Carson River Relative Bed Stability Investigation

A supporting document for the Carson River Report Card

September 2006

Upper Carson Canyon Survey Site (PHAB-10)

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Acknowledgements

This project would not have been possible without the contributions of several individuals:

- Obviously without the field and calculation protocols developed by Phil Kaufmann and his colleagues at EPA, this project never would have happened. A special thanks goes to Phil for his help in applying the protocols to the Carson River.
- Karen Vargas (NDEP) had the vision to see the possible uses for the relative bed stability indices as part of our assessment process. Karen brought the resources and staff together and led the fieldwork activities.
- Along with Karen, Paul Comba and John Heggeness were key NDEP staff involved in the fieldwork, not always under the best of conditions. When we were short on available staff, Kathy Sertic (NDEP) also helped out in the field.
- Thanks to Dan Greytak (Washoe Tribe of California-Nevada) for loaning us the Tribe's laser level for a portion of the project.

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Introduction

In support of our Clean Water Act responsibilities, the Nevada Division of Environmental Protection (NDEP) – Bureau of Water Quality Planning (BWQP) is developing a Carson River Watershed Assessment or Report Card. Drawing upon numerous studies and monitoring efforts, the Report Card will provide a compilation of current knowledge about the chemical, physical and biological health of the Carson River watershed with a focus on aquatic life uses from the Nevada/California stateline to Lahontan Reservoir. It is hoped that the Report Card will be a valuable tool for educating the public, agencies and decisionmakers on the state of the river (from a Clean Water Act perspective), thereby providing direction for their future actions and decisions. The Report Card will also be a key planning tool for BWQP in possible future steps, such as standards revisions, comprehensive Total Maximum Daily Loads (TMDLs), watershed plan development and restoration projects.

The purpose of this report is to present the results of field work and analyses related to the stability of the Carson River streambed at various locations. An understanding of the channel substrate stability is important when evaluating physical conditions that affect the health of Carson basin's aquatic life. Streambed stability and other physical conditions play a large role in the ecosystem health.

Background on Relative Bed Stability Index

As part of its Environmental Monitoring and Assessment Program (EMAP), U.S. Environmental Protection Agency (EPA) has developed extensive field collection and data analysis procedures for characterizing physical habitat in wadeable streams (Lazorchak et al., 1998; Kaufmann et al., 1999). Following EMAP protocols, one can calculate various ecological health indicators or indices related to physical conditions affecting aquatic health: stream size and gradient, sinuosity, substrate size and stability, habitat complexity and cover, woody debris size and abundance, residual pool dimensions and frequency, riparian vegetation cover and structure, anthropogenic disturbances, and channel-riparian interaction (Kaufmann et al., 1999). The development of substrate condition and stability indices for the Carson River will be the focus of this report. Channel substrate has been found to be one of the most important determinants of habitat character for fish and macroinvertebrates in streams (U.S. EPA, 2002).

The stability (or lack of stability) of a river's bed affects the aquatic ecosystem health. Kaufmann et al. (1999) describes it best:

> *"Good quality in-channel habitat is generally neither excessively stable (substrate coarse relative to transport capability), or unstable (substrate fine relative to transport capability). Some movement of the streambed is beneficial and essential to maintaining habitat quality, because it allows flows to scour and rework substrates to maintain complex pool habitat and to clean gravels that are important for fish spawning and production of aquatic invertebrates."*

Using data collected during the EMAP field survey, a Relative Bed Stability Index can be calculated by comparing median particle size of the substrate to the diameter of the largest particle the stream could theoretically move at bankfull[1] flow conditions (flows that typically occur every year or two):

$$RBSI = \frac{D_{50}}{D_{cbf}} \qquad \text{(Eq. 1)}$$

where: RBSI = Relative Bed Stability Index
D_{50} = median diameter of substrate particles in the study reach
D_{cbf} = diameter of the largest particle the stream could move at bankfull flows

Equation 1 yields values greater than 1 for more stable systems and less than 1 for more unstable substrates. However, another form of Equation 1 is more commonly used in calculating a bed stability index. By taking the logarithm (base 10) of both sides of Equation 1, the following is derived:

$$LRBSI = \log_{10}(D_{50}) - \log_{10}(D_{cbf}) \qquad \text{(Eq. 2)}$$

where: LRBSI = Logarithmic Relative Bed Stability Index
D_{50} = median diameter of substrate particles in the study reach
D_{cbf} = diameter of the largest particle the stream could move at bankfull flows

In this form, Equation 2 yields an index value of 0 when D_{50} and D_{cbf} are equal. LRBSI values greater than 0 indicate more stable streambeds while values less than 0 indicate more unstable conditions. LRBSI values equal to 0 suggest that at least half of the substrate particles become mobile during bankfull flows that typically occur every year or two (Kaufmann, et al., 1999). A high positive value (such as +3.0) indicates an extremely stable substrate such as observed in an armored canal. A low negative value (such as –2.5) indicates a channel with substrate material frequently moved even during small floods. LRBSI is not only a measure of streambed mobility

[1] According to Leopold (1997), bankfull discharge is the flow that transports a majority of a stream's sediment load over the years and thereby is a major factor in forming the channel. The bankfull stage may or may not be at the top of the streambank. If the stream is downcut or incised, the bankfull stage will be below the top of the bank.

but it also provides an indication of the sediment supply to the stream. An increase in fine substrate particles (and a lower LRBSI) often occurs when the sediment supply to the stream is increased due to land use impacts and streambank erosion (Kaufmann et al., 1999). A poor LRBSI value (low negative value) may be an indication that the sediment supply is exceeding the sediment transport ability of a particular reach.

There is no absolute LRBSI value which demarcates between a healthy and nonhealthy system. As discussed above, even healthy systems experience substrate movement. Most relatively undisturbed watersheds will have LRBSI values near or slightly above zero. Kaufmann et al. (1999) have found LRBSI values <-1.0 for highly disturbed basins in the mid-Atlantic and values <-2.0 for highly disturbed basins in Western Oregon and the Great Plains.

It is important to recognize that the LRBSI is an averaged stability index over the entire reach in question. Streams naturally have varying substrate particle sizes in different regions: riffles, glides, pools, etc. Within a reach, certain subreaches with pools and riffles may be more or less stable than the reach as a whole. Kappesser (2002) has presented a different index for evaluating only riffle stability and sediment loading to streams.

Another important indicator of aquatic system health is substrate particle size. As fine particles accumulate, the spaces between coarser bed materials are filled, reducing habitat availability and the circulation of hydrogenated water (Kaufmann et al., 1999).

Field Methods

During November-December 2004, NDEP staff performed modified-EMAP field surveys at 13 sites throughout the Carson River basin (Table 1; Figure 1). These survey locations were selected to encompass current NDEP macroinvertebrate sampling sites. Following is a general discussion of the main steps followed in laying out the study reach and collecting the data pertinent to the LRBSI calculations. Much of the fieldwork was based upon procedures described in Lazorchak et al. (1998).

1. **Laying out the study area:** First, the typical wetted width for the study reach was estimated. The entire study reach is then set as 40 times the typical wetted width. Next, the study reach was divided into 10 sub-reaches of equal length (Figure 2). In the field, each of the 11 transects were marked off with flagging or other means.

2. **Determine water surface slopes for each subreach and the overall study reach:** To determine the water surface slopes, a laser level and level rod were used to the measure the differences in water surface elevations between each transect.[2] Dividing these elevation differences by the subreach length yielded slope values.

[2] Lazorchak, et al. (1998) describes the use of a clinometer for determining water surface slope. Due to the low gradients on the Carson system, the more accurate laser level was deemed appropriate per P. Kaufmann (2004).

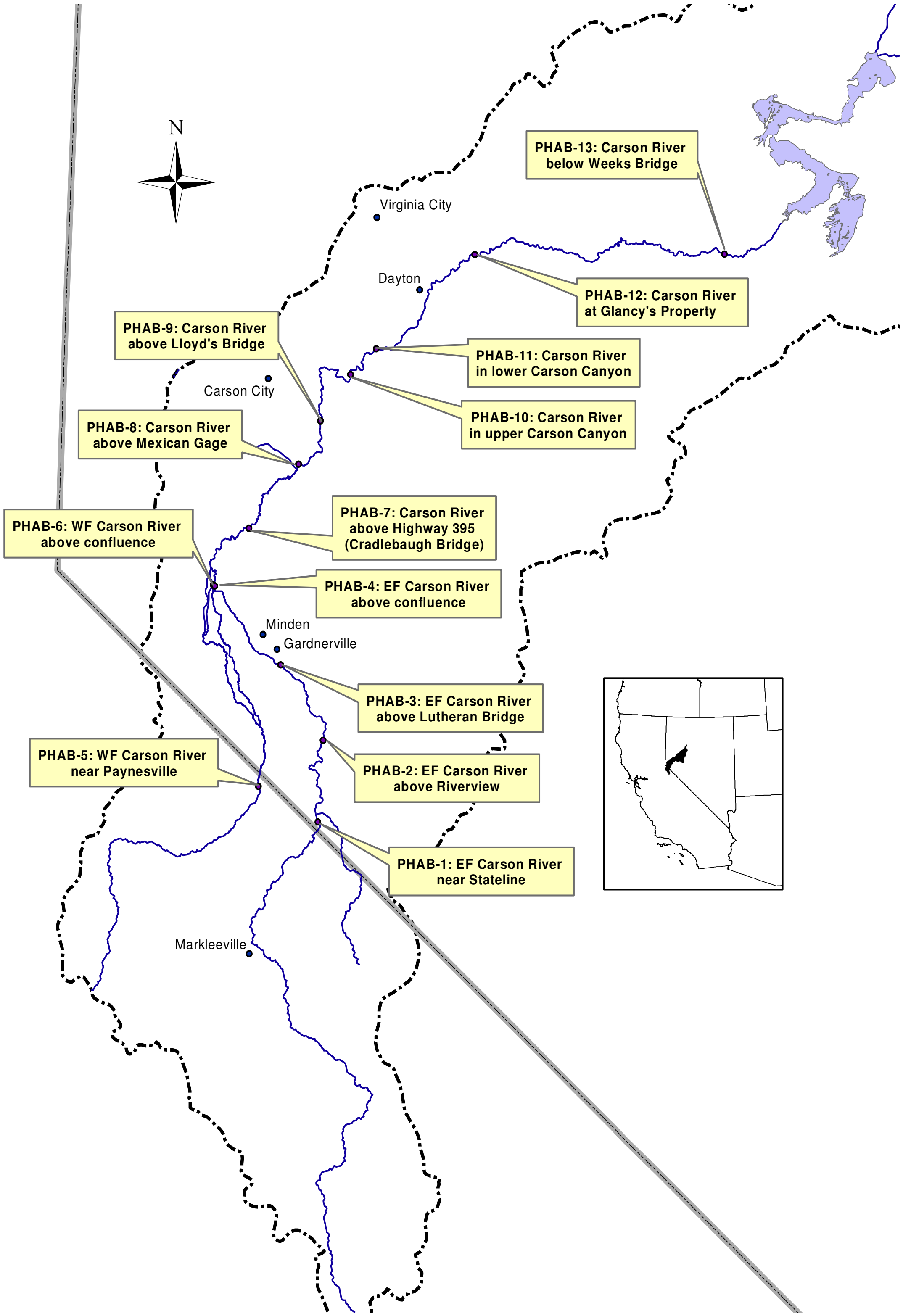


Figure 1. Physical Habitat Assessment Sites

Table 1. List of Physical Habitat Assessment Sites

Site ID	Site Name	UTM Coordinates of Mid-Reach (meters)		Reach Length (ft)
		Northing	Easting	
PHAB-1	EF Carson River near stateline	4297703	265942	2,400
PHAB-2	EF Carson River above Riverview	4305383	266479	2,400
PHAB-3	EF Carson River above Lutheran Bridge	4312483	262186	2,000
PHAB-4	EF Carson River above confluence	4319899	255549	1,600
PHAB-5	WF Carson River near Paynesville	4301058	259941	1,300
PHAB-6	WF Carson River above confluence	4320020	255418	920
PHAB-7	Carson River above Highway 395	4325344	258998	4,120
PHAB-8	Carson River above Mexican Gage	4331380	263990	3,200
PHAB-9	Carson River above Lloyd's Bridge	4335436	266198	4,000
PHAB-10	Carson River in upper Carson Canyon	4339802	269222	2,000
PHAB-11	Carson River in lower Carson Canyon	4342229	271816	2,200
PHAB-12	Carson River at Glancy's Property	4351083	281737	2,400
PHAB-13	Carson River below Week's Bridge	4351124	306868	4,500

3. **Determine substrate size characteristics:** Systematic substrate sampling occurred at each of the major 11 transects and each of the 10 mid-subreach transects (Figure 2). At each transects, substrate particles were sampled at five locations – 1) left edge of water; 2) center of left half of wetted width; 3) center of wetted width; 4) center of right half of wetted width; and 5) right edge of water. The median diameter of each particle was classified as falling in one of the size categories shown in Table 2. This process resulted in 105 "pebble counts" for the entire study reach. The EMAP protocols rely on fewer size classes than presented in Table 2. However given the sandy substrate conditions and low channel gradients (0.04 to 0.85%), P. Kaufmann (2004) recommended that additional size classes be added. For this project, the number of classes for sand were increased from 1 to 5 and the classes for gravel were increased from 2 to 5.

4. **Measure thalweg depths:** Using a graduated rod, maximum water depths were measured at each major transect and at 9 equally spaced locations between the major transects (Figure 2). This work resulted in 101 thalweg depth measurements.

5. **Measure bankfull depths:** Using a graduated rod, the height of bankfull flow above the present water levels was estimated for both the left and right banks at each of the 11 major transects. In identifying the bankfull height, field staff looked for evidence of:

   - an obvious slope break that differentiates the channel from a relatively flat floodplain terrace higher than the channel;
   - a transition from exposed stream sediments to terrestrial vegetation;
   - moss growth on rocks along the banks;
   - presence of drift material caught on overhanging vegetation; or
   - transition from flood- and scour-tolerant vegetation to that which is relatively intolerant of these conditions (Lazorchak et al., 1998).

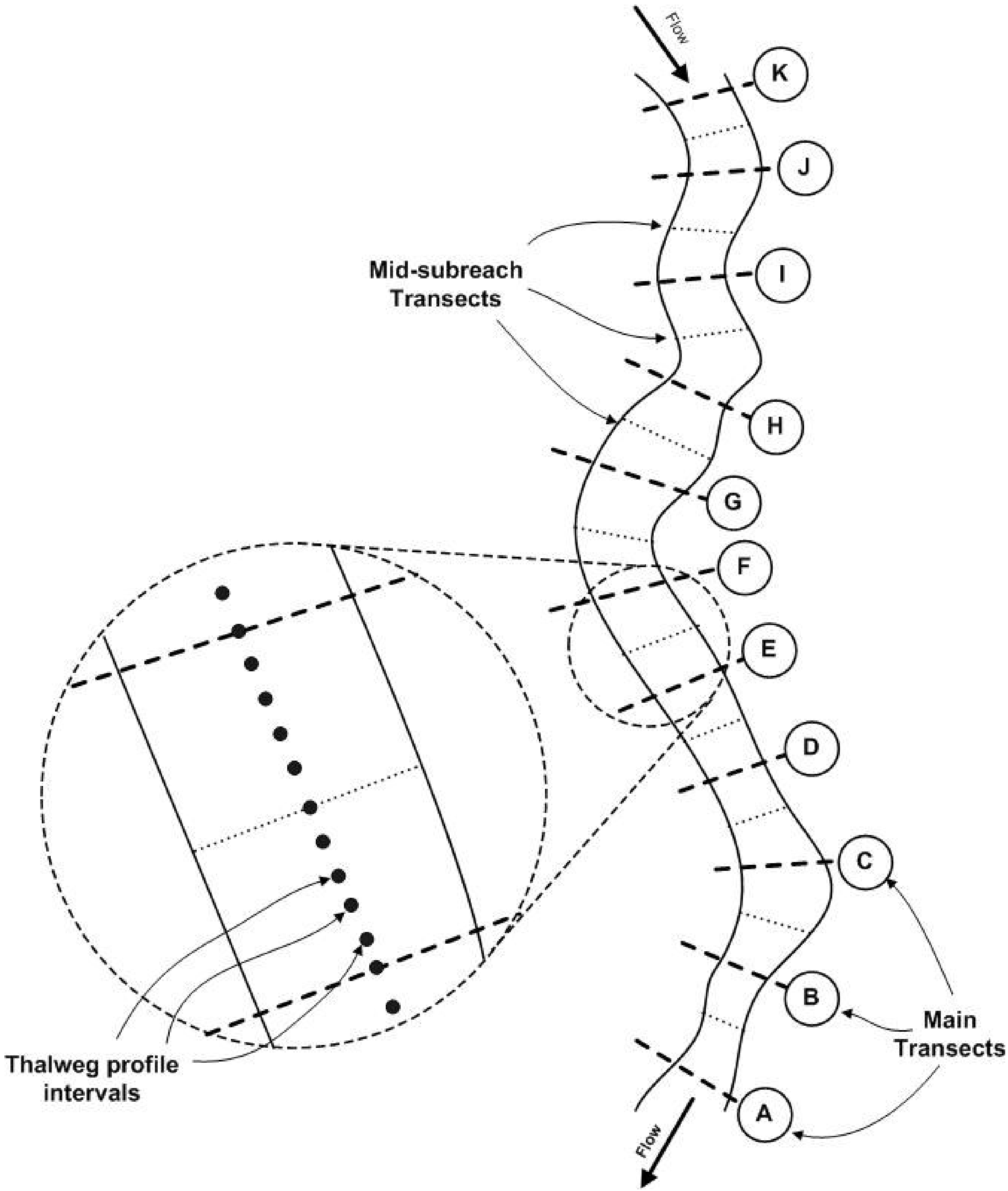


Figure 2. Sample Reach Layout for Modified EMAP Field Survey

Table 2. Size Classes Used in Substrate Sampling

Code	Size Class	Size Range (millimeters)
ST	Silt	<1/16
VFS	Very fine sand	1/16 – 1/8
FS	Fine sand	1/8 – 1/4
MS	Medium sand	1/4-1/2
CS	Coarse sand	½-1
VCS	Very coarse sand	1 – 2
VFG	Very fine gravel	2 – 4
FG	Fine gravel	4 – 8
MG	Medium gravel	8 – 16
CG	Coarse gravel	16 – 32
VCG	Very coarse gravel	32 – 64
CB	Cobble (tennis ball to basketball)	64 –256
SB	Small boulder (basketball to meterstick)	256 – 1024
LB	Large boulder (meterstick to car)	1024 – 4096
BR	Bedrock	>4096

Calculations

Following is a discussion of the specific calculations used in deriving the LRBSI for the 13 study site. The reader is referred to Kaufmann et al. (1999) for a more detailed discussion of the equations and the underlying assumptions.

As discussed above, Kaufmann et al (1999) provides the following basic equation for calculating the LRBSI:

$$LRBSI = \log_{10}(D_{50}) - \log_{10}(D_{cbf}) \quad \text{(Eq. 2)}$$

where: LRBSI = Logarithmic Relative Bed Stability Index
D_{50} = median diameter of sampled substrate particles in the study reach (mm)
D_{cbf} = diameter of the largest particle the stream could move at bankfull flows (mm)

By substituting the following relationship (Eq. 3) for D_{cbf}, Equation 4 is developed:

$$D_{cbf} = 13.7 \times R_{bf} \times S \quad \text{(Eq. 3)}$$

$$LRBSI = \log_{10}(D_{50}) - \log_{10}(13.7 \times R_{bf} \times S) \quad \text{(Eq. 4)}$$

where: D_{cbf} = diameter of the largest particle the stream could move at bankfull flows (mm)
R_{bf} = hydraulic radius at bankfull flows (mm)
S = average slope of water surface over the entire study reach (m/m)

Equation 4 is further refined to account for the influences of pools[3]:

$$LRBSI = \log_{10}(D_{50}) - \log_{10}(13.7 \times (R_{bf} - R_p) \times S) \qquad \text{(Eq. 5)}$$

where: R_p = adjustment to R_{bf} due to pools

Kaufmann et al. (1999) also presents an additional adjustment to account for stabilizing influences of woody debris. However, woody debris was considered to be minimal at all the Carson sites and any influence was considered insignificant for this analysis.

Following is a discussion of the calculations needed to solve Equation 5:

<u>D_{50} (median diameter of sampled substrate particles)</u>

The median particle size (D_{50}) was determined by assigning a nominal diameter to each of the 105 pebble counts (see Table 3) and then calculating the median[4] particle diameters of these 105 values.

<u>R_{bf} (hydraulic radius at bankfull flow conditions)</u>

The hydraulic radius was calculated using the following equation (Kaufmann et al. (1999)):

$$R_{bf} = 0.5 \times (\textit{mean thalweg depth} + \textit{mean bankfull depth}) \qquad \text{(Eq. 6)}$$

where: mean thalweg depth = mean of the 101 thalweg depths recorded during the field survey
mean bankfull depth = mean of the bankfull depths recorded for each of the 11 major transects

[3] Kaufmann et al. (1999) also provides for further adjustments in the hydraulic radius due to the influences of woody debris in the stream. With the minimal woody debris found at the 13 survey sites, the effects of woody debris upon the relative bed stability were assumed to be insignificant for the Carson study.
[4] Kaufmann et al. (1999) uses the geometric mean to approximate the median value to account for the small number of size classes used. Since this project used a larger number of size classes, Kaufmann (2005) stated that the use of the median value would be appropriate.

Table 3. Particle Diameters Assigned to Size Classes

Code	Size Class	Size Range (millimeters)	Lower Limit for Class (mm)	Upper Limit for Class (mm)	Nominal Diameter for Class (mm)
ST	Silt	<1/16	0.001	0.0625	0.0079
VFS	Very fine sand	1/16 – 1/8	0.0625	0.125	0.0884
FS	Fine sand	1/8 – 1/4	0.125	0.25	0.1768
MS	Medium sand	1/4-1/2	0.25	0.5	0.354
CS	Coarse sand	½-1	0.5	1	0.707
VCS	Very coarse sand	1 – 2	1	2	1.41
VFG	Very fine gravel	2 – 4	2	4	2.83
FG	Fine gravel	4 – 8	4	8	5.66
MG	Medium gravel	8 – 16	8	16	11.3
CG	Coarse gravel	16 – 32	16	32	22.6
VCG	Very coarse gravel	32 – 64	32	64	45.3
CB	Cobble (tennis ball to basketball)	64 –256	64	256	128
SB	Small boulder (basketball to meterstick)	256 – 1024	256	1,024	512
LB	Large boulder (meterstick to car)	1024 – 4096	1,024	4,096	2,048
BR	Bedrock	Solid	4,096	8,000	5,724

Note: Per P. Kaufmann (2005), nominal diameters were calculated by taking the geometric mean of the upper and lower limits. Lower limit for silt were assigned as 0.001 mm. Upper limit for bedrock assigned as 8000 mm.

