Mitigation Report
Kings Creek Restoration Project
Transylvania County, North Carolina

HU 06010105

SCO ID # 01-05721-01A

Prepared For:

North Carolina Department of Environment and Natural Resources
Ecosystem Enhancement Program

Prepared By:

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Project Engineer

EEP Project Manager: Michael McDonald

Executive Summary

In 2005 and 2006, the North Carolina Ecosystem Enhancement Program (EEP) restored 2,119 linear feet of stream along three reaches of Kings Creek in Brevard, North Carolina. The project reaches are located on Brevard College property and are bordered on the right (south) bank by eight private parcels. The downstream end of the project reach is about 6/10 of a mile upstream of the Kings Creek confluence with the French Broad River (USGS Hydrologic Unit 06010105).

Prior to restoration, Kings Creek had been straightened and was incised due to historic channel and buffer alterations. Active bank erosion along the project was a significant water quality and safety problem. The lack of riparian vegetation, particularly along the left bank, coupled with water quality degradation impacted the aquatic habitat.

The primary goals of the project were to improve water quality and gain stream mitigation credit. The stream restoration design was based on natural channel design principles and accounted for drainage area, adjacent land uses, and future development potential. The design addressed the channel dimension, pattern, and profile based on reference reach parameters and hydraulic geometry relationships.

The following table summarizes reach lengths and restoration approaches. One landowner in Reach 2 chose to not grant a conservation easement and no work was performed on the right bank of this parcel. In addition to reducing bank erosion, improving water quality and enhancing aquatic habitat, the restoration project resulted in the creation of an additional 304 linear feet of stream.

Reach	Pre-Project Length (ft)	Restored Length (ft)	Restoration Approach
1	824	990	Excavated new off-line bankfull channel and constructed floodplain at lower elevation (Priority 2 restoration of incised channel).
2	191	191	Excavated floodplain on left bank and stabilized left bank slopes. No work right bank
3	800	938	Excavated new off-line bankfull channel and constructed floodplain at lower elevation (Priority 2 restoration of incised channel).
Total	**1,815**	**2,119**	

Success criteria for geomorphic and vegetation parameters are discussed in detail in Section 4 of the report. In general, success will be defined by stable stream dimension, pattern and profile and survival of at least 81 percent of the planted riparian vegetation. The methodology for evaluating project performance is described in Section 3 of this report.

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1 Introduction

1.1 Project Goals

The goals of the Kings Creek Restoration Project are to improve the water quality, habitat value, and stability along the project reach and within the larger watershed. As in many developed watersheds, the increase of peak flow events, loss of floodplains and adjacent wetlands, and past manipulation of streams have caused a substantial loss of the ecological value and have resulted in degraded water quality. By stabilizing channels, establishing native riparian buffers, enhancing habitat structure, and allowing natural storage capacity for storm flows, the overall watershed health can be enhanced.

The specific objectives of the Kings Creek restoration project are to:

- Restore 2,119 linear feet of channel dimension, pattern, and profile to the extent possible;
- Improve floodplain functionality by matching floodplain elevation with bankfull stage, thereby increasing watershed attenuation and reducing peak flows;
- Establish native floodplain vegetation, which will allow treatment of diffuse storm flow and nutrient uptake while establishing part of a wildlife corridor in the watershed;
- Remove invasive exotic vegetation species from the stream corridor;
- Improve the natural aesthetics of the stream corridor; and,
- Improve the water quality in the Kings Creek watershed by reducing bank erosion, increasing nutrient storage and uptake, and increasing the dissolved oxygen of the system.

1.2 Project Location

The project site is located on the Brevard College campus, in Brevard, Transylvania County, North Carolina (Figure 1). Prior to restoration, the left bank of the creek was an un-mowed field and marsh. A recently-constructed track and softball field border the project reach to the north. Several private residences border the south (right) bank of the creek. The conservation easement area covers 6.1 acres, mainly on Brevard College property.

Kings Creek lies within the French Broad River basin (USGS Hydrologic Unit 06010105) and flows across the wide French Broad floodplain along the project reach. The immediate site topography is characterized by gently rolling hills and a wide alluvial valley with a dendritic stream pattern.

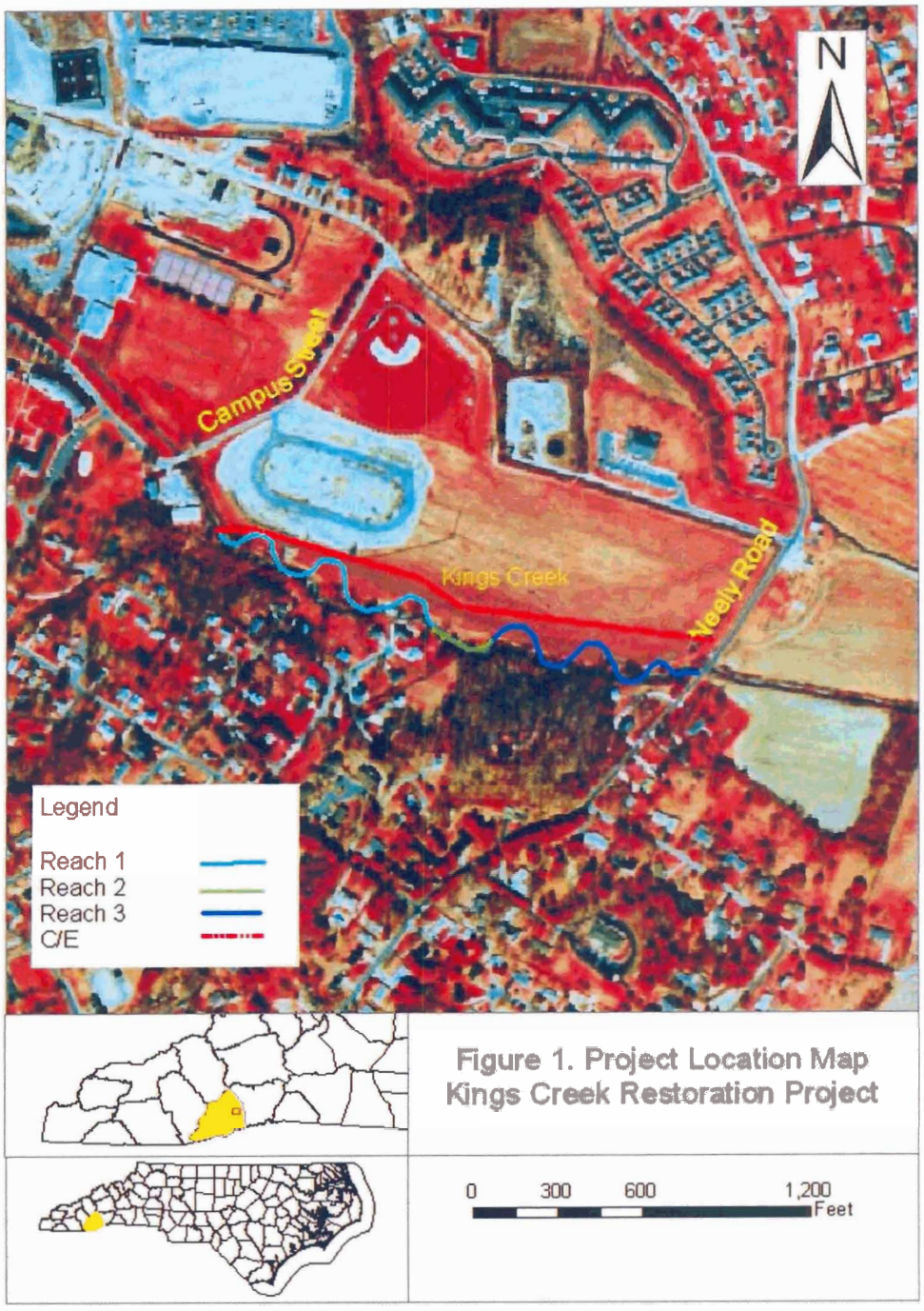

Figure 1. Project Location Map
Kings Creek Restoration Project

2 Restoration Summary

2.1 Project Description and Watershed Characterization

The Kings Creek drainage area at the downstream end of the project reach is 4.2 square miles. The headwaters of Kings Creek are located in Pisgah National Forest; the uppermost portion of the Kings Creek watershed is characterized by steep gradient, colluvial step-pool morphology. The lower end of the watershed connects with the wide, relatively flat French Broad River floodplain, and the creek has a flatter slope and alluvial morphology.

Land use in the immediate project vicinity is mixed urban commercial and residential. The Brevard College campus consists of several large buildings and parking lots. The right bank along the project reach is bordered by eight residential parcels. US Highway 64 borders the western edge of the campus and is a commercial corridor with recent development activity.

Transylvania County is developing at a rapid pace, with 15 percent growth between 1990 and 2000. A comprehensive plan for the County was adopted in February 2006. This plan includes provisions for protecting high quality waters and other environmentally sensitive areas. Given that a significant portion of the Kings Creek watershed is in the Pisgah National Forest and that the rest of the watershed is nearly built-out, significant increases in impervious area in the watershed appear unlikely.

The project was divided into three reaches based on design approach and easement constraints; one landowner in the middle of the project chose to not grant a conservation easement, so no work was done on this parcel. Reach 1 begins about 400 feet downstream of Campus Street and extends to a private parcel off Hilt Street. Reach 2 is the 189-foot section of stream bordering the private parcel where no easement was granted. Reach 3 extends from the downstream end of Reach 2 to the upstream side of Neely Road. In terms of the Rosgen classification system, all reaches are classified as E channels.

2.2 Methodologies

Buck Engineering used natural channel design principles to develop a design that achieves the highest level of restoration feasible within the site constraints. The design addressed the channel dimension, pattern, and profile based on reference reach parameters and hydraulic geometry relationships. The new channel and floodplain were sized to allow flood flows larger than bankfull to spread across the floodplain.

The design process began with an existing condition survey. Field data collected included: longitudinal profile and cross sections, floodplain topographic survey, bed

material analysis, valley morphology, stream classification, channel stability assessment, channel evolution, riparian conditions, water quality impacts, and photographs. Other data analyzed included watershed size and percent impervious and land use survey (historical and present).

