TRENDS IN SUBSTRATE COMPOSITION OF THE TRINITY RIVER, 1991-2009

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January 2010

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INTRODUCTION

In 2000, the Trinity River Restoration Program (TRRP) contracted with Graham Matthews and Associates (GMA) to conduct an investigation of spawning gravels on the mainstem Trinity River between the Lewiston Dam and the North Fork Trinity River. The focus of the project was to formally investigate the quality of salmon spawning gravel on the Trinity River, a critical habitat which lays the foundation for salmon runs (GMA 2003). The objectives were to:

(a) Establish baseline substrate composition and permeability conditions for long-term trend monitoring in the Trinity River and tributaries.
(b) Assess the relationship between substrate composition and permeability.
(c) Evaluate the longitudinal changes to gravel quality along the mainstem Trinity River to assess the influence of tributary derived sediments.
(d) Estimate survival rate of eggs to fry emergence for chinook salmon along the mainstem Trinity River.

The result was a set of baseline permeability and substrate data representing a system which could support suitable survival to fry emergence in most reaches. The notable exception was immediately downstream of Grass Valley Creek represented by a Poker Bar site with a high percentage of fines and exhibiting less than 20% survival rates.

In 2009, TRRP contracted with GMA to revisit seven of the eight sites and two additional sites which were first bulk sampled in 1991 by Trinity Restoration Associates (TRA 1993) and again in 2001 by McBain and Trush, Inc. (personal contact). Three sites were added upstream of Rush Creek to examine spawning habitat criteria and one site was added near the Old Lewiston Bridge.

OBJECTIVES

The objectives this year were to revisit the 2000 study sites, repeat the sampling and identify changes and trends to spawning gravel quality after 10 years of restoration and high flows.

STUDY SITES

Seven of the eight study sites from the 2000 study were revisited. They had been selected to: 1) represent river sections below key tributaries; 2) sample known spawning areas identified on aerial photos in 1999 by Jay Glase (USFWS) and Scott McBain (McBain and Trush) and/or used by chinook spawners during fall, 2000; and 3) permit access for sampling equipment and removal of substrate for lab treatment. The latter depended on areas where there was public land access (BLM or USFS) or where private landowners allowed admittance.

In 2000, sample cross sections were selected which exhibited good spawning characteristics and had spawning redds nearby but which were not themselves disturbed by spawning, that is, areas which fish would, but had not yet, selected to spawn. The cross sections were marked with rebar endpins but not tied to real world coordinates except as they were “eyeballed” on aerial photographs. Thus relocating them in 2009 was the first priority. In most cases, neither of the endpins were located and in some cases, the spawning habitat had shifted and therefore had to be adjusted to be appropriate for sampling.

The study sites established in 2000 and updated in 2009 (Figure 1) were:
<u>LEWISTON RM 111.5</u>

This run is on an existing cross section, 2500' downstream of the Lewiston Dam was discarded as being unrepresentative.

RUSH CREEK RM 107.4

Approximately 900' downstream of the Rush Creek confluence, this riffle exhibited numerous spawning redds. Since the delta deposit downstream of Rush Creek underwent a major change when the main river flow shifted left and broke through the levee separating it from a secondary channel in 2005 (?), this cross section was moved slightly but still is at the downstream end of the deposition. Neither of the original endpins were located but new ones were established.

POKER BAR RM 102.7

This was a site recovered from the Wilcock et al (1995) flushing flow study. This run is 2000' upstream from the Poker Bar Bridge. The left bank rebar endpin was located but not the right bank.

STEELBRIDGE RM 98.95

Near the downstream end of the BLM campground and on the right bank side of a mi-channel island, this shallow run is heavily spawned most years. We recovered a cross section and bulk sampling locations established for a flushing flow study (Wilcock et al. 1995) which used similar methods. Neither of the rebar endpins were relocated so the cross section was slightly adjusted to an old staff gage fencepost on the left side of the channel.

INDIAN CREEK RM 95.3

Approximately 300' downstream of the mouth of Indian Creek, the cross section was newly established on a pool tail/riffle crest with several redds nearby. Neither rebar endpin was relocated so two new endpins were established.

STEINER FLAT RM 91.95

This site was established as a study site for a channel maintenance flow study and subsequently underwent bank restoration (feather edging) in 1993 and as such has been heavily investigated by various entities. We recovered an existing uniformly shallow cross section (#1+45) in an area with several redds. The left bank endpin was relocated for the 2009 effort and a new right bank pin was established.

EVANS BAR (BELL GULCH) RM 84.1

This is a long run with a coarse gravel/cobble bed at another bank restoration site. Neither of the old endpins was recovered so we established two new rebar endpins. Dolomite scour cores were not established at this site.

JUNCTION CITY RM 80.3

Upstream 3900' from the Douglas City Bridge, this was a riffle crest with suitable spawning characteristics. The left bank endpin was relocated and a new right bank endpin was established.

Six additional sites were added to the 2009 study:

STEINER FLAT RM 91.7

This site is downstream of Steiner Flat XS 91.95 and a deep bedrock pool and was. The upper and lower right bank rebar endpins were located, although the bank has eroded and the lower rebar is mostly exposed. A new left bank rebar was established.

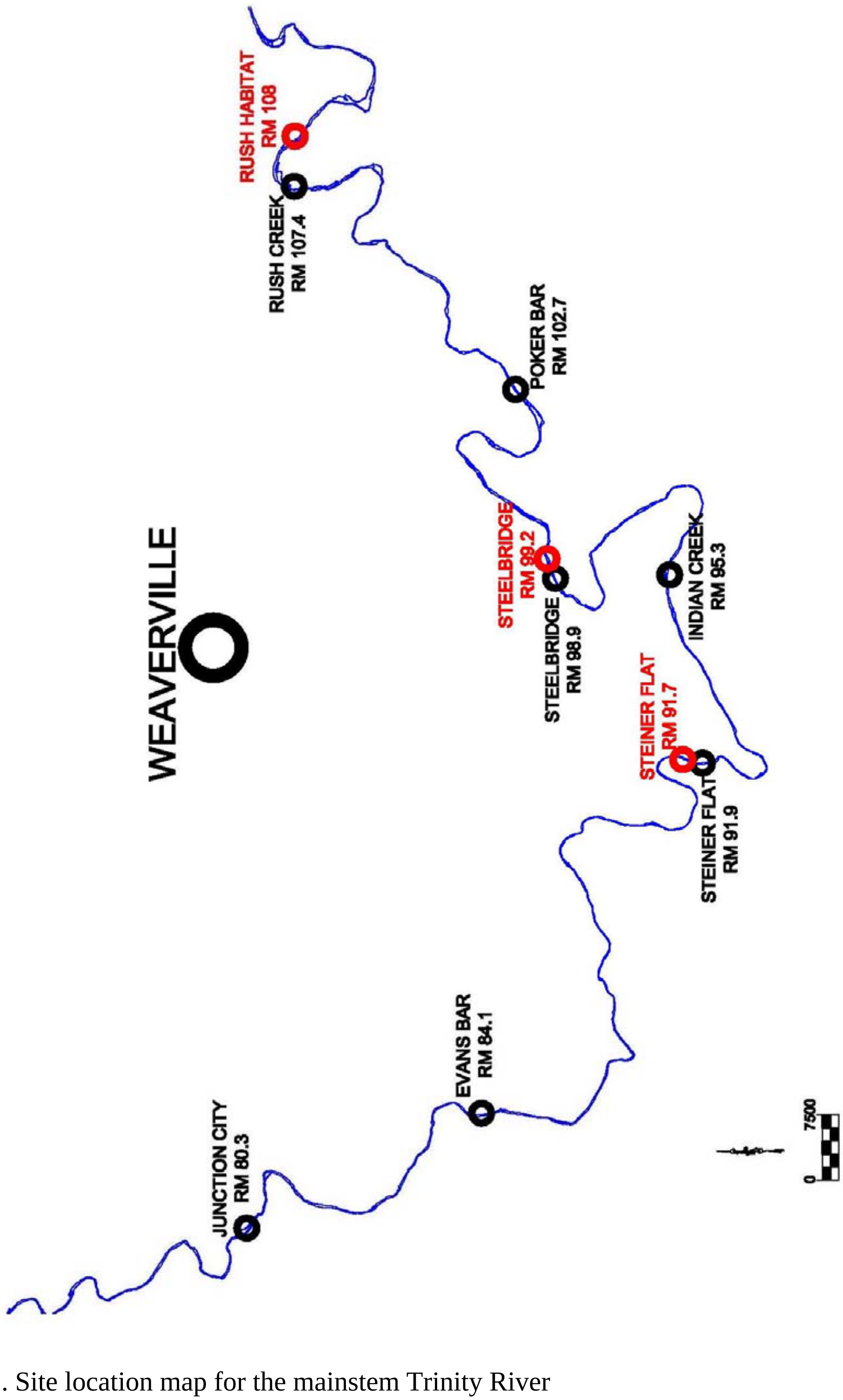


Figure 1. Site location map for the mainstem Trinity River

STEELBRIDGE RM 99.2

This site is another originally established and bulk sampled by Trinity Associates (TRA 1993) in 1991 for a channel maintenance study and then resampled by McBain and Trush in 2001 (personal correspondence). It is upstream of Steelbridge RM 98.95 and upstream of the Steelbridge Campground. Both right and left bank endpins from one of the original cross sections were recovered. No pebble count and no scour cores were conducted at this site.

RUSH CREEK HABITAT RM 108

Three new sites were established in 2009 in a well-spawned run adjacent to the Rush Creek RV Park after discussion with USFWS, Yurok, and McBain and Trush personnel. Each of the three was a polygon representing one of three categories of spawning habitat based on the substrate component of the habitat suitability criteria for Chinook adult spawning (personal communication) and actual spawning use during 2008 (and 2009):

1) Meets habitat criteria and is used for spawning
2) Meets habitat criteria and is not used for spawning
3) Does not meet habitat criteria and is used for spawning.

Three bulk samples and six permeability samples were taken from each polygon. No pebble counts or surveys were conducted.

OLD LEWISTON BRIDGE RM 110

This was an existing cross section at the gage house just downstream of the Old Lewiston Bridge. TRRP requested that GMA take a single bulk sample on a mid-channel bar on the cross section. No pebble count, permeability samples or surveys were conducted at this site.

METHODS

Sampling methods were essentially identical to the 2001 study except three bulk samples and associated permeability samples were taken rather than the original two in order to better represent the full cross section and better analyze site variability and cross section surveys were conducted with real world coordinates.

Once a site was selected, a cross section was established using 5/8” rebar on each bank as endpins. A measuring tape was strung between endpins with station 0 on the left bank and all further sampling at the site was referenced to the tape. A cross section was measured with a total station or survey grade GPS system referenced to the NAD83 California State Plane, Zone 1 horizontal datum and NAVD88 vertical datum in US survey feet. All major slope breaks and points at least every five feet were surveyed. Pre-existing cross sections were used where they coincided with the spawning areas in order to allow comparisons with previous studies. Prospective bulk sampling locations were identified during this stage (Appendix A).

Surface particle counts were conducted generally between the bulk sample locations following methods described by Wolman (1954). Each of the 100+ particles for each count were measured using a “gravelometer” template with square openings representing phi and half phi sieve sizes which closely duplicates standard sieving methods

Intragravel permeability was measured at fifteen locations along or adjacent to each cross section using a modified Terhune (1958) method with a backpack electric pump (McBain and Trush 2000) mounted on a tripod for use by one person (Figure 3). Two samples were taken within each of the two bulk sample areas. The permeability standpipe was driven into the gravel until the bottom of the perforated portion was 35 cm below the bed surface. This depth was selected because a 2001 freeze core study of chinook salmon spawning indicated this as an average depth of egg deposition (Danni Everson, personal communication).

At each site, three bulk samples were taken along the cross section in undisturbed locations which matched the spawning characteristics of the area. We used a McNeil type method but At each site, three bulk samples were taken along the cross section in undisturbed locations which matched the spawning characteristics of the area. We used a McNeil type method but our samplers were 2.0' cylinders (Figure 4) which were worked down into the gravel bed, removing the bed material into buckets until the hole was excavated to a depth of 1.0'-1.2' (Figure 5). The top surface layer, defined as the depth of the largest surface particle was kept separate from the subsurface.

Three of the sites were sampled during warm summer conditions where once removed, samples were air-dried and field sieved in rocker boxes through a 16 mm screen (Figure 6) and the finer fraction bagged for transport to our lab. The rest of the sites were bulk sampled between October 15 and November 15, 2009 during the spring-run Chinook salmon spawning season under a special permit by California Department of Fish and Game (CDFG). In order to reduce instream disturbance, bulk sampling was expedited so only large particle sizes >32 mm were sorted and weighed semi-dry in the field. The rest of the samples were transported to the lab. At the lab, the samples were thoroughly dried, split into quarters or eighths, sieved and weighed dry.

At some sites after bulk sampling, a bucket of ¾" crushed, white dolomite was placed in the hole, the sampler removed and the hole backfilled with bed material to leave a core of tracer pebbles (Figure 7). The scour core surface was level surveyed and the center noted on the cross section tape to allow future recovery and determination of bed scouring during high flows.

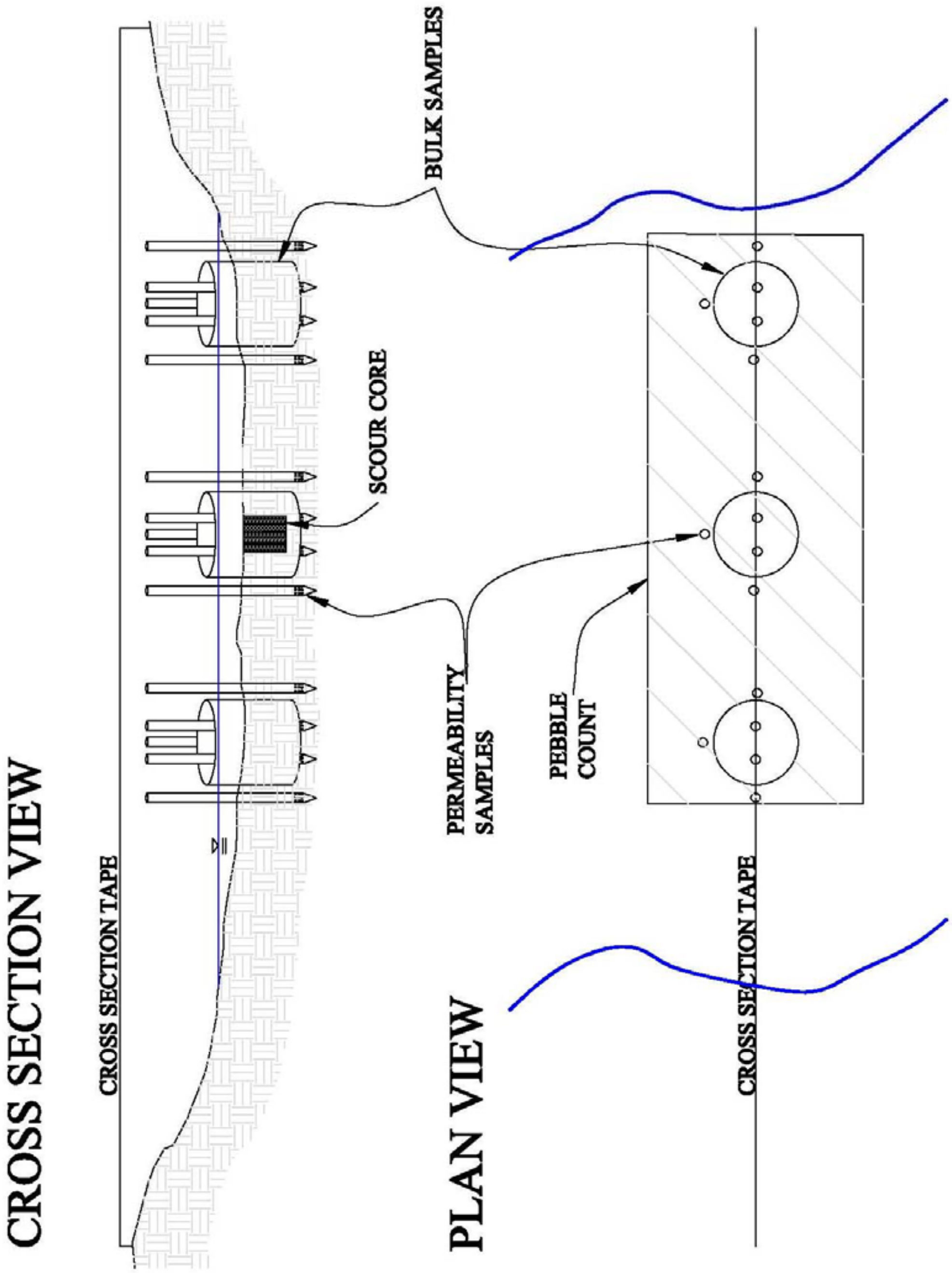


Figure 2. Typical sampling methods used at each site.

Figure 3. Permeability sampling using the backpack pump mounted on a tripod.

Figure 4. Two foot diameter McNeil type bulk sampler.

Figure 5. Bulk sampling using modified 2' diameter McNiel type sampler. Canoe was used to retain buckets during sampling and transport to the bank for sieving.

Figure 6. Initial wet sieving of bulk sample through 16 mm screen in rocker box.

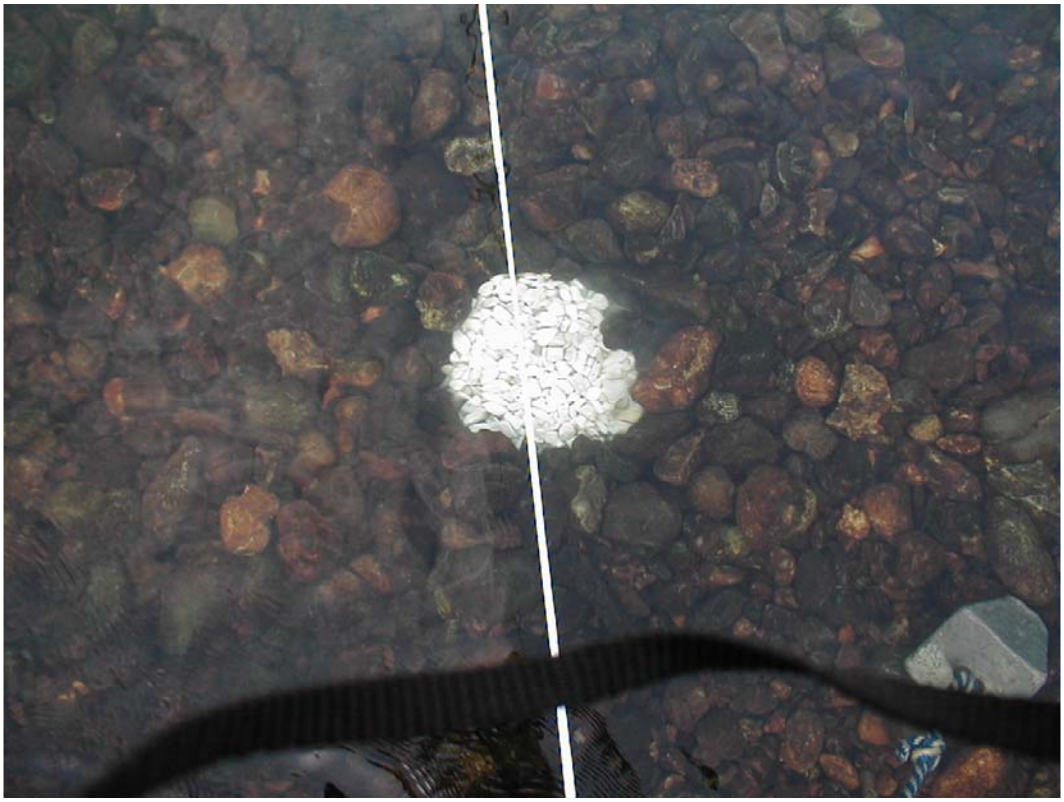


Figure 7. Scour core of ¾” crushed tracer rocks after bulk sample has been removed.

RESULTS

All data for each site was entered into a site workbook (MS Excel 2003). The permeability worksheet (adapted from McBain and Trush 2000) took measurements entered as elapsed time and cm of water inflow and converted them to inflow rate (ml/s), raw permeability (cm/hr) from a curve generated by Terhune (1958) and Barnard and McBain (1994), final permeability (cm/hr) adjusted by a water temperature factor (Terhune 1958), mean permeability for each sample location, and mean permeability for the entire site.

The pebble counts were entered as the number of particles retained in each sieve class and converted to the cumulative percentage (by number) finer than the corresponding sieve size. Although no formal statistical analysis was completed, graphic results (see Appendix B) demonstrate that pebble counts do not appear to represent the surface bulk samples.

Each bulk sample was treated in two distinct methods, field and lab. Since sampling was performed mostly during the fall to take advantage of low flow releases on the Trinity River, sieve analysis was adjusted from our “normal” procedure. Many investigators agree that bulk samples should be sun-dried in the field, entirely sieved through an 8 mm sieve, and the larger sizes sieved by rocker boxes and weighed dry. The smaller size fraction (<8 mm) is then weighed in its entirety, split into quarters (or eighths) and one split taken to a lab, shaken and weighed. Weather and permit restrictions prevented our fully drying samples in the field so we sorted each sample through a 32 mm sieve and took the smaller fractions (3 – 5 buckets/sample) to our lab for drying, splitting, sieving, and weighing. The larger material was sorted and weighed in the field. Most of the surface samples consisted of a single bucket and were transported entirely to the lab for sieve analysis.

Field weights for the larger sizes were combined with lab weights for the smaller sizes and all were converted to cumulative percent finer than each sieve size used. Particle size distribution charts

(Appendix B) generated for each site, show the surface and subsurface curves for each sample and the pebble count for the site.

The results of the individual bulk samples are compiled in Table 1 and include the particle size distributions for the subsurface and for the combined surface and subsurface, several particle size indexes (for subsurface samples only), and the mean value for the two permeability samples within each bulk sample. The particle size distribution curves for these individual samples as well as the mean surface and subsurface curves per site are included in Appendix B.

The relationship between permeability and particle size distribution was tested by running a correlation test between them (MS Excel 2003). Various combinations were tested but the best used the combined surface and subsurface for each site with the mean permeability for each site. The resultant R-squared values (Table 2) show the strongest relationship between permeability and D50 (0.3362), dg (0.3275), and Fines < 0.85 mm (0.3280) although neither are very good.

Table 2. R-squared values for correlations between Mean Site Permeability and several gravel indexes for fully combined site bulk samples (surface and subsurfaces combined).

	D16	D25	D50	dg	Fredle	% Fines <2mm	% Fines <0.85mm
Mean Site Permeability	0.1144	0.1386	0.3362	0.3275	0.1734	0.0692	0.3280

For further analysis, each site was treated as a single unit. Bulk samples were combined to yield a single mean subsurface particle size distribution and all ten permeability samples combined and a mean site permeability calculated. Table 3 includes these and several gravel indexes generated from the mean distribution to describe the baseline gravel quality for each section of the Trinity River for use with long-term trend monitoring.