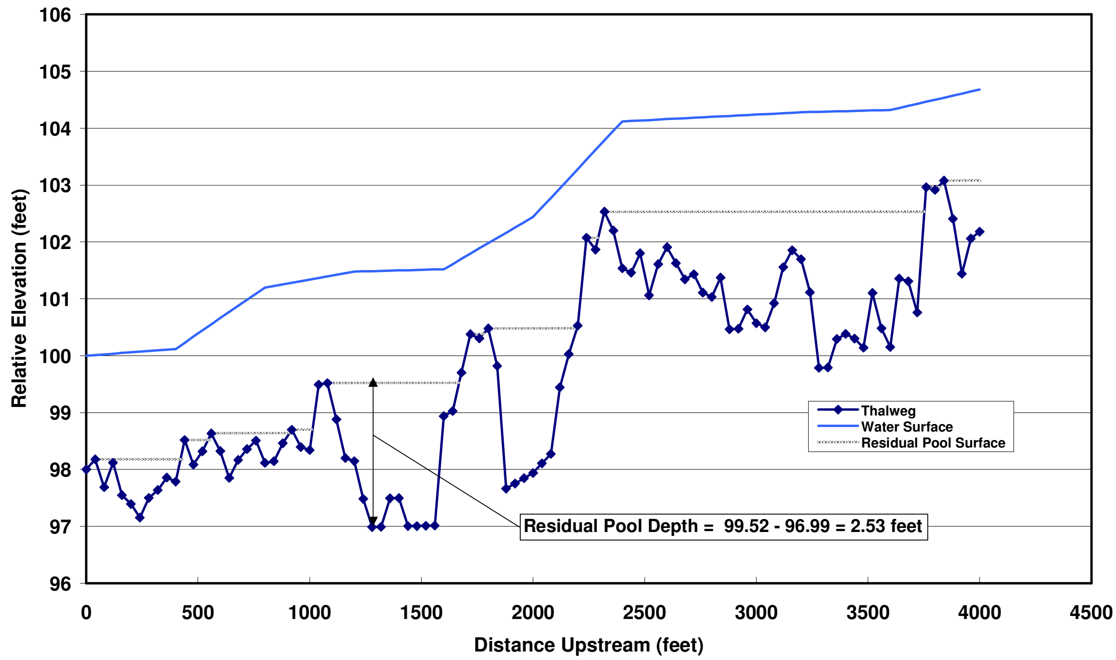
R_p (adjustment to R_{bf} due to pool influences)

"Adjustments to R_{bf} due to pool influences" were calculated using the following equation:

$$R_p = 0.5 \times mean\ residual\ \ pool\ depth\,(in\ mm) \qquad \text{(Eq. 7)}$$

In Kaufmann et al. (1999), "residual pools" are considered to be those areas in the stream that would contain water during near no-flow conditions. To aid in the identification of residual pools, relative profiles of the thalweg and water surface were developed[5] (Figure 3). High points in the thalweg were then identified as the downstream control points for the various residual pools. From this information, the residual pool depths were compiled for each of the 101 thalweg profile locations. For those locations outside of a residual pool, a residual pool depth of zero was assigned. The mean of these values were used to solve Equation 7.

Figure 3. Relative Thalweg, Water Surface and Residual Pool Profiles - PHAB-9:Carson River above Lloyd's Bridge



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[5] The following steps were taken to generate the thalweg and water surface profiles:

1. Assuming a relative elevation datum (100 feet) for the water surface at the downstream end (Transect A) of the reach, water surface elevations for the upstream transects were generated using the subreach water slope values and subreach lengths. The following equation shows the basic approach as applied to Transect B:

   *Water surface at Transect B = Water surface elevation at Transect A + Slope * subreach length*

   From these 11 water surface elevation points, a water surface profile is then generated. Next, water surface elevations for the thalweg profile locations between the transects are interpolated.

2. Using the water surface elevation data, relative stream thalweg elevations are calculated:

   Thalweg elevation = Water surface elevation – Thalweg depth

Results

Tables 4 and 5 summarize the results of the LRBSI calculations. In general, the reaches in the upper watershed (PHAB-1: EF Carson River near stateline; PHAB-2: EF Carson River above Riverview; PHAB-3: EF Carson River above Lutheran Bridge; PHAB-5: WF Carson River near Paynesville) scored better than the other reaches (Figure 4). These results suggest that these reach substrates are in better condition than at the lower sites; and that the sediment supply is not overwhelming the transport ability of these reaches.

Sites throughout the lower Carson Valley (PHAB-4: EF Carson River above confluence; PHAB-6: WF Carson River above confluence; PHAB-7: Carson River above Highway 395 (Cradlebaugh Bridge); PHAB-8: Carson River above Mexican Gage), Carson City area (PHAB-9: Carson River above Lloyd's Bridge), Carson Canyon area (PHAB-10: Carson River in upper Carson Canyon; PHAB-11: Carson River in lower Carson Canyon), and Dayton/Weeks area (PHAB 12: Carson River at Glancy's Property; PHAB-13: Carson River at Weeks) scored at the lower end (-0.73 to –1.89) (Figure 4).

The Carson Canyon sites (PHAB-10, PHAB-11) scored poorer on the LRBSI scale than expected. Visual inspections of the much of the river through the Carson Canyon show significant levels of larger substrate material (cobbles, boulders, etc.) greater stability than the data suggest. Additional investigations may be appropriate to check the 2004 results.

In addition to LRBSI values, other measures of the substrate conditions were calculated for additional comparisons (Table 5):

- Percent of substrate particles < C_{cbf}
- Percent of substrate particles < 2 mm

Percent of substrate particles < C_{cbf}: Since LRBSI compares D_{50} to C_{cbf}, it is a measure of mobility of ½ of the substrate particles. It does not give one an estimate of the percentage of substrate particles that are potentially mobile during bankfull conditions. In general, the higher this value the greater the extent of mobile particles. The higher values (corresponding to poorer substrate conditions) were generally observed in the lower sites (Figure 5).

Percent particles < 2mm: Another helpful metric in evaluating substrate condition is the percent of fine materials in the streambed. For purposes of this study, a diameter of 2 mm was selected as the cutoff point for fines. This is consistent with some other assessment protocols (New Mexico Environment Dept., 2002).

The four upper sites (PHAB-1; PHAB-2; PHAB-3 and PHAB-5) scored better (lower % of fines) than the other sites lower in the system (Figure 6). The highest values (corresponding to the most impacted) were observed at PHAB-7: Carson River above Highway 395; PHAB-8: Carson River above Mexican Gage; and PHAB-13: Carson River below Weeks Bridge. At each of these 3 sites, over 80% of the substrate particles counted were silt or sand leaving little useable habitat for fish spawning and macroinvertebrates.

Table 4. Summary of Relative Bed Stability Findings

Site ID	Site Name	Reach Length (ft)	Average Water Surface Slope (m/m)	Bankfull Channel Hydraulic Radius (R_{bf}) (mm)	Residual Pool Hydraulic Radius Adjustment (R_p) (mm)	Critical Substrate Diameter (C_{cbf}) (mm)	Median Substrate Diameter (D_{50}) (mm)	LRBSI
PHAB-1	EF Carson River near stateline	2,400	0.0034	665.5	119.4	25.1	45.255	0.26
PHAB-2	EF Carson River above Riverview	2,400	0.0030	763.3	144.8	25.4	22.627	-0.05
PHAB-3	EF Carson River above Lutheran Bridge	2,000	0.0036	659.1	104.1	27.4	22.627	-0.08
PHAB-4	EF Carson River above confluence	1,600	0.0008	657.9	92.7	6.5	0.707	-0.96
PHAB-5	WF Carson River near Paynesville	1,300	0.0084	478.8	58.4	48.2	22.627	-0.33
PHAB-6	WF Carson River above confluence	920	0.0005	567.7	47.0	3.9	0.354	-1.04
PHAB-7	Carson River above Highway 395	4,120	0.0004	764.5	88.9	3.8	0.707	-0.73
PHAB-8	Carson River above Mexican Gage	3,200	0.0006	596.9	69.9	4.5	0.354	-1.10
PHAB-9	Carson River above Lloyd's Bridge	4,000	0.0012	868.7	166.4	11.3	0.707	-1.20
PHAB-10	Carson River in upper Carson Canyon	2,000	0.0055	825.5	106.7	54.5	0.707	-1.89
PHAB-11	Carson River in lower Carson Canyon	2,200	0.0037	809.0	119.4	34.6	0.707	-1.69
PHAB-12	Carson River at Glancy's Property	2,400	0.0007	798.8	123.2	6.4	0.707	-0.96
PHAB-13	Carson River below Week's Bridge	4,500	0.0008	731.5	53.3	7.4	0.354	-1.32

Table 5. Summary of Relative Bed Stability Indices with other Factors

Site ID	Site Name	LRBSI	% of Substrate Particles ≤ C_{cbf}	% of Substrate Particles ≤ 2 mm
PHAB-1	EF Carson River near stateline	0.26	47.6	18.4
PHAB-2	EF Carson River above Riverview	-0.05	58.1	32.4
PHAB-3	EF Carson River above Lutheran Bridge	-0.08	55.2	32.4
PHAB-4	EF Carson River above confluence	-0.96	80.0	66.7
PHAB-5	WF Carson River near Paynesville	-0.33	64.8	38.1
PHAB-6	WF Carson River above confluence	-1.04	80.0	76.2
PHAB-7	Carson River above Highway 395	-0.73	81.9	81.9
PHAB-8	Carson River above Mexican Gage	-1.10	98.1	98.1
PHAB-9	Carson River above Lloyd's Bridge	-1.20	67.6	61.0
PHAB-10	Carson River in upper Carson Canyon	-1.89	60.8	54.6
PHAB-11	Carson River in lower Carson Canyon	-1.69	63.2	58.9
PHAB-12	Carson River at Glancy's Property	-0.96	76.9	66.3
PHAB-13	Carson River below Week's Bridge	-1.32	96.1	93.2

Figure 4. Carson River PHAB Survey - Relative Bed Stability Values

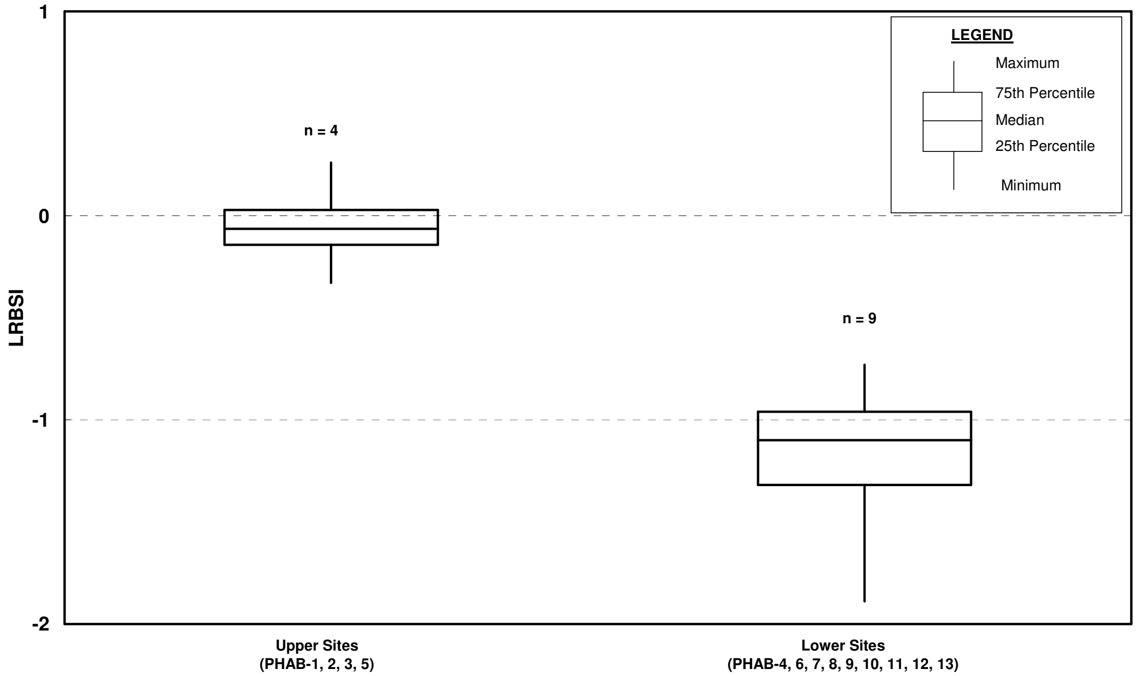


Figure 5. Carson River PHAB Survey - % Substrate < C_{cbf}

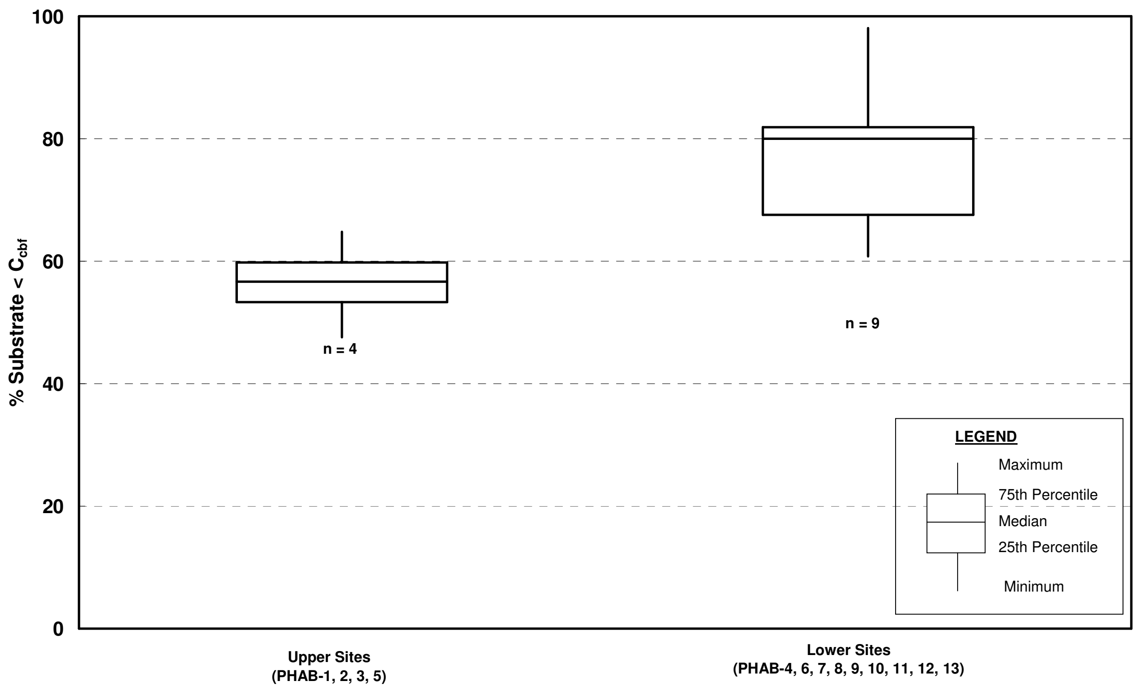
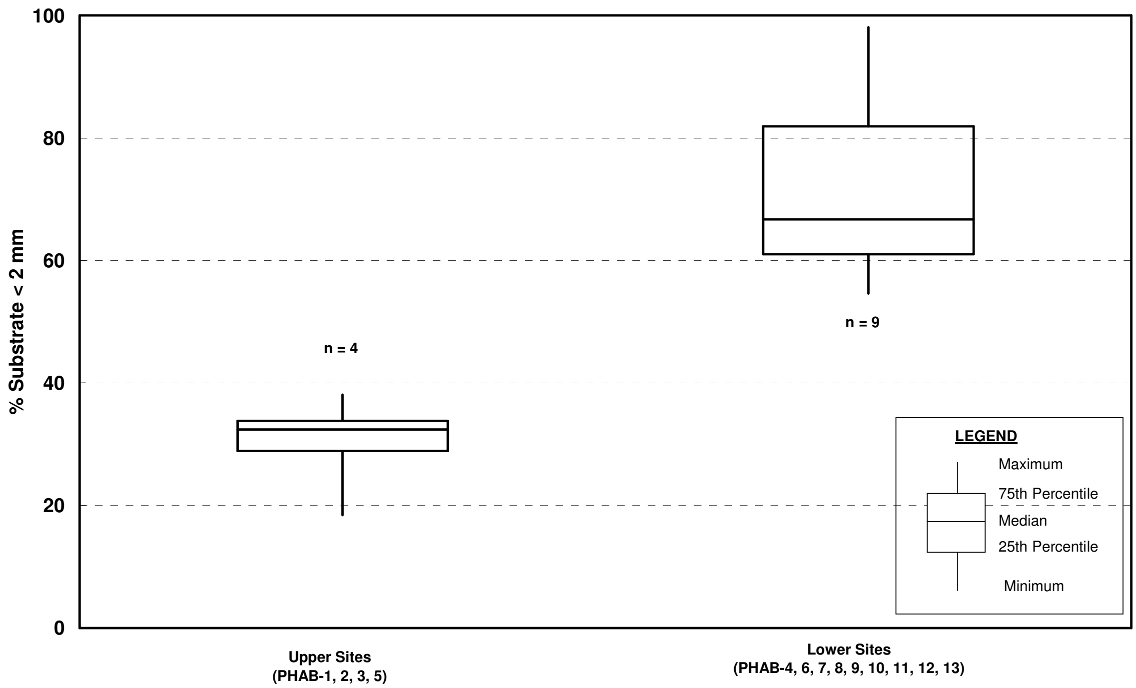


Figure 6. Carson River PHAB Survey - % Substrate < 2mm



Closing Remarks

The Relative Bed Stability Index method was developed by EPA as a component of an overall physical habitat assessment. The developers of the EMAP methods "*strove to make the approach objective and repeatable*" (Kaufmann, et al., 1999). Nevertheless there are inherent inprecisions in the measurements, and temporal/spatial variability in some characteristics (metrics). This is the first such effort by NDEP and the availability of resources to perform similar investigations in the future is uncertain. However, additional such surveys would be useful in quantifying the precision of these results and further developing these techniques for Nevada streams. The LRBSI is intended to serve as another in a suite of tools for better understanding the assessing the Carson system health.

One of the concerns raised during this investigation was the effect of flow conditions on the results. Some of the measurements can be considered quite precise and independent upon the flows that existed at the time of the field survey, and flows that have existing for the preceding years. Other measurements are affected by the flow conditions. For the previous four years, the Carson River has experienced below average flows. This could have resulted in bankfull indicators lower than the actual long-term bankfull limits. However during most of these years, the system did experience bankfull conditions (peak flows with an approximate recurrence interval of 1.5 years). Without additional future surveys, it will be difficult to quantify how the 4 years of drought may have affected these results.

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APPENDIX A – Plan View of PHAB Survey Sites

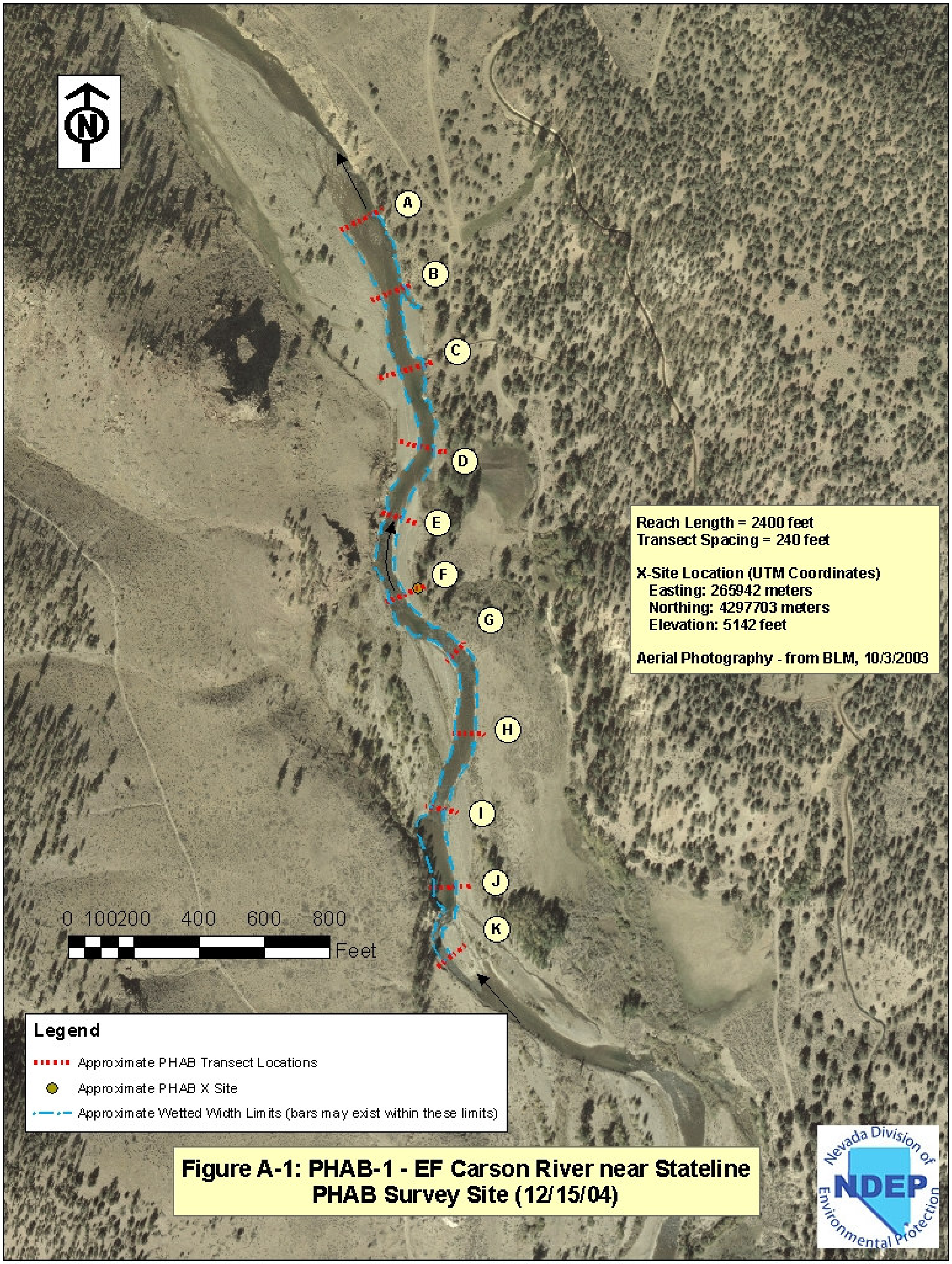


Figure A-1: PHAB-1 - EF Carson River near Stateline PHAB Survey Site (12/15/04)

