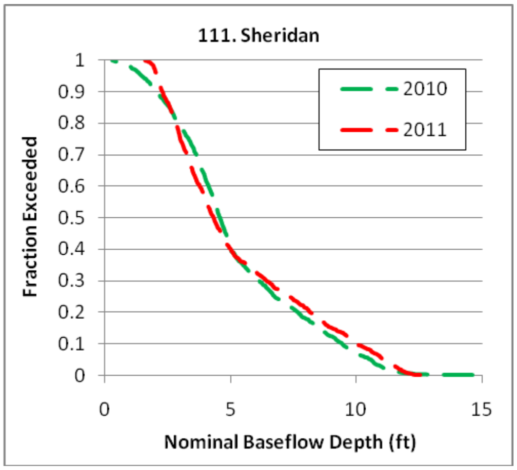

106. RM 84.2
Fraction Exceeded
Nominal Baseflow Depth (ft)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
2009
2011

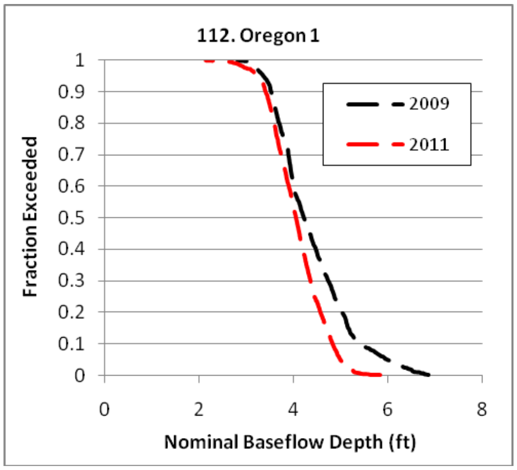

107. RM 83.75
Fraction Exceeded
Nominal Baseflow Depth (ft)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
2009
2011

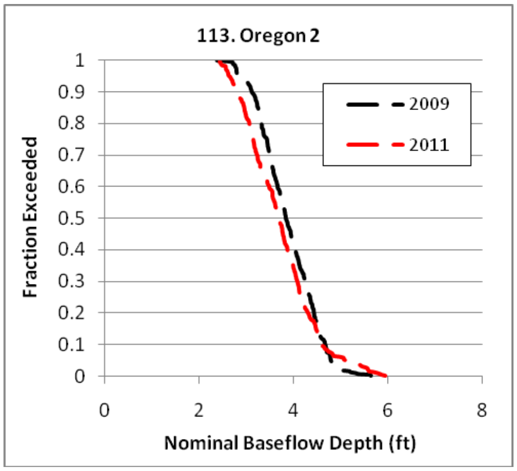

108. Icebox
Fraction Exceeded
Nominal Baseflow Depth (ft)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
2009
2011

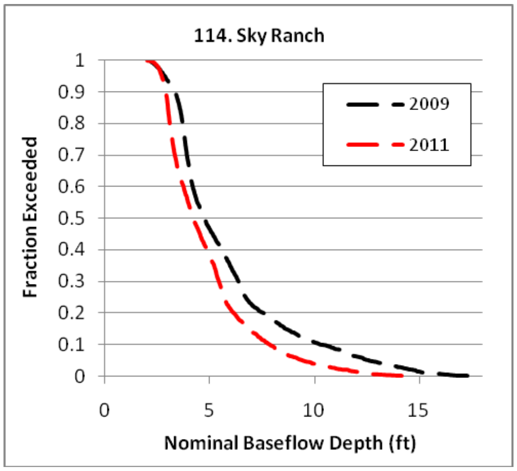

109. Eds
Fraction Exceeded
Nominal Baseflow Depth (ft)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
2009
2011

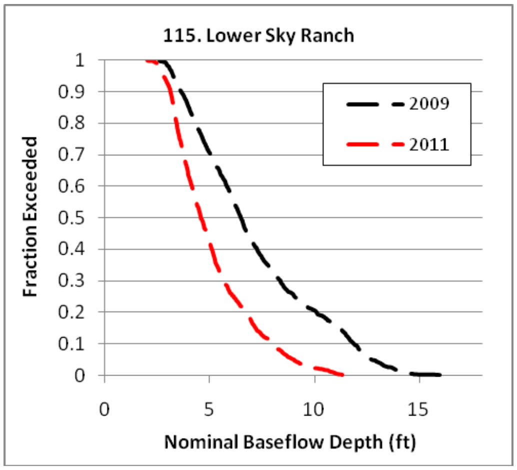

110. RM 82.25
Fraction Exceeded
Nominal Baseflow Depth (ft)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
2009
2011