The results from the 2009 sampling were next compared to those from 2001 for each site. Figure 8 shows the site surface and subsurface particle size distribution curves from 2001 and 2009 for each of the seven main sites established in 2001. In all seven sites, the subsurface comparison demonstrates a coarsening or the lowering of percent fines over the time period. The surface samples suggest the same coarsening although not as dramatically or universally. The most dramatic change was at the Poker Bar site where the Percent Fines < 2mm was reduced from 30% to 14.5%. Inspection of the Poker Bar cross sections (Appendix A) shows sediment deposition in the middle of the channel. Note that the three 2009 bulk samples were taken wholly within the depositional feature, only sampling newly deposited sediment which appears to contain significantly less fines then previously at the site.

The two added sites first established in 1991, Steelbridge US and Steiner Flat DS were compared in the same way with their particle size distribution curves (Figure 9). The same general trend of substrate coarsening is evident by comparing the 1991, 2001 and 2009 subsurface curves.

Three additional sites were added to the sampling effort to try and identify substrate characteristics that might influence Chinook spawning. The substrate component of the habitat suitability criteria for Chinook adult spawning have been developed and mapped in the upper mainstem Trinity River. Three polygons were identified in the run upstream of the Rush Creek pool representing three different combinations of characteristics: 1). <u>Polygon with redds</u> meets the criteria and is used for spawning; 2). <u>No polygon with redds</u> does not meet the criteria but is spawned in and; 3). <u>Polygon with no redds</u> meets the criteria but is not used for spawning. The three bulk samples from each polygon were accumulated and the particle size distribution curves of the surface and subsurface were plotted together in Figure 10. In general, both the surface and subsurface curve of the "no polygon" site are coarser than the other two sites that meet the criteria. The substrate and permeability data collected do not obviously explain why the fish spawn in one and not the other of the two sites that meet the criteria suggesting that the difference may be in water velocity, depth or other aspect of the criteria. Indeed the substrate characteristics of the non-spawned area fall between the two spawned sites.

The Old Lewiston Bridge site data is presented in Table 1 and Appendix B.

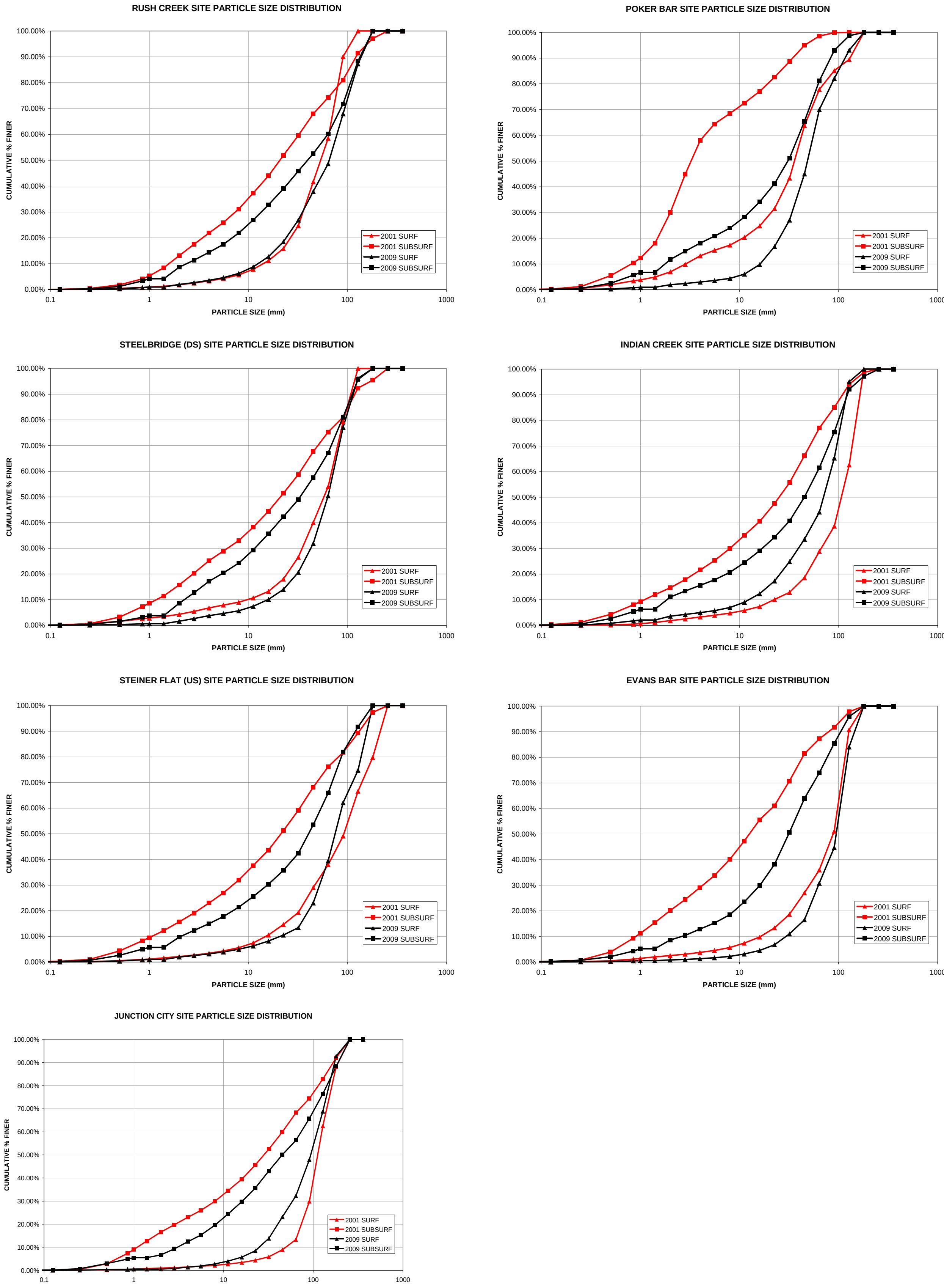
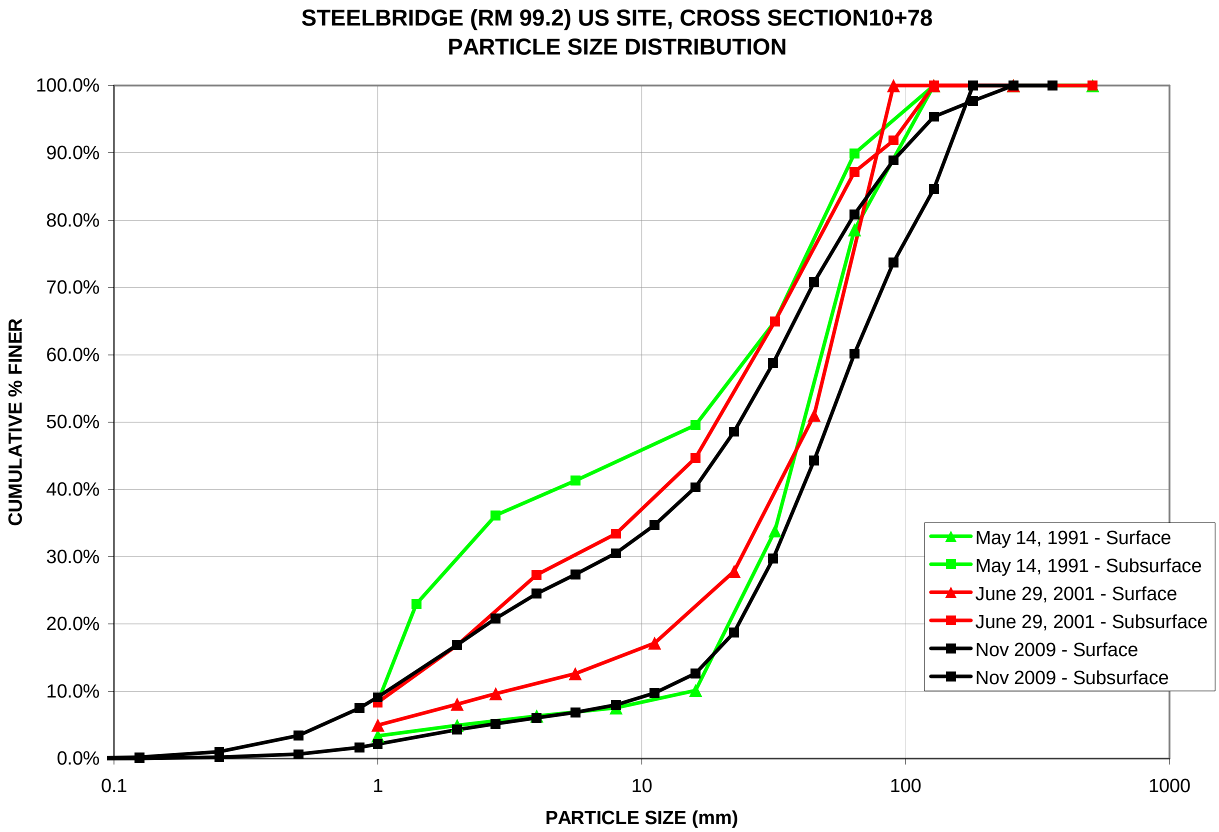


Figure 8. Surface and subsurface cumulative particle size distribution curves for seven main Trinity River sites comparing 2001 and 2009 mean site substrate.



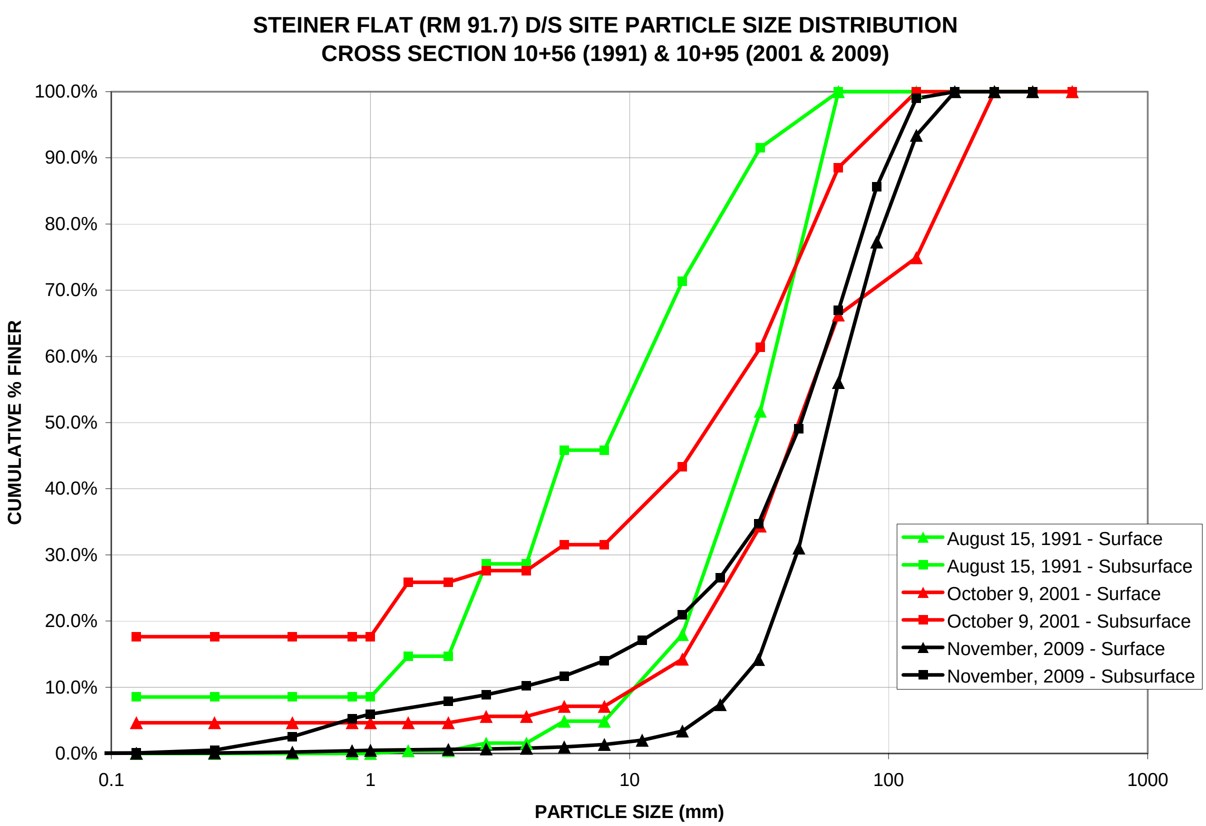


Figure 9. Surface and subsurface cumulative particle size distribution curves for two Trinity River sites comparing 1991, 2001 and 2009 mean site substrate.

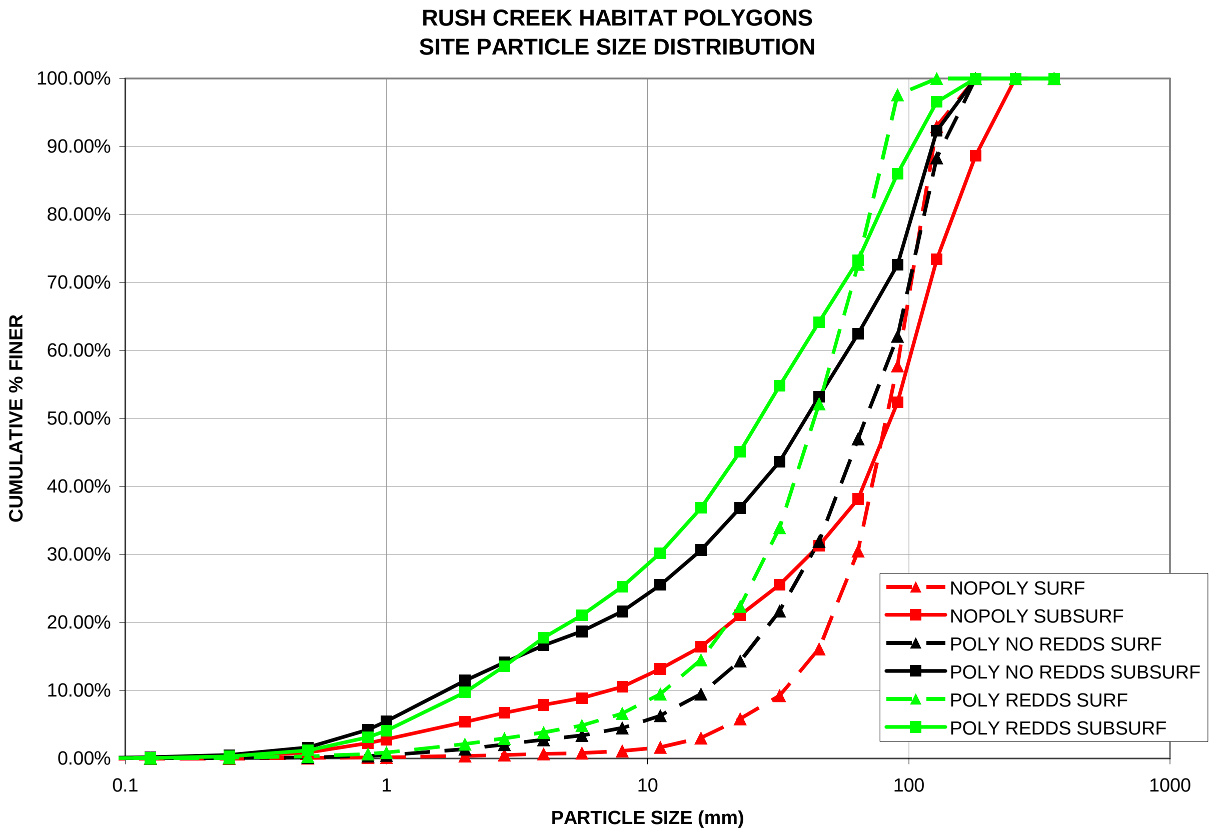


Figure 10. Mean surface and subsurface cumulative particle size distribution curves for three habitat sites upstream of the Rush Creek pool on the Trinity River.

Next, permeability and several gravel indexes were averaged per site, plotted by river mile and compared between 2001 and 2009 for the seven 2001 sites and the two 1991 sites. Permeability (Fig. 11) continues to trend downward in a downstream direction in 2009 as it did generally in 2001 but there does not appear to be a consistent change over time.

Four commonly used gravel indexes are presented here for site comparison longitudinally along the river and over time. The mean geometric mean diameter (dg), percentage of fines < 2mm, fredle index and Tappel and Bjornn Chinook survival to emergence were generated for each site from the combined subsurface bulk samples taken in 2001 and 2009. For all four indexes (and others not shown) an overall trend of the coarsening of the bed is clear. Geometric mean diameter (Fig. 12) has increased at each site. The percent finer than 2mm (Fig. 13) has decreased at every site with by far the largest change at the Poker Bar site (RM 102.7).The fredle index (Fig. 14), which uses the dg in the calculation, has increased at every site and seems to increase in a downstream direction. The Tappel and Bjornn index (Fig. 15) which attempts to estimate egg survival to emergence by using two particle size classes in the substrate sample increased at each site but in particular at the Poker Bar site. It should be noted that all of these are strictly indexes which represent certain characteristics of the bed samples. The Tappel and Bjornn index, for example, is calculated from a bulk sample taken before being "cleaned" of some fines by the act of spawning and so should not be used to actually calculate survival to emergence.

The biggest changes seem to be at the Poker Bar site which has already been shown to represent brand new material deposited since the 2001 sampling (Appendix A).

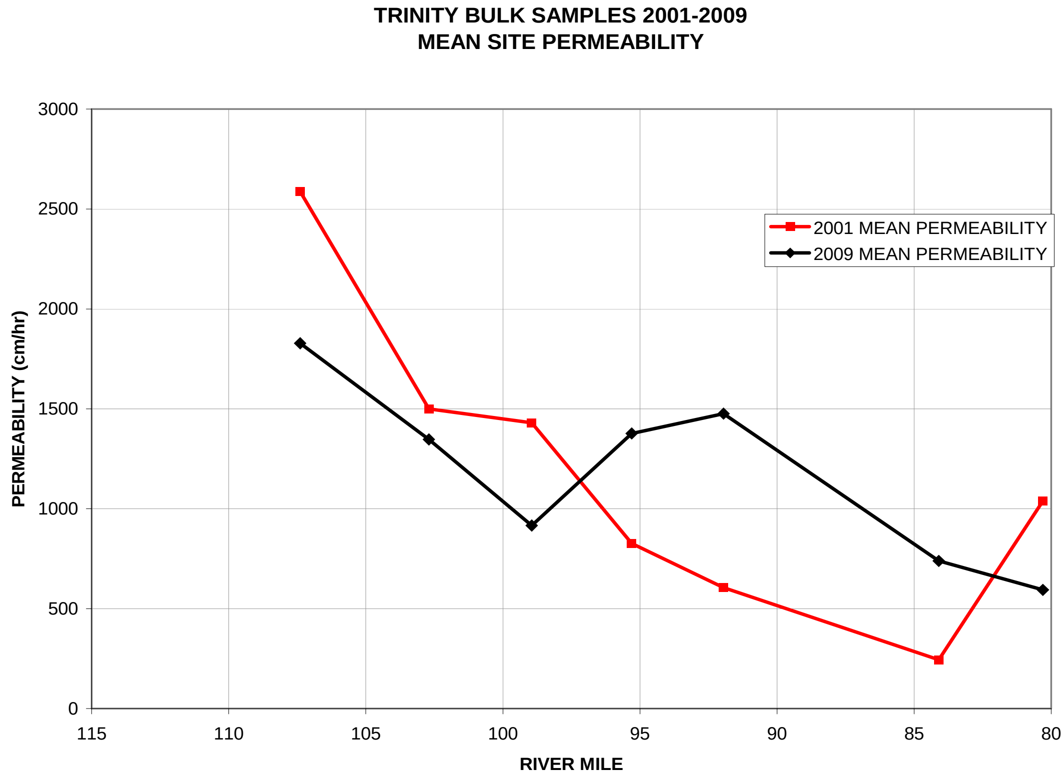


Figure 11. Mean site permeability from 2001 and 2009 compared to river miles for seven Trinity River sites.

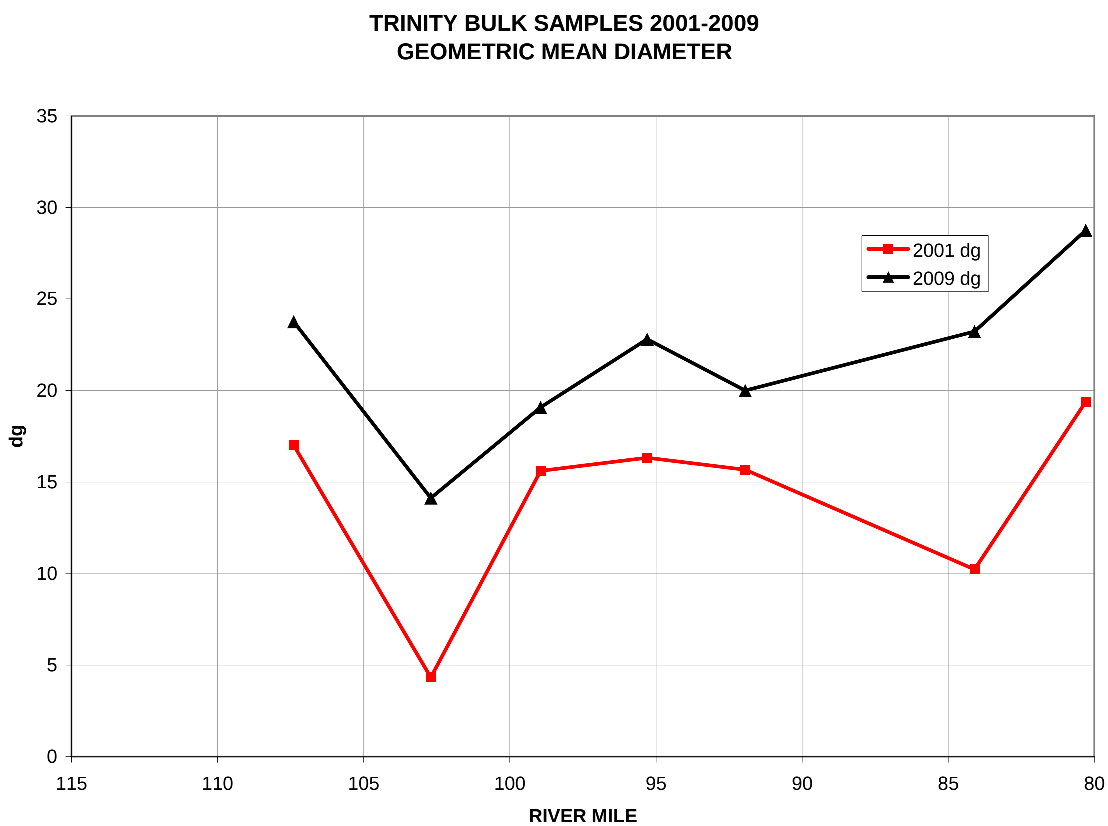


Figure 12. Site Dg from 2001 and 2009 compared to river miles for seven Trinity River sites.