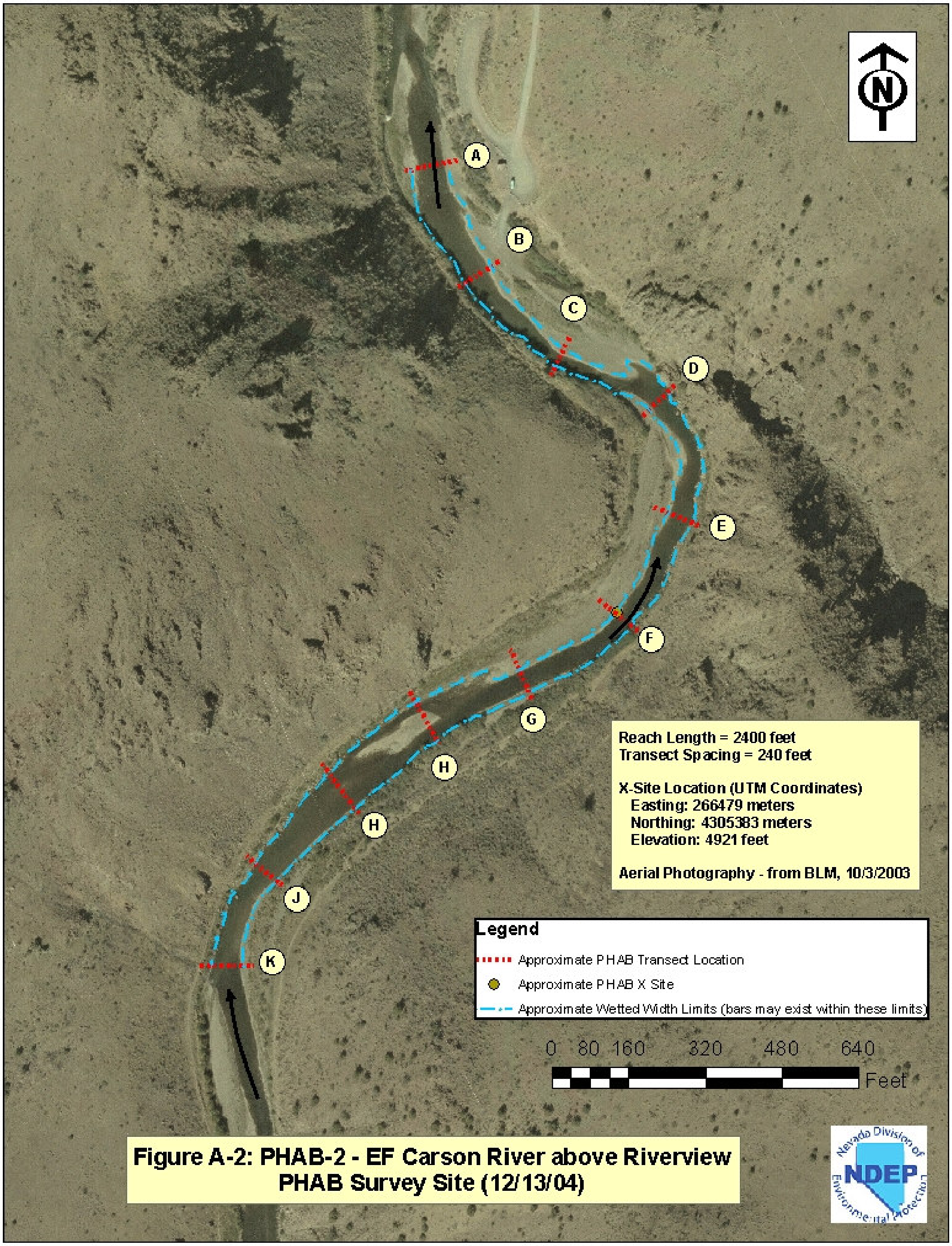


Figure A-2: PHAB-2 - EF Carson River above Riverview PHAB Survey Site (12/13/04)

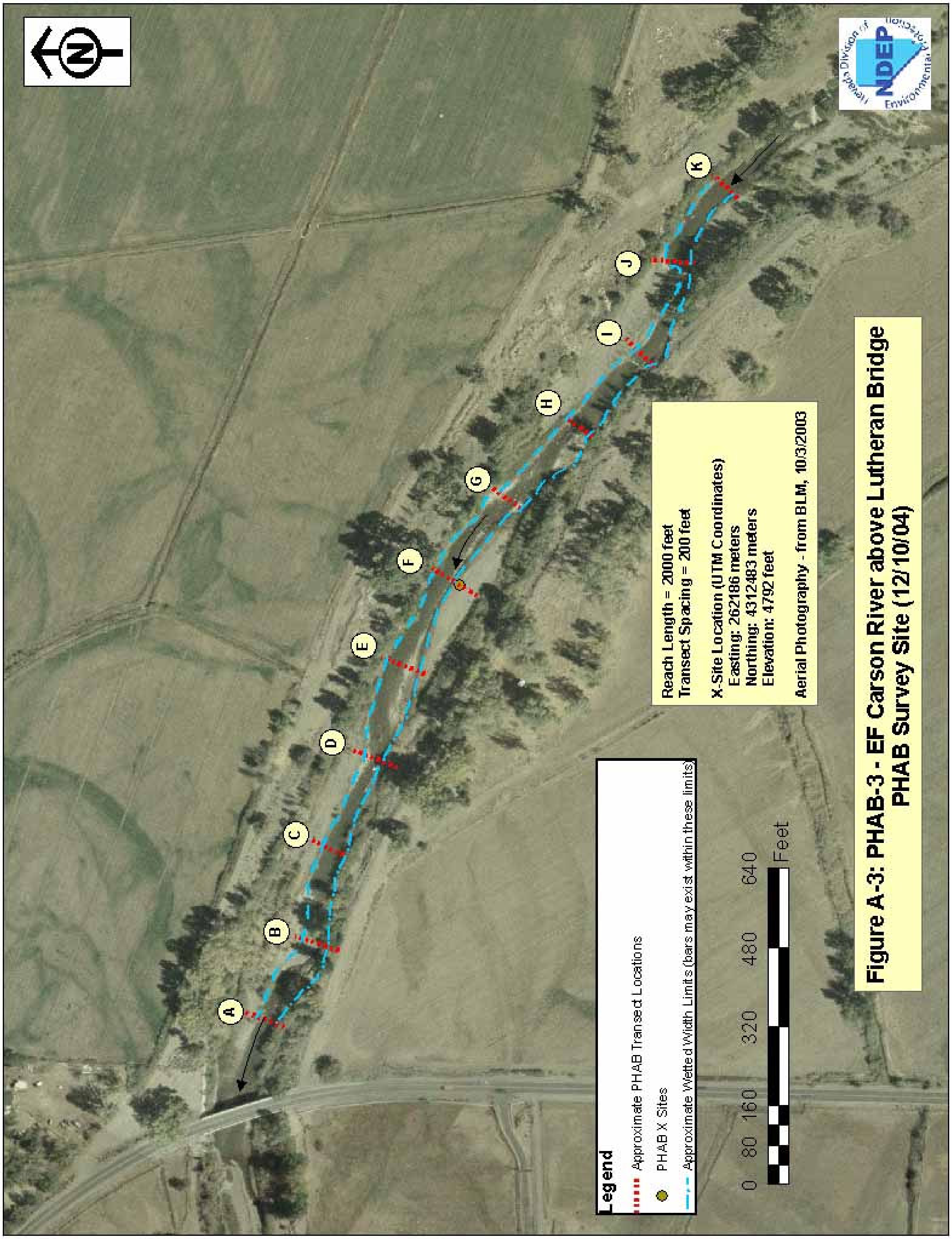


Figure A-3: PHAB-3 - EF Carson River above Lutheran Bridge PHAB Survey Site (12/10/04)

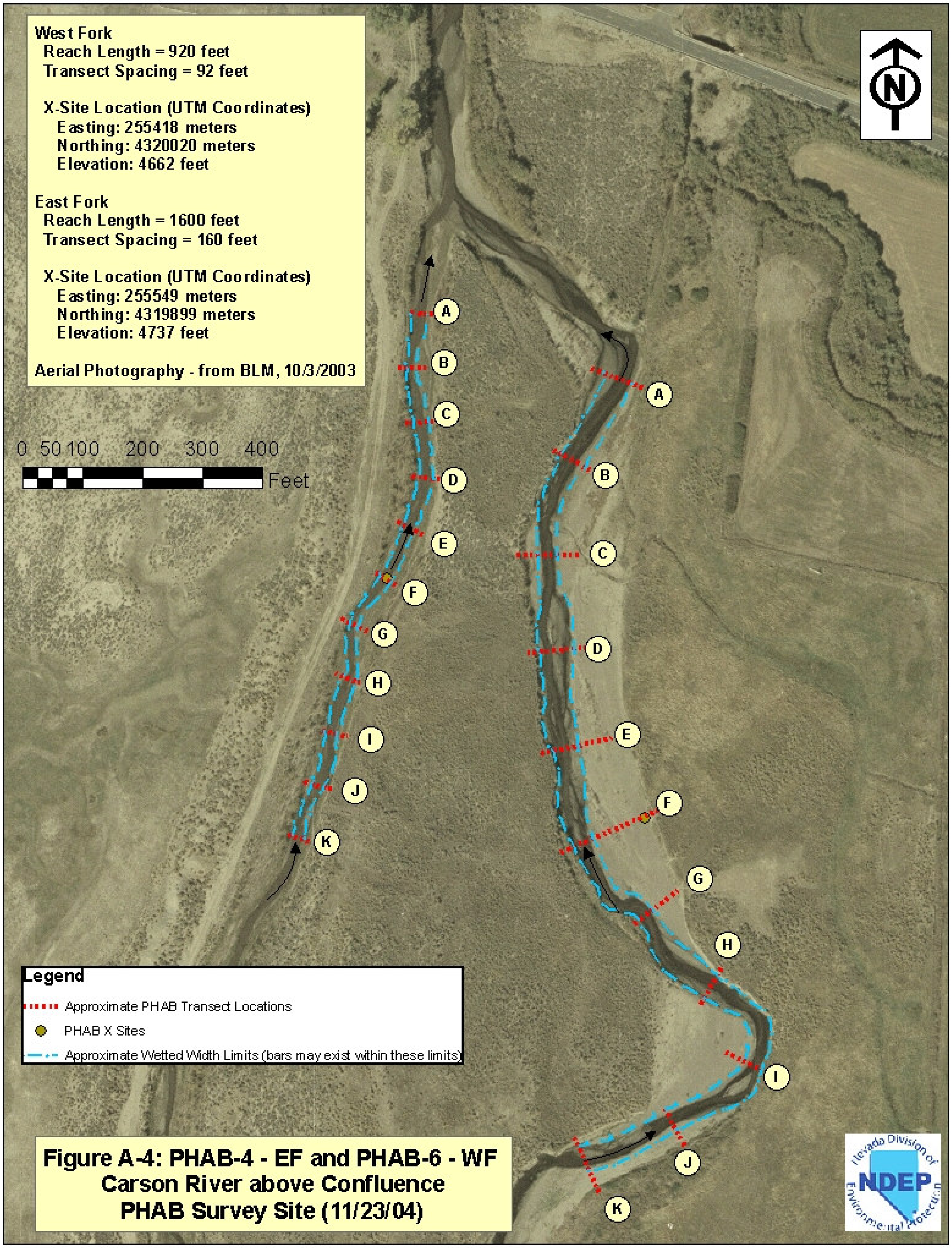
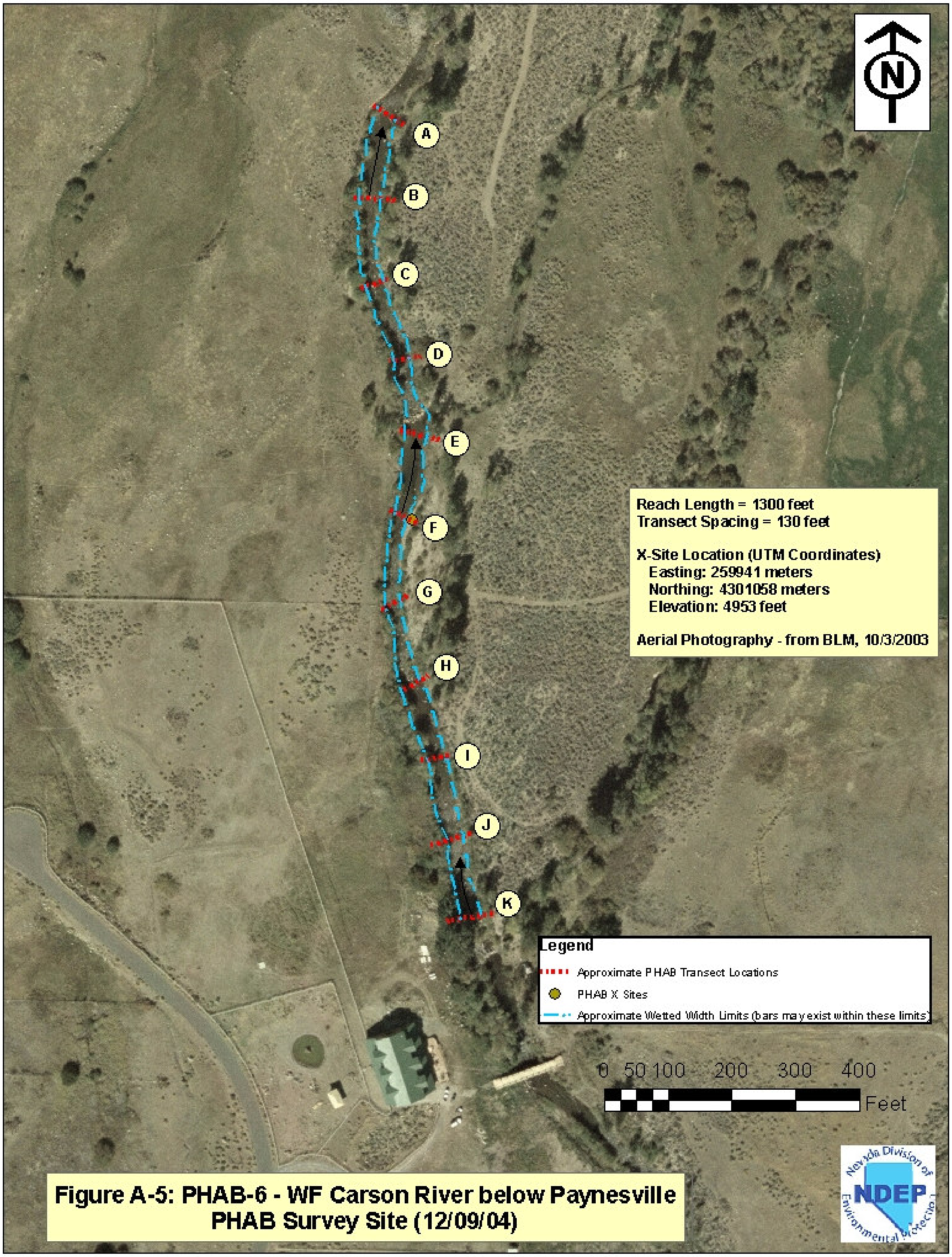


Figure A-4: PHAB-4 - EF and PHAB-6 - WF
Carson River above Confluence
PHAB Survey Site (11/23/04)


A
B
C
D
E
F
G
H
I
J
K
N
Reach Length = 1300 feet
Transect Spacing = 130 feet
X-Site Location (UTM Coordinates)
Easting: 259941 meters
Northing: 4301058 meters
Elevation: 4953 feet
Aerial Photography - from BLM, 10/3/2003
Legend
Approximate PHAB Transect Locations
PHAB X Sites
Approximate Wetted Width Limits (bars may exist within these limits)
0 50 100 200 300 400
Feet
Figure A-5: PHAB-6 - WF Carson River below Paynesville
PHAB Survey Site (12/09/04)
Nevada Division of Environmental Protection
NDEP

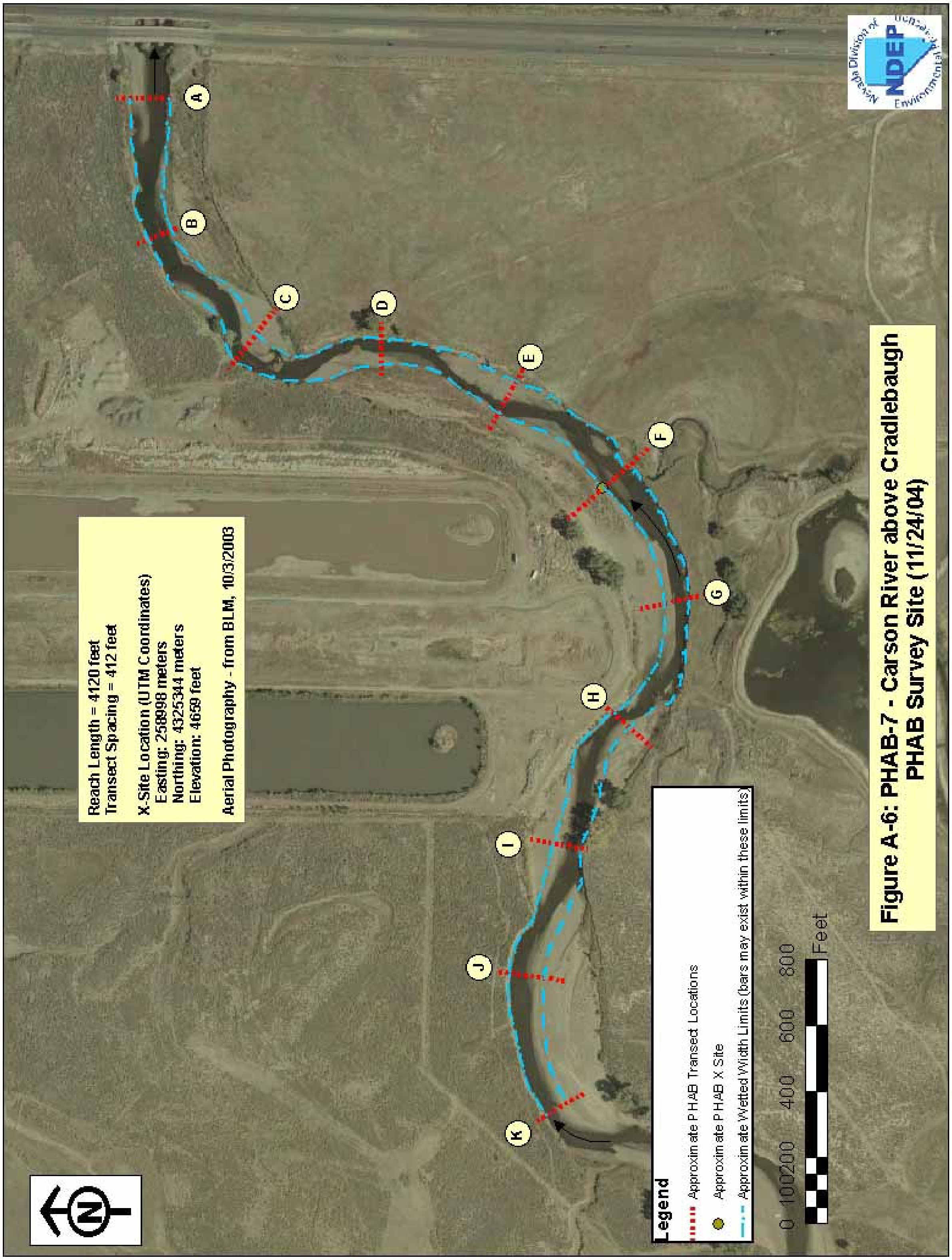


Figure A-6: PHAB-7 - Carson River above Cradlebaugh PHAB Survey Site (11/24/04)

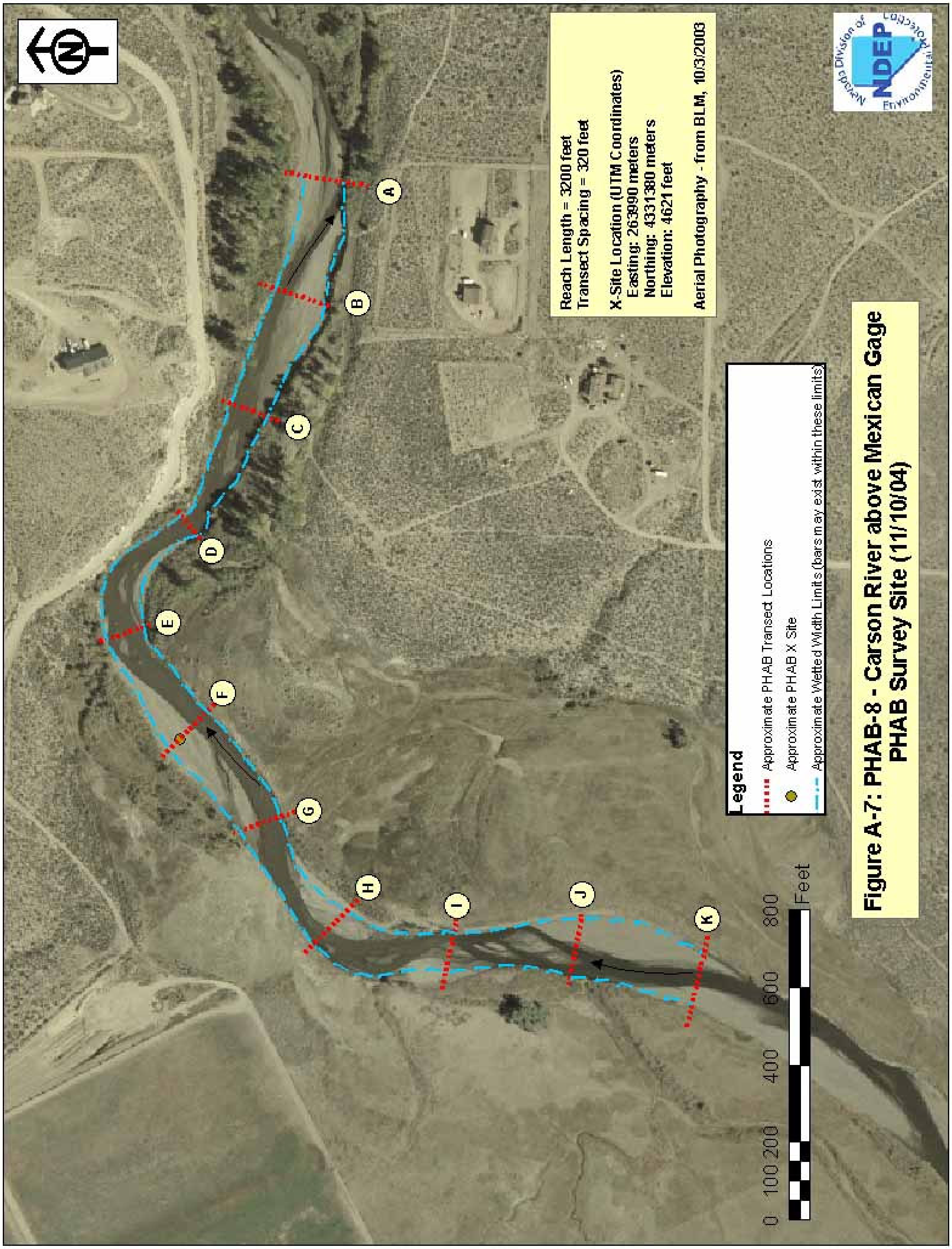


Figure A-7: PHAB-8 - Carson River above Mexican Gage PHAB Survey Site (11/10/04)

