MITIGATION PLAN

For

Hatchery Creek

Prepared for:

Army Corps of Engineers Nashville District

U.S. Fish and Wildlife Service Frankfort, KY

U.S. Environmental Protection Agency Atlanta, GA

KY Division of Water Frankfort, KY

Prepared by:

Kentucky Dept of Fish and Wildlife Resources
Kentucky Wetland and Stream Mitigation Program
#1 Sportsman's Lane
Frankfort, KY 40601

January 10, 2014

Title Page

Project Title: **Hatchery Creek**

Watershed, County, State: **Upper Cumberland, Russell County, Kentucky**

Corps District and Section: **Nashville, Regulatory**

Corps I.D. & State I.D.: **LRN-2010-00444 , AI No: 3895**

Permittee: **Andy Mowrey**

Responsible Party: **Kentucky Department of Fish and Wildlife Resources**

Property Owner: **U.S. Army Corps of Engineers, Nashville District**

Easement Holder: **Kentucky Department of Fish and Wildlife Resources**

Date Document Prepared: **January 3, 2013; (Revised July 18, 2013) (Revised January 10, 2014)**

Sponsor: **Kentucky Department of Fish and Wildlife Resources**

Service Area: **Lower Cumberland**

Project Partner(s): **None**

Date of Pre-Application Site Visit: **May 30, 2013**

Date Concept Plan Approval: **March 17, 2010**

1. Objectives

The Kentucky Department of Fish and Wildlife Resources (KDFWR) propose to use In-Lieu-Fee Trust funds to re-establish and enhance 2.2 acres of wetland and re-establish approximately 6,000 linear feet of new stream channel downstream of the discharge of the U.S. Fish and Wildlife Wolf Creek Hatchery (Figure 1).

- The project will be in-kind mitigation.
- The project will re-establish approximately 6,000 linear feet of Upper Perennial, Unconsolidated Bottom, Unconsolidated Shore stream (Cowardin 1979)
- The project will re-establish and enhance 2.2 acres of forested and emergent wetland.
- There was an opportunity to re-establish a stream using the discharge water of the hatchery and to create habitat that will be designed specifically to meet the life requirements of rainbow, brook, and brown trout including feeding, refuge, spawning, and nursery.
- The existing ditch that the hatchery was discharging to is eroding and increasing the sediment load in the Cumberland River. This project will reduce this erosion and reduce sediment in the Cumberland River.
- The existing ditch is a safety hazard to existing campers and fishermen.
- There is a lack of suitable trout habitat and there is a large demand for trout fishing in the Commonwealth.

2. Site Selection

The site was selected to begin where the existing discharge from the U.S. Fish and Wildlife Wolf Creek Hatchery discharges into an eroding ditch. The location of the stream was determined based on existing topography, existing drainage features, existing facilities and infrastructure, cost, and Corps of Engineers approval. The base flow in the stream will be controlled by a pipe that collects water from the bottom of Lake Cumberland, conveys it to the Wolf Creek Hatchery, which is subsequently discharged into a constructed stream which flows to the ravine. There is small amount of watershed that will flow to the new stream with a drainage area of 454 acres. (Figure 2)

The stream will be located parallel to the Cumberland River above the 100 year floodplain on a relatively flat forested terrace. The stream will take advantage of existing channels on site including a small segment of ephemeral channel that flows in the opposite direction. The design alternatives for this project are all contained within the same corridor and the alternatives all dealt with getting the best fit within this corridor and design features such as instream habitat and bank treatments. No other location alternatives were considered.

The stream terminates adjacent to an existing channel which enters the Cumberland River. A series of step pools will be constructed which will allow fish from the Cumberland River to access this stream. The step pools will be designed specifically for trout, but other species may likely be capable of passage.

As planned and designed the newly created channel will be an ecologically self-sustaining aquatic resource. The design is intended to provide habitat for all life stages of trout. The stream is designed specifically to the discharge of the existing hatchery and for the small amount of watershed that drains to it.

The proposed stream mitigation is very compatible with the existing land use. The property at the location of the proposed project is adjacent to public campgrounds, boating, and fishing areas maintained by the Corps of Engineers and connects to a small segment of stream below the hatchery that is currently used for trout fishing. The proposed project will provide additional opportunity for recreation. The stream crosses an existing road that will have a bridge or culvert installed to provide access to the campground. The location of the bridge will be near the location 36.8786 N; -85.14443 W.

The project is compatible with both the geology and soils of the site. A geotechnical study of the project site confirmed that the soils and bedrock are compatible for the project (Attachment IV). The potential for sinkholes was identified as a potential in the project area and three alternative methods were recommended in the event that one is encountered. These include, in order of preference, relocation of channel, filling the karst location with compactable material such clay, or synthetic channel liner.

There are no known populations of any state or federal threatened, endangered or listed species in the study area (Correspondence with KDFWR and USFWS, 2012). Trees that could serve as potential roost sites for the Indiana bat (*Myotis sodalis*) will need to be removed. The number of large trees will be minimized by keeping the construction limits small, using existing disturbed locations for staging and stockpiling, and by avoidance at the time of construction. Any trees that need to be removed will be cut down within the required time frame to minimize impact. New trees will be planted that will provide equal or better habitat in the future and the new stream will offer forage habitat.

KDFWR shall be consistent with the site selection requirements specified in the Compensation Planning Framework of the In-Lieu Fee Mitigation Program Instrument and any Corps of Engineers district specific requirements.

3. Site Protection

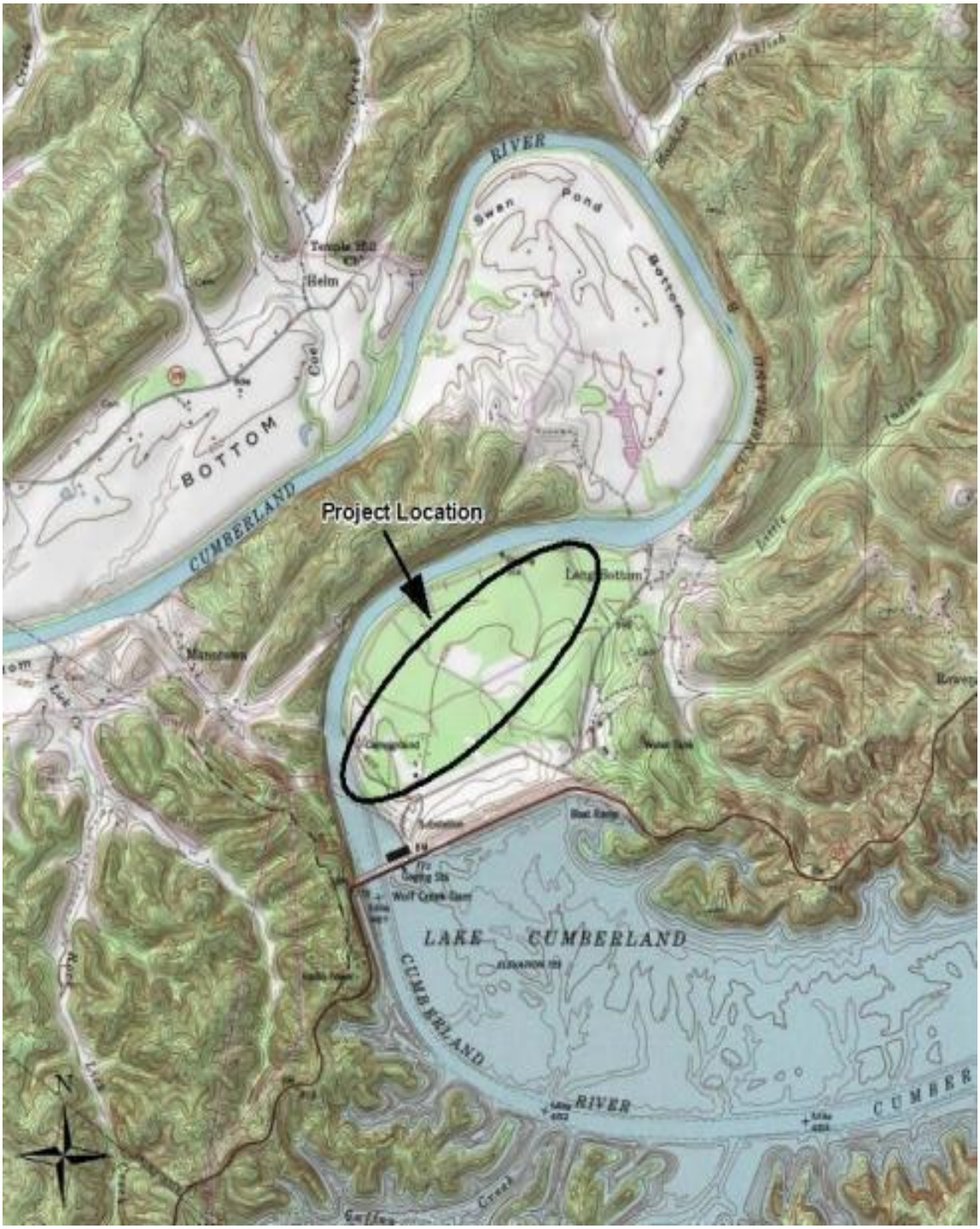
The project area is currently owned and maintained by the U.S. Army Corps of Engineers, Nashville District. KDFWR will ensure permanent protection of the site through modification of an existing lease between the Lake Cumberland resource area and the Wolf Creek National Fish Hatchery. This will include a lease extension which will incorporate the new channel and its associated 300’ protective corridor.

4. Baseline Information

Location: The site is located off of US 127 in southern Russell County, Kentucky. The project begins at the existing discharge to the hatchery at the end of a constructed channel used to convey flow to a ravine and for fishing. This channel is located to the north of the hatchery.

Directions: From Jamestown, KY, proceed south on US 127. Turn right on Dam Road and proceed toward the Wolf Creek National Fish Hatchery. Turn right on Kendall Road. The project is located to the northeast of the hatchery.

Figure 1 Site Location Map



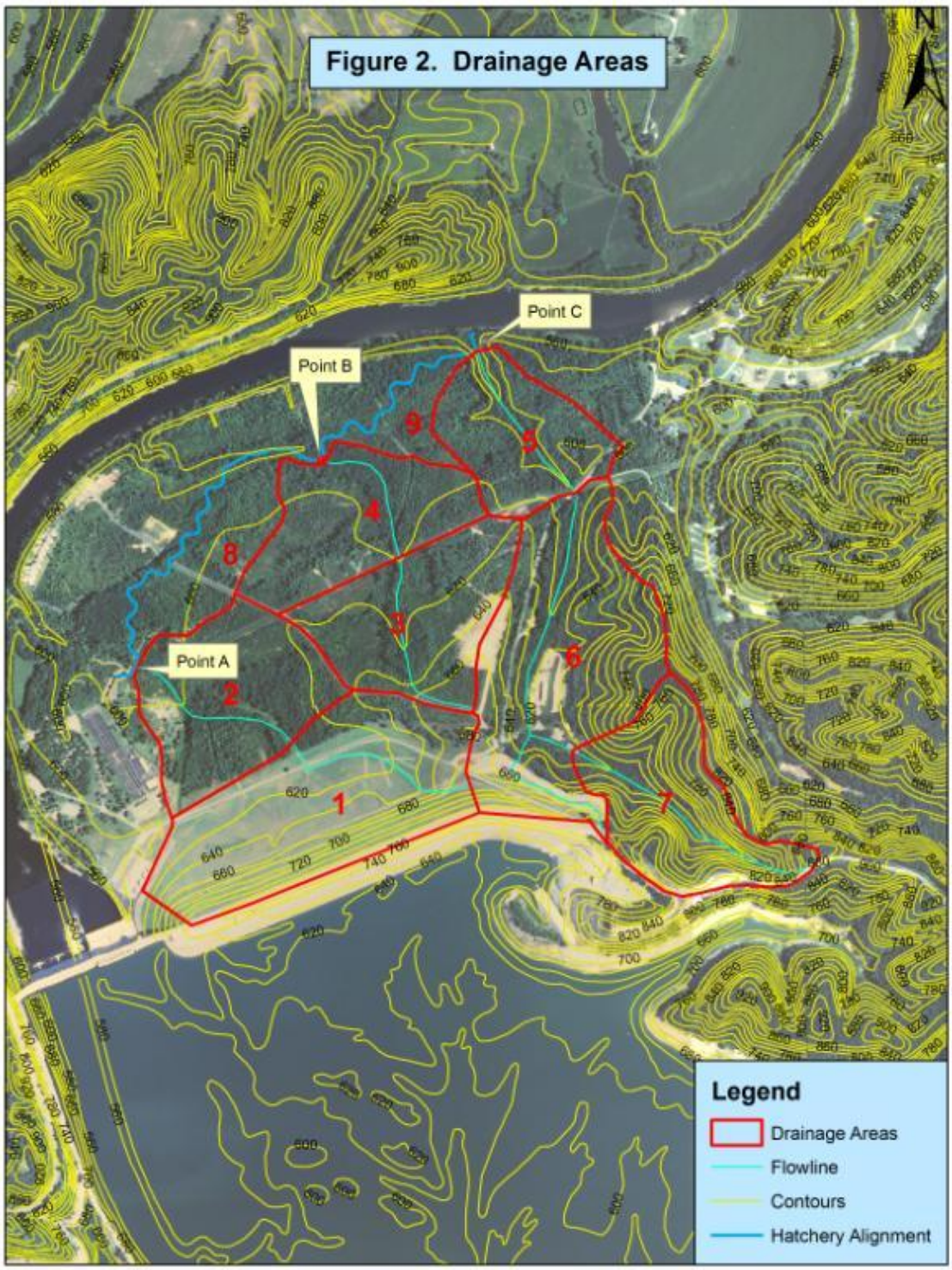


Figure 2. Drainage Areas
N
Point A
Point B
Point C
1
2
3
4
5
6
7
8
9
Legend
Drainage Areas
Flowline
Contours
Hatchery Alignment

Figure 3

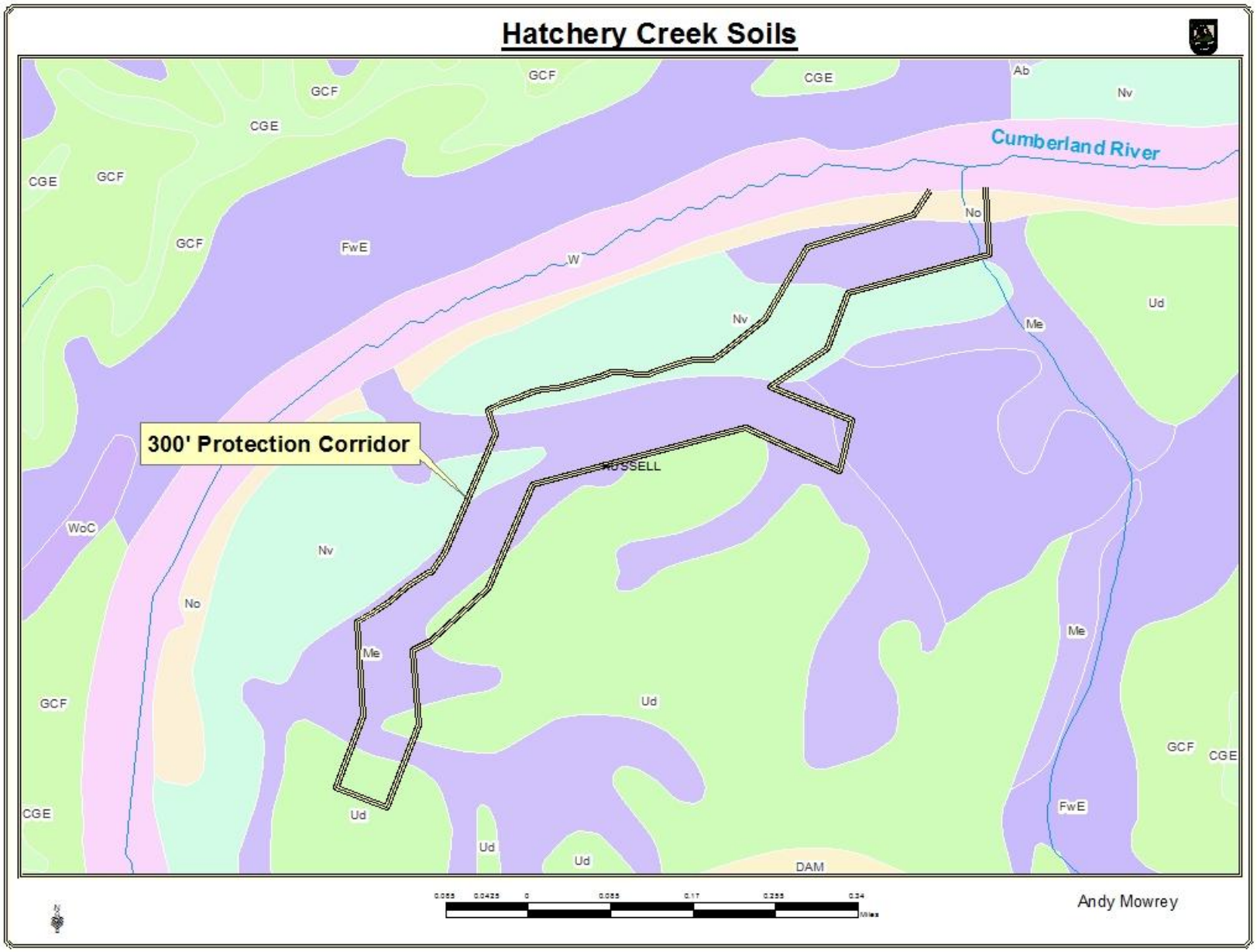
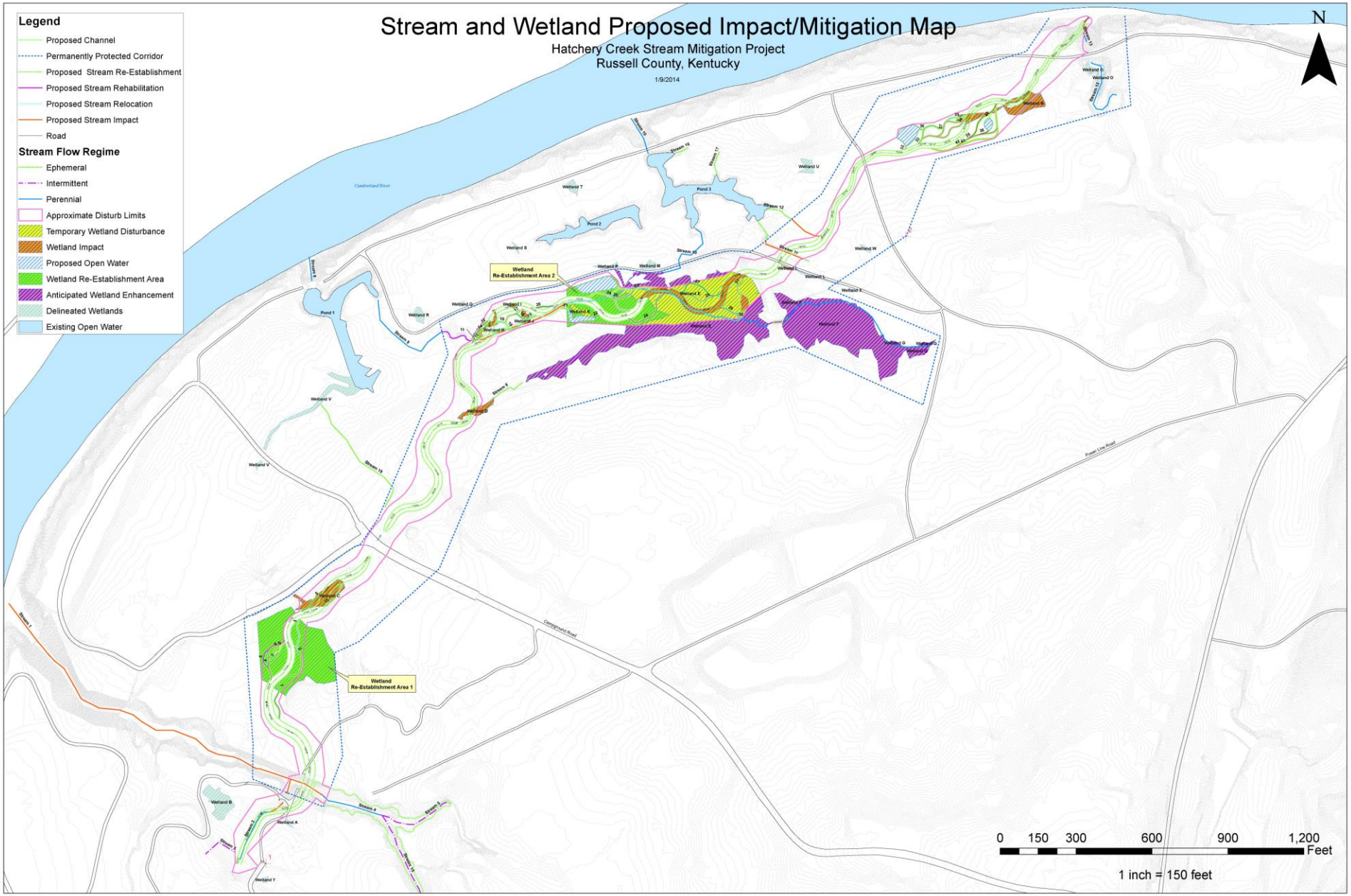

Hatchery Creek Soils
Cumberland River
300' Protection Corridor
GCF
CGE
Ab
Nv
FwE
W
No
Ud
Me
RUSSELL
WoC
DAM
Andy Mowrey

Figure 4


Stream and Wetland Proposed Impact/Mitigation Map
Hatchery Creek Stream Mitigation Project
Russell County, Kentucky
1/9/2014
Legend
Proposed Channel
Permanently Protected Corridor
Proposed Stream Re-Establishment
Proposed Stream Rehabilitation
Proposed Stream Relocation
Proposed Stream Impact
Road
Stream Flow Regime
Ephemeral
Intermittent
Perennial
Approximate Disturb Limits
Temporary Wetland Disturbance
Wetland Impact
Proposed Open Water
Wetland Re-Establishment Area
Anticipated Wetland Enhancement
Delineated Wetlands
Existing Open Water
N
Wetland Re-Establishment Area 2
Wetland Re-Establishment Area 1
Cumberland River
Campground Road
Power Line Road
0 150 300 600 900 1,200
Feet
1 inch = 150 feet

USGS HUC 8: **05130103 / Upper Cumberland-Lake Cumberland; 05130102**

Service Area: **Upper Cumberland**

Level III Ecoregion & Bioregion: **Interior Plateau, Pennyroyal**

Watershed Size: Flow derived primarily from hatchery discharge, an additional 454 acres drain to the stream
Coordinates: **36.523370 N; -85.084598W (upstream end of project) 36.520326 N; -85.075911W (downstream end of project)**

Numerous wetlands have been identified within the project corridor (Figure 4). These wetlands have been delineated and credit scores calculated (Table 1). It is proposed that the project will enhance the hydrology of the wetlands through design of intentional flooding of the channel through a portion of the stream. Further improvements of the project site will include invasive species removal. The plant community for the region is oak hickory forest on the hillsides with mixed mesophytic forest on the plains of the Cumberland River. According to the floodplain coordinator, the project area is located entirely on the historic (500 year) floodplain terrace of the Cumberland River downstream of the Wolf Creek Dam. Soils for the project site are highly variable and include Melvin and Nolin Variant, however were found to be problem soils during delineations due to significant modifications throughout recent history. Groundwater depth ranges from 3 to 9 feet. The project area lies within a valley type II with a wide gently sloping valley bottom (Rosgen, 1996).

The current Hatchery Creek channel has no KY Division of Water (DOW) designated use for the project site or its surrounding area. The stream as designed is intended to be a Rosgen Type C4 stream (Rosgen, 1996).

Threatened and Endangered Species / Cultural Resources

KDFWR has coordinated with the USFWS for potential impacts to federally protected species as a result of the proposed project. Coordination and protected species located within Russell County are listed in Attachments I & II.

The State Historical Preservation Office (SHPO) was contacted and a site survey to determine the extent of impact to cultural resources was performed.

There are no historical structures located on the property. A phase I archaeological survey was completed and the SHPO office found no further investigations required. (Attachment III).

5. Determination of Credits

The project proposes to create approximately 6,000 linear feet of new high quality trout stream habitat resulting in 13,661.4 stream AMU's and 2.2 wetland AMU's within the Lower Cumberland service area. The method used in the credit determination was the Adjusted Mitigation Units method (Table I).

Table I

Stream Debit/Credit Tables

PROPOSED STREAM DEBITS FOR THE HATCHERY CREEK STREAM RESTORATION PROJECT							
Stream Reach	Flow Regime	EXISTING				Impact Type	Debit AMU
		RBP Score	Stream Quality	SFSQR	Length (ft)		
Stream 1	Perennial	127	Poor	1.5	8.3	Fill (Weir)	12.5
				1.00	1370.7	Flow Regime Change: Perennial to Ephemeral	1370.7
Stream 2	Perennial	109	Poor	1.5	123.7	Fill (Stream Relocated)	185.6
Stream 3	Intermittent	136	Average	NO IMPACT			
Stream 4	Perennial	109	Poor	1.5	142.3	Fill	213.45
Stream 5	Intermittent	99	Poor	NO IMPACT			
Stream 8	Ephemeral	99	Poor	NO IMPACT			
Stream 9	Perennial	99	Poor	1.5	409.2	Grading/flow reversal	613.8
					742.4	Relocation	1113.6*
Stream 10	Perennial	68, 94	Poor	NO IMPACT			
Stream 11	Ephemeral	85	Poor	0.5	171.2	Grading	85.6
Stream 12	Ephemeral	83	Poor	0.5	141.6	Grading	70.8
Stream 13	Perennial	110	Poor	1.5	76.9	Grading/Structure Placement	115.35
Stream 15	Intermittent	113	Poor	NO IMPACT			
Stream 16	Ephemeral	110	Poor	NO IMPACT			
Stream 17	Ephemeral	N/A	Poor	NO IMPACT			
Stream 18	Ephemeral	N/A	Poor	NO IMPACT			
						Total Stream Debit	**2667.7**

*No debit included - stream is being replaced in kind. See Hatchery Creek Station 132+50 to 141+50 on the Stream Mitigation Credit Table.

PROPOSED HATCHERY CREEK STREAM MITIGATION CREDITS									
Stream Reach	Flow Regime	EXISTING		PROPOSED					Credit AMU
		Initial Stream Quality	Initial SFSQ	Final Stream Quality	Final SFSQ	Mitigation Type	Length	Mitigation Ratio[2]	
Hatchery Creek (STA 104+10 to STA 109+00 - Migration Barrier to Wetland Re-Establishment Area 1)	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/150 ft buffer each side	490	1.1	1617.0
Hatchery Creek (STA 109+00-112+30 - Wetland Re-Establishment Area 1)	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/150 ft buffer each side	330	0.0	0.0
Hatchery Creek (STA 112+30-116+27 - Wetland Re-Establishment Area 1 to Road)	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/150 ft buffer each side	397	1.1	1310.1
Hatchery Creek (STA 117+42-132+50 - Road to Wetland Re-Establishment Area 2)	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/150 ft buffer each side	1508	1.1	4976.4
Hatchery Creek (STA 132+50-141+50 - Wetland Re-Establishment Area	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/150 ft buffer each side	900	1.1	2970.0***
Hatchery Creek (STA 141+50 to STA 159+92 - Road to End of Project)	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/150 ft buffer each side	1842	1.1	6078.6
Stream 9 (between Disturb Limits and Permanently Protected Corridor near STA	Perennial	Poor	1.5	Excellent	3.0	Rehabilitation w/100 ft buffer each side	141.3	0.7	148.4
Stream 9 (between Wetland E and F)	Perennial	Poor	1.5	Excellent	3.0	Rehabilitation w/100 ft buffer each side	55.7	0.7	58.5
Braid 1	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/50 ft buffer each side	117.2	0.3	116.0
							35.0	0.0	0.0
Braid 2	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/50 ft buffer each side	169.1	0.0	0.0
Braid 3	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/50 ft buffer each side	140.0	0.0	0.0
Braid 4	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/50 ft buffer each side	199.2	0.0	0.0
Braid 5	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	84.4	0.0	0.0
Braid 6	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	61.1	0.0	0.0
Braid 7	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	74.0	0.0	0.0
Braid 8	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	66.3	0.0	0.0
Braid 9	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/50 ft buffer each side	110.6	0.3	109.5
Braid 10	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/50 ft buffer each side	113.9	0.3	112.8

Continued on next page…

Braid 11	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	66.6	0.3	44.0
Braid 12	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/50 ft buffer each side	114.3	0.3	113.2
Braid 13	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	40.7	0.3	26.9
Braid 14	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	37.2	0.3	24.6
Braid 15	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/50 ft buffer each side	196.2	0.3	194.2
Braid 16	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	40.0	0.3	26.4
Braid 17	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	87.2	0.3	57.6
Braid 18	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	57.4	0.3	37.9
Braid 19	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	32.7	0.3	21.6
Braid 20	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/50 ft buffer each side	68.9	0.3	68.2
Braid 21	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/50 ft buffer each side	22.3	0.3	22.1
							7.6	0.0	0.0
Braid 22	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/50 ft buffer each side	21.6	0.0	0.0
Braid 23	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/50 ft buffer each side	275.9	0.0	0.0
Braid 24	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	131.9	0.0	0.0
Braid 25	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	92.6	0.0	0.0

Continued on next page…

Braid 26	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/50 ft buffer each side	212.8	0.0	0.0
Braid 27	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/50 ft buffer each side	197.4	0.0	0.0
Braid 28	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	138.1	0.0	0.0
Braid 29	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/50 ft buffer each side	78.3	0.0	0.0
Braid 30	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	28.9	0.0	0.0
Braid 31	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/50 ft buffer each side	86.0	0.0	0.0
Braid 32	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/50 ft buffer each side	18.6	0.3	18.4
Braid 33	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	153.4	0.3	101.2
Braid 34	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	150.8	0.3	99.5
Braid 35	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	93.9	0.3	62.0
Braid 36	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/50 ft buffer each side	15.3	0.3	15.1
Braid 37	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/50 ft buffer each side	204.7	0.3	202.7
Braid 38	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	39.0	0.3	25.7
Braid 39	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	190.4	0.3	125.7
Braid 40	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	19.8	0.3	13.1
Braid 41	Perennial	N/A	0	Excellent	3.0	Re-Establishment w/50 ft buffer each side	388.4	0.3	384.5
Braid 42	Intermittent	N/A	0	Excellent	2.0	Re-Establishment w/50 ft buffer each side	177.9	0.3	117.4
								Subtotal	16329.1
								Debit Subtotal	2667.7
								Net Credit	**13661.366**

***No stream credit claimed because located within proposed Wetland Mitigation Area. Stream re-establishment offsets the 1113.6 AMUs of relocation impact to Stream 9.

[2]A Mitigation Ratio of 0.0 denotes stream length where wetland credit is anticipated. No stream credit is claimed at this time.

Wetland Debit/Credit Tables

PROPOSED HATCHERY CREEK WETLAND DEBITS					
Wetland	**Cowardin Class**	**Impact Acreage**	**Impact Type[1]**	**Ratio**	**Debit AMU**
Wetland A	PEM	NO IMPACT			
Wetland B	PFO	NO IMPACT			
Wetland C	PFO	0.206	Channel Construction	2.0	0.412
Wetland D	PFO	0.079	Channel Construction	2.0	0.158
Wetland E	PFO	0.423	Channel Construction	2.0	0.846
		1.088	Temporary	1.0	N/A
Wetland F	PFO	NO IMPACT			
Wetland G	PFO	NO IMPACT			
Wetland H	PFO	0.049	Channel Construction	2.0	0.098
Wetland I	PFO	0.008	Channel Construction	2.0	0.016
Wetland J	PFO	0.018	Channel Construction	2.0	0.036
Wetland K	PFO	0.039	Temporary	1.0	N/A
Wetland L	PEM	0.006	Channel Construction	2.0	0.012
Wetland M	PFO	NO IMPACT			
Wetland N	PFO	0.270	Channel Construction	2.0	0.540
Wetland O	PEM	NO IMPACT			
Wetland P	PSS	NO IMPACT			
Wetland Q	PSS	NO IMPACT			
Wetland R	PFO	NO IMPACT			
Wetland S	PEM	NO IMPACT			
Wetland T	PFO	NO IMPACT			
Wetland U	PFO	NO IMPACT			
Wetland V	PEM	NO IMPACT			
Wetland W	PEM	NO IMPACT			
Wetland X	PEM	NO IMPACT			
Wetland Y	PEM	NO IMPACT			
				Total Wetland Debit	**2.118**

[1]Temporary impacts will be restored to original or better condition

PROPOSED HATCHERY CREEK WETLAND MITIGATION CREDITS					
Proposed Wetland Mitigation Area	**Proposed Cowardin Class**	**Mitigation Type**	**Ratio[3]**	**Proposed Acreage**	**Adjusted Mitigation Units (AMU)**
Re-Establishment Area 1	PFO	Re-Establishment	1.0	1.370	1.370
Re-Establishment Area 2	PFO	Re-Establishment	1.0	0.632	0.632
Wetland E	PFO	Enhancement	0.5	2.824	1.412
Wetland F	PFO	Enhancement	0.5	1.659	0.830
Wetland G	PFO	Enhancement	0.5	0.130	0.065
Wetland K	PFO	Enhancement	0.5	0.039	0.020
			TOTAL	6.654	4.328
				TOTAL EXCESS WETLAND MITIGATION	2.210

NOTE: Enhancement Areas include wetland areas temporarily impacted, as well as portion of wetland outside of proposed disturb limits (see accompanying impact map).

[3]Wetland credits are calculated using the new instrument ratios. Stream credits are calculated using the old instrument.

6. Mitigation Work Plan

The proposed project is consistent with the Master Plan for the Wolf Creek Dam and surrounding property owned by the Corps of Engineers. A set of plans are included in the appendix and provided the basis for the majority of these responses. The geographic boundaries of the project are identified on the plans and identified as protection corridor. The limits of disturbance are identified on the drawings. The construction methods, timing, sequencing, staging and excavation and stockpile areas will be determined by the contractor and approved by the KDFWR. All actions will be in compliance with the terms and conditions of the Section 404 permit, Section 401 Water Quality Certification, Floodplain permit, Notice of Intent, and any conditions from other resource agencies. The source of water is the hatchery. The project begins where the hatchery channel discharges into a ditch. The watershed is relatively small and will enter the stream at 3 different locations. The channel has been sized to accommodate these flows and at one location, there is a water control structure that allows excess amounts of water to leave the new channel and enter an existing channel.

The planting and vegetation plan will include species lists and details for installation. Species selection is based upon what is native to this region and habitat, what KDOW suggests in their suggested riparian vegetation list, what is commercially available from nurseries, what species grow well for an ecological restoration, and species cost. The selected species will establish both short and long term soil stabilization and to compete with invasive species. Invasive species control shall be the responsibility of KDFWR or their representatives which will adhere to the In-Lieu Fees success criteria (Attachment IV).

It will be the contractors' responsibility to manage both soil and water and install erosion control measures. The contractor will be required to obtain a Notice of Intent and prepare a Sediment and Erosion Control Plan. KDFWR will perform periodic inspections, but it is anticipated that the Corps of Engineers will also inspect. Compliance will be performance based.

The Rosgen classification of the proposed stream is C4.

The planform geometry and channel form are shown on the plan set.

The watershed size is 454 acres and the base flow is derived entirely from the discharge of the hatchery. The design discharge is fixed by the discharge of the hatchery which averages 15,000 gallons per minute (Correspondence USFWS, 2011) which converts to 34 cfs. The stream is designed to flow at or slightly below top of bank. Storm flow is intended to flood the riparian area, be buffered by the wetland, be diverted off, or be discharged in the step pools.

The streambed composition has been modeled to have the following distribution of material. This material size is considered optimal for trout habitat. Riffles will have larger material and pools will have finer material. This material size was selected using published literature for both the rainbow and brown trout (Raleigh 1984). The substrate size is intended to meet the habitat requirements for spawning, fry, juveniles, and adults of both species. Table II below shows particle sizes that are optimum for trout redds that would need to be retained. Smaller particle sizes will be somewhat mobile; however there will be a mix of settling and flushing based on location of the channel.