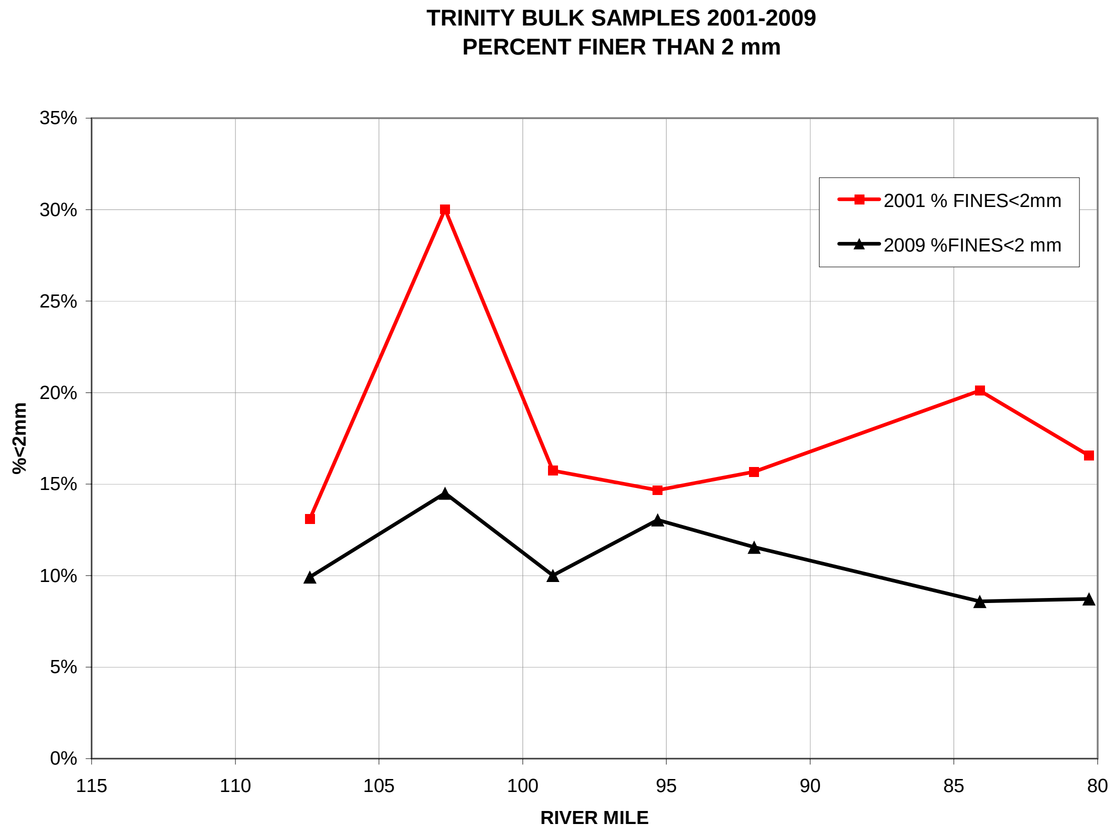


Figure 13. Percent <2mm from 2001 and 2009 compared to river miles for seven Trinity River sites.

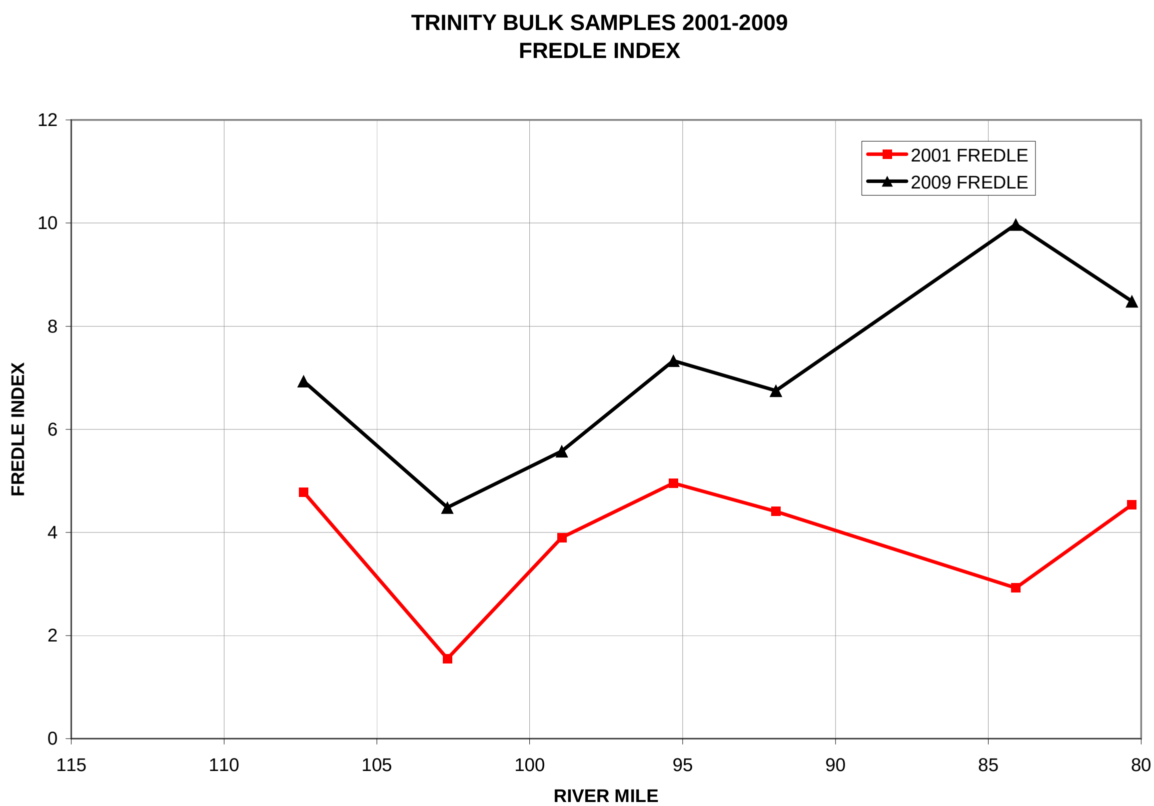


Figure 14. Fredle index from 2001 and 2009 compared to river miles for seven Trinity River sites.

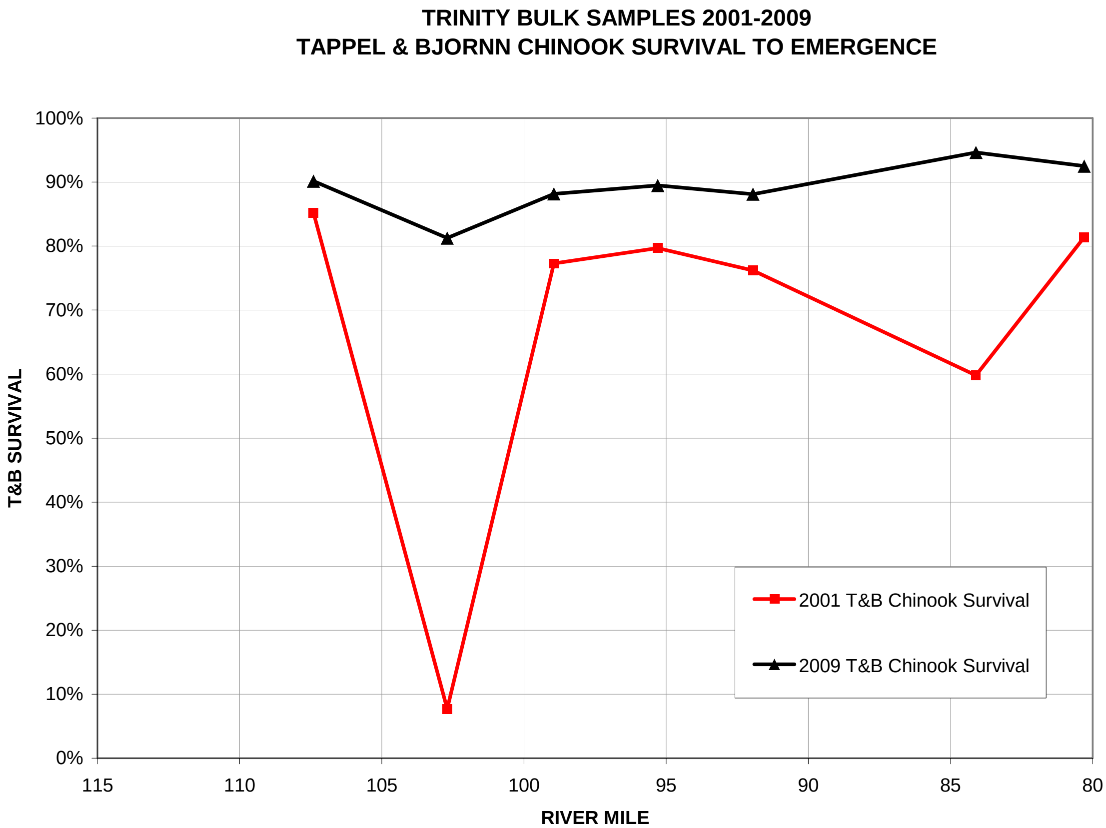


Figure 15. Tappel and Bjornn Chinook survival to emergence index from 2001 and 2009 compared to river miles for seven Trinity River sites.

DISCUSSION

The methods used in the 2001 study were developed in discussion with numerous investigators and literature review in an effort to reduce errors commonly made using small sample sizes in highly variable habitat. The 2009 version of the methods improves on it by using three bulk samples rather than two to represent each cross section.

Comparison of permeability results from 2001 with those of 2009 did not reveal any definite trends. Where there were relatively strong correlations between permeability and smaller gravel sizes in 2001, they weren't as clear cut during the 2009 sampling. It may be that permeability is so highly variable that by spreading out the sampling more with 3 bulk samples and five permeability samples per bulk sample, the relationships are not as strong. In any case, it seems like permeability is probably not a reliable indicator of particle size distribution and that its biggest value is that it is an inexpensive method. The value would be improved if the relationship between permeability and egg survival to emergence were better developed.

Cross sections were hard to recover and relatively few rebar endpins were found although the cross section locations were pretty well "eyeballed" on aerial photos, judging from the sites where we did recover endpins. The Rush Creek site cross section had to be totally replaced because of the major channel changes there so the cross sections (Appendix A) are essentially unrelated. The Poker Bar cross section was recovered and the survey shows a sizeable depositional feature from which all three bulk samples were entirely taken. The left bank endpin at the Steiner Flat upstream site was relocated and the site exhibited little change. The downstream Steiner Flat site (Cross Section IIMS

91XS11+71), established in 1991 and last surveyed in 2001 (McBain and Trush, personal communication) shows scour along the right side and up to four feet of deposition along the left as well as significant scouring at the left edge. The 2009 bulk samples were taken from aggraded section and probably represents entirely new material since the 2001 bulk sampling. At the downstream Steelbridge site, neither endpin was located but the cross section surveyed this time around was likely very close to the 2001 location. It appears that there was some slight scour at the site. The upstream Steelbridge site (IIMS # 99xs1443+85) was last surveyed in 2001 for another project (McBain and Trush, personal communication) and the comparison with 2009 survey shows slight, varied changes across the section but little change at the bulk sample locations. The Indian Creek site endpins were not located but the "new" section was probably just downstream of the 2001. The middle of the channel was too deep to bulk sample so the samples were located towards the banks and appear to be in newly deposited material since 2001. Neither endpin was located at Evans Bar although the cross section is likely very close to the 2001 location and very little change has occurred on the cross section. At the Junction City site the left bank endpin was located and the cross section appears to have aggraded to the point that the bulk samples toward the left bank are mostly composed of new material since 2001.

A big difference/improvement in the 2009 version of the study is that cross sections were surveyed in real world coordinates so future iterations should be easier to compare, since cross sections can be relocated even if the endpins are lost. One important consideration though is that the study focuses on spawning habitat and the methods used are limited to those depths and velocities appropriate to spawning. Over time, spawning areas do shift anyway so sampling will need to shift as well as it did in 2009. The Rush Creek site is an example where the site has entirely changed and even if endpins had been located, the cross section would be inappropriate for bulk sampling.

In the 2001 study, bulk sample results indicated the spawning gravels sampled would generally support good survival to emergence for salmonids with the exception of the Poker Bar site which exhibited a high percentage of fines (GMA 2003). The follow-up sampling in 2009 showed better gravel conditions at all sites and in particular at the Poker Bar site. It appeared from the surveyed cross section that material that was sampled in 2009 was newly deposited since 2001 and was significantly coarser than previously existed. That may be the case at other sites though not as obvious because the cross section comparisons were not as clear cut.

The scour core technique using crushed dolomite as tracers has worked and revealed scour and deposition in other projects. In the present study, no scour cores from 2001 were recovered. The reasons might be that cross sections were not exactly recovered at some sites, that deposition had thoroughly covered them above the depth that was sampled (such as at Poker Bar), or that scour had completely removed them. Regardless, it seems like a valuable technique that could reveal scour and later deposition and since the effort was not too great to set them up, should be a technique to continue in the future.

The Rush Creek habitat criteria sites did not reveal to this investigator a reason for spawning selection based on gravel size distribution or permeability. The size distribution and the permeability of the substrate that was not selected for spawning falls between the other two (Figure 10, Table 1). Apparently the reason for not selecting certain sites must be due to other criteria not part of this investigation, such as velocity or depth.

Spawning gravel conditions improved at every site between the 2001 and 2009 sampling periods. The seven sites revisited from the 2001 GMA study showed improvement in all gravel parameters.

For the two sites established in 1991, the changes by the 2001 sampling were not consistent but in 2009, both sites had had improved gravel quality. In general, all of these sites have experienced a general coarsening of the bed presumably resulting from increased high flows flushing out some of the finer fractions and their not being replaced.

CONCLUSIONS

This gravel quality study that was begun in 2001 and continued in 2009 represents changes over a time period that falls fully within the Trinity River Record of Decision (ROD) to increase the amount of water to the river. The resulting differences in gravel quality are hard to argue about. At all of the sampling sites, spawning gravel has coarsened and the quality has improved. It seems likely that the reason is because the increased flow releases during this period have “flushed” the finer fractions of the size distribution and they have not been replaced. The reasons for that may not be as clear. It suggests that tributaries may not be delivering as much fine sediment as in the past, perhaps due to better land management practices. Grass Valley Creek has seen considerable effort to decrease sediment production to the Trinity River with the dam and settling ponds, and the dramatic gravel quality improvement at the Poker Bar site immediately downstream suggests that it is working.

After identifying these significant changes, it seems important that the study be continued in the future to determine if these trends continue.

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Table 1. Individual bulk sample and mean site surface and subsurface particle size distributions, particle size indexes, mean within sample permeability and site permeability and pebble counts.

SITE STATION	RUSH CREEK 72.5	RUSH CREEK 77	RUSH CREEK 83	RUSH CREEK MEAN	RUSH CREEK PEBBLE	POKER BAR 39	POKER BAR 74	POKER BAR 84	POKER BAR MEAN	POKER BAR PEBBLE
CUM. % FINER THAN (SURFACE)										
360	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
256	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
180	100.00%	100.00%	100.00%	100.00%	99.12%	100.00%	100.00%	100.00%	100.00%	99.12%
128	64.77%	100.00%	100.00%	87.26%	96.46%	100.00%	83.01%	100.00%	93.10%	96.46%
90	30.71%	89.30%	88.86%	67.97%	92.04%	100.00%	67.61%	85.91%	82.10%	92.04%
64	19.79%	56.87%	72.61%	48.69%	84.96%	96.40%	49.73%	74.29%	70.00%	84.96%
45	13.51%	44.73%	58.18%	37.91%	68.14%	52.28%	38.49%	47.34%	45.02%	68.14%
31.5	6.23%	30.72%	45.87%	26.90%	53.10%	24.71%	25.51%	30.68%	27.05%	53.10%
22.4	2.80%	20.49%	33.79%	18.51%	35.40%	11.02%	17.14%	20.83%	16.80%	35.40%
16	1.86%	14.88%	22.56%	12.72%	19.47%	4.52%	9.67%	13.86%	9.75%	19.47%
11.2	1.21%	10.29%	15.63%	8.78%	8.85%	1.30%	5.78%	10.02%	6.05%	8.85%
8	0.92%	7.11%	11.20%	6.23%	6.19%	0.50%	3.85%	8.02%	4.39%	6.19%
5.6	0.73%	5.14%	8.26%	4.58%	1.77%	0.32%	3.16%	6.48%	3.55%	1.77%
4	0.58%	3.96%	6.50%	3.58%	0.88%	0.27%	2.60%	5.46%	2.96%	0.88%
2.8	0.46%	3.06%	4.72%	2.67%	0.88%	0.24%	2.11%	4.50%	2.43%	0.88%
2	0.33%	2.33%	3.48%	1.99%	0.00%	0.21%	1.59%	3.66%	1.93%	0.00%
1	0.16%	1.21%	1.65%	0.98%	0.00%	0.17%	0.62%	1.94%	0.95%	0.00%
0.85	0.13%	0.98%	1.29%	0.78%	0.00%	0.16%	0.44%	1.51%	0.73%	0.00%
0.5	0.05%	0.38%	0.42%	0.27%	0.00%	0.12%	0.14%	0.55%	0.27%	0.00%
0.25	0.01%	0.08%	0.11%	0.07%	0.00%	0.09%	0.04%	0.13%	0.08%	0.00%
0.125	0.00%	0.02%	0.06%	0.03%	0.00%	0.06%	0.01%	0.03%	0.03%	0.00%
0.063	0.00%	0.01%	0.03%	0.01%	0.00%	0.05%	0.01%	0.01%	0.02%	0.00%
CUM. % FINER THAN (SUBSURFACE)										
360	100.00%	100.00%	100.00%	100.00%		100.00%	100.00%	100.00%	100.00%	
256	100.00%	100.00%	100.00%	100.00%		100.00%	100.00%	100.00%	100.00%	
180	100.00%	100.00%	100.00%	100.00%		100.00%	100.00%	100.00%	100.00%	
128	90.26%	86.12%	88.92%	88.43%		100.00%	100.00%	100.00%	98.69%	
90	72.20%	75.86%	70.42%	71.85%		96.32%	96.28%	94.90%	93.02%	
64	66.50%	64.60%	56.32%	60.21%		81.68%	89.04%	85.77%	81.20%	
45	57.59%	58.30%	50.65%	52.56%		61.59%	79.97%	78.01%	65.42%	
31.5	50.50%	53.43%	45.18%	45.84%		45.60%	69.28%	67.00%	51.17%	
22.4	43.68%	46.03%	39.57%	38.99%		35.95%	57.96%	56.97%	41.25%	
16	36.84%	39.90%	33.64%	32.75%		28.23%	50.32%	50.39%	34.14%	
11.2	30.18%	33.55%	28.00%	26.90%		23.48%	41.94%	42.43%	28.23%	
8	24.22%	27.60%	23.26%	21.85%		20.43%	35.38%	35.98%	24.00%	
5.6	18.88%	22.26%	19.23%	17.48%		18.07%	30.33%	31.07%	20.84%	
4	15.18%	18.45%	16.31%	14.42%		15.81%	26.29%	26.91%	18.09%	
2.8	11.33%	14.44%	13.73%	11.38%		12.65%	20.86%	22.61%	14.95%	
2	8.33%	10.87%	10.86%	8.65%		9.68%	15.35%	18.02%	11.76%	
1	4.02%	4.86%	5.62%	4.20%		5.74%	7.05%	10.16%	6.71%	
0.85	3.21%	3.80%	4.53%	3.35%		5.07%	5.77%	8.42%	5.67%	
0.5	1.21%	1.40%	1.66%	1.24%		2.57%	2.70%	3.38%	2.48%	
0.25	0.26%	0.28%	0.25%	0.23%		0.67%	0.66%	0.56%	0.51%	
0.125	0.06%	0.05%	0.03%	0.04%		0.14%	0.18%	0.16%	0.13%	
0.063	0.02%	0.02%	0.01%	0.01%		0.04%	0.07%	0.05%	0.04%	
PARTICLE SIZE DISTRIBUTION INDEXES										
D16	4.3	3.2	3.8	3.8		4.1	2.1	1.7	2.2	
D25	8.4	6.7	9.1	8.1		12.6	3.7	3.4	4.7	
D50	31.2	27.1	43.2	33.0		35.1	15.8	15.7	21.6	
D75	95.0	87.7	98.2	94.9		56.9	38.4	41.0	46.9	
D84	113.3	119.0	116.6	115.6		67.6	52.6	59.1	61.0	
dg	23.7	21.5	25.8	23.8		21.2	11.9	11.6	14.1	
FREDLE	7.0	5.9	7.8	6.9		10.0	3.7	3.4	4.5	
% FINES<2mm	8.3%	10.9%	10.9%	9.9%		9.7%	15.3%	18.0%	14.5%	
% FINES<0.85mm	3.2%	3.8%	4.5%	3.8%		5.1%	5.8%	8.4%	6.5%	
PERMEABILITY	2253	1228	1542	1828.3		1600	1160	1205	1347.4	

Table 1. Individual bulk sample and mean site surface and subsurface particle size distributions, particle size indexes, mean within sample permeability and site permeability and pebble counts (cont)