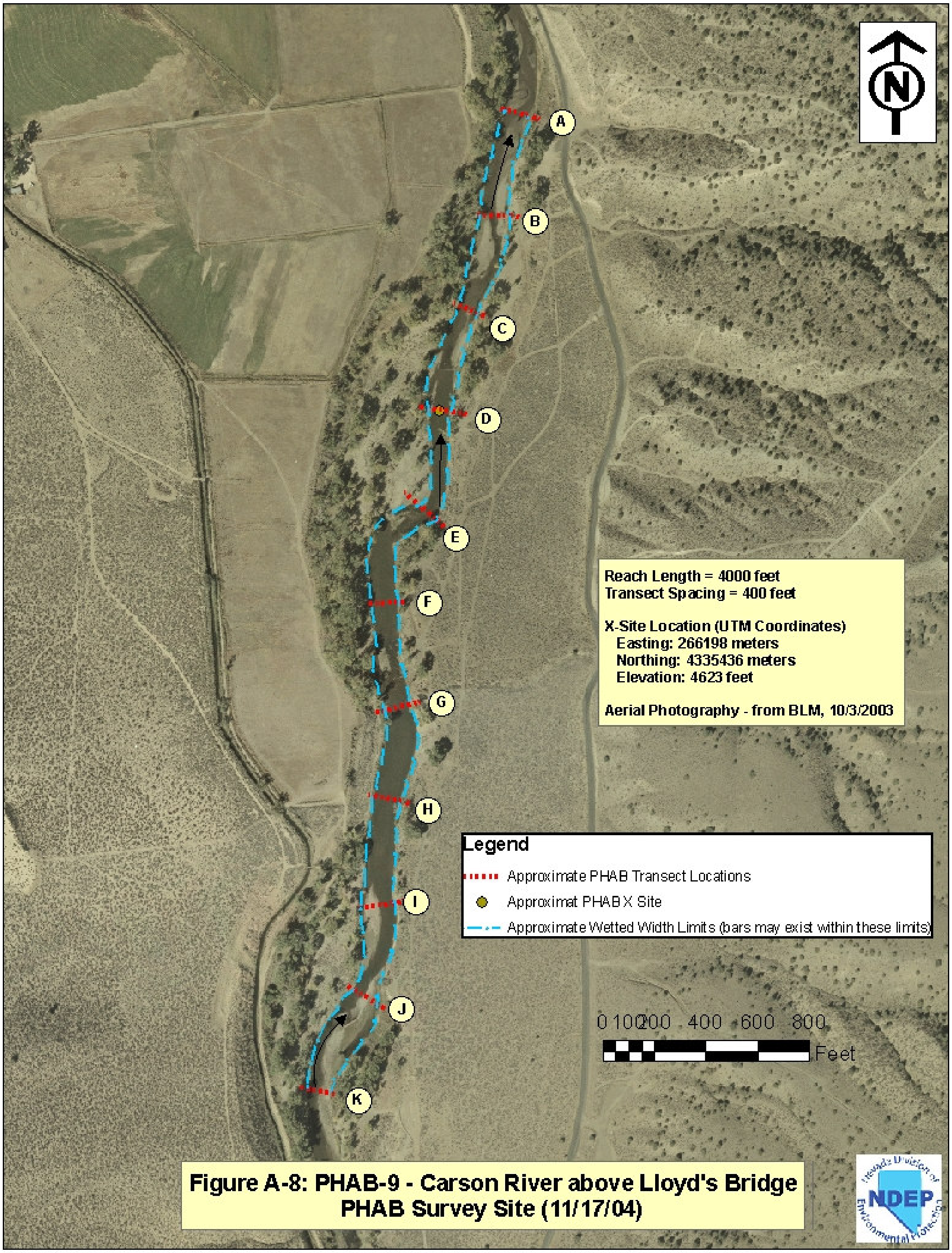


Figure A-8: PHAB-9 - Carson River above Lloyd's Bridge PHAB Survey Site (11/17/04)

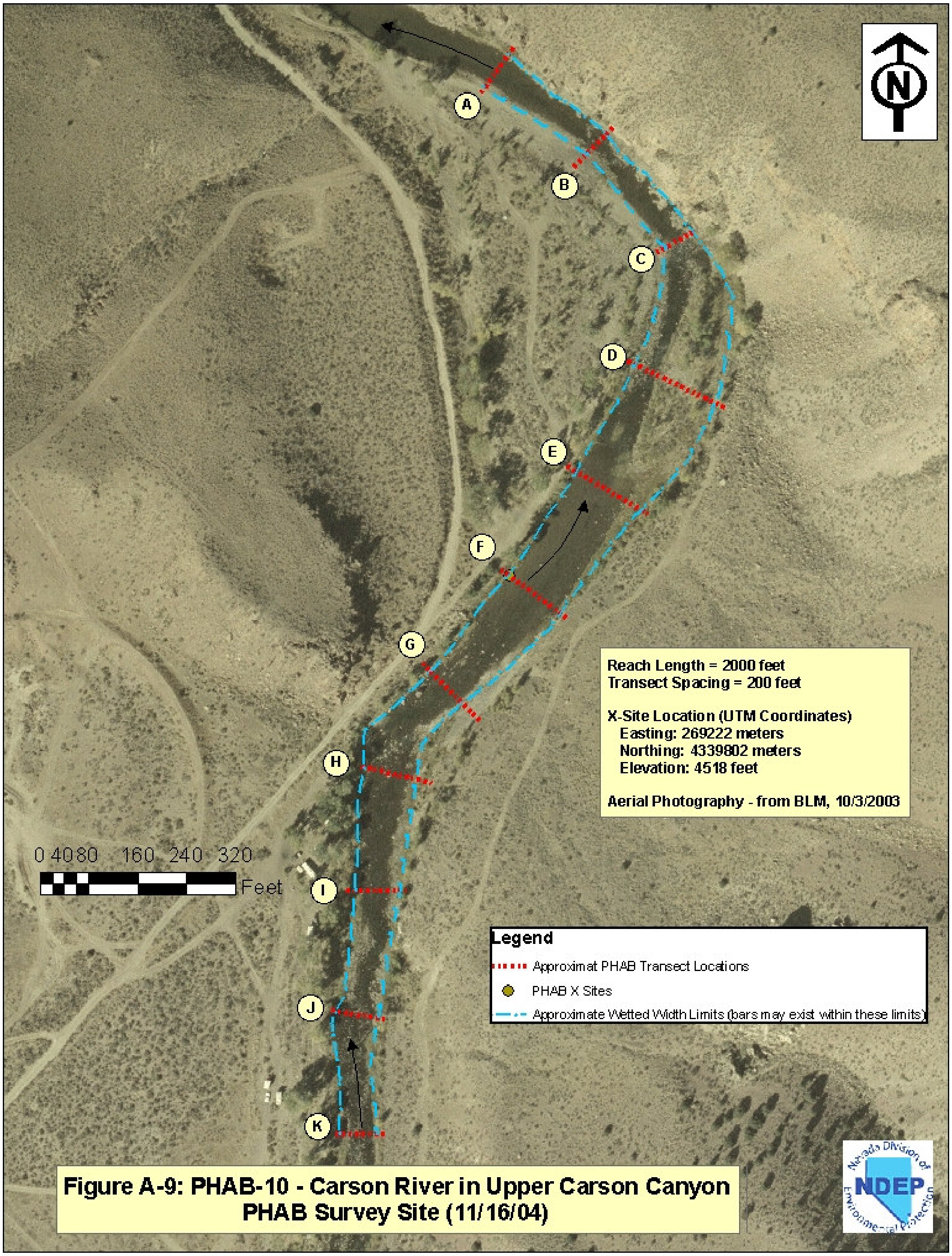


Figure A-9: PHAB-10 - Carson River in Upper Carson Canyon PHAB Survey Site (11/16/04)

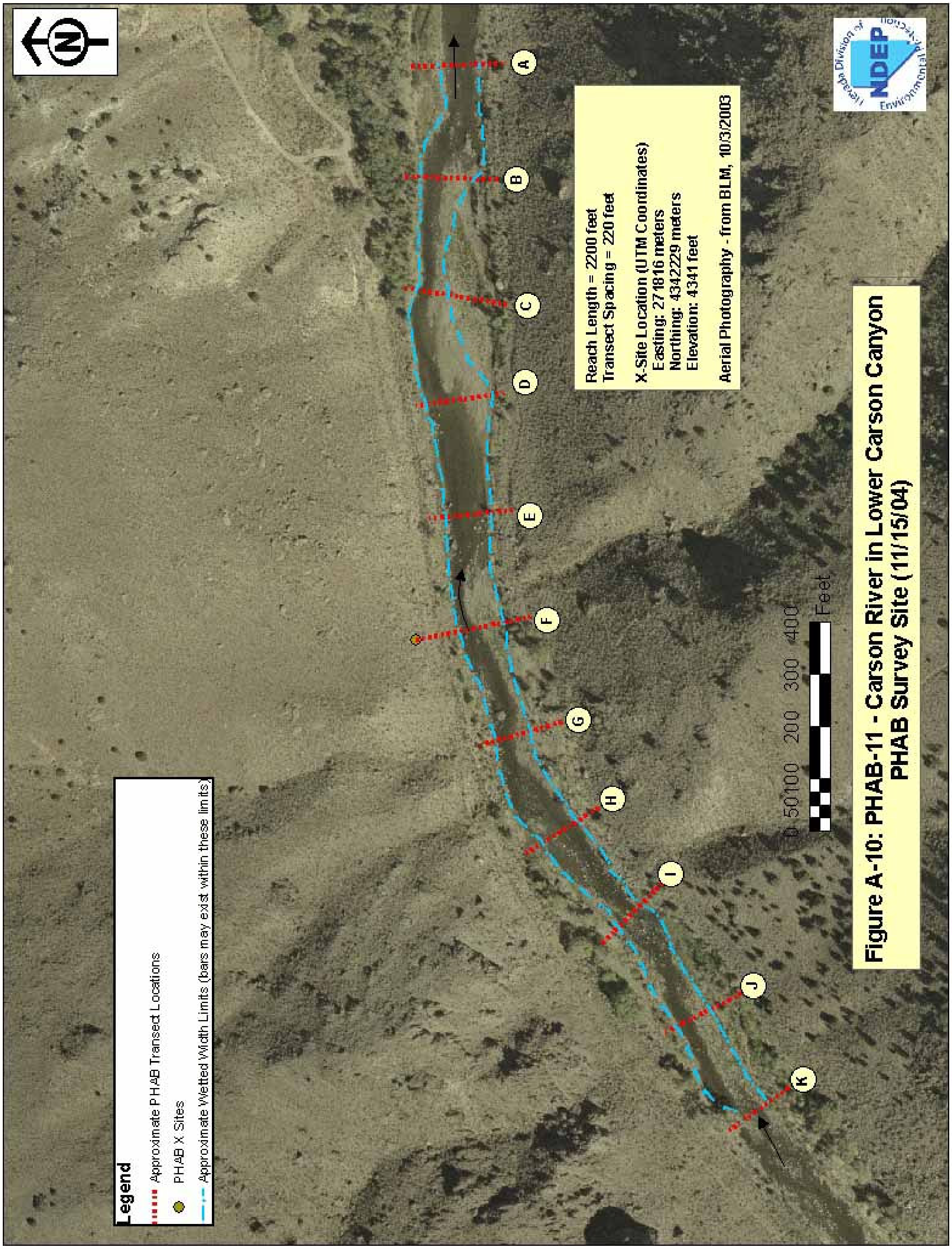


Figure A-10: PHAB-11 - Carson River in Lower Carson Canyon PHAB Survey Site (11/15/04)

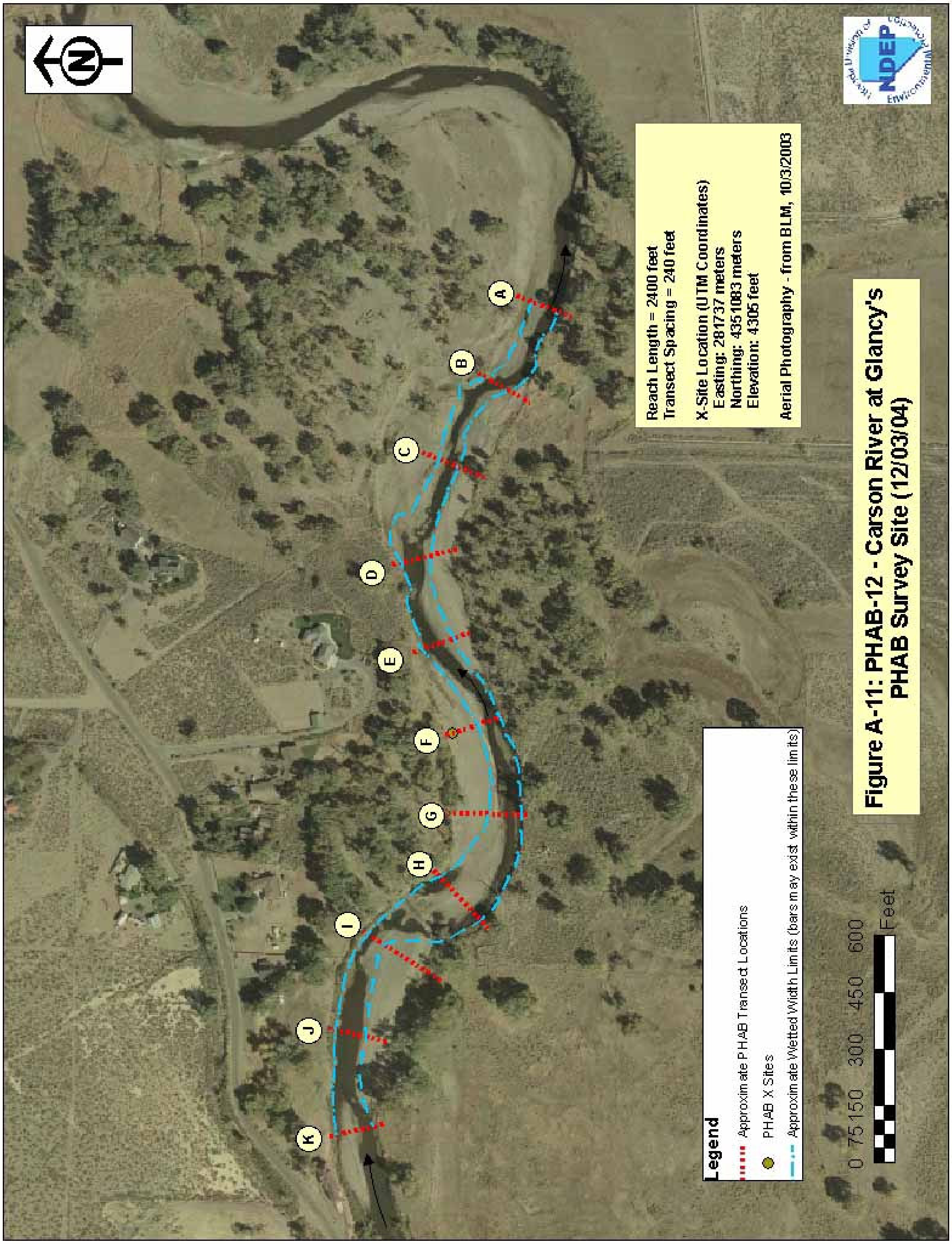


Figure A-11: PHAB-12 - Carson River at Glancy's PHAB Survey Site (12/03/04)

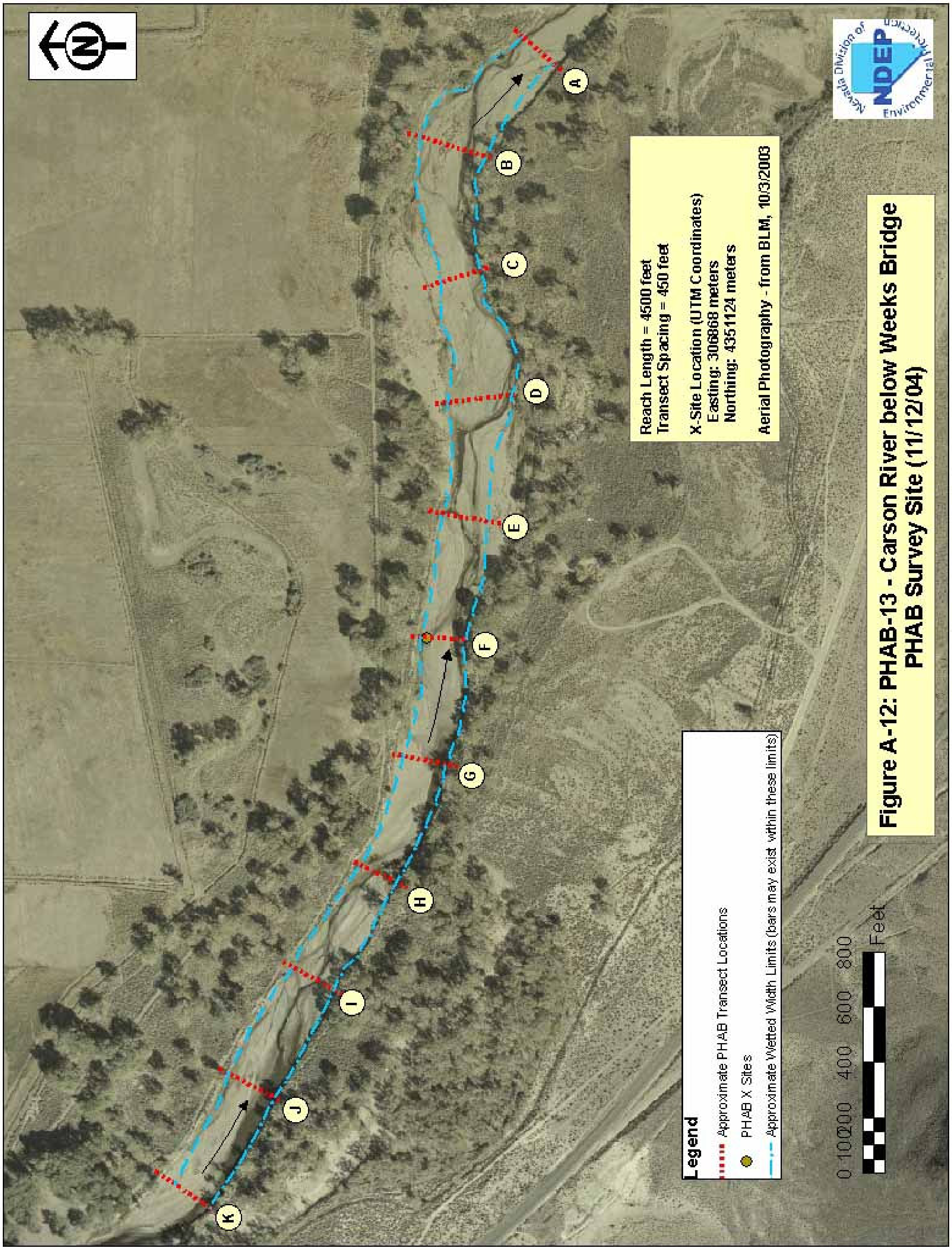


Figure A-12: PHAB-13 - Carson River below Weeks Bridge PHAB Survey Site (11/12/04)

APPENDIX B – Summary PHAB Field Data

Summary of Bankfull Data (inches)

Transects	PHAB-1		PHAB-2		PHAB-3		PHAB-4		PHAB-5		PHAB-6	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
A	18	24	31	32	26	18	37	37	27	17	34	27
B	14	14	24	34	24	15	21	43	20	12	27	27
C	16	24	30	26	15	20	19	38	18	18	25	24
D	13	22	25	24	18	20	29	22	16	18	22	24
E	21	20	32	41	20	30	47	36	18	20	25	34
F	24	19	30	30	24	28	22	17	18	14	35	44
G	21	27	23	26	19	24	32	26	20	18	36	24
H	21	27	26	22	29	28	40	47	18	18	20	39
I	24	22	31	26	36	30	23	34	18	24	34	20
J	24	19	27	29	21	27	34	27	48	19	39	23
K	24	24	31	28	24	27	29	31	32	24	27	32

Transects	PHAB-7		PHAB-8		PHAB-9		PHAB-10		PHAB-11		PHAB-12		PHAB-13	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
A	48	36	30	19	36	36	33	33	33	22	36	36	42	31
B	30	36	12	24	35	31	34	36	24	31	15	48	41	29
C	32	35	21	36	33	32	72	72	32	24	18	32	36	35
D	32	28	30	18	30	36	24	24	27	33	28	24	44	44
E	27	31	20	22	32	40	24	24	18	22	23	27	29	35
F	21	28	26	25	32	28	27	20	27	24	24	32	40	40
G	24	34	25	28	48	27	31	32	22	25	30	30	41	26
H	34	27	34	18	39	32	26	29	28	34	26	60	46	36
I	34	34	20	17	26	31	28	21	33	23	36	38	41	36
J	34	35	16	15	27	33	24	33	36	36	42	42	46	18
K	33	34	23	23	24	36	26	28	24	24	36	28	36	29

Summary of Slope Data

Subreach	PHAB-1	PHAB-2	PHAB-3	PHAB-4	PHAB-5	PHAB-6	PHAB-7	PHAB-8	PHAB-9	PHAB-10	PHAB-11	PHAB-12	PHAB-13
A - B	0.18%	0.56%	0.12%	0.08%	0.11%	0.03%	0.02%	0.07%	0.03%	0.07%	0.28%	0.02%	0.08%
B - C	0.10%	0.11%	0.64%	0.10%	1.12%	0.03%	0.02%	0.06%	0.27%	0.51%	0.26%	0.11%	0.11%
C - D	0.02%	0.12%	0.16%	0.19%	2.85%	0.02%	0.07%	0.06%	0.07%	2.59%	0.28%	0.12%	0.09%
D - E	0.01%	0.17%	0.62%	0.05%	0.00%	0.03%	0.07%	0.06%	0.01%	0.88%	0.05%	0.01%	0.10%
E - F	0.47%	0.19%	0.11%	0.06%	0.48%	0.07%	0.03%	0.04%	0.23%	0.06%	0.03%	0.03%	0.07%
F - G	0.59%	0.35%	0.73%	0.14%	0.80%	0.05%	0.06%	0.08%	0.42%	0.02%	0.21%	0.03%	0.05%
G - H	0.90%	0.78%	0.46%	0.03%	0.75%	0.09%	0.07%	0.04%	0.02%	0.04%	0.27%	0.03%	0.07%
H - I	0.11%	0.50%	0.10%	0.03%	0.04%	0.04%	0.03%	0.09%	0.02%	0.33%	0.24%	0.10%	0.08%
I - J	0.68%	0.12%	0.54%	0.05%	0.48%	0.09%	0.01%	0.07%	0.01%	0.35%	1.71%	0.18%	0.07%
J - K	0.30%	0.10%	0.12%	0.11%	1.74%	0.09%	0.03%	0.05%	0.09%	0.68%	0.33%	0.06%	0.08%

Summary of Thalweg Measurements

PHAB-1 Thalwegs (inches)

	Subreach									
Station	**A-B**	**B-C**	**C-D**	**D-E**	**E-F**	**F-G**	**G-H**	**H-I**	**I-J**	**J-K**
0 (downstream station)	49	36	26	37	39	18.5	19.5	26	25.5	32
1	46	29.5	23.5	37	37	20	18	26	19	35.5
2	43	30.5	27.5	44	23.5	20	20	26	18	35
3	45	28	47	38	18	21.5	18	31	17.5	36
4	31	24	48	27	21	26.5	29	27.5	16	44
5	25	23	98	27	20	53	15.5	28.5	16	>50
6	17	19.5	90	32.5	18	53	22	28	19.5	>50
7	14.5	19.5	74.5	52	17.5	60	21.5	27	23	48
8	29	19	55	60	18	29	19.5	22	22	48
9	33	24.5	38.5	48	16	24	22	21	27	24
10 (upstream station)	36	26	37	39	18.5	19.5	26	25.5	32	24