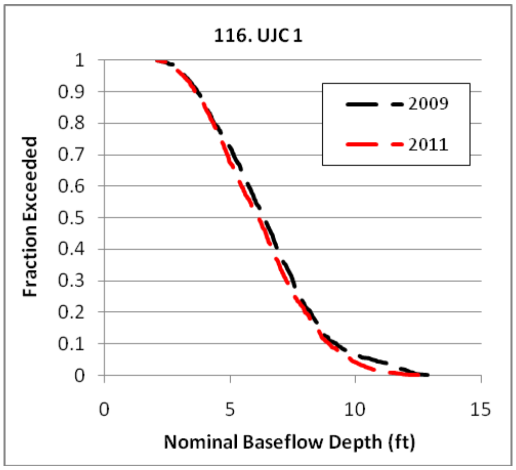

111. Sheridan
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
Nominal Baseflow Depth (ft)
2010
2011

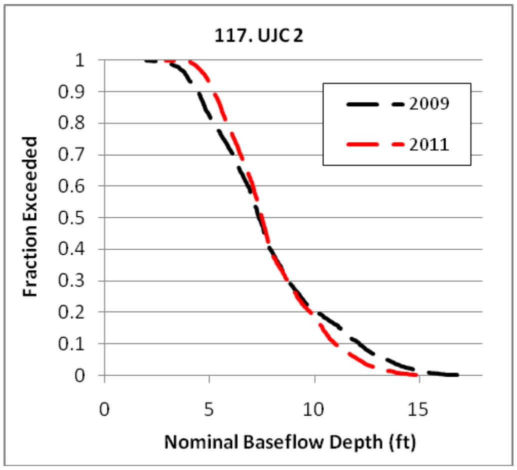

112. Oregon 1
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
Nominal Baseflow Depth (ft)
2009
2011

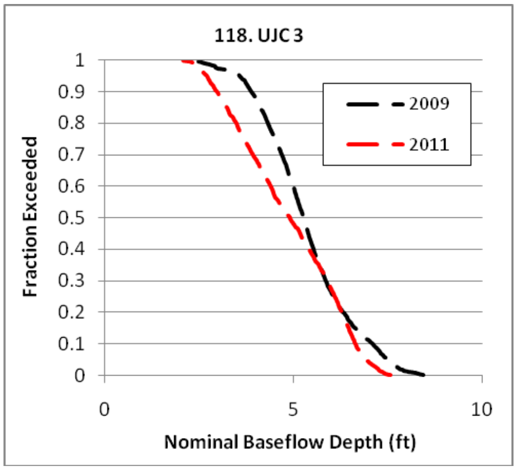

113. Oregon 2
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
Nominal Baseflow Depth (ft)
2009
2011

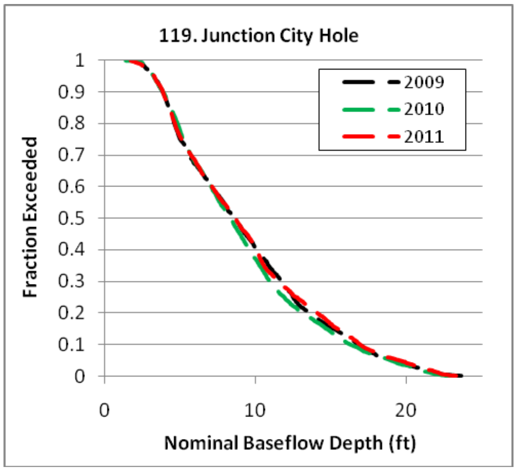

114. Sky Ranch
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
Nominal Baseflow Depth (ft)
2009
2011


115. Lower Sky Ranch
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
Nominal Baseflow Depth (ft)
2009
2011


116. UJC 1
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
Nominal Baseflow Depth (ft)
2009
2011


117. UJC 2
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
Nominal Baseflow Depth (ft)
2009
2011


118. UJC 3
Fraction Exceeded
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
Nominal Baseflow Depth (ft)
2009
2011


119. Junction City Hole
Fraction Exceeded
1
0.9
0.8
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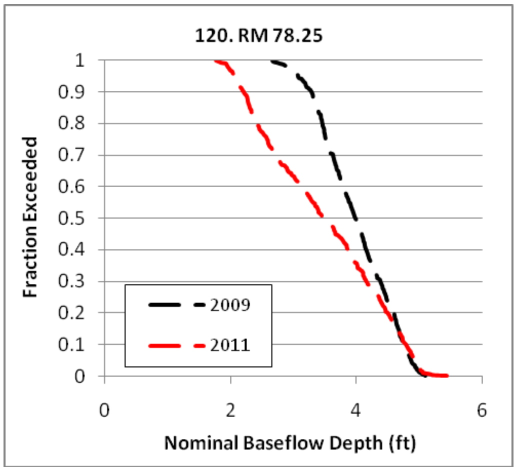
20
Nominal Baseflow Depth (ft)
2009
2010
2011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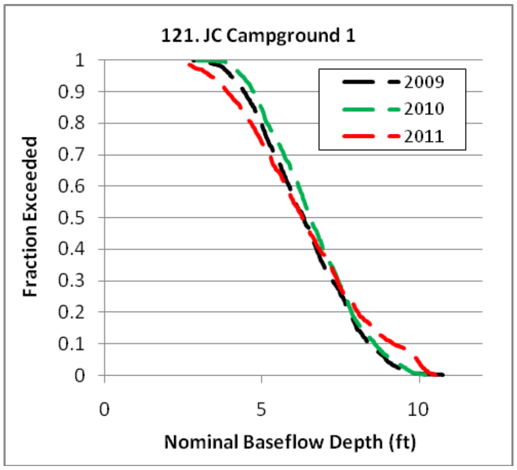
Nominal Baseflow Depth (ft)
2009
2011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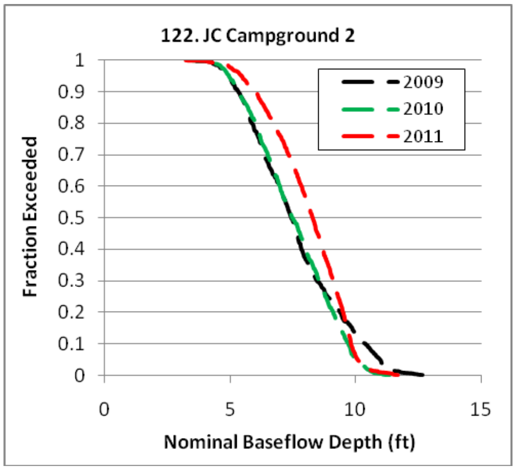
Nominal Baseflow Depth (ft)
2009
2010
2011