SITE STATION	STEELBR DS 27	STEELBR DS 36	STEELBR DS 45	STEELBR DS MEAN	STEELBR DS PEBBLE	INDIAN CREEK 15.5	INDIAN CREEK 27.5	INDIAN CREEK 120.5	INDIAN CREEK MEAN	INDIAN CREEK PEBBLE
CUM. % FINER THAN (SURFACE)										
360	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
256	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
180	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	99.16%
128	84.97%	100.00%	100.00%	96.21%	100.00%	85.21%	100.00%	100.00%	95.06%	98.32%
90	69.92%	85.91%	72.66%	77.09%	99.07%	62.57%	76.48%	55.07%	65.33%	92.44%
64	41.08%	55.00%	52.20%	50.48%	94.44%	48.23%	47.81%	35.51%	44.21%	79.83%
45	26.69%	35.37%	31.72%	31.86%	80.56%	32.98%	34.59%	33.20%	33.63%	71.43%
31.5	14.47%	25.04%	20.32%	20.67%	62.96%	22.30%	28.41%	23.43%	24.86%	56.30%
22.4	8.15%	18.69%	12.95%	13.96%	41.67%	15.47%	19.29%	17.06%	17.34%	39.50%
16	5.10%	15.11%	8.28%	10.12%	27.78%	11.29%	13.80%	11.74%	12.34%	30.25%
11.2	3.25%	11.92%	5.49%	7.41%	23.15%	8.58%	9.92%	8.55%	9.05%	20.17%
8	2.26%	9.87%	3.59%	5.68%	16.67%	6.82%	7.32%	6.64%	6.95%	10.08%
5.6	1.76%	8.31%	2.65%	4.61%	12.96%	5.85%	5.72%	5.63%	5.74%	5.88%
4	1.41%	6.96%	2.03%	3.78%	10.19%	5.16%	4.91%	4.82%	4.97%	5.04%
2.8	0.94%	4.89%	1.39%	2.63%	5.56%	4.65%	4.13%	4.00%	4.26%	1.68%
2	0.53%	3.06%	0.86%	1.63%	1.85%	4.15%	3.36%	3.16%	3.56%	0.84%
1	0.16%	1.28%	0.32%	0.65%	0.00%	2.90%	1.71%	1.63%	2.09%	0.00%
0.85	0.13%	1.09%	0.27%	0.55%	0.00%	2.54%	1.34%	1.38%	1.75%	0.00%
0.5	0.06%	0.63%	0.16%	0.32%	0.00%	1.30%	0.44%	0.69%	0.80%	0.00%
0.25	0.03%	0.17%	0.05%	0.09%	0.00%	0.23%	0.08%	0.06%	0.12%	0.00%
0.125	0.01%	0.04%	0.01%	0.02%	0.00%	0.03%	0.02%	0.02%	0.02%	0.00%
0.063	0.00%	0.01%	0.00%	0.01%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
CUM. % FINER THAN (SUBSURFACE)										
360	100.00%	100.00%	100.00%	100.00%		100.00%	100.00%	100.00%	100.00%	
256	100.00%	100.00%	100.00%	100.00%		100.00%	100.00%	100.00%	100.00%	
180	100.00%	100.00%	100.00%	100.00%		100.00%	89.29%	100.00%	97.19%	
128	100.00%	97.73%	89.56%	95.72%		96.17%	77.18%	100.00%	92.08%	
90	76.80%	86.45%	82.70%	81.04%		79.90%	67.57%	85.91%	75.46%	
64	66.96%	70.69%	74.07%	67.16%		66.04%	62.29%	69.14%	61.52%	
45	61.06%	62.60%	64.91%	57.57%		55.03%	55.92%	52.26%	50.09%	
31.5	54.11%	52.78%	57.34%	48.98%		45.80%	49.07%	40.26%	40.76%	
22.4	47.23%	45.75%	51.14%	42.29%		39.78%	43.66%	33.73%	34.44%	
16	39.77%	38.60%	44.29%	35.70%		34.96%	37.46%	28.63%	29.14%	
11.2	32.57%	31.53%	37.23%	29.35%		30.37%	31.48%	24.14%	24.48%	
8	26.70%	25.67%	31.55%	24.25%		26.69%	26.15%	20.39%	20.67%	
5.6	22.30%	21.20%	27.08%	20.38%		23.77%	21.87%	17.43%	17.73%	
4	18.67%	17.74%	23.05%	17.16%		21.78%	18.83%	15.23%	15.65%	
2.8	13.30%	12.95%	17.74%	12.68%		19.87%	15.62%	12.64%	13.44%	
2	8.76%	9.33%	11.80%	8.57%		17.98%	12.09%	9.90%	11.11%	
1	3.35%	5.04%	4.91%	3.78%		13.13%	5.28%	4.61%	6.31%	
0.85	2.72%	4.31%	3.99%	3.13%		11.82%	4.01%	3.75%	5.34%	
0.5	1.34%	2.01%	1.98%	1.52%		6.63%	1.29%	1.90%	2.64%	
0.25	0.37%	0.48%	0.55%	0.40%		1.16%	0.23%	0.53%	0.52%	
0.125	0.09%	0.13%	0.16%	0.11%		0.21%	0.05%	0.09%	0.10%	
0.063	0.03%	0.04%	0.10%	0.05%		0.11%	0.02%	0.02%	0.04%	
PARTICLE SIZE DISTRIBUTION INDEXES										
D16	3.3	3.5	2.5	3.0		1.5	2.9	4.5	2.9	
D25	7.0	7.6	4.7	6.2		6.5	7.3	12.0	8.5	
D50	25.9	27.8	21.2	24.7		37.4	33.5	42.2	38.5	
D75	84.6	70.3	66.4	73.1		79.8	118.2	72.1	82.6	
D84	100.4	85.4	96.2	95.1		98.4	155.1	86.6	105.4	
dg	20.5	19.8	17.3	19.1		18.8	24.8	24.7	22.8	
FREDLE	5.9	6.5	4.6	5.6		5.4	6.2	10.1	7.3	
% FINES<2mm	8.8%	9.3%	11.8%	10.0%		18.0%	12.1%	9.9%	13.0%	
% FINES<0.85mm	2.7%	4.3%	4.0%	3.7%		11.8%	4.0%	3.8%	6.3%	
PERMEABILITY	545	113	284	915.7		396	524	1137	1376.7	

Table 1. Individual bulk sample and mean site surface and subsurface particle size distributions, particle size indexes, mean within sample permeability and site permeability and pebble counts (cont)

SITE STATION	STEINER FLAT US 55	STEINER FLAT US 81	STEINER FLAT US 129	STEINER FLAT US MEAN	STEINER FLAT US PEBBLE	EVANS BAR 19	EVANS BAR 67.8	EVANS BAR 116	EVANS BAR MEAN	EVANS BAR PEBBLE
CUM. % FINER THAN (SURFACE)										
360	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
256	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
180	100.00%	100.00%	100.00%	100.00%	99.15%	100.00%	100.00%	100.00%	100.00%	99.16%
128	61.92%	79.25%	84.62%	74.77%	96.58%	78.75%	85.76%	87.50%	84.07%	98.32%
90	53.71%	64.89%	68.83%	62.15%	84.62%	60.56%	33.29%	40.32%	44.73%	92.44%
64	27.72%	52.33%	39.85%	39.50%	79.49%	46.32%	26.57%	20.07%	30.78%	79.83%
45	13.45%	36.52%	20.37%	23.05%	70.94%	22.56%	14.03%	13.03%	16.48%	71.43%
31.5	7.45%	24.67%	8.84%	13.40%	55.56%	14.15%	7.97%	10.75%	10.98%	56.30%
22.4	5.91%	20.43%	5.78%	10.51%	37.61%	7.91%	4.43%	7.79%	6.76%	39.50%
16	4.83%	16.07%	4.06%	8.18%	22.22%	4.78%	2.31%	6.27%	4.51%	30.25%
11.2	3.80%	12.70%	2.56%	6.25%	15.38%	2.72%	1.26%	5.17%	3.11%	20.17%
8	3.17%	10.02%	2.00%	4.98%	11.11%	1.67%	0.71%	4.06%	2.20%	10.08%
5.6	2.59%	7.62%	1.67%	3.90%	7.69%	1.19%	0.46%	3.20%	1.66%	5.88%
4	2.08%	6.11%	1.54%	3.19%	4.27%	0.94%	0.32%	2.50%	1.29%	5.04%
2.8	1.59%	4.59%	1.45%	2.50%	1.71%	0.78%	0.22%	1.91%	1.00%	1.68%
2	1.15%	3.42%	1.39%	1.95%	0.85%	0.67%	0.16%	1.49%	0.80%	0.84%
1	0.45%	1.51%	1.17%	1.02%	0.85%	0.48%	0.07%	0.91%	0.50%	0.00%
0.85	0.36%	1.12%	1.07%	0.83%	0.00%	0.43%	0.06%	0.78%	0.43%	0.00%
0.5	0.19%	0.36%	0.58%	0.37%	0.00%	0.23%	0.03%	0.38%	0.22%	0.00%
0.25	0.07%	0.09%	0.14%	0.10%	0.00%	0.07%	0.01%	0.09%	0.06%	0.00%
0.125	0.02%	0.03%	0.03%	0.03%	0.00%	0.02%	0.00%	0.01%	0.01%	0.00%
0.063	0.01%	0.01%	0.01%	0.01%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%
CUM. % FINER THAN (SUBSURFACE)										
360	100.00%	100.00%	100.00%	100.00%		100.00%	100.00%	100.00%	100.00%	
256	100.00%	100.00%	100.00%	100.00%		100.00%	100.00%	100.00%	100.00%	
180	100.00%	100.00%	100.00%	100.00%		100.00%	100.00%	100.00%	100.00%	
128	95.19%	92.56%	100.00%	91.65%		96.86%	94.70%	95.88%	95.86%	
90	82.04%	84.58%	95.52%	81.88%		89.19%	83.52%	83.06%	85.43%	
64	70.79%	68.01%	79.06%	65.89%		82.47%	72.00%	65.93%	73.89%	
45	62.44%	57.29%	62.33%	53.49%		69.50%	65.59%	55.74%	63.91%	
31.5	52.04%	48.97%	45.64%	42.35%		52.24%	55.74%	43.51%	50.63%	
22.4	44.10%	42.83%	37.34%	35.77%		30.75%	48.44%	36.10%	38.15%	
16	36.88%	37.80%	31.48%	30.36%		21.08%	40.64%	28.80%	29.83%	
11.2	30.31%	33.25%	26.39%	25.54%		15.52%	33.59%	22.25%	23.47%	
8	24.19%	29.13%	22.62%	21.39%		11.70%	27.37%	17.05%	18.45%	
5.6	18.70%	24.86%	20.06%	17.73%		9.22%	22.85%	14.35%	15.24%	
4	14.62%	20.99%	18.68%	14.96%		7.80%	19.29%	12.09%	12.86%	
2.8	11.28%	16.38%	17.59%	12.31%		6.57%	15.41%	9.61%	10.39%	
2	8.69%	11.04%	16.32%	9.70%		5.66%	12.60%	7.87%	8.60%	
1	5.95%	4.03%	11.11%	5.66%		4.16%	6.94%	4.44%	5.14%	
0.85	5.53%	3.91%	9.30%	5.05%		3.81%	5.57%	3.51%	4.28%	
0.5	3.23%	1.93%	4.39%	2.61%		2.43%	2.26%	1.48%	2.07%	
0.25	0.77%	0.42%	1.25%	0.66%		0.92%	0.59%	0.38%	0.64%	
0.125	0.11%	0.06%	0.29%	0.12%		0.40%	0.16%	0.10%	0.23%	
0.063	0.03%	0.01%	0.07%	0.03%		0.17%	0.06%	0.03%	0.09%	
PARTICLE SIZE DISTRIBUTION INDEXES										
D16	4.5	2.7	1.9	3.3		11.5	3.0	7.0	6.1	
D25	8.4	5.7	9.9	7.8		18.3	6.6	13.0	12.2	
D50	29.2	33.4	35.0	32.7		30.8	24.2	38.3	31.4	
D75	72.7	73.9	58.8	68.4		52.3	69.9	76.7	66.1	
D84	94.8	88.9	70.9	84.6		69.2	91.4	92.4	86.3	
dg	21.0	20.3	18.4	20.0		25.8	18.2	26.5	23.2	
FREDLE	7.1	5.6	7.5	6.8		15.3	5.6	10.9	10.0	
% FINES<2mm	8.7%	11.0%	16.3%	11.6%		5.7%	12.6%	7.9%	8.6%	
% FINES<0.85mm	5.5%	3.9%	9.3%	6.1%		3.8%	5.6%	3.5%	4.3%	
PERMEABILITY	973	2524	1	1476.4					739.2	

Table 1. Individual bulk sample and mean site surface and subsurface particle size distributions, particle size indexes, mean within sample permeability and site permeability and pebble counts (cont)

SITE STATION	JUNCTION CITY 86.5	JUNCTION CITY 76.5	JUNCTION CITY 16.5	JUNCTION CITY MEAN	JUNCTION CITY PEBBLE	STEELBR US 74	STEELBR US 109	STEELBR US 115	STEELBR US MEAN
CUM. % FINER THAN (SURFACE)									
360	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
256	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
180	100.00%	100.00%	78.49%	92.80%	99.12%	100.00%	100.00%	100.00%	100.00%
128	87.67%	69.42%	49.23%	68.89%	96.46%	66.29%	100.00%	100.00%	84.63%
90	54.42%	51.12%	38.38%	47.98%	92.04%	42.38%	100.00%	100.00%	73.73%
64	36.19%	33.85%	26.80%	32.29%	84.96%	27.72%	77.62%	97.32%	60.15%
45	26.36%	23.56%	19.60%	23.19%	68.14%	14.70%	54.66%	84.08%	44.33%
31.5	15.45%	10.91%	15.13%	13.88%	53.10%	6.77%	36.64%	61.67%	29.73%
22.4	9.02%	4.21%	12.03%	8.47%	35.40%	3.56%	24.01%	39.24%	18.77%
16	5.36%	1.90%	9.75%	5.71%	19.47%	1.56%	17.84%	26.18%	12.65%
11.2	3.29%	0.70%	7.80%	3.96%	8.85%	1.06%	13.68%	20.55%	9.77%
8	1.95%	0.34%	5.99%	2.78%	6.19%	0.87%	11.06%	16.90%	7.98%
5.6	1.12%	0.18%	4.35%	1.90%	1.77%	0.78%	9.74%	14.30%	6.87%
4	0.70%	0.12%	3.20%	1.35%	0.88%	0.67%	8.79%	12.37%	6.05%
2.8	0.40%	0.08%	2.09%	0.86%	0.88%	0.55%	7.95%	10.25%	5.19%
2	0.25%	0.06%	1.33%	0.55%	0.00%	0.42%	6.84%	8.26%	4.29%
1	0.17%	0.05%	1.33%	0.52%	0.00%	0.19%	3.52%	4.10%	2.16%
0.85	0.16%	0.04%	1.20%	0.47%	0.00%	0.15%	2.69%	3.22%	1.67%
0.5	0.13%	0.03%	0.80%	0.32%	0.00%	0.06%	0.93%	1.42%	0.66%
0.25	0.05%	0.02%	0.24%	0.10%	0.00%	0.02%	0.27%	0.45%	0.20%
0.125	0.01%	0.01%	0.04%	0.02%	0.00%	0.00%	0.08%	0.10%	0.05%
0.063	0.00%	0.01%	0.01%	0.01%	0.00%	0.00%	0.02%	0.02%	0.01%
CUM. % FINER THAN (SUBSURFACE)									
360	100.00%	100.00%	100.00%	100.00%		100.00%	100.00%	100.00%	100.00%
256	100.00%	100.00%	100.00%	100.00%		100.00%	100.00%	100.00%	100.00%
180	89.04%	100.00%	79.37%	88.41%		92.04%	100.00%	100.00%	97.74%
128	71.23%	85.53%	74.17%	76.47%		92.04%	100.00%	100.00%	95.37%
90	63.83%	75.36%	60.33%	65.77%		81.23%	94.08%	100.00%	88.89%
64	59.37%	61.55%	49.88%	56.30%		71.42%	85.44%	97.78%	80.88%
45	52.36%	55.42%	44.27%	50.09%		60.88%	74.08%	92.81%	70.80%
31.5	44.34%	48.17%	38.23%	43.06%		47.84%	64.42%	80.77%	58.77%
22.4	35.80%	39.89%	32.32%	35.62%		37.68%	56.18%	68.80%	48.56%
16	29.74%	32.55%	27.72%	29.76%		30.66%	47.49%	58.67%	40.35%
11.2	24.65%	25.83%	23.07%	24.37%		26.24%	40.43%	51.65%	34.70%
8	19.33%	20.58%	18.88%	19.51%		23.13%	35.10%	46.24%	30.52%
5.6	14.78%	16.13%	15.15%	15.31%		20.56%	31.45%	41.73%	27.34%
4	12.33%	12.72%	12.32%	12.44%		18.08%	28.45%	37.52%	24.50%
2.8	9.54%	9.48%	9.01%	9.31%		14.75%	24.22%	32.53%	20.84%
2	7.47%	7.05%	5.79%	6.70%		10.91%	19.51%	27.56%	16.89%
1	5.60%	5.05%	5.79%	5.51%		4.86%	10.03%	16.64%	9.13%
0.85	5.30%	4.78%	4.66%	4.90%		3.75%	8.10%	14.09%	7.49%
0.5	3.74%	3.23%	2.01%	2.92%		1.27%	3.59%	7.07%	3.42%
0.25	0.95%	0.72%	0.48%	0.70%		0.26%	1.18%	2.05%	1.00%
0.125	0.16%	0.14%	0.11%	0.13%		0.06%	0.23%	0.43%	0.21%
0.063	0.05%	0.05%	0.04%	0.05%		0.02%	0.04%	0.08%	0.04%
PARTICLE SIZE DISTRIBUTION INDEXES									
D16	6.2	5.5	3.5	4.9		3.2	1.5	1.0	1.6
D25	11.5	10.6	9.2	10.4		9.8	3.0	1.7	3.1
D50	40.7	34.9	53.7	42.5		33.9	17.6	10.1	19.2
D75	137.6	89.2	126.0	119.8		72.5	46.3	26.9	44.2
D84	163.4	121.4	191.7	157.1		98.5	61.2	35.1	62.4
dg	31.5	26.2	31.2	28.8		23.3	11.9	6.8	12.5
FREDLE	9.1	9.0	8.4	8.5		8.6	3.0	1.7	3.3
% FINES<2mm	7.5%	7.1%	11.0%	8.7%		10.9%	19.5%	27.6%	19.2%
% FINES<0.85mm	5.3%	4.8%	4.4%	5.3%		3.7%	8.1%	14.1%	8.5%
PERMEABILITY	366	843	1294	594.2		839	1059	463	995.9

Table 1. Individual bulk sample and mean site surface and subsurface particle size distributions, particle size indexes, mean within sample permeability and site permeability and pebble counts (cont)

SITE STATION	STEINER FLAT DS 16	STEINER FLAT DS 41	STEINER FLAT DS 66	STEINER FLAT DS MEAN	STEINER FLAT DS PEBBLE	RUSH HAB NOPOLY 1	RUSH HAB NOPOLY 2	RUSH HAB NOPOLY 3	RUSH HAB NOPOLY MEAN
CUM. % FINER THAN (SURFACE)									
360	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
256	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
180	100.00%	100.00%	100.00%	100.00%	99.16%	100.00%	100.00%	100.00%	100.00%
128	100.00%	79.13%	100.00%	93.40%	98.32%	79.52%	100.00%	100.00%	92.98%
90	100.00%	49.49%	83.20%	77.29%	92.44%	28.06%	75.81%	71.02%	57.74%
64	89.06%	37.64%	47.36%	56.07%	79.83%	16.44%	43.79%	32.86%	30.54%
45	58.06%	21.45%	19.54%	31.03%	71.43%	7.12%	29.16%	13.64%	16.11%
31.5	22.96%	14.49%	7.79%	14.20%	56.30%	3.42%	20.55%	5.17%	9.24%
22.4	10.93%	10.32%	2.52%	7.36%	39.50%	2.51%	13.75%	2.24%	5.83%
16	3.21%	6.43%	1.08%	3.38%	30.25%	1.02%	8.21%	0.52%	3.03%
11.2	1.39%	4.44%	0.51%	2.00%	20.17%	0.41%	4.82%	0.14%	1.65%
8	0.94%	2.98%	0.35%	1.35%	10.08%	0.20%	3.31%	0.09%	1.11%
5.6	0.73%	2.07%	0.28%	0.98%	5.88%	0.12%	2.47%	0.07%	0.82%
4	0.62%	1.64%	0.25%	0.79%	5.04%	0.09%	1.98%	0.07%	0.66%
2.8	0.51%	1.41%	0.22%	0.68%	1.68%	0.07%	1.51%	0.06%	0.50%
2	0.42%	1.31%	0.18%	0.61%	0.84%	0.04%	1.08%	0.05%	0.36%
1	0.31%	1.03%	0.13%	0.46%	0.00%	0.02%	0.43%	0.04%	0.15%
0.85	0.28%	0.91%	0.11%	0.41%	0.00%	0.01%	0.33%	0.04%	0.12%
0.5	0.18%	0.46%	0.05%	0.22%	0.00%	0.01%	0.12%	0.03%	0.05%
0.25	0.08%	0.13%	0.02%	0.07%	0.00%	0.00%	0.04%	0.01%	0.02%
0.125	0.04%	0.03%	0.01%	0.02%	0.00%	0.00%	0.01%	0.00%	0.00%
0.063	0.02%	0.01%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%
CUM. % FINER THAN (SUBSURFACE)									
360	100.00%	100.00%	100.00%	100.00%		100.00%	100.00%	100.00%	100.00%
256	100.00%	100.00%	100.00%	100.00%		100.00%	100.00%	100.00%	100.00%
180	100.00%	100.00%	100.00%	100.00%		100.00%	83.32%	79.25%	88.62%
128	100.00%	100.00%	100.00%	99.00%		82.04%	57.41%	69.36%	73.39%
90	95.85%	85.13%	81.91%	85.62%		61.14%	36.37%	56.45%	52.39%
64	86.21%	64.98%	58.64%	66.97%		48.41%	26.92%	44.87%	38.14%
45	72.16%	50.03%	38.85%	49.09%		45.54%	22.86%	37.72%	31.29%
31.5	57.25%	34.35%	27.01%	34.73%		38.69%	19.47%	31.41%	25.53%
22.4	45.54%	25.77%	21.27%	26.57%		32.71%	17.29%	25.51%	21.07%
16	36.06%	20.15%	17.75%	20.91%		26.16%	13.54%	20.31%	16.43%
11.2	29.18%	15.80%	15.49%	17.06%		20.41%	12.00%	16.19%	13.17%
8	23.55%	11.88%	13.98%	14.01%		16.32%	9.28%	13.31%	10.53%
5.6	19.17%	9.03%	12.67%	11.67%		13.39%	8.13%	11.32%	8.90%
4	16.14%	7.67%	11.67%	10.17%		11.44%	7.39%	10.13%	7.86%
2.8	13.39%	6.84%	10.58%	8.87%		9.22%	6.31%	8.95%	6.69%
2	10.92%	6.48%	9.75%	7.85%		7.13%	5.29%	7.17%	5.36%
1	7.27%	5.46%	7.68%	5.92%		2.83%	2.88%	4.32%	2.83%
0.85	6.46%	4.96%	6.70%	5.25%		2.08%	2.31%	3.54%	2.25%
0.5	3.50%	2.62%	2.80%	2.55%		0.67%	0.92%	1.45%	0.88%
0.25	0.75%	0.58%	0.45%	0.50%		0.16%	0.21%	0.33%	0.20%
0.125	0.11%	0.10%	0.05%	0.07%		0.05%	0.05%	0.07%	0.05%
0.063	0.04%	0.03%	0.01%	0.02%		0.02%	0.02%	0.02%	0.02%
PARTICLE SIZE DISTRIBUTION INDEXES									
D16	3.9	11.4	12.1	7.7		7.7	19.9	11.0	11.3
D25	8.7	21.4	28.2	16.9		14.9	54.2	21.7	22.9
D50	25.7	45.0	54.9	42.5		66.8	113.1	74.4	87.0
D75	48.3	75.8	81.3	71.7		113.7	161.3	155.5	144.9
D84	60.6	88.3	93.7	84.9		132.9	182.6	195.1	173.3
dg	17.2	31.5	32.9	26.6		34.4	68.1	46.3	49.0
FREDLE	7.3	16.7	19.4	12.9		12.5	39.4	17.3	19.5
% FINES<2mm	10.9%	6.5%	9.8%	9.1%		7.1%	5.3%	7.2%	6.5%
% FINES<0.85mm	6.5%	5.0%	6.7%	6.1%		2.8%	2.3%	3.5%	2.8%
PERMEABILITY	1450	791	329	2985.5		362	126	205	230.2

Table 1. Individual bulk sample and mean site surface and subsurface particle size distributions, particle size indexes, mean within sample permeability and site permeability and pebble counts (cont)