Channel Braids

Complex channel patterns such as the DA proposed in this project provide excellent trout habitat. Multi-channel streams, such as anatomosed or braided channels, have more confluences than single channel streams (Cluer and Thorne 2013) a feature that may contribute to increased biological diversity (Benda et al. 2004). The tighter pool to pool spacing in side channels results in greater physical habitat heterogeneity via patchwork patterns of turbulence, velocity acceleration and deceleration, sediment sorting, and wood recruitment (Cluer and Thorne 2013).

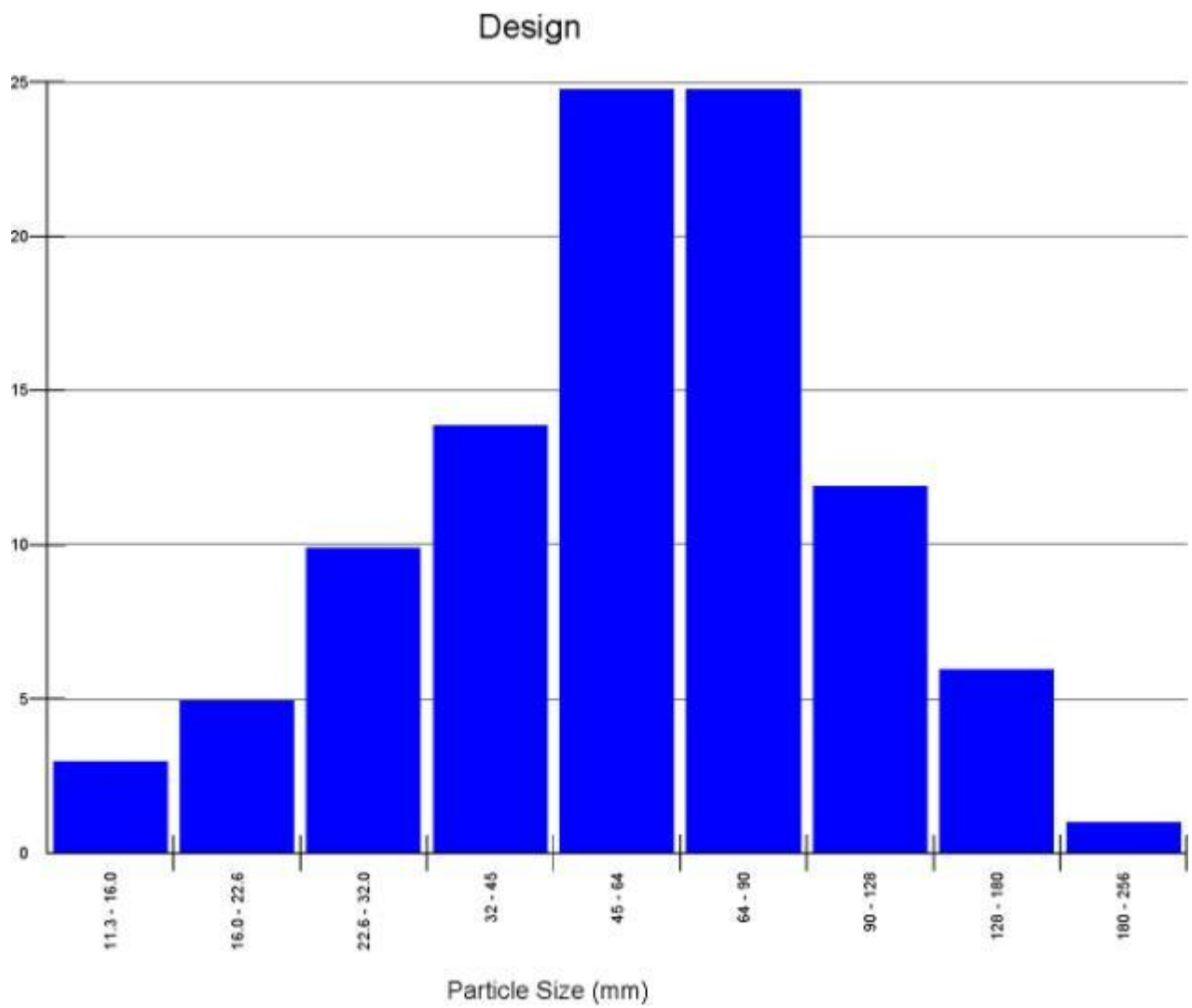
Pierce and Podner (2012) state "higher proportion of smaller fish and higher species diversity in post-treatment" restored streams. The goal is to provide very high quantities of instream cover at the time that the project is fully operational. This instream cover is an important requirement for all life stages of trout, however is critical for juvenile trout in providing refuge from predators during a vulnerable stage in their development. It has been further shown that emerging juvenile trout seek near shore and side channel protection. Moore and Gregory (1988) show that "when emergence occurs from midchannel spawning sites, dispersal mechanisms may also result in the establishment of territories in lateral habitats".

These braids will also serve to slow velocities down for juvenile trout which cannot withstand prolonged exposure to higher velocities. Shallow side channels and connected, off-channel oxbows in the C and D stream types provide excellent rearing areas for fry and juvenile trout and offer refugia from larger bodied predators that will avoid shallow water. Drucker (2006) demonstrated that juvenile trout densities were significantly higher in side channel versus main channel habitats. Adult rainbow trout were also observed to use side channels in higher densities than main channel habitats. Ambient temperatures in the project area are expected to range between 4.4 and 18 °C (40 – 65 °F) and may constrain fry and juvenile growth in some periods of the year. In these

circumstances, fry will seek out shallow, warmer areas (i.e., the side channels) open to solar radiation in order to stimulate increased foraging and growth. DA channels also maximize the interface between the juveniles and the aquatic terrestrial transition zone, which increases the quantity of feeding opportunities. Multiple authors have noted the relationship between habitat complexity on the lateral margins of the channel and juvenile population density (Moore and Gregory 1988) and survival (Bjornn and Reiser 1991).

Anastomosed channels may also influence shallow subsurface (hyporheic) flow patterns causing localized areas of groundwater upwelling. Curry and Noakes (1995) found that the occurrence of groundwater upwelling was consistently present in brook trout spawning areas and the presence of groundwater could be a predictor of good spawning habitat. The upwelling could produce physical, chemical, or temperature gradients that cause the brook trout to hone in on those areas to spawn (Curry and Noakes 1995).

Table II. Particle Size Percent Retained



Riparian area plantings are shown on the plans under the planting and vegetation set. It is anticipated that the point bars will be vegetated and the shorelines fully vegetated. Live stakes and shrubs will be planted on the outside bend of the channel where the largest sheer stress occurs. This vegetation will hold the soil in place, reinforce the bank and provide overhanging vegetation for habitat.

Along riffles, runs, and glides the banks will be comprised of cobbles and soil and will be held together with a mixture of grasses and sedges. This will help prevent erosion and provide high quality habitat.

7. Maintenance Plan

There will be annual monitoring of the stream for a 5 year period. Based on the results of monitoring, it will be determined if and when maintenance is needed.

8. Performance Standards

Performance standards will include channel stability, habitat use by target species, and vegetation. Almost all of the performance standards will be able to be verified visually.

Since the source of flow is from a hatchery and there is very little watershed attached to the stream, there will be very little bedload movement over the long term. The channels will be over excavated and bankrun material will be added to the channel during construction. This material will be sized to provide optimum habitat and will not mobilize. Erosion or stream instability will not be acceptable.

The ability of trout to pass through the step pools will be required. Based on existing literature, the design will allow successful passage. If the pools are installed per design it should be possible to visually verify passage. Trout should also use this stream for resting, feeding, spawning, and nursery habitat. Again, all of these trout behaviors should be clearly visible.

Vegetation goals will include adequate cover to prevent erosion. Bareroot seedling trees, live stakes, and shrubs will be installed and monitored for 80 percent survival with no one species representing more than 20 percent of the species after a 5 year period. Credit will be given for native volunteer species that help in meeting goals. This parameter will be measured in number per acre. The goal for herbaceous plantings will be 70% cover measured using the point quadrat method.

9. Monitoring Requirements

There will be 5 years of annual monitoring for stream stability and vegetative success performed on this stream once it is constructed with annual reports submitted to the KY Dept of Fish and Wildlife, and U.S. Army Corps of Engineers (Nashville District), and KY Division of Water.

POST CONSTRUCTION MONITORING

Permanent picture stations will be established where pictures can be taken biannually (summer/winter).

a. One station will be established downstream of each structure to provide an upstream view of the structure such that each large rock within the structure is visible.
b. One station will be established at each bend such that a downstream view of the downstream ½ of each bend is visible.
c. Photographs will also show riparian plantings.

Additional stations may be added to show areas where aggradations, degradation, erosion, and mid channel bars have formed. Summer pictures will focus on documenting the vegetation and bank erosion, while winter pictures will show the stream stability and geomorphology. Erosion and sediment control measures will also be documented. The locations of the photograph stations will be located on the Plan View with arrows indicating the direction the picture is to be taken. Photographs will include a detailed description of the view and label any problem areas identified during the monitoring. Pictures will be color and at least 4" X 6".

Planted vegetation and geomorphology will be monitored during a 5-year monitoring period and begin following the completion of construction and the creation of the as-built survey. The following success measurements will be reported annually (Attachment IV). Note that only 25% of volunteers can account toward success criteria standards. Invasive/exotics will be included, reported and managed.

10. Long-Term Management

The project area will be owned and operated by the U.S. Army Corps of Engineers, Nashville District. The Corps is drafting real estate language extending the current lease with Wolf Creek National Fish Hatchery to encompass the new project corridor. This language will include the In-Lieu fees easement language to ensure permanent protection and provide guidance to the fish hatchery staff.

11. Adaptive Management Plan

Once the stream is constructed, the stream will be monitored for performance and adjusted if needed. This adjustment is considered adaptive management. Post construction modifications of the project will be reported to KDOW and USACE as part of the regular annual monitoring report.

The life requirements for trout are fairly well documented and the stream has been designed to meet those requirements. During the monitoring phase, it will be determined if the stream is meeting all of the design parameters. Many of the stream features have been designed in a manner that allows adjustment including boulder clusters and riffles. Material can also be added to the channel to modify substrate size, roughness, and cross section. The stream will be very conducive to minor adjustments because it does not have a bedload.

Vegetation will be monitored. The majority of species being selected for planting are climax species in the region. It is anticipated that pioneer species will occur due to seed dispersal or from the seed bank in the soil. These pioneer species will augment the vegetation by growing densely and quickly.

For the first year of operation, the stream will be under warrantee by the contractor. Bank stability, areas of erosion, vegetation mortality, and other parameters will be addressed at this time. After this period, the KDFWR will decide which measures are necessary to achieve success and meet the project goals.

12. Financial Assurances

Reference section B.3.0 (Financial Assurances) of Appendix B of the In-Lieu Fee Mitigation Program Instrument.

13. Threatened and Endangered Species and National Historic Preservation Act Compliance
There are no known populations of any state or federal threatened, endangered or listed species in the study area (Correspondence with KDFWR and USFWS, 2012). There are trees that could serve as maternity colony roost sites for the Indiana bat (*Myotis sodalis*) that will need to be removed. The number of large trees will be minimized by keeping the construction limits small, using existing disturbed locations for staging and stockpiling, and by avoidance at the time of construction. Any trees that need to be removed will be cut down within the required time frame to minimize impact. New trees will be planted that will provide equal or better habitat in the future and the new stream will offer forage habitat.

The State Historical Preservation Office (SHPO) has conducted a site survey and determined no impacts to cultural resources will occur. There are no historical structures located on the property and further archaeological analysis will not be required. Therefore, the project has met concurrence with the SHPO office.

Attachment I

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Kentucky Ecological Services Field Office
330 West Broadway, Suite 265
Frankfort, Kentucky 40601
(502) 695-0468

September 21, 2012

Mr. Mike Hardin
Kentucky Department of Fish and Wildlife Resources
#1 Sportsman's Lane
Frankfort, KY 40601

Subject: FWS #2010-B-0971, Hatchery Creek, Proposed Stream Establishment, Russell County, Kentucky

Dear Mr. Hardin:

The U.S. Fish and Wildlife Service Kentucky Field Office (KFO) has reviewed the August 21, 2012 Biological Assessment (BA) prepared for the proposed Hatchery Creek Stream Establishment Project, in Russell County, Kentucky. According to the BA, this project proposes to establish approximately 5,900 linear feet of stream to carry effluent from the U.S. Fish and Wildlife Service's Wolf Creek National Fish Hatchery to the Cumberland River. The effluence is presently discharged to a 380-foot, eroding outlet channel. The water source for the hatchery is Lake Cumberland.

The submitted BA addresses the project's potential to affect the following listed species:

Group	Species	Common Name	Status
Mammal	*Myotis sodalis*	Indiana Bat	Endangered
Mussel	*Villosa trabilis*	Cumberland bean	Endangered
	Epioblasma brevidens	Cumberland combshell	Endangered
	Ptychobranchus subtenum	Fluted kidneyshell	Endangered
	Epioblasma capaeiformis	Oyster mussel	Endangered
	Cyprogenia stegaria	Fanshell	Endangered
	Pleurobema plenum	Rough Pigtoe	Endangered
	Obovaria retusa	Ring Pink	Endangered
	Plethoblasus cooperianus	Orangefoot Pimpleback	Endangered
	Lampsilis abrupta	Pink Mucket	Endangered

The proposed project will involve the removal of 20.3 acres of potentially suitable summer habitat for the Indiana bat. All acres will be replanted to forest. Approximately 71% of the surrounding landscape (2.5 mile buffer) is forested. All tree removal will occur between October 15 and March 31 to avoid direct impacts to roosting Indiana bats. The proposed project is 54 miles from the nearest designated critical habitat for the Indiana bat.

The proposed project area does not contain suitable habitat for the above-listed federally endangered mussel species and an Erosion and Sediment Control Plan and Storm Water Pollution Prevention Plan will be implemented to minimize potential effects to water quality within and downstream of the site.

Based on this information, the KFO concurs with the determination that the proposed project may affect but is not likely to adversely affect *Myotis sodalis, Villosa trabilis, Epioblasma brevidens, Ptychobranchus subtenum, Epioblasma capsaeiformis, Cyprogenia stegaria, Pleurobema plenum, Obovaria retusa, Plethobasus cooperianus* and *Lampsilis abrupta;* and no effect on critical habitat for *Myotis sodalis*.

Based on these determinations and our concurrences with them, we believe that the requirements of section 7 have been fulfilled as it relates to federally listed species listed in the BA. Obligations under section 7 must be reconsidered, however, if: (1) new information reveals that the proposed project may affect listed species or proposed critical habitat in a manner or to an extent not previously considered, (2) the proposed project is subsequently modified to include activities which were not considered during this consultation, or (3) new species are listed or critical habitat designated that might be affected by the proposed project.

If you need additional assistance in determining if a proposed project may impact a federally listed species, we recommend that you contact us for further assistance. Thank you for the opportunity to comment on this proposed action. If you have any questions regarding the information which we have provided, please contact Jennifer Garland at (502) 695-0468 extension 115.

Sincerely,

Virgil Lee Andrews, Jr.
Field Supervisor

Attachment II

U.S. Fish & Wildlife Service
Kentucky Ecological Services Field Office

U.S. Fish & Wildlife Service
3761 Georgetown Rd.
Frankfort, KY 40601
Phone: 502-695-0468
Fax: 502-695-1024

Endangered, Threatened, & Candidate Species in ____RUSSELL_____ County, KY

Group	Species	Common name	Legal* Status	Known** Potential	Special Comments
Mammals	*Myotis sodalis*	Indiana bat	E	P	
Mussels	*Villosa trabilis*	Cumberland bean pearlymussel	E	K	
	Epioblasma brevidens	Cumberlandian combshell	E	K	
	Cyprogenia stegaria	fanshell	E	K	
	Ptychobranchus subtentum	fluted kidneyshell	C	K	
	Plethobasus cooperianus	orangefoot pimpleback	E	K	
	Epioblasma capsaeiformis	oyster mussel	E	K	
	Lampsilis abrupta	pink mucket	E	K	
	Obovaria retusa	ring pink	E	K	
	Pleurobema plenum	rough pigtoe	E	K	

NOTES:

* Key to notations: E = Endangered, T = Threatened, C = Candidate, CH = Critical Habitat

**Key to notations: K = Known occurrence record within the county, P = Potential for the species to occur within the county based upon historic range, proximity to known occurrence records, biological, and physiographic characteristics.

Attachment III

STEVEN L. BESHEAR
GOVERNOR

TOURISM, ARTS AND HERITAGE CABINET
KENTUCKY HERITAGE COUNCIL

MARCHETA SPARROW
SECRETARY

THE STATE HISTORIC PRESERVATION OFFICE
300 WASHINGTON STREET
FRANKFORT, KENTUCKY 40601
PHONE (502) 564-7005
FAX (502) 564-5820
www.heritage.ky.gov

LINDY CASEBIER
ACTING EXECUTIVE DIRECTOR AND
STATE HISTORIC PRESERVATION OFFICER

October 16, 2012

Andrew Mowrey
Environmental Section
Kentucky Department of Fish and Wildlife Resources
#1 Sportsman Lane
Frankfort, Kentucky 40601

Re: ***Phase I Archaeological Survey of the Proposed Hatchery Creek Stream Restoration Project in Russell County, Kentucky***
By Steven R. Ahler, Monica L. Chism, and Henry W. Goodman

Dear Mr. Mowrey:

Thank you for submitting the above-listed archaeological report for review and comment. This investigation entailed pedestrian survey, screened shovel testing and auger testing within the 30-acre project area. No new historic or prehistoric archaeological sites were recorded as a result of this survey, and the author recommends no further investigations of the project area. I concur with the authors' findings and recommendation. As proposed, this undertaking should have no effect to National Register eligible or listed historic properties. Therefore, we have no further comments and responsibility for consultation with the Kentucky State Historic Preservation Officer under the Section 106 review process in relation to the proposed project is fulfilled.

Should you have any questions, feel free to contact Kary Stackelbeck of my staff at (502)564.7005, ext. 147.

Sincerely,

Lindy Casebier,
Acting Executive Director and
State Historic Preservation Officer

LC:kls
cc: George Crothers (OSA)
Steve Ahler (UK-PAR)

Attachment IV

Example Stream Performance Standards – Bare Root Seedlings

Type/Category	Criteria	Pre-Construction/ Initial Design Value	Year 1	Year 2	Year 3	Year 4	Final Value (after 5 years)
Geomorphological	Bank Erosion Hazard Index BEHI	Baseline Survey Values	Moderate (<30)	Moderate (<30)	Moderate (<30)	Moderate (<25)	Low (<20)
	Vertical Stability – (Degrading) BHR	"As-Built" Report	1.0-1.1	1.0-1.1	1.0-1.1	1.0-1.1	1.0-1.1
	Vertical Stability – (Aggrading) W/D		0.8-1.2	0.8-1.2	0.8-1.2	0.8-1.2	0.8-1.2
	Lateral Stability - Meander Width Ratio (MWR)	"As-Built" Report	< 5% change from constructed value	< 5% change from constructed value	< 5% change from constructed value	< 5% change from constructed value	< 5% change from constructed value
	Stable Banks and Channel (assessed visually and documented photographically)	"As-Built" Report	No bank sloughing, head cuts, significant deposition, or significant instability	No bank sloughing, head cuts, significant deposition, or significant instability	No bank sloughing, head cuts, significant deposition, or significant instability	No bank sloughing, head cuts, significant deposition, or significant instability	No bank sloughing, head cuts, significant deposition, or significant instability
	Bankfull Flow Events		A minimum of three bank full flow events within a five year monitoring period				
Hydrological/ Stream Flow	Stream Flow Type (ephemeral, intermittent, perennial) as documented in JD	Approved or Preliminary JD	Consistent with JD	Consistent with JD	Consistent with JD	Consistent with JD	Consistent with JD
Habitat	RBP Scores	Predicted RBP score of Average or Excellent	Average - Excellent		Average - Excellent		Average - Excellent
	Bare Root Tree Seedlings	"As-Built" Report # per acre Max % any one spp * Max % invasives ** Max % volunteers	450 20% 5% 25%	400 20% 5% 25%	400 20% 5% 25%	360 20% 5% 25%	360 20% 5% 25%
	Shrubs (1 gallon containers)	"As-Built" Report # per acre Max % any one spp * Max % invasives ** Max % volunteers	108-162 20% 5% 25%	108-162 20% 5% 25%	108-162 20% 5% 25%	108-162 20% 5% 25%	108 20% 5% 25%
	Species List	"As-Built" Report (Scientific & Common Name, Wetland Status Indicator, Native vs. Non-Native vs. Invasive)	Provide list by planting zone	Provide list by planting zone	Provide list by planting zone	Provide list by planting zone	Provide list by planting zone
Biotic	Fish Index (KIBI for KY)	Baseline Survey Values					***Greater than or equal to baseline survey value
	Macroinvertebrate Index (MBI for KY)	Baseline Survey Values					***Greater than or equal to baseline survey value

*0% for *Pueraria lobata* (kudzu), *Polygonum cuspidatum* (knot weed), *Lythrum salicaria* (purple loosestrife), *Phragmites australis* (common reed), *Phalaris arundinacea* (reed canarygrass) & 5% *Typha sp*. (cattails).

Unless otherwise approved by the Louisville District * or substitute "Monitor and report value"

Example Stream Performance Standards – Container Trees

Type/Category	Criteria	Pre-Construction/ Initial Design Value	Year 1	Year 2	Year 3	Year 4	Final Value (after 5 years)
Geomorphological	Bank Erosion Hazard Index BEHI	Baseline Survey Values	Moderate (<30)	Moderate (<30)	Moderate (<30)	Moderate (<25)	Low (<20)
	Vertical Stability – (Degrading) BHR	"As-Built" Report	1.0-1.1	1.0-1.1	1.0-1.1	1.0-1.1	1.0-1.1
	Vertical Stability – (Aggrading) W/D		0.8-1.2	0.8-1.2	0.8-1.2	0.8-1.2	0.8-1.2
	Lateral Stability - Meander Width Ratio (MWR)	"As-Built" Report	< 5% change from constructed value	< 5% change from constructed value	< 5% change from constructed value	< 5% change from constructed value	< 5% change from constructed value
	Stable Banks and Channel (assessed visually and documented photographically)	"As-Built" Report	No bank sloughing, head cuts, significant deposition, or significant instability	No bank sloughing, head cuts, significant deposition, or significant instability	No bank sloughing, head cuts, significant deposition, or significant instability	No bank sloughing, head cuts, significant deposition, or significant instability	No bank sloughing, head cuts, significant deposition, or significant instability
	Bankfull Flow Events		A minimum of three bank full flow events within five year monitoring period				
Hydrological/ Stream Flow	Stream Flow Type (ephemeral, intermittent, perennial) as documented in JD	Approved or Preliminary JD	Consistent with JD	Consistent with JD	Consistent with JD	Consistent with JD	Consistent with JD
Habitat	RBP Scores	Predicted RBP score of Average or Excellent	Average - Excellent		Average - Excellent		Average - Excellent
	Container Trees (3 gallon)	"As-Built" Report # per acre Max % any one spp * Max % invasives ** Max % volunteers	108-162 20% 5 % 0 %	108-162 20% 5 % 0 %	108-162 20% 5% 0 %	108-162 20% 5 % 0 %	108-162 20% 5 % 0 %
	Shrubs (1 gallon containers)	"As-Built" Report # per acre Max % any one spp * Max % invasives ** Max % volunteers	108-162 20% 5% 0%	108-162 20% 5% 0%	108-162 20% 5% 0%	108-162 20% 5% 0%	108 20% 5% 0%
	Species List	"As-Built" Report (Scientific & Common Name, Wetland Status Indicator, Native vs. Non-Native vs. Invasive)	Provide list by planting zone	Provide list by planting zone	Provide list by planting zone	Provide list by planting zone	Provide list by planting zone
Biotic	Fish Index (KIBI for KY)	Baseline Survey Values					***Greater than or equal to baseline survey value
	Macroinvertebrate Index (MBI for KY)	Baseline Survey Values					***Greater than or equal to baseline survey value

*0% for *Pueraria lobata* (kudzu), *Polygonum cuspidatum* (knot weed), *Lythrum salicaria* (purple loosestrife), *Phragmites australis* (common reed), *Phalaris arundinacea* (reed canarygrass) & 5% *Typha sp*. (cattails).
Unless otherwise approved by the Louisville District * or substitute "Monitor and report value"

Example Stream Performance Standards – RPM or "Equivalent" Trees

Type/Category	Criteria	Pre-Construction/ Initial Design Value	Year 1	Year 2	Year 3	Year 4	Final Value (after 5 years)
Geomorphological	Bank Erosion Hazard Index BEHI	Baseline Survey Values	Moderate (<30)	Moderate (<30)	Moderate (<30)	Moderate (<25)	Low (<20)
	Vertical Stability – (Degrading) BHR	"As-Built" Report	1.0-1.1	1.0-1.1	1.0-1.1	1.0-1.1	1.0-1.1
	Vertical Stability – (Aggrading) W/D		0.8-1.2	0.8-1.2	0.8-1.2	0.8-1.2	0.8-1.2
	Lateral Stability - Meander Width Ratio (MWR)	"As-Built" Report	< 5% change from constructed value	< 5% change from constructed value	< 5% change from constructed value	< 5% change from constructed value	< 5% change from constructed value
	Stable Banks and Channel (assessed visually and documented photographically)	"As-Built" Report	No bank sloughing, head cuts, significant deposition, or significant instability	No bank sloughing, head cuts, significant deposition, or significant instability	No bank sloughing, head cuts, significant deposition, or significant instability	No bank sloughing, head cuts, significant deposition, or significant instability	No bank sloughing, head cuts, significant deposition, or significant instability
	Bankfull Flow Events		A minimum of three bank full flow events within five year monitoring period				
Hydrological/ Stream Flow	Stream Flow Type (ephemeral, intermittent, perennial) as documented in JD	Approved or Preliminary JD	Consistent with JD	Consistent with JD	Consistent with JD	Consistent with JD	Consistent with JD
Habitat	RBP Scores	Predicted RBP score of Average or Excellent	Average - Excellent		Average - Excellent		Average - Excellent
Vegetation	RPM or "equivalent" Trees (3 gallon)	"As-Built" Report # Survival per acre Max % any one spp ***Max % invasives *Max % volunteers	60 20% 5 % 0	54 20% 5 % 0	54 20% 5 % 0	54 20% 5 % 0	54 20% 5 % 0
	Shrubs (1 gallon containers)	"As-Built" Report # per acre Max % any one spp * Max % invasives ** Max % volunteers	108-162 20% 5% 0%	108-162 20% 5% 0%	108-162 20% 5% 0%	108-162 20% 5% 0%	108 20% 5% 0%
	Species List	"As-Built" Report (Scientific & Common Name, Wetland Status Indicator, Native vs. Non-Native vs. Invasive)	Provide list by planting zone	Provide list by planting zone	Provide list by planting zone	Provide list by planting zone	Provide list by planting zone
Biotic	Fish Index (KIBI for KY)	Baseline Survey Values					***Greater than or equal to baseline survey value
	Macroinvertebrate Index (MBI for KY)	Baseline Survey Values					***Greater than or equal to baseline survey value

*0% for *Pueraria lobata* (kudzu), *Polygonum cuspidatum* (knot weed), *Lythrum salicaria* (purple loosestrife), *Phragmites australis* (common reed), *Phalaris arundinacea* (reed canarygrass) & 5% *Typha sp*. (cattails).

Unless otherwise approved by the Louisville District * or substitute "Monitor and report value"

Attachment V

REPORT OF GEOTECHNICAL EXPLORATION

PROPOSED HATCHERY CREEK STREAM RELOCATION

WOLF CREEK NATIONAL FISH HATCHERY
RUSSEL COUNTY, KENTUCKY

STATE OF KENTUCKY
NICHOLAS G. SCHMITT
10311
LICENSED
PROFESSIONAL ENGINEER

10/15/12

Ariel I. Sarno, E.I.T.
Staff Engineer

Nicholas G. Schmitt, P.E.
Principal Engineer
Licensed Kentucky 10311

Prepared for:

Andy Mowrey
Kentucky Fish and Wildlife Resources
#1 Sportsman Lane
Frankfort, Kentucky, 40601

AMEC Project Number 3353-11-2536
October 9, 2012

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APPENDIX

1. PURPOSE AND SCOPE OF EXPLORATION

The purpose of this exploration was to obtain specific subsurface data at the site, review available geologic information, evaluate the suitability of the stream extension location, and to develop specifications and recommendations regarding site preparation and back fill specifications for the proposed roadway embankment.

The scope of our exploration was outlined in AMEC's Proposal Number PROP09CINC.38. The scope of our field activities included drilling 2 conventional soil test borings and advancing 10 hand auger borings with dynamic cone penetrometer readings, to obtain subsurface information.

2. PROJECT INFORMATION

The site is located adjacent to the outfall stream of the Wolf Creek National Fish Hatchery. The hatchery, located below Wolf Creek Dam draws flow from Lake Cumberland and ultimately discharges into Hatchery Creek. The creek is diverted into a drainage trench before flowing into the Cumberland River, just below the dam. The existing reach of Hatchery Creek consists of several hundred linear feet of enhanced stream prior to passing through a culvert, and eventually discharging into the Cumberland River via an incised drainage trench. Flow through the culvert has caused massive erosion throughout the drainage trench, resulting in degradation of the limited fish-spawning habitat, as well as creating a safety hazard for the visitors and anglers of the National Hatchery. The Kentucky Department of Fish and Wildlife Resources (KDFWR) and the Inter-Agency Review team have identified this mitigation site as a priority for stream restoration and enhancement.

The proposed relocation project involves creating a new stream channel beginning at the existing Hatchery Creek Fish Hatchery outfall, traversing the valley parallel to the existing confluence with an unnamed tributary to the Cumberland River. The length of new channel will be approximately 5,000 to 6,000 linear feet long. In addition to the new channel, this project involves stabilizing 500 feet of the existing drainage trench by placing structural fill; material excavated from the new stream channel and properly placed with controlled lift thicknesses and compactive effort; for support of the proposed road.

A detailed topographic survey, which included survey station numbers, of the proposed Hatchery Creek extension was provided by Vision Engineering LLC. Proposed cut depths were developed at each station based on the flow requirements for the creek and the fill quantities needed for the proposed road crossing. The proposed hand-auger depths were based on these proposed cut depths.

3. EXPLORATORY FINDINGS

AMEC conducted a site reconnaissance on August 26, 2011, to observe and document surface conditions at the site. The information gathered was used to help us interpret the subsurface data, and to detect conditions which could affect our recommendations.

The geotechnical exploration was conducted by performing 2 soil test borings (B-1 and B-2) in the vicinity of the proposed roadway crossing, and 10 hand-auger borings (HA-1 through HA-10) with dynamic cone penetrometer readings, along the proposed Hatchery Creek extension. The borings were performed according to the procedures presented in the Appendix. The proposed boring locations and depths were selected by AMEC. The actual boring locations were determined by our engineers who utilized a hand held global positioning device to reference input coordinates gathered from the topographic survey of the site. Existing landmarks were used as a reference to check the accuracy of the boring locations. The boring locations shown in Figures 2 through 2C in the Appendix should be considered approximate.

3.1 SURFACE CONDITIONS

The proposed creek extension and proposed road crossing areas were heavily overgrown at the time of our reconnaissance. The growth consisted of thick brush, and trees of various sizes, spacing, and root clusters. Portions of the proposed extension crossed existing gravel roads and paralleled overhead power line easements.

The proposed creek extension area is relatively flat with slight relief, except for an area towards the northeast, at a road crossing within close proximity to the Cumberland River near station 2+00, and a low-lying area near an existing creek and overflow weir between station 25+00 and 32+00. At the crossing, the road slopes deeply from each shoulder. The proposed creek extension near the existing weir was not accessible at the time of our exploration due to heavy overgrowth, however, the existing creek and weir were observed on the topographical survey and in aerial images.

The proposed road crossing area slopes sharply on each side of an existing drainage trench, and a functioning campground, equipped with bathhouses and utilities, exist within the boundary limits of the south side of the proposed road crossing. The test borings were located as close as possible to the proposed road crossing boundaries.

3.2 SITE GEOLOGY

A review of the *Geologic Map of the Creelsboro Quadrangle, Russel County, Kentucky*, published by the Kentucky Geologic Map Information Service, indicates the site is underlain by Alluvium-silty and sandy clay of orangish-gray, grayish yellow brown, and pale grayish-yellow hues which contain lenses of gravel as much as several feet thick, in which pebbles and cobbles are subangular to round and consist of white, yellow, and brown chart, black slate, and white quartz, deposited largely on eroded Leipers Limestone surfaces of Upper Ordovician Age. The Geologic Map of the Creelsboro Quadrangle is presented as Figure 1A in the Appendix.

Leipers Limestone is crystalline and bioclastic. The bedding can be thinly to thickly laminated and irregular, and may contain thin lenses of pure limestone. Leipers Limestone weathers to grayish orange, slabby, irregular surfaces; fossils abundant throughout, bryozoans especially abundant in the upper 20 feet. The formation is generally characterized by abundant brachiopods such as the coarsely costate Platystrophia ponderosa.

3.2.1 Near Surface Soils

A review of the *Soil Survey of Russel County, Kentucky*, published by the United States Department of Agriculture in 1979, indicates the site is overlain by Melvin (Me-silt loam) and Nolin Variant (Nv-fine sandy loam) soil types. A description of each soil type is described below.

Me- silt loam: This deep, poorly drained, nearly level soil is on flood plains. Typically, the surface layer is dark gray, friable silt loam about 8 inches thick. The subsoil, which extends to about 27 inches, is gray friable silt loam with pale brown mottles. The underlying material is gray silt loam to a depth of more than 60 inches. The soil has moderate permeability and high available water capacity. The root zone is deep and the organic content is moderate. Runoff is slow to ponded. The seasonal high water table is within a foot of the surface. Depth to bedrock is more than 60 inches. This soil is subject to occasional flooding, but it is protected below Wolf Creek Dam on the Cumberland River.

Nv- fine sandy loam: This deep, well drained, nearly level soil is on flood plains. Typically, the surface layer is dark grayish brown, friable fine sandy loam about 8 inches thick. The subsoil,

which extends to a depth of about 42 inches, is brown, friable sandy loam. The underlying material is fine sandy loam more than 60 inches deep. This soil has moderately rapid permeability and high available water capacity. The root zone is deep, and the organic matter content is low. Runoff is slow. The seasonal high water table is 4 to 6 feet below the surface. Depth to bedrock is more than 60 inches. This soil is subject to occasional flooding, except where it is protected below Wolf Creek Dam on the Cumberland River.

3.3 SUBSURFACE CONDITIONS

The subsurface conditions encountered at the test boring locations are shown on the Test Boring Records in the Appendix. These Test Boring Records represent our interpretation of the subsurface conditions based on the field logs, visual examination of field samples by an engineer, and laboratory tests of the field samples. The interface between various strata on the Test Boring Records represents the approximate interface location. In addition, the transition between strata may be gradual. Water levels shown on the Test Boring Records represent the conditions only at the time of our exploration. In general, our borings encountered mixtures of sand, silt, and clay (alluvium) which can be categorized into three soil strata. These strata were encountered below a surface veneer of topsoil. The topsoil veneer ranged from 1 to 4 inches, except in one hand-auger location (HA-1) where the top soil was measured to be 18 inches thick.

Laboratory testing, including classification testing, moisture content, and compaction testing were performed on selected split spoon samples, hand-auger samples, and bulk samples obtained from the soil strata encountered.

3.3.1 Stratum I

Stratum I soils consisted of light-reddish brown and light to mottled gray silty and clayey coarse to fine sand, with trace amounts of gravel fragments. Stratum I soils were visually classified as "SM" or "SC" type soils according to the Unified Soil Classification System (USCS).

Hand-Auger Locations:

Stratum I was encountered underlying the topsoil in hand-auger borings HA-2, HA-4, HA-5, and HA-6 and extended to depths ranging from approximately 3 to 9 feet. The DCP values recorded for the hand auger borings, averaged over three 1 ¾ inch increments, within Stratum I ranged from 7 to over 30 blows per 1 ¾ inch. The average DCP value was measured to be 22 blows per increment indicating a very firm relative density.