The second step in the design process was an evaluation of stream potential and restoration alternatives (priority levels of restoration, urban considerations, and built-out scenarios). This evaluation included an examination of reference reach data, verification of bankfull using the mountain regional curves, restored channel morphology design (channel dimension, pattern, and profile), sediment transport analysis, structure design and placement, streambank stabilization/bioengineering, design of an erosion and sediment control plan, flood impact analysis, and completion of design plans.

Buck Engineering provided construction phase services, including field layout, construction observation, maintenance of record drawings, preparation of the as-built survey, and collection of photographs.

2.3 Points of Contact

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2.4 Construction Summary

The foremost objective was to construct a new bankfull channel and re-establish contact between the channel and a floodplain. The steps toward meeting this objective were to: excavate a new floodplain; construct a new, meandering channel to achieve dimension, pattern, and profile characteristic of a stable stream for the valley type; and fill original incised channel.

2.4.1 Reaches 1 and 3

With donated conservation easements from several property owners on the right bank and from Brevard College on the left bank, restoration of channel dimension, pattern and profile was feasible in reaches 1 and 3. Incised pre-project conditions and the need to conform to thalweg grades at the upstream and downstream ends of the reach necessitated excavation of a new floodplain at the bankfull elevation.

The new channel was constructed off-line as much as possible. Where the new channel intersected the original channel, flow diversions (pump around and flume pipes) were employed to minimize sediment pollution to the creek. Silt checks were installed in the original channel at the downstream ends of reaches 1 and 3 to minimize off-site migration of sediment. In-stream boulder structures (rock vanes and constructed riffles) and root wad clusters were installed and the banks were seeded and matted prior to turning water into the new channel.

The original channel was backfilled with excavated materials. Channel plugs consisting of compacted on-site soils were installed at the upstream end of each backfilled channel section to prevent avulsions from forming through the original channel. Prior to backfilling, gravel from the original channel was harvested and stockpiled for use in constructed riffles. Excess excavated soil was stockpiled on-site beyond the conservation easement on the left terrace in reach 3. Much of the material was later hauled off-site. Roughly half of the excess material was left on-site at the request of Brevard College for their use in future projects.

2.4.2 Reach 2

As mentioned previously, a single property owner on the right bank declined to offer a conservation easement, so no work could take place in the channel or on the right bank along this parcel. The new floodplain excavation on the left bank did continue through reach 2, and the left bank of the original channel was graded and planted as in the other reaches of the project. The channel was left in its original alignment through the parcel in question. No in-stream structures were installed in reach 2.

2.5 Buffer Vegetation

Buffer planting consisted of herbaceous and woody vegetation. The following tables summarize species of both types.

Table 2.1. Herbaceous Vegetation

Common Name	Scientific Name	Percent
Soft Rush	*Juncus effusus*	20
Deertongue	*Panicum clandestinum*	20
Switchgrass	*Panicum vergatum*	10
Ironweed	*Veronia noveboracensis*	5
Virginia Wildrye	*Elymus virginicus*	10
Hop Sedge	*Carex lupilina*	10
Fox Sedge	*Carex vulpinoidea*	10
Joe Pye Weed	*Eupatorium fistulosum*	10
Showy Tickseed	*Bidens aristosa*	5

The seed mix was applied at a rate of 11 pounds per acre. Temporary seed (rye grain and browntop millet) was sown at the same time as the permanent seed mix. Both mixes had to be re-applied in the spring 2006 due to poor growth.

Table 2.2. Woody Vegetation

Installation	Common Name	Scientific Name	Quantity
Live Stakes	Silky Dogwood	*Cornus amomum*	2,000
	Silky Willow	*Salix sericea*	2,000
	Elderberry	*Sambucus canadensis*	1,500
Bare Root Trees	River Birch	*Betula nigra*	500
	Black Gum	*Nyssa sylvatica*	500
	Tag Alder	*Alnus serrulata*	450
	Sycamore	*Platanus occidentalis*	300
	Green Ash	*Fraxinus pennsylvanica*	250
	American Hazelnut	*Corylus americana*	150
	Arrowwood	*Viburnum dentatum*	150
	Spicebush	*Lindera benzoin*	150
	Red Chokeberry	*Aronia arbutifolia*	150
	Witch Hazel	*Hamamelis virginiana*	150
	Elderberry	*Sambucus canadensis*	150
	Silky Dogwood	*Cornus amomum*	100

Live stakes were installed at roughly 3 feet on center, except at the outside of meander bends where the spacing was generally 1 to 2 feet on center. Shrubs were planted at 4 to

6 feet on center, small trees were planted 6 to 9 feet on center, and large trees were planted 10 to 15 feet on center.

2.6 Mitigation Summary

The following table lists the proposed mitigation credit for the project.

Table 2.3. Proposed Mitigation Credit

Reach	Pre-Project Length (ft)	Restored Length (ft)	Category (Credit Ratio)	SMU
1	824	990	Restoration (1:1)	990
2	191	191	Enhancement I (1:1)	191
3	800	938	Restoration (1:1)	938
Total	**1,815**	**2,119**		**2,119**

3 Monitoring Plan

The monitoring plan covers a five year period, post-construction. Buck Engineering conducted the as-built survey in November and December 2005 and will conduct the first annual survey in December 2006.

The monitoring plan includes cross section surveys each year using a total station or level between the permanent cross section pins. During each monitoring event, points in each cross-section survey should be taken at breaks in slope and at each three foot interval. This will ensure that points are taken in the same locations along the cross-sections each year. Photographs of each cross section should be taken from the upstream side looking downstream ensuring both banks are visible in the photograph.

The monitoring plan includes a longitudinal profile survey for the first year and then every two years for a total of four times (as-built is completed, then winter 2006, 2008 and 2010).

The monitoring plan includes annual photographs at the cross sections listed above as well as longitudinal photographs taken to provide an overview of the site. These supplement the cross section photos to ensure the entire reach is covered.

The monitoring plan includes annual counting of the vegetation survival plots shown on the plan view. Coordinates at the corners of the plots are listed on the plan view. For success criteria, the 3-year period is through February 2008, and the 5-year period is through February 2011.

4 Success Criteria

Project elements monitored in this project are those that allow an evaluation of channel stability and riparian survivability. Specifically, the success of channel modification, erosion control, seeding, and woody vegetation plantings will be evaluated. In order for the geomorphic monitoring data to be considered valid, the project reach will have had to undergone at least two bankfull events during the monitoring period.

Monitoring will be accomplished through the following activities for 5 years after the project is built.

4.1 Dimension

Four permanent cross-sections were established on Kings Creek, two at riffles and two at pools. Each cross-section is marked on both banks with permanent pins set in concrete to establish the exact transect used. A common benchmark is used for cross-sections to facilitate easy comparison of year-to-year data. The as-built cross-section survey includes points measured at all breaks in slope, including top of bank/bankfull, toe of bank, and thalweg. In the future, points will be measured at all breaks and slope, as well as at three foot intervals across the section. This will ensure that points are taken at the same locations each year. Riffle cross-sections will be classified using the Rosgen stream classification system.

Success Criteria: Minor changes such as settling, increase in vegetative density, deposition along the banks, decrease in width/depth ratio, and a decrease in cross sectional area may occur. Such changes are indicative of the stream moving towards stability. Larger shifts in cross-sectional area should be evaluated to determine if they represent a movement toward a more unstable condition such as down-cutting or bank erosion, at which time repair strategies should be developed.

4.2 Pattern and Profile

A longitudinal profile survey was completed after construction and will be repeated every two years for a total of five years (for a total of 4 times). Measurements include thalweg, water surface, bankfull, and edge of water. Each measurement is taken at the head of feature, e.g. riffle, run, pool, and glide, and the maximum pool depth. Cross section pins will serve as permanent benchmarks. The survey is also used to calculate sinuosity.

Success Criteria: The as-built longitudinal profiles should show that the bedform features are remaining stable, e.g., they are not aggrading or degrading over the 5-year period. Short term aggradation/degradation may occur depending on the peak annual discharge. The gravel bed pools should remain deep with flat water surface slopes and the riffles should remain steeper and shallower than the pools. Bedforms observed should be consistent with those observed in Rosgen "E" type channels. The pattern should not

change and there should be no change in sinuosity. The pool/riffle sequence should also remain constant.

4.3 Bed Material Analysis

Annual pebble counts will be performed on all project reaches based on the percent of pools and riffles.

Success Criteria: Established D50 and D85 should increase in coarseness in riffles, and increase fineness in pools.

4.4 Photo Reference Sites

Photographs used to evaluate restored sites will be made with a 35-mm camera using slide film or a digital camera. Reference sites were photographed after construction and will be taken once a year for at least 5 years following construction. Reference sites were marked with wooden stakes and were located on as-built drawings.

Longitudinal reference photos: Photographs were taken looking downstream at each cross section location. Since the total project site is generally visible in these photos, they will serve as the reference photo locations. When modifications of stream position have to be made in the view due to obstructions or other reasons, the position should be noted along with any landmarks and the same position used in the future.

Lateral reference photos: Reference photo transects will be taken at each permanent cross-section. Photographs will show both banks at each cross-section. The water line will be located in the lower edge of the frame and as much of the bank as possible included in each photo. Photographers should make an effort to consistently maintain the same area in each photo over time.

Success Criteria: Photographs will be used to qualitatively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation and effectiveness of erosion control measures. Longitudinal photos should indicate the absences of developing bars within the channel or an excessive increase in channel depth. Lateral photos should not indicate excessive erosion or continuing degradation of the bank over time. A series of photos over time should indicate successional maturation of riparian vegetation. Vegetative succession should include initial herbaceous growth, followed by increasing densities of woody vegetation and then ultimately a mature overstory with herbaceous understory.

4.5 Vegetation Survival Plots

Survival of live stakes and bare root woody vegetation will be evaluated using three plots along Kings Creek. Evaluations of live stake and bare root woody vegetation survival will continue for at least 5 years. When vegetation does not survive, a determination will

be made as to the need for replacement; in general if greater than 25% die, replacements will need to be installed.