PHAB-2 Thalwegs (inches)

	Subreach									
Station	**A-B**	**B-C**	**C-D**	**D-E**	**E-F**	**F-G**	**G-H**	**H-I**	**I-J**	**J-K**
0 (downstream station)	14	27	75	22	40	51	22.5	21	18	38
1	18.5	29.5	58	60	37	45	18.5	19.5	17.5	51
2	16	32.5	55	63	31	28	18.5	17	21.5	47
3	19	36	45	52	23	37	16	18.5	25	57
4	17	33	36	63	34	23	17	19	15.5	59
5	19	28	33	>64	50	19	18.5	17.5	22.5	43
6	16.5	30.5	40	42	49	16	19.5	16.5	28.5	41
7	15	28.5	64	36	31	17	20	15	33.5	40
8	15	35	26	34	46	19.5	22	13.5	43.5	42
9	17	36	21	28	51	20	25	17	36	43
10 (upstream station)	27	75	22	40	51	22.5	21	18	38	36

PHAB-3 Thalwegs (inches)

	Subreach									
Station	**A-B**	**B-C**	**C-D**	**D-E**	**E-F**	**F-G**	**G-H**	**H-I**	**I-J**	**J-K**
0 (downstream station)	34	38	31.5	17.5	18	31	18	16.5	22	24
1	38	38	36	18	21	33	16.5	20	18	39
2	41	22	38	13	20	30	34	25	24	51
3	35	17	37	13	26	21	>50	31	33	51
4	>50	18.5	30	17	32.5	18	48	38	48	30.5
5	>50	20	27	19	32	20	32	42	46	29
6	48	23	22	25	35	16	17	34	38	17
7	19	23.5	20	21.5	37	12	22	48	37.5	18
8	25	26	17	16	44	11	20	>50	15	16.5
9	33	26.5	18	16	39	16	19	48	13	18.5
10 (upstream station)	38	31.5	17.5	18	31	18	16.5	22	24	16.5

PHAB-4 Thalwegs (inches)

	Subreach									
Station	**A-B**	**B-C**	**C-D**	**D-E**	**E-F**	**F-G**	**G-H**	**H-I**	**I-J**	**J-K**
0 (downstream station)	22.5	12	13.5	23	17	32.5	12	17.5	22	17
1	18.5	15	12	19	21	28.5	15.5	18.5	31	21
2	18	15	12	16	21	66.5	18	22	36	22
3	17	16	11	16	25.5	26.5	27	27	17	18
4	17	9	12	15	26	24	19.5	18	18.5	17.5
5	16	12	11	18	33	35.5	18	30	15.5	20
6	15	22	11	20	36	45	14.5	38	16	25
7	17	18	14	23	22	25.5	12	39	15.5	14.5
8	15	14.5	13	16	17	29	11.5	31	17	14
9	15	15	18	16	24	40	17	30	17	15
10 (upstream station)	12	13.5	23	17	32.5	12	17.5	22	17	15

PHAB-5 Thalwegs (inches)

Station	Subreach									
	A-B	B-C	C-D	D-E	E-F	F-G	G-H	H-I	I-J	J-K
0 (downstream station)	20	15	13	11	21.5	31	9	11.5	17	13.5
1	17	18	14.5	18.5	22	30.5	10	8	13	14
2	20	13.5	13.5	14	25.5	34	11.5	15	15	11.5
3	21	10.5	14	14	33	30	10.5	17.5	13	12
4	22	11.5	8.5	13	42	25.5	11	22.5	12	14
5	19	14	11	15.5	44	21	11.5	22	12	13
6	20	13.5	11	9	48	18.5	9	13.5	12	11
7	21	12	10	16.5	43	19	8	15	10	13.5
8	22	11	13	24	31.5	9	11	14.5	10	16
9	24.5	12	8	24	31	8.5	8.5	19	12	14
10 (upstream station)	15	13	11	21.5	31	9	11.5	17	13.5	18

PHAB-6 Thalwegs (inches)

Station	Subreach									
	A-B	B-C	C-D	D-E	E-F	F-G	G-H	H-I	I-J	J-K
0 (downstream station)	15	17	13	20.5	18.5	20	17	12.5	20.5	14
1	14.5	16	11.5	17	17.5	16.5	13.5	12	11	14
2	12.5	15.5	12	15.5	16	16.5	12	12.5	10.5	18
3	12	17	15	17.5	17	13	10.5	12.5	10.5	22
4	14	18.5	15	15	19.5	13.5	11	15.5	11	17
5	16.5	14.5	13.5	18	17.5	14	10.5	16	21	11.5
6	16.5	18	16.5	16.5	15	15	13	18	15.5	13
7	16.5	14	17.5	17	18.5	13	14.5	15	13.5	17.5
8	18	12.5	18	17	18	19	17	16	14	21
9	17.5	11.5	19	18	17.5	22.5	14.5	17	14	18
10 (upstream station)	17	13	20.5	18.5	20	17	12.5	20.5	14	18.5

PHAB-7 Thalwegs (inches)

Station	Subreach									
	A-B	B-C	C-D	D-E	E-F	F-G	G-H	H-I	I-J	J-K
0 (downstream station)	31	38	30	30	18.5	17	32	43	18	22
1	28.5	41	34	31	16	22	33	32	18.5	22
2	36	26	36	38	15.5	18	36	20	19.5	21
3	29	26	34	35	18	18	28	20.5	23	27
4	29	35	22	29	18	20	21	20	25	26
5	35	27.5	25	21	26	28	29	21	>50	24
6	>50	22	28	26	17	28	>50	22	32	34
7	>50	22	33.5	25	21.5	17.5	31	27.5	19	32
8	44	23	35	28	30	18	32	19	22	31
9	39	33	29	23	22	25	>50	18	26	37
10 (upstream station)	38	30	30	18.5	17	32	43	18	22	37

PHAB-8 Thalwegs (inches)

Station	Subreach									
	A-B	B-C	C-D	D-E	E-F	F-G	G-H	H-I	I-J	J-K
0 (downstream station)	32	28	20	36	26	29	21.5	37	20.5	20
1	18	25	21	36	20	27	20	30	25.25	14.75
2	17	28	34	33	31	28	19	22.25	19	18.25
3	22.5	31.5	26	35.5	22	26.5	19	20	26.5	15.25
4	19	30	24	30	18	26	19	19.5	29	20.5
5	19	30.5	18	29	18.5	21.5	21	25.5	25	16
6	18	30	32.5	25	18.5	27.75	28.5	20.75	24.5	14.5
7	17	26	31	16.5	18.5	26	29	21.5	18	15
8	21	17.5	>46	19.5	22.5	22.5	30.5	26.5	18.5	19
9	25	18	34.5	27.5	26	25.5	33	28	19.5	20.5
10 (upstream station)	28	20	36	26	29	21.5	37	20.5	20	20.5

PHAB-9 Thalwegs (inches)

	Subreach									
Station	**A-B**	**B-C**	**C-D**	**D-E**	**E-F**	**F-G**	**G-H**	**H-I**	**I-J**	**J-K**
0 (downstream station)	24	28	37	40	31	>50	31	38	31	50
1	22	20.5	37	48	31	>50	32	34	38	36
2	28	27	33.5	>50	24	>50	28	45	>50	37
3	23	25.5	31	>50	17	42	37	45	>50	44
4	30	23	35	48	19	37	30.5	41	48	18
5	32	28	36	48	18	33	27	44	47	19
6	35	35	22.5	>50	27	16.5	30.5	45	48	17.5
7	31	32.5	22.5	>50	>50	21	34	40	50	26
8	29.5	31.5	30.5	>50	>50	15	33	32.5	38.5	38
9	27	31	39	>50	>50	21	37	29	46	31
10 (upstream station)	28	37	40	31	>50	31	38	31	50	30

PHAB-10 Thalwegs (inches)

	Subreach									
Station	**A-B**	**B-C**	**C-D**	**D-E**	**E-F**	**F-G**	**G-H**	**H-I**	**I-J**	**J-K**
0 (downstream station)	39	33	>50	21	20	31	36	24	25	33
1	51	29	16	26	19	32	>48	20	27	28
2	49	25	16	25	25	41	>48	26	25	28
3	46	36	20	27	25	41	>48	27	24	25
4	47	35	29	24.5	28	40	>48	25	27	22
5	49	36	27	23	26	>48	>48	27	23	29.5
6	39	>50	31	22	35	>48	>48	25	30	23
7	38	48	27.5	16	31	>48	>48	24	27	25
8	>50	37	29	15	32	43	>48	25	31	26
9	38	>50	23	16	30	38	36	26	31	26
10 (upstream station)	33	>50	21	20	31	36	24	25	33	28.5

PHAB-11 Thalwegs (inches)

	Subreach									
Station	**A-B**	**B-C**	**C-D**	**D-E**	**E-F**	**F-G**	**G-H**	**H-I**	**I-J**	**J-K**
0 (downstream station)	32	29.5	Missing	33	47	40	38	37	37	26
1	28	Missing	29	30	47	>48	50	47	33	25
2	17	Missing	25	24	47	>48	>48	36	34	33
3	25	Missing	36	25	>50	39	>48	34	34	28
4	26	Missing	35	36	>50	36	>48	26	35	36
5	29	Missing	41	41	>50	34	34.5	32.5	45	47
6	31	Missing	38	41	>50	28	50	35	24	47
7	28	Missing	38	42	>50	32	36	36	18	45
8	29	Missing	38	42	>50	32	39	45	22	45
9	32	Missing	36	41	34	28	24	29	22	50
10 (upstream station)	29.5	Missing	33	47	40	38	37	37	26	50

PHAB-12 Thalwegs (inches)

	Subreach									
Station	**A-B**	**B-C**	**C-D**	**D-E**	**E-F**	**F-G**	**G-H**	**H-I**	**I-J**	**J-K**
0 (downstream station)	25	40	28	25.5	23	33	28.5	40	32	34
1	30.5	>50	23	28	20	37	24	37	33	28
2	34	25	23	32	19	45	35	49	>46	33
3	46	23	24.5	38	19	28	29.5	33	28	>47
4	29	25	24.5	40	19.5	19	31	50	44	38
5	>48	20	27.5	27	23.5	25	29	23	19	40
6	45	20	25	24	20.5	19.5	31.5	33	21.5	44
7	31	17	25.5	23	24	20	32	>50	21	38
8	26	20	32	21	26	22.5	44	>50	23	33
9	24.5	29	18	21	29.5	24	37	46	26	28
10 (upstream station)	40	28	25.5	23	33	28.5	40	32	34	29

PHAB-13 Thalwegs (inches)

Station	Subreach									
	A-B	B-C	C-D	D-E	E-F	F-G	G-H	H-I	I-J	J-K
0 (downstream station)	21	18	17	37	18	38	23	14.5	26	21
1	21	15	15.5	17	16.5	31	20	15	31	17
2	24	16	15.5	20	16	23	29	18.5	19.5	16.5
3	32	21.5	20	20	22.5	20	25	15	16	15.5
4	13.5	26	19	17.5	27	25	25.5	34	15	17.5
5	19.5	21	31	20	30	23	19	21	17	16
6	15	17	32	16	31	34	17	24	22	28
7	12	17.5	19.5	18	22.5	18	20	17	20	32.5
8	16	21	18.5	20	18	20.5	16.5	16	17	36
9	15	20.5	21	19.5	28.5	17.5	19.5	17	21.5	28
10 (upstream station)	18	17	37	18	38	23	14.5	26	21	25

Summary of Pebble Count Data

PHAB-1 Pebble Count

Transect	Left	Left Center	Center	Right Center	Right
A	MS	VCG	VFS	MS	MG
mid A - B	CG	CB	VCG	CB	BR
B	ST	ST	VCG	VCG	BR
mid B - C	CG	VCG	CS	MG	CB
C	VFG	FG	CB	VFG	CG
mid C - D	MG	FS	FS	BR	BR
D	MG	VCG	CS	BR	MG
mid D - E	CG	CB	CB	VCG	CG
E	VFS	VFS	BR	CB	VCG
mid E - F	BR	BR	BR	BR	MG
F	CB	CB	BR	CB	CG
mid F - G	MG	MG	CG	MG	MS
G	VCG	CB	CB	CB	FS
mid G - H	FG	CB	BR	BR	VCG
H	MG	VCS	SB	CB	CB
mid H - I	MG	CB	CB	CG	MS
I	VCG	VCG	CB	CB	MG
mid I - J	ST	FG	CG	FG	CB
J	MS	MG	VCG	CS	CG
mid J - K	BR	TOO DEEP TO SIZE		CB	CS
K	SB	BR	SB	VCG	MG

PHAB-2 Pebble Count

Transect	Left	Left Center	Center	Right Center	Right
A	VFS	VCG	VCG	CG	FS
mid A - B	CB	CB	VCG	CB	VFG
B	ST	CB	CB	CS	MS
mid B - C	SB	CB	VCG	CB	VCS
C	VFS	VFS	VFS	VFS	CG
mid C - D	ST	CB	CB	CB	FG
D	VCG	MG	CB	FG	FG
mid D - E	CS	CS	CS	CS	LB
E	VCG	CG	VCS	CG	SB
mid E - F	VCG	MS	CS	CG	CB
F	CB	ST	ST	CS	CG
mid F - G	CS	MG	VCG	FG	SB
G	CS	VCG	VCG	VCG	CG
mid G - H	CB	VFG	CB	CB	VCG
H	VCS	MG	VCG	VCG	MG
mid H - I	CS	VCS	MG	VCG	VFG
I	LB	VCS	CG	CB	MG
mid I - J	FS	MG	VCG	CG	CG
J	FS	VCS	CG	FS	CG
mid J - K	ST	CB	MS	CB	VCG
K	SB	SB	FS	CG	VCG

PHAB-3 Pebble Count

Transect	Left	Left Center	Center	Right Center	Right
A	FS	CB	CB	VCS	FS
mid A - B	CB	CB	CB	CS	CG
B	MS	CB	VCG	CB	CG
mid B - C	ST	CB	FG	VCG	ST
C	FS	VCS	SB	CS	MS
mid C - D	CG	CB	CB	CG	ST
D	MS	CB	CG	MG	MS
mid D - E	ST	VCS	CB	CB	ST
E	FS	CB	VCG	VCG	CG
mid E - F	ST	VCG	VFG	FG	ST
F	FS	CB	SB	VCS	FS
mid F - G	ST	CB	CB	CB	VFG
G	CB	CB	CB	CG	VCG
mid G - H	CB	FG	CB	VFG	ST
H	VCG	CG	MG	MG	CB
mid H - I	ST	CB	CB	MS	CB
I	VCG	VCG	CB	CG	CG
mid I - J	ST	CB	MS	MS	MG

PHAB-4 Pebble Count

Transect	Left	Left Center	Center	Right Center	Right
A	VCS	CS	CS	MG	VCS
mid A - B	VFG	VFG	VFG	MS	ST
B	ST	MG	MG	FG	MG
mid B - C	ST	CS	CG	FG	CS
C	CG	VFG	MG	MG	MG
mid C - D	FS	CG	CS	FG	CG
D	ST	FG	MS	FS	FS
mid D - E	FS	MS	MS	MS	MS
E	ST	FS	FS	VCS	CS
mid E - F	ST	CS	FS	MS	MS
F	ST	CS	CS	MS	FG
mid F - G	FS	CS	FG	FG	CS
G	ST	CG	MG	MG	CG
mid G - H	FS	MS	MS	CS	VCS
H	CS	CS	CS	MS	ST
mid H - I	CS	FS	MS	ST	ST
I	ST	MS	FG	MG	VCS
mid I - J	CS	CG	CS	CS	ST
J	CS	FG	VCS	VCS	ST
mid J - K	CS	MS	CS	MG	FS
K	ST	MG	FG	CG	CG

PHAB-5 Pebble Count

Transect	Left	Left Center	Center	Right Center	Right
A	ST	VFG	CB	VFS	ST
mid A - B	ST	LB	FS	CS	ST
B	LB	CB	VCG	VCS	VFS
mid B - C	FS	CG	CB	CB	VCS
C	MS	CB	VCG	VCG	VFG
mid C - D	MS	VCG	CB	CB	VCG
D	SB	CS	CB	CB	MG
mid D - E	SB	CB	CB	CB	CB
E	FS	CS	CS	CB	FS
mid E - F	ST	ST	ST	VFS	ST
F	SB	MS	CG	CS	CS
mid F - G	VCG	VCG	CG	SB	SB
G	FG	CB	CB	SB	SB
mid G - H	FS	CB	VCG	CG	CB
H	FS	VCG	VCG	MG	CB
mid H - I	ST	VCG	VFS	FS	FG
I	VFS	CS	CB	CS	VFS
mid I - J	ST	CG	VCS	CG	ST
J	CS	CB	VFG	CB	VFG
mid J - K	SB	CB	VFG	CB	CG
K	FG	CB	SB	CB	VCS

PHAB-6 Pebble Count

Transect	Left	Left Center	Center	Right Center	Right
A	ST	MS	VFG	MS	CS
mid A - B	ST	CG	CG	MS	ST
B	ST	VCS	MS	MS	CS
mid B - C	ST	CS	CS	VCS	VCS
C	ST	VCS	VCS	CS	ST
mid C - D	MS	VCS	VCS	VFG	ST
D	VFS	ST	MS	VFG	FS
mid D - E	ST	VFS	CS	CS	ST
E	ST	MG	MS	FG	ST
mid E - F	FG	FS	VCS	ST	CS
F	ST	VCS	MS	CS	MS
mid F - G	ST	MG	VCS	CS	MS
G	ST	FG	FS	VCS	ST
mid G - H	ST	MG	MG	FG	ST
H	ST	MG	FG	VCS	ST
mid H - I	ST	MG	MS	VFS	ST
I	ST	VCS	MG	FG	VFS
mid I - J	ST	ST	MS	MG	ST
J	ST	MG	FG	MG	FS
mid J - K	ST	FG	CG	ST	ST

PHAB-7 Pebble Count

Transect	Left	Left Center	Center	Right Center	Right
A	CS	MS	MS	CS	CS
mid A - B	FS	MS	MS	MS	CS
B	VFS	CS	CS	CS	VFS
mid B - C	MG	FG	CS	FG	MS
C	MG	CS	CS	CG	MG
mid C - D	CB	CS	CS	CS	CS
D	VFS	CS	MS	CS	FS
mid D - E	FS	MS	MG	MG	CS
E	MS	CS	CS	CG	CG
mid E - F	MS	MG	CS	VCS	ST
F	CS	CS	CS	FG	CG
mid F - G	CS	MS	MS	FS	ST
G	VCS	MG	CS	CS	MS
mid G - H	ST	CS	CS	MS	ST
H	SB	CS	CS	VCS	FG
mid H - I	VCS	CS	VCS	VCS	VFS
I	CS	MG	FG	CS	VFS
mid I - J	FS	CS	CS	VCS	VCS
J	CS	CS	CS	CS	VCS
mid J - K	ST	CS	CS	CS	MS
K	VFS	VCS	VCS	CS	VCS

PHAB-8 Pebble Count

Transect	Left	Left Center	Center	Right Center	Right
A	MS	MS	MS	MS	ST
mid A - B	FS	FS	MS	CS	ST
B	ST	MS	MS	FS	ST
mid B - C	ST	MS	CS	VCS	ST
C	ST	CS	CS	CS	ST
mid C - D	ST	CS	MS	VCS	ST
D	ST	CS	CS	CS	ST
mid D - E	ST	MS	CS	CS	MS
E	ST	MS	CS	MS	FS
mid E - F	MS	MS	MS	MS	ST
F	ST	ST	MS	CS	ST
mid F - G	CS	MS	VFS	MS	ST
G	ST	MS	MS	MS	ST
mid G - H	ST	MS	CS	MS	ST
H	ST	MS	CS	CS	VCS
mid H - I	ST	FS	VCS	FG	ST
I	FS	FG	VCS	CS	ST
mid I - J	ST	MS	MS	CS	ST
J	ST	MS	MS	CS	ST
mid J - K	ST	CS	FS	MS	ST
K	ST	MS	MS	CS	ST

PHAB-9 Pebble Count

Transect	Left	Left Center	Center	Right Center	Right
A	VFS	CS	CS	CS	MS
mid A - B	ST	CS	CS	CS	MS
B	VFS	VCG	CG	CS	FS
mid B - C	VFS	VCG	CG	CS	MS
C	VFS	VCG	CS	CS	VFS
mid C - D	CG	CB	MS	CG	FS
D	VCG	CB	MS	MS	VFS
mid D - E	CG	CG	CS	CB	MG
E	CB	CB	CB	CB	CB
mid E - F	CG	CG	CG	CG	FS
F	MS	MS	MS	VCG	FS
mid F - G	ST	CG	CS	CS	ST
G	MS	CS	CB	CB	MS
mid G - H	CS	MS	MS	MS	ST
H	ST	MS	MS	MS	VFS
mid H - I	ST	FG	MS	FS	ST
I	ST	VFS	CB	CB	ST
mid I - J	ST	CB	MG	MS	ST
J	ST	MG	CS	MS	MG
mid J - K	CB	VCG	VCG	MG	FS

PHAB-10 Pebble Count

Transect	Left	Left Center	Center	Right Center	Right
A	MS	CB	CB	CB	ST
mid A - B	ST	CS	VCS	BR	BR
B	MS	CB	LB	MS	BR
mid B - C	ST	VFG	CS	CS	MS
C	VCG	VCS	BR	BR	BR
mid C - D	SB	CS	SB	SB	CB
D	CB	CB	VCG	CB	CB
mid D - E	ST	VCG	CS	SB	ST
E	ST	CS	VFG	ST	ST
mid E - F	ST	CS	MS	MS	FS
F	VFS	MS	FS	CB	VFS
mid F - G	FS	FS	FS	FS	FS
G	ST	CS	CB	CB	ST
mid G - H	MB	COULDN'T MEASURE		MS	CB
H	ST	SB	LB	CB	ST
mid H - I	VFS	VCG	CS	FS	ST
I	VFS	CS	CS	VCS	ST
mid I - J	ST	CS	CB	CB	VFS
J	SB	ST	CB	LB	SB
mid J - K	FS	SB	CB	SB	ST
K	SB	CB	CS	SB	SB

PHAB-11 Pebble Count

Transect	Left	Left Center	Center	Right Center	Right
A	ST	FG	VCS	MS	FG
mid A - B	FVS	CB	SB	FS	SB
B	VFS	VCG	CB	MS	Missing
mid B - C	Missing	Missing	Missing	Missing	Missing
C	VFS	CB	CB	CB	Missing
mid C - D	FS	CS	CB	CS	FS
D	VFS	CB	MG	FS	ST
mid D - E	FS	CS	CS	CS	FS
E	ST	VFS	MS	CS	FS
mid E - F	FS	MS	CS	CS	FS
F	VFS	CS	CS	CS	ST
mid F - G	CB	CB	MS	CS	MS
G	FS	CS	CB	CS	SB
mid G - H	LB	SB	CB	CB	CS
H	ST	SB	CS	CS	ST
mid H - I	FS	SB	FG	CB	FS
I	MS	SB	SB	SB	SB
mid I - J	MS	CS	CB	CB	MB
J	ST	SB	SB	SB	SB
mid J - K	MS	MB	CB	CB	CS
K	ST	CS	SB	SB	ST