Laboratory classification tests were performed on selected samples of the Stratum I soils. Sieve analyses with a wash 200 and hydrometer, and Atterberg limits testing were performed on a composite sample obtained from HA-4 and HA-5 at a depth ranging from approximately 1 to 2 feet. The results of the sieve analysis indicate 37 percent of the material passing the minus 200 sieve. The Atterberg limits testing indicated a Liquid Limit of 19 percent and a Plasticity Index of 4 percent. Although a low amount of plasticity is present within the Stratum I soils, the amount of soil retained on the 200 sieve indicate Stratum I to be classified as "SM" or "SC" type soils according to the Unified Soil Classification System (USCS). Moisture contents from the samples tested ranged from approximately 8 to 24 percent.

Soil Test Boring Locations:

Stratum I was also encountered in soil test boring B-1 from approximately 29 ½ to 37 ½ feet, and in B-2 from a depth of approximately 25 to 39 ½ feet. SPT N-values within Stratum I ranged from 5 blows per foot (bpf) to 16 bpf with an average value of approximately 10 bpf. Based on the penetration resistance values and observations of the recovered soils, the Stratum I soils were judged to have a firm relative density. Moisture contents from the samples tested ranged from approximately 13 to 30 percent.

3.3.2 Stratum II

Stratum II soils consisted of light-reddish mottled gray clay and silt, with variable amounts of coarse to fine sand. Stratum II soils were visually classified as "ML" or "CL" type soils according to the Unified Soil Classification System (USCS).

Hand-Auger Locations:

Stratum II was encountered underlying the topsoil in hand-auger borings HA-1, HA-3, HA-7, HA-8, HA-9, and HA-10 and extended to depths ranging from approximately 1 ½ to 9 ½ feet. The DCP values recorded for the hand-auger borings, averaged over three 1 ¾ inch increments within Stratum II ranged from 8 to 22 blows per increment. The average DCP value was measured to be 15 blows per increment, indicating a stiff consistency.

In one hand-auger location, HA-1, the penetration readings indicated the presence of soils too soft to sustain the weight of the DCP.

Laboratory classification tests were performed on selected samples of the Stratum II soils. Sieve analyses with a wash 200 and hydrometer, and Atterberg limits testing were performed on samples obtained from HA-1, HA-3, HA-7, HA-8 and HA-9 at depths ranging from approximately 0 to 7 feet. The results of the sieve analysis indicate approximately 37 to 67 percent of the material passing the minus 200 sieve. The results of the Atterberg limits testing indicate the Liquid Limit ranged from 20 to 48 percent and the Plasticity Index ranged from 1 to 13 percent. Moisture contents from the samples tested ranged from 14 to 49 percent.

Soil Test Boring Locations:

Stratum II was also encountered in soil test boring B-1 at depths ranging from approximately 1 ½ to 22 ½ feet; however, a portion of B-1 from a depth of 22 ½ to 29 ½ was visually classified as "MH", silts of high plasticity. Stratum II was encountered in B-2 underlying the topsoil to a depth of approximately 25 feet. SPT N-values within Stratum II ranged from 5 bpf to 11 bpf with an average value of approximately 10 bpf. Based on the penetration resistance values and observations of the recovered soils, the Stratum II soils were judged to have a stiff consistency.

3.3.3 Stratum III

Stratum III soils were encountered in the soil test boring locations and consisted of a light to dark gray sandy gravel, with trace amounts of limestone fragments and silt. No laboratory classification tests were performed on the Stratum III soil. Using standard visual-manual soil classification techniques, Stratum III soils were classified as "GM" type soils according to the Unified Soil Classification System (USCS). Stratum III was encountered underlying Stratum I in soil test borings B-1 and B-2 at depths ranging from approximately 37 ½ to 39 ½ feet to split spoon refusal depths of approximately 39 to 39.7 feet. SPT N-values within Stratum III exceeded 50 bpf and were interpreted to be refusal material.

3.3.4 Refusal Material

Hand-Auger Locations:

Refusal was encountered in the hand-auger borings at depths ranging from approximately 1 ½ to 9 ½ feet. Hand-auger refusal was due to large gravel fragments, abundant root systems, or hand-auger collapse due to the occurrence of ground water. Hand-auger borings HA-3, HA-4, and HA-8 were terminated at the predetermined cut depths of their respective stations without encountering refusal materials.

Soil Test Boring Locations:

Sampler refusal was encountered in the soil test borings at depths ranging from approximately 39 to 39.7 feet. Sampler refusal was interpreted to be the top of the apparent weathered rock surface.

The hand-auger/soil test boring depths are tabulated below:

Table 1. Summary of hand-auger/soil test boring depths.

Boring Location	Station Number	Proposed Depth (ft)	Boring Termination/Refusal Depth (ft)
B-1	-	40	39
B-2	-	40	39.7
HA-1	1+50	5	4
HA-2	5+00	6	3
HA-3	10+00	3	3
HA-4	15+00	8	8
HA-5	20+00	8	6.5
HA-6	40+00	12	9
HA-7	45+00	16	10
HA-8	50+00	6	6
HA-9	55+00	8	7
HA-10	58+00	11	1.5

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Checked by: *NGS*

3.4 GROUND WATER CONDITIONS

Water was detected in three of our hand-auger borings, HA-1, HA-6, and HA-7, at a depth of 3 feet (Elevation 562 feet NGVD), 4 ½ feet (Elevation 586 ½ feet NGVD), and 9 ½ feet (Elevation 582 ½ feet NGVD), respectively. The water encountered in the hand auger borings was interpreted as perched water conditions. Trapped or perched water, which occurs in irregular, discontinuous locations within the soil overburden, may be encountered at lower elevations. These perched water sources are often not linked to the more continuous relatively stable ground water table that typically occurs at elevations similar to the average pool level of the Cumberland River of 547 feet NGVD.

In the soil test borings water was encountered at a depth of approximately 33 feet (Elevation 562 ½ feet National Geodetic Vertical Datum (NGVD)). The water encountered in the soil test borings was interpreted as ground water. Ground water levels may vary from those measured at the time of our field activities.

4. GEOTECHNICAL EVALUATION- HATCHERY CREEK EXTENSION

Based on the subsurface conditions encountered in our borings, our engineering analyses, and our experience, we believe the site is suitable for construction of the proposed Creek Extension and gravel roadway; however, there were some site and subsoil conditions which pose concerns from a geotechnical standpoint. These concerns are discussed below.

4.1 POSSIBLE SOLUTION FEATURES

Our experience with the rock formation underlying the site indicates the rock surface may be irregular. Rock pinnacles may protrude up into the soil overburden, and soil-filled slots can extend down into the rock mass. In addition, horizontal voids or soil-filled seams are also common to the formations. Typically, the irregular rock surface poses a difficulty in accurately estimating the depth to rock and quantity of rock removal.

Based on knowledge of the area geology, sinkholes may be exposed during excavation activities for the proposed creek extension. If encountered, sinkholes must be evaluated and treated on an individual basis. The geotechnical engineer should be retained for remediation recommendations if a sinkhole is exposed during construction.

In addition, our experience in this portion of Russell County indicates that soil dropouts, particularly in areas of significant soil cuts, are frequently encountered during construction. Cavities in the soil mass are difficult to locate since there is no surface indication of their presence. It is our opinion that the risk associated with sinkhole formations is no greater at this site than at other developed sites in this area of Russell County. It should be noted that no exploration or construction monitoring program can assure that any or all of the dropouts will be uncovered. For that reason, there will always be some risk of dropouts occurring in any developments in limestone terrain.

According to documents published by the US Army Corps of Engineers (Nashville District), in the late 1960's, muddy flows below Wolf Creek dam and two sinkholes near the downstream end of the dam signaled serious reservoir seepage problems. The excessive seepage was determined to be a cause of progressive erosion as a result of the highly fractured and jointed nature of the limestone within the foundation of the dam.

4.2 SITE DEVELOPMENT METHODS TO REDUCE SINKHOLE DROPOUT RISKS

An existing sinkhole, if undetected or untreated, may contain deposits of soft soils which could experience erosion due to channel flow. In all karst regions, there is a risk of future soil dropouts related to previously undetected sinkholes, newly developed sinkholes, or in areas of past sinkhole activity. Site development planning in karst areas must weigh the cost of site development with the risk of future sinkhole activity. The following sub-sections outlined in section 4.2 provide several methods available to reduce the risk of sinkhole development, and provide general guidelines in the event sinkholes form during the construction of the new Hatchery Creek extension. However, sinkhole remediation techniques are specific to the nature of the sinkhole encountered, therefore, we recommend the geotechnical engineer be notified in the event a sinkhole is encountered during excavation of the Hatchery Creek extension.

4.2.1 Soil Excavation

During excavation and construction activities, newly exposed sinkholes may be observed. Once excavation is complete, indications of solution activity may become more evident and the location of additional sinkholes may be discovered. The indicators of sinkhole throats include, but are not limited to, zones of concentrated organic debris, zones of soft, wet soils and rubbly areas with weathered rock mixed into the overlying residual soil. If these indicators are observed, the next step would be to perform excavation to identify an active sinkhole throat. We recommend a geotechnical engineer evaluate the site periodically during earthwork activities. The geotechnical engineer should be present during the sinkhole remediation process.

4.2.2 Sinkhole Treatment Method A

When the throat is less than 2 feet in diameter and no evidence of flowing water is present a concrete plug may be used. The plug should be constructed of high slump concrete and be 1½ to 2 times as tall or long as it is wide to facilitate the filling of voids and crevices. It is essential that a good concrete to rock bond be created by the plug, and the plug increase in diameter with elevation. After the concrete plug has set up, the resulting excavation shall be properly backfilled with engineered fill material from the borrow areas on site compacted to at least 95 percent of the soil's standard Proctor maximum dry density (ASTM D698). The area of the channel bed within the sinkhole excavation shall be lined with Geosynthetic Clay Liner (GCL) as seen in Figure 3.

4.2.3 Sinkhole Treatment Method B

When the throat is greater than 2 feet in diameter or evidence of flowing water is observed, an inverted filter should be constructed; however smaller features may also be filled in this manner. To plug the throat, a zone of rip-rap or durable limestone boulders should be placed and wedged into the throat. Using the large stone pieces as a base, place an 18-inch-thick layer of Kentucky Depart of Highways (KDOH) gradation No. 3 and/or No. 57 crushed limestone over the larger stone and tamp into place with hand tampers. Next, construct a 12-inch-thick layer of dense-graded aggregate (DGA) tamped into place with hand tampers. The entire throat area and 10 feet of the surrounding area should be covered with a geotextile filter fabric. The resulting excavation may then be properly backfilled with engineered fill material from the borrow areas on site compacted to at least 95 percent of the soil's standard Proctor maximum dry density (ASTM D698). The area of the channel bed within the sinkhole excavation shall be lined with Geosynthetic Clay Liner (GCL) as seen in Figure 4.

4.2.4 Sinkhole Treatment Method C

If well-defined sinkhole throats are not identifiable after stripping the surficial soils from the sinkholes to expose the residual soils, shallow test pits should be excavated to check for voids present below the ground surface as a result of solution activity. The pits should be excavated at the lowest elevations of the depression. If no throat is found, then the excavation and depression should be properly backfilled using engineered fill material from the borrow areas on site. The fill material should be compacted the same as in Methods A and B.

4.3 SITE PREPARATION

4.3.1 Erosion Potential

Based on a review of the *Soil Survey for Russell County, Kentucky*, published by the United States Department of Agriculture (USDA), the onsite soils are slightly erodible; however, based on our site observations, and our experience, we believe the on-site soils range from moderately to highly erodible. Erosion prevention planning should be included in the design of the creek extension.

4.3.2 Old Fill Materials

Evidence of demolition debris associated with the Wolf Creek Dam was not observed in the soil samples obtained from our borings. However, conditions between borings may be different and fill material may be encountered. If fill material is encountered, construction planning should include delineating the fill within the creek extension limits, undercutting these fill soils, laying back the side slopes, and placing suitable fill soils in controlled lifts.

4.3.3 Reusable Soils

Soils encountered in Stratum I and II are suitable for use as backfill for the proposed road embankment, however, soils encountered in low lying areas or within overburden containing perched water will require drying in order to achieve suitable compaction. Perched conditions were encountered in the hand auger borings HA-1, HA-6, and HA-7; soil conditions near the existing creek, between stations 22+00 and 34+00, were not explored and shallow ground water associated with the existing creek may be encountered.

4.4 REFUSAL DEPTHS

As previously stated, refusal material was encountered in our hand-auger borings at depths ranging from approximately 1 ½ to 9 ½ feet. The refusal material encountered in our hand-auger borings were due to large gravel fragments, root clusters, and collapse due to the presence of ground water.

5. GEOTECHNICAL RECOMMENDATIONS- ROADWAY EMBANKMENT

The following recommendations should be considered for the construction of the gravel roadway embankment. Detailed specifications and Drawings can be found within the project details of the construction documents.

5.1 SETTLEMENT ANALYSIS

The settlement analysis was based on our interpretation of the subsurface stratigraphy, our laboratory test results, and elastic theories for coarse grained (sand and gravel) soils, and the geometry of the embankment as seen in Figure 2 of the Appendix. AMEC has assumed that the embankment will have side slopes of 3 horizontal to 1 vertical for the purpose of this analysis. The total settlements were calculated to be under an inch.

5.2 EARTHWORK

5.2.1 Subsurface Confirmation

Accessibility issues were experienced at the locations of the proposed gravel roadway limits. The soil test borings were offset and drilled as close as possible to the limits proposed by our design team. We believe that our borings are indicative of the soil conditions at the location of the proposed gravel roadway. However, we recommend confirming the site conditions during construction by careful examination by a geotechnical engineer. The engineer may choose to extend hand-auger borings at the bottom of the existing drainage trench, or request the excavation of shallow test pits. If conditions vary from the soil conditions encountered in the soil test borings, the recommendations will be adjusted. We expect some soft soil or “muck” may exist in the drainage trench which will require undercutting and replacement.

5.2.2 Embankment Site Preparation

- Before any embankment material is placed in a given area, all clearing shall be performed in that area, with topsoil removed and stockpiled.
- Any soft soils, such as sediment or muck, encountered at the bottom of the drainage trench must be removed prior to fill placement.
- Scarify and recompact the existing subgrade soils to a depth of at least 8 inches prior to fill placement or pavement construction.
- Embankment material will not be placed on frozen earth.
- Embankment materials loosened as a result of frost action shall be re-compacted prior to placement of additional lifts.
- Compacted material that has been flooded and no longer meets the density specifications shall be removed and replaced.

5.2.3 Compacted Fill

Representative bulk samples from Stratum I and Stratum II were collected and tested to determine their laboratory compaction characteristics and natural moisture content. These tests results determined that Stratum I and Stratum II soils are suitable as fill material for the proposed embankment. Table 2 is a summary of the compaction results.

Table 2. Summary of laboratory compaction results.

Stratum	Hand Auger Locations	Natural Moisture Content (%)	Maximum Dry Density (pcf)	Optimum Moisture Content (%)
II	HA-8	22	107	18
I	HA-10	24.7	115	13.5

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Checked by: *NGS*

The following criteria are recommended for structural fill construction:

- Limit the fill materials to a Plasticity Index less than 25, a maximum particle size of 3 inches, and less than 3 percent by weight fibrous, organic matter.
- Construct compacted fill by spreading suitable soil in maximum 8-inch-thick loose lifts.

- The fill placement must be keyed into the existing side slopes a minimum of 6 inches in a stair step fashion.

- Compact the fill within structural areas to at least 95 percent of the standard maximum dry density (ASTM D698).

- Maintain the moisture content of the fill soils to within ±2 percentage points of the soils' optimum moisture content.

- Perform at least one in-place density test in every 5,000 square-feet, for each 8-inch- thick fill layer.

- Retain the geotechnical engineer to observe, document and test the fill placement and compaction operations.

5.2.4 General

- No sod, frozen material, or any material which by decay or otherwise, might cause settlement, shall be placed or allowed to remain in the embankment.

- The Embankment shall be constructed to the height and width deemed necessary to provide for shrinkage during compaction; upon completion, it shall conform to the lines, grades, and cross-sections shown on the Plans, with proper provision for shrinkage.

- Lift thickness shall conform to the maximum loose lift thickness of eight (8) inches.

- So far as practicable, each lift of material shall extend the entire length and width of the embankment before the next lift is placed. The material shall be leveled by means of bulldozers, blade graders, or other equipment approved by the ENGINEER.

- Materials shall be disked sufficiently on each lift to break down oversized clods, mix the different materials, secure uniform moisture content, and insure uniform density and compaction.

- Materials shall be compacted with a sheepsfoot roller or smooth-drum roller, as required to achieve the required compaction.

- Maintain positive surface drainage to prevent water from ponding on the surface during all earthwork operations.

- Roll the fill surface with a rubber-tired or steel-drummed roller to improve surface runoff, if precipitation is expected.

- Contact the geotechnical engineer should the subgrade soils become excessively wet, dry, or frozen.

5.3 GROUND WATER CONTROL

Typically, ground water encroaching upon construction excavations can be removed by placing a sump near the source of seepage and then pumping from the sump. Should heavy seepage occur, or should there be evidence of soil particle migration, such as silting of the sump, then the geotechnical engineer should be contacted.

6. BASIS FOR RECOMMENDATIONS

The recommendations provided are based in part on project information provided to AMEC and only apply to the specific project and site discussed in this report. If the project information section in this report contains incorrect information or if additional information is available, you should convey the correct or additional information to us and retain us to review our recommendations. We can then modify our recommendations if they are inappropriate for the proposed project.

The assessment of site environmental conditions or the presence of contaminants in the soil, rock, and ground water of the site was beyond the scope of this exploration.

Regardless of the thoroughness of a geotechnical exploration, there is always a possibility that conditions between borings will be different from those at specific boring locations and that conditions will not be as anticipated by the designers or contractors. In addition, the construction process may itself alter soil conditions. Therefore, experienced geotechnical personnel should observe and document the construction procedures used and the conditions encountered. Unanticipated conditions and inadequate procedures should be reported to the design team along with timely recommendations to solve the problems created. We recommend that the owner retain AMEC to provide this service based upon our familiarity with the project, the subsurface conditions and the intent of the recommendations.

We recommend that this complete report be provided to the various design team members, the contractors and the project owner. Potential contractors should be informed of this report in the "instructions to bidders" section of the bid documents. The report should not be included or referenced in the actual contract documents.

We wish to remind you that our exploration services include storing the samples collected and making them available for inspection for 30 days. The samples are then discarded unless you request otherwise.

APPENDIX:

Site Location Plan

Geology Map

Boring Location Plan

Sinkhole Repair Method A

Sinkhole Repair Method B

Field Testing Procedures

Key to Symbols and Descriptions

Test Boring Records

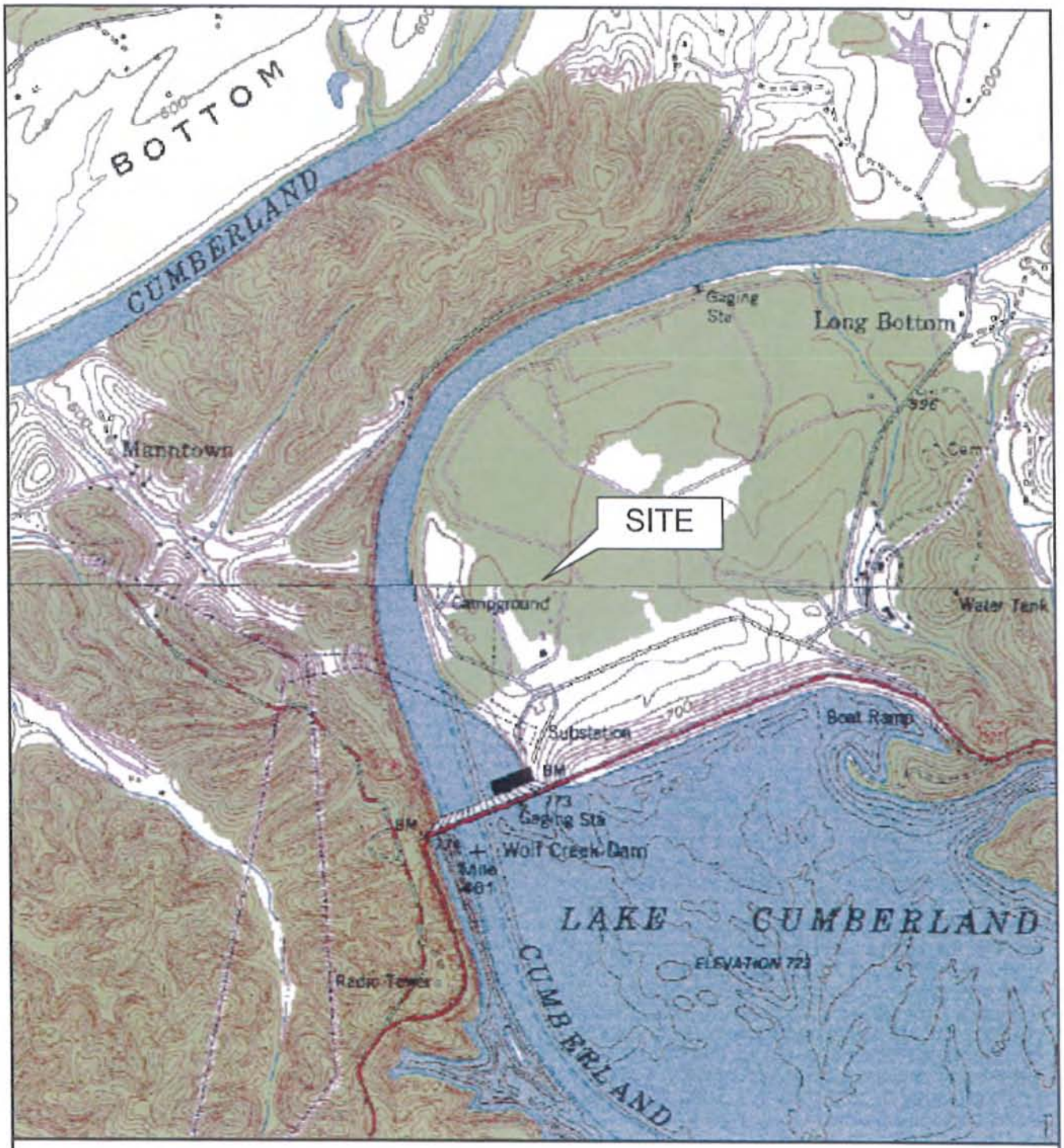
Laboratory Testing Procedures

Summary of Laboratory Test Data

Atterberg Limits

Grain-Size Distribution

Moisture Density Relationship



SOURCE: USGS 7.5' TOPOGRAPHIC QUADRANGLE MAP, CREELSBORO, KY, 1953. PHOTOREVISED 1982.

0 1000 2000
SCALE IN FEET

NORTH

amec
13425 Eastpoint Centre Drive, Suite 122
Louisville, Kentucky 40223
Phone: (502) 253-2500

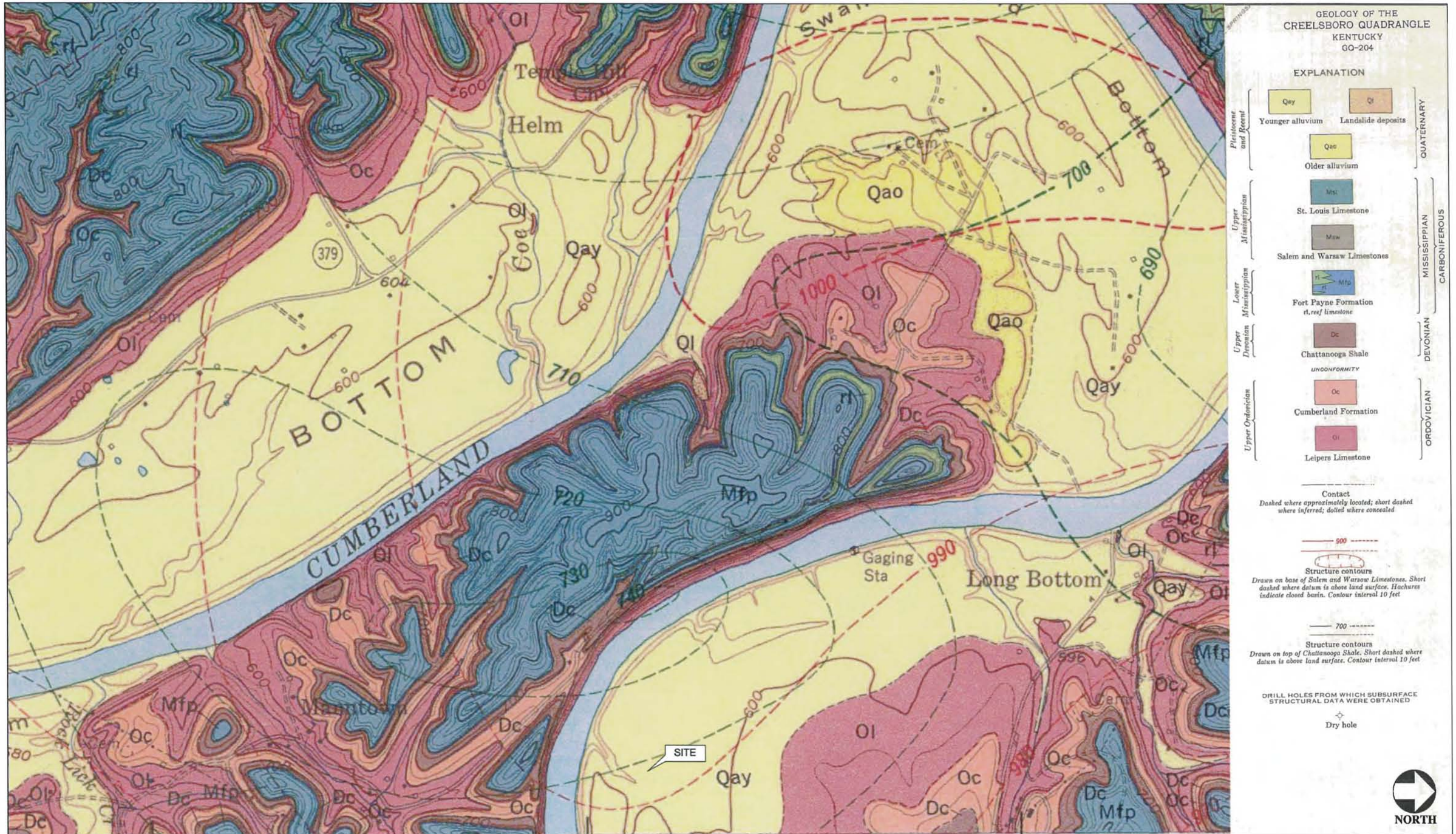
SITE LOCATION MAP

WOLF CREEK DAM-HATCHERY CREEK EXTENSION
RUSSEL COUNTY, KY

PROJECT NUMBER: 3353-11-2536

SCALE	1" = 2000'
DATE	09/21/11
DRAWN BY	CSRP
APPROVED BY	AIS

FIG. 1



REV	DATE	BY	SUB	APP	DESCRIPTION	REV	DATE	BY	SUB	APP	DESCRIPTION

DESIGNED	MR
DRAWN	CSRP
CHECKED	AIS
IN CHARGE	NGS
DATE	02/28/12

amec
13425 Eastpoint Centre Drive, Ste 122
Louisville, KY. 40223
Phone: 502-253-2500 Fax: 502-253-2501

GEOLOGLY MAP

WOLF CREEK DAM-HATCHERY CREEK
RUSSEL COUNTY, KY

PROJECT NUMBER: 3353-11-2536

FIG 1A

SCALE	1" = 500'	
CONTRACT NO.		
DWG. NO. -	REV. -	FIGURE 1A

CADD FILE: 2011-06-21 Hatchery Creek.
PLOT DATE: 02/28/12

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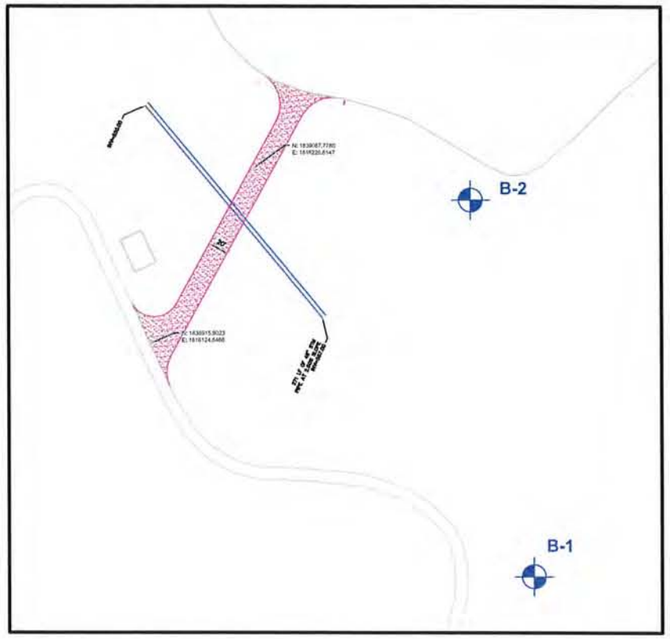

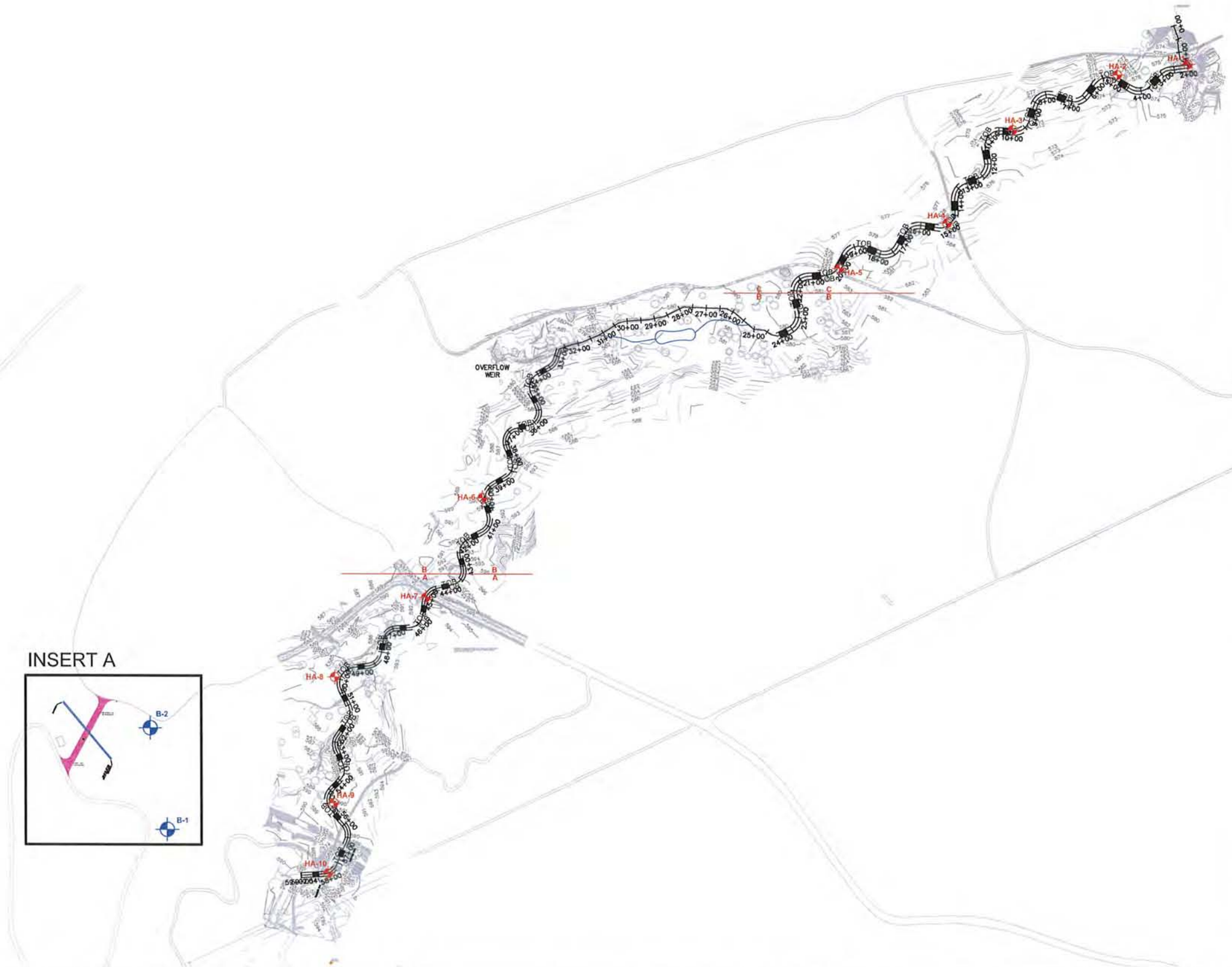

INSERT A

LEGEND

- SOIL TEST BORING LOCATION
- HAND AUGER BORING LOCATION

NORTH

REV	DATE	BY	SUB	APP	DESCRIPTION	REV	DATE	BY	SUB	APP	DESCRIPTION

DESIGNED	MR
DRAWN	CSRP
CHECKED	AIS
IN CHARGE	NGS
DATE	10/05/11

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Louisville, KY. 40223
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BORING LOCATION PLAN