Success Criteria: The interim measure of vegetative success will be the survival of at least 320 3-year old planted trees per acre at the end of year three of the monitoring period. The final vegetative success criteria will be the survival of 260 5-year old planted trees per acre at the end of year five of the monitoring period. In addition, for the five year monitoring period, the presence of volunteer facultative softwood species such as red maple, sweet gum, and loblolly pine will be limited to less than 10% each of the total number of trees utilized to determine success. These trees may contribute more than 10% of the total trees on the site, but they will not constitute more than 10% each of the 260 trees per acre.

4.6 Benthic Macroinvertebrate Monitoring

Benthic macroinvertebrate monitoring is not part of the monitoring plan.

5 Maintenance and Contingency Plans

Future maintenance concerns noted during monitoring shall be reported to the NCEEP Project Manager. Plans for maintenance operations can then be established. The maintenance approach should take into account trends in channel stability and/or vegetation survival and should weigh the potential impacts to vegetation against the potential benefits of maintenance or repair work.

One area that should be observed carefully during subsequent monitoring periods is the right bank in reach 2. Some bank erosion was noted in this area during and immediately after construction, and a mid-channel bar has formed near the downstream end of reach 2. Without a conservation easement or at least a temporary construction easement, it will not be possible to make adjustments in this area. However, to promote a well functioning system, it would be worthwhile to contact this landowner and discuss alternatives.

6 References

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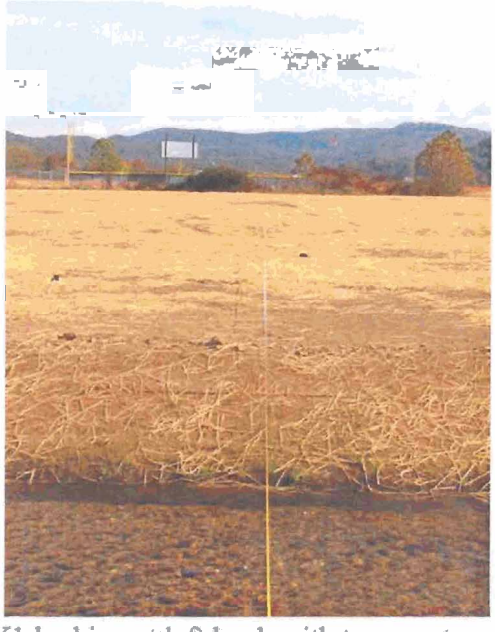
Appendix 1

Photographic Record

King Creek Stream Restoration
Photo Log

Notes:

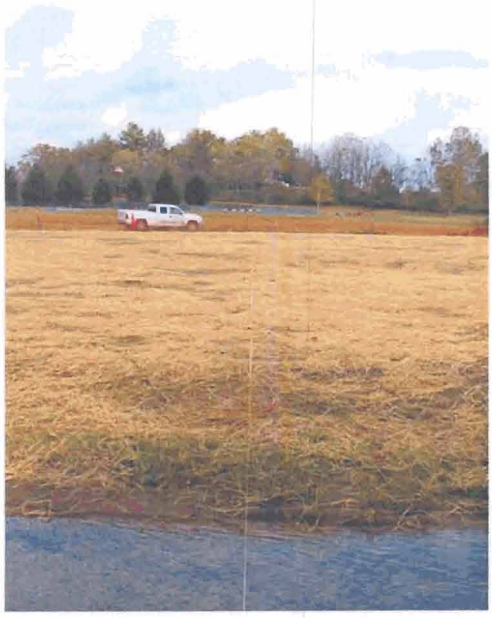
1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and orange flagging tape. For channel points, the stake is set up on the most accessible bank at that same station.
3. Photo locations include longitudinal photos and cross sections.



X1 looking at left bank with tape centered.

X1 looking at right bank with tape centered.

Panaramic view of X1 from upstream of the cross-section.



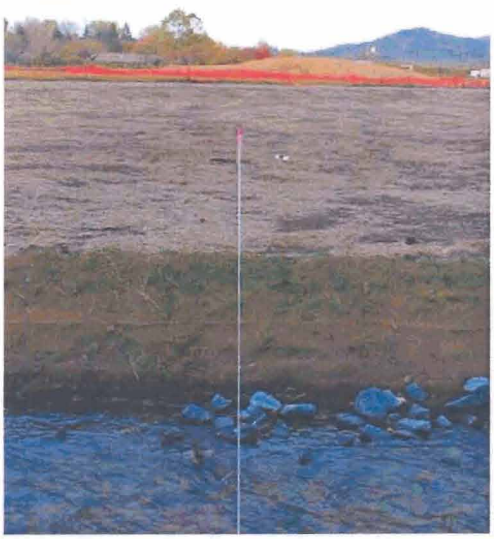
X2 looking at left bank with tape in center

X2 looking at right bank with tape in center.

X2 at pool viewing left bank from upstream.

X2 at pool viewing center channel from upstream.

X2 at pool viewing right bank from upstream.

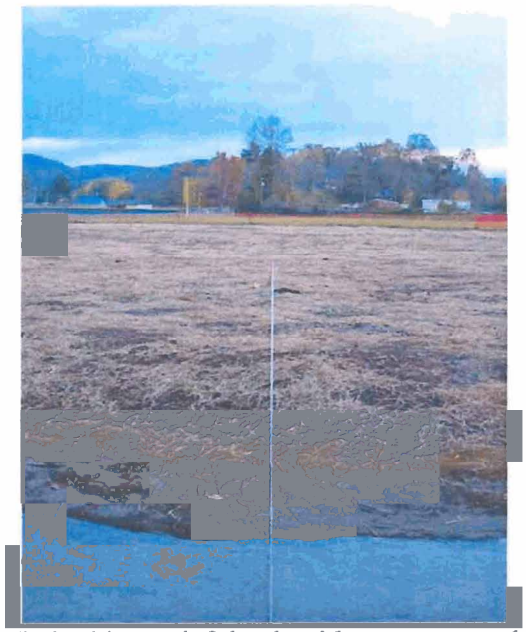


X3 looking at left bank with tape centered.

X3 looking at right bank with tape centered.

Panaramic view of X3 from upstream of the cross-section.

Riffle at X3 from upstream of the cross-section.



X4 looking at left bank with tape centered.

X4 looking at right bank with tape centered.

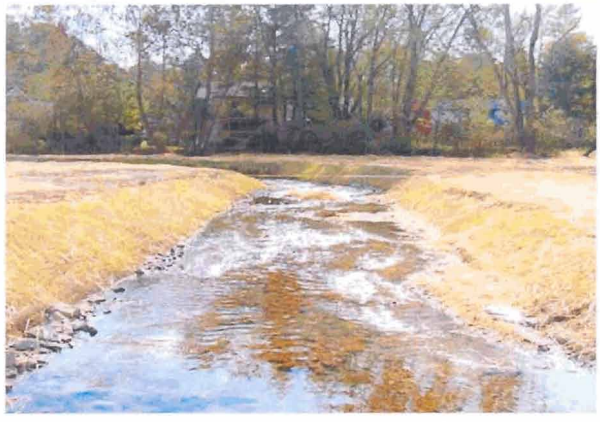
Panaramic view of X4 from upstream of the cross-section.

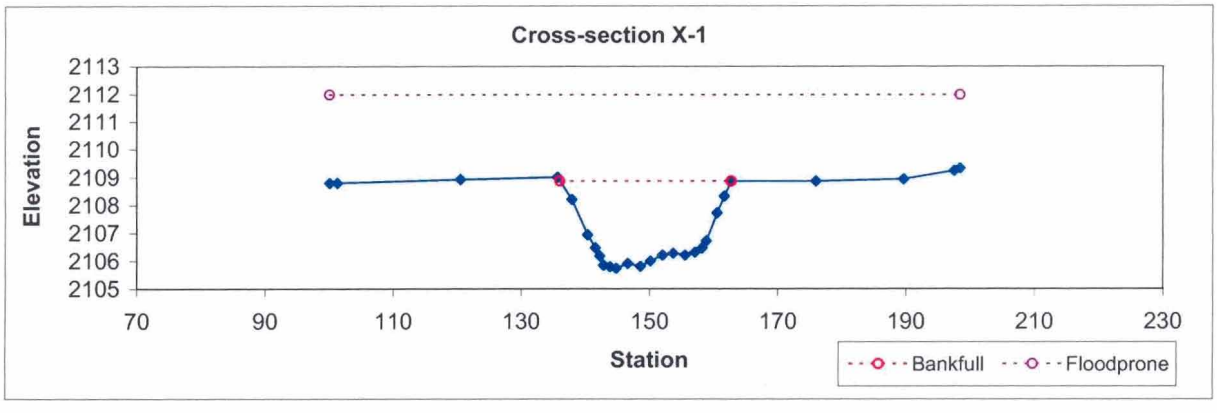
Pool at X4 from upstream of the cross-section.