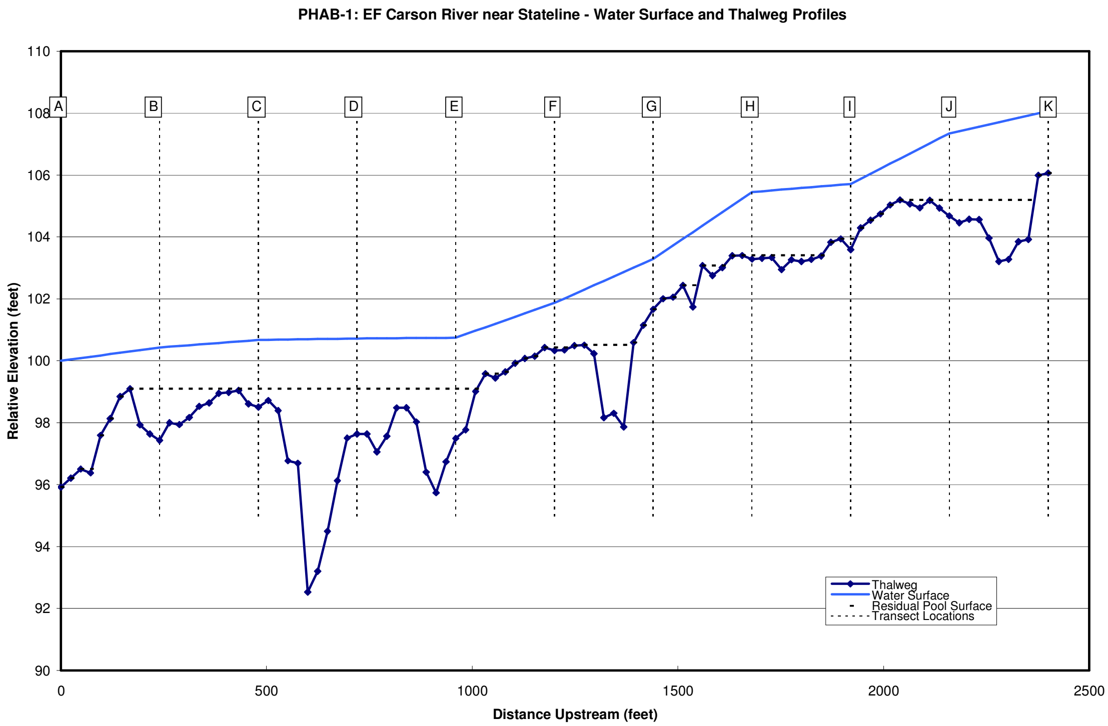
PHAB-12 Pebble Count

Transect	Left	Left Center	Center	Right Center	Right
A	ST	MS	FG	FG	ST
mid A - B	ST	FG	CS	VCS	FS
B	ST	CG	CS	FS	ST
mid B - C	CS	CS	CG	CG	VCS
C	MG	ST	VCG	VCS	MG
mid C - D	CB	CG	CG	CS	VCS
D	ST	CS	CS	MS	MG
mid D - E	VFS	VCS	VCS	VCS	MG
E	ST	VCS	VFG	VFG	MG
mid E - F	ST	VFG	VCS	MS	FS
F	MG	MS	VCS	VCS	FS
mid F - G	CS	FS	CS	CS	FS
G	CG	ST	CS	VCS	ST
mid G - H	ST	MS	MG	MS	ST
H	VCS	ST	MS	FS	ST
mid H - I	ST	CB	CS	concrete slab	ST
I	SB	FG	FG	CS	CS
mid I - J	ST	VCG	CG	FG	VCG
J	SB	VCS	MS	MS	MS
mid J - K	ST	MS	FG	MS	MS

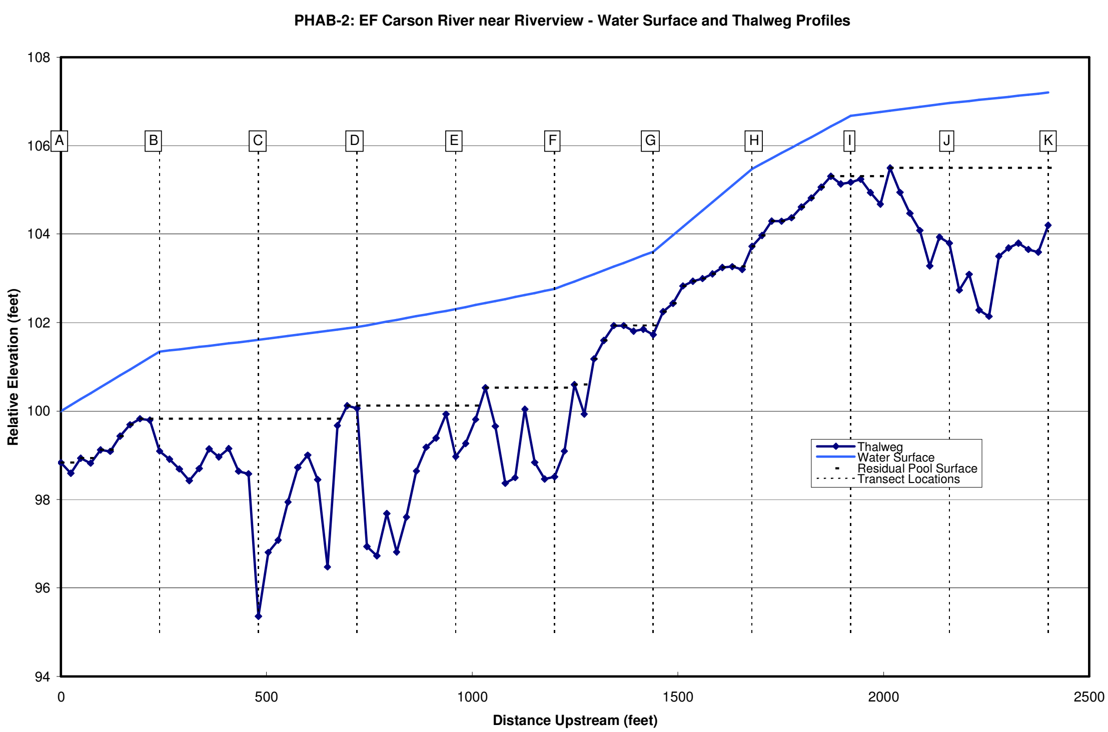
PHAB-13 Pebble Count

Transect	Left	Left Center	Center	Right Center	Right
A	ST	MS	MS	VCS	VFS
mid A - B	MS	MS	MS	MS	ST
B	ST	CS	FG	MS	FS
mid B - C	CS	CS	CS	VCS	ST
C	CG	MS	MS	MS	TOO DEEP
mid C - D	CG	VCS	CS	CS	ST
D	FS	FS	FS	MS	CS
mid D - E	CS	VCS	MS	VCG	ST
E	ST	VCS	VCS	MG	CS
mid E - F	VFG	CS	CS	VCS	ST
F	ST	VFS	ST	MS	TOO DEEP
mid F - G	MS	CS	CS	CS	FS
G	CS	MS	CS	ST	FS
mid G - H	MS	MS	MS	VCS	FS
H	FS	FS	CS	CS	FS
mid H - I	FS	CS	CS	FG	MS
I	FS	FS	CS	FS	MS
mid I - J	FS	VCS	MS	CS	ST
J	CS	CS	MS	MS	ST
mid J - K	CS	CS	CS	CS	FS
K	CS	MS	MS	CS	ST

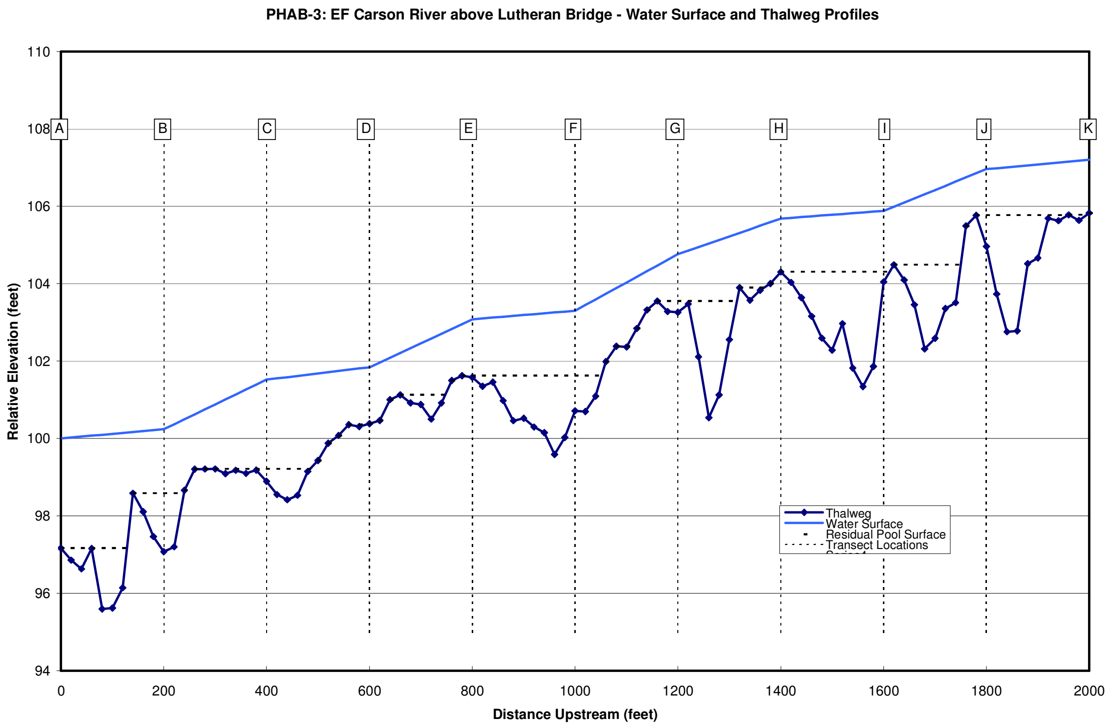
APPENDIX C – Thalweg and Water Profiles at PHAB Survey Sites

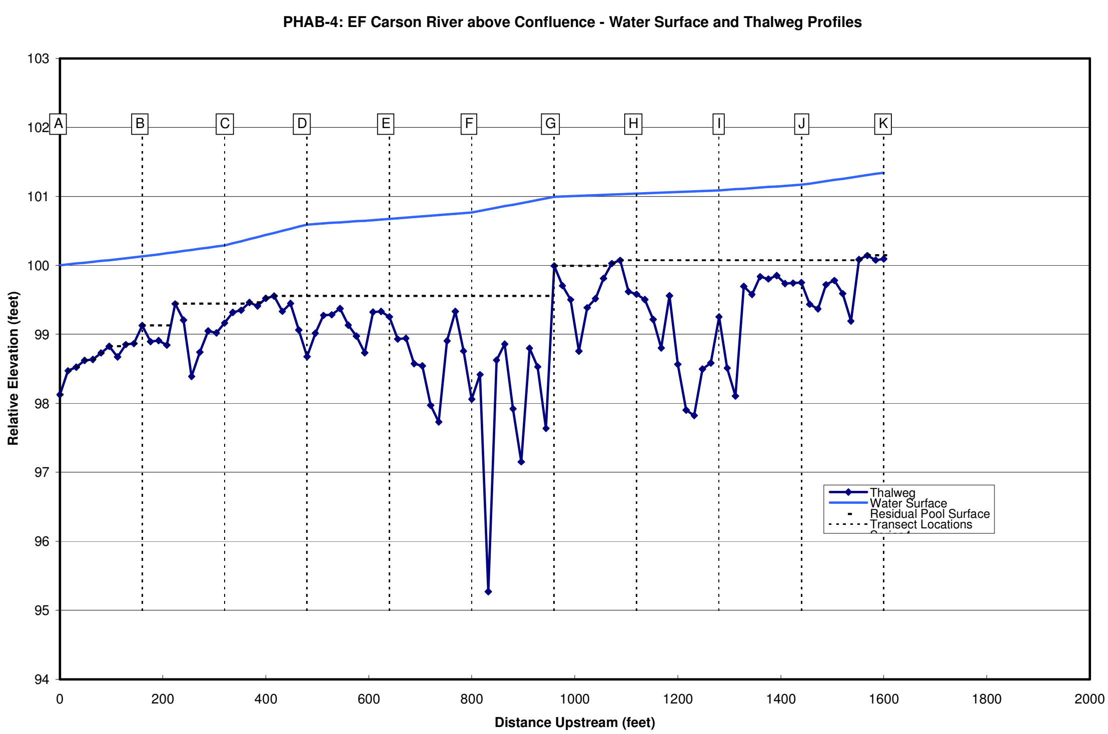


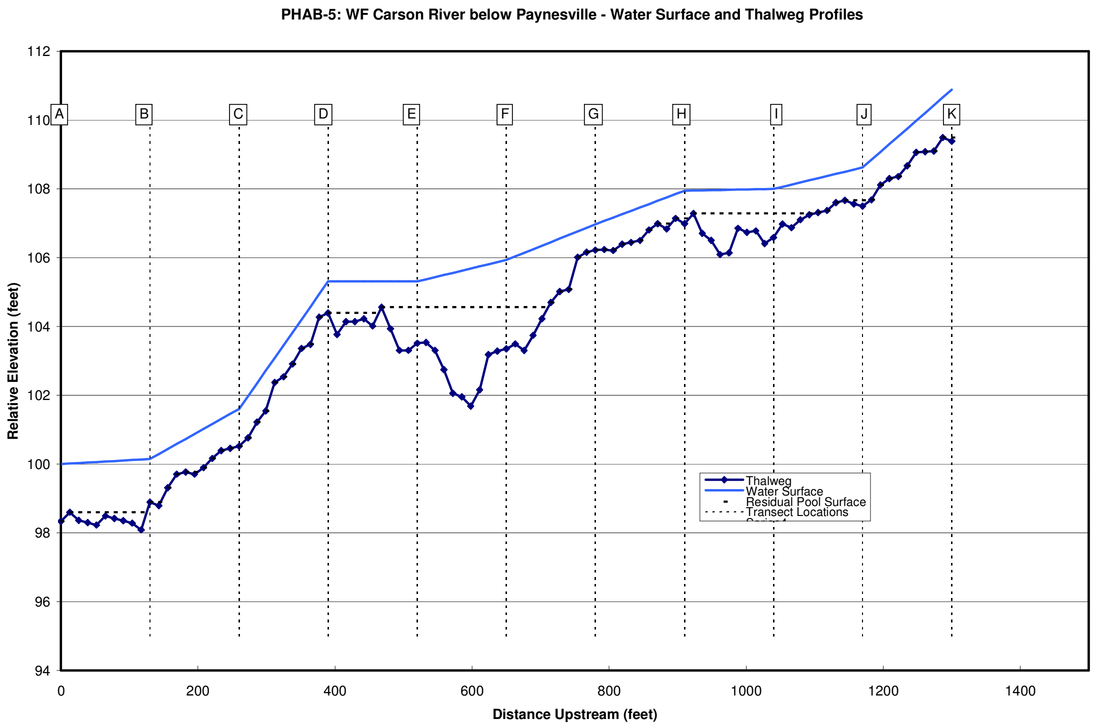
PHAB-1: EF Carson River near Stateline - Water Surface and Thalweg Profiles
Relative Elevation (feet)
Distance Upstream (feet)
A
B
C
D
E
F
G
H
I
J
K
Thalweg
Water Surface
Residual Pool Surface
Transect Locations
110
108
106
104
102
100
98
96
94
92
90
0
500
1000
1500
2000
2500

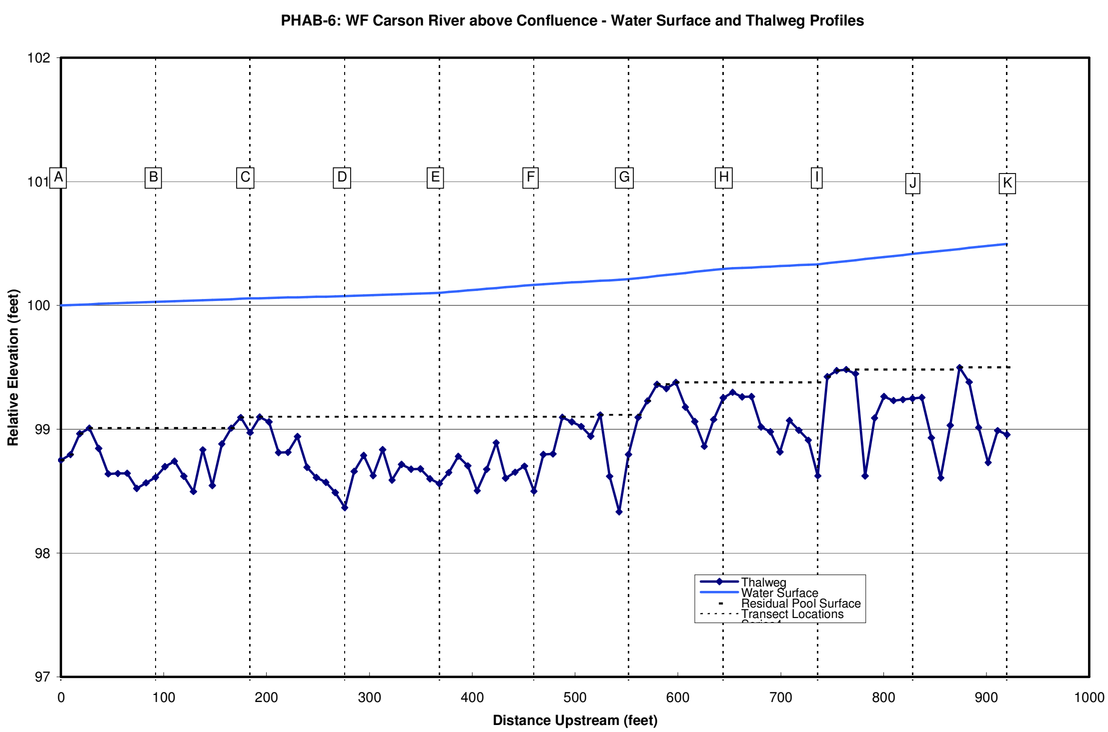


PHAB-2: EF Carson River near Riverview - Water Surface and Thalweg Profiles
Relative Elevation (feet)
Distance Upstream (feet)
A
B
C
D
E
F
G
H
I
J
K
Thalweg
Water Surface
Residual Pool Surface
Transect Locations
108
106
104
102
100
98
96
94
0
500
1000
1500
2000
2500

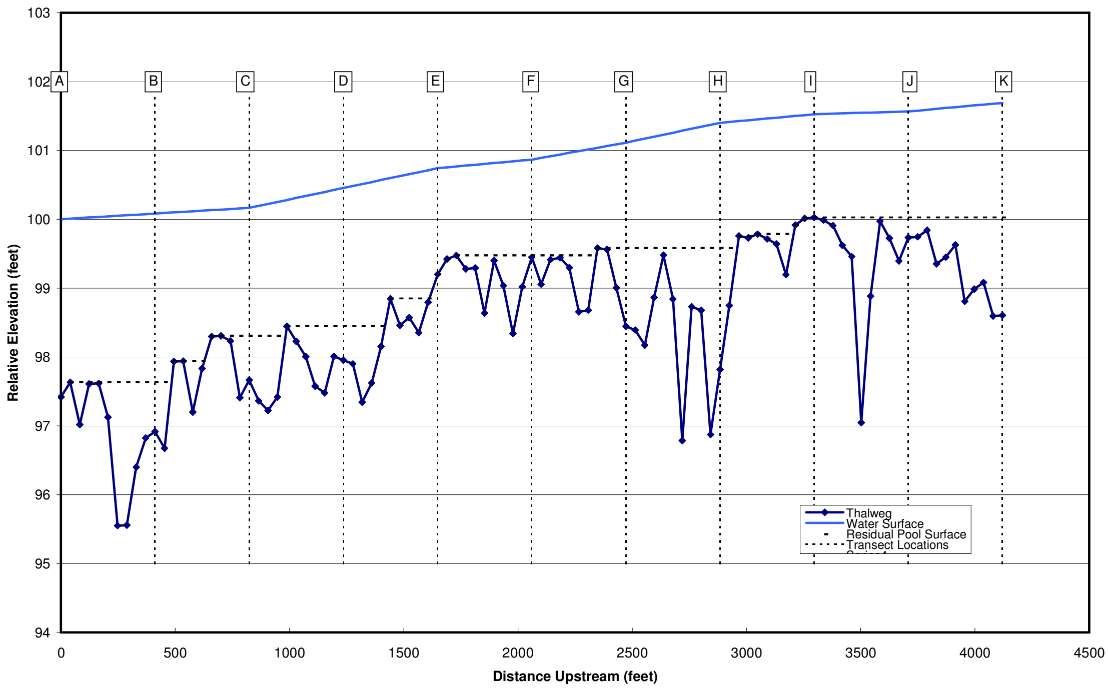

PHAB-3: EF Carson River above Lutheran Bridge - Water Surface and Thalweg Profiles
Relative Elevation (feet)
Distance Upstream (feet)
A
B
C
D
E
F
G
H
I
J
K
Thalweg
Water Surface
Residual Pool Surface
Transect Locations


PHAB-4: EF Carson River above Confluence - Water Surface and Thalweg Profiles
Relative Elevation (feet)
Distance Upstream (feet)
A
B
C
D
E
F
G
H
I
J
K
Thalweg
Water Surface
Residual Pool Surface
Transect Locations