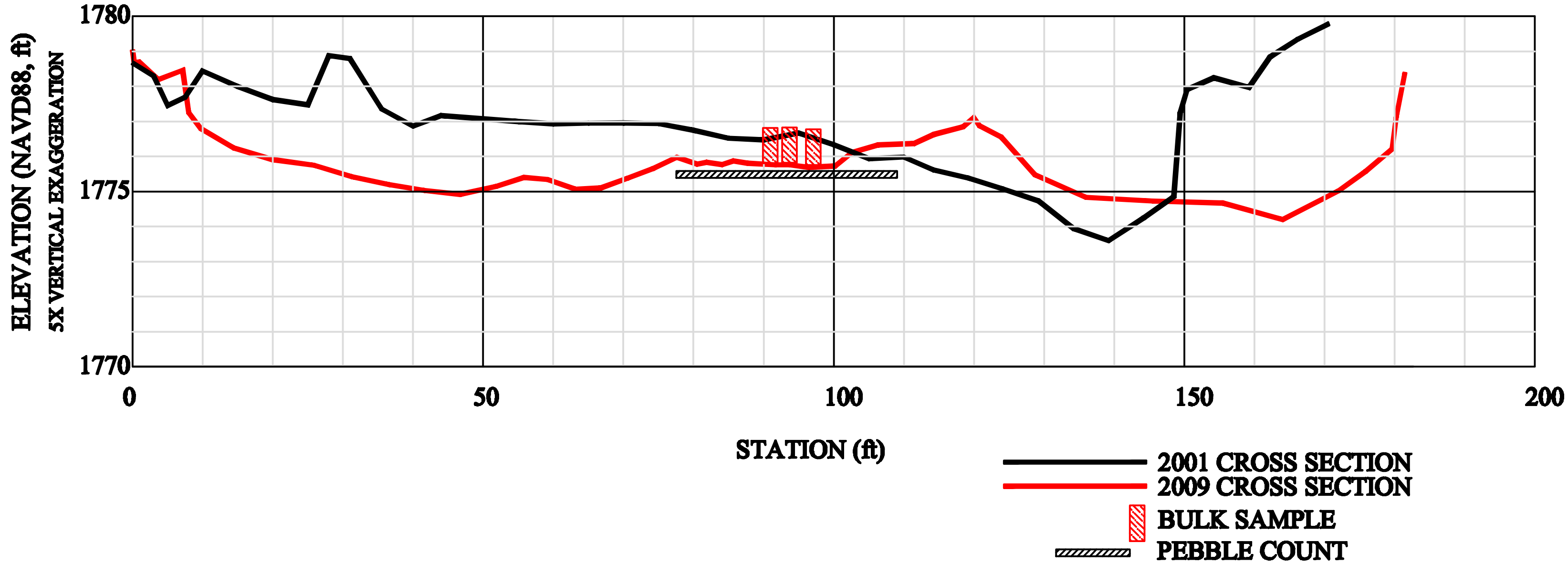
SITE STATION	RUSH HAB POLY NO REDDS 1	RUSH HAB POLY NO REDDS 2	RUSH HAB POLY NO REDDS 3	RUSH HAB POLY NO REDDS MEAN	RUSH HAB POLY WREDDS 1	RUSH HAB POLY WREDDS 2	RUSH HAB POLY WREDDS 3	RUSH HAB POLY WREDDS MEAN	OLD LEWISTON BRIDGE 1
CUM. % FINER THAN (SURFACE)									
360	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
256	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
180	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	66.60%
128	85.04%	100.00%	82.88%	88.33%	100.00%	100.00%	100.00%	100.00%	66.60%
90	64.61%	71.53%	52.41%	62.11%	100.00%	93.22%	100.00%	97.63%	52.31%
64	39.11%	53.59%	50.18%	47.03%	98.04%	44.72%	76.82%	72.68%	36.97%
45	25.69%	38.37%	33.45%	31.93%	78.71%	26.77%	52.30%	52.19%	24.52%
31.5	16.46%	29.39%	21.24%	21.70%	57.95%	14.68%	29.90%	33.93%	16.87%
22.4	10.94%	19.99%	13.59%	14.36%	39.07%	10.64%	17.79%	22.38%	11.55%
16	7.03%	14.30%	8.36%	9.48%	26.15%	6.81%	10.76%	14.50%	8.29%
11.2	4.41%	10.06%	5.39%	6.30%	18.54%	3.96%	6.06%	9.48%	6.18%
8	3.01%	7.56%	3.69%	4.49%	14.04%	2.65%	3.22%	6.63%	4.43%
5.6	2.28%	5.87%	2.65%	3.39%	10.72%	1.98%	1.86%	4.85%	3.06%
4	1.88%	4.83%	2.05%	2.74%	8.55%	1.57%	1.29%	3.81%	2.15%
2.8	1.54%	3.51%	1.44%	2.04%	6.81%	1.18%	0.80%	2.93%	1.45%
2	1.11%	2.31%	0.97%	1.39%	5.01%	0.83%	0.46%	2.11%	0.96%
1	0.43%	0.75%	0.35%	0.49%	2.15%	0.31%	0.14%	0.87%	0.35%
0.85	0.31%	0.56%	0.25%	0.36%	1.70%	0.23%	0.11%	0.68%	0.26%
0.5	0.11%	0.25%	0.10%	0.14%	0.78%	0.09%	0.05%	0.31%	0.11%
0.25	0.04%	0.11%	0.04%	0.06%	0.27%	0.03%	0.03%	0.11%	0.06%
0.125	0.02%	0.06%	0.02%	0.03%	0.08%	0.01%	0.01%	0.04%	0.03%
0.063	0.01%	0.02%	0.01%	0.01%	0.03%	0.00%	0.01%	0.01%	0.02%
CUM. % FINER THAN (SUBSURFACE)									
360	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
256	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
180	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
128	94.02%	94.55%	90.74%	92.28%	100.00%	91.73%	96.81%	96.54%	81.18%
90	77.23%	70.82%	75.71%	72.63%	96.41%	77.40%	80.30%	85.98%	79.51%
64	66.96%	60.23%	68.80%	62.45%	84.50%	69.51%	67.97%	73.26%	69.16%
45	59.03%	53.30%	59.59%	53.22%	75.44%	62.74%	62.04%	64.18%	60.64%
31.5	49.87%	45.52%	48.29%	43.63%	65.31%	55.25%	55.57%	54.78%	52.07%
22.4	43.33%	39.27%	41.10%	36.85%	53.30%	46.44%	48.02%	45.15%	44.23%
16	36.36%	33.57%	34.42%	30.64%	43.36%	38.49%	40.47%	36.84%	37.85%
11.2	30.54%	28.59%	28.73%	25.51%	36.46%	31.92%	33.19%	30.19%	32.01%
8	26.00%	24.63%	24.34%	21.61%	31.72%	26.88%	27.14%	25.24%	25.63%
5.6	22.58%	21.58%	21.02%	18.70%	27.46%	22.51%	21.98%	21.03%	17.94%
4	20.18%	19.23%	18.73%	16.63%	24.02%	19.04%	18.02%	17.77%	12.88%
2.8	17.09%	16.23%	16.17%	14.12%	19.99%	14.48%	12.45%	13.57%	9.15%
2	13.80%	13.03%	13.38%	11.43%	15.54%	10.34%	7.97%	9.73%	6.56%
1	6.76%	5.82%	6.67%	5.45%	7.53%	4.30%	2.53%	4.08%	3.05%
0.85	5.29%	4.37%	5.20%	4.21%	5.90%	3.28%	1.81%	3.11%	2.45%
0.5	2.24%	1.46%	2.00%	1.62%	2.31%	1.22%	0.60%	1.17%	1.12%
0.25	0.82%	0.37%	0.61%	0.52%	0.56%	0.30%	0.15%	0.29%	0.40%
0.125	0.23%	0.12%	0.18%	0.15%	0.16%	0.08%	0.04%	0.08%	0.18%
0.063	0.05%	0.05%	0.06%	0.05%	0.06%	0.03%	0.02%	0.03%	0.08%
PARTICLE SIZE DISTRIBUTION INDEXES									
D16	2.5	2.7	2.7	2.6	2.1	3.2	3.5	2.9	4.9
D25	7.2	8.3	8.4	8.0	4.4	6.9	6.9	6.2	7.8
D50	32.2	38.9	33.7	34.4	20.0	25.9	24.6	23.3	29.1
D75	83.6	95.8	86.9	90.5	44.3	81.1	77.7	67.5	77.6
D84	103.7	109.4	109.3	107.6	62.8	105.9	97.4	90.0	134.7
dg	20.5	23.6	21.8	21.9	13.6	20.5	20.5	18.2	23.7
FREDLE	6.0	6.9	6.8	6.5	4.3	6.0	6.1	5.5	7.5
% FINES<2mm	13.8%	13.0%	13.4%	13.4%	15.5%	10.3%	8.0%	11.0%	6.6%
% FINES<0.85mm	5.3%	4.4%	5.2%	5.0%	5.9%	3.3%	1.8%	3.5%	2.5%
PERMEABILITY	294	429	321	348.0	519	475	1214	1367.4	

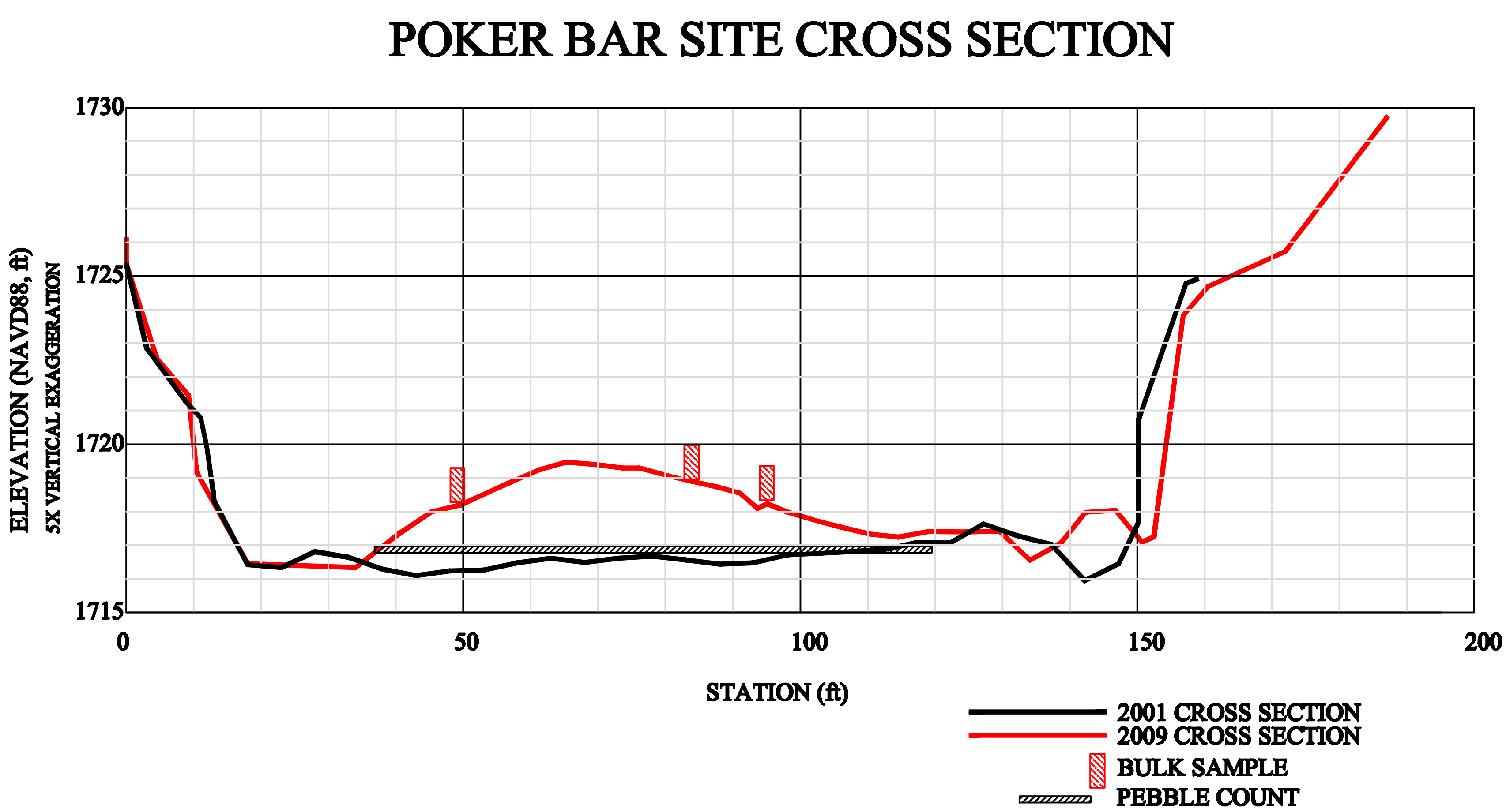
APPENDIX A

TRENDS IN SUBSTRATE COMPOSITION OF THE TRINITY RIVER, 1991-2009

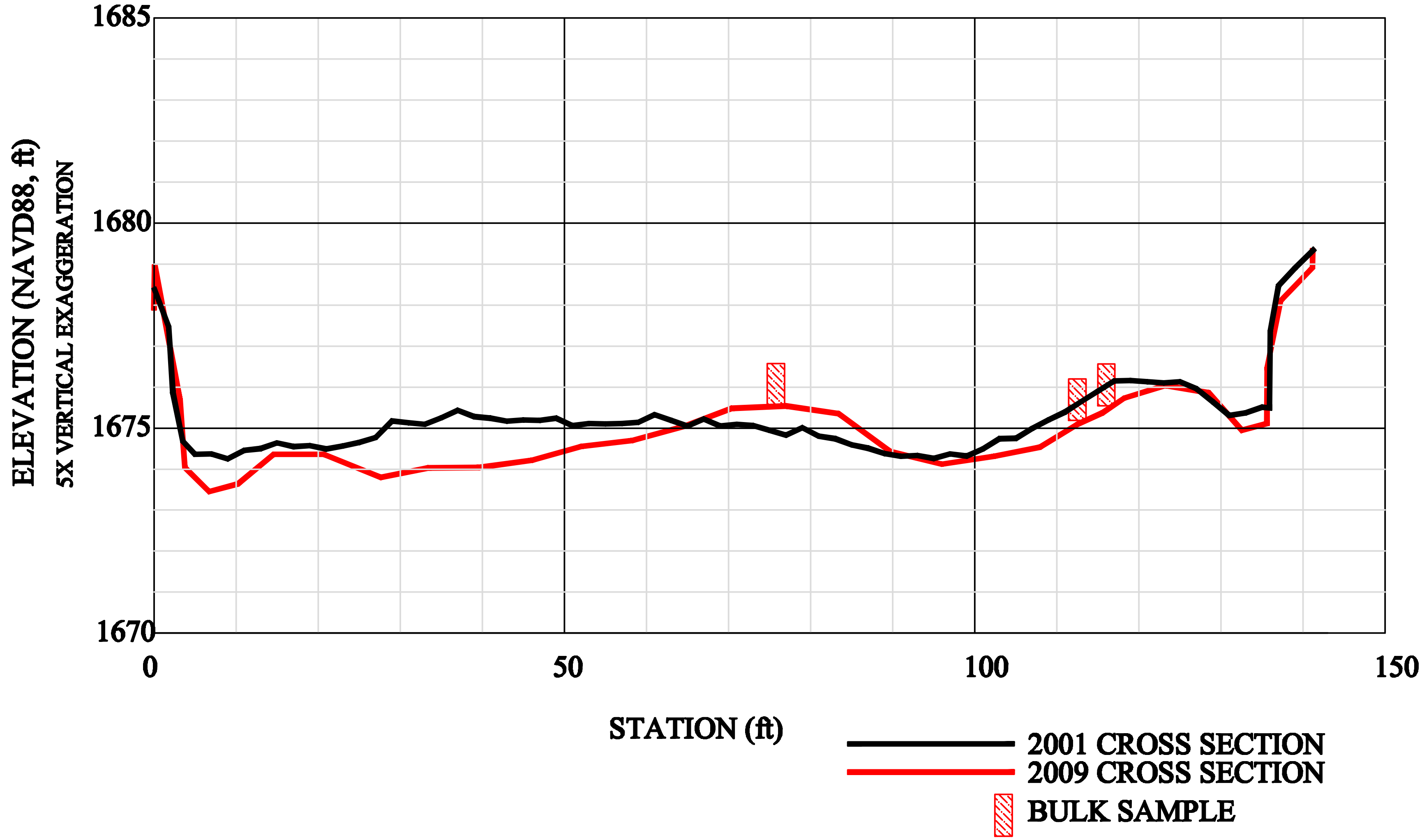
SITE CROSS SECTIONS

RUSH CREEK SITE CROSS SECTION

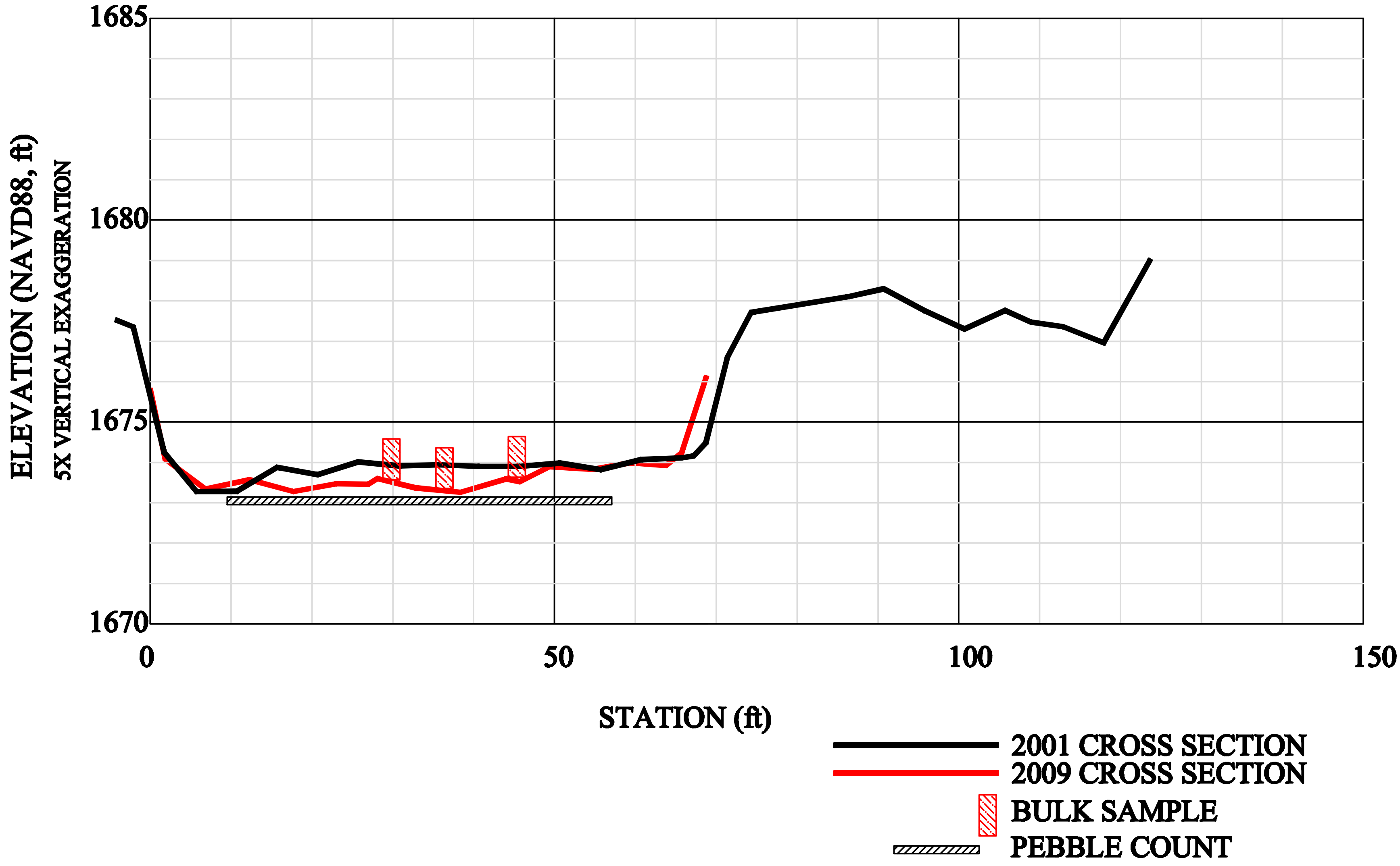



POKER BAR SITE CROSS SECTION
ELEVATION (NAVD88, ft)
5X VERTICAL EXAGGERATION
1730
1725
1720
1715
0
50
100
150
200
STATION (ft)
2001 CROSS SECTION
2009 CROSS SECTION
BULK SAMPLE
PEBBLE COUNT