Appendix 2

As-Built Geomorphic Data

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E4	58.5	26.74	2.19	3.12	12.23	1	3.7	2108.86	2108.86

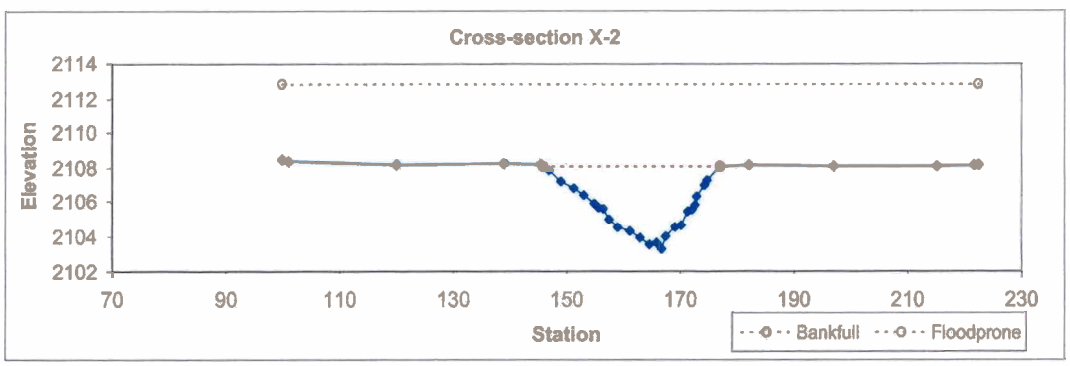




Pt #	North	East	Elevation	Note	Station
315	561504.8	888226	2108.790025	X1 RIFFLE LPIN	100
316	561504.8	888224.8	2108.795835	X1	101.2329
317	561504.3	888205.6	2108.9186	X1	120.4533
318	561503.7	888190.5	2109.002767	X1 LTB LBF	135.5686
319	561504.2	888188.2	2108.200038	X1	137.8025
320	561504.2	888185.7	2106.946298	X1	140.2884
321	561503.8	888184.5	2106.476605	X1 WSF	141.4777
322	561503.7	888183.8	2106.181263	X1 LCH	142.1953
323	561503.7	888183.2	2105.842357	X1	142.7798
324	561503.6	888182.3	2105.788161	X1	143.7386
325	561503.6	888181.3	2105.742317	X1 TWG	144.7469
326	561503.5	888179.5	2105.916095	X1	146.5449
327	561503.2	888177.5	2105.799067	X1	148.5005
328	561503.3	888176	2106.001893	X1	150.0548
329	561503.2	888174.1	2106.215816	X1	151.959
330	561503.2	888172.4	2106.27546	X1	153.6298
331	561503.3	888170.5	2106.210326	X1	155.4928
332	561503.2	888169	2106.310979	X1	156.9976
333	561503	888167.9	2106.460038	X1 RCH	158.1474
334	561503.2	888167.2	2106.730002	X1	158.8139
335	561503	888165.6	2107.723152	X1	160.4735
336	561502.8	888164.5	2108.324388	X1	161.593
337	561502.7	888163.3	2108.86249	X1 RTB	162.7136
338	561502.4	888150.1	2108.863454	X1	175.9257
339	561502.2	888136.5	2108.935949	X1	189.5911
340	561501.9	888128.6	2109.246836	X1	197.4794
341	561502	888127.7	2109.32889	X1 RPIN	198.3816

Bankfull Line		Floodprone Line	
Station	Elevation	Station	Elevation
135.97	2108.86	100	2111.98
162.71	2108.86	198.38	2111.98

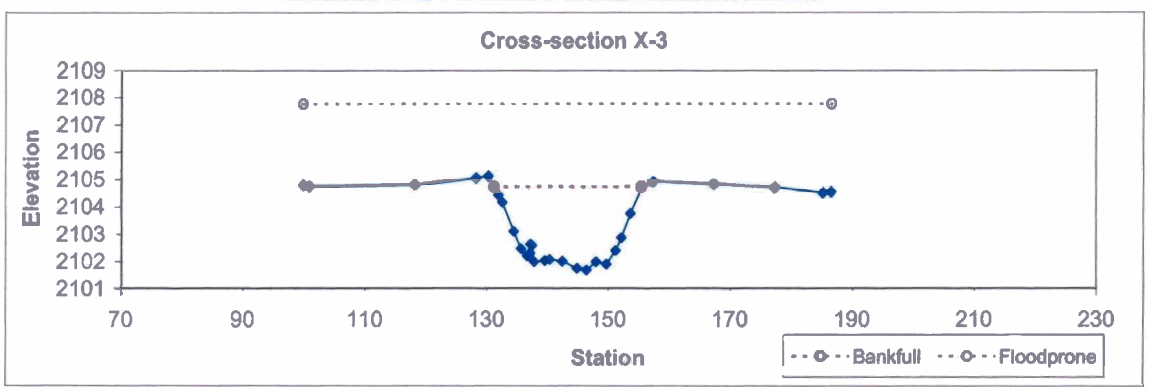
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	E4	76.6	31.14	2.46	4.74	12.66	1	3.9	2108.08	2108.08



			Elevation		
342	561482	888234.5	2108.47009	X2 POOL LPIN	100
343	561480.9	888234.1	2108.353393	X2	101.1507
344	561463.1	888228	2108.174114	X2	120.0756
345	561445.2	888221.7	2108.228446	X2	139.0091
346	561439.2	888219.3	2108.180788	X2 LTB LBF	145.4858
347	561437.7	888219	2107.83875	X2	146.9368
348	561435.7	888218.3	2107.18407	X2	149.059
349	561433.6	888217.6	2106.796149	X2	151.2824
350	561432	888216.9	2106.417821	X2	153.0664
351	561430.2	888216.3	2105.915668	X2	154.9045
352	561429.6	888215.8	2105.702961	X2 LCH	155.6638
353	561428.8	888215.6	2105.630092	X2 WSF	156.4625
354	561427.8	888215.4	2105.016024	X2	157.5306
355	561426.3	888215	2104.560111	X2	159.0239
356	561424.3	888214.3	2104.345948	X2	161.1764
357	561422.6	888213.9	2103.969633	X2	162.947
358	561421.1	888213.2	2103.577964	X2	164.583
359	561419.9	888212.7	2103.673464	X2	165.8123
360	561419	888212.6	2103.333948	X2 TWG	166.7387
361	561418.3	888212.4	2104.051954	X2	167.4507
362	561416.8	888211.6	2104.568922	X2	169.1294
363	561415.8	888211.3	2104.686311	X2	170.189
364	561414.8	888210.6	2105.494423	X2	171.3679
365	561414.1	888210.4	2105.568673	X2 RCH	172.1026
366	561413.5	888210.2	2105.860095	X2	172.6711
367	561413.3	888210.1	2106.34705	X2	172.9304
368	561411.9	888209.9	2106.985604	X2	174.2961
369	561411.5	888209.7	2107.251872	X2	174.773
370	561409.4	888208.8	2108.077656	X2 RTB RBF	177.0604
371	561404.6	888207.2	2108.16663	X2	182.1182
372	561390.5	888202.4	2108.10159	X2	196.9854
373	561373.4	888196.3	2108.102014	X2	215.1062
374	561367.3	888194	2108.146843	X2	221.6768
375	561366.6	888193.7	2108.172057	X2 RPIN	222.4113

Bankfull Line		Floodprone Line	
Station	Elevation	Station	Elevation
145.92	2108.08	100	2112.82
177.06	2108.08	222.41	2112.82

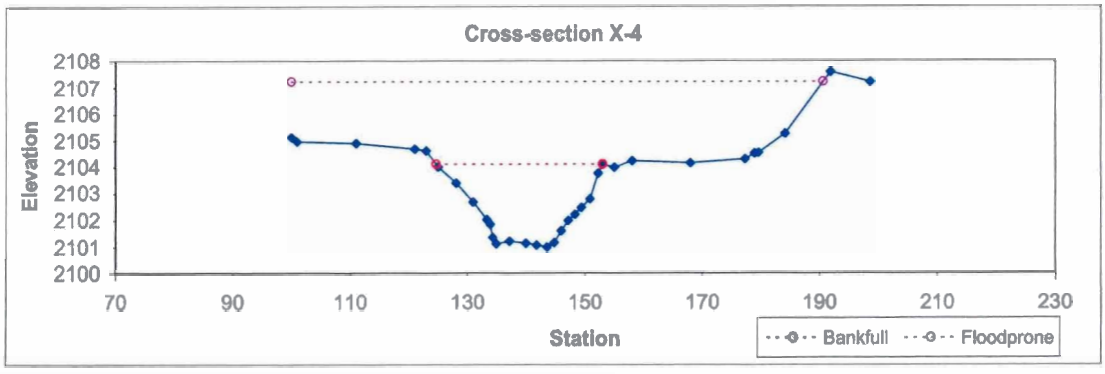
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E4	51.9	24.22	2.14	3.04	11.31	1	3.6	2104.72	2104.72



Pt #	North	East	Elevation	Note	Station
387	561251.6	888825.2	2104.782714	X3 RIFFLE LPIN	100
388	561250.9	888824.4	2104.737747	X3	101.002
389	561242.2	888809.4	2104.796335	X3	118.3053
390	561237.2	888800.8	2105.070397	X3	128.2711
391	561236.2	888799.1	2105.131434	X3 LTB LBF	130.2767
392	561235.3	888797.7	2104.410205	X3	131.9423
393	561235.1	888797	2104.139575	X3	132.5963
394	561234	888795.5	2103.082396	X3	134.4958
395	561233.6	888794.4	2102.455855	X3 LCH WSF	135.6184
396	561232.9	888793.7	2102.180205	X3	136.6088
397	561232.6	888793.2	2102.3007	X3	137.1054
398	561232.7	888793.1	2102.617953	X3	137.1938
399	561232.6	888792.9	2102.576562	X3	137.4394
400	561232.4	888792.7	2101.977562	X3	137.7549
401	561231.5	888791.1	2102.023305	X3	139.5335
402	561231.1	888790.4	2102.06378	X3 TWG	140.3344
403	561230	888788.7	2101.993123	X3	142.4047
404	561228.9	888786.5	2101.743641	X3	144.8117
405	561228.1	888785.2	2101.676043	X3	146.3469
406	561227.2	888783.9	2101.978622	X3	147.9071
407	561226.3	888782.5	2101.897295	X3	149.5859
408	561225.7	888781.1	2102.386986	X3 RCH	151.0877
409	561225.2	888780.3	2102.85195	X3	152.0505
410	561224.4	888779	2103.732294	X3	153.543
411	561223.4	888777.4	2104.715732	X3 RTB RBF	155.4583
412	561222.5	888775.8	2104.925317	X3	157.2974
413	561217.5	888767.2	2104.823258	X3	167.264
414	561212.4	888758.5	2104.716998	X3	177.2982
415	561208.4	888751.6	2104.518281	X3	185.2933
416	561207.7	888750.5	2104.556218	X3 RPIN	186.6339