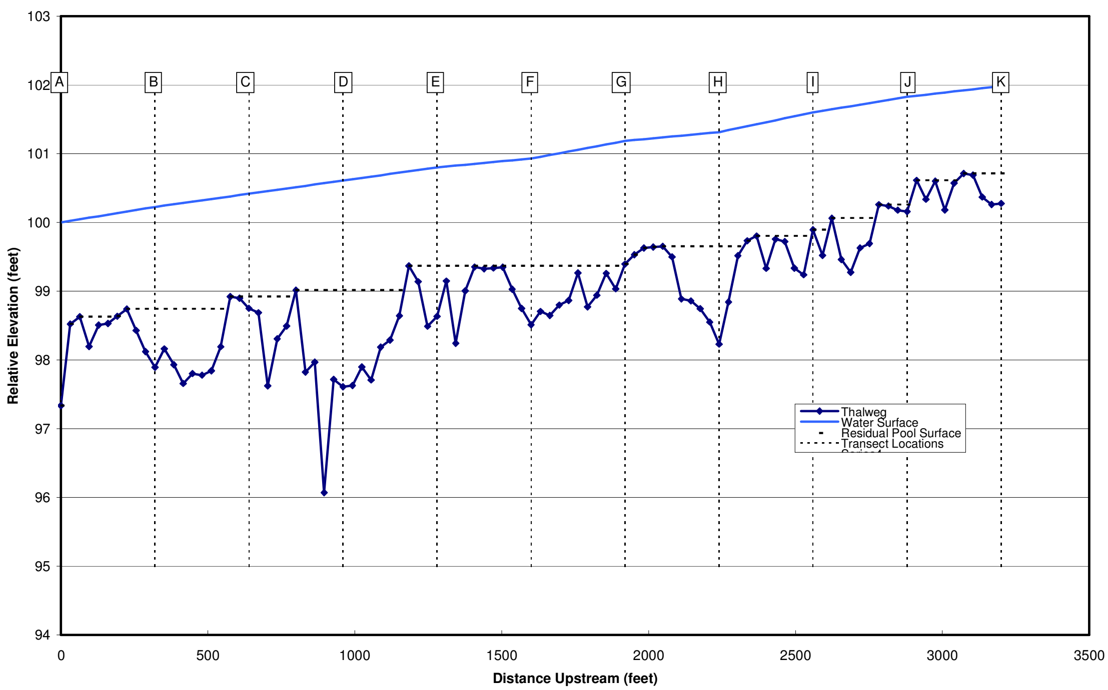

PHAB-5: WF Carson River below Paynesville - Water Surface and Thalweg Profiles
Relative Elevation (feet)
Distance Upstream (feet)
A
B
C
D
E
F
G
H
I
J
K
Thalweg
Water Surface
Residual Pool Surface
Transect Locations


PHAB-6: WF Carson River above Confluence - Water Surface and Thalweg Profiles
Relative Elevation (feet)
Distance Upstream (feet)
A
B
C
D
E
F
G
H
I
J
K
Thalweg
Water Surface
Residual Pool Surface
Transect Locations

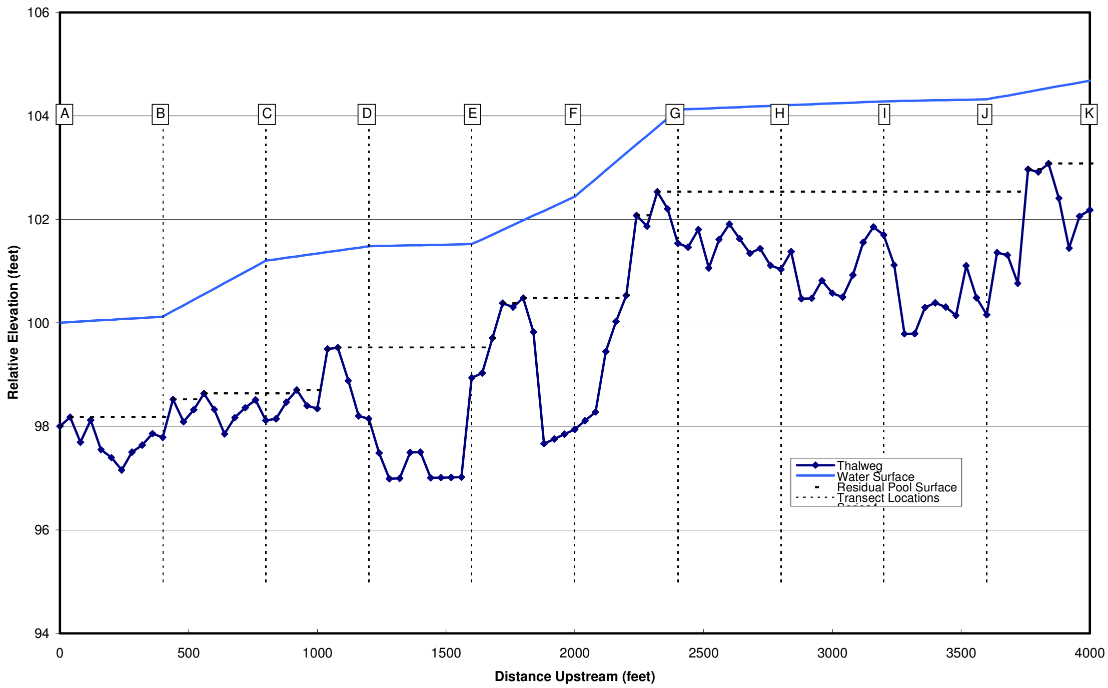
PHAB-7: Carson River above Cradlebaugh Bridge - Water Surface and Thalweg Profiles



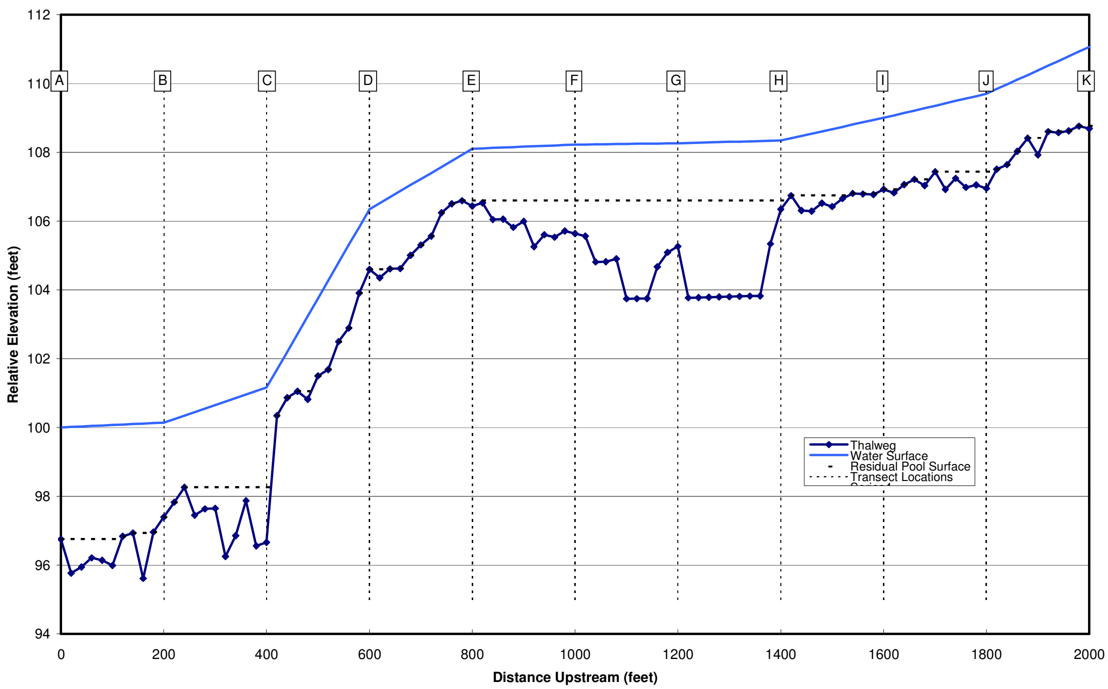
PHAB-8: Carson River above Mexican Gage - Water Surface and Thalweg Profiles

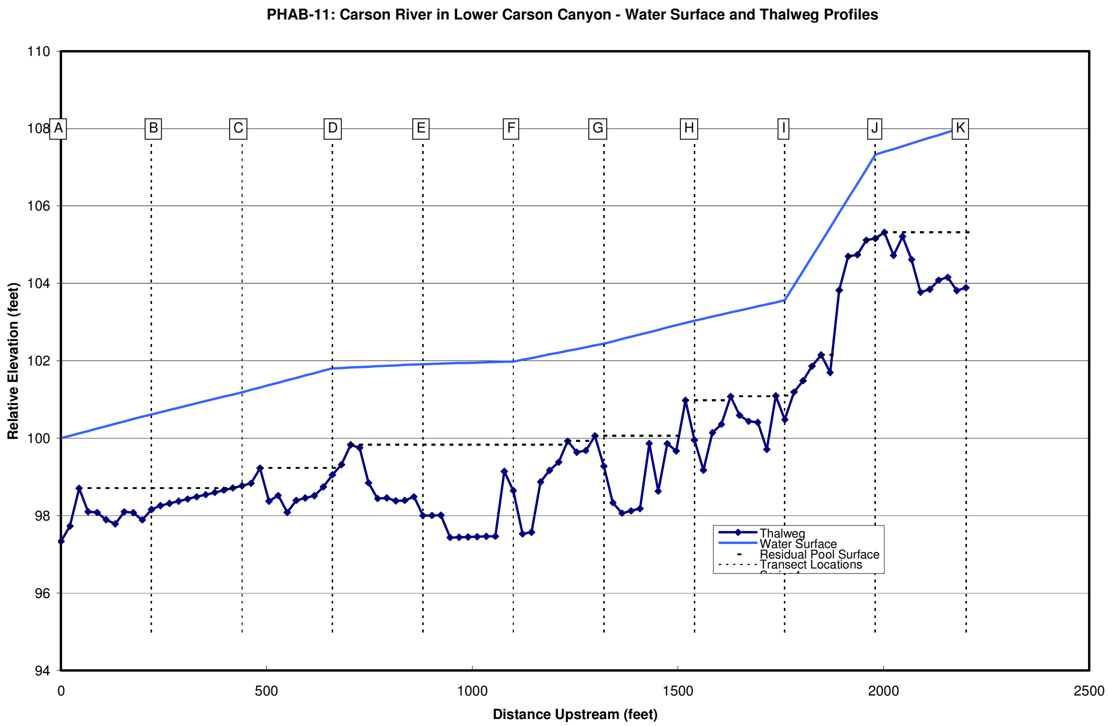


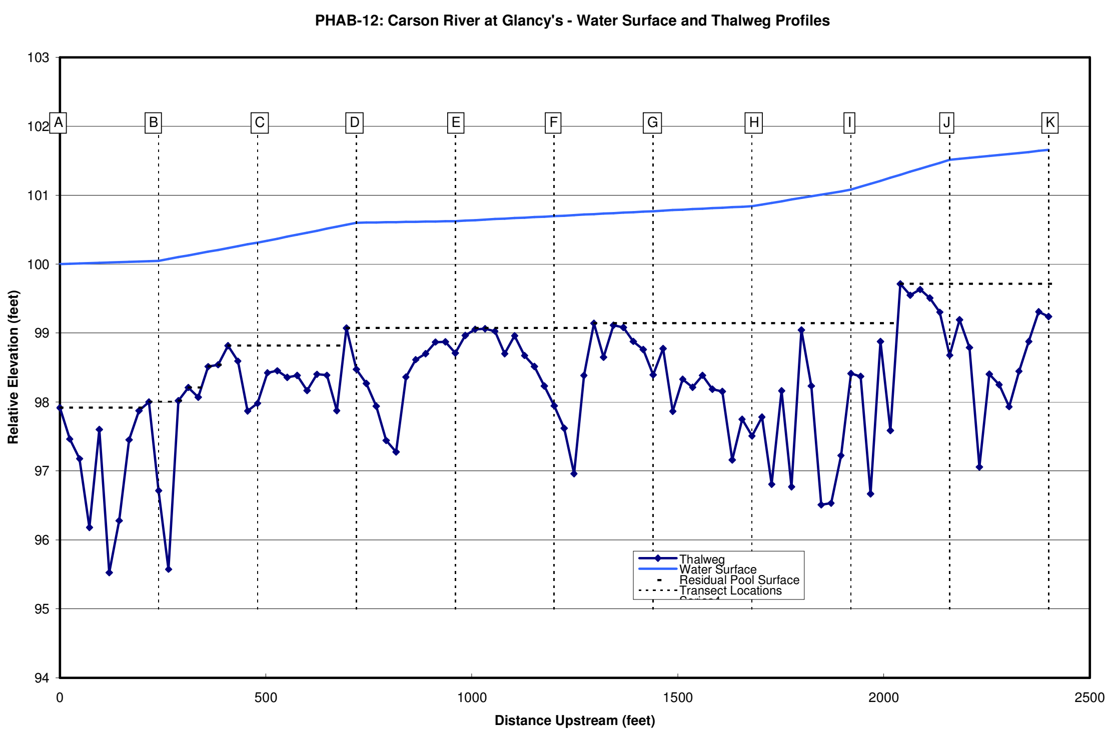
PHAB-9: Carson River above Lloyd's Bridge - Water Surface and Thalweg Profiles



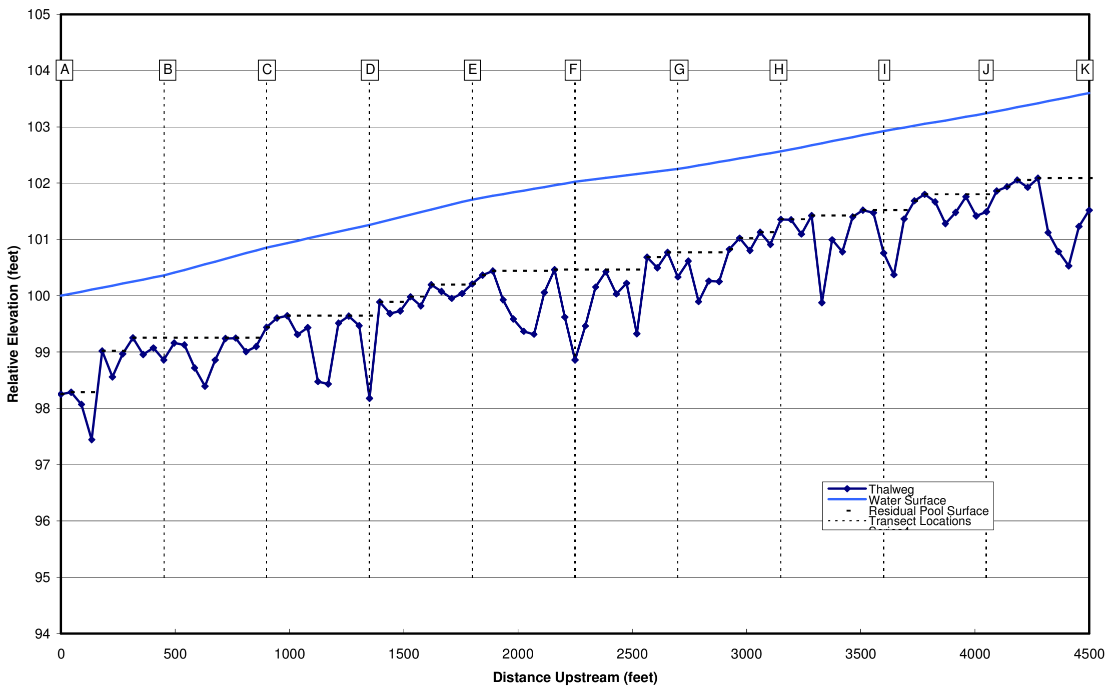
PHAB-10: Carson River in Upper Carson Canyon - Water Surface and Thalweg Profiles




PHAB-11: Carson River in Lower Carson Canyon - Water Surface and Thalweg Profiles
Relative Elevation (feet)
Distance Upstream (feet)
A
B
C
D
E
F
G
H
I
J
K
Thalweg
Water Surface
Residual Pool Surface
Transect Locations

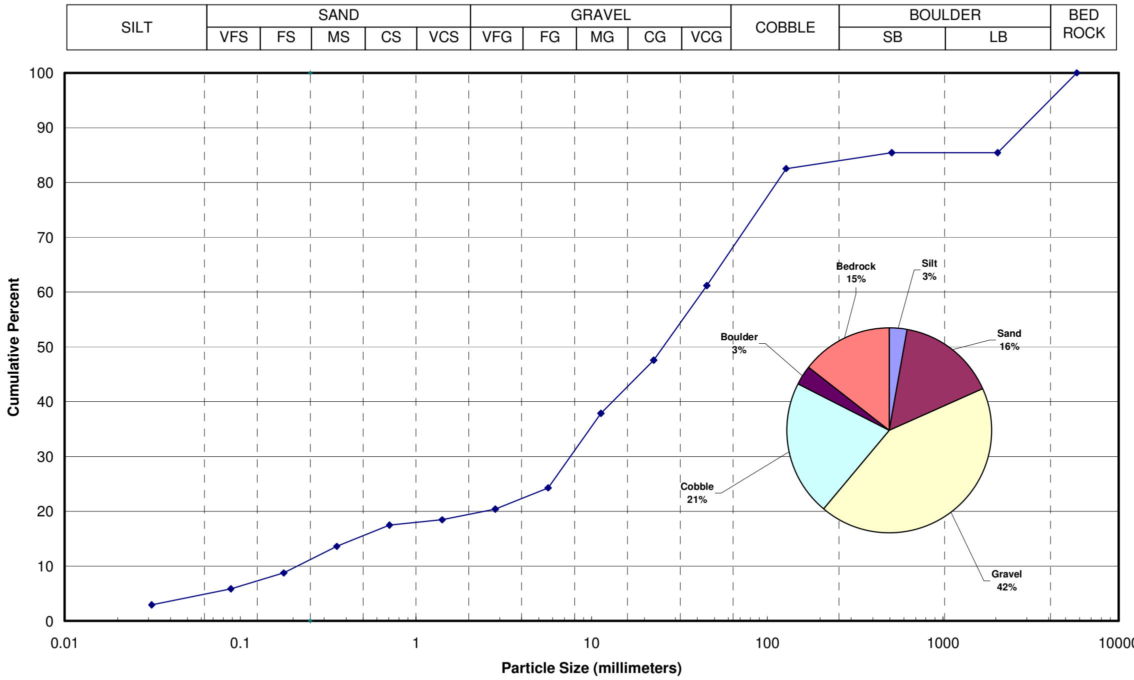

PHAB-12: Carson River at Glancy's - Water Surface and Thalweg Profiles
Relative Elevation (feet)
Distance Upstream (feet)
A
B
C
D
E
F
G
H
I
J
K
Thalweg
Water Surface
Residual Pool Surface
Transect Locations

PHAB-13: Carson River below Weeks Bridge - Water Surface and Thalweg Profiles

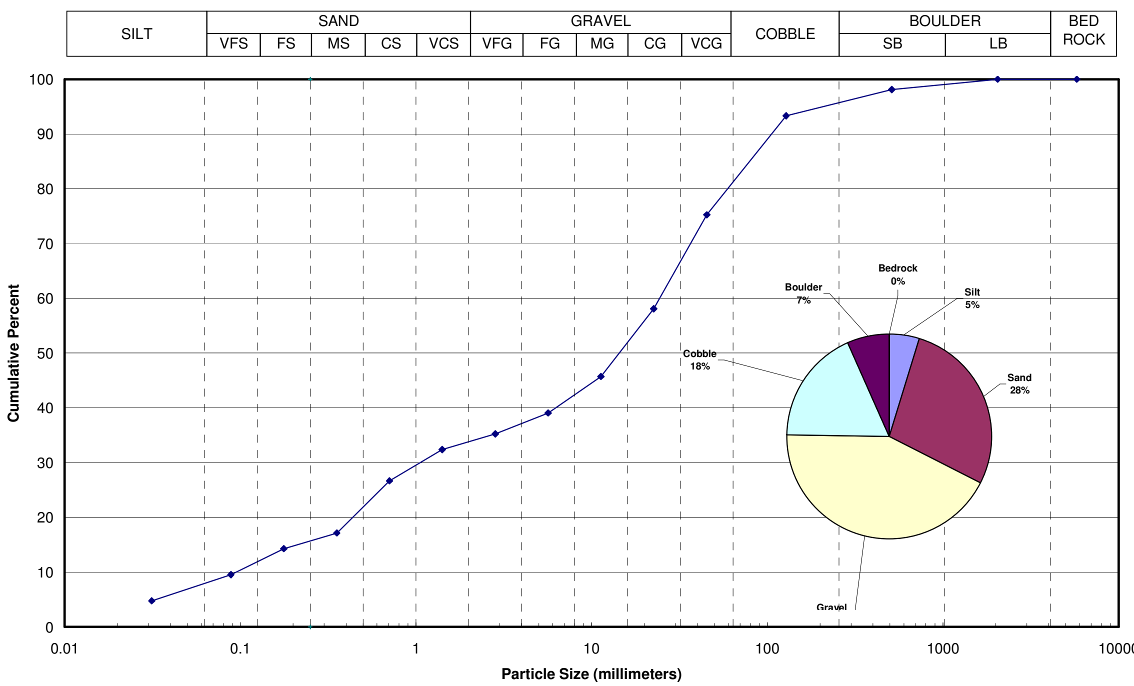


APPENDIX D – Substrate Particle Distribution Graphs for PHAB Survey Sites

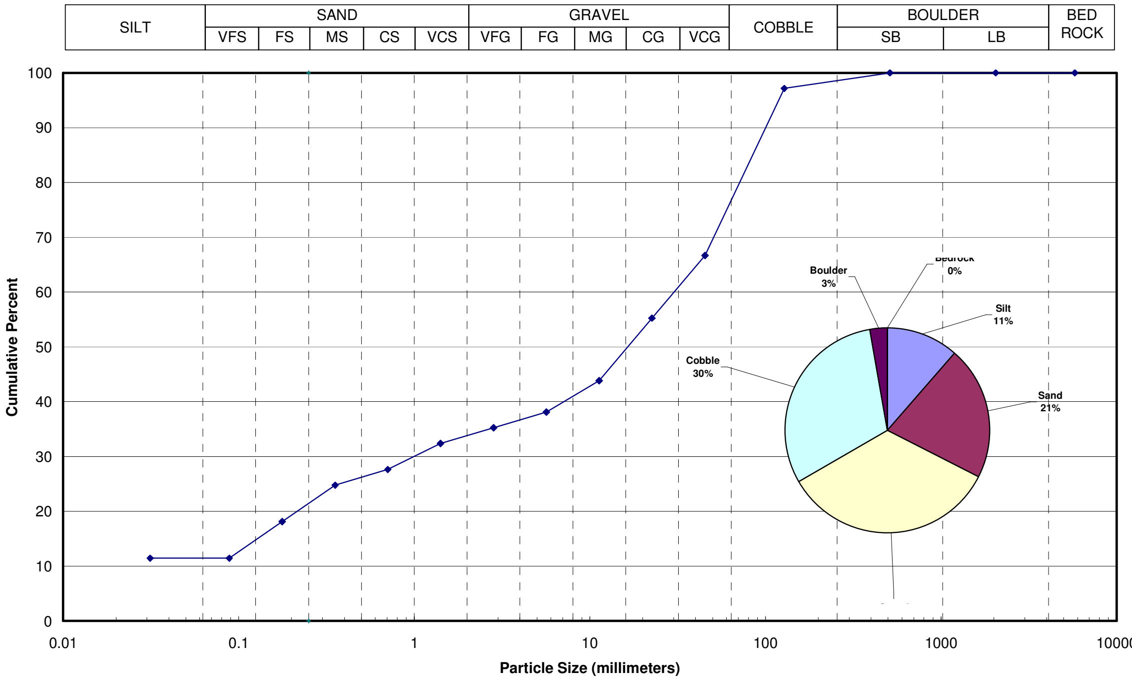
PHAB-1: EF Carson River near Stateline - Substrate Particle Distribution