122. JC Campground 2
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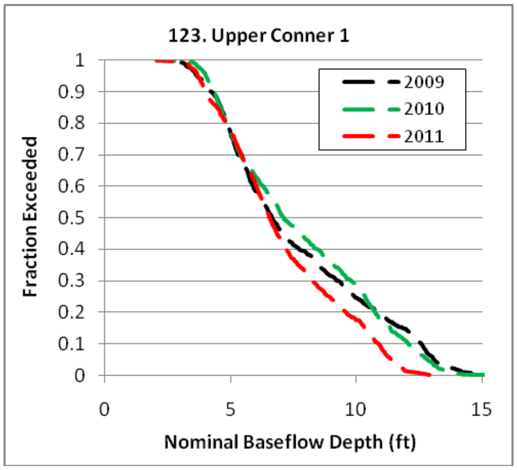
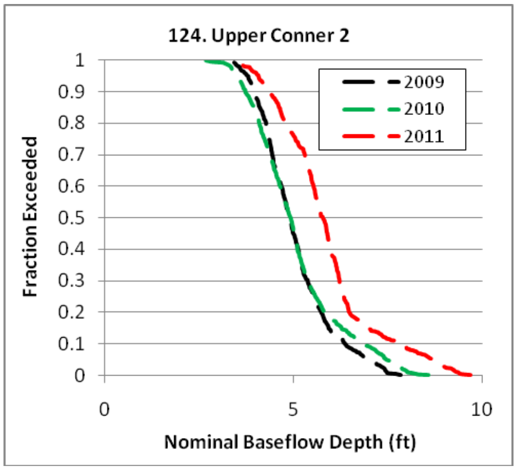
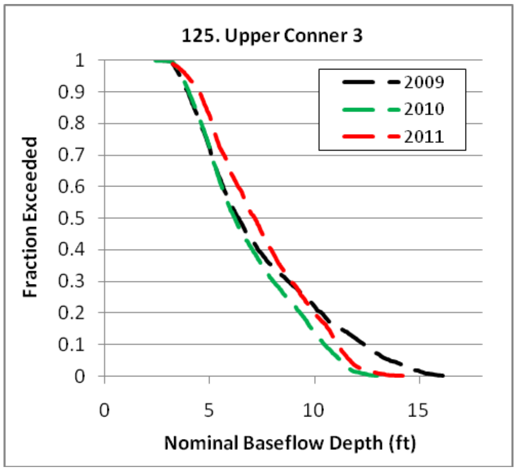
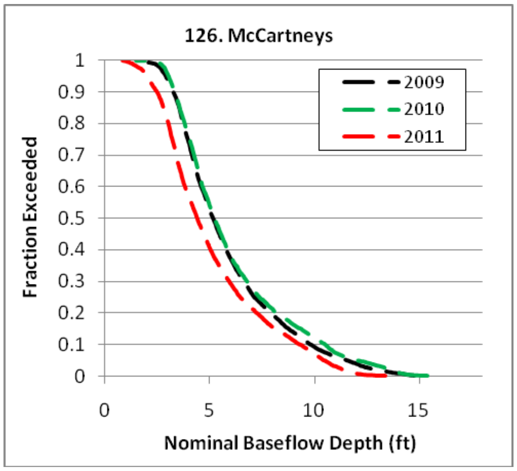
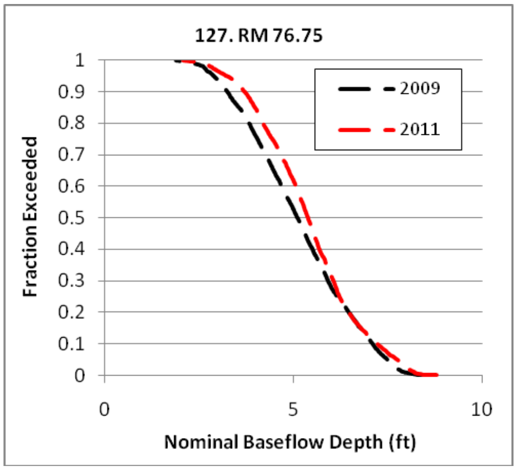
Nominal Baseflow Depth (ft)
2009
2010
2011

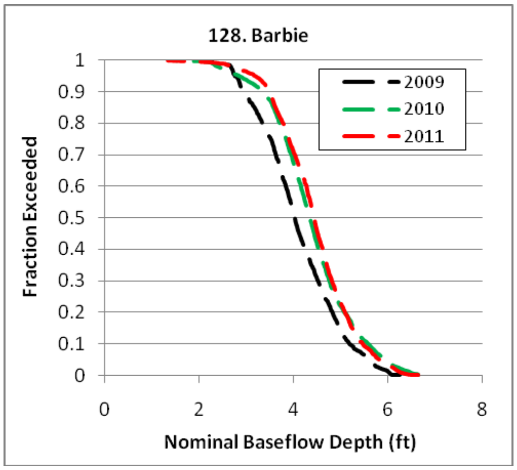

123. Upper Conner 1

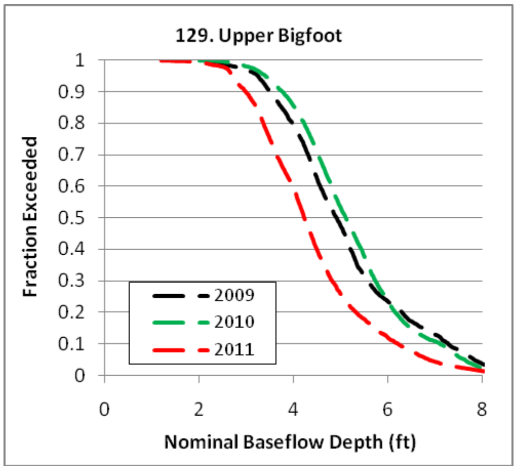

124. Upper Conner 2


125. Upper Conner 3


126. McCartneys


127. RM 76.75


128. Barbie


129. Upper Bigfoot
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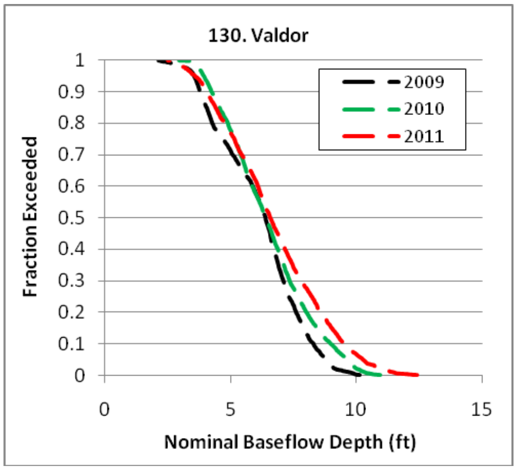
6
8
Nominal Baseflow Depth (ft)
2009
2010
2011


130. Valdor
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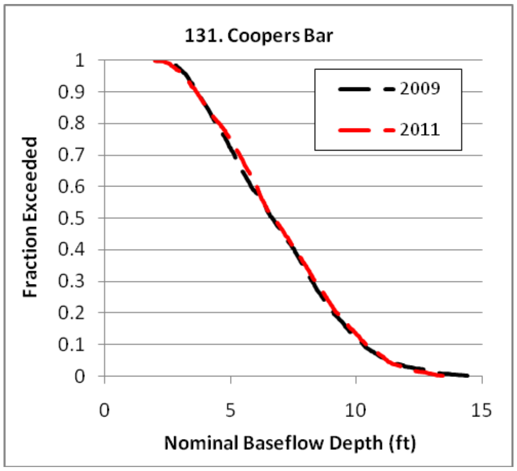
Nominal Baseflow Depth (ft)
2009
2010
2011