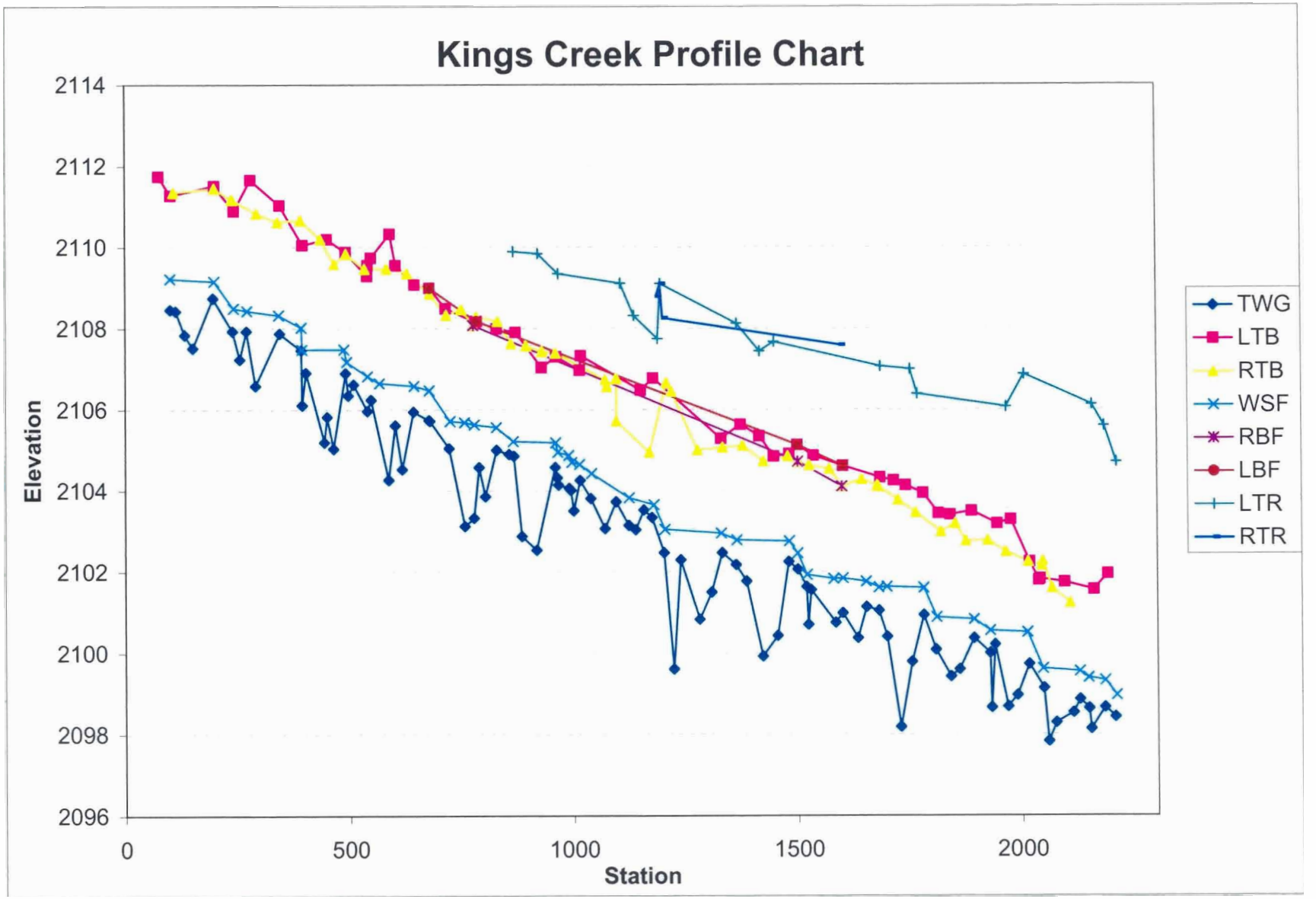
Bankfull Line		Floodprone Line	
Station	Elevation	Station	Elevation
131.24	2104.72	100	2107.76
155.46	2104.72	186.63	2107.76

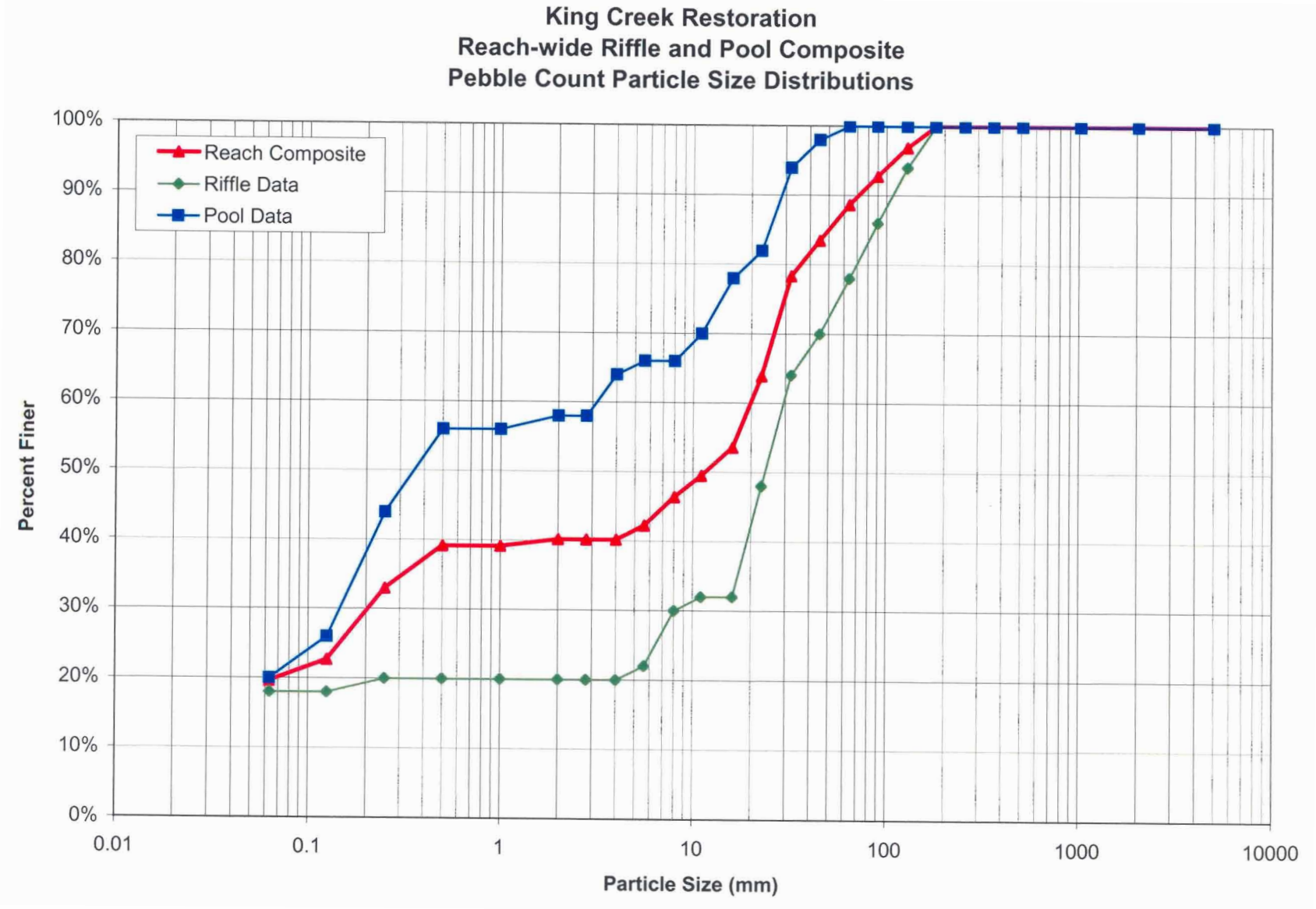
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	E4	55.5	28.31	1.96	3.12	14.43	1	3.2	2104.11	2104.11