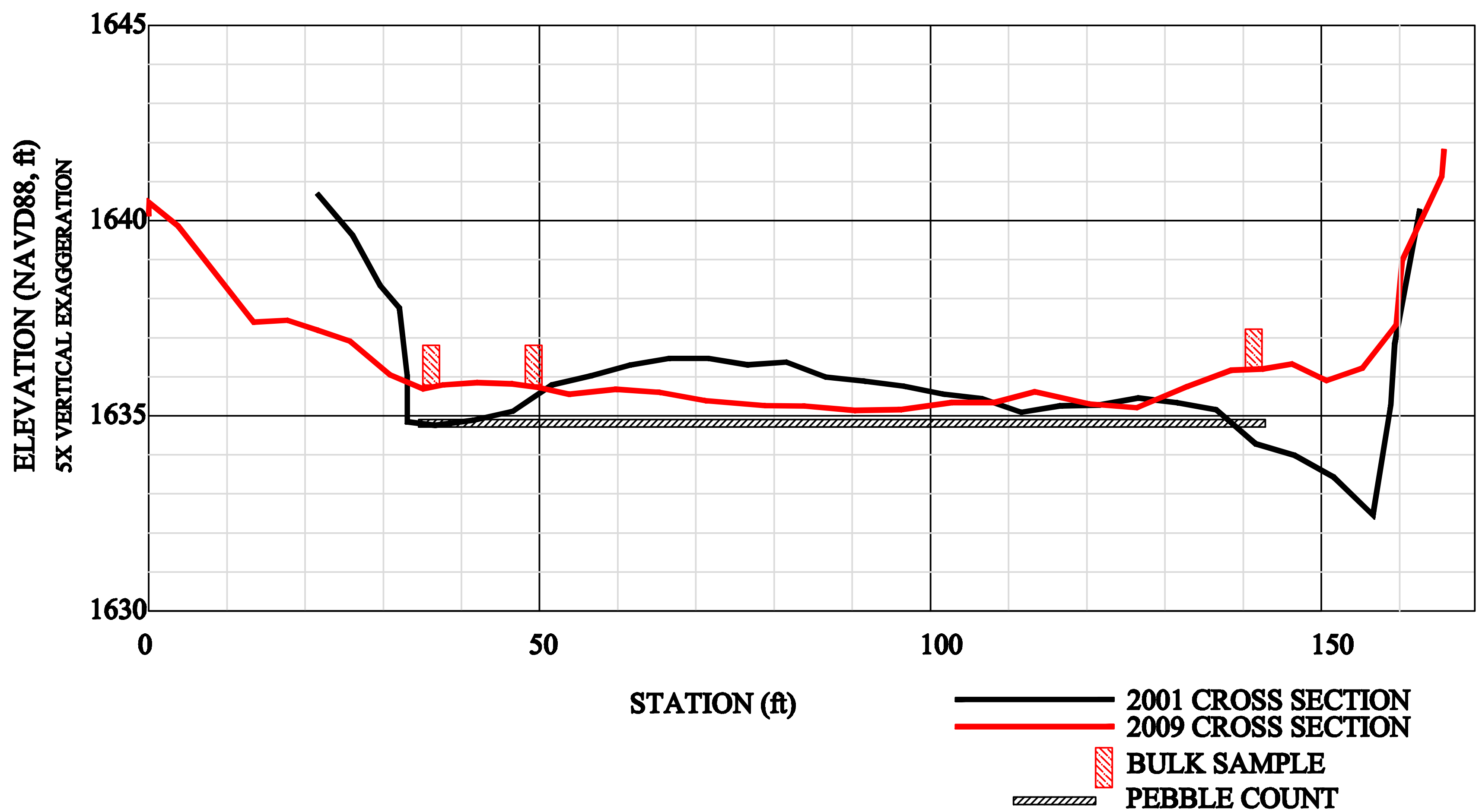
STEELBRIDGE US SITE CROSS SECTION

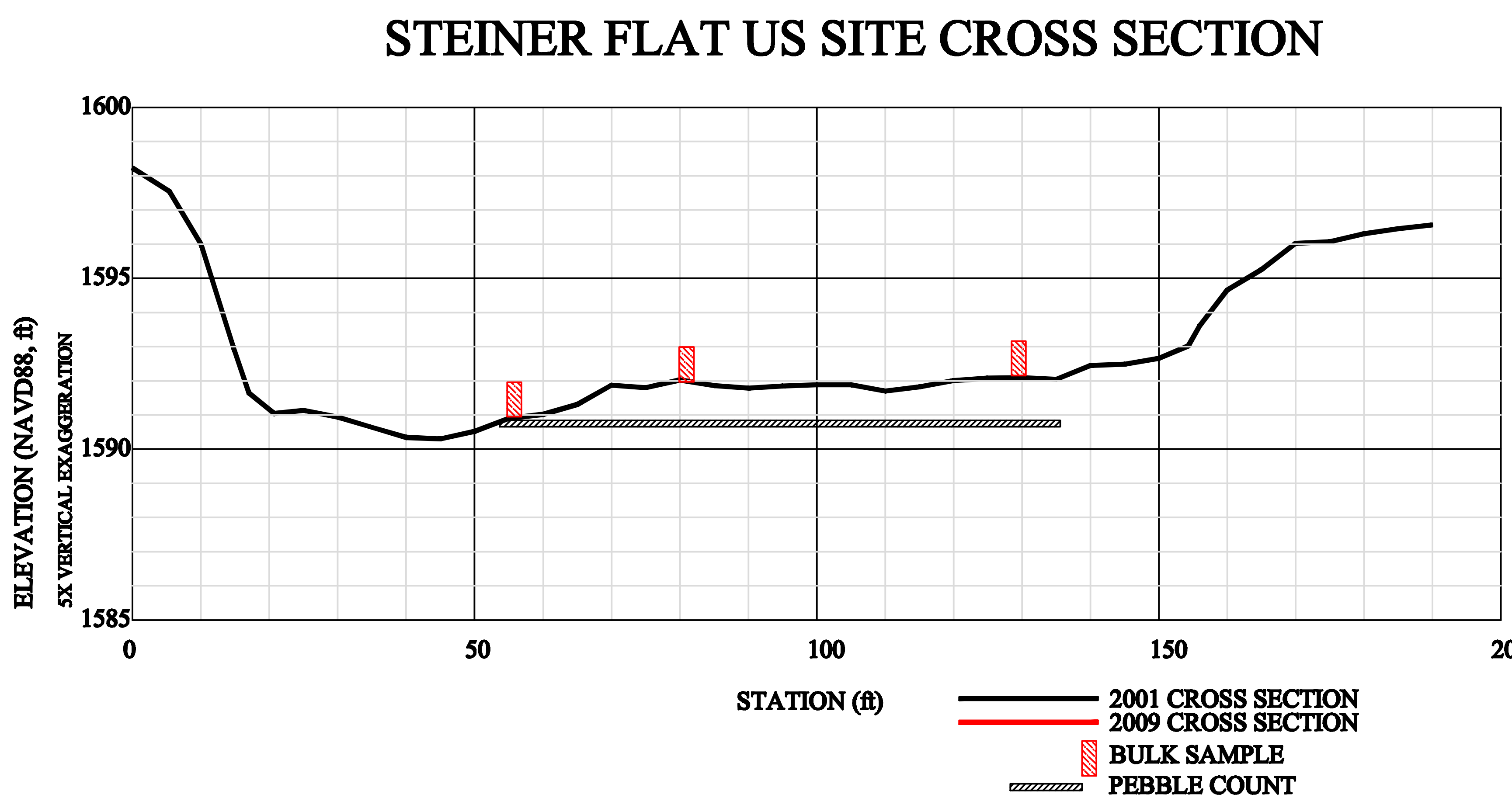


STEELBRIDGE DS SITE CROSS SECTION

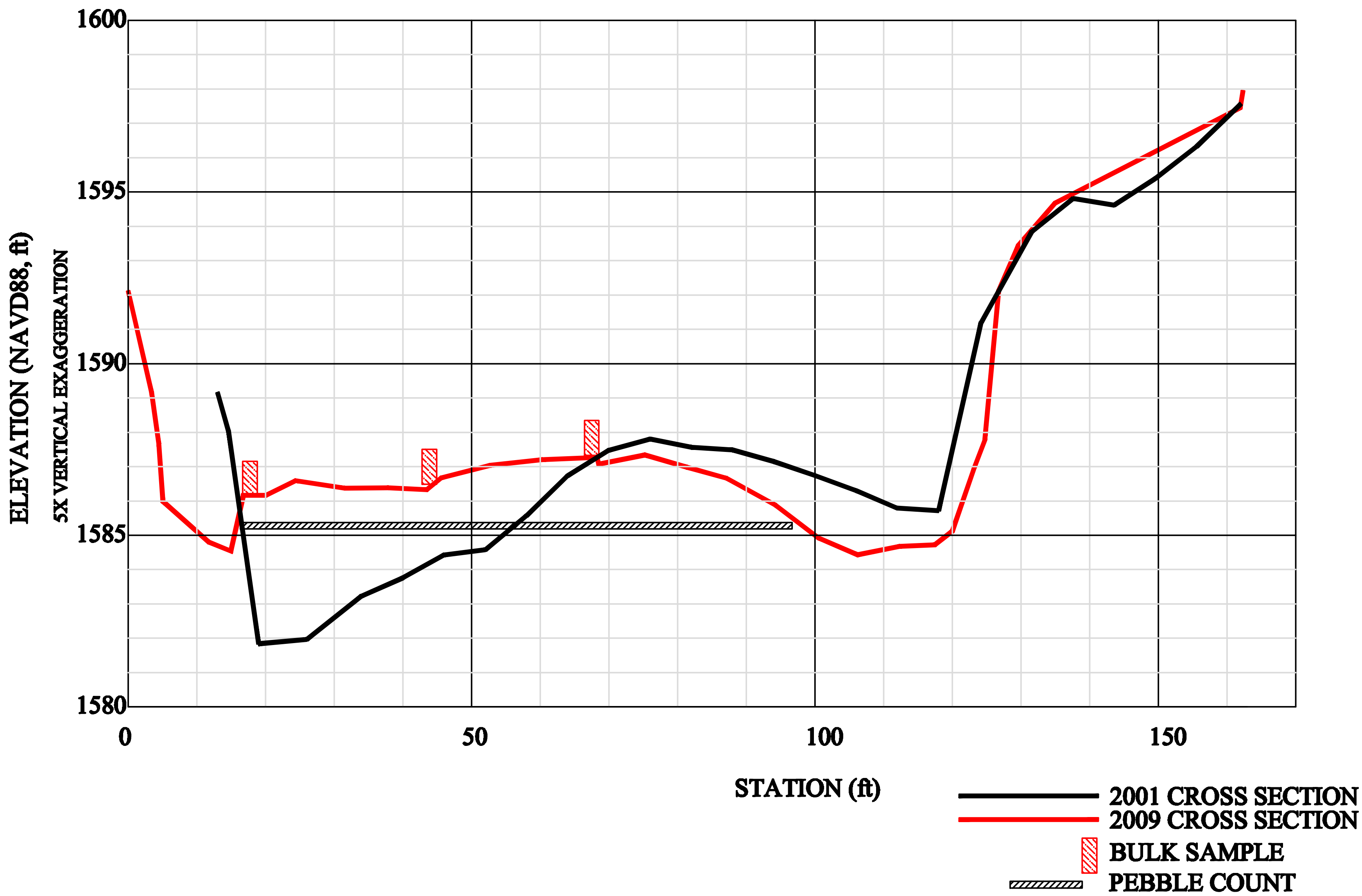


INDIAN CREEK SITE CROSS SECTION

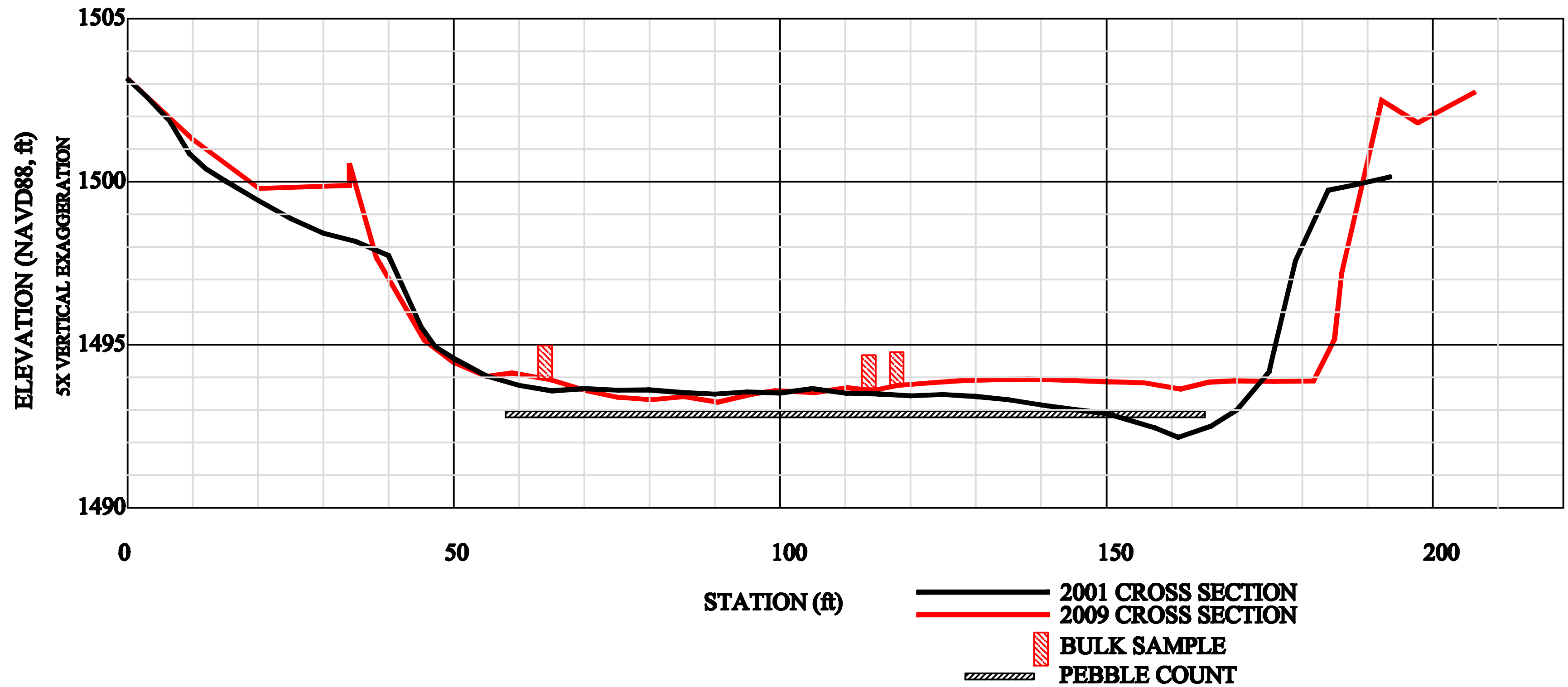



STEINER FLAT US SITE CROSS SECTION
ELEVATION (NAVD88, ft)
5X VERTICAL EXAGGERATION
1600
1595
1590
1585
0
50
100
150
200
STATION (ft)
2001 CROSS SECTION
2009 CROSS SECTION
BULK SAMPLE
PEBBLE COUNT