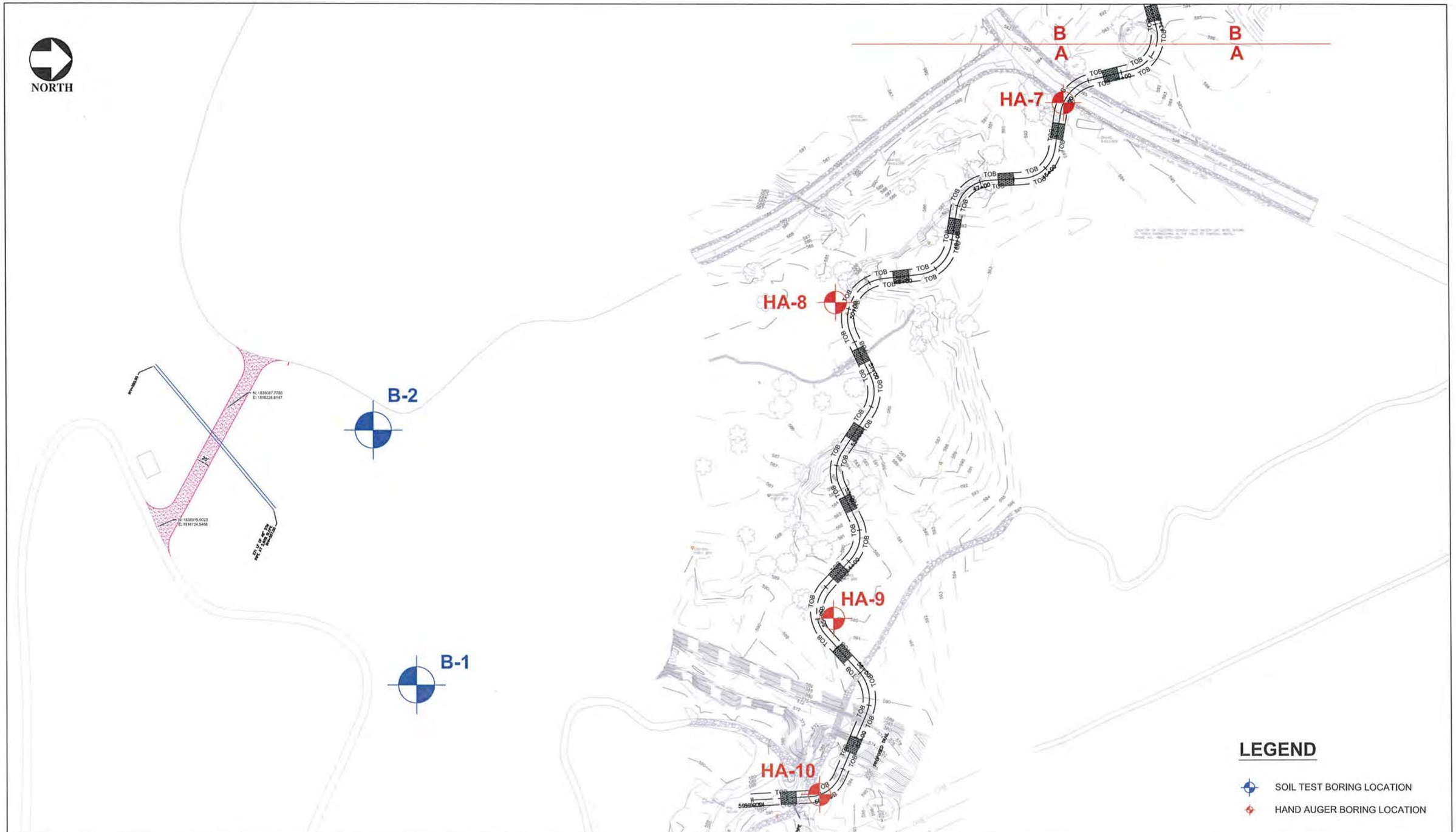
WOLF CREEK DAM-HATCHERY CREEK
RUSSEL COUNTY, KY

PROJECT NUMBER: 3353-11-2536

FIG 2

SCALE		
GRAPHIC		
CONTRACT NO.		
DWG. NO.	REV.	FIGURE
-	-	-

CADD FILE: 2011-09-21 Hatchery Creek
PLOT DATE: 10/05/11



REV	DATE	BY	SUB	APP	DESCRIPTION	REV	DATE	BY	SUB	APP	DESCRIPTION

DESIGNED	MR
DRAWN	CSRP
CHECKED	AIS
IN CHARGE	NGS
DATE	10/05/11

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BORING LOCATION PLAN

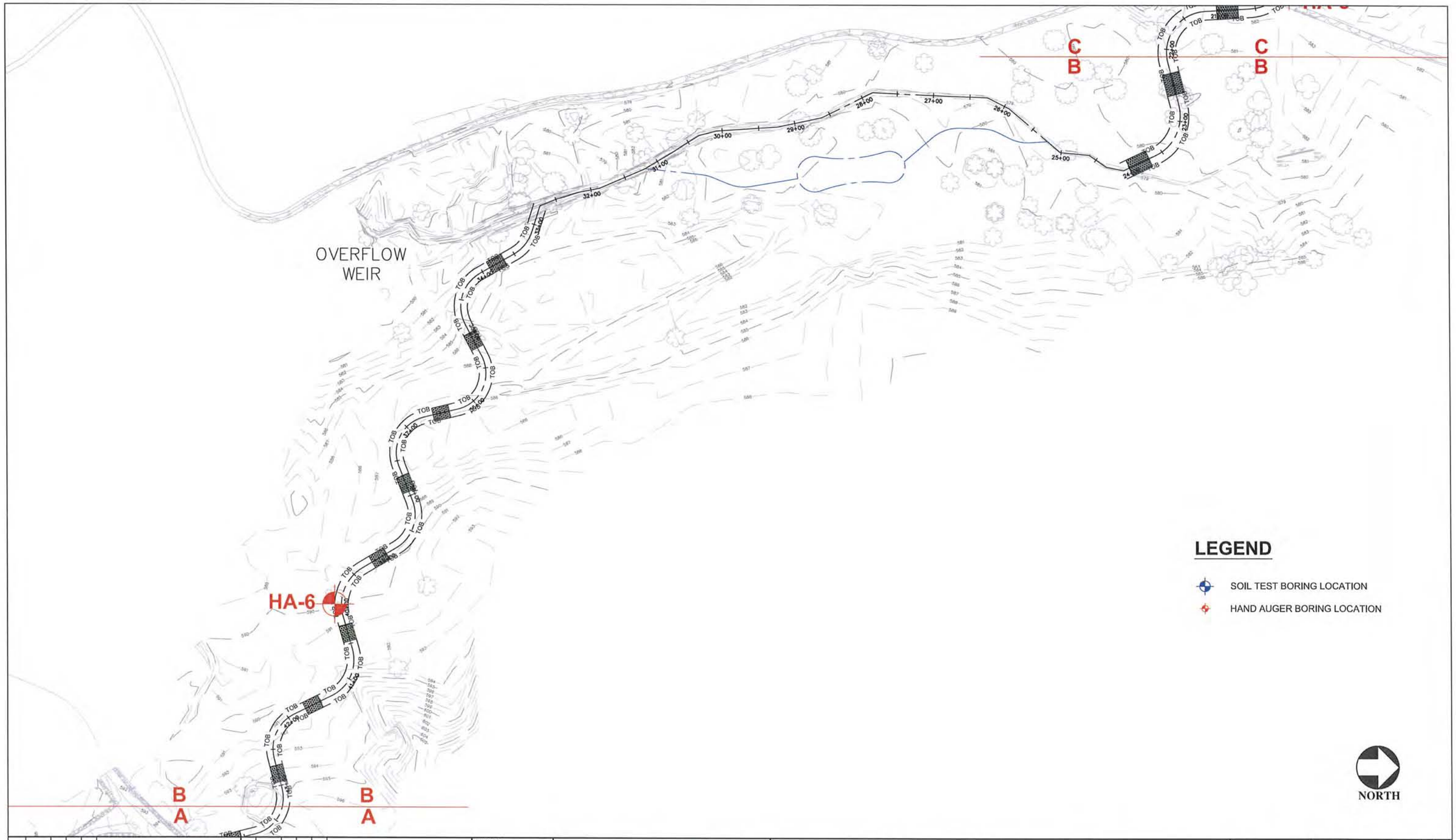
WOLF CREEK DAM-HATCHERY CREEK
RUSSEL COUNTY, KY

PROJECT NUMBER: 3353-11-2536

FIG 2A

SCALE		
GRAPHIC		
CONTRACT NO.		
DWG. NO.	REV.	FIGURE
-	-	-

CADD FILE: 2011-09-21 Hatchery Creek
PLOT DATE: 10/05/11



REV	DATE	BY	SUB	APP	DESCRIPTION	REV	DATE	BY	SUB	APP	DESCRIPTION

DESIGNED	MR
DRAWN	CSRP
CHECKED	AIS
IN CHARGE	NGS
DATE	10/05/11

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BORING LOCATION PLAN

WOLF CREEK DAM-HATCHERY CREEK
RUSSEL COUNTY, KY

PROJECT NUMBER: 3353-11-2536

FIG 2B

SCALE		
GRAPHIC		
CONTRACT NO.		
DWG. NO.	REV.	FIGURE
-	-	-

CADD FILE: 2011-09-21 Hatchery Creek
PLOT DATE: 10/05/11

REV	DATE	BY	SUB	APP	DESCRIPTION	REV	DATE	BY	SUB	APP	DESCRIPTION

DESIGNED	MR
DRAWN	CSRP
CHECKED	AIS
IN CHARGE	NGS
DATE	10/05/11

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BORING LOCATION PLAN

WOLF CREEK DAM-HATCHERY CREEK
RUSSEL COUNTY, KY

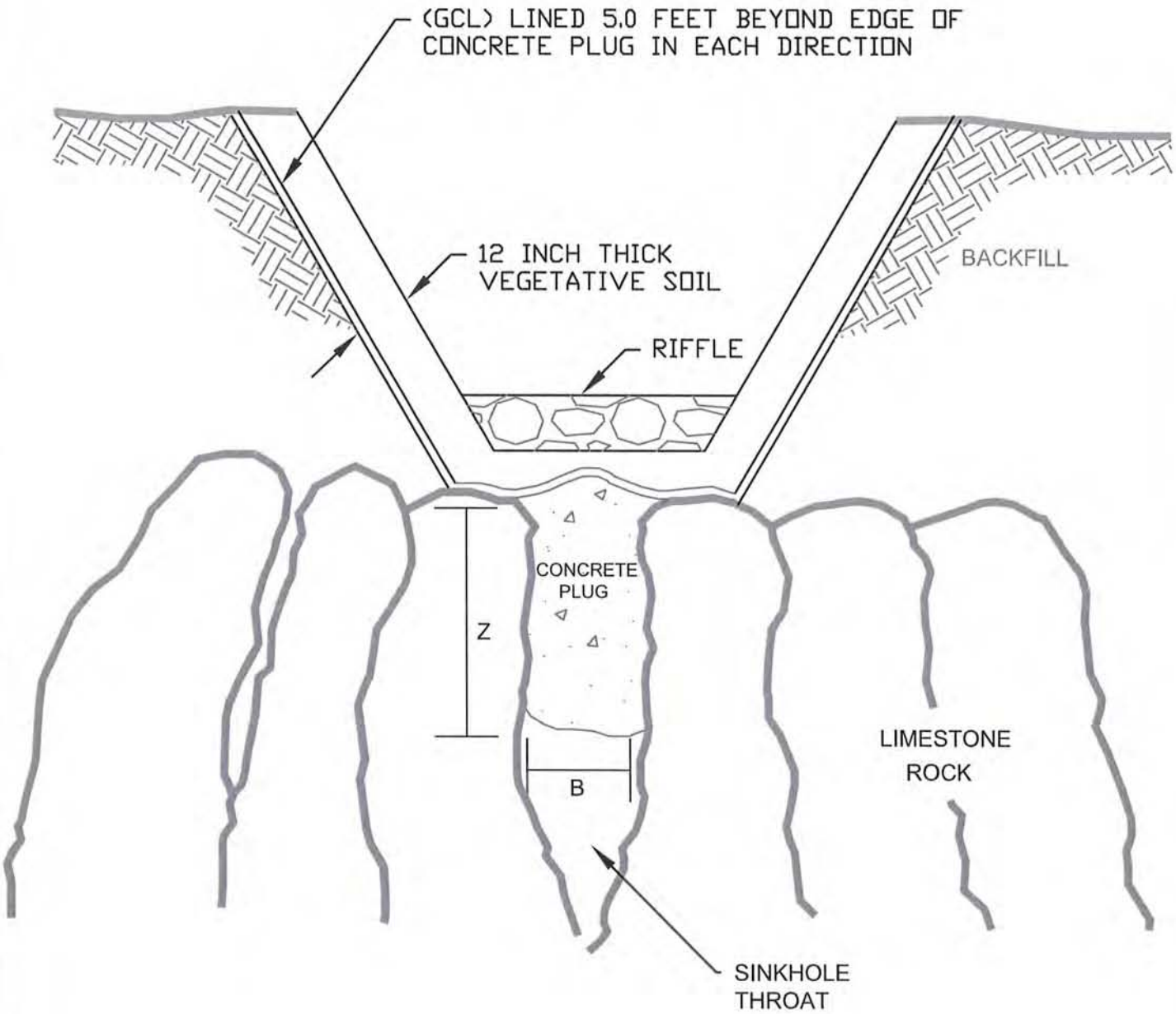
PROJECT NUMBER: 3353-11-2536

FIG 2C

SCALE		
GRAPHIC		
CONTRACT NO.		
DWG. NO.	REV.	FIGURE
-	-	-

CADD FILE: 2011-09-21 Hatchery Creek
PLOT DATE: 10/05/11

NOTE: Good concrete to rock bond is essential (Z=1.5 to 2 times B)



MARKESBERY & RICHARDSON Co., LPA
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PROJECT NO. 3353-11-2536

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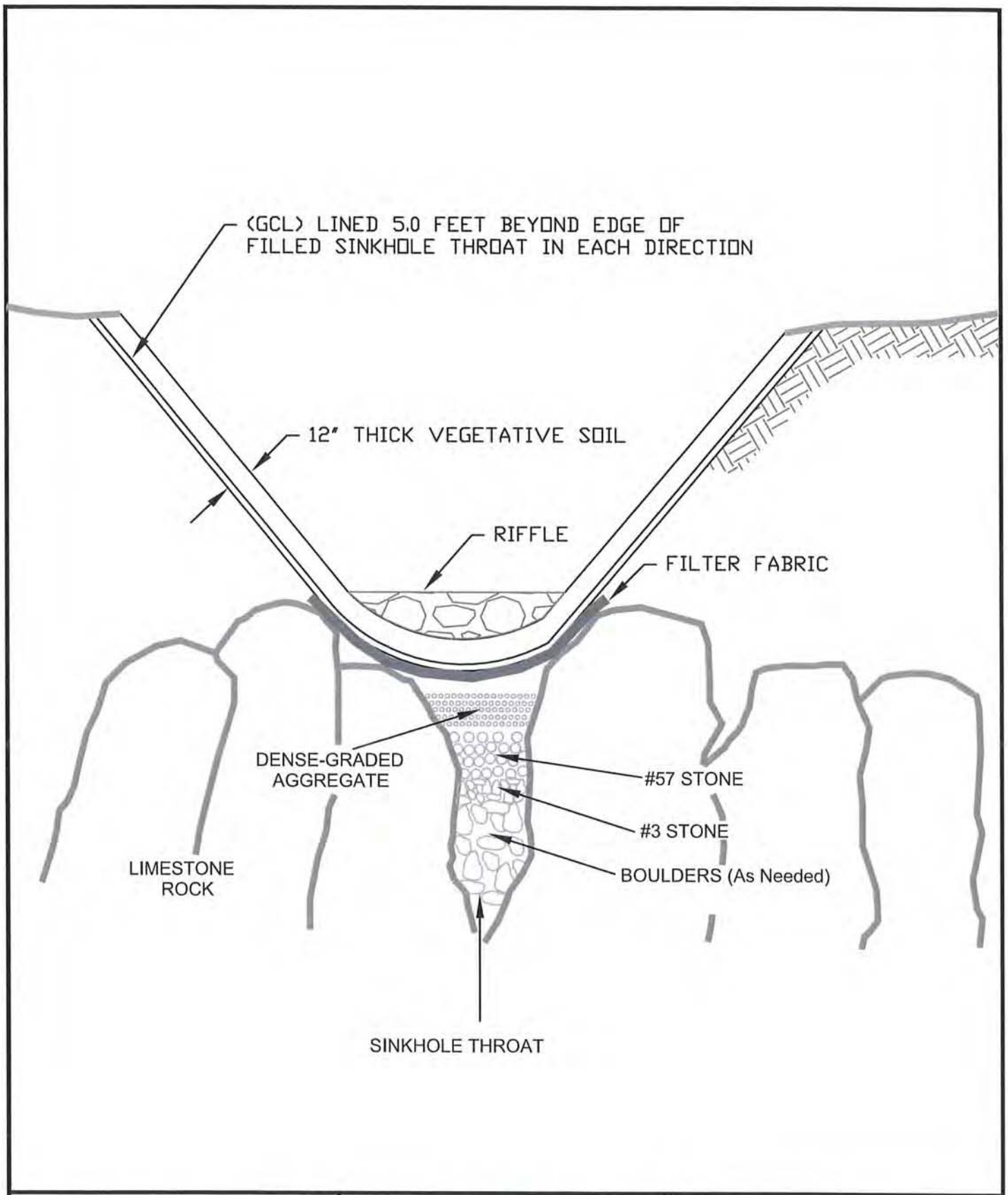
PREPARED BY: CSRP CHECKED BY: AIS

SINKHOLE REPAIR METHOD A
CONCRETE PLUG

PLOT DATE: Fri, 02 Mar 2012
CADD FILE: METHOD A

FIGURE 3



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PROJECT NO. 3353-11-2536

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PREPARED BY: CSRP CHECKED BY: AIS

SINKHOLE REPAIR METHOD B
GRADED FILTER

PLOT DATE: Fri, 02 Mar 2012
CADD FILE: METHOD B

FIGURE 4

FIELD TESTING PROCEDURES

Field Operations: The general field procedures employed by AMEC are summarized in ASTM D420 which is entitled "Investigating and Sampling Soils and Rocks for Engineering Purposes." This recommended practice lists recognized methods for determining soil and rock distribution and ground water conditions. These methods include geophysical and in situ methods as well as borings.

Borings are drilled to obtain subsurface samples using one of several alternative techniques depending upon the subsurface conditions. These techniques are:

a. Continuous 2½ or 3¼ inch inside diameter (I.D.) hollow stem augers;
b. Wash borings using roller cone or drag bits (using drilling mud or water);
c. Continuous flight augers (ASTM D1425).

These drilling methods are not capable of penetrating through material designated as "refusal materials." Refusal, thus indicated, may result from hard cemented soil, soft weathered rock, coarse gravel or boulders, thin rock seams, or the upper surface of sound continuous rock. Core drilling procedures are required to determine the character and continuity of refusal materials.

The subsurface conditions encountered during drilling are reported on a field test boring record by the chief driller. The record contains information concerning the boring method, samples attempted and recovered, indications of the presence of various materials such as coarse gravel, cobbles, etc., and observations between samples. Therefore, these boring records contain both factual and interpretive information. The field boring records are on file in our office.

The soil and rock samples plus the field boring records are reviewed by a geotechnical engineer. The engineer classifies the soils in general accordance with the procedures outlined in ASTM D2488 and prepares the final boring records which are the basis for all evaluations and recommendations.

The final boring records represent our interpretation of the contents of the field records based on the results of the engineering examinations and tests of the field samples. These records depict subsurface conditions at the specific locations and at the particular time when drilled. Soil conditions at other locations may differ from conditions occurring at these boring locations. Also, the passage of time may result in a change in the subsurface soil and ground water conditions at these boring locations. The lines designating the interface between soil or refusal materials on the records and on profiles represent approximate boundaries. The transition between materials may be gradual. The final boring records are included with this report.

The detailed data collection methods used during this exploration are discussed below.

Soil Test Borings: Soil test borings were made at the site at locations shown on the attached Boring Plan. Soil sampling and penetration testing were performed in accordance with ASTM D1586.

The borings were made by mechanically twisting a hollow stem steel auger into the soil. At regular intervals, the drilling tools were removed and soil samples obtained with a standard 1.4 inch I.D., 2 inch outside diameter (O.D.), split tube sampler. The sampler was first seated 6 inches to penetrate any loose cuttings, then driven an additional foot with blows of a 140-pound hammer free falling 30

FIELD TESTING PROCEDURES (continued)

inches. The number of hammer blows required to drive the sampler the final foot was recorded and is designated the "penetration resistance". The penetration resistance, when properly evaluated, is an index to the soil strength and foundation supporting capability.

Representative portions of the soil samples, thus obtained, were placed in glass jars and transported to the laboratory. In the laboratory, the samples were examined to verify the driller's field classifications. Test Boring Records are attached which graphically show the soil descriptions and penetration resistances.

Water Level Readings: Water table readings are normally taken in conjunction with borings and are recorded on the "Test Boring Records". These readings indicate the approximate location of the hydrostatic water table at the time of our field investigation. Where impervious (more clayey) soils are encountered the amount of water seepage into the boring is small, and it is generally not possible to establish the location of the hydrostatic water table through water level readings. The ground water table may also be dependent upon the amount of precipitation at the site during a particular period of time. Fluctuations in the water table should be expected with variations in precipitation, surface run-off, evaporation and other factors.

The time of boring, water level reported on the boring records is determined by field crews as the drilling tools are advanced. The time of boring water level is detected by changes in the drilling rate, soil samples obtained, or by measurement after the drilling tools are withdrawn. Additional water table readings may be obtained after the borings are completed. A time lag of 24 hours may allow stabilization of the ground water table which has been disrupted by the drilling operations. The readings are taken by dropping a weighted line down the boring or using an electrical probe to detect the water level surface.

Occasionally, the borings will cave-in, preventing water level readings from being obtained or trapping drilling water above the caved-in zone. The cave-in depth is also measured and recorded on the boring records.

Bag Sampling: We obtained bulk samples of soil at selected locations. These samples consist of 50 to 100 pounds of soil brought to the surface by the drilling augers, or obtained from test pits or the ground surface using hand tools. The samples were placed in bags, with sealed jar samples of the material, and were taken to our laboratory for testing. The locations of these samples are indicated on the appropriate logs, or on the Boring Location Plan.

Hand-Auger Borings: Hand-auger borings were made at the site at locations shown on the attached Boring Location Plan. The borings were made by manually twisting a hand auger into the soil. Representative soil samples were obtained from the auger cuttings and placed in glass jars and transported to the laboratory.

Dynamic Cone Penetrometer (DCP) Tests: At regular intervals, the soil consistency was measured with a cone penetrometer. The conical point was first seated 2 inches to penetrate any loose cuttings, then driven an additional 3½ inches in two 1¾-inch increments with blows from a 15-pound hammer

falling 20 inches. The average number of hammer blows required to achieve the final two 1¾-inch increments was recorded, and is an index to the soil strength and density.

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS (More than 50% of material is LARGER than No. 200 sieve size)	GRAVELS (More than 50% of coarse fraction is LARGER than the No. 4 sieve size)	CLEAN GRAVELS (Little or no fines)	GW	Well graded gravels, gravel - sand mixtures, little or no fines.
			GP	Poorly graded gravels or gravel - sand mixtures, little or no fines.
		GRAVELS WITH FINES (Appreciable amount of fines)	GM	Silty gravels, gravel - sand - silt mixtures.
			GC	Clayey gravels, gravel - sand - clay mixtures.
	SANDS (More than 50% of coarse fraction is SMALLER than the No. 4 Sieve Size)	CLEAN SANDS (Little or no fines)	SW	Well graded sands, gravelly sands, little or no fines.
			SP	Poorly graded sands or gravelly sands, little or no fines.
		SANDS WITH FINES (Appreciable amount of fines)	SM	Silty sands, sand - silt mixtures.
			SC	Clayey sands, sand - clay mixtures.
FINE GRAINED SOILS (More than 50% of material is SMALLER than No. 200 sieve size)	SILTS AND CLAYS (Liquid limit LESS than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts and with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
			OL	Organic silts and organic silty clays of low plasticity.
	SILTS AND CLAYS (Liquid limit GREATER than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
			CH	Inorganic clays of high plasticity, fat clays.
			OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS			PT	Peat and other highly organic soils.

Undisturbed Sample (UD)		Auger Cuttings	
Split Spoon Sample (SS)		Bulk Sample	
Rock Core (RC)		Crandall Sampler	
Dilatometer		Pressure Meter	
Packer		No Recovery	
Water Table at time of drilling		Water Table after 24 hours	
WOH - Weight of Hammer		Loss of Water	
		C	Caved Depth of Boring

Correlation of Penetration Resistance (N) with Relative Density and Consistency

SAND & GRAVEL		SILT & CLAY	
No. of Blows	Relative Density	No. of Blows	Consistency
0 - 4	Very Loose	0 - 2	Very Soft
5 - 10	Loose	3 - 4	Soft
11 - 20	Firm	5 - 8	Firm
21 - 30	Very Firm	9 - 15	Stiff
31 - 50	Dense	16 - 30	Very Stiff
Over 50	Very Dense	Over 31	Hard

BOUNDARY CLASSIFICATIONS: Soils possessing characteristics of two groups are designated by combinations of group symbols.

CLAY	SILT	SAND			GRAVEL		Cobbles	Boulders
		Fine	Medium	Coarse	Fine	Coarse		

0.005 mm No.200 No.40 No.10 No.4 3/4" 3" 12"

U.S. STANDARD SIEVE SIZE

Reference: The Unified Soil Classification System, Corps of Engineers, U.S. Army Technical Memorandum No. 3-357, Vol. 1, March, 1953 (Revised April, 1960)

KEY TO SYMBOLS AND DESCRIPTIONS

amec

TEST BORING RECORD

Project: Hatchery Creek
Project No: 3353-11-2536.02.03
Checked By: AIS

Boring No.: B-1

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV (ft)	Sample Number	Sample Type	RECOV (in.)	N-COUNT 1st 6" 2nd 6" 3rd 6" / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil; psi-rock)	Percent Passing #200 Sieve	REMARKS
0	TOPSOIL (8 inches)	597	SS-1		14	3-3-4 (N = 7)						Surface cover: Grass/Topsoil (8 inches)
	LOOSE, dark brown and reddish brown, medium to fine SAND (SC), little CLAY, moist		SS-2		16	6-5-6 (N = 11)						
	STIFF, dark brown, lean CLAY (CL), some fine SAND, moist											
5	STIFF to FIRM, dark brown and light reddish brown, sandy SILT (ML), moist	592	SS-3		16	4-5-4 (N = 9)						
			SS-4		16	4-2-3 (N = 5)						
	FIRM to STIFF, light to dark gray and mottled reddish brown, SILT (ML), trace fine SAND, very moist (possible organic SILT)		SS-5		18	3-2-4 (N = 6)						
10		587	UD-1		24							An Undisturbed Sample was obtained from a depth of approximately 10 feet to 12 feet.
	Same as above, STIFF (ML)		SS-6		18	4-4-6 (N = 10)						
	Same as above, highly mottled (ML)		SS-7		18	5-5-6 (N = 11)						
15		582										
20		577	SS-8		18	5-5-6 (N = 11)						
	FIRM, light to dark gray and mottled reddish brown, elastic SILT (MH), trace fine SAND, very moist		SS-9		18	4-4-4 (N = 8)						
25		572										
	Same as above, wet (MH)											
30	FIRM, light gray and light brown, fine SAND (SM), some SILT, wet	567	SS-10		18	3-3-4 (N = 7)						
35		562	SS-11		18	7-7-6 (N = 13)						Groundwater was encountered at a depth of 33 feet at the time of drilling.
	VERY DENSE, brown, coarse to fine GRAVEL (GM) and coarse to fine SAND, some SILT and trace weathered SHALE fragments, wet		SS-12		5	50/5 (N = 50/5)						
40		557										
45		552										

START DATE: 8/26/2011
CONTRACTOR: Hoosier Drilling
DRILLER: Blake Sumler
EQUIPMENT: CME 55
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Manual
LOGGED BY: A. Sarno
PREPARED BY: N. Jones
REMARKS:

Note: *No information on the borings should be used without considering the entire content of the main document.*

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AMEC SOIL-ROCK-LABS 3353112536.02.03.GPJ MACTEC DATABASE TEMPLATE 01.GDT 11/16/11

TEST BORING RECORD

Project: Hatchery Creek
Project No: 3353-11-2536.02.03
Checked By: ACS

Boring No.: B-2

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV (ft)	Sample Number	Sample Type	REC (in.)	N-COUNT 1st 6" 2nd 6" 3rd 6" / RQD % REC	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Unconfined Compression (psf-soil, psi-rock)	Percent Passing #200 Sieve	REMARKS
0	TOPSOIL (4 inches)	588										Surface cover: Grass/Topsoil (4 inches)
	STIFF, light reddish brown, sandy SILT (ML), moist		SS-1		14	3-5-7 (N = 12)	14.7					
			SS-2		18	7-8-8 (N = 16)		20	19		58	
	Same as above, trace ORGANICS (ML)											
5		583	SS-3		14	9-7-7 (N = 14)	15.4					
	Same as above, STIFF, with some pockets of silty SAND, no organics (ML)		SS-4		14	3-5-5 (N = 10)	16.8					
	Same as above, STIFF, very moist (ML)		SS-5		18	5-5-5 (N = 10)	11.8					
10		578										
15		573	SS-6		18	4-4-5 (N = 9)	22.1					
20		568	SS-7		18	6-5-5 (N = 10)	18.9					
	Same as above, STIFF, wet (ML)											
25	LOOSE, dark gray, medium to fine silty SAND (SM), wet	563	SS-8		18	3-4-3 (N = 7)	23.2					
30		558	SS-9		18	3-4-3 (N = 7)	28.4					
	Same as above, FIRM											Groundwater was encountered at a depth of 33 feet at the time of drilling.
35		553	SS-10		18	7-5-6 (N = 11)	21.7					
40	VERY DENSE, light to dark gray, fine to coarse SAND (SW) and LIMESTONE fragments, with trace silt, wet	548	SS-11		14	19-12-50/2 (N = 50/2)	13.6					
45		543										

Note: *No information on the borings should be used without considering the entire content of the main document.*

START DATE: 8/26/2011
CONTRACTOR: Hoosier Drilling
DRILLER: Blake Sumler
EQUIPMENT: CME 55
METHOD: HSA
HOLE DIA.: 3¼" ID
HAMMER: Manual
LOGGED BY: A. Sarno
PREPARED BY: N. Jones
REMARKS:

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AMEC SOIL-ROCK-LABS 3353112536.02.03.GPJ MACTEC DATABASE TEMPLATE 01.GDT 11/16/11

HAND AUGER BORING RECORD

Project: Hatchery Creek
Project No: 3353-11-2536.02.03
Checked By: ACS

Boring No.: HA-1

DEPTH (ft)	DESCRIPTION SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES: Sample Number	SAMPLES: Sample Type	SAMPLES: DCP (bpi)	Moisture Content (%)	Liquid Limit/ Plastic Limit	Percent Passing #200 Sieve	REMARKS **Note:** *No information on the borings should be used without considering the entire content of the main document.*
0	TOPSOIL (18 inches);		570							Surface cover: Grass/Topsoil (18 inches)
				AU-1		1				
	VERY SOFT, dark gray and mottled brown, SILT (ML), trace ORGANICS and trace fine SAND, wet			AU-2		WOH				
				AU-3		WOH	49.2	48/27	83	
	VERY SOFT, dark gray, SILT (ML), trace fine SAND, wet									Water encountered at 3 feet at time of exploration.
				AU-4		1				
	HAND AUGER REFUSAL AT 4.0 FEET									
5			565							
10			560							

START DATE: 8/25/2011
CONTRACTOR: AMEC
DRILLER: A. Sarno / N. Jones
EQUIPMENT: Hand Auger
METHOD: Hand Auger
HOLE DIA.: 4" OD
HAMMER: Dynamic Cone Penetrometer
LOGGED BY: A. Sarno / N. Jones
PREPARED BY: N. Jones
REMARKS: Blows per increment (BPI) is the average number of hammer blows required to achieve the 1¾-inch increment from a 15 pound hammer falling 20 inches.

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AMEC HAND AUGER LOG (W/ PIC ATTERBERG) 3353112536.02.03.GPJ MACTEC DATABASE TEMPLATE 01.GDT 11/16/11

HAND AUGER BORING RECORD

Project: Hatchery Creek
Project No: 3353-11-2536.02.03
Checked By: ARS

Boring No.: HA-2

DEPTH (ft)	DESCRIPTION SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES: Sample Number	SAMPLES: Sample Type	SAMPLES: DCP (bpi)	Moisture Content (%)	Liquid Limit/ Plastic Limit	Percent Passing #200 Sieve	REMARKS **Note:** *No information on the borings should be used without considering the entire content of the main document.*
0	TOPSOIL (4 inches)		574							Surface cover: Topsoil (4 inches)
	STIFF, light brown, fine SAND (SM), some SILT, moist			AU-1		10				
				AU-2		21				
				AU-3		12				Boring offset three times due to large roots.
	HAND AUGER REFUSAL AT 3.0 FEET									Hand Auger terminated at 3.0 feet due to large root clusters.
5			569							
10			564							

START DATE: 8/25/2011
CONTRACTOR: AMEC
DRILLER: A. Sarno / N. Jones
EQUIPMENT: Hand Auger
METHOD: Hand Auger
HOLE DIA.: Dynamic Cone Penetrometer
HAMMER: Dynamic Cone Penetrometer
LOGGED BY: A. Sarno / N. Jones
PREPARED BY: A. Sarno / N. Jones
REMARKS: Blows per increment (BPI) is the average number of hammer blows required to achieve the 1¾-inch increment from a 15 pound hammer falling 20 inches.

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HAND AUGER BORING RECORD

Project: Hatchery Creek
Project No: 3353-11-2536.02.03
Checked By: AES

Boring No.: HA-3

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	LEGEND	ELEV (ft)	SAMPLES: Sample Number	Sample Type	DCP (bpi)	Moisture Content (%)	Liquid Limit/ Plastic Limit	Percent Passing #200 Sieve	REMARKS
0	TOPSOIL (4 inches)		573							Surface cover: Topsoil (4 inches)
	STIFF, light brown, lean CLAY (CL) with silt, moist			AU-1		22	17.6	33/21	95	
				AU-2		18				
				AU-3		15				
	HAND AUGER REFUSAL AT 3.0 FEET			AU-4		13				
5			568							
10			563							

Note: *No information on the borings should be used without considering the entire content of the main document.*

START DATE: 8/25/2011
CONTRACTOR: AMEC
DRILLER: A. Sarno / N. Jones
EQUIPMENT: Hand Auger
METHOD: Hand Auger
HOLE DIA.: Dynamic Cone Penetrometer
HAMMER: Dynamic Cone Penetrometer
LOGGED BY: A. Sarno / N. Jones
PREPARED BY: A. Sarno / N. Jones
REMARKS: Blows per increment (BPI) is the average number of hammer blows required to achieve the 1¾-inch increment from a 15 pound hammer falling 20 inches.

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HAND AUGER BORING RECORD

Project: Hatchery Creek
Project No: 3353-11-2536.02.03
Checked By: AES

Boring No.: HA-4

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	LEGEND	ELEV (ft)	SAMPLES: Sample Number	Sample Type	DCP (bpi)	Moisture Content (%)	Liquid Limit/ Plastic Limit	Percent Passing #200 Sieve	REMARKS
0	STIFF, light brown, fine SAND, some coarse GRAVEL and some SILT, moist; FILL		581	AU-1		12				Surface cover: Grassy GRAVEL (FILL) (12 inches)
	STIFF, light reddish brown, silty clayey SAND (SC-SM), moist			AU-2		22	7.7	19/15		
				AU-3		24				
				AU-4		16				
	STIFF, reddish brown and light gray, silty clayey SAND (SC-SM), trace GRAVEL, moist			AU-5		17				
5	Same as above, light reddish brown (SC-SM)		576	AU-6		8				
				AU-8		13				
	HAND AUGER TERMINATED AT 8.0 FEET			AU-9		22				
10			571							

Note: *No information on the borings should be used without considering the entire content of the main document.*

START DATE: 8/25/2011
CONTRACTOR: AMEC
DRILLER: A. Sarno / N. Jones
EQUIPMENT: Hand Auger
METHOD: Hand Auger
HOLE DIA.: Dynamic Cone Penetrometer
HAMMER: Dynamic Cone Penetrometer
LOGGED BY: A. Sarno / N. Jones
PREPARED BY: A. Sarno / N. Jones
REMARKS: Blows per increment (BPI) is the average number of hammer blows required to achieve the 1¾-inch increment from a 15 pound hammer falling 20 inches.

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AMEC HAND AUGER LOG (W/ PIC ATTERBERG) 3353112536.02.03.GPJ MACTEC DATABASE TEMPLATE 01.GDT 11/16/11

HAND AUGER BORING RECORD

Project: Hatchery Creek
Project No: 3353-11-2536.02.03
Checked By: AIS

Boring No.: HA-5

DEPTH (ft)	DESCRIPTION SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES: Sample Number	Sample Type	DCP (bpi)	Moisture Content (%)	Liquid Limit/ Plastic Limit	Percent Passing #200 Sieve	REMARKS **Note:** *No information on the borings should be used without considering the entire content of the main document.*
0	TOPSOIL (3 inches)		581							Surface cover: Grass/Topsoil (3 inches)
	FIRM to STIFF, medium brown, silty clayey SAND (SC-SM), moist			AU-1		7				
				AU-2		10	7.7	19/15	38	
				AU-3		10				
				AU-4		8				
				AU-5		12				
5			576							
				AU-6		11				
	HARD, brown, gravelly SAND (SG)									
	HAND AUGER REFUSAL AT 6.5 FEET			AU-7		30				Hand Auger refusal at a depth of 6.5 feet on apparent large gravel fragments.
10			571							

START DATE: 8/26/2011
CONTRACTOR: AMEC
DRILLER: A. Sarno / N. Jones
EQUIPMENT: Hand Auger
METHOD: Hand Auger
HOLE DIA.: Dynamic Cone Penetrometer
HAMMER: Dynamic Cone Penetrometer
LOGGED BY: A. Sarno / N. Jones
PREPARED BY: A. Sarno / N. Jones
REMARKS: Blows per increment (BPI) is the average number of hammer blows required to achieve the 1¾-inch increment from a 15 pound hammer falling 20 inches.