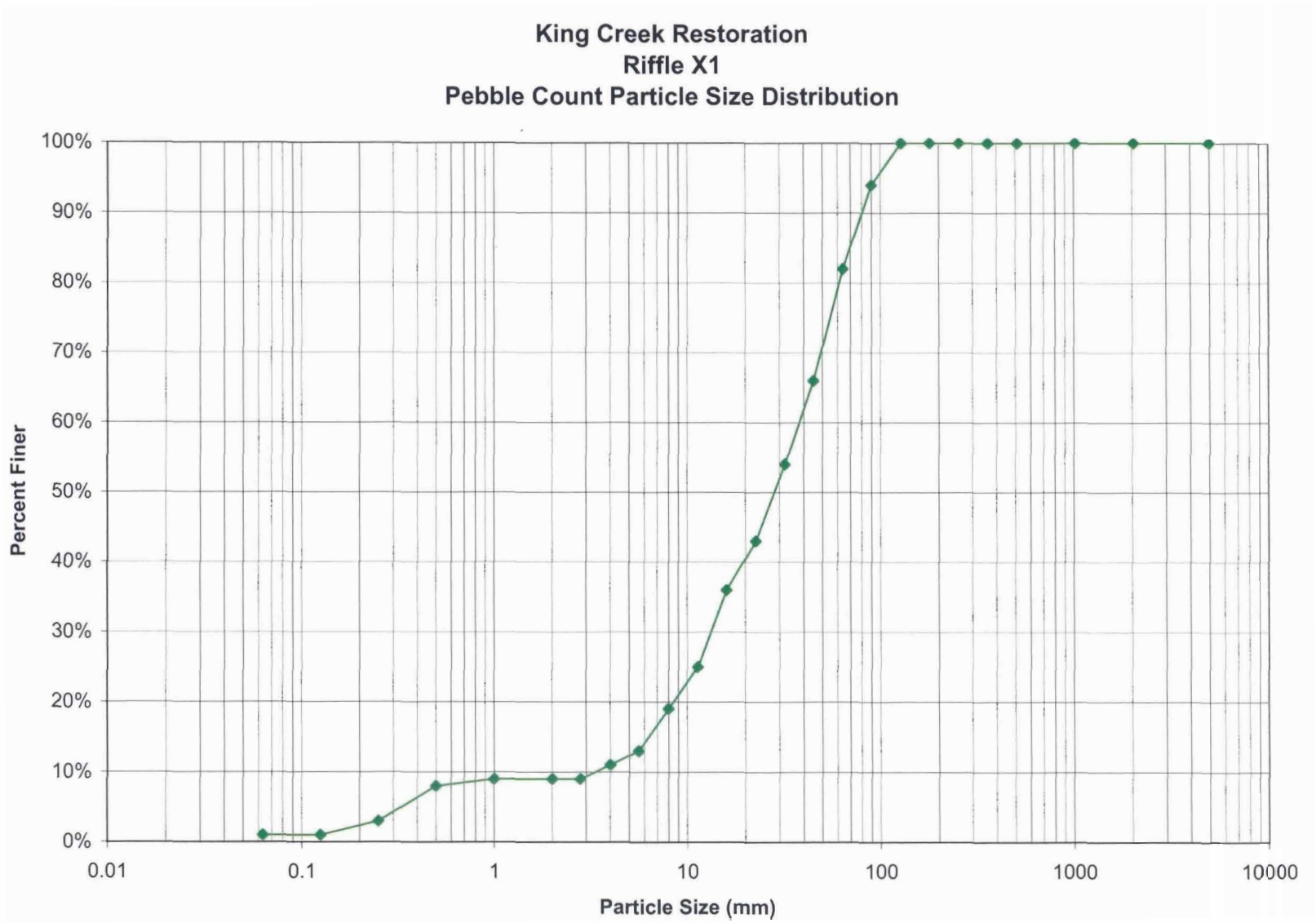


Pt #	North	East	Elevation	Note	Station
417	561214.8	888849.3	2105.130994	X4 POOL LPIN	100
418	561213.9	888849.5	2104.96723	X4	100.9114
419	561204.1	888851.7	2104.894588	X4	110.9841
420	561194.3	888853.8	2104.681446	X4	120.9999
421	561192.4	888854.2	2104.613372	X4 LTB LBF	122.9245
422	561190.4	888854.6	2104.014828	X4	124.9595
423	561187.5	888855.3	2103.391141	X4	128.0195
424	561184.6	888856	2102.68802	X4	130.9293
425	561182.4	888856.5	2102.025061	X4	133.2651
426	561181.8	888856.8	2101.84254	X4 WSF	133.8583
427	561181.4	888856.8	2101.351576	X4 LCH	134.2233
428	561180.8	888856.9	2101.115441	X4	134.8963
429	561178.6	888857.2	2101.208895	X4	137.0998
430	561175.9	888857.9	2101.139993	X4	139.8919
431	561174.1	888858.3	2101.070238	X4	141.7359
432	561172.4	888858.7	2100.987657	X4 TWG	143.4689
433	561171.1	888859	2101.157584	X4	144.7419
434	561170	888859.3	2101.612193	X4	145.9189
435	561168.9	888859.7	2101.995857	X4 RCH	147.1181
436	561167.7	888859.7	2102.220367	X4	148.2866
437	561166.6	888859.9	2102.484905	X4	149.3402
438	561165.2	888860.2	2102.798548	X4	150.8141
439	561163.9	888860.5	2103.771667	X4	152.1905
440	561163.1	888860.7	2104.10616	X4 RTB RBF	152.9569
441	561161.1	888861	2103.991669	X4	154.9567
442	561158.2	888861.7	2104.240284	X4	158.0054
443	561148.5	888863.8	2104.155074	X4	167.9347
444	561139.4	888865.8	2104.311967	X4	177.2123
445	561137.8	888866.2	2104.526826	X4	178.8399
446	561137.2	888866.4	2104.542102	X4 RPIN	179.5199
447	561132.8	888867.4	2105.27626	X4	184.0329
448	561125.2	888869	2107.59337	X4 RTR	191.7407
449	561118.7	888870.5	2107.213439	X4	198.4736

Bankfull Line		Floodprone Line	
Station	Elevation	Station	Elevation
124.65	2104.11	100	2107.22
152.96	2104.11	190.51	2107.22


Kings Creek Profile Chart
Elevation
2114
2112
2110
2108
2106
2104
2102
2100
2098
2096
0
500
1000
1500
2000
Station
TWG
LTB
RTB
WSF
RBF
LBF
LTR
RTR

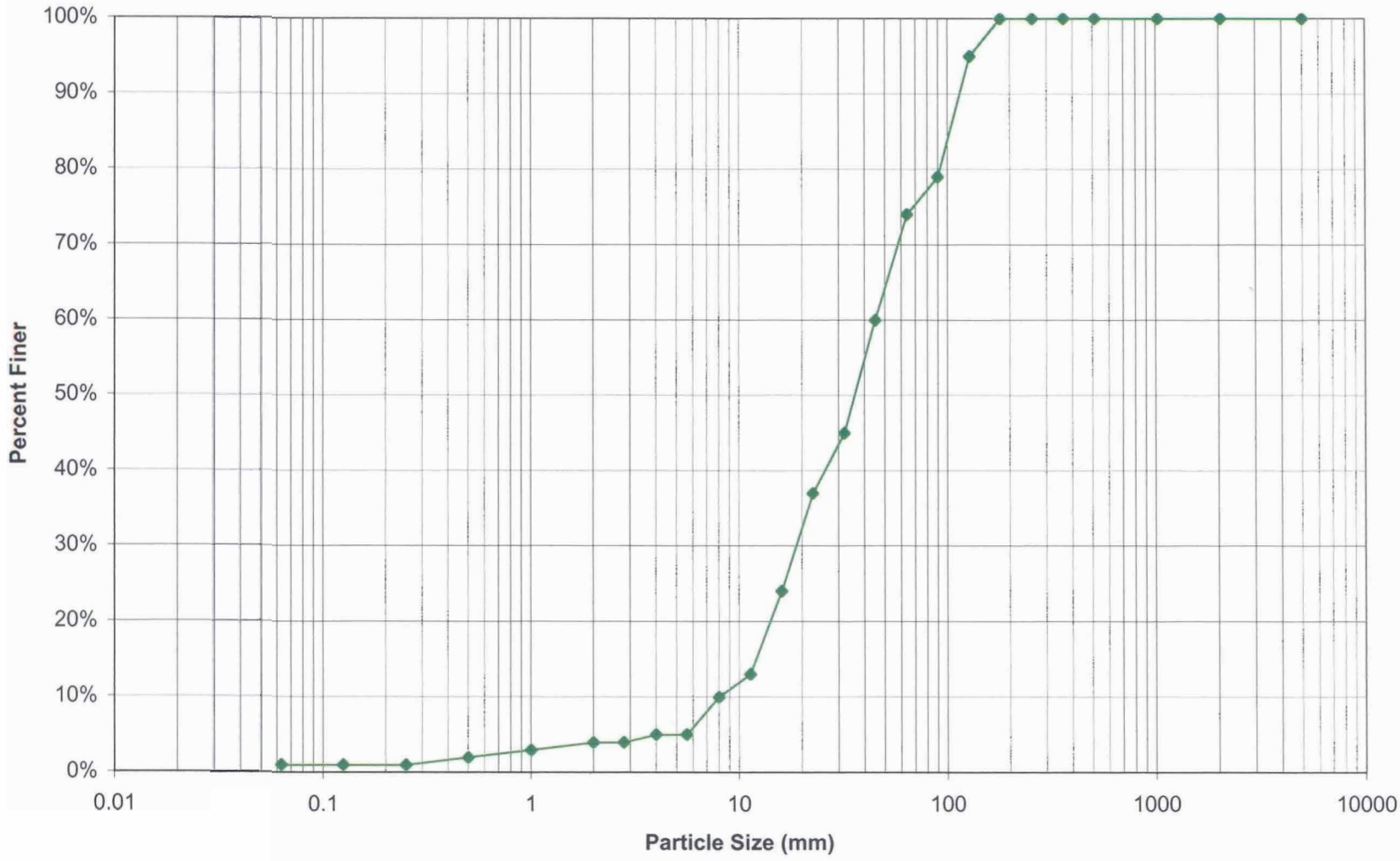

King Creek Restoration
Reach-wide Riffle and Pool Composite
Pebble Count Particle Size Distributions
Reach Composite
Riffle Data
Pool Data
Percent Finer
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0.01
0.1
1
10
100
1000
10000
Particle Size (mm)



\\192.168.7.100\ashdata$\projects\147\monitoring\AsBuilt\geomorphic data\X1-Riffle 100cnt, Riffle Dist

5/4/2006

King Creek Restoration
Riffle X3
Pebble Count Particle Size Distribution



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5/5/2006

Appendix 3

As-Built Plans

PROJECT REFERENCE NO.	SHEET NO.
147	P1

PROJECT ENGINEER
EEG

APPROVED BY:
ADB

DATE:
05/03/2006

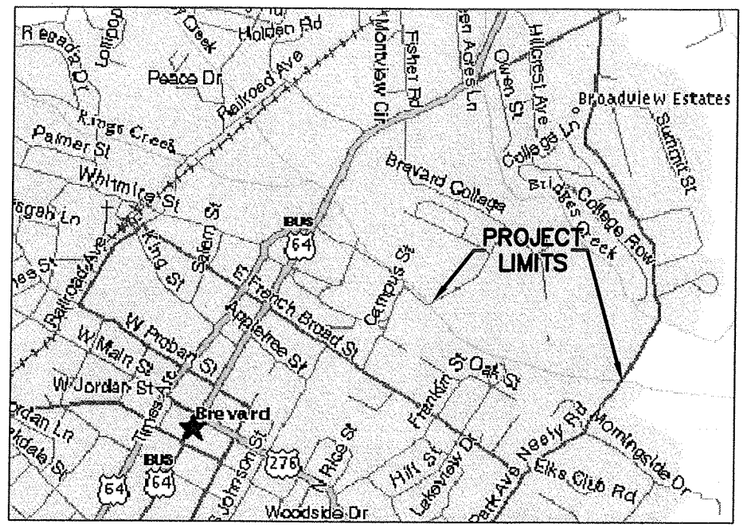
BUCK ENGINEERING
1347 Harding Place Suite 100
Charlotte, North Carolina 28204
Phone: 704-334-4454
Fax: 704-334-4492