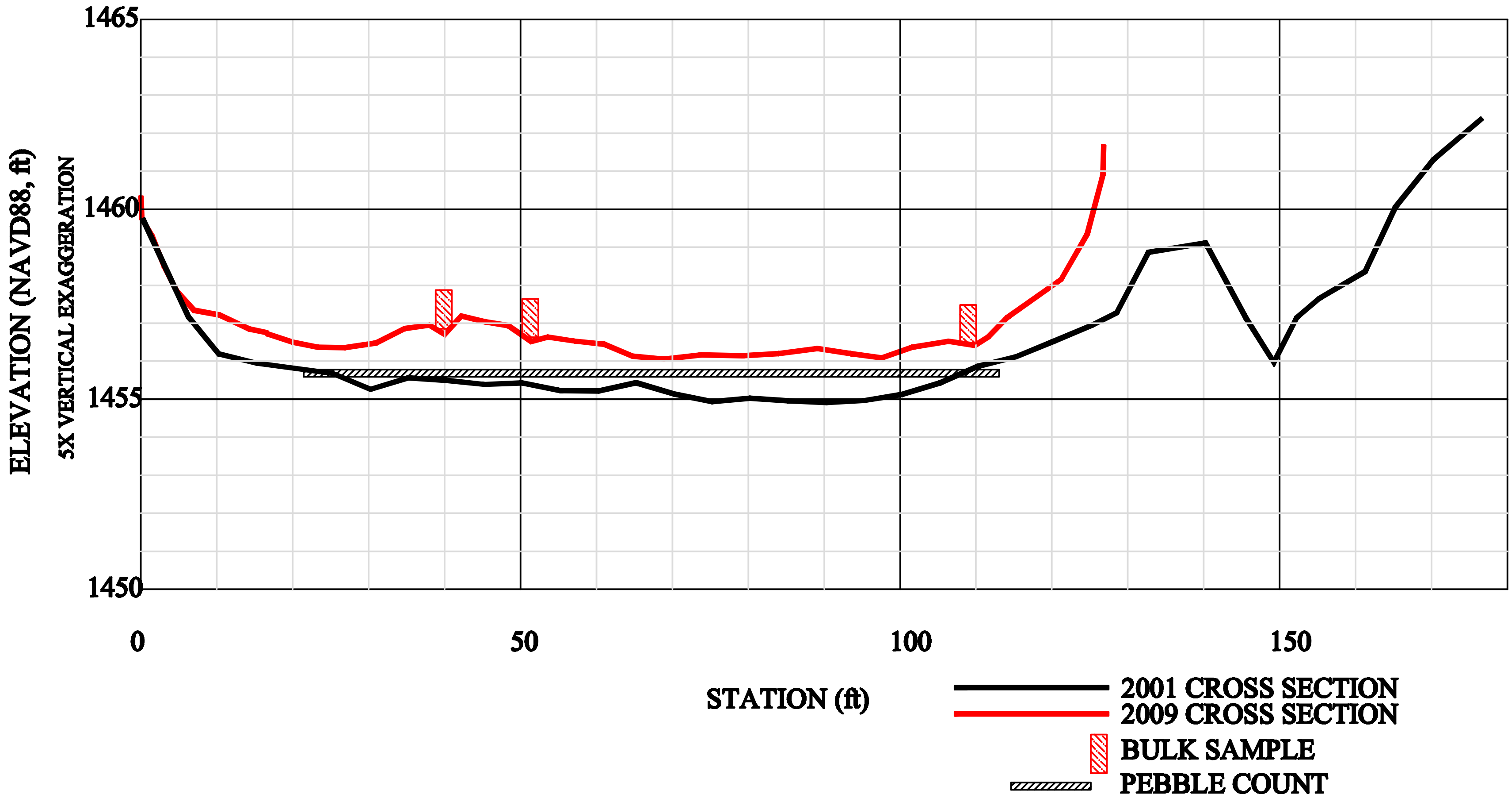
STEINER FLAT DS SITE CROSS SECTION



EVANS BAR SITE CROSS SECTION



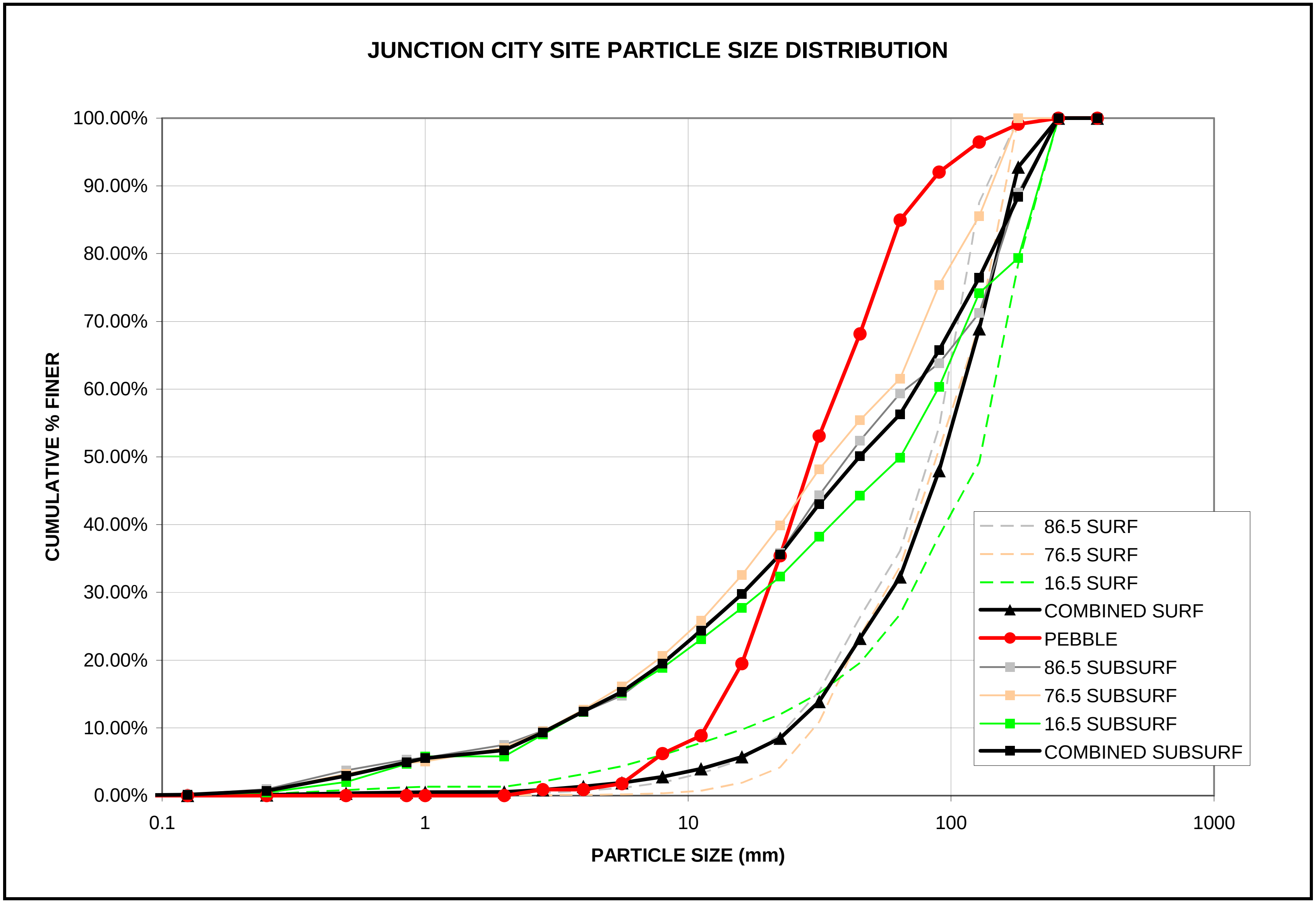
JUNCTION CITY SITE CROSS SECTION



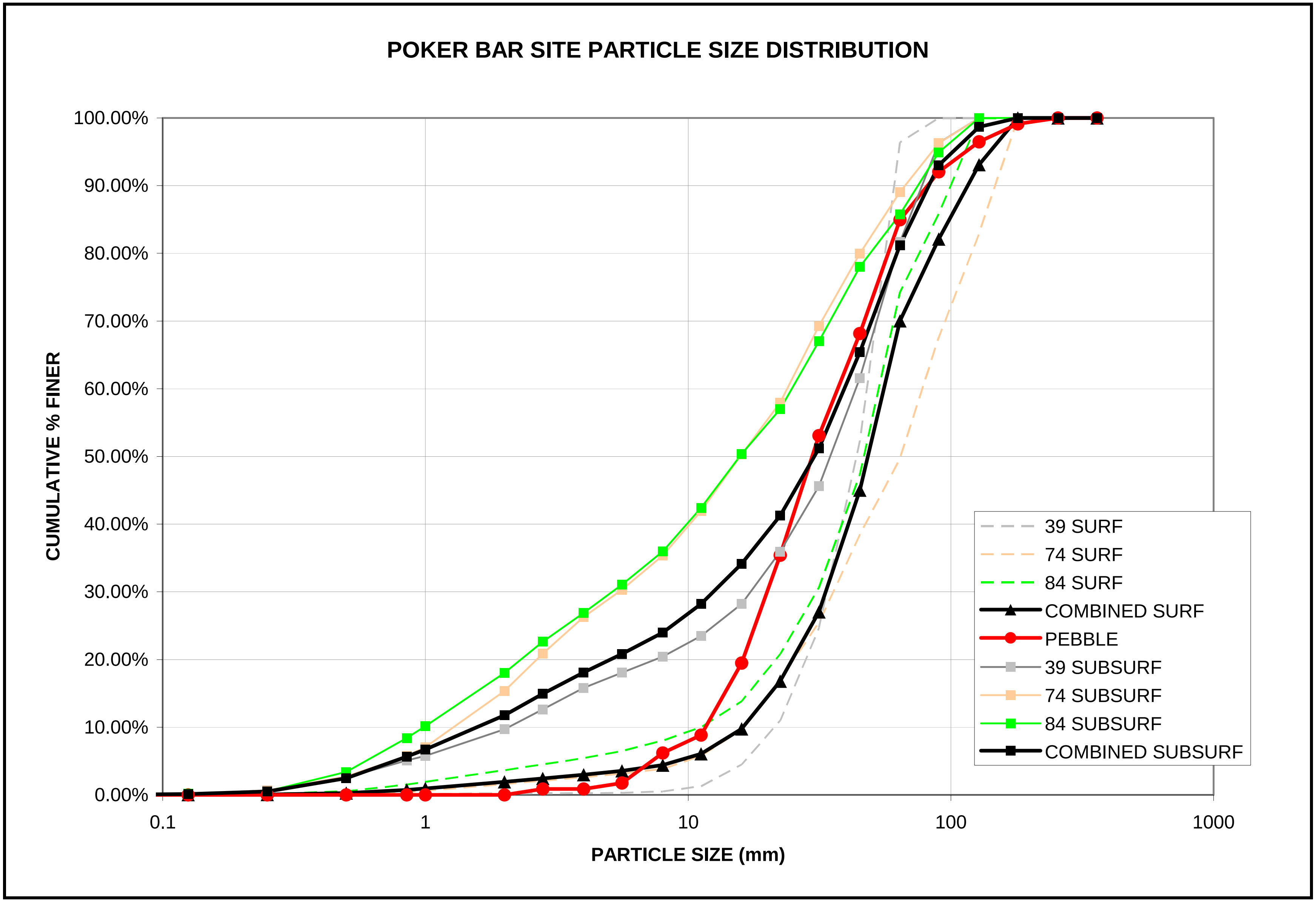
APPENDIX B

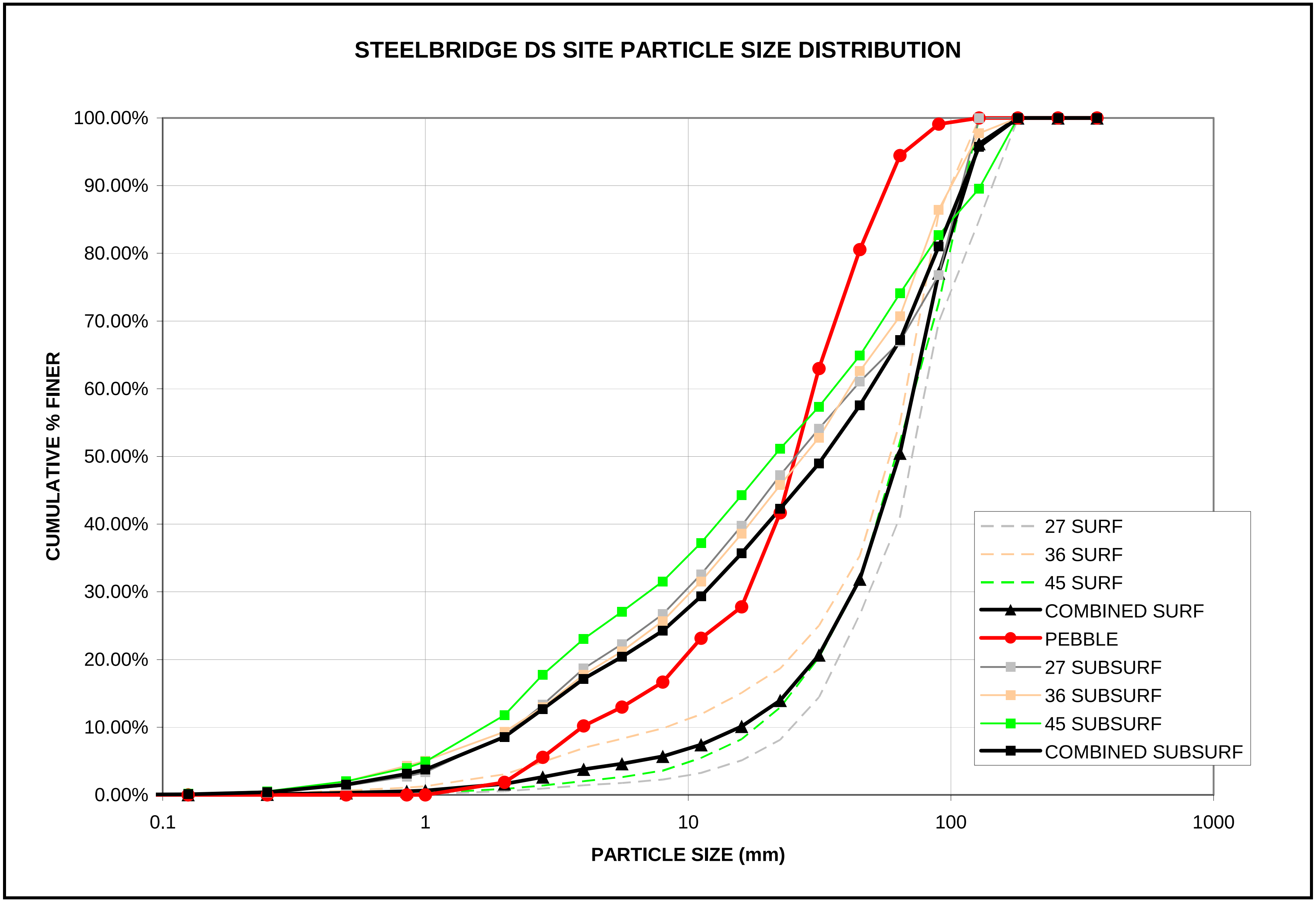
TRENDS IN SUBSTRATE COMPOSITION OF THE TRINITY RIVER, 1991-2009

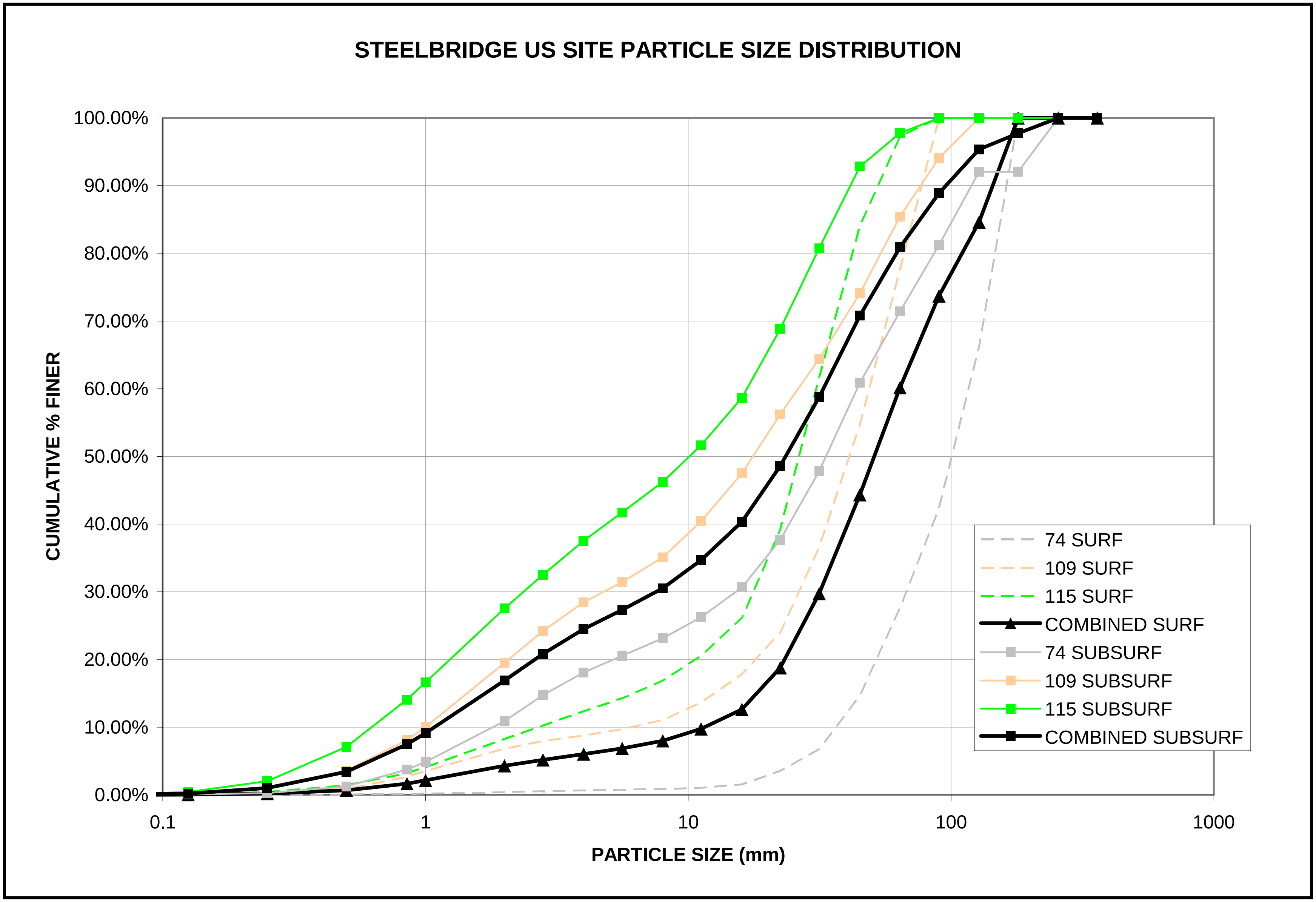
CUMULATIVE PARTICLE SIZE DISTRIBUTION CURVES



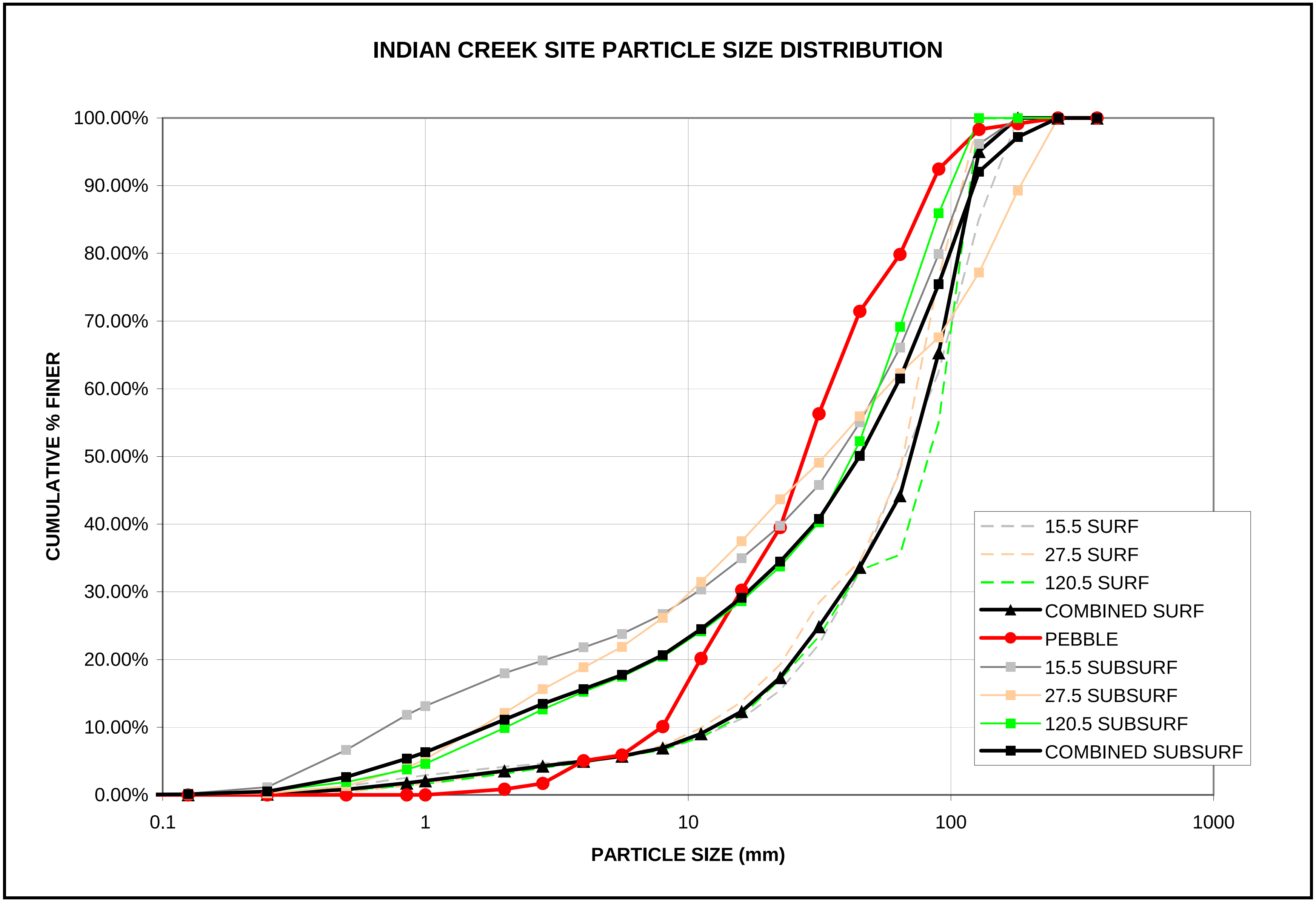
JUNCTION CITY SITE PARTICLE SIZE DISTRIBUTION
CUMULATIVE % FINER
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
0.1
1
10
100
1000
PARTICLE SIZE (mm)
86.5 SURF
76.5 SURF
16.5 SURF
COMBINED SURF
PEBBLE
86.5 SUBSURF
76.5 SUBSURF
16.5 SUBSURF
COMBINED SUBSURF


POKER BAR SITE PARTICLE SIZE DISTRIBUTION
CUMULATIVE % FINER
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
0.1
1
10
100
1000
PARTICLE SIZE (mm)
39 SURF
74 SURF
84 SURF
COMBINED SURF
PEBBLE
39 SUBSURF
74 SUBSURF
84 SUBSURF
COMBINED SUBSURF

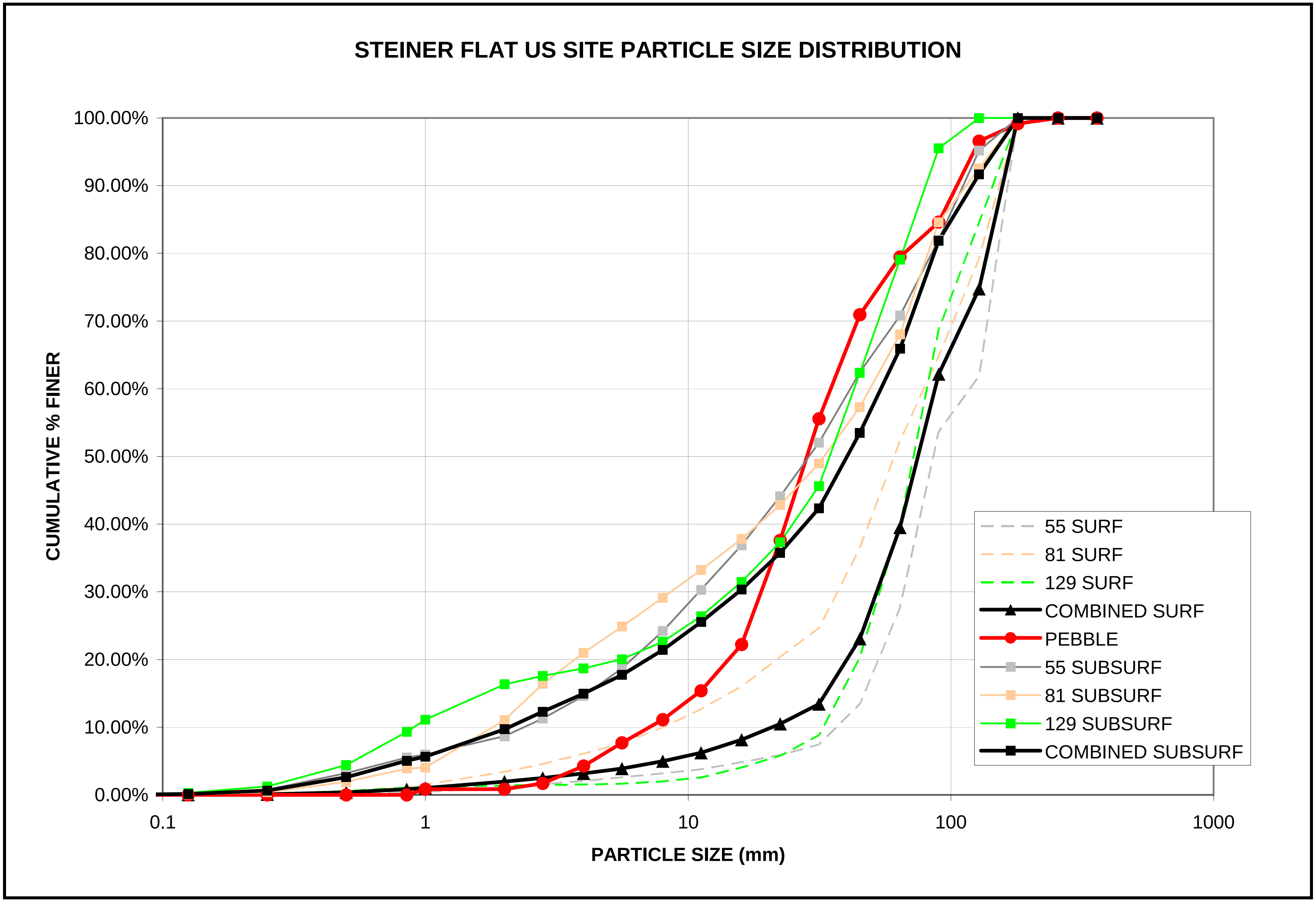

STEELBRIDGE DS SITE PARTICLE SIZE DISTRIBUTION
CUMULATIVE % FINER
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
0.1
1
10
100
1000
PARTICLE SIZE (mm)
27 SURF
36 SURF
45 SURF
COMBINED SURF
PEBBLE
27 SUBSURF
36 SUBSURF
45 SUBSURF
COMBINED SUBSURF



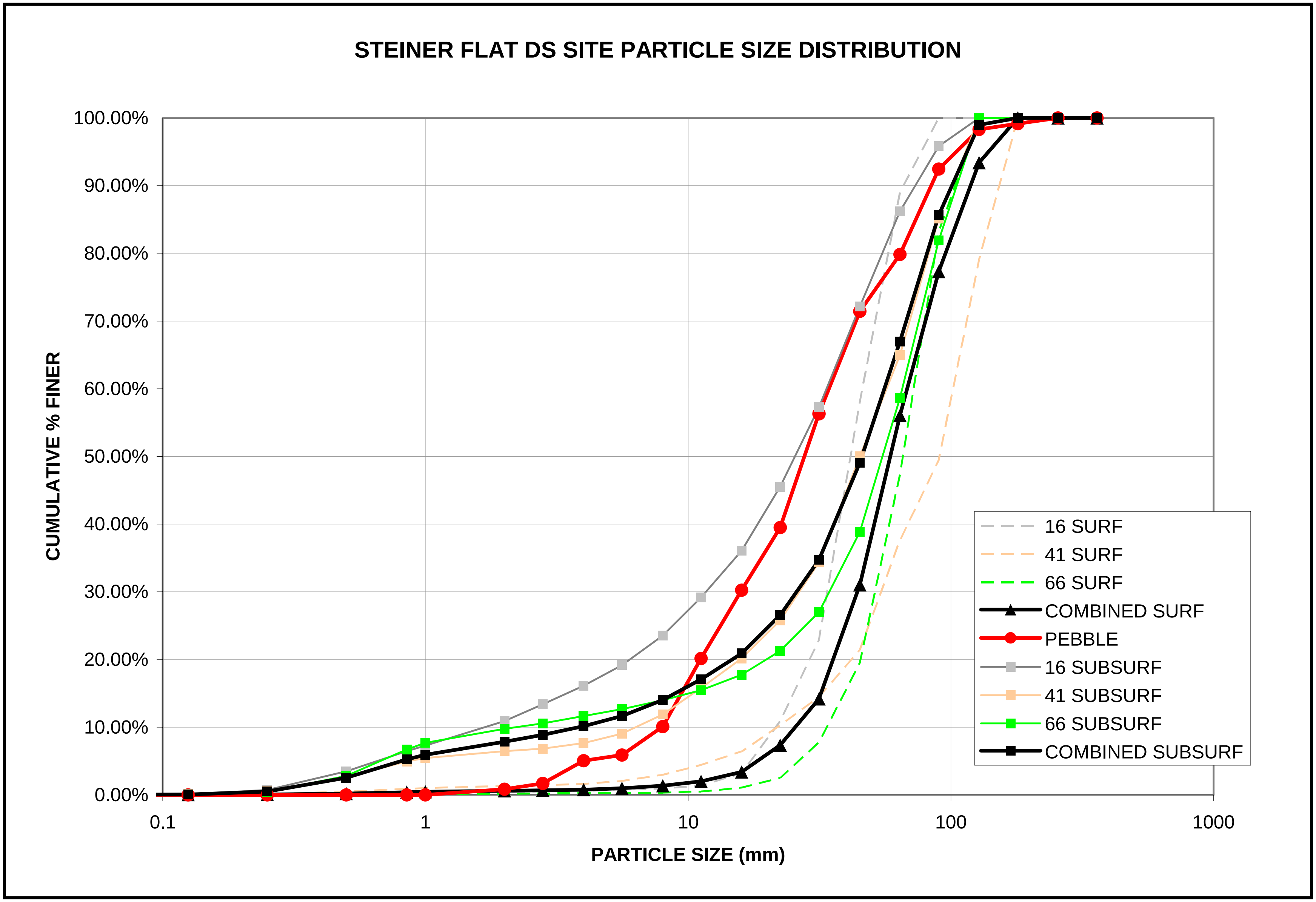
STEELBRIDGE US SITE PARTICLE SIZE DISTRIBUTION
CUMULATIVE % FINER
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
0.1
1
10
100
1000
PARTICLE SIZE (mm)
74 SURF
109 SURF
115 SURF
COMBINED SURF
74 SUBSURF
109 SUBSURF
115 SUBSURF
COMBINED SUBSURF