131. Coopers Bar
Fraction Exceeded
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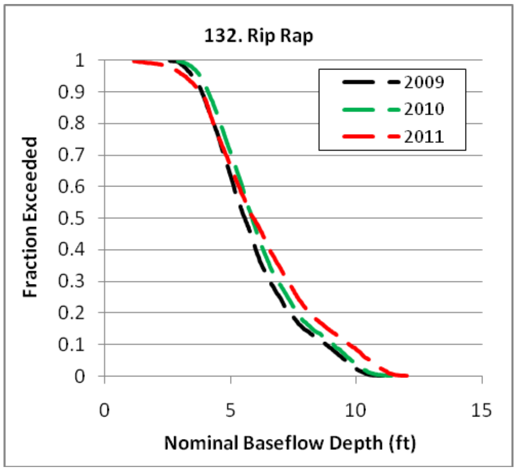
10
15
Nominal Baseflow Depth (ft)
2009
2011


132. Rip Rap
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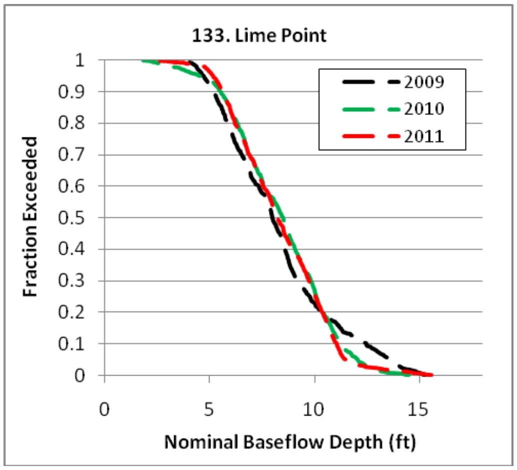
15
Nominal Baseflow Depth (ft)
2009
2010
2011


133. Lime Point
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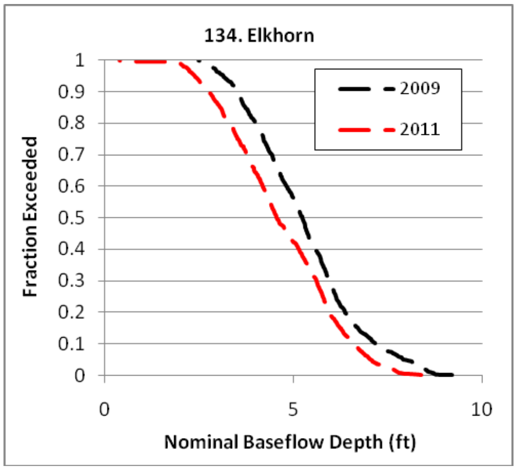
15
Nominal Baseflow Depth (ft)
2009
2010
2011


134. Elkhorn
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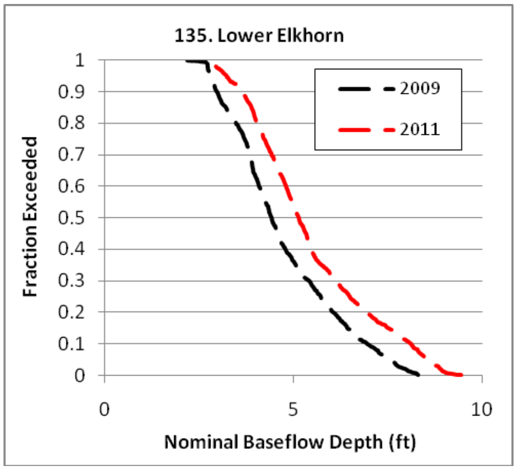
Nominal Baseflow Depth (ft)
2009
2011


135. Lower Elkhorn
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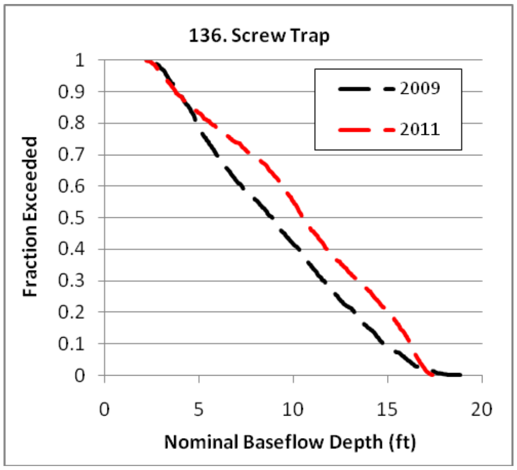
10
Nominal Baseflow Depth (ft)
2009
2011


136. Screw Trap
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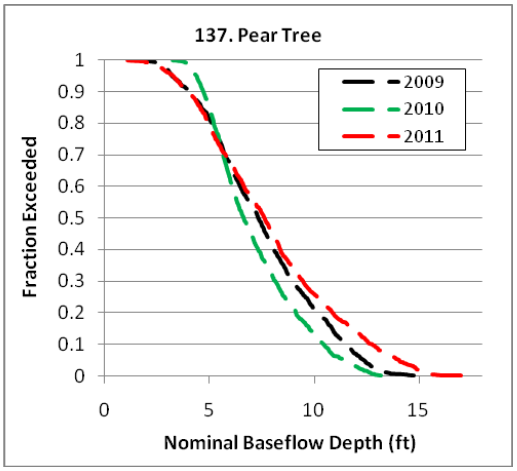
15
20
Nominal Baseflow Depth (ft)
2009
2011