RECORD DRAWING

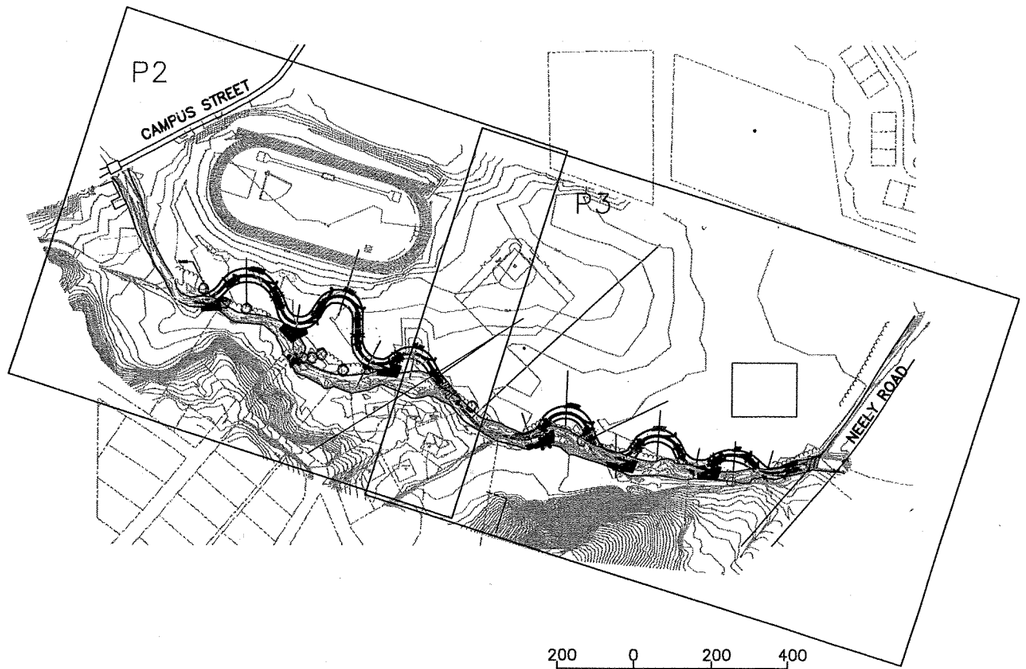
NORTH CAROLINA PROFESSIONAL SEAL 22209 ENGINEER ANDREW DAVID BICK
5/4/06

KINGS CREEK RESTORATION PROJECT BREVARD, TRANSYLVANIA COUNTY, NORTH CAROLINA

PREPARED FOR: NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM



SITE LOCATION MAP



LEGEND

- PROPOSED LIMIT OF BENCH GRADING
- PROPOSED RUNNING TRAIL
- PROPERTY LINE
- EXISTING TROUT BUFFER
- EXISTING TOP OF BANK
- EXISTING FENCE LINE
- SILT FENCE (5/D2)
- SAFTEY FENCE
- STORM PIPE
- CONSERVATION EASEMENT
- FLUME PIPE
- ROCK VANE (1/D1)
- ROOT WAD (2/D3)
- VANE / RIFFLE (2/D1)
- EXISTING MID-CHANNEL BAR
- DOUBLE WING DELFECTOR (6/D4)
- CONSTRUCTED RIFFLE (3/D1)
- TEMPORARY ROCK CHECK DAM (1/D4)
- CHANNEL PLUG (3/D4)
- CONSTRUCTION ENTRANCE (4/D2)
- RIPRAP PAD (2/D4)
- EXISTING TREE TO BE PROTECTED
- EXISTING TREE TO BE REMOVED
- TEMPORARY STREAM CROSSING (1/D2)

DIP	DUCTILE IRON PIPE
PCC	PORTLAND CEMENT CONCRETE
CPP	CORRUGATED PLASTIC PIPE
VIF	VERIFY IN FIELD

INDEX OF SHEETS

NOTE:
TOPOGRAPHIC SURVEY INFORMATION DEVELOPED BY NORTH CAROLINA STATE UNIVERSITY AND BUCK ENGINEERING.

KINGS CREEK
SCO ID# 01-05721-01A
TRANSYLVANIA CO., N.C.

TITLE SHEET

PROJECT REFERENCE NO.	SHEET NO.
147	P2

PROJECT ENGINEER
EEG

APPROVED BY:
ADB

DATE:
05/03/2006

BUCK ENGINEERING
1347 Harding Place Suite 100
Charlotte, North Carolina 28204
Phone: 704-334-4454
Fax: 704-334-4492

RECORD DRAWING

NORTH CAROLINA PROFESSIONAL SEAL 22209 ENGINEER ANDREW DAVID BICK 5/1/06

CAMPUS STREET

KINGS CREEK

CUT EXISTING PIPE
INSTALL RIPRAP PAD AT OUTLET
PER DETAIL 2/D4

EXISTING 14" CPP OUTLET
INV 2111.1 VIF
REMOVE 43 LF PIPE

CUT EXISTING PIPE
INSTALL RIPRAP PAD AT OUTLET
PER DETAIL 2/D4

ROCK VANE
OMITTED

CUT EXISTING PIPE
INSTALL RIPRAP PAD AT OUTLET
PER DETAIL 2/D4

PERFORM GRADING FOR
12' WIDE RUNNING TRAIL
SEE SECTION 4/D4

ADDED VERNAL
POOL

OMITTED UPPER
SECTION OF
SWALE

TRANSPLANT EXISTING
SOFT RUSH TO NEW
CHANNEL BANKS

NO WORK OR
CONTRACTOR
ACCESS BEYOND
SAFETY FENCE

GRADING LIMITS
EXTEND TO
CONSERVATION
EASEMENT ON
NORTH SIDE

PROPOSED CREEK
ALIGNMENT

PROPOSED
VEGETATED SWALE,
SEE 2/D4

STOCKPILE

PROPOSED
VERNAL POOL,
SEE 5/D4

STA 10+00
BEGIN REACH 1

FLOW

10+00
11+00
12+00
13+00
14+00
15+00
16+00
17+00
18+00
19+00
20+00
21+00

PLASTIC COVER
STOCKPILE

PLASTIC
COVER
STOCKPILE

STOCKPILE

UNNAMED
TRIBUTARY

CONSTRUCT CHANNEL PLUG
AFTER COMPLETION OF
PROPOSED CHANNEL TYP,
SEE 3/D4

TRANSPLANT EXISTING ALDERS
TO NEW TOP OF BANK

GRADE AROUND
TREES TO REMAIN
(TYP)

EXISTING CREEK CHANNEL
TO BE BACKFILLED TO BANKFULL
ELEVATION AFTER COMPLETION OF
PROPOSED CHANNEL

SHORTENED RIFFLE
AND ADDED
DOWNSTREAM SILL

MATCH LINE STA 19+00 P3

HILT STREET

2113.98 FF
2112.01 FF
2113.20 FF
2113.19 FF
2113.91 FF
2113.0 FF

40 0 40 80
SCALE (FT)

KINGS CREEK
SCO ID# 01-05721-01A
TRANSYLVANIA CO., N.C.

SITE PLAN

PROJECT REFERENCE NO.	SHEET NO.
147	P3

PROJECT ENGINEER
EEG

APPROVED BY:
ADB

DATE:
05/03/2006

BUCK ENGINEERING
1347 Harding Place Suite 100
Charlotte, North Carolina 28204
Phone: 704-334-4454
Fax: 704-334-4492

NORTH CAROLINA PROFESSIONAL SEAL 22209 ENGINEER ANDREW DAVID BICK
5/4/06

RECORD DRAWING

NO WORK OR CONTRACTOR ACCESS BEYOND SAFETY FENCE

PROTECT EXISTING GUARDRAIL AT NEELY BRIDGE

NEELY ROAD

PROPOSED AREA FOR TEMPORARY STOCKPILE PRIOR TO OFFSITE DISPOSAL

STA 31+17 END REACH 3 CONFORM TO EXISTING TOP OF BANK AT ELEV 2102+/-

GRADING LIMITS EXTEND TO CONSERVATION EASEMENT ON NORTH SIDE

CUT EXISTING STORM PIPE AND INSTALL RIPRAP PAD PER DETAIL, (2/D4)

EXISTING 18" DIP
INV 2107.61 VIF
REMOVE 124 LF PIPE
AND PCC HEADWALL

VERIFY LOCATION OF PIPE IN FIELD
CUT EXISTING PIPE
INSTALL RIPRAP PAD AT
OUTLET PER DETAIL (2/D4)

VERNAL POOL OMITTED IN CONSTRUCTION

STOCKPILE

STOCKPILE

EXISTING 12" DIP
REMOVE 119 LF PIPE AND
PCC HEADWALL

CONSTRUCT VEGETATED SWALE AND VERNAL POOL SEE (2/D4) (5/D4)

GRADE AROUND TREES TO REMAIN (TYP)

PROPOSED CREEK ALIGNMENT

STA 19+90 END REACH 1 / BEGIN REACH 2 CONFORM TO EXISTING TOP OF BANK AT ELEV 2106+/-

MATCH LINE STA 19+00 P2

TRANSPLANT EXISTING ALDERS TO NEW TOP OF BANK

NO WORK THIS PARCEL

UNNAMED TRIBUTARY

STA 21+79 END REACH 2/BEGIN REACH 3

REMOVE EXISTING MID-CHANNEL BAR

CONSTRUCT CHANNEL PLUG AFTER COMPLETION OF PROPOSED CHANNEL, SEE (3/D4)

EXISTING CREEK CHANNEL TO BE BACKFILLED TO BANKFULL ELEVATION AND GRADED AFTER COMPLETION OF PROPOSED CHANNEL

18+00 19+00 20+00 21+00 22+00 23+00 24+00 25+00 26+00 27+00 28+00 29+00 30+00 31+00

2115 2110 2107 2106 2113.98 FF 2112.01 2113.20 FF 2113.19

40 0 40 80
SCALE (FT)

KINGS CREEK
SCO ID# 01-05721-01A
TRANSYLVANIA CO., N.C.