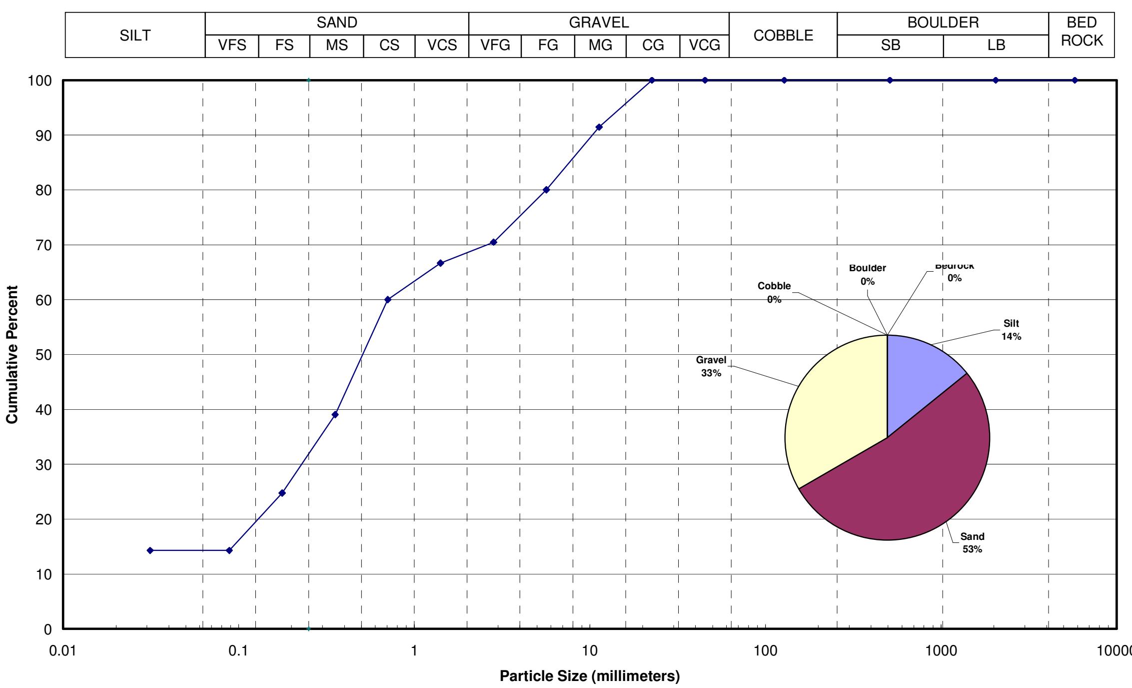
PHAB-2: EF Carson River above Riverview - Substrate Particle Distribution



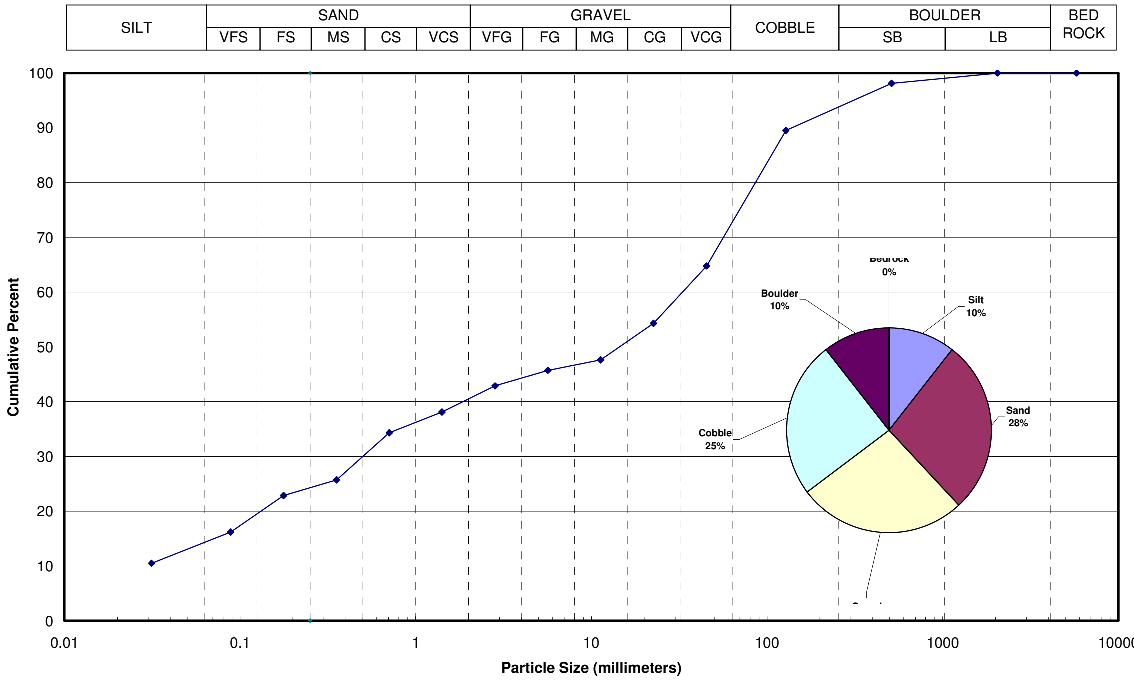
PHAB-3: EF Carson River above Lutheran Bridge - Subtrate Particle Distribution



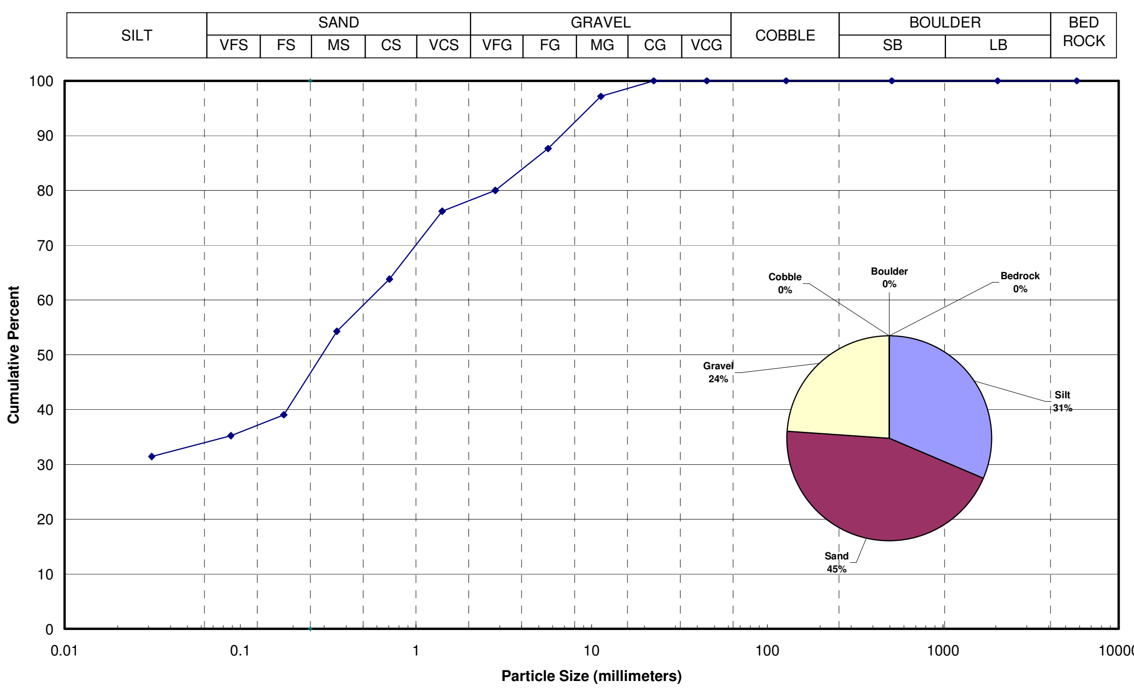
PHAB-4: EF Carson River above Confluence - Substrate Particle Distribution



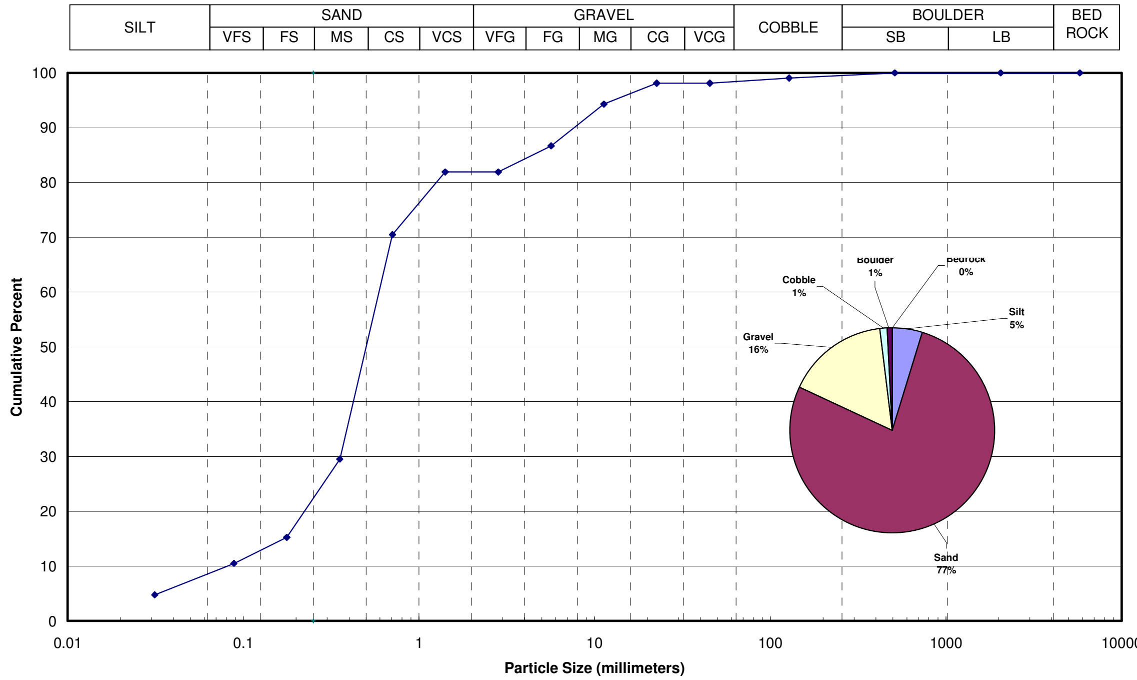
PHAB-5: WF Carson River below Paynesville - Particle Size Distribution



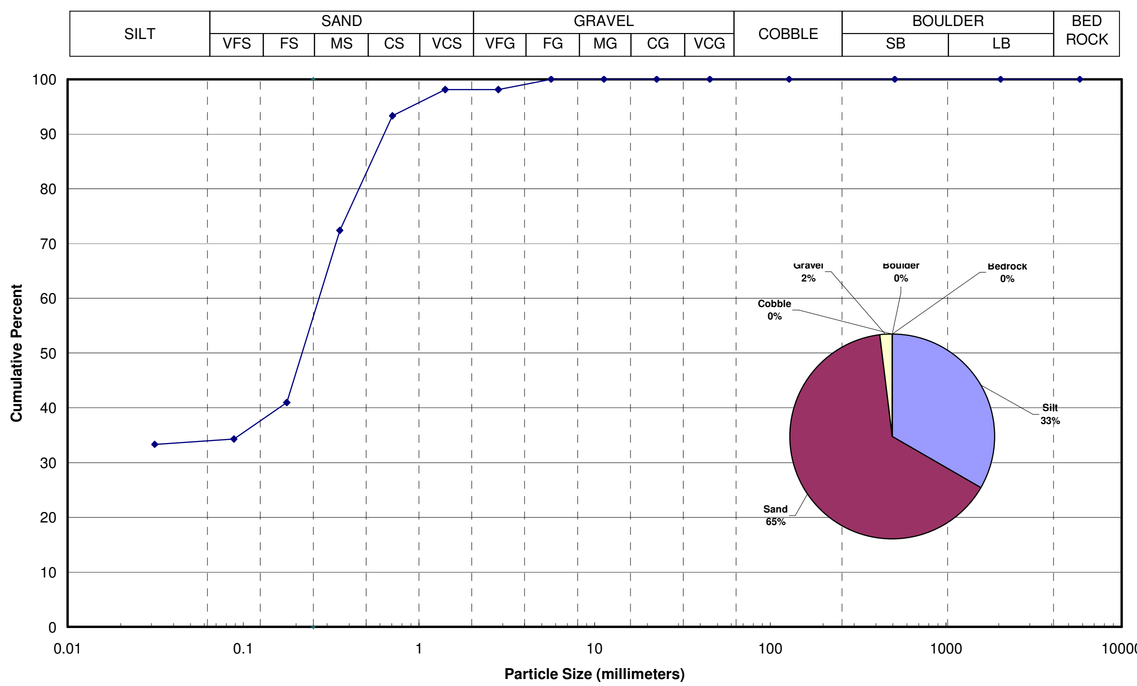
PHAB-6: WF Carson River above Confluence - Substrate Particle Distribution



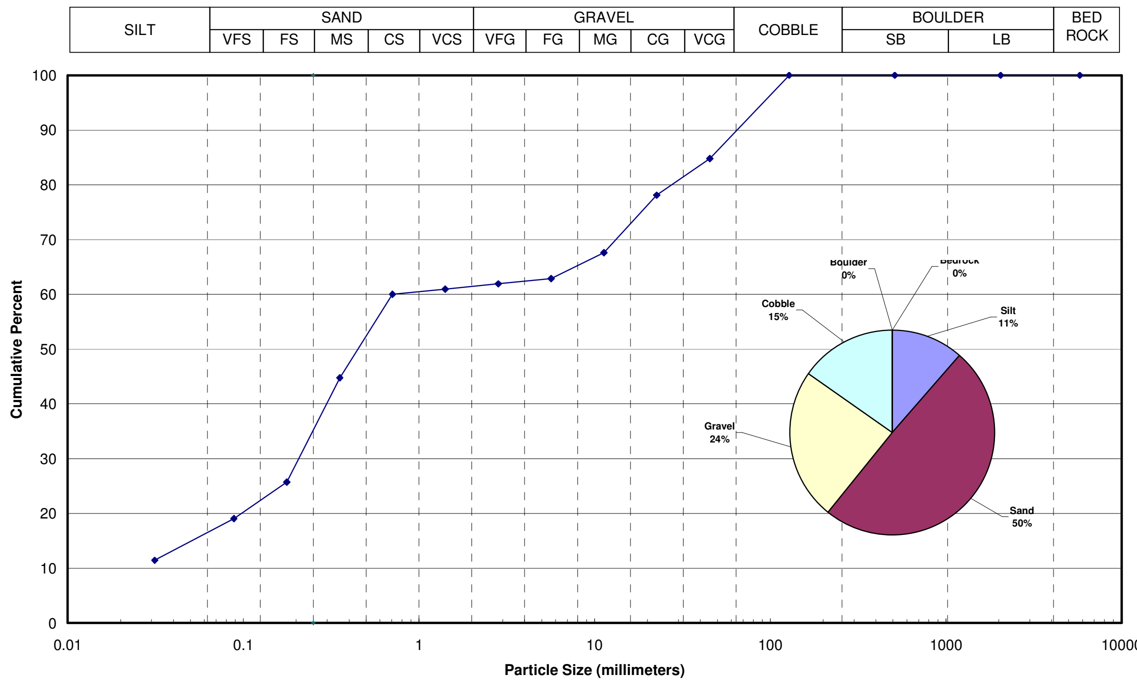
PHAB-7: Carson River above Cradlebaugh Bridge - Substrate Particle Distribution



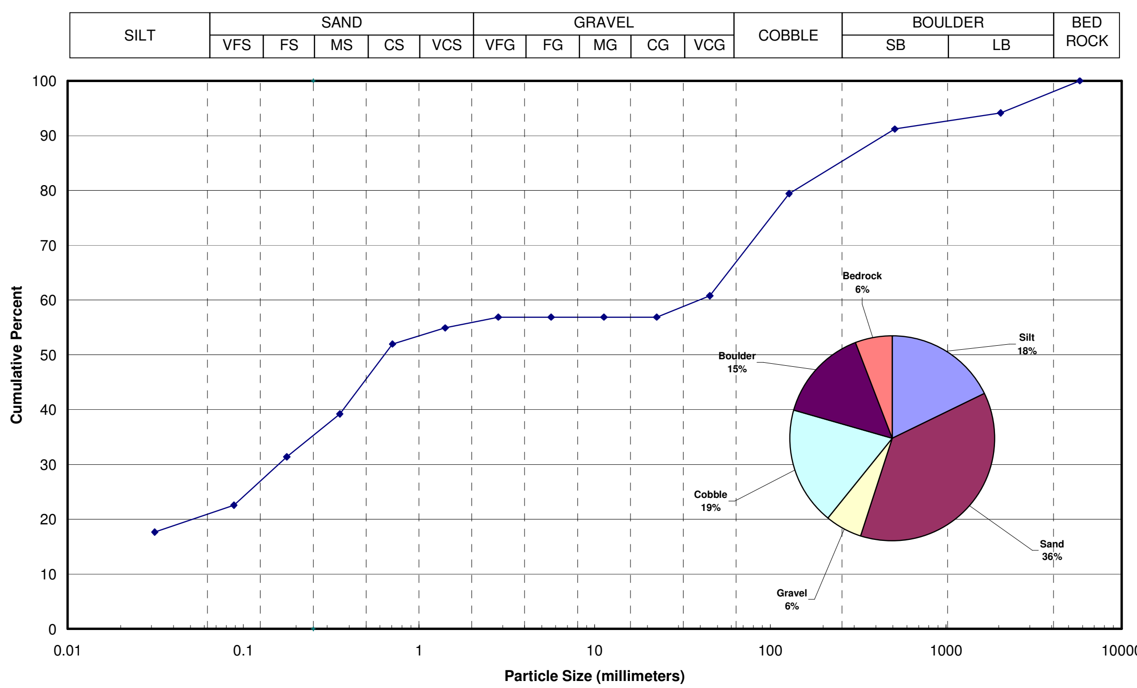
PHAB-8: Carson River above Mexican Gage - Substrate Particle Distribution



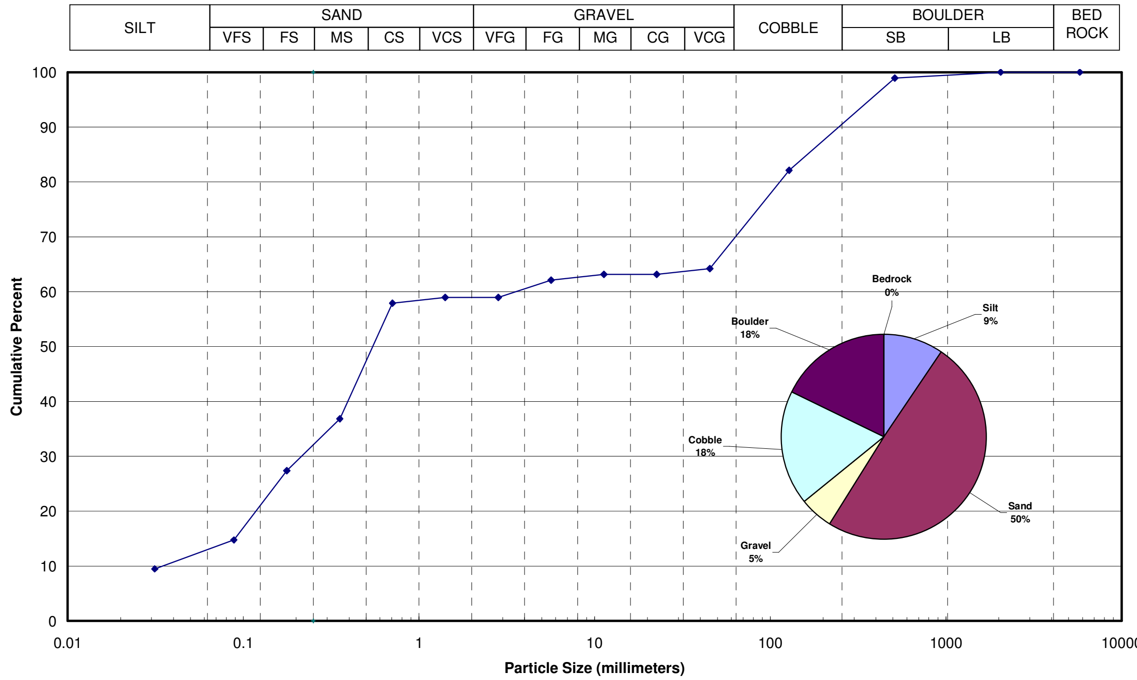
PHAB-9: Carson River above Lloyd's Bridge - Substrate Particle Distribution



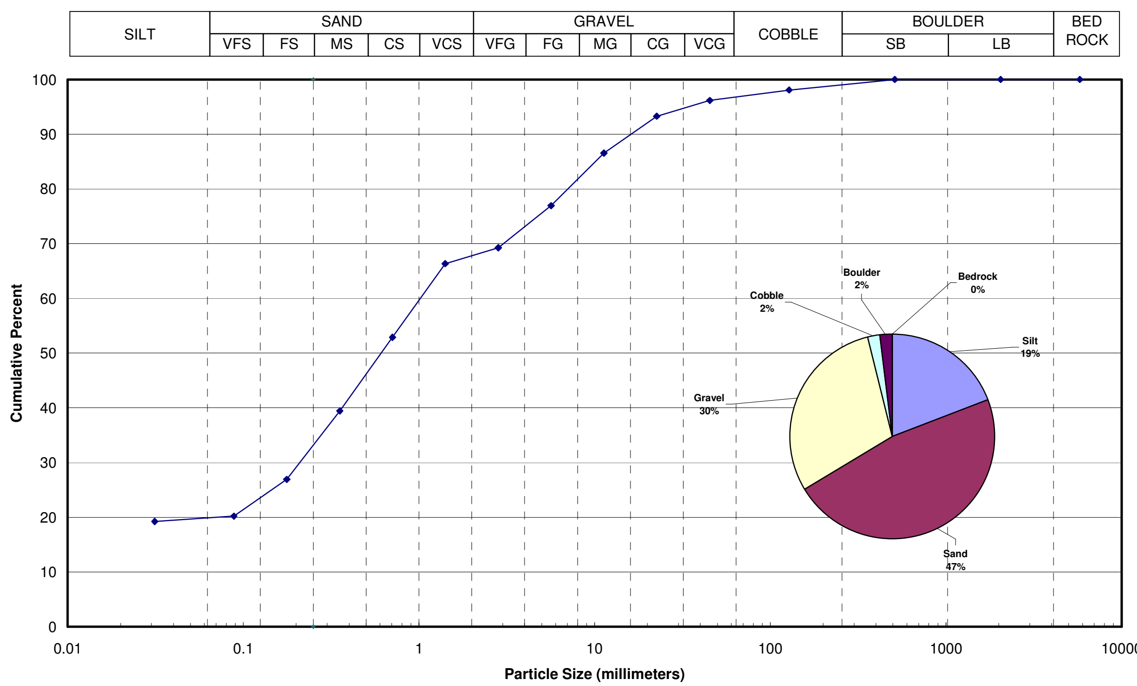
PHAB-10: Carson River in Upper Carson Canyon - Substrate Particle Distribution



PHAB-11: Carson River in Lower Carson Canyon - Substrate Particle Distribution



PHAB-12: Carson River at Glancy's - Substrate Particle Distribution



PHAB-13: Carson River below Weeks Bridge - Substrate Particle Distribution