137. Pear Tree
Fraction Exceeded
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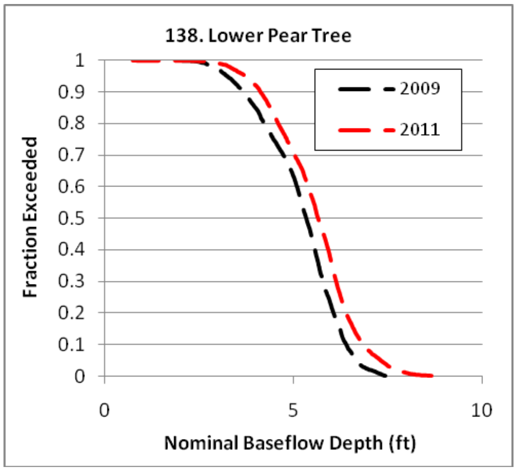
15
Nominal Baseflow Depth (ft)
2009
2010
2011


138. Lower Pear Tree
Fraction Exceeded
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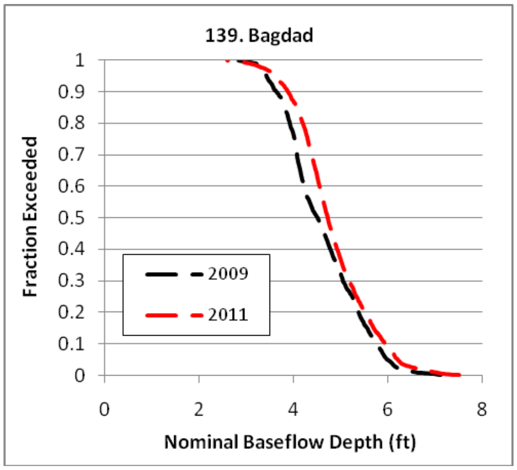
5
10
Nominal Baseflow Depth (ft)
2009
2011


139. Bagdad
Fraction Exceeded
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0.1
0
0
2
4
6
8
Nominal Baseflow Depth (ft)
2009
2011

Appendix E

Changes in median, 75th-percentile, and 90th-percentile depths at polygon locations.
(*Changes at Sawmill Burner since 2008 instead of 2009)

			2009-2011			2009-2010			2010-2011		
ID	Name	RM	Δmedian	Δ75th	Δ90th	Δmedian	Δ75th	Δ90th	Δmedian	Δ75th	Δ90th
2	Deadwood	111.03	0.32	0.19	0.19						
3	Upper New Bridge	110.97	-0.28	-0.78	-0.75						
4	Lower New Bridge	110.94	1.35	1.55	1.72						
5	Upper B2	110.7	-0.04	-0.07	-0.13						
6	Lower B2	110.63	0.56	0.57	0.54						
7	Old Bridge	110.2	0.14	-0.24	-0.42	-0.13	-0.40	-0.57	0.26	0.17	0.14
8	Hoadley Bar	109.98	-0.39	-0.50	-0.67						
9	Hoadley Pool	109.9	0.47	0.88	1.38						
10	Upper Cemetery Run	109.5	-0.68	-0.74	-1.16	-0.03	-0.01	0.01	-0.65	-0.72	-1.17
11	Upper Cemetery Pool	109.47	-0.67	-0.42	-1.00	-0.05	-0.15	-0.91	-0.62	-0.26	-0.09
12	Cemetery	109.43							-0.48	-0.28	-0.65
13	Below Cemetery	109.39							0.37	0.48	0.54
14	Sawmill FM1	109.35							-0.39	0.18	0.12
15	Sawmill FM2	109.13							0.54	0.29	0.15
16	Sawmill Burner	109	-1.98*	-2.07*	-1.64*	-2.29*	-2.70*	-2.24*	0.31	0.63	0.60
17	Lower Burner 1	108.93	1.18	2.01	2.56	0.35	0.28	0.20	0.83	1.74	2.36
18	Lower Burner 2	108.88	0.10	0.18	0.17						
19	RM108.8	108.8							-0.09	0.16	0.10
20	RM108.7	108.7							0.20	0.28	0.16
21	Rush Creek Pool	108.1	0.60	0.59	0.70						
22	RM107.55	107.55	1.14	0.99	1.04						
23	Salt Flat 1	106.85	-3.15	-2.16	-2.15						
24	Salt Flat 2	106.8	-1.21	-1.28	-1.28						
25	Gold Bar	106.6	0.24	0.22	-0.07	0.38	0.10	0.13	-0.14	0.11	-0.21
26	Lower Gold Bar	106.5	1.02	1.34	1.63	0.43	0.45	0.92	0.59	0.89	0.71
27	RM106.25	106.25	0.44	0.03	0.13						
28	Dirty Bird	105.72	-0.03	-0.02	-0.14						
29	Bucktail Island Backwater	105.65	0.10	-0.14	-0.23						

30	Upper Bucktail Pool	105.45	0.29	1.89	2.56						
31	Bucktail Hole	105.4	0.59	-0.91	-0.60	0.68	-0.55	-0.57	-0.09	-0.36	-0.03
32	RM105.25	105.25	-0.30	-0.34	-0.15						
33	Upper Lowden	105.05	0.29	0.24	0.28	0.25	0.19	0.26	0.04	0.05	0.02
34	Lowden FM	104.95							0.46	0.59	0.42
35	Lowden FP Convergence	104.65	0.54	0.95	1.24	0.25	0.31	0.33	0.29	0.64	0.91
36	Wellock Pool	104.3	-3.43	-3.08	-1.32	0.11	0.10	0.24	-3.55	-3.18	-1.55
37	Little Tree 1	104.07	-0.91	-0.87	-1.30						
38	Little Tree 2	104.07							-0.93	-1.07	-2.12
39	Trinity House	104							-0.78	-0.33	0.39
40	SP-Ponderosa	103.85	0.14	0.66	1.18	0.19	0.20	0.50	-0.05	0.46	0.68
41	RM103.5	103.5	-0.51	-0.30	0.05						
42	Tom Lang	103.2	-0.31	0.09	0.66						
43	RM102.95	102.95	-0.62	-0.73	-0.61						
44	Stott Hole	102.5	-1.76	-2.13	-2.37						
45	Stott Trough	102.45	-0.82	-1.52	-2.42						
46	Stott Convergence	102.4	-0.27	0.14	0.46						
47	RM102.1	102.1	-0.70	-0.61	-0.52						
48	Society Pool	101.8	-0.93	-0.32	-0.27	-0.62	-0.68	-0.67	-0.31	0.37	0.40
49	Montana	101.35							0.37	0.01	-0.26
50	Snell	101.15	-0.16	0.11	1.42	0.03	-0.09	-0.03	-0.19	0.20	1.45
51	Crosby	101.05							0.65	0.48	0.24
52	RM100.85	100.85	-0.09	-0.16	-0.22	-0.03	-0.01	0.00	-0.06	-0.15	-0.22
53	Leos 1	100.6	0.18	0.27	0.59	0.11	0.21	0.19	0.06	0.06	0.40
54	Leos 2	100.6							-0.12	0.06	0.00
55	Upper Limekiln	100.4	0.39	0.32	0.36						
56	Limekiln Trough	100.1	0.18	0.33	0.33						
57	Lower Limekiln	99.7	0.27	0.20	-0.28	0.34	0.17	-0.53	-0.08	0.04	0.25
58	RM99.5	99.5	0.58	0.61	0.56	0.28	0.31	0.21	0.30	0.31	0.35
59	Upper Steel Bridge	99.45	1.74	1.75	1.26	0.20	0.05	0.12	1.54	1.69	1.14
60	RM99.15	99.15	0.51	0.53	0.22	0.37	0.33	0.26	0.14	0.20	-0.04
61	Steel Bridge	98.95	0.77	-0.86	-0.21	0.26	0.39	-0.06	0.51	-1.25	-0.14
62	RM98.7	98.7	1.13	1.33	1.38						
63	Steel Bridge Day Use	98.55	0.46	1.39	2.30						