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AMEC HAND AUGER LOG (W/ PIC ATTERBERG) 3353112536.02.03.GPJ MACTEC DATABASE TEMPLATE 01.GDT 11/16/11

HAND AUGER BORING RECORD

Project: Hatchery Creek
Project No: 3353-11-2536.02.03
Checked By: ACS

Boring No.: HA-6

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	LEGEND	ELEV (ft)	SAMPLES: Sample Number	Sample Type	DCP (bpi)	Moisture Content (%)	Liquid Limit/ Plastic Limit	Percent Passing #200 Sieve	REMARKS
0	TOPSOIL (3 inches)		590							Surface cover: Grass/Topsoil (3 inches)
	STIFF to FIRM, light gray to light brown, medium to fine grained CLAY and SAND mixture (CL), slightly moist			AU-1		12				
				AU-2		7				A Bulk Sample was obtained from a depth of 1.5 feet to 3.0 feet.
	Same as above, moist (CL)									
	Same as above, little GRAVEL, moist (CL)			AU-3		16				
				AU-4		14				
	Same as above, wet (CL)			AU-5		13				
5			585							
				AU-6		21				
				AU-8		21				
	HAND AUGER REFUSAL AT 9.0 FEET			AU-9		30				Hand auger terminated at 9.0 feet due to excessive cave in.
10			580							

START DATE: 8/26/2011
CONTRACTOR: AMEC
DRILLER: A. Sarno / N. Jones
EQUIPMENT: Hand Auger
METHOD: Hand Auger
HOLE DIA.: Dynamic Cone Penetrometer
HAMMER: Dynamic Cone Penetrometer
LOGGED BY: A. Sarno / N. Jones
PREPARED BY: A. Sarno / N. Jones
REMARKS: Blows per increment (BPI) is the average number of hammer blows required to achieve the 1¾-inch increment from a 15 pound hammer falling 20 inches.

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HAND AUGER BORING RECORD

Project: Hatchery Creek
Project No: 3353-11-2536.02.03
Checked By: AIS

Boring No.: HA-7

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	LEGEND	ELEV (ft)	SAMPLES: Sample Number	Sample Type	DCP (bpi)	Moisture Content (%)	Liquid Limit/ Plastic Limit	Percent Passing #200 Sieve	REMARKS
0	TOPSOIL (1 inch)		595							Surface cover: Grass/Topsoil (1 inch)
	STIFF, light reddish brown, fine SAND (SC), some CLAY, slightly moist			AU-1		8				
				AU-2		14				
				AU-3		30				
	HARD to STIFF, light gray, sandy lean CLAY (CL) with silt, moist			AU-4		13				A Bulk Sample was obtained from a depth of 3.5 feet to 6.0 feet.
				AU-5		30				
5			590							
	HARD, reddish brown and light gray, lean CLAY (CL), some fine SAND, moist			AU-6		30				
	HARD, light gray mottled with reddish brown, lean to fat CLAY (CL-CH), some fine SAND and trace fine ORGANICS, very moist			AU-7		23				
	Same as above, wet									
10	HAND AUGER REFUSAL AT 10.0 FEET		585							Hand auger terminated at 10.0 feet due to excessive cave in.
15			580							

START DATE: 8/26/2011
CONTRACTOR: AMEC
DRILLER: A. Sarno / N. Jones
EQUIPMENT: Hand Auger
METHOD: Hand Auger
HOLE DIA.: Dynamic Cone Penetrometer
HAMMER: Dynamic Cone Penetrometer
LOGGED BY: A. Sarno / N. Jones
PREPARED BY: A. Sarno / N. Jones
REMARKS: Blows per increment (BPI) is the average number of hammer blows required to achieve the 1¾-inch increment from a 15 pound hammer falling 20 inches.

Note: *No information on the borings should be used without considering the entire content of the main document.*

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HAND AUGER BORING RECORD

Project: Hatchery Creek
Project No: 3353-11-2536.02.03
Checked By: AIS

Boring No.: HA-8

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	LEGEND	ELEV (ft)	Sample Number	Sample Type	DCP (bpi)	Moisture Content (%)	Liquid Limit/ Plastic Limit	Percent Passing #200 Sieve	REMARKS
0	TOPSOIL (5 inches)		586							Surface cover: Grass/Topsoil (5 inches)
	FIRM to STIFF, light brown, clayey SILT (ML), trace fine SAND, moist			AU-1		9	24.7	41/28	91	
				AU-2		8				A Bulk Sample was obtained from a depth of 0 feet to 2.5 feet
	STIFF, mottled light gray, lean CLAY (CL), some SILT, trace fine SAND, moist			AU-3		13				A Bulk Sample was obtained from a depth of 2.5 feet to 6.0 feet
				AU-4		12				
				AU-5		9				
5			581							
				AU-6		9				
	HAND AUGER TERMINATED AT 6.0 FEET					15				
10			576							

Note: *No information on the borings should be used without considering the entire content of the main document.*

START DATE: 8/26/2011
CONTRACTOR: AMEC
DRILLER: A. Sarno / N. Jones
EQUIPMENT: Hand Auger
METHOD: Hand Auger
HOLE DIA.: Dynamic Cone Penetrometer
HAMMER: Dynamic Cone Penetrometer
LOGGED BY: A. Sarno / N. Jones
PREPARED BY: A. Sarno / N. Jones
REMARKS: Blows per increment (BPI) is the average number of hammer blows required to achieve the 1¾-inch increment from a 15 pound hammer falling 20 inches.

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HAND AUGER BORING RECORD

Project: Hatchery Creek
Project No: 3353-11-2536.02.03
Checked By: ACS

Boring No.: HA-9

DEPTH (ft)	DESCRIPTION (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	LEGEND	ELEV (ft)	Sample Number	Sample Type	DCP (bpi)	Moisture Content (%)	Liquid Limit/ Plastic Limit	Percent Passing #200 Sieve	REMARKS (**Note:** *No information on the borings should be used without considering the entire content of the main document.*)
0	TOPSOIL (1 inch)		589							Surface cover: Grass (1 inch)
	VERY STIFF to HARD, light gray and reddish brown, lean CLAY (CL), with SAND, moist			AU-1		20				
	DENSE, light gray and light reddish brown, sandy lean CLAY (CL), moist			AU-2		16				
	HARD, light reddish brown, sandy lean CLAY (CL), moist			AU-3		30	11.6	29/20	54	
				AU-4		30				
				AU-5		30				
5			584							
				AU-6		30				
	Same as above, with trace weathered SHALE fragments and trace iron concretions, moist			AU-7		30				
	HAND AUGER REFUSAL AT 7.0 FEET					30				Hand Auger refusal at 7.o feet on apparent weathered shale fragments.
10			579							

START DATE: 8/26/2011
CONTRACTOR: AMEC
DRILLER: A. Sarno / N. Jones
EQUIPMENT: Hand Auger
METHOD: Hand Auger
HOLE DIA.: Dynamic Cone Penetrometer
HAMMER: Dynamic Cone Penetrometer
LOGGED BY: A. Sarno / N. Jones
PREPARED BY: A. Sarno / N. Jones
REMARKS: Blows per increment (BPI) is the average number of hammer blows required to achieve the 1¾-inch increment from a 15 pound hammer falling 20 inches.

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HAND AUGER BORING RECORD

Project: Hatchery Creek
Project No: 3353-11-2536.02.03
Checked By: AES

Boring No.: HA-10

DEPTH (ft)	DESCRIPTION SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES: Sample Number	SAMPLES: Sample Type	SAMPLES: DCP (bpi)	Moisture Content (%)	Liquid Limit/ Plastic Limit	Percent Passing #200 Sieve	REMARKS **Note:** *No information on the borings should be used without considering the entire content of the main document.*
0	TOPSOIL (1 inch)		592							Surface cover: Grass/Topsoil (1 inch)
	VERY DENSE, light reddish brown, medium to fine SAND (SC), some CLAY, some GRAVEL and trace iron concretions, moist			AU-1		30		30/20		
				AU-2		30				
	HAND AUGER REFUSAL AT 1.5 FEET									Hand Auger refusal at 1.5 feet on apparent large gravel fragments. Hand Auger boring was attempted at two different locations.
5			587							

START DATE: 8/26/2011
CONTRACTOR: AMEC
DRILLER: A. Sarno / N. Jones
EQUIPMENT: Hand Auger
METHOD: Hand Auger
HOLE DIA.: Dynamic Cone Penetrometer
HAMMER: Dynamic Cone Penetrometer
LOGGED BY: A. Sarno / N. Jones
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REMARKS: Blows per increment (BPI) is the average number of hammer blows required to achieve the 1¾-inch increment from a 15 pound hammer falling 20 inches.

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AMEC HAND AUGER LOG (W/ PIC ATTERBERG) 3353112536.02.03.GPJ MACTEC DATABASE TEMPLATE 01.GDT 11/16/11

LABORATORY TESTING PROCEDURES

Soil Classification: Soil classifications provide a general guide to the engineering properties of various soil types and enable the engineer to apply past experience to current situations. In our investigations, samples obtained during drilling operations are examined in our laboratory and visually classified by an engineer. The soils are classified according to consistency (based on number of blows from standard penetration tests), color and texture. These classification descriptions are included on our "Test Boring Records."

The classification system discussed above is primarily qualitative and for detailed soil classification two laboratory tests are necessary: grain size tests and plasticity tests. Using these test results the soil can be classified according to the AASHTO or Unified Classification Systems (ASTM D2487). Each of these classification systems and the in-place physical soil properties provide an index for estimating the soil's behavior. The soil classification and physical properties determined are presented in this report.

Atterberg Limits: Portions of the samples are taken for Atterberg Limits testing to determine the plasticity characteristics of the soil. The plasticity index (PI) is the range of moisture content over which the soil deforms as a plastic material. It is bracketed by the liquid limit (LL) and the plastic limit (PL). The liquid limit is the moisture content at which the soil becomes sufficiently "wet" to flow as a heavy viscous fluid. The plastic limit is the lowest moisture content at which the soil is sufficiently plastic to be manually rolled into tiny threads. The liquid limit and plastic limit are determined in accordance with ASTM D4318.

Grain Size Tests: Grain Size Tests are performed to determine the soil classification and the grain size distribution. The soil samples are prepared for testing according to ASTM D421 (dry preparation) or ASTM D2217 (wet preparation). The grain size distribution of soils coarser than a number 200 sieve (0.074 mm opening) is determined by passing the samples through a standard set of nested sieves. Materials passing the number 200 sieve are suspended in water and the grain size distribution calculated from the measured settlement rate. These tests are conducted in accordance with ASTM D422.

Percent Finer Than 200 Sieve: Selected samples of soils are washed through a number 200 sieve to determine the percentage of material less than 0.074 mm in diameter.

Compaction Tests: Compaction tests are run on representative soil samples to determine the dry density obtained by a uniform compactive effort at varying moisture contents. The results of the test are used to determine the moisture content and unit weight desired in the field for similar soils. Proper field compaction is necessary to decrease future settlements, increase the shear strength of the soil and decrease the permeability of the soil.

The two most commonly used compaction tests are the standard Proctor test and the modified Proctor test. They are performed in accordance with ASTM D698 and D1557, respectively. Generally, the standard Proctor compaction test is run on samples from building or parking areas where small compaction equipment is anticipated. The modified Proctor compaction test is generally performed for heavy structures, highways, and other areas where large compaction equipment is expected. In both tests a representative soil sample is placed in a mold and compacted with a compaction hammer. Both tests have three alternate methods.

LABORATORY TESTING PROCEDURES (continued)

The moisture content and unit weight of each compacted sample is determined. Usually 4 to 5 such tests are run at different moisture contents. Test results are presented in the form of a dry unit weight versus moisture content curve. The compaction method used and any deviations from the recommended procedures are noted in this report.

Moisture Content: The Moisture Content is determined according to ASTM D2216.

Borehole	Depth	Sample Type	Atterberg Limits			USCS Class-ification	Natural Moisture Content (%)	Unconfined Compress. Strength (Soil-psf)	% Finer than #200 Sieve	Unit Weight (pcf)		Maximum Dry Density (pcf)	Optimum Moisture Content (%)	CBR	Swell (%)	Rock Core		Unconfined Compress. Strength (Rock-psi)
			Liquid Limit	Plastic Limit	Plasticity Index					Dry Density	Wet Density					RQD	Percent Recovery	
B-2	0.0	SS					14.7											
B-2	1.5	SS	20	19	1	ML			58									
B-2	4.0	SS					15.4											
B-2	6.5	SS					16.8											
B-2	8.5	SS					11.8											
B-2	13.5	SS					22.1											
B-2	18.5	SS					18.9											
B-2	23.5	SS					23.2											
B-2	28.5	SS					28.4											
B-2	33.5	SS					21.7											
B-2	38.5	SS					13.6											
HA-1	2.0	AU	48	27	21	ML	49.2		83									
HA-3	0.0	AU	33	21	12	CL	17.6		95									
HA-5	1.0	AU	19	15	4	SC-SM	7.7		38									
HA-6	1.5	BK	39	20	19	CL	23.6											
HA-7	3.5	BG	26	17	9	CL	13.5		69									
HA-8	2.5	BG	39	35	4	CL	22.0											
HA-8	0.0	AU	41	28	13	ML	24.7		91									
HA-9	2.0	AU	29	20	9	CL	11.6		54									
HA-10	0.0	AU	30	20	10	SC	24.7					115.0	13.5					

Remarks:

* SPT/SS = Split-spoon BK / BG = Bulk / bag sample HA / AU = Hand Auger sample
UD/SH = Undisturbed sample RC = Rock core

Summary of Laboratory Results

Project: Hatchery Creek
Project No: 3353-11-2536.02.03
Checked By: AFS

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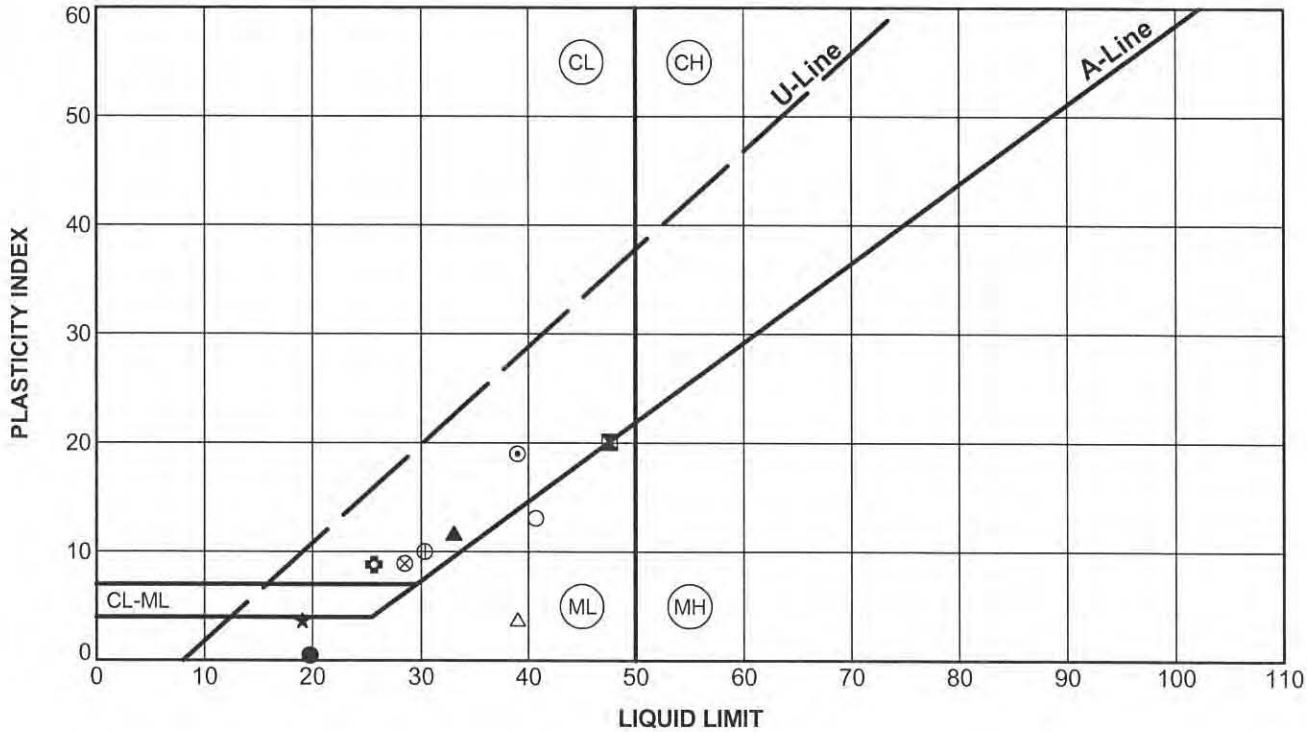

Symbol	Location	Depth, feet	LL	PL	PI	Natural Moisture Content, %	LI	USCS	Soil Classification
●	B-2	1.5 to 5.5	20	19	1			ML	Sandy Silt
⊠	HA-1	2.0 to 3.0	48	27	21	49.2	1.1	ML	Silt with Sand
▲	HA-3	0 to 1.0	33	21	12	17.6	-0.3	CL	Lean Clay, with Silt
★	HA-5	1.0 to 2.0	19	15	4	7.7	-2.1	SC-SM	Silty, clayey Sand
⊙	HA-6	1.5 to 3.0	39	20	19	23.6	0.2	CL	Light gray sandy CLAY
✿	HA-7	3.5 to 6.0	26	17	9	13.5	-0.4	CL	Sandy, lean Clay, with Silt
○	HA-8	0 to 2.5	41	28	13	24.7	-0.2	ML	Clayey SILT
△	HA-8	2.5 to 6	39	35	4	22.0	-3.5	CL	Lean CLAY, trace sand
⊗	HA-9	2.0 to 7.0	29	20	9	11.6	-0.9	CL	Sandy, lean Clay
⊕	HA-10	0 to 1.5	30	20	10	24.7	0.4	SC	Clayey Sand

Remarks:

Test Method - ASTM D4318

LL=Liquid Limit; PL= Plastic Limit; PI=Plasticity Index; LI=Liquidity Index

ATTERBERG LIMITS RESULTS

Project: Hatchery Creek

Project No: 3353-11-2536.02.03

Checked By: AIS

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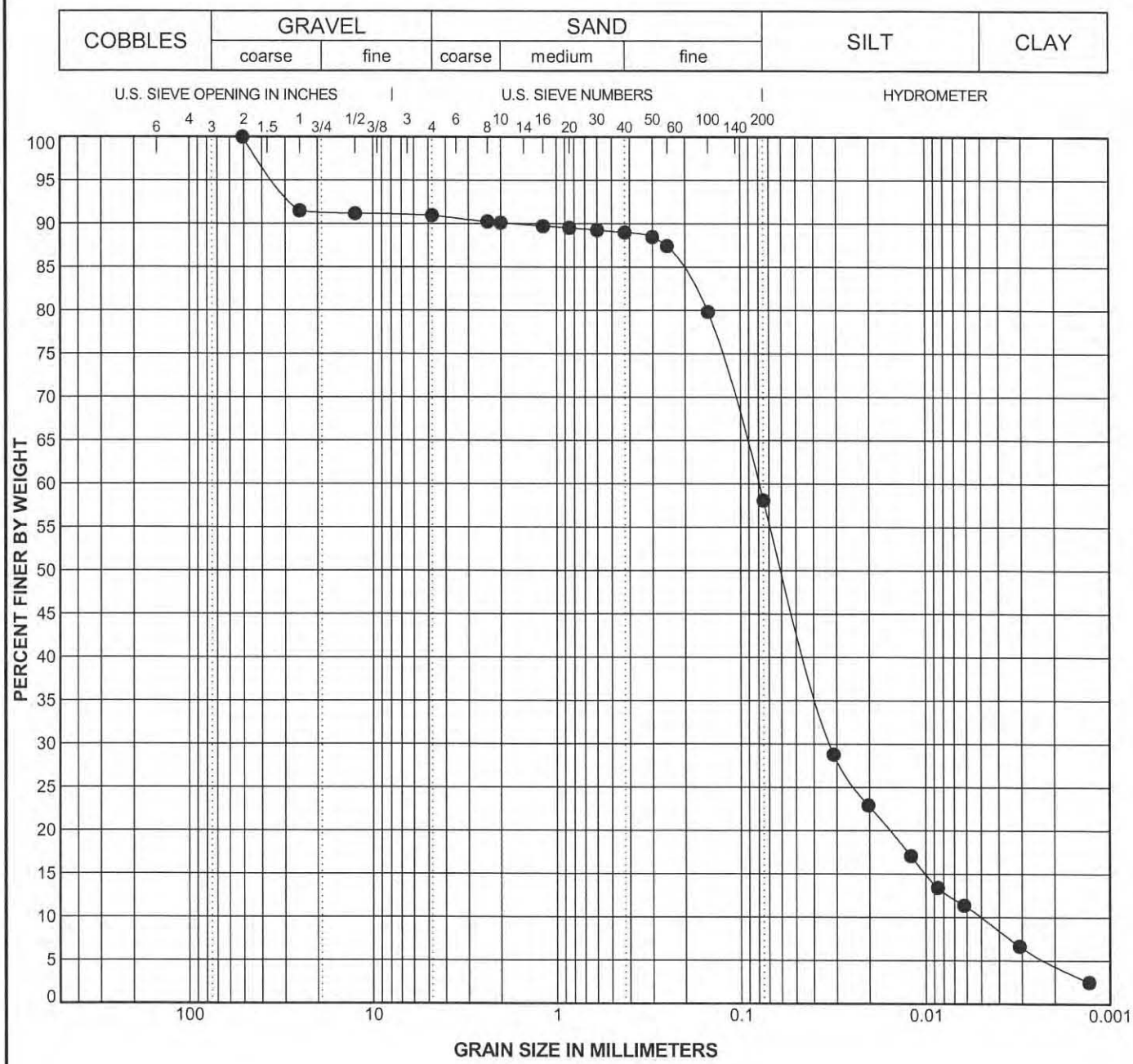
MACTEC_ATTERBERG_LIMITS 3353112536.02.03.GPJ MACTEC DATABASE TEMPLATE 01.GDT 11/17/11



Symbol	Location	Depth, feet	Soil Classification	USCS	D_{100}, mm	D_{60}, mm	D_{50}, mm	D_{30}, mm	D_{10}, mm	C_c	C_u
●	B-2	1.5 to 5.5	Sandy Silt	ML	50.8	0.08	0.059	0.032	0.005	2.60	15.76

Remarks:

Test Method - ASTM D422

GRAIN SIZE DISTRIBUTION

Project: Hatchery Creek

Project No: 3353-11-2536.02.03

Checked By: AIS

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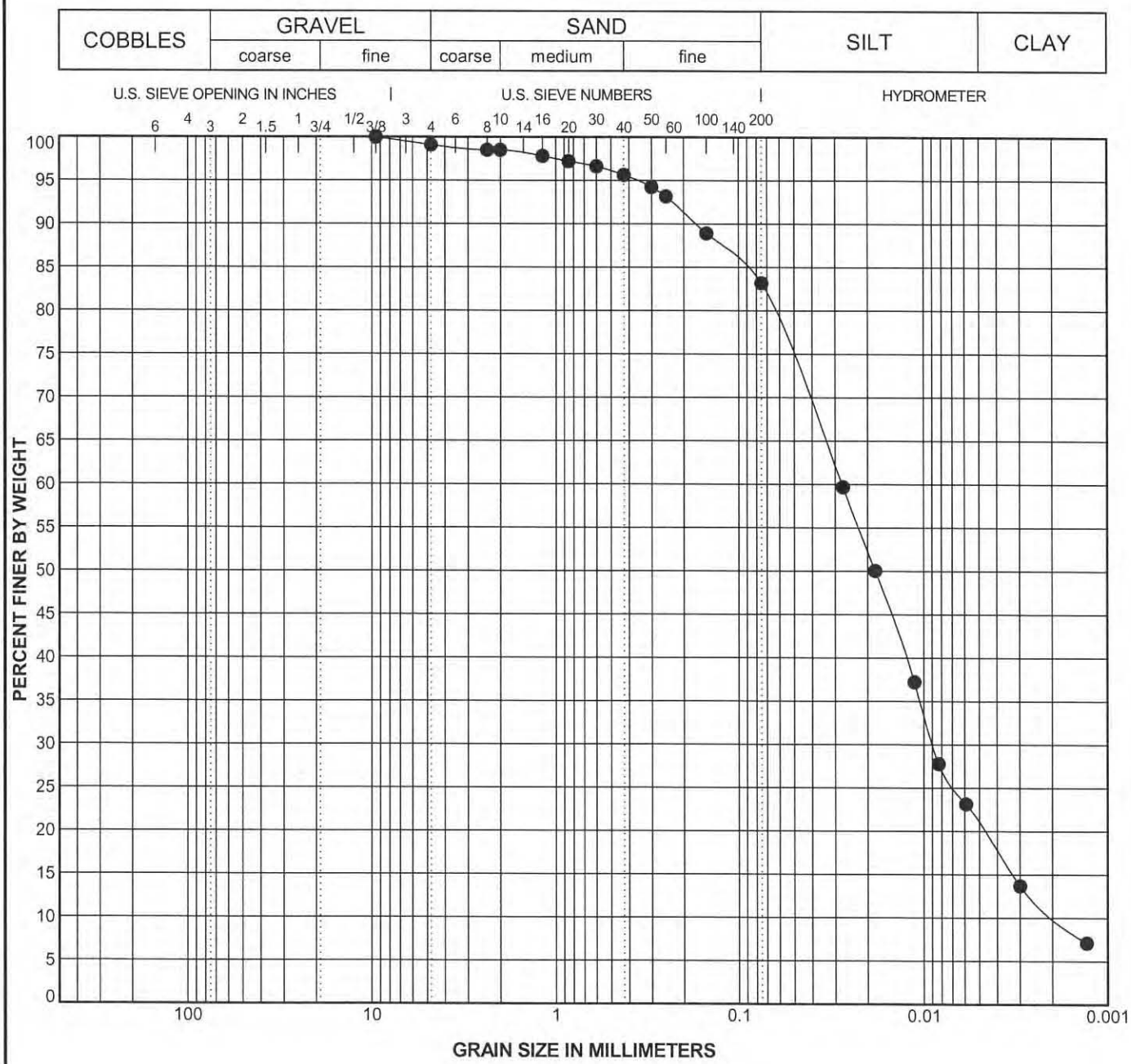
MACTEC_GRAIN_SIZE (W/ D50) 3353112536.02.03.GPJ LAW_GIBB.GDT 11/16/11



Symbol	Location	Depth, feet	Soil Classification	USCS	D_{100}, mm	D_{60}, mm	D_{50}, mm	D_{30}, mm	D_{10}, mm	C_c	C_u
●	HA-1	2.0 to 3.0	Silt with Sand	ML	9.5	0.028	0.018	0.009	0.002	1.54	14.72

Remarks:

Test Method - ASTM D422

GRAIN SIZE DISTRIBUTION

Project: Hatchery Creek

Project No: 3353-11-2536.02.03

Checked By: AFS

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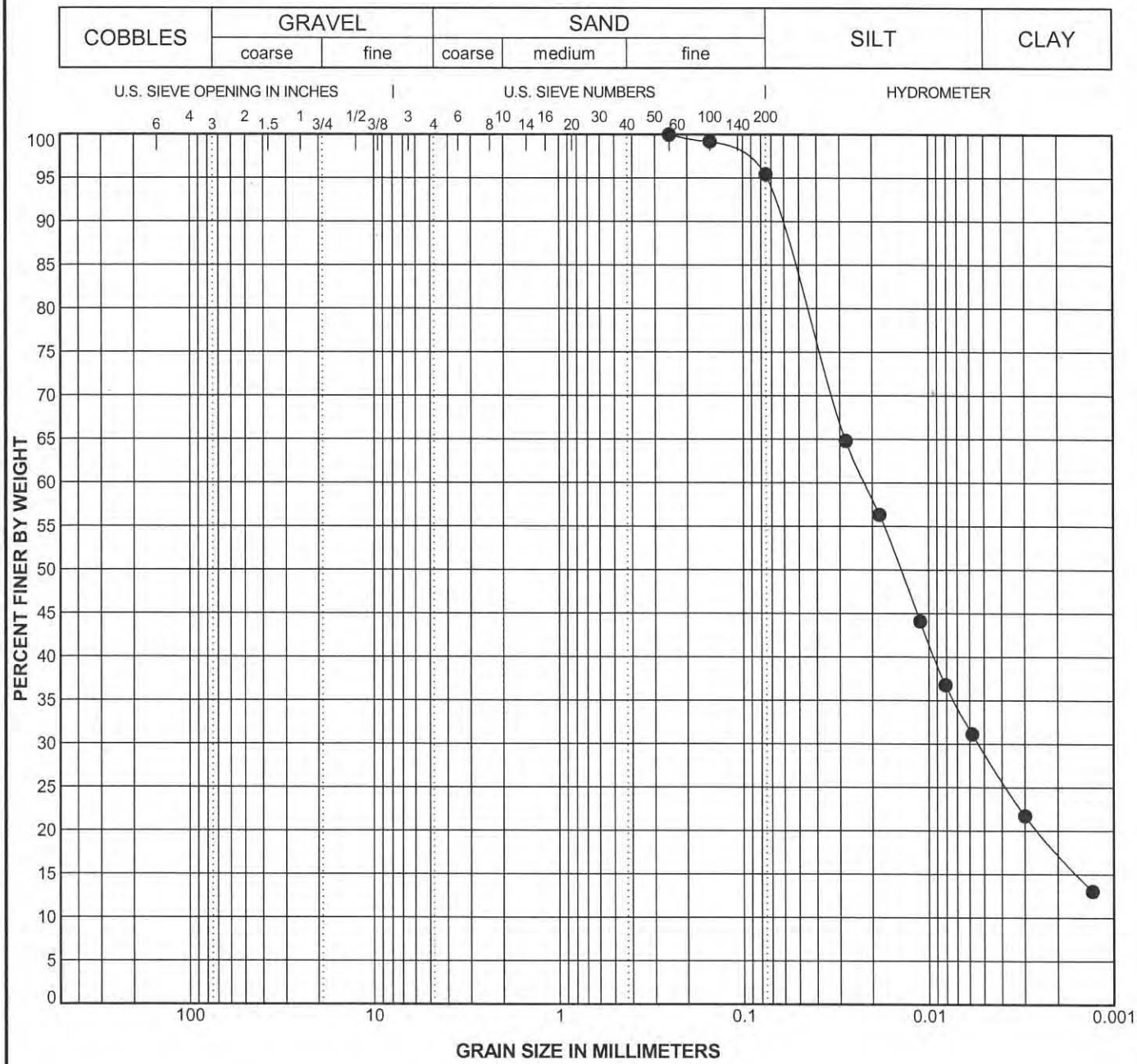
MACTEC_GRAIN_SIZE (W/ D50) 3353112536.02.03.GPJ LAW_GIBB.GDT 11/16/11



Symbol	Location	Depth, feet	Soil Classification	USCS	D_{100}, mm	D_{60}, mm	D_{50}, mm	D_{30}, mm	D_{10}, mm	C_c	C_u
●	HA-3	0 to 1.0	Lean Clay, with Silt	CL	0.25	0.022	0.014	0.005			

Remarks:

Test Method - ASTM D422

GRAIN SIZE DISTRIBUTION

Project: Hatchery Creek

Project No: 3353-11-2536.02.03

Checked By: AIS

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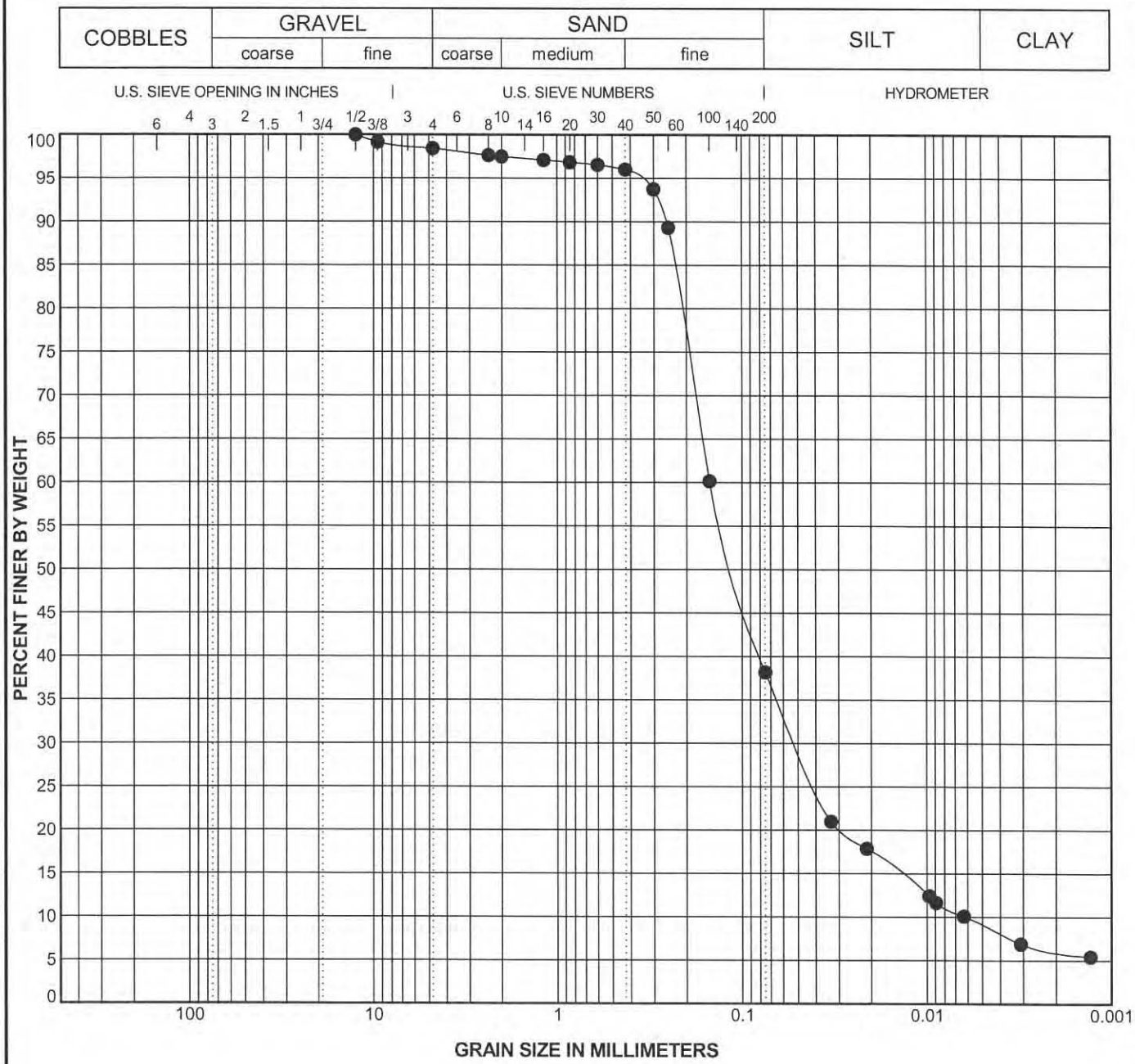

Symbol	Location	Depth, feet	Soil Classification	USCS	D_{100}, mm	D_{60}, mm	D_{50}, mm	D_{30}, mm	D_{10}, mm	C_c	C_u
●	HA-5	1.0 to 2.0	Silty, clayey Sand	SC-SM	12.5	0.149	0.109	0.051	0.006	2.81	24.25

Remarks:

Test Method - ASTM D422

GRAIN SIZE DISTRIBUTION

Project: Hatchery Creek

Project No: 3353-11-2536.02.03

Checked By: AIS

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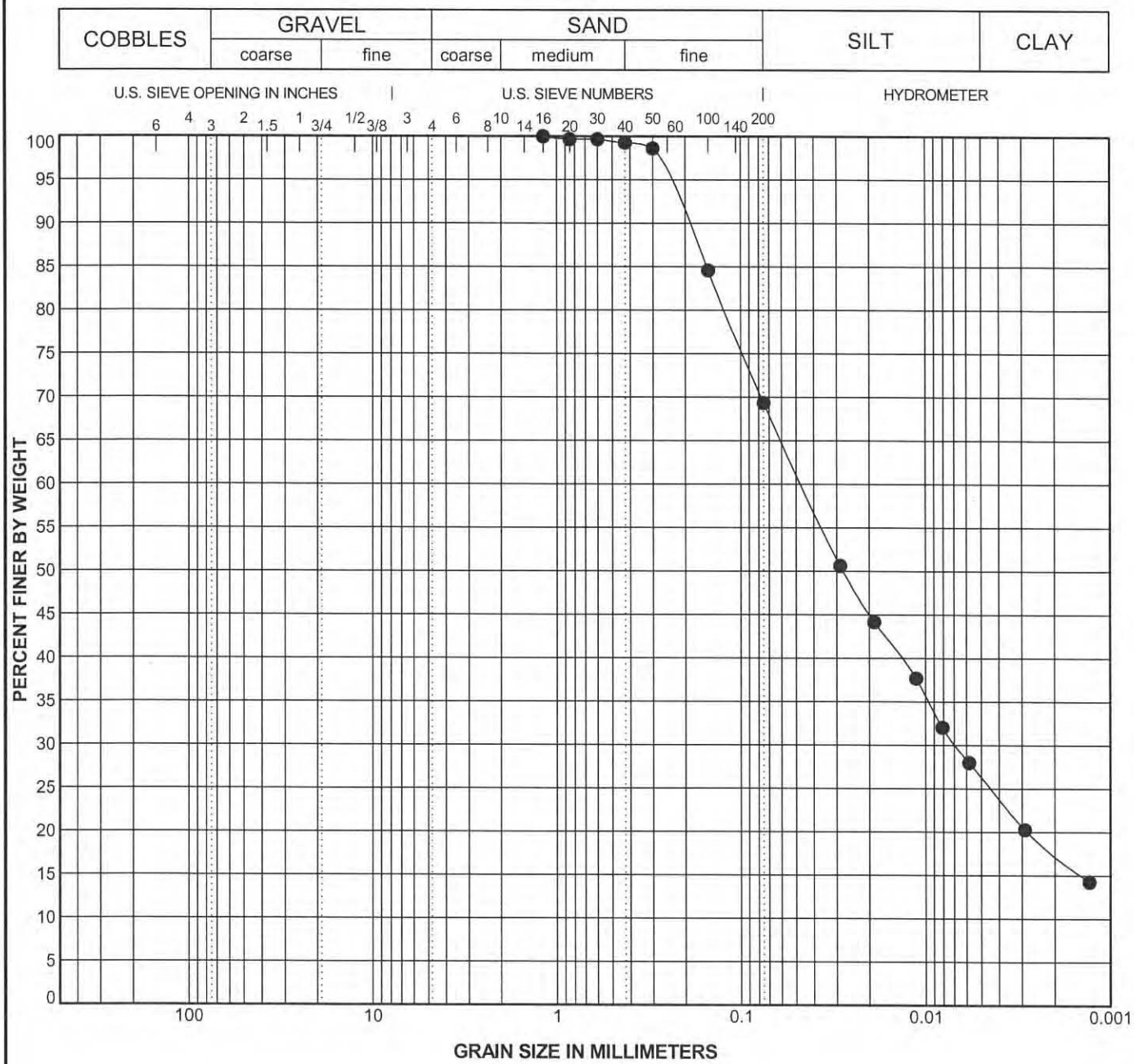
MACTEC_GRAIN_SIZE (W/ D50) 3353112536.02.03.GPJ LAW_GIBB.GDT 11/16/11



Symbol	Location	Depth, feet	Soil Classification	USCS	D_{100}, mm	D_{60}, mm	D_{50}, mm	D_{30}, mm	D_{10}, mm	C_c	C_u
●	HA-7	3.5 to 6.0	Sandy, lean Clay, with Silt	CL	1.18	0.046	0.028	0.007			

Remarks:

Test Method - ASTM D422

GRAIN SIZE DISTRIBUTION

Project: Hatchery Creek

Project No: 3353-11-2536.02.03

Checked By: AIS

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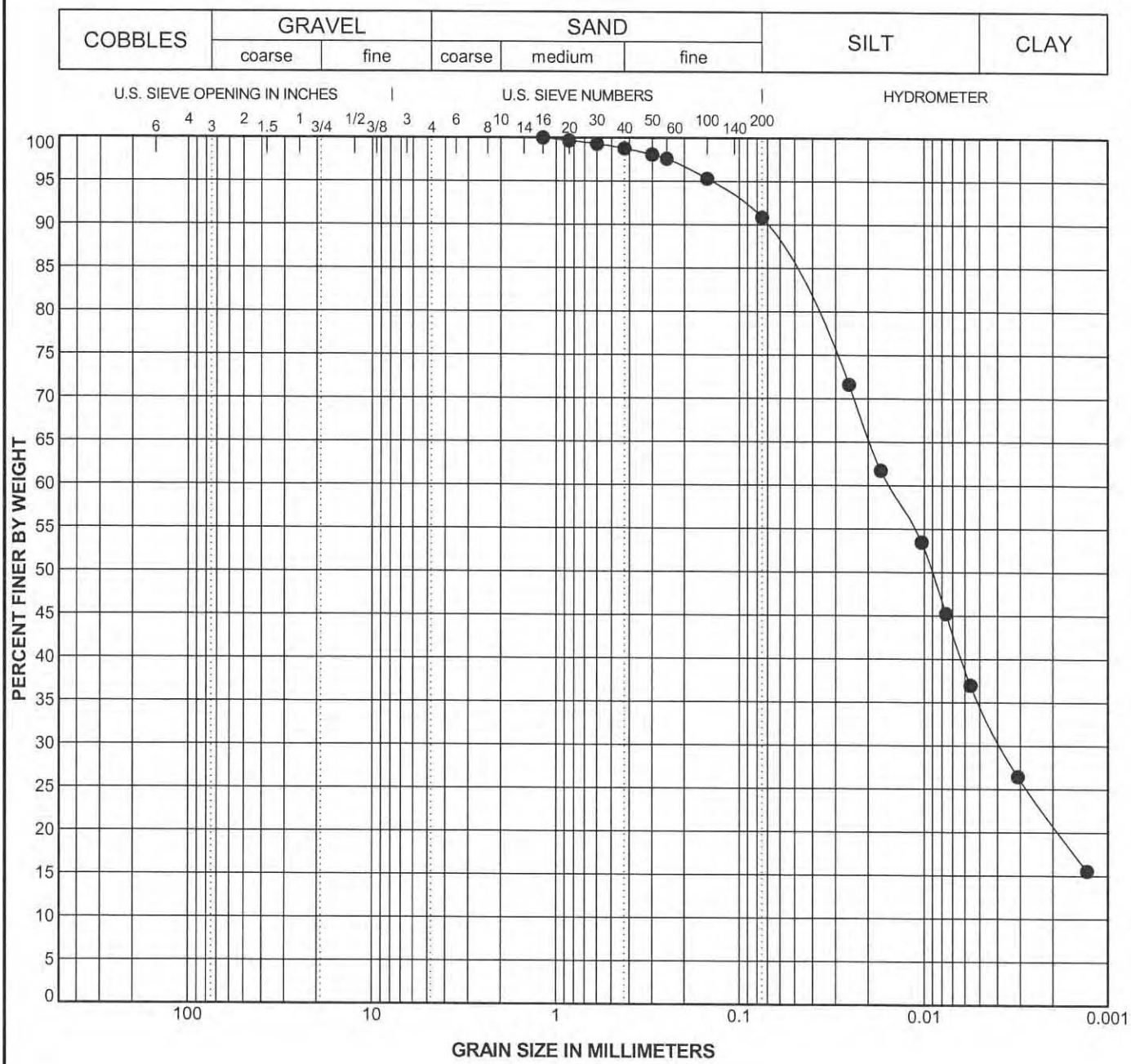

Symbol	Location	Depth, feet	Soil Classification	USCS	D_{100}, mm	D_{60}, mm	D_{50}, mm	D_{30}, mm	D_{10}, mm	C_c	C_u
●	HA-8	0 to 2.5	Clayey SILT	ML	1.18	0.015	0.009	0.004			

Remarks:

Test Method - ASTM D422

GRAIN SIZE DISTRIBUTION

Project: Hatchery Creek

Project No: 3353-11-2536.02.03

Checked By: AFS

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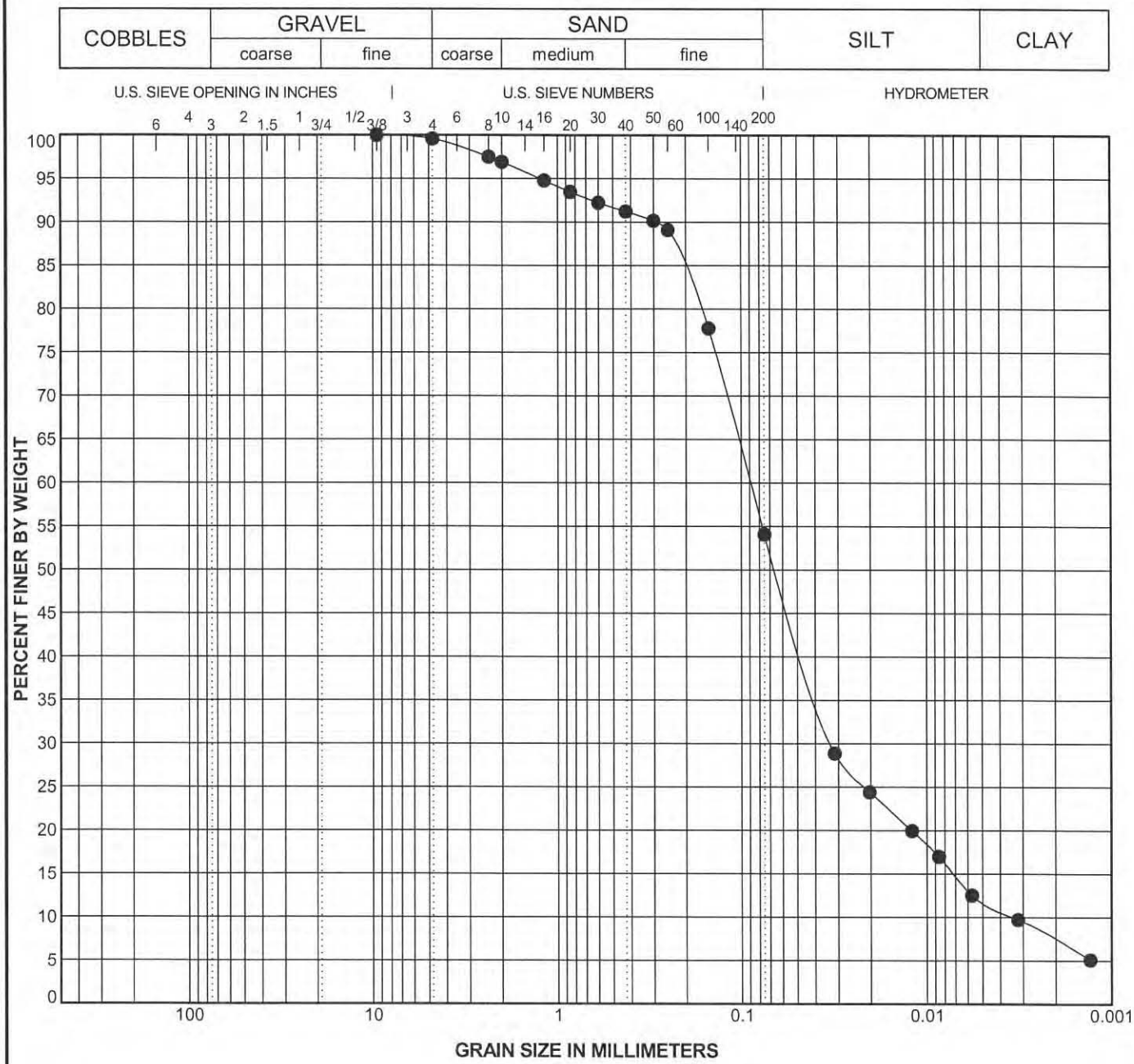
MACTEC_GRAIN_SIZE (W/ D50) 3353112536.02.03.GPJ LAW_GIBB.GDT 11/16/11



Symbol	Location	Depth, feet	Soil Classification	USCS	D_{100}, mm	D_{60}, mm	D_{50}, mm	D_{30}, mm	D_{10}, mm	C_c	C_u
●	HA-9	2.0 to 7.0	Sandy, lean Clay	CL	9.5	0.089	0.065	0.033	0.003	3.54	26.39

Remarks:

Test Method - ASTM D422

GRAIN SIZE DISTRIBUTION

Project: Hatchery Creek

Project No: 3353-11-2536.02.03

Checked By: AIS

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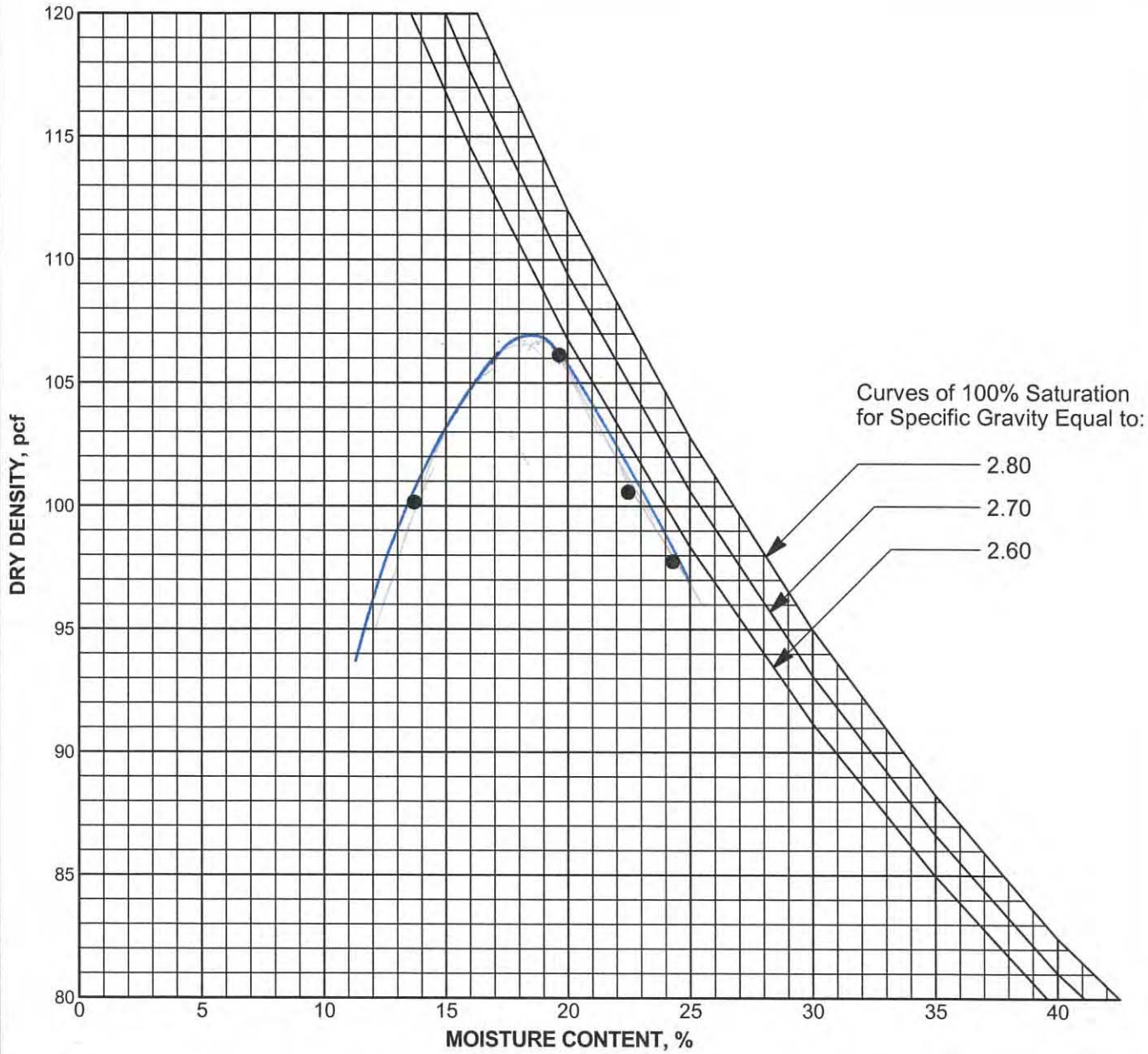
MACTEC_GRAIN_SIZE (W/ D50) 3353112536.02.03.GPJ LAW_GIBB.GDT 11/16/11



Symbol	Location	Depth, feet	Soil Classification	Maximum Dry Density, pcf	Optimum Moisture Content, %	Natural Moisture Content, %
●	HA-8	2.0 to 6.0	Sandy, lean Clay	107.0	18.0	22.0

Remarks:

Test Method - ASTM D698A (Standard Effort)

MOISTURE-DENSITY RELATIONSHIP

Project: Hatchery Creek

Project No: 3353-11-2536.02.03

Checked By: ACS

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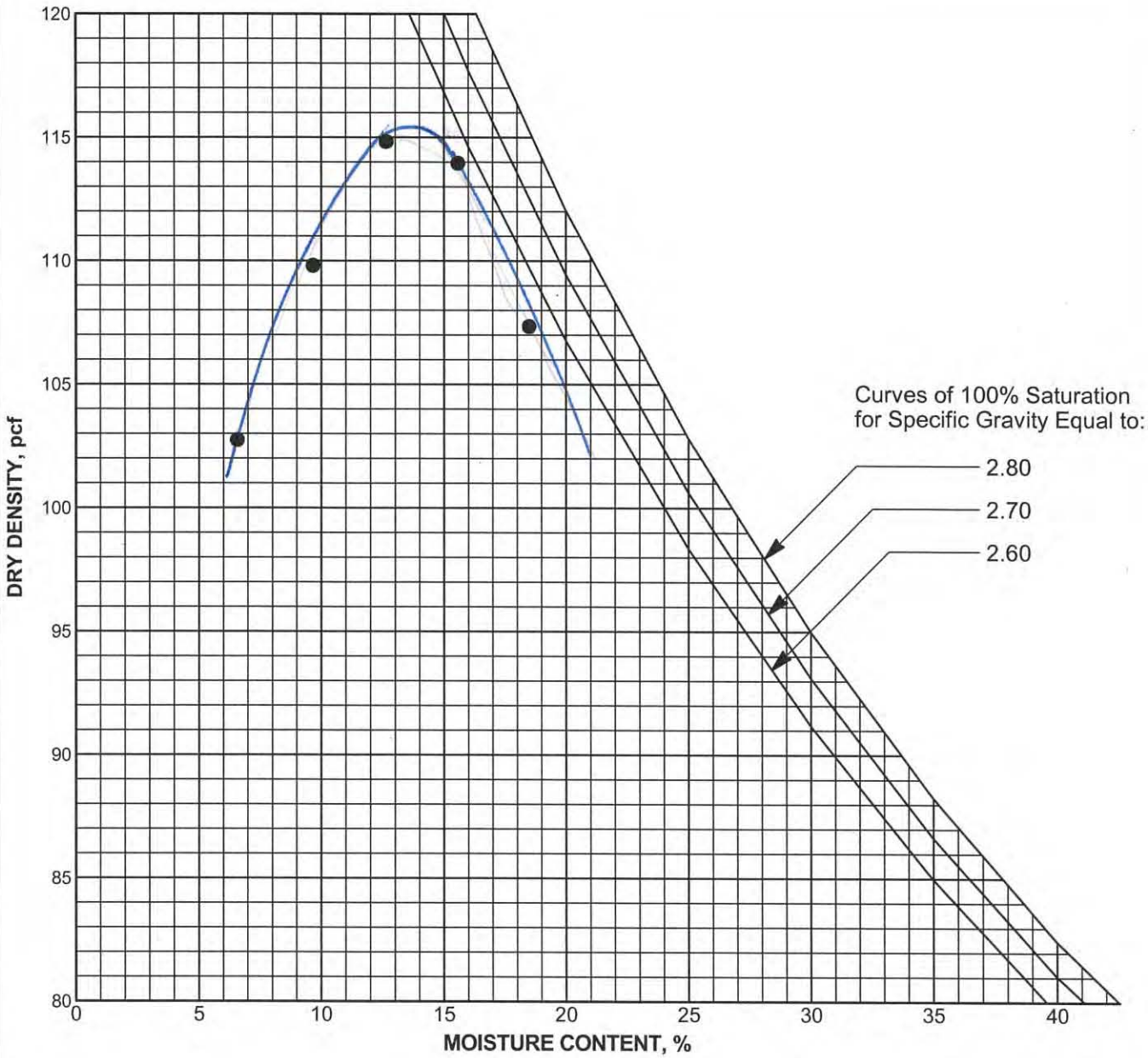
MACTEC_COMPACT_80-120_NO_LINE 3353112536.02.03.GPJ MACTEC DATABASE TEMPLATE 01.GDT 11/14/11



Symbol	Location	Depth, feet	Soil Classification	Maximum Dry Density, pcf	Optimum Moisture Content, %	Natural Moisture Content, %
●	HA-10	0 to 1.5	Clayey Sand	115.0	13.5	

Remarks:

Test Method - ASTM D698A (Standard Effort)

MOISTURE-DENSITY RELATIONSHIP

Project: Hatchery Creek

Project No: 3353-11-2536.02.03

Checked By: AES

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14. Service Area and Credit Release Schedule

See section III; subsection C (Compensatory Mitigation Project Credits) of the In-Lieu Fee Mitigation Program Instrument in reference to the release of credits. Service Area considerations and prioritizations are addressed in Appendix C of the In-Lieu Fee Mitigation Program Instrument, specifically section C.18.1 (Upper and Lower Cumberland Areas).

Photograph 1: Discharge of hatchery into fishing area.

Photograph 2: Discharge of fishing area into ravine and beginning of new channel.

Photograph 3: Ravine that receives discharge from hatchery.

Photograph 4: Erosion on slope of ravine.

Photograph 5: Location where new channel will enter the Cumberland River. Erosion on slope of ravine.

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HATCHERY CREEK DESIGN/BUILD PROJECT

HATCHERY CREEK
RUSSELL COUNTY, KENTUCKY

INDEX OF DRAWINGS

1	COVER SHEET AND PROJECT INFORMATION
2	SHEET LAYOUT & LEGEND
3 - 13	PLAN & PROFILE : HATCHERY CREEK STA. 100+00 TO STA. 159+92
14-16	PROPOSED TYPICAL CROSS SECTIONS
17	PLANTING PLAN
18-25	TYPICAL DETAILS

GENERAL PROJECT INFORMATION

HATCHERY CREEK

STREAM LENGTH: ALONG CENTERLINE - 5,992 LF
STREAM CLASSIFICATION:
EXISTING - N/A / G5
PROPOSED - C3, C4, B3, B4, D A5, A2
STREAM ORDER: I
WATERSHED SIZE: 288 ACRES

COMMONWEALTH OF KENTUCKY

GOVERNOR STEVEN L. BESHEAR

FINANCE AND ADMINISTRATION CABINET
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FRANKFORT, KENTUCKY

STREAM RESTORATION DESIGN/BUILD TEAM

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HATCHERY CREEK DESIGN/BUILD PROJECT
RUSSELL COUNTY, KENTUCKY

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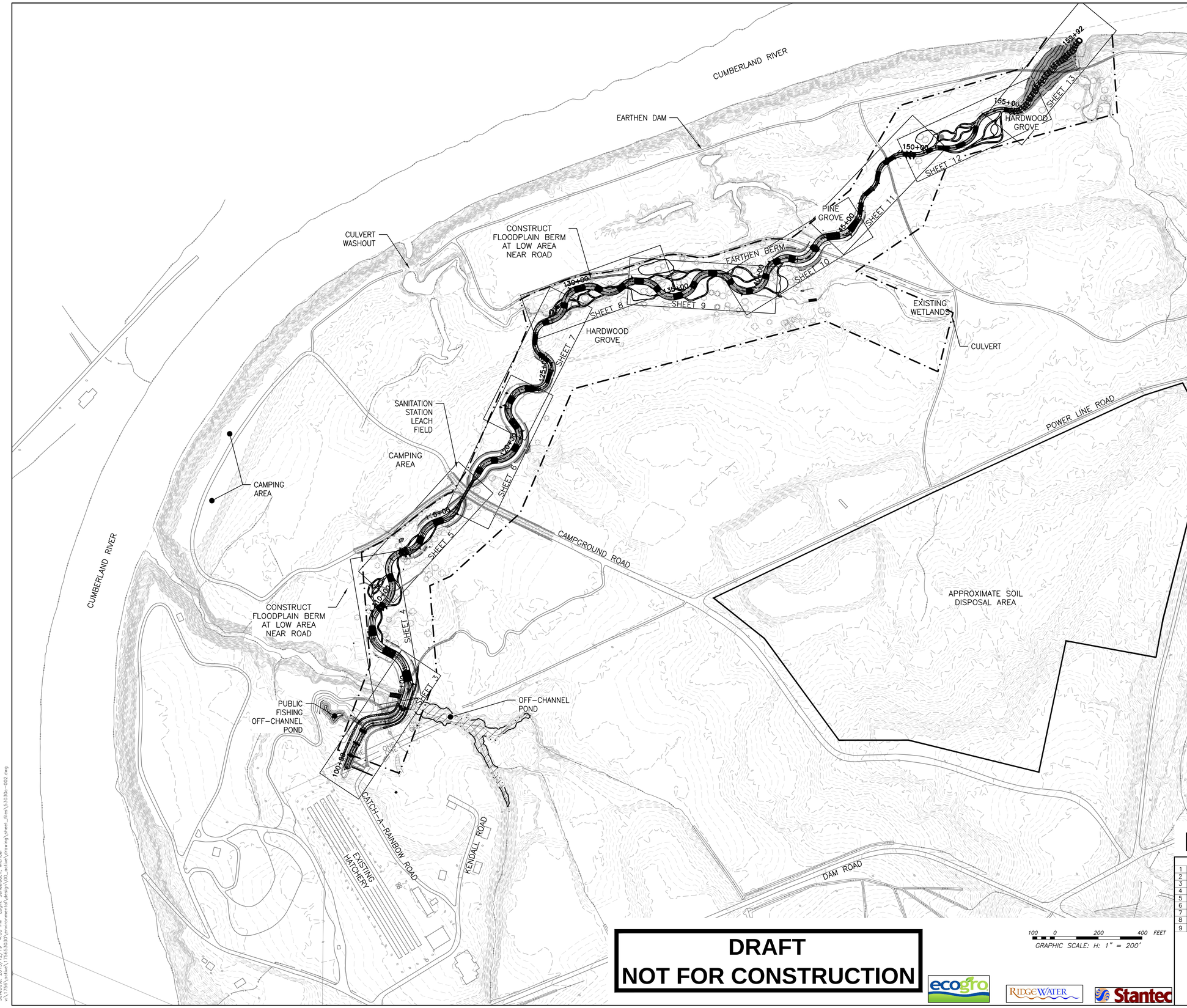

SURVEY NOTES

SURVEY INFORMATION ON THESE DRAWINGS WAS PROVIDED BY KDFWR.

LEGEND

- (590) EXISTING INDEX CONTOURS
- EXISTING INTERIM CONTOURS
- 590 PROPOSED INDEX CONTOURS
- PROPOSED INTERIM CONTOURS
- EXISTING STREAM LINE
- EXISTING TREELINE
- CONSERVATION EASEMENT
- LOG VANE/ROOTWAD
- ROCK RIFFLE
- ROCK AND ROLL RIFFLE
- BOULDER CLUSTER RIFFLE
- LOG/ROCK AND ROLL RIFFLE
- BOULDER JAM RIFFLE
- LOG RIFFLE
- BOULDER JAM STEP
- BOULDER CROSS VANE
- TOE WOOD/SOD MAT
- RIP RAP
- LOW WATER CROSSING

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SHEET LAYOUT & LEGEND

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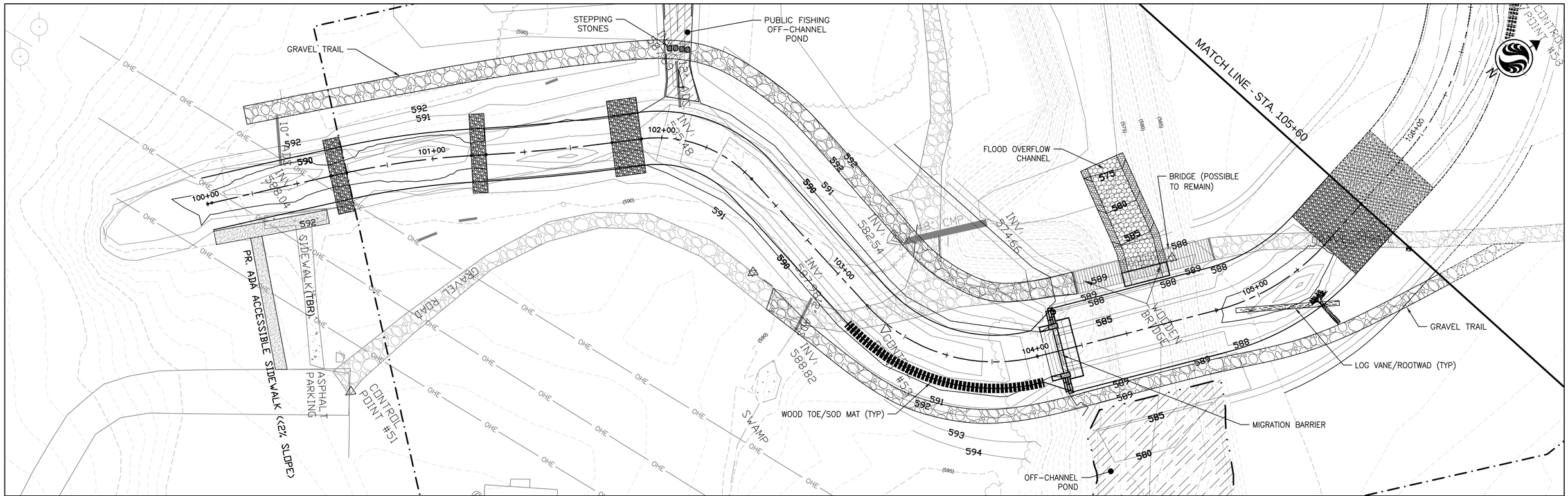

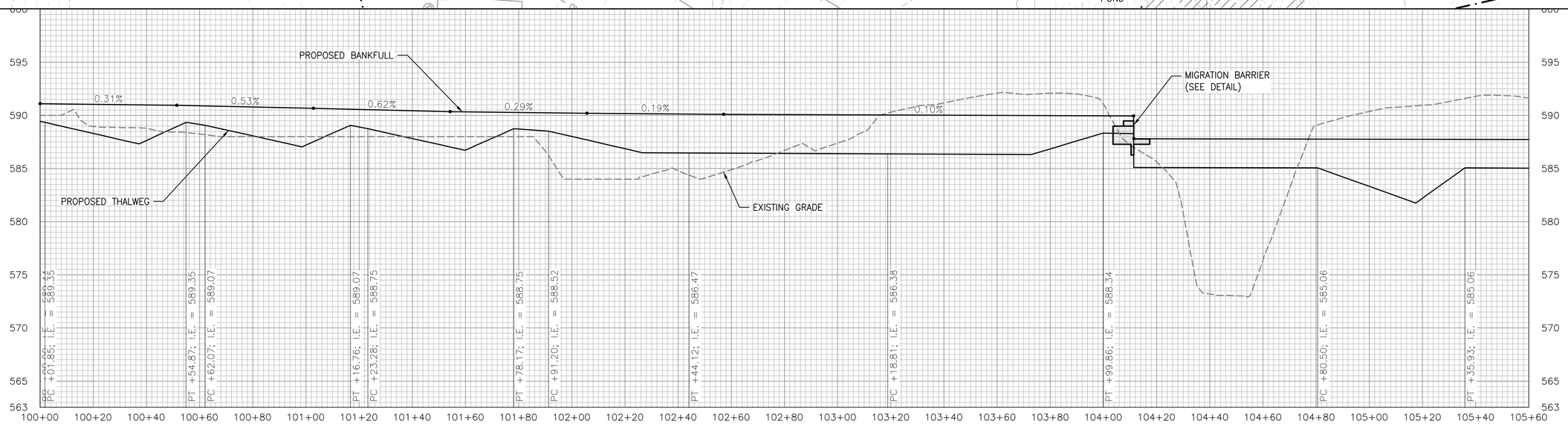

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PLAN & PROFILE

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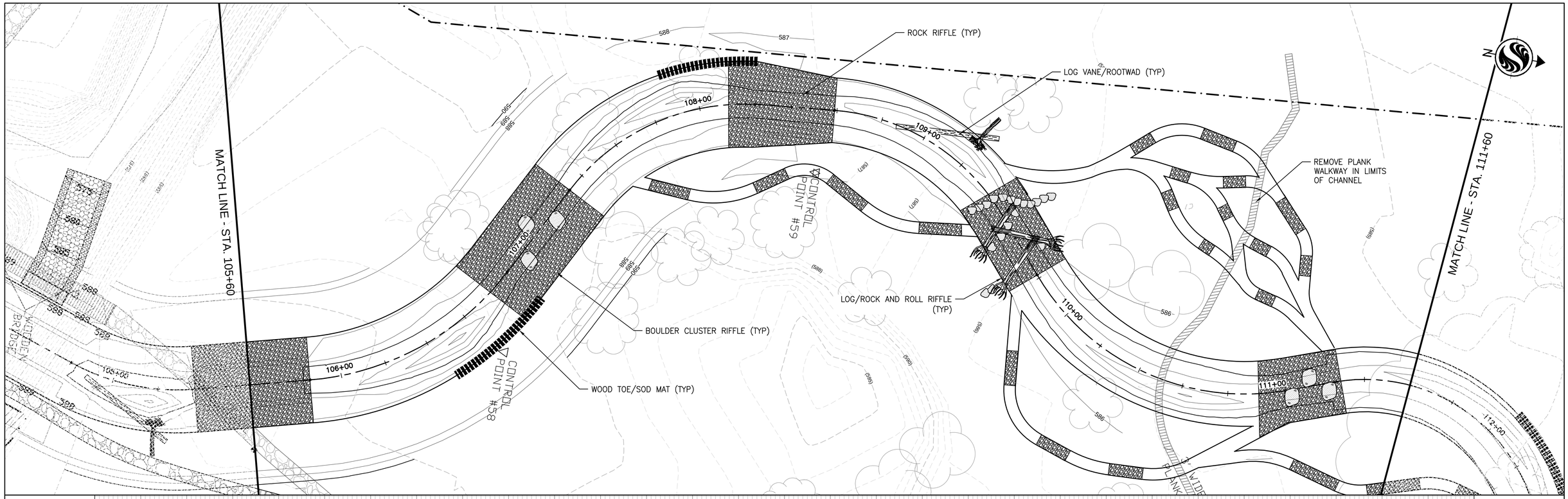

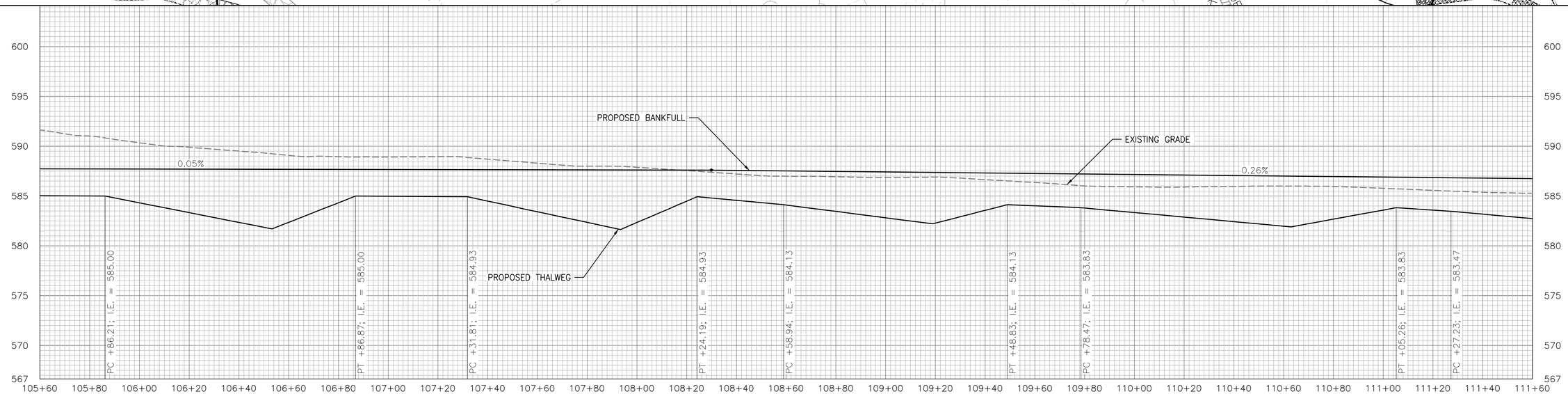

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HATCHERY CREEK DESIGN/BUILD PROJECT
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PLAN & PROFILE