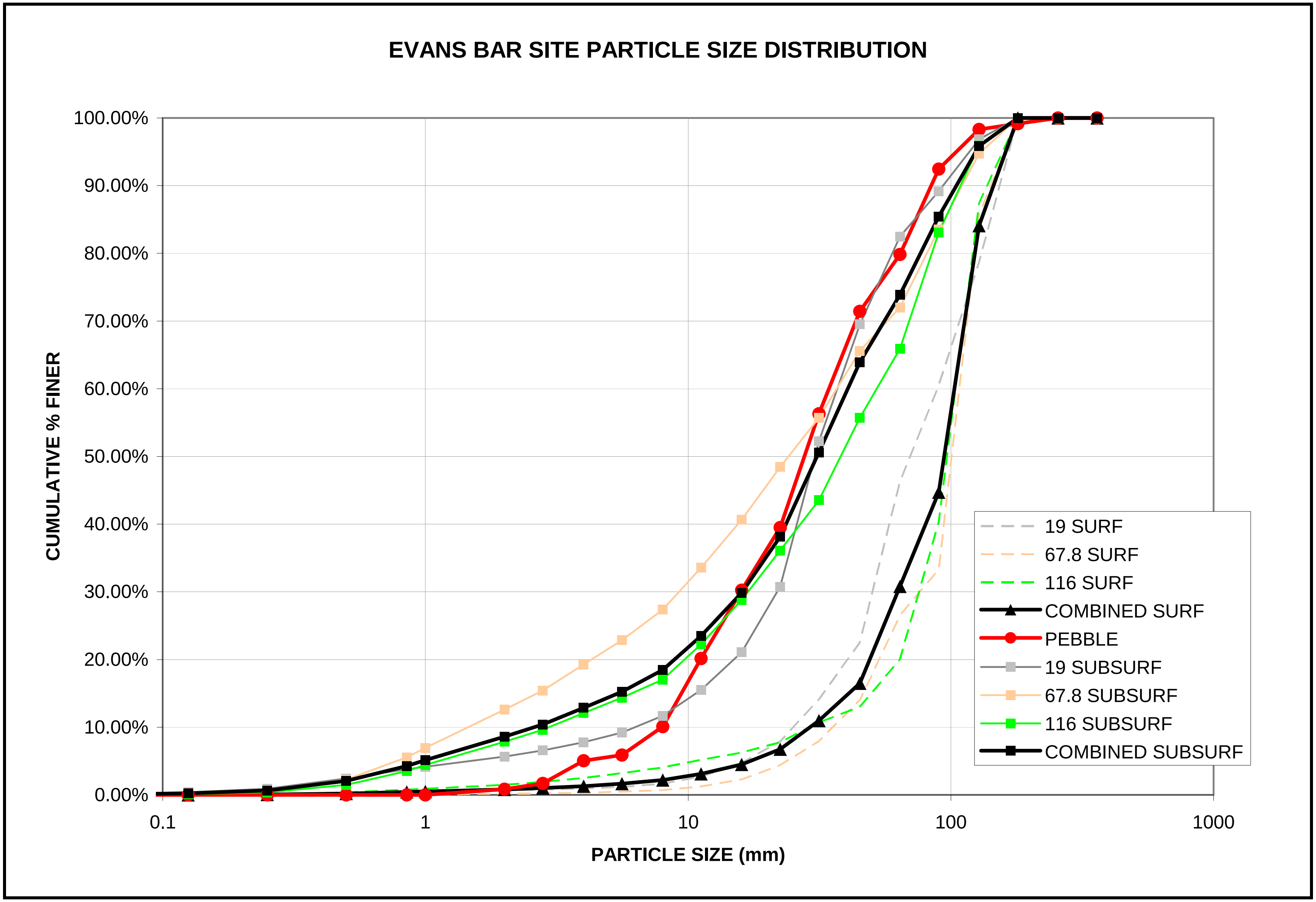


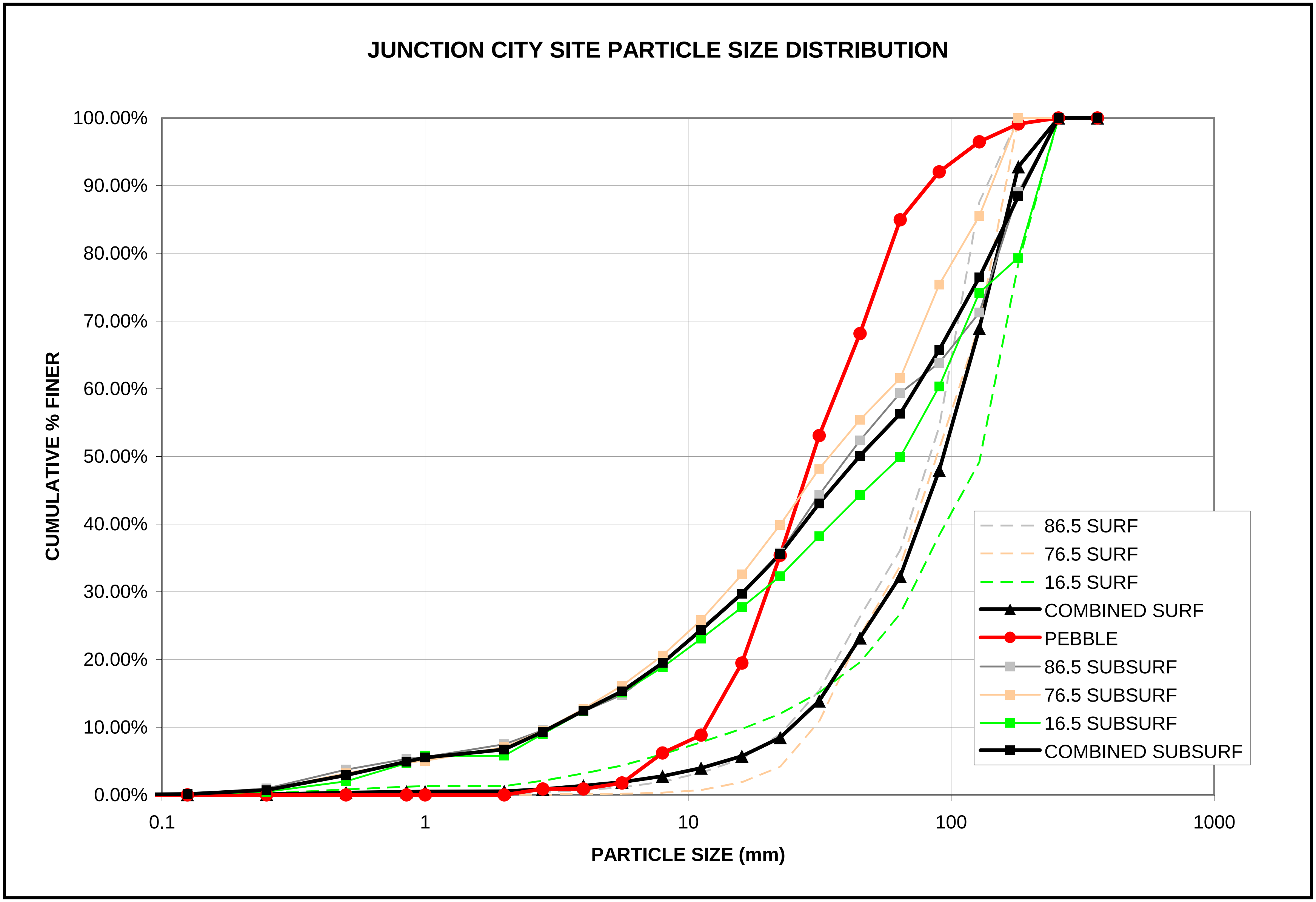
INDIAN CREEK SITE PARTICLE SIZE DISTRIBUTION
CUMULATIVE % FINER
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
0.1
1
10
100
1000
PARTICLE SIZE (mm)
15.5 SURF
27.5 SURF
120.5 SURF
COMBINED SURF
PEBBLE
15.5 SUBSURF
27.5 SUBSURF
120.5 SUBSURF
COMBINED SUBSURF

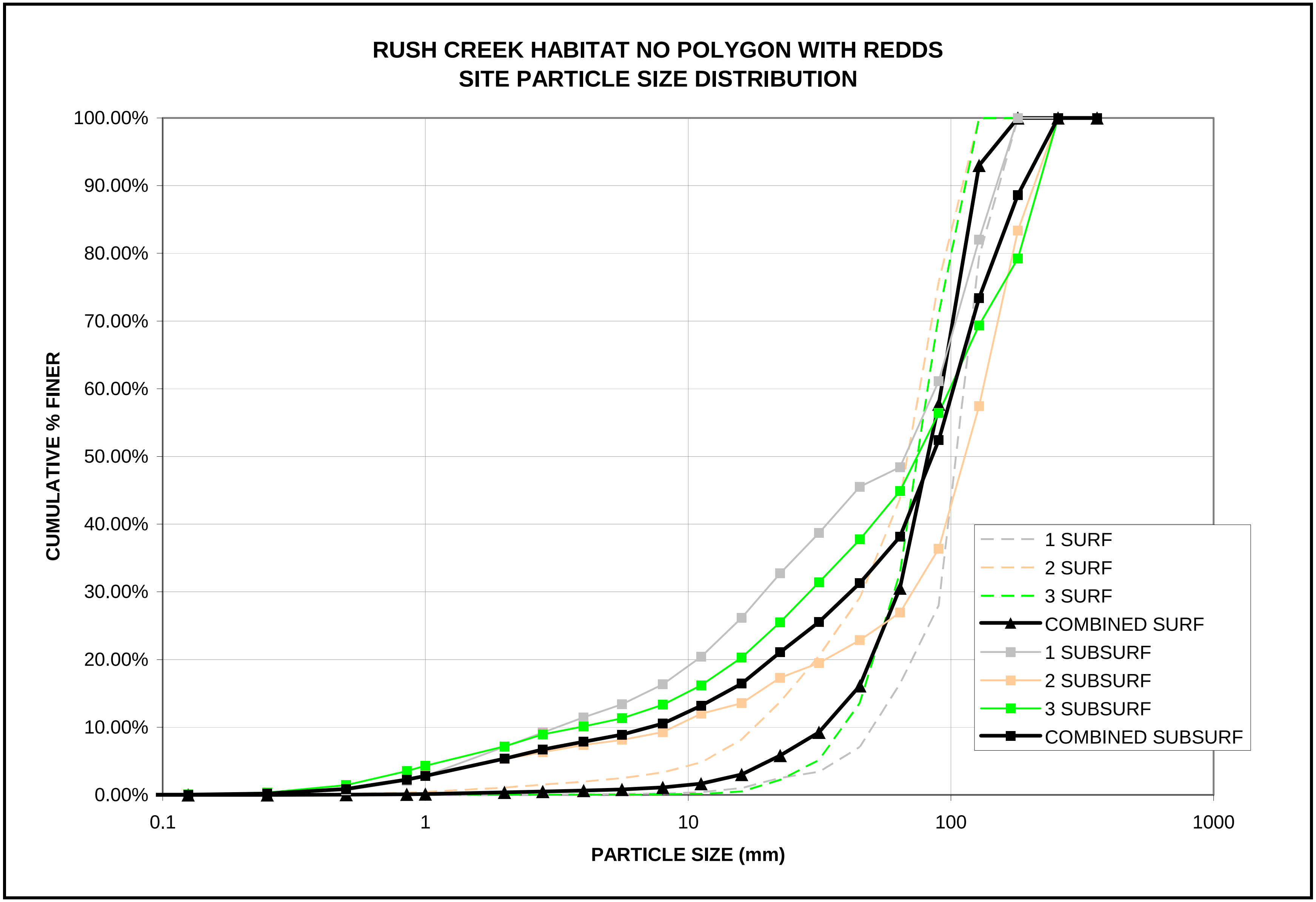


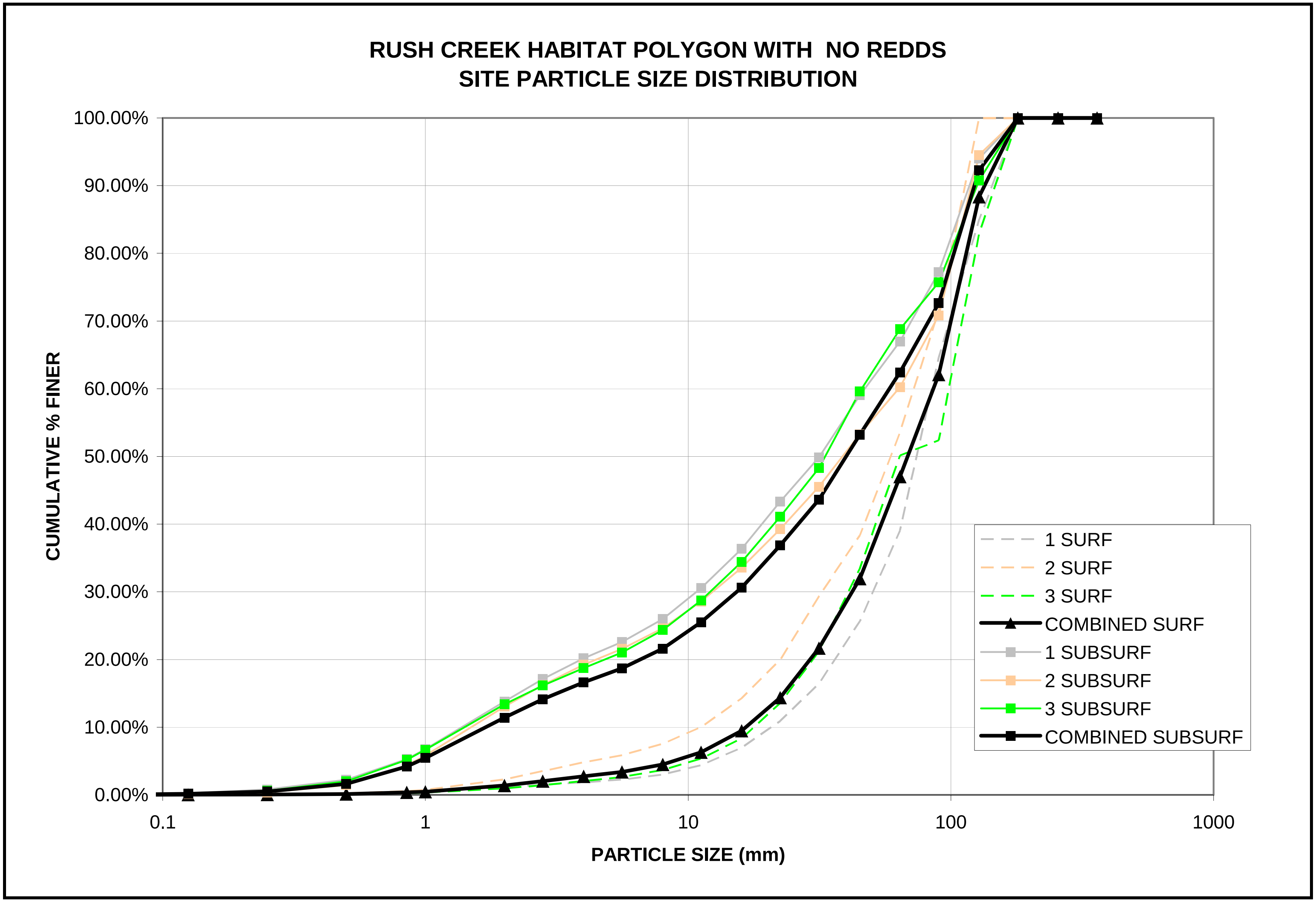
STEINER FLAT US SITE PARTICLE SIZE DISTRIBUTION
CUMULATIVE % FINER
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
0.1
1
10
100
1000
PARTICLE SIZE (mm)
55 SURF
81 SURF
129 SURF
COMBINED SURF
PEBBLE
55 SUBSURF
81 SUBSURF
129 SUBSURF
COMBINED SUBSURF

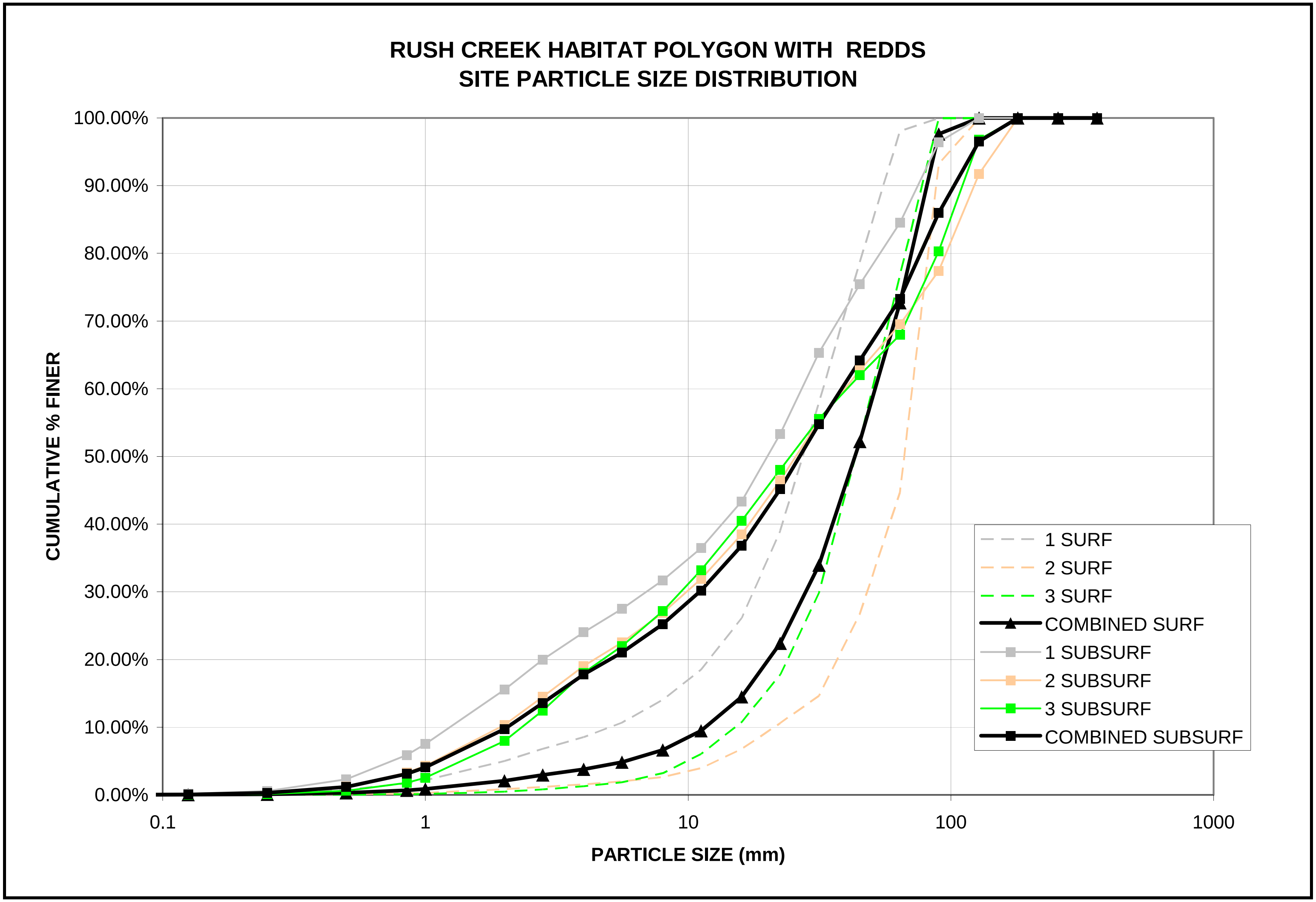

STEINER FLAT DS SITE PARTICLE SIZE DISTRIBUTION
CUMULATIVE % FINER
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
0.1
1
10
100
1000
PARTICLE SIZE (mm)
16 SURF
41 SURF
66 SURF
COMBINED SURF
PEBBLE
16 SUBSURF
41 SUBSURF
66 SUBSURF
COMBINED SUBSURF


EVANS BAR SITE PARTICLE SIZE DISTRIBUTION
CUMULATIVE % FINER
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
0.1
1
10
100
1000
PARTICLE SIZE (mm)
19 SURF
67.8 SURF
116 SURF
COMBINED SURF
PEBBLE
19 SUBSURF
67.8 SUBSURF
116 SUBSURF
COMBINED SUBSURF

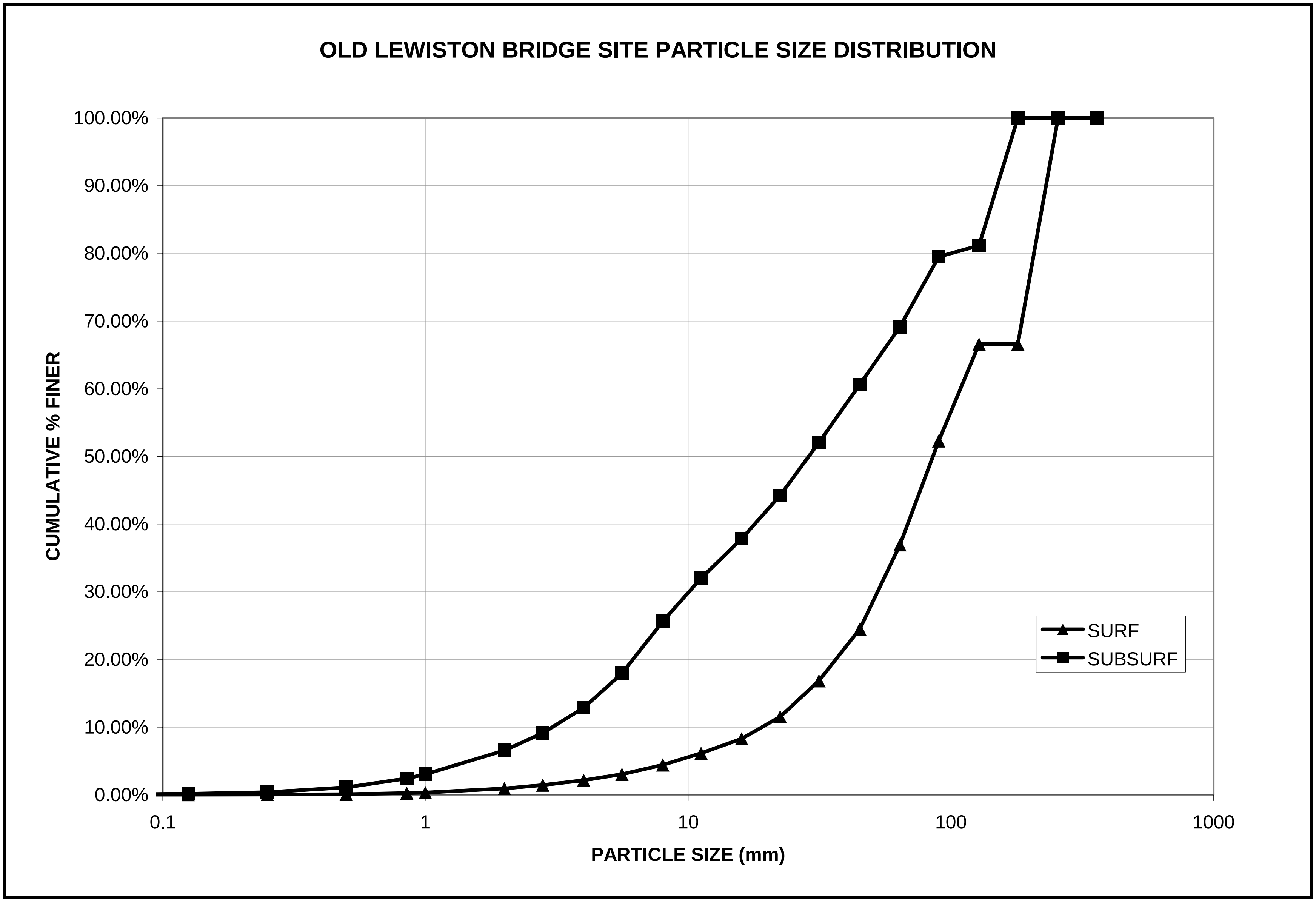

JUNCTION CITY SITE PARTICLE SIZE DISTRIBUTION
CUMULATIVE % FINER
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
0.1
1
10
100
1000
PARTICLE SIZE (mm)
86.5 SURF
76.5 SURF
16.5 SURF
COMBINED SURF
PEBBLE
86.5 SUBSURF
76.5 SUBSURF
16.5 SUBSURF
COMBINED SUBSURF


RUSH CREEK HABITAT NO POLYGON WITH REDDS
SITE PARTICLE SIZE DISTRIBUTION
CUMULATIVE % FINER
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
0.1
1
10
100
1000
PARTICLE SIZE (mm)
1 SURF
2 SURF
3 SURF
COMBINED SURF
1 SUBSURF
2 SUBSURF
3 SUBSURF
COMBINED SUBSURF


RUSH CREEK HABITAT POLYGON WITH NO REDDS
SITE PARTICLE SIZE DISTRIBUTION
CUMULATIVE % FINER
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
0.1
1
10
100
1000
PARTICLE SIZE (mm)
1 SURF
2 SURF
3 SURF
COMBINED SURF
1 SUBSURF
2 SUBSURF
3 SUBSURF
COMBINED SUBSURF



RUSH CREEK HABITAT POLYGON WITH REDDS
SITE PARTICLE SIZE DISTRIBUTION
CUMULATIVE % FINER
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
0.1
1
10
100
1000
PARTICLE SIZE (mm)
1 SURF
2 SURF
3 SURF
COMBINED SURF
1 SUBSURF
2 SUBSURF
3 SUBSURF
COMBINED SUBSURF


OLD LEWISTON BRIDGE SITE PARTICLE SIZE DISTRIBUTION
CUMULATIVE % FINER
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
0.1
1
10
100
1000
PARTICLE SIZE (mm)
SURF
SUBSURF