64	RM98.4	98.4	0.14	0.40	1.15						
65	RM98.27	98.27	0.36	0.28	0.33						
66	RM98.2	98.2	0.22	0.38	0.47						
67	RM98.1	98.1	0.60	0.65	0.55						
68	RM97.9	97.9	0.29	0.31	0.85						
69	Biggers	97.72	0.17	0.16	0.38						
70	Upper Ind. Ck. Backwater	95.75	0.43	0.13	-0.39						
71	Highway 299 Bridge	94.1	-0.82	-1.38	-1.62						
72	Goodyears	93.15	-2.92	-2.67	-2.20						
73	Upper Bend	92.97	-0.19	-0.24	-0.04						
74	Lower Bend	92.93	-0.58	-0.90	-1.40	0.34	0.24	0.07	-0.92	-1.14	-1.47
75	Painted Rock	92.7	0.70	0.73	1.16	0.48	-0.13	0.03	0.22	0.87	1.13
76	Alcatraz	92.3	-2.34	-2.01	-1.82	0.60	0.46	-0.20	-2.94	-2.47	-1.62
77	Upper Steiner	92.24	-0.82	-0.96	-0.48	0.40	0.50	0.57	-1.22	-1.46	-1.05
78	Steiner	92.2	0.17	0.26	0.36	0.40	0.36	0.35	-0.23	-0.10	0.01
79	Lower Steiner	92	0.30	-0.17	-0.97	0.35	0.11	-0.02	-0.04	-0.27	-0.94
80	RM91.75	91.75	-1.73	-1.50	-0.67						
81	X Factor	91.6							0.12	-0.13	-0.45
82	Skeletor	91.5	-0.47	-0.46	-1.17	0.02	-0.52	-1.20	-0.49	0.07	0.03
83	RM91.4	91.4	-0.23	-0.44	-0.89	0.17	0.26	-0.53	-0.39	-0.70	-0.36
84	Picnic Table	91.05	1.32	1.20	1.02	1.20	1.40	1.45	0.13	-0.20	-0.44
86	Dump Hole	90.75	0.84	0.36	-0.16	1.07	0.82	0.72	-0.24	-0.46	-0.89
87	Center Pin	89.75	1.58	1.60	1.52	1.25	1.16	1.22	0.32	0.44	0.30
88	Goat Hole	89.45	0.66	0.92	0.83	0.87	0.58	0.64	-0.21	0.35	0.19
89	RM89.3	89.3	-0.34	-0.18	0.18						
90	Dutton	89.15	1.77	2.24	2.37	1.42	1.69	1.62	0.35	0.55	0.74
91	RM88.7	88.7	0.36	0.46	-0.22						
92	RM88.65	88.65	1.59	1.04	1.03						
93	RM88.24	88.24	1.82	2.03	2.33						
94	RM88.12	88.12	0.48	0.52	0.92						
95	RM88.07	88.07	1.19	1.71	1.80						
96	Browns 1	87.98	1.24	1.27	1.22						
97	Browns 2	87.93	1.40	1.26	1.14						
98	Browns 3	87.85	1.65	0.59	0.45						

99	RM87.8	87.8	1.41	1.42	1.60						
100	RM87.75	87.75	0.56	0.99	1.48						
101	RM87.6	87.6	1.58	2.33	2.51						
102	Dutch	85.8	-0.83	-0.99	-0.96						
103	Last Hole on the Left	85.38	-0.30	-0.05	-0.19						
104	Upper Evans Bar	85	-1.16	-1.34	-1.28						
105	Evans Bar	84.5	-0.19	-0.06	0.12						
106	RM84.2	84.2	-0.12	-0.25	-0.58						
107	RM83.75	83.75	0.31	0.66	0.81						
108	Icebox	82.75	0.41	0.30	-0.11						
109	Eds	82.3	-1.00	-1.35	-2.22						
110	RM82.25	82.25	-0.28	-0.40	-0.32						
111	Sheridan	81.65							-0.26	0.60	0.54
112	Oregon 1	81.25	-0.17	-0.42	-0.55						
113	Oregon 2	81.2	-0.15	-0.18	-0.05						
114	Sky Ranch	80.7	-0.49	-0.99	-2.39						
115	Lower Sky Ranch	80.45	-1.93	-2.91	-3.94						
116	UJC 1	80.2	-0.20	-0.19	-0.28						
117	UJC 2	80.15	0.12	-0.19	-1.18						
118	UJC 3	80	-0.36	0.03	-0.46						
119	Junction City Hole	79.5	0.15	0.26	0.12	-0.19	-0.59	-0.55	0.34	0.84	0.67
120	RM78.25	78.25	-0.52	-0.12	0.03						
121	JC Campground 1	78.05	-0.04	0.13	0.75	0.20	0.07	0.13	-0.24	0.06	0.62
122	JC Campground 2	77.97	0.85	0.41	-0.59	0.05	-0.09	-0.69	0.79	0.50	0.10
123	Upper Conner 1	77.77	-0.09	-1.02	-1.69	0.47	0.42	-0.52	-0.56	-1.44	-1.17
124	Upper Conner 2	77.75	0.87	0.75	1.51	0.02	0.01	0.48	0.85	0.74	1.03
125	Upper Conner 3	77.67	0.75	-0.14	-1.25	-0.21	-0.93	-1.91	0.96	0.79	0.65
126	McCartneys	77.1	-0.72	-0.64	-0.47	0.09	0.26	0.73	-0.81	-0.90	-1.19
127	RM76.75	76.75	0.29	0.06	0.14						
128	Barbie	76.4	0.42	0.30	0.29	0.33	0.24	0.40	0.10	0.05	-0.10
129	Upper Bigfoot	75.8	-0.69	-0.83	-1.07	0.20	0.08	-0.18	-0.88	-0.91	-0.89
130	Valdor	75.05	0.17	0.89	1.21	-0.01	0.35	0.66	0.18	0.54	0.55
131	Coopers Bar	74.85	0.08	0.15	0.12						
132	Rip Rap	74.65	0.36	0.72	0.93	0.28	0.31	0.30	0.08	0.41	0.63