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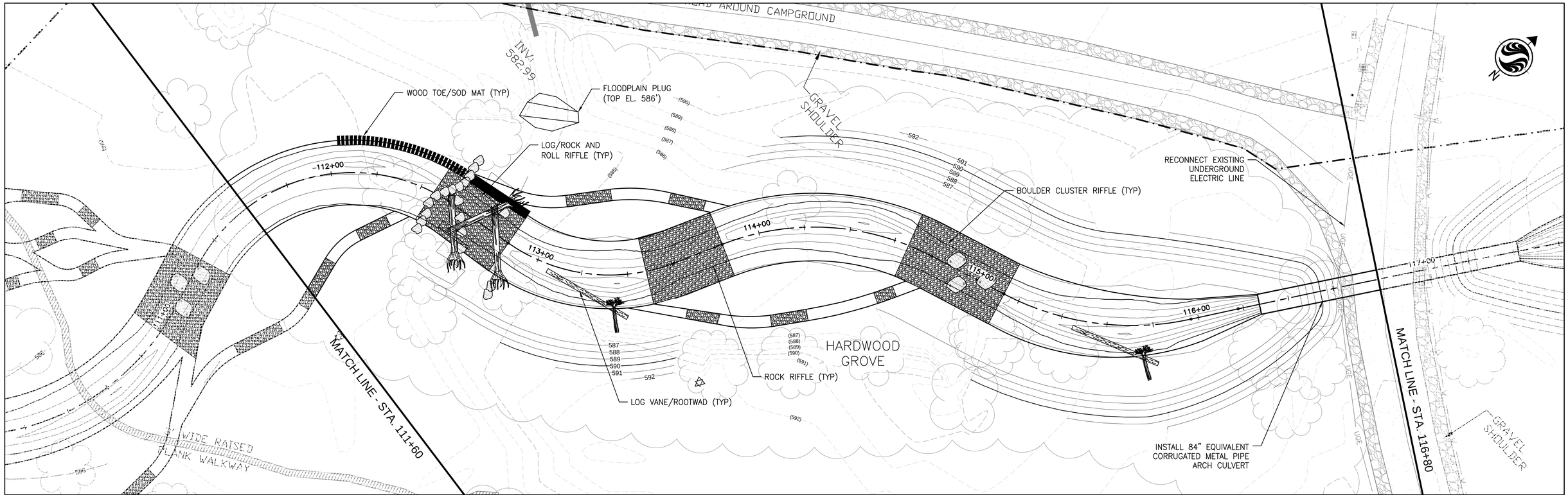

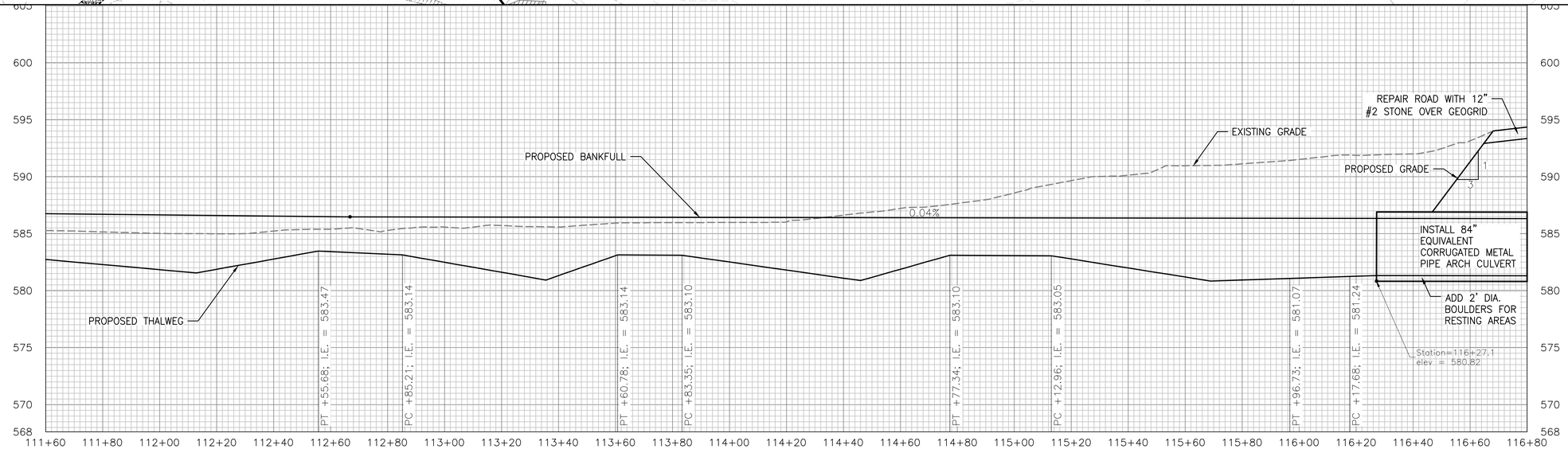

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HATCHERY CREEK DESIGN/BUILD PROJECT
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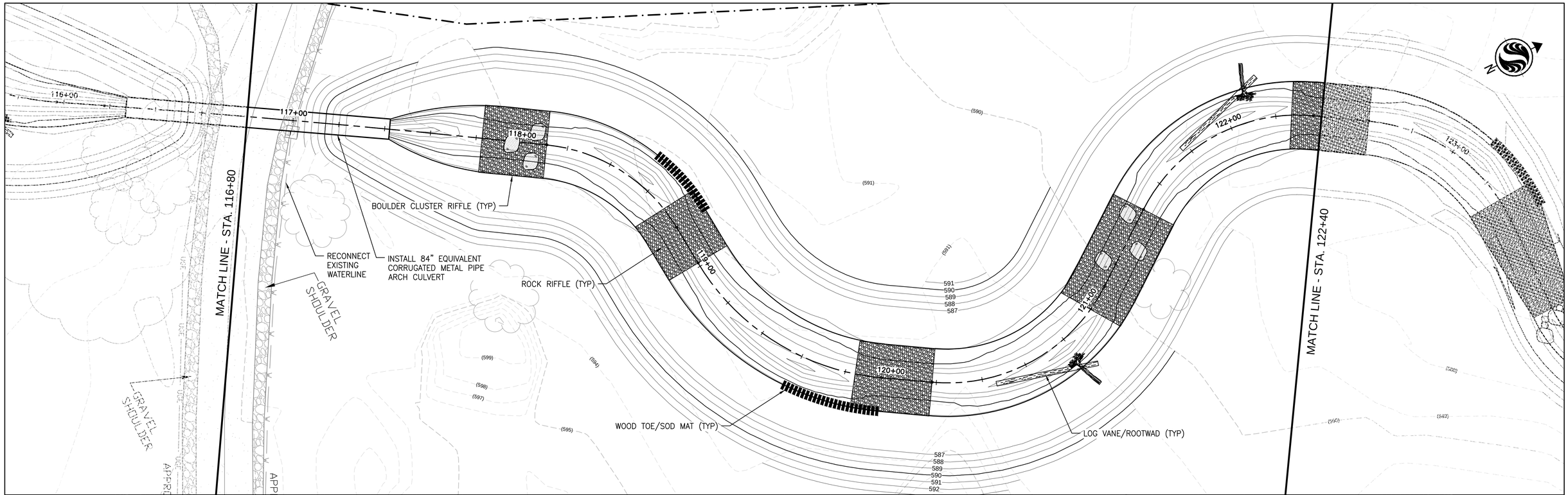

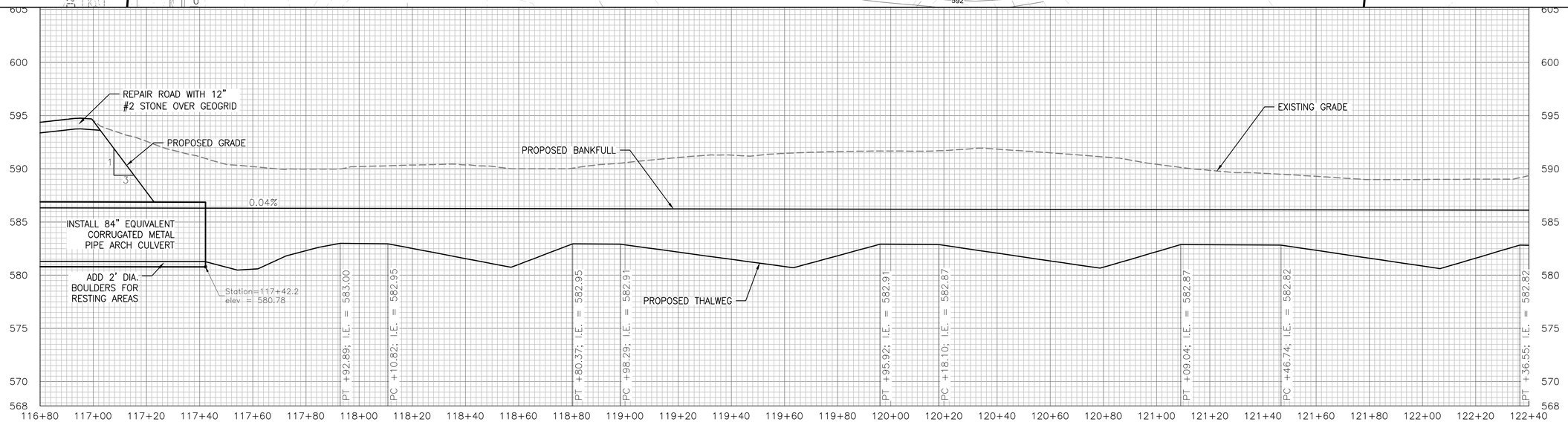

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HATCHERY CREEK DESIGN/BUILD PROJECT
RUSSELL COUNTY, KENTUCKY

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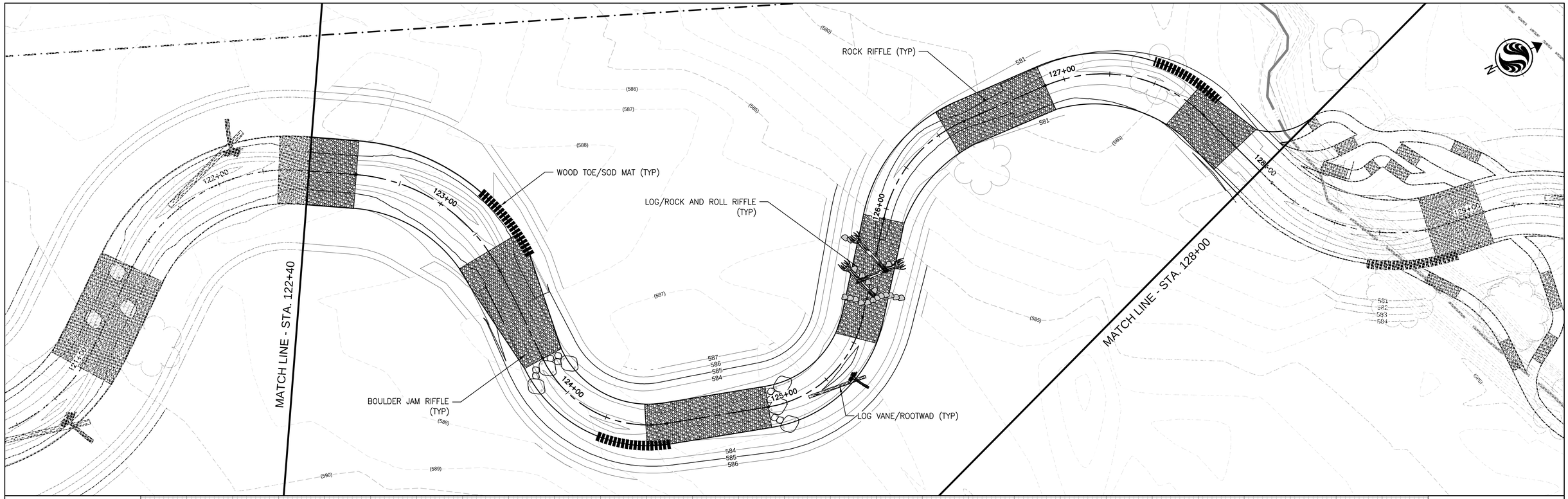

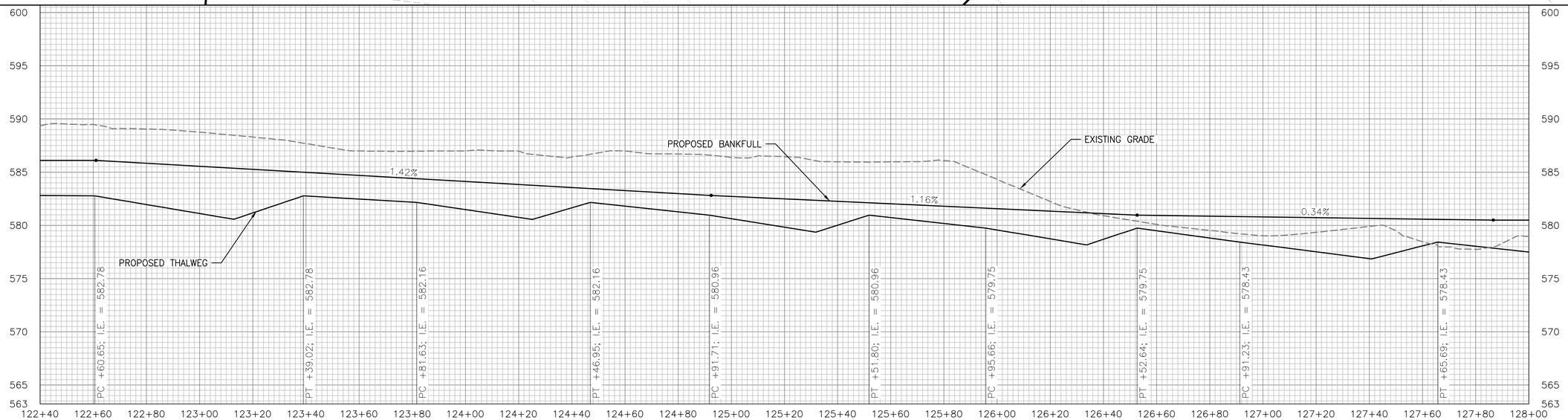

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HATCHERY CREEK DESIGN/BUILD PROJECT
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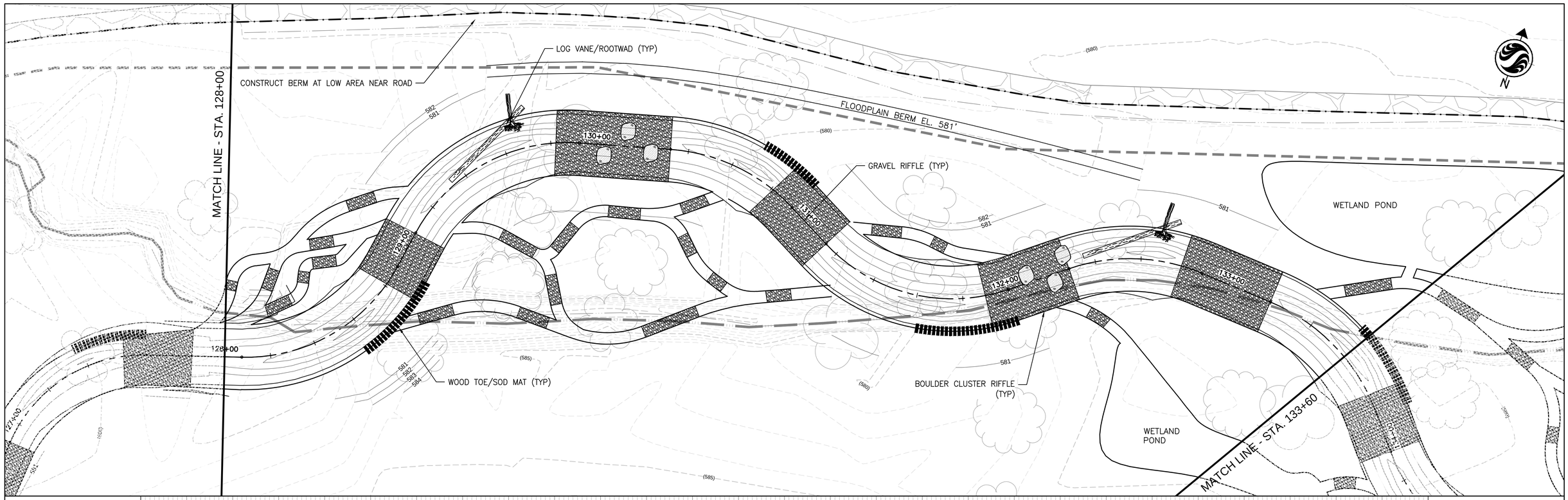

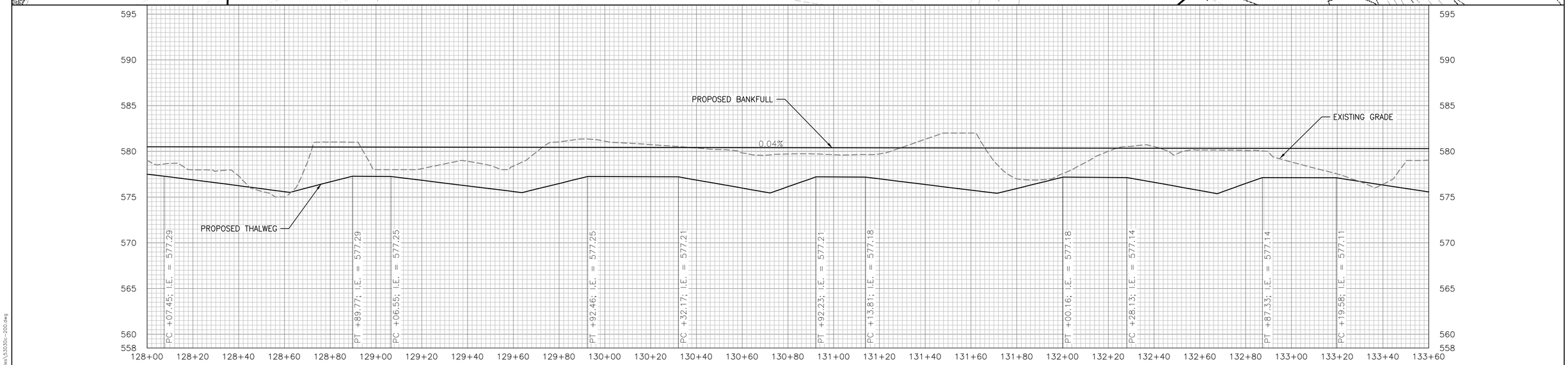

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HATCHERY CREEK DESIGN/BUILD PROJECT
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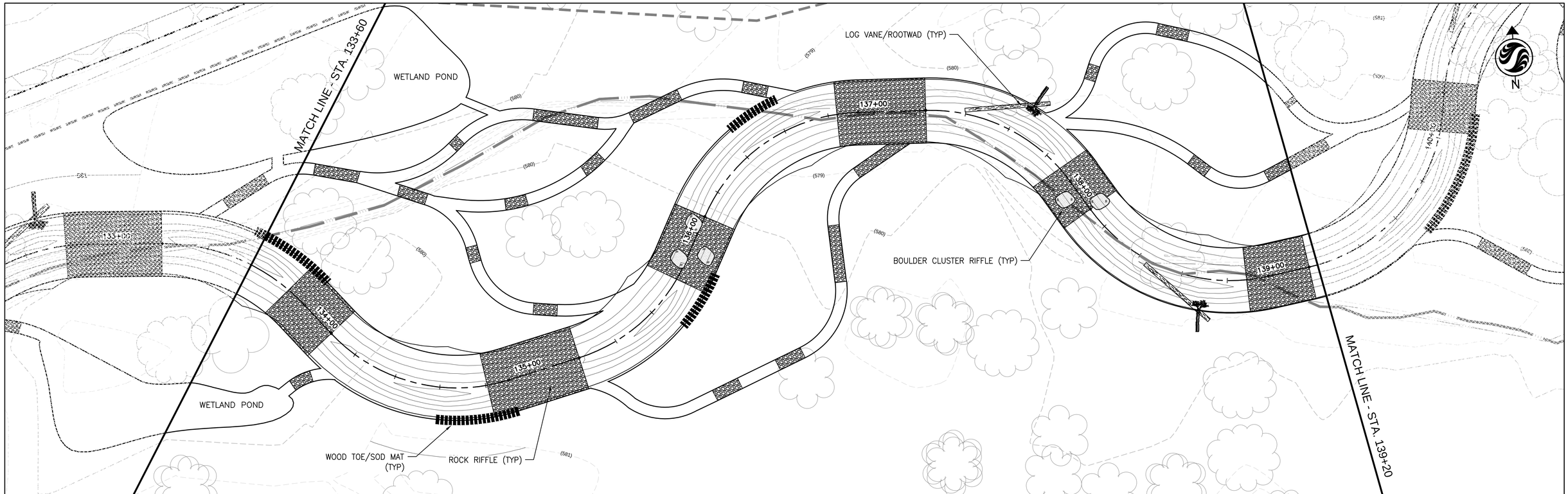

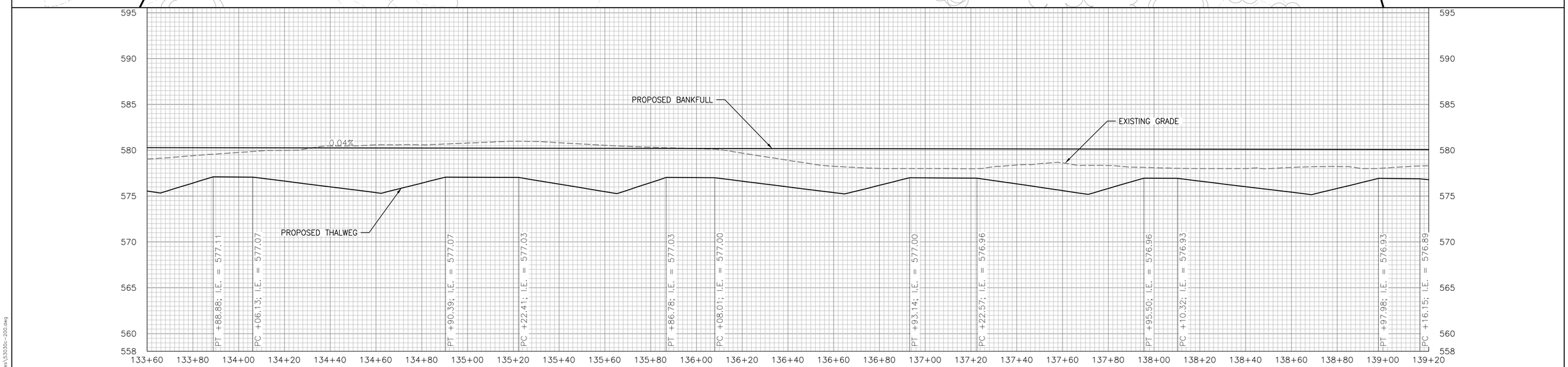

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HATCHERY CREEK DESIGN/BUILD PROJECT
RUSSELL COUNTY, KENTUCKY

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PLAN & PROFILE

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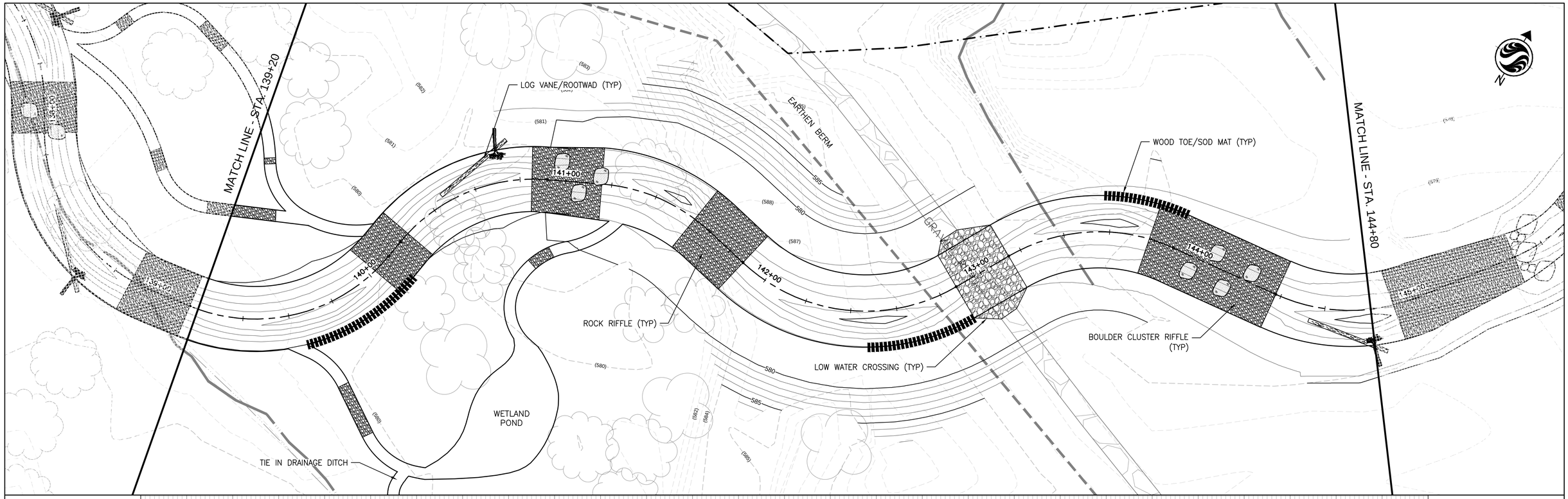

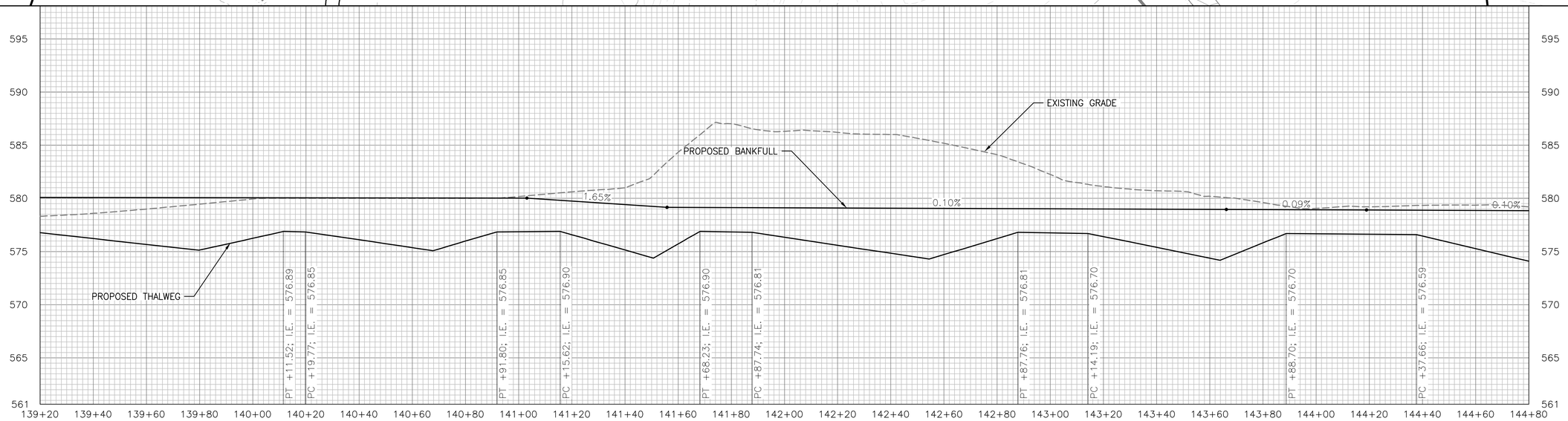

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HATCHERY CREEK DESIGN/BUILD PROJECT
RUSSELL COUNTY, KENTUCKY

AS BUILT DATE

PLAN & PROFILE

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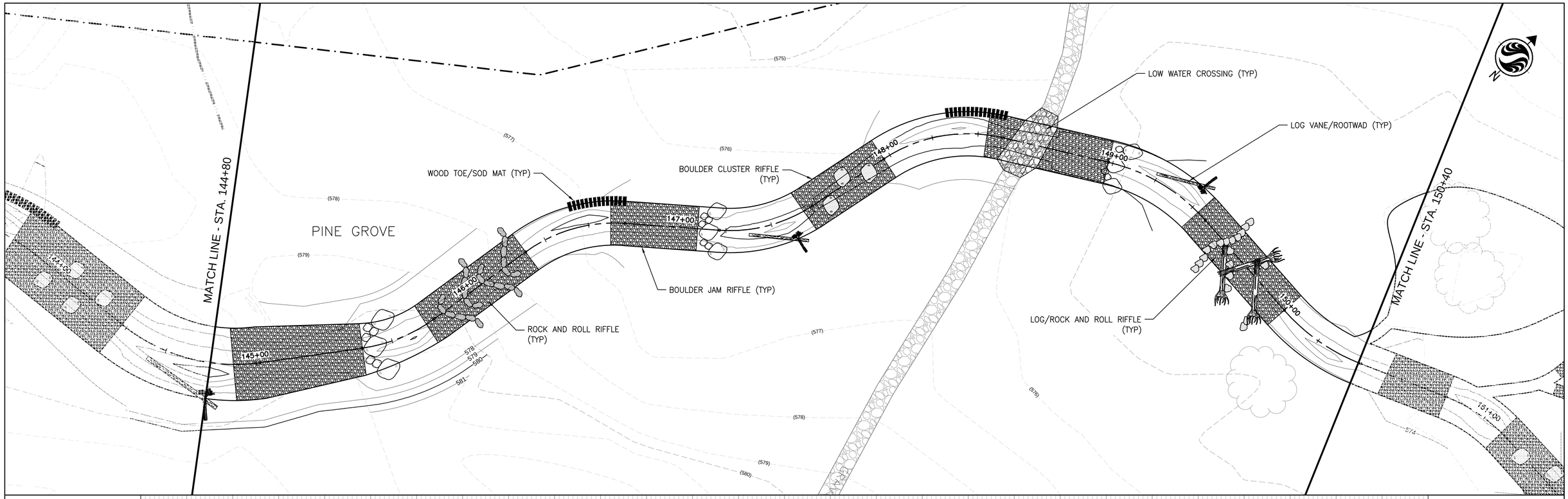

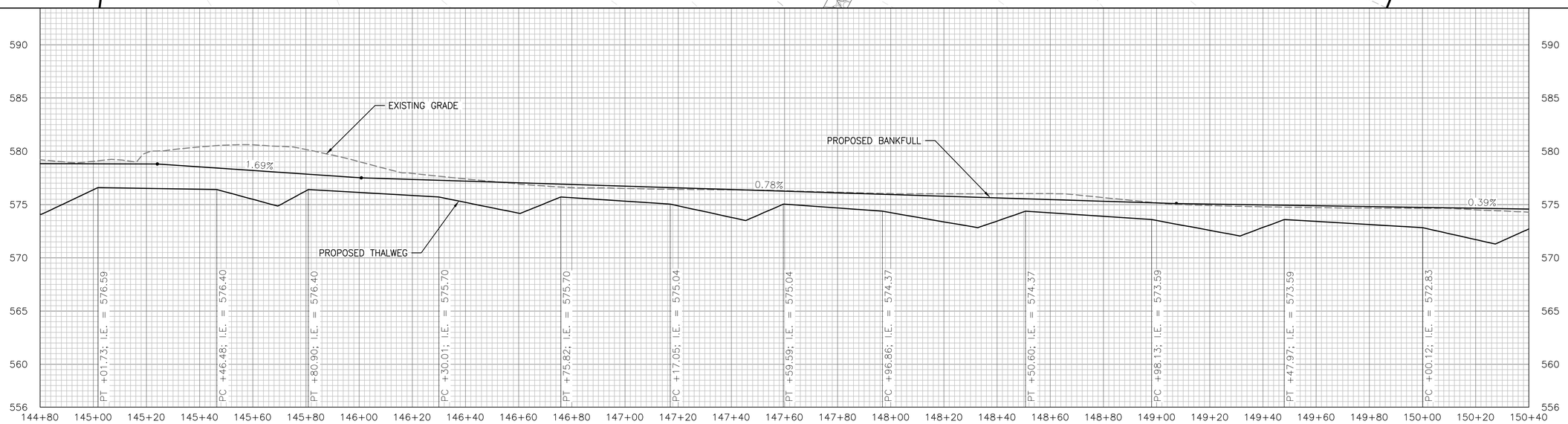

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HATCHERY CREEK DESIGN/BUILD PROJECT
RUSSELL COUNTY, KENTUCKY

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PLAN & PROFILE

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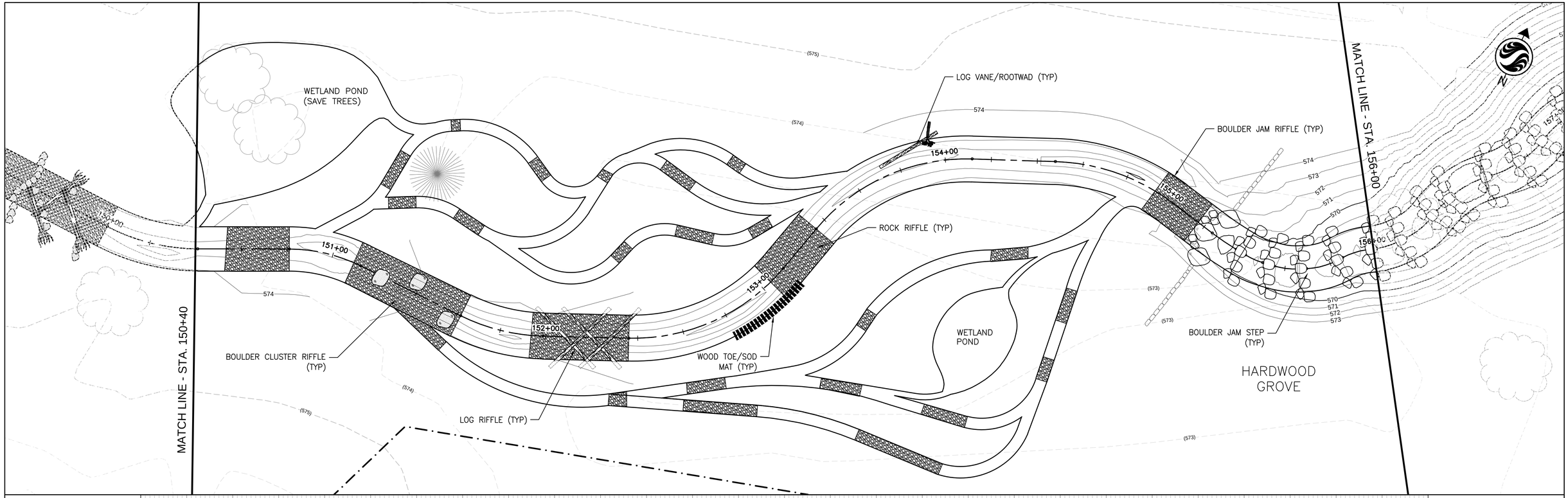