SITE PLAN

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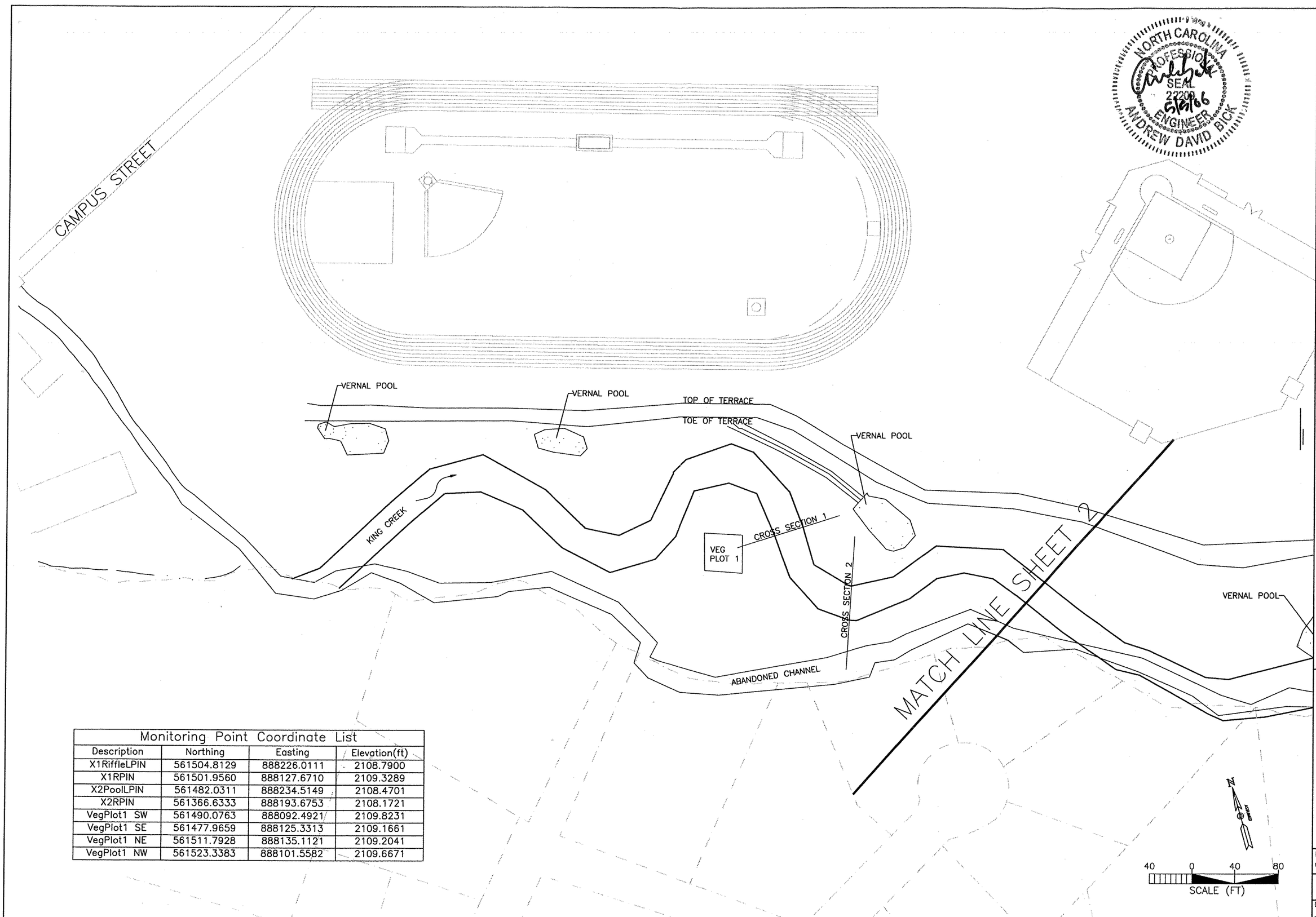


Monitoring Point Coordinate List			
Description	Northing	Easting	Elevation(ft)
X1RiffleLPIN	561504.8129	888226.0111	2108.7900
X1RPIN	561501.9560	888127.6710	2109.3289
X2PoolLPIN	561482.0311	888234.5149	2108.4701
X2RPIN	561366.6333	888193.6753	2108.1721
VegPlot1 SW	561490.0763	888092.4921	2109.8231
VegPlot1 SE	561477.9659	888125.3313	2109.1661
VegPlot1 NE	561511.7928	888135.1121	2109.2041
VegPlot1 NW	561523.3383	888101.5582	2109.6671

NORTH CAROLINA PROFESSIONAL SEAL 22209 ENGINEER ANDREW DAVID BICK 5/16/06

		Date
Designed:	E. Godbold	May 2006
Drawn:	J. Fulton	May 2006
Checked:	A. Bick	May 2006
Approved:	A. Bick	May 2006

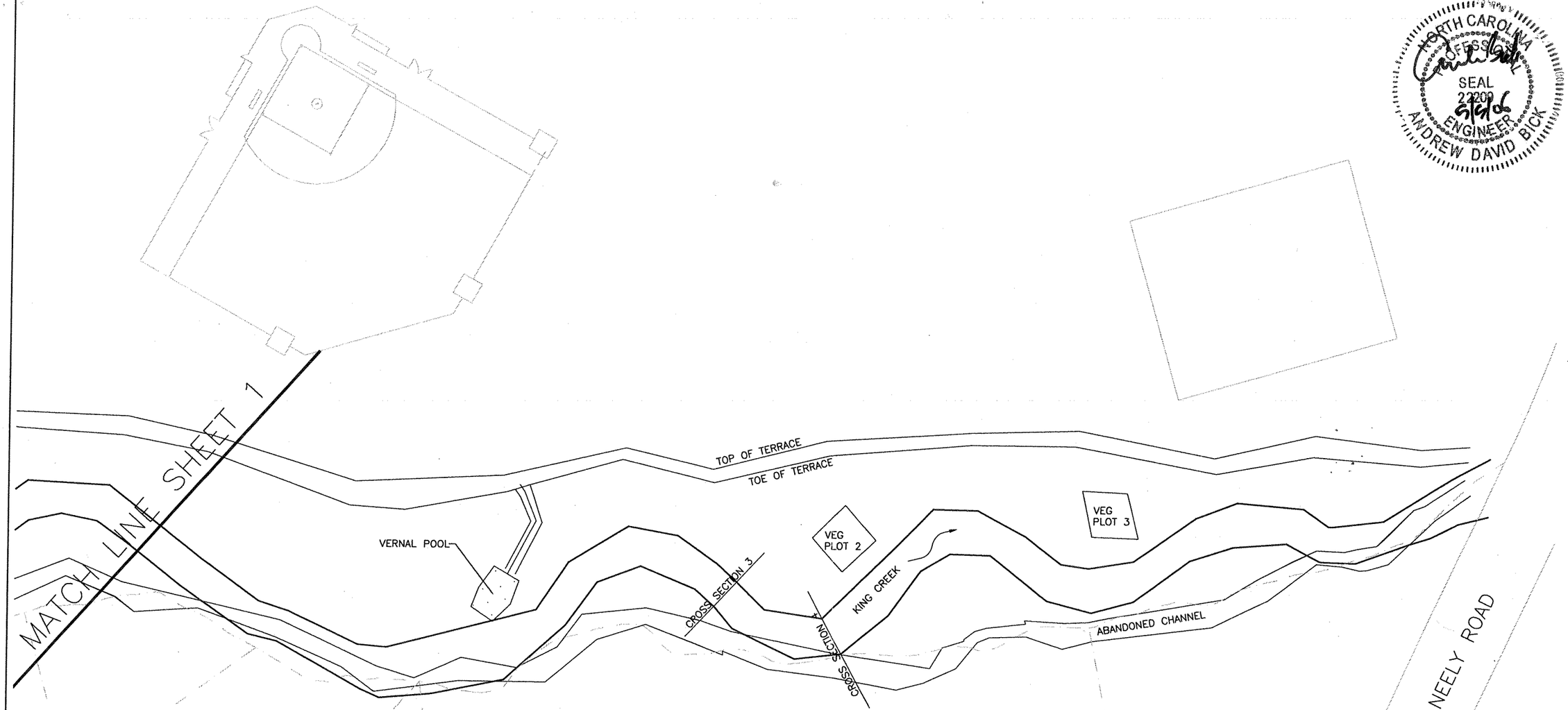
Prepared in the Office Of:
BUCK ENGINEERING
797 Haywood Road Suite 201
Asheville, NC 28806
Phone 828-350-1400
Fax 828-350-1409

KING CREEK RESTORATION PROJECT (# 01-05721-01A)
BREVARD, NORTH CAROLINA
FRENCH BROAD RIVER BASIN (06010105)
AS-BUILT PLANS

Prepared for:
NC Ecosytem Enhancement Program
2728 Capital Blvd, Suite 1H 103
Raleigh NC 27604
(919)715-0476
(919)715-2219 (fax)

File No.
0147AH_PSH.DWG

Drawing Sheet No.
Sheet 1 of 2



Monitoring Point Coordinate List			
Description	Northing	Easting	Elevation
X3RiffleLPIN	561251.5705	888825.1619	2104.7827
X3RPIN	561207.6942	888750.4605	2104.5562
X4PoolLPIN	561214.8268	888849.2953	2105.1310
X4RPIN	561137.1594	888866.3598	2104.5421
VegPlot2 SW	561222.1742	888878.0117	2104.6021
VegPlot2 SE	561238.0212	888908.4862	2104.3951
VegPlot2 NE	561269.4422	888893.7637	2104.4621
VegPlot2 NW	561252.8844	888863.2967	2104.7441
VegPlot3 SW	561196.3134	889065.9257	2103.4001
VegPlot3 SE	561185.3977	889099.0941	2103.3731
VegPlot3 NE	561220.4302	889100.2062	2103.1711
VegPlot3 NW	561231.4495	889068.3813	2103.1561

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40 0 40 80
SCALE (FT)

NORTH CAROLINA
PROFESSIONAL
SEAL
22209
ENGINEER
ANDREW DAVID BICK

		Date
Designed:	E. Godbold	May 2006
Drawn:	J. Fulton	May 2006
Checked:	A. Bick	May 2006
Approved:	A. Bick	May 2006

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KING CREEK RESTORATION PROJECT (# 01-05721-01A)
BREVARD, NORTH CAROLINA
FRENCH BROAD RIVER BASIN (06010105)

AS-BUILT PLANS

Prepared for the Office Of:
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Drawing Sheet No.
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