133	Lime Point	74.5	0.26	0.27	-1.41	0.51	0.30	-1.20	-0.25	-0.03	-0.21
134	Elkhorn	73.8	-0.67	-0.34	-0.60						
135	Lower Elkhorn	73.5	0.71	0.77	1.16						
136	Screw Trap	73.3	1.59	1.88	1.39						
137	Pear Tree	73.05	0.34	0.59	1.26	-0.67	-0.96	-1.06	1.02	1.55	2.31
138	Lower Pear Tree	72.9	0.32	0.33	0.46						
139	Bagdad	72.6	0.21	0.08	0.18						

APPENDIX F

Dredge and fill history for Trinity River pools.

Pool Name	Date	Pool Dredged (yes/no)	Measured Bottom Elevation (ft)	Depth from reference WSE (ft)	Source:	Notes:
B2	Oct-1977	Y		14	Taskforce 1978	Dredged to 12 to 14 feet deep
B2	Aug-2003		1799	9	GMA 2003	
B2	Nov-2009			9	This report	
B2	Nov-2011			9	This report	
Baxter	Oct-1980	Y		11	Taskforce 1981	
Baxter	Aug-2003		1772	3	GMA 2003	
Baxter	Nov-2009		1772	3	This report	
Baxter	Nov-2011		1771	4	This report	
Bucktail	Oct-1976	Y		15	USBR 1976	Construction specification: Dredge depths generally 10-15 ft.
Bucktail	Aug-1988			22	Aceituno 1988	
Bucktail	Aug-1989			22	Aceituno 1990	
Bucktail	Oct-1989	Y		22	Aceituno 1990	
Bucktail	Aug-2003		1725	21	GMA 2003	
Bucktail	Nov-2009			21.0	This report	
Bucktail	Nov-2011			21.2	This report	
Cemetery	Oct-1976	Y		15	USBR 1976	Dredge depths were 10-15 feet.
Cemetery	Aug-1988			12	Aceituno 1988	
Cemetery	Aug-1989			12	Aceituno 1990	
Cemetery	Oct-1989	Y		12	Aceituno 1990	
Cemetery	Aug-2003		1778	16	GMA 2003	
Cemetery	Nov-2009		1779	15.4	This report	
Cemetery	Nov-2011		1779	14.6	This report	
New Bridge	Oct-1976	Y		15	USBR 1976	Construction specification: Dredge depths generally 10-15 ft.
New Bridge	Oct-1978	Y		15	Smith, 1999	

Pool Name	Date	Pool Dredged (yes/no)	Measured Bottom Elevation (ft)	Depth from reference WSE (ft)	Source:	Notes:
New Bridge	Aug-1980			8	Taskforce 1981	Pool was filled to half capacity before dredging.
New Bridge	Oct-1980	Y		15	Taskforce 1981	Removed sediment filled 50% of pool capacity.
New Bridge	Oct-1985	Y		15	DWR 2003	
New Bridge	Aug-1988			15	Aceituno 1988	
New Bridge	Aug-1993		1799	15	McBain and Trush 1997	
New Bridge	Aug-1997		1799	15	McBain and Trush 1997	
New Bridge	Aug-2003		1803	11	GMA 2003	
New Bridge	Nov-2009			12.4	This report	
New Bridge	Nov-2011			11.1	This report	
Old Lewiston Bridge	Oct-1976	Y		14	USBR 1976, Dolcini 1979	Construction specification: Dredge depths generally 10-15 ft. Dredge depth of 14 feet assumed, same as in 1977.
Old Lewiston Bridge	Oct-1977	Y		14	USBR 1977, Taskforce 1978	Dredged to depths of 12-14 feet using a dragline.
Old Lewiston Bridge	Oct-1978	Y		14	Smith, 1999	Dredge depth of 14 feet assumed, same as in 1977.
Old Lewiston Bridge	Aug-1983			4	DWR 1986	Old Lewiston bridge pool was first constructed in 1977, filled with sediment in 1983. Assume depth = 4 feet in 1983 (same as 2011).
Old Lewiston Bridge	Oct-1985	Y		12	Kennedy 1985, Gentry 1986	Dredged 10 to 12 feet deep
Old Lewiston Bridge	Oct-1988	Y		12	Taskforce 1988	Assume dredge depth is 12 feet as in 1985.
Old Lewiston Bridge	Aug-2003		1796	7	GMA 2003	
Old Lewiston Bridge	Nov-2009			5.3	This report	
Old Lewiston Bridge	Nov-2011			4.7	This report	
Ponderosa	Oct-1987	Y		12	Brown 1994	Depth 10 to 12 feet after initial construction
Ponderosa	Apr-1992			12	Wilcock et. al. 1995	Pre release depth

Pool Name	Date	Pool Dredged (yes/no)	Measured Bottom Elevation (ft)	Depth from reference WSE (ft)	Source:	Notes:
Ponderosa	Aug-1992			12	Wilcock et. al. 1995	The pool filled at the upstream end during the 1992 release, but the depth at the downstream end did not change.
Ponderosa	Aug-1993			8	McBain and Trush 1997	
Ponderosa	Aug-1997			11	McBain and Trush 1997	
Ponderosa	Nov-2009			10.7	This report	
Ponderosa	Nov-2011			11.9	This report	
Society Pool	Feb-1986			9	Aceituno 1990	
Society Pool	Aug-1989			6	Aceituno 1990	Fill to 6 ft depth reported for the " years following the flood of February 1986…”
Society Pool	Aug-1990			6.9	Aceituno 1990	
Society Pool	Oct-1990	Y		11.5	Aceituno 1990	
Society Pool	Aug-1991			9	Wilcock et. al. 1995	Pool depth decreased to 8-10 feet during the 1991 release. The deepest areas filled 1 to 4 feet creating a uniform surface between elevations 91 and 92 (arbitrary datum) with the transition to the downstream riffle degraded from 1 to 3 feet. Much of the sand fill over the cobble riffle downstream was removed during the release.
Society Pool	Aug-1992			11	Wilcock et. al. 1995	The pool scoured to a depth of approximately 10 to 12 feet during the 1992 release.
Society Pool	Apr-1993			11	Wilcock et. al. 1995	
Society Pool	Aug-1993			12	McBain and Trush 1997	
Society Pool	Aug-1997			12	McBain and Trush 1997	
Society Pool	Nov-2009			11.8		
Society Pool	Nov-2011			11.6		
Society Poo	Nov-2012		1690	16	This report	

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Pool Name	Date	Pool Dredged (yes/no)	Measured Bottom Elevation (ft)	Depth from reference WSE (ft)	Source:	Notes:
SP	Oct-1977	Y		10	Brown 1994	
SP	Feb-1978			1	Taskforce 1979	"SP pool was completely filled in with sand during the high runoff in January and February 1978". Depth of 1 ft assumed.
SP	Oct-1978	Y		12	Barnes 1978	proposed dredging to lower depth to 15-20 feet. Dredging in 1983 specified a 20 feet dredge depth but dredging was only able to produce 12 feet. Assume 12 feet max depth, same as in 1983.
SP	Oct-1983	Y		12	Brown 1994	Spec calls for 20 foot depth, but a depth of just 12 ft was reached.
SP	Oct-1985	Y		12	Kennedy 1985	Assumed same as 1983.
SP	Oct-1987	Y		12	Kennedy 1987	Assumed same as 1983.
SP	Apr-1992			8	Wilcock et. al. 1995	
SP	Aug-1992			10	Wilcock et. al. 1995	The surveyed portion of the pool scoured slightly to a depth of 8 to 10 feet during 1992 and showed essentially no change during the 1993 release.
SP	Aug-1993			10	Wilcock et. al. 1995	
SP	Nov-2009		1721	8	This report	
SP	Nov-2011		1721	8	This report	
Upper Steel Bridge	Oct-1985	Y		12	DWR 1985	Assume dredge depth of 12 feet.
Upper Steel Bridge	Apr-1992			11	Wilcock et. al. 1995	
Upper Steel Bridge	Aug-1992			12	Wilcock et. al. 1995	
Upper Steel Bridge	Aug-1993			12	McBain and Trush 1997	
Upper Steel Bridge	Aug-1997			12	McBain and Trush 1997	
Upper Steel Bridge	Nov-2009			11.5	This report	
Upper Steel Bridge	Nov-2011			13.6	This report	

Pool Name	Date	Pool Dredged (yes/no)	Measured Bottom Elevation (ft)	Depth from reference WSE (ft)	Source:	Notes:
Upper Steel Bridge	Nov-2012		1660	15	This report	
Stott	Aug-1963			10	La Faunce 1968	Depth 4-10 ft reported.
Stott	Aug-1966			0.25	La Faunce 1968	
Stott	Aug-1967			1	La Faunce 1968	
Stott	Oct-1976	Y		15	Denton 1980	Assume same dredge depth at 1991.
Stott	Oct-1979	Y		15	Denton 1980	Assume same dredge depth at 1991.
Stott	Oct-1985	Y		15	DWR 1985	Assume same dredge depth at 1991.
Stott	Oct-1991	Y		15	USBR 1991	Dredge depth to 15 feet specified.
Stott	Aug-1992			16	Wilcock et. al. 1995	Thalweg deepened but sand bar filled by 7 ft. Assume thalweg depth deepened by 1 foot over 1992 (i.e. pool depth = 16 feet).
Stott	Aug-1993			17	McBain and Trush 1997	Depth based on 450 ft^3/s WSE.
Stott	Aug-1997			17	McBain and Trush 1997	Depth based on 450 ft^3/s WSE.
Stott	Nov-2009			22.3	This report	
Stott	Nov-2011			18.9	This report	
Stott	Nov-2012		1690	24	This report	
Tom Lang	Oct-1991	Y		12	USBR 1991	Dredged depth assumed same as 1992 pre-release.
Tom Lang	May-992			12	Wilcock et. al. 1995, McBain and Trush 1997	
Tom Lang	Aug-1992			9	Wilcock et. al. 1995	Pool depth decrease to 7-9 feet during the 1992 release. Fill of 1-4 feet in the central portion of the pool reported.
Tom Lang	Aug-1993			10	McBain and Trush 1997	
Tom Lang	Aug-1997			8	McBain and Trush 1997	
Tom Lang	Nov-2009			8.0	This report	
Tom Lang	Nov-2011			10	This report	
Tom Lang	Nov-2012		1710	10	This report	

Pool Name	Date	Pool Dredged (yes/no)	Measured Bottom Elevation (ft)	Depth from reference WSE (ft)	Source:	Notes:
Wellock	Oct-1984	Y		15	DWR 1984	Dredge to 15 ft depth specified for initial construction.
Wellock	Oct-1986	Y		20	DWR 1986	Construction specification: "Excavate river channel deposits to bedrock or a max depth of 20 feet."
Wellock	May1993		1724	12	Brown 1994	
Wellock	Aug-2003		1728	7	This report	
Wellock	Nov-2009			6.8	This report	
Wellock	Nov-2011			5.5	This report	

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