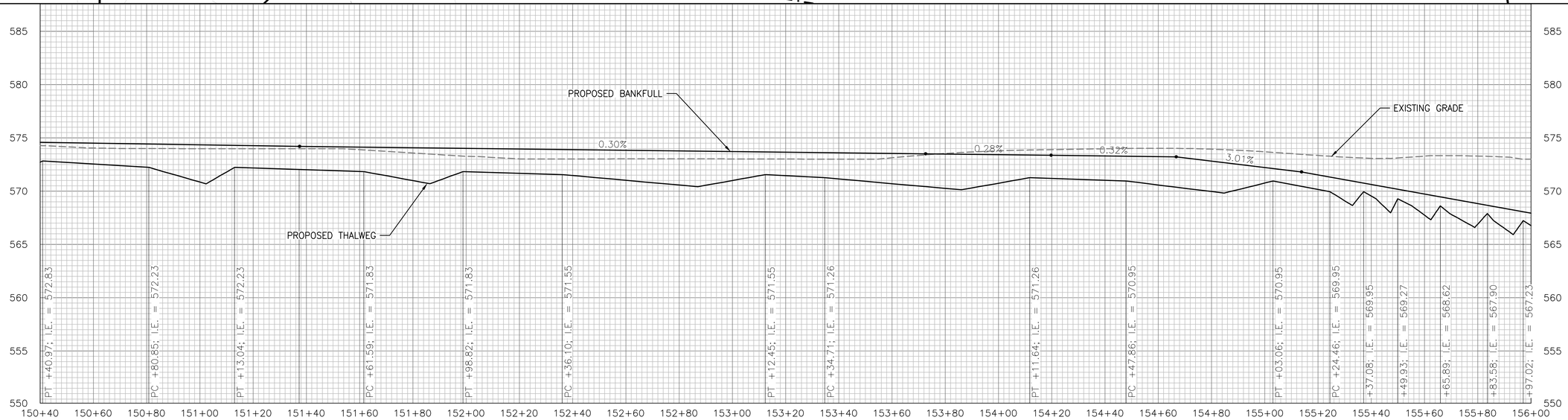

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HATCHERY CREEK DESIGN/BUILD PROJECT
RUSSELL COUNTY, KENTUCKY

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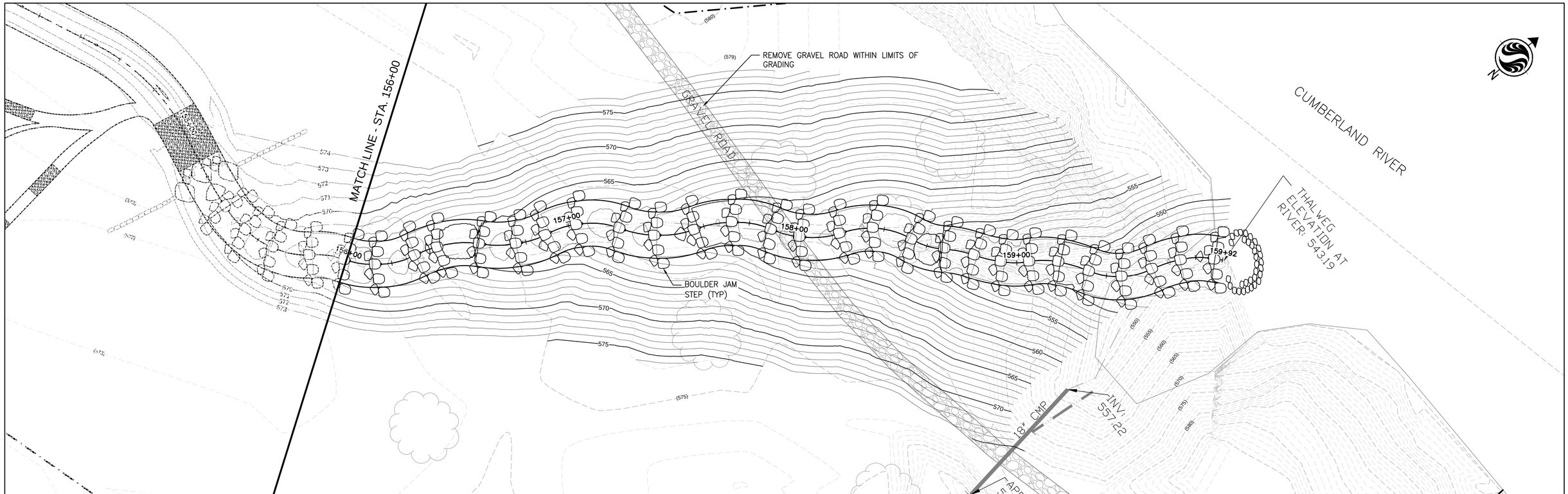

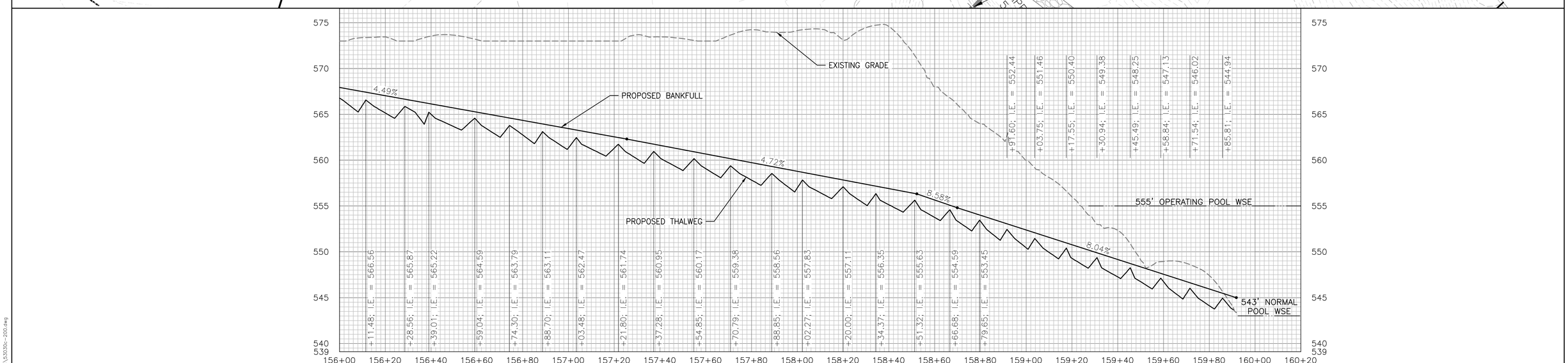

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HATCHERY CREEK DESIGN/BUILD PROJECT
RUSSELL COUNTY, KENTUCKY

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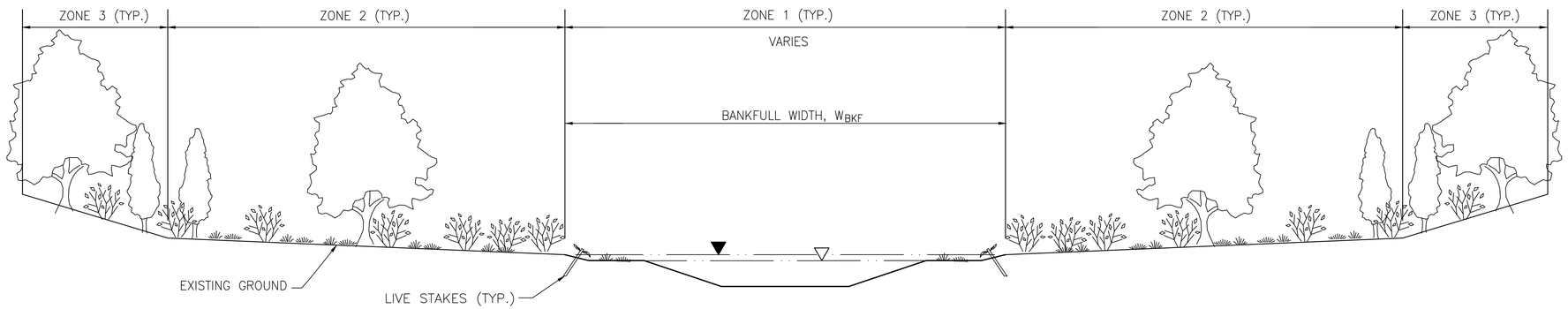
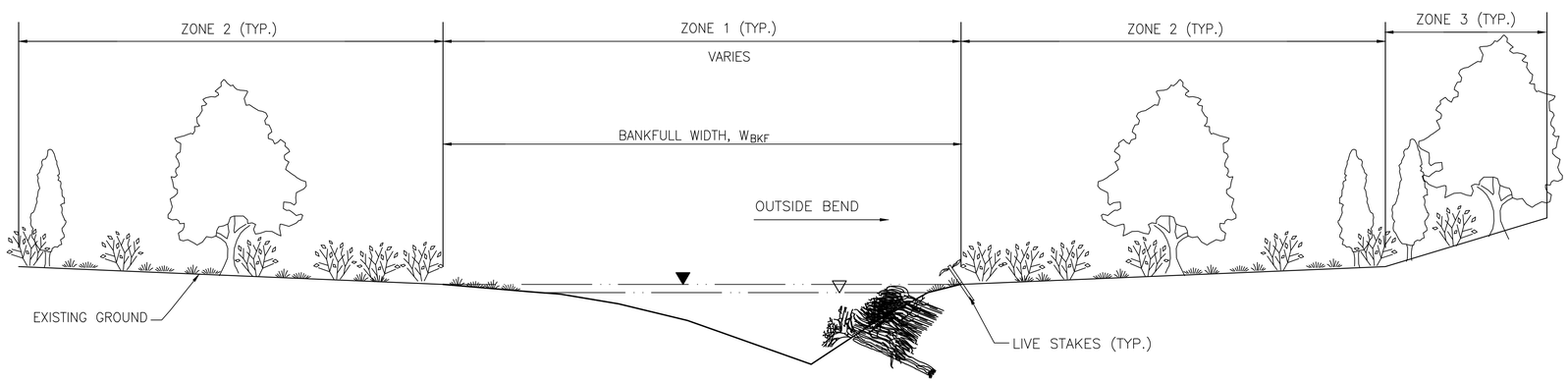


RIFFLE



POOL

REACH	RIFFLE						POOL			
	ABKF (ft2)	WBKF (ft)	WIB (ft)	DMAX (ft)	DMEAN (ft)	W/D	ABKF (ft2)	WBKF (ft)	DMAX (ft)	DMEAN (ft)
1	21.3	23.1	12.0	1.66	0.92	25	42.9	27.7	3.7	1.55
2	56.1	37.4	19.6	2.70	1.50	25	110.4	44.9	6.0	2.46
3	31.9	28.2	16.4	2.03	1.13	25	54.6	33.9	4.0	1.61
4	54.2	29.4	17.4	3.31	1.84	16	86.9	35.3	5.5	2.46

NOTE: THESE ARE TYPICAL DIMENSIONS. CONTRACTOR SHOULD REVIEW PROPOSED CONTOURS AND PROPOSED CROSS SECTIONS FOR ACTUAL DIMENSIONS.

▼ BANKFULL WATER SURFACE

▽ APPROXIMATE LOW FLOW WATER SURFACE

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HATCHERY CREEK DESIGN/BUILD PROJECT
RUSSELL COUNTY, KENTUCKY

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TYPICAL SECTIONS – C STREAM TYPE

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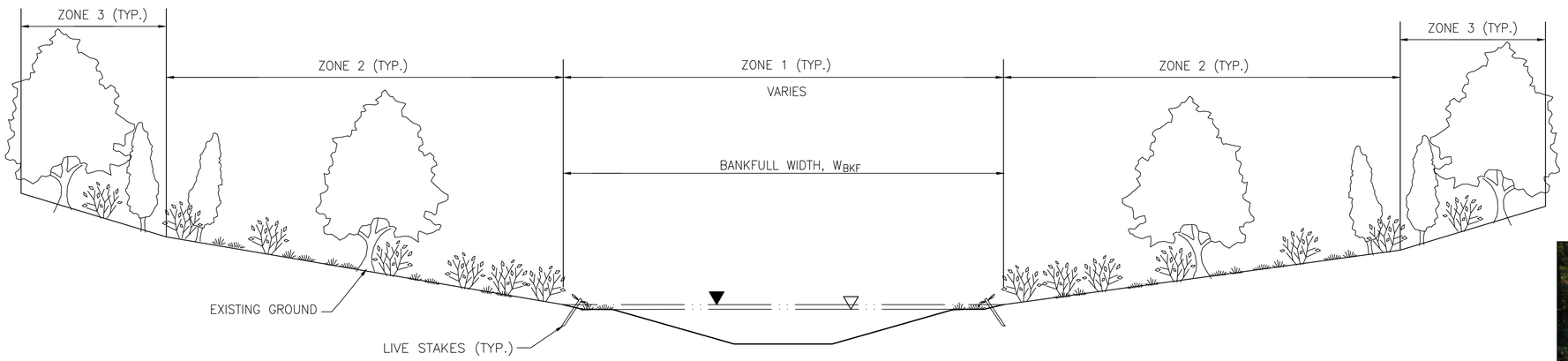

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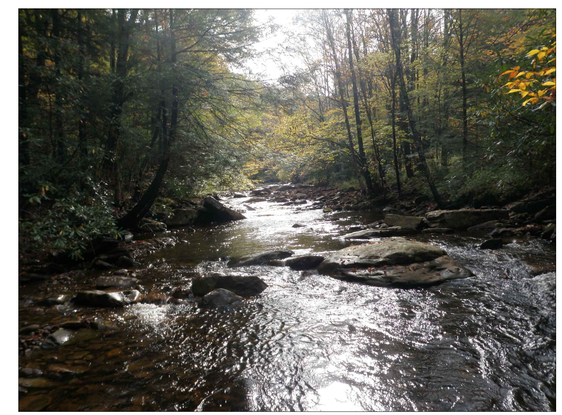

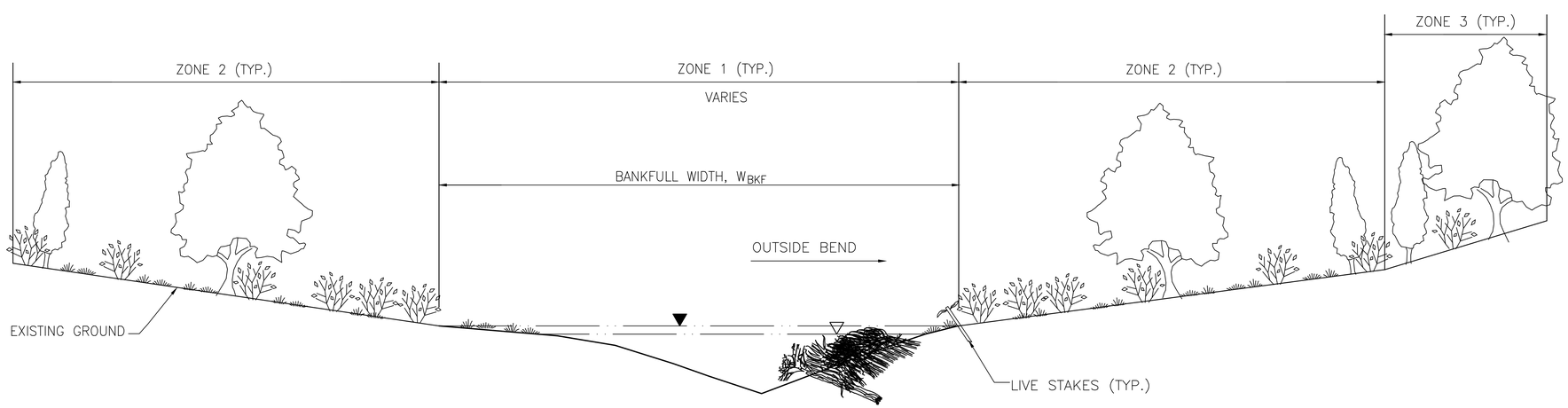

POOL

REACH	RIFFLE						POOL			
	ABKF (ft2)	WBKF (ft)	WIB (ft)	DMAX (ft)	DMEAN (ft)	W/D	ABKF (ft2)	WBKF (ft)	DMAX (ft)	DMEAN (ft)
5	13.1	18.1	10.6	1.30	0.72	25	23.7	21.7	2.9	1.09

NOTE: THESE ARE TYPICAL DIMENSIONS. CONTRACTOR SHOULD REVIEW PROPOSED CONTOURS AND PROPOSED CROSS SECTIONS FOR ACTUAL DIMENSIONS.

▼ BANKFULL WATER SURFACE

▽ APPROXIMATE LOW FLOW WATER SURFACE

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HATCHERY CREEK DESIGN/BUILD PROJECT
RUSSELL COUNTY, KENTUCKY

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TYPICAL SECTIONS – B STREAM TYPE

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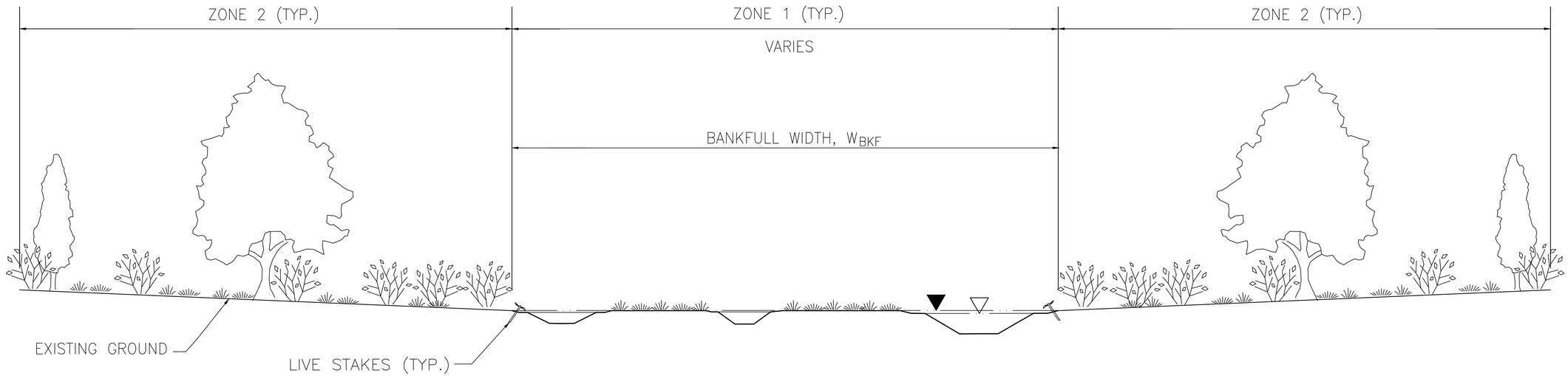

RIFFLE

REACH	RIFFLE				
	ABKF (ft2)	WBKF (ft)	DMAX (ft)	DMEAN (ft)	W/D
DA	48.9	51.6	2.20	0.95	54

NOTE: THESE ARE TYPICAL DIMENSIONS. CONTRACTOR SHOULD REVIEW PROPOSED CONTOURS AND PROPOSED CROSS SECTIONS FOR ACTUAL DIMENSIONS.

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HATCHERY CREEK DESIGN/BUILD PROJECT
RUSSELL COUNTY, KENTUCKY

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TYPICAL SECTIONS – D STREAM TYPE

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Shrubs and Trees					
Zone 1: Littoral Shelf - Live Stakes					
Scientific Name	**Common Name**	**FAC Status**	**Approximate Spacing**	**Composition**	**Stems per Acre**
Alnus serrulata	Smooth Alder	OBL	6 x 6	25%	302
Cephalanthus occidentalis	Buttonbush	OBL	6 x 6	25%	303
Cornus amomum	Silky Dogwood	FACW	6 x 6	25%	302
Itea virginica	Virginia Willow	OBL	6 x 6	25%	303
				100%	**1210**
Wetlands:					
Scientific Name	**Common Name**	**FAC Status**	**Approximate Spacing**	**Composition**	**Stems per Acre**
Cephalanthus occidentalis	Buttonbush	OBL	9 x 9	20%	109
Cornus amomum	Silky Dogwood	FACW	9 x 9	15%	80
Hibiscus moscheutos	Swamp Mallow	OBL	9 x 9	15%	80
Itea virginica	Virginia Willow	OBL	9 x 9	20%	109
Sambucus nigra ssp. canadensis	Common Elderberry	FACU	9 x 9	15%	80
Spiraea tomentosa	Steeplebush	FACW	9 x 9	15%	80
				100%	**538**
Zone 2: Bankfull Bench and Floodplain					
Scientific Name	**Common Name**	**FAC Status**	**Approximate Spacing**	**Composition**	**Stems per Acre**
Carpinus caroliniana	Ironwood	FAC	9 x 9	10%	54
Cephalanthus occidentalis	Buttonbush	OBL	9 x 9	7%	37
Cornus amomum	Silky Dogwood	FACW	9 x 9	10%	54
Frangula caroliniana	Carolina Buckthorn	FAC	9 x 9	10%	54
Itea virginica	Virginia Willow	OBL	9 x 9	7%	37
Sambucus nigra ssp. canadensis	Common Elderberry	FACU	9 x 9	10%	54
Spiraea tomentosa	Steeplebush	FACW	9 x 9	10%	54
Acer rubrum	Red Maple	FAC	9 x 9	5%	27
Acer saccharinum	Silver Maple	FACW	9 x 9	5%	27
Betula nigra	River Birch	FACW	9 x 9	8%	43
Liquidambar styraciflua	Sweetgum	FAC	9 x 9	5%	27
Liriodendron tulipifera	Tulip Poplar	FACU	9 x 9	5%	27
Nyssa sylvatica	Black Gum	FAC	9 x 9	8%	43
				100%	**538**
Zone 3: Uplands					
Scientific Name	**Common Name**	**FAC Status**	**Approximate Spacing**	**Composition**	**Stems per Acre**
Cornus racemosa	Grey Dogwood	FAC	9 x 9	10%	54
Corylus americana	Hazelnut	FACU	9 x 9	10%	54
Frangula caroliniana	Carolina Buckthorn	FAC	9 x 9	10%	54
Ostrya virginica	Hop Hornbeam	FACU	9 x 9	10%	54
Aesculus flava	Yellow Buckeye	FACU	9 x 9	5%	27
Acer saccharum	Sugar Maple	FACU	9 x 9	5%	27
Carya glabra	Pignut Hickory	FACU	9 x 9	6%	32
Diospyros virginiana	Persimmon	FAC	9 x 9	5%	27
Liriodendron tulipifera	Tulip Poplar	FACU	9 x 9	5%	27
Quercus alba	White Oak	FACU	9 x 9	6%	32
Quercus muhlenbergii	Chinquapin Oak	UPL	9 x 9	6%	32
Quercus rubra	Northern Red Oak	FACU	9 x 9	6%	32
Tilia americana	American Basswood	FACU	9 x 9	5%	27
Tsuga canadensis	Eastern Hemlock	FACU	9 x 9	6%	32
Ulmus rubra	Slippery Elm	FAC	9 x 9	5%	27
				100%	**538**

Herbaceous Seed Mix				
Zone 1: Wetlands and Littoral Shelf				
Scientific Name	**Common Name**	**FAC Status**	**Composition**	**For 20lbs per Acre**
Elymus riparius	Riverbank Wild Rye	FACW	15%	10.36
Carex frankii	Frank's Sedge	OBL	15%	1.71
Carex lurida	Shallow Sedge	OBL	15%	5.07
Carex vulpinoidea	Fox Sedge	OBL	15%	1.55
Juncus effusus	Common Rush	FACW	15%	0.41
Scirpus polyphyllus	Leafy Bulrush	OBL	15%	0.41
Verbena hastata	Blue Vervain	FACW	10%	0.46
			100%	**20.00**
Zone 2: Bankfull Bench and Floodplain				
Scientific Name	**Common Name**	**FAC Status**	**Composition**	**For 20lbs per Acre**
Chasmanthium latifolium	Wild Oats	FACU	10%	4.58
Dichanthelium clandestinum	Deertongue Grass	FAC	10%	0.15
Elymus riparius	Riverbank Wild Rye	FACW	10%	3.43
Elymus virginicus	Virginia Wild Rye	FACW	10%	5.15
Panicum virgatum	Switchgrass	FAC	10%	1.48
Tripsacum dactyloides	Eastern Gama Grass	FACW	10%	2.75
Carex frankii	Frank's Sedge	OBL	10%	0.57
Carex vulpinoidea	Fox Sedge	OBL	10%	0.52
Juncus effusus	Common Rush	FACW	10%	0.14
Bidens frondosa	Beggars Ticks	FACW	5%	1.06
Verbena hastata	Blue Vervain	FACW	5%	0.17
			100%	**20.00**
Zone 3: Uplands				
Scientific Name	**Common Name**	**FAC Status**	**Composition**	**For 20lbs per Acre**
Chasmanthium latifolium	Wild Oats	FACU	14%	5.80
Andropogon gerardii	Big Bluestem	FAC	14%	3.18
Dichanthelium clandestinum	Deertongue Grass	FAC	14%	0.20
Elymus canadensis	Canada Wild Rye	FACU	14%	4.54
Panicum virgatum	Switchgrass	FAC	14%	1.88
Coreopsis tripteris	Tall Coreopsis	FAC	15%	3.29
Rudbeckia triloba	Brown Eyed Susan	FACU	15%	1.12
			100%	**20.00**

NOTES:
1. ALL TREES AND SHRUBS ARE BARE ROOTS
2. SOME SPECIES MAY BE SUBSTITUTED BASED ON AVAILABILITY

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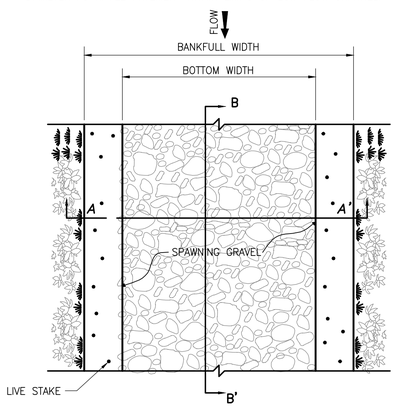
NOTES:

1. SPAWNING GRAVEL DEPTH SHALL AVERAGE 6 INCHES.
2. IF NECESSARY EXCAVATE FOR RIFFLE PLACEMENT AND EXTEND RIFFLE ARMOR OUT TO BANKFULL WIDTH. FEATHER BANK MATERIAL BACK ONTO EDGE OF RIFFLE MATERIAL, DOWN TO HALF BANKFULL.
3. LOW POINT (THALWEG) SHALL BE IN THE CENTER OF CHANNEL.
4. CONSTRUCT GROUNDWATER PLUG 2 FT THICK AT HEAD OF RIFFLE. BURY TO A DEPTH OF 2 FT BELOW RIFFLE.
5. RIFFLE SUBPAVEMENT SHALL CONSIST OF CLASS II CHANNEL LINING. CONSTRUCT RIFFLE SUBPAVEMENT BY PUSHING ROCK WITH EXCAVATOR INTO BED OF THE CHANNEL.
6. BEYOND THE LOW FLOW CHANNEL, RIFFLE SUBPAVEMENT SHALL BE BURIED A MINIMUM OF 1 FOOT BELOW FINISH GRADE.
7. LOOSELY PLACE SPAWNING GRAVEL CONSISTING OF ROUNDED ROCK 1/8 INCH TO 2 1/2 INCHES IN DIAMETER AS RIFFLE PAVEMENT WITHIN LIMITS OF LOW FLOW CHANNEL.



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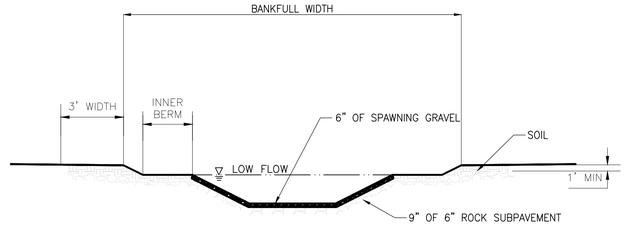
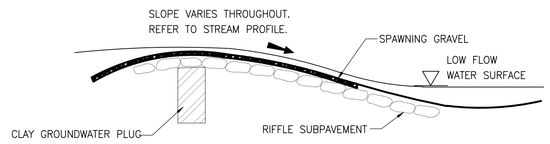


CROSS-SECTION A-A'



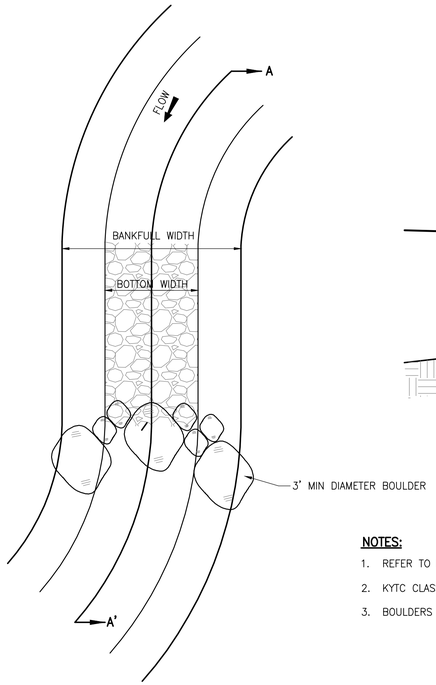
PROFILE B-B'

1/18 DETAIL – ROCK RIFFLE
NOT TO SCALE

SPAWNING GRAVEL

SPAWNING GRAVEL UNDER WATER

DRAFT
NOT FOR CONSTRUCTION



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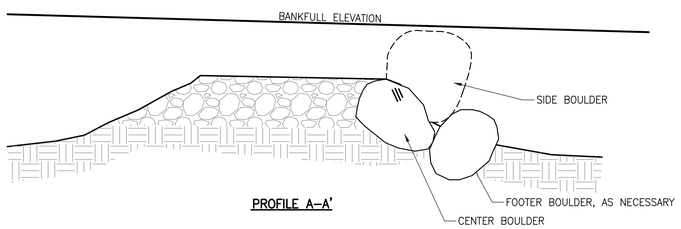
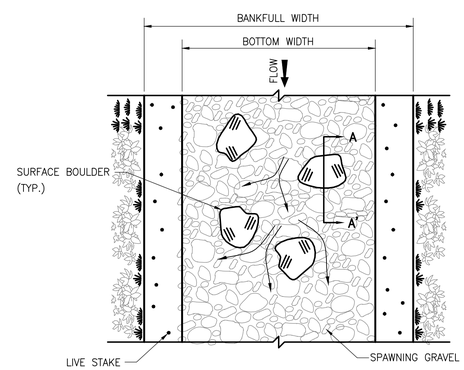


PROFILE A-A'

NOTES:

1. REFER TO ROCK RIFFLE DETAIL (SHEET 18) FOR RIFFLE CONSTRUCTION.
2. KYTC CLASS II CHANNEL LINING SHALL BE USED FOR PAVEMENT AND SUBPAVEMENT.
3. BOULDERS SHALL BE 3 FT IN DIAMETER.

2/18 DETAIL – BOULDER JAM RIFFLE
NOT TO SCALE



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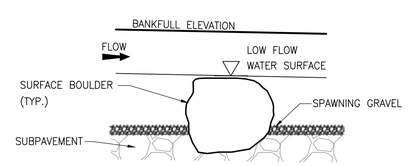
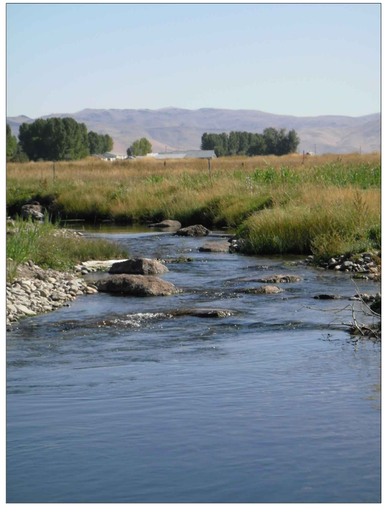


PROFILE A-A'

NOTES:

1. REFER TO ROCK RIFFLE DETAIL (SHEET 18) FOR RIFFLE CONSTRUCTION.
2. BOULDERS SHALL BE 4' DIAMETER.

3/18 DETAIL – BOULDER CLUSTER RIFFLE
NOT TO SCALE



DECEMBER 2013 - 75%

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HATCHERY CREEK DESIGN/BUILD PROJECT
RUSSELL COUNTY, KENTUCKY

AS BUILT DATE	TYPICAL DETAILS	DRAWING NO. 18
DRAWN BY MS	COMMONWEALTH OF KENTUCKY FINANCE AND ADMINISTRATION CABINET DEPARTMENT FOR FACILITIES MANAGEMENT DIVISION OF ENGINEERING FRANKFORT, KENTUCKY	SCALE AS SHOWN
CHECKED BY WL/GA		REVIEWED DIV. OF ENGR.
A & E FILE NO. 1756530.30	ECOGRO/RIDGEWATER P.O. BOX 22272 Lexington, Kentucky 40522 859-231-0600 www.ecogro.net Stantec Consulting Services Inc. 10509 Timberwood Circle, Suite 100 Louisville, Kentucky 40223-5301 502-212-5000 www.stantec.com	For Intent Only
DATE DEC 2013		ACCOUNT NO. ----

AGENCY AUTHORIZED AGENT _____ DATE _____
Approved for Program Concept Only

DIVISION OF ENGINEERING _____ DATE _____
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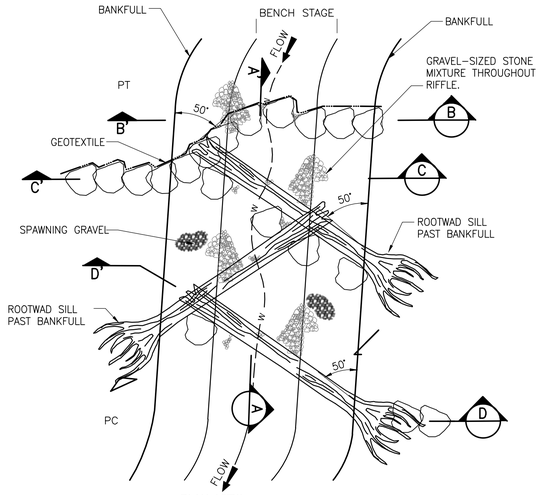
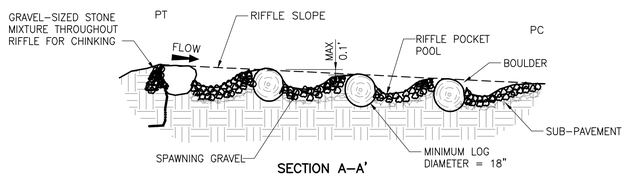


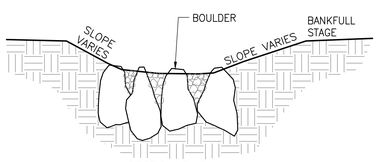
PLAN VIEW

NOTES:

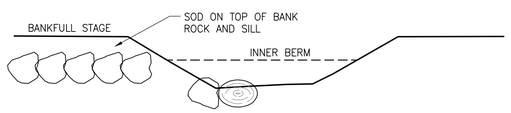
1. GRAVEL SIZED ROCK SHALL BE USED IN THE RIFFLES TO CHINK GAPS IN THE MINI-VANES MADE WITH ANCHOR BOULDERS. CONTRACTOR MAY SUBSTITUTE CLASS II CHANNEL LINING (APPROXIMATELY 5-9 INCHES) FOR CHINKING ROCK AS PER ENGINEER'S APPROVAL.
2. THE MOST UPSTREAM MINI-VANE SHALL HAVE A SILL ON THE SAME SIDE AS THE OUTSIDE BEND AND SHALL HAVE FOOTER BOULDERS. IF BEDROCK IS PRESENT DIRECTLY BELOW THE SURFACE BOULDER, THE FOOTING BOULDER MAY BE OMITTED AT THE DISCRETION OF STANTEC. THE MOST DOWNSTREAM MINI-VANE SHALL HAVE A SILL ON THE SAME SIDE AS THE DOWNSTREAM OUTSIDE BEND.
3. NO COIR BLANKET SHALL BE INSTALLED IN THE LOW-FLOW CHANNEL. COIR BLANKET SHALL BE INSTALLED ABOVE THE INNER-BERM STAGE. SEE TYPICAL CROSS-SECTION DATA FOR INNER BERM INFORMATION.
4. THE MAXIMUM AMOUNT OF DROP FROM ONE MINI-VANE TO THE NEXT SHALL BE NO GREATER THAN 0.1 FT. THE COMBINED AMOUNT OF DROP OVER ALL THE MINI-VANES IN THE SAME RIFFLE SHALL NOT EXCEED THE TOTAL AMOUNT OF FALL IN THE RIFFLE SLOPE.
5. LOW POINT SHALL ALTERNATE LEFT AND RIGHT OF CENTERLINE BY 6".
6. MINI-VANES SHALL BE EQUALLY SPACED ALONG RIFFLE THALWEG.
7. CONTRACTOR MAY INSTALL BOULDERS IN PLACE OF LOGS AS PER ENGINEER'S APPROVAL.
8. SUB-PAVEMENT CONSISTING OF KYTC CLASS II CHANNEL LINING SHALL BE PLACED 2 FEET BELOW SURFACE OF RIFFLE AND SHALL BE OVERLAIN WITH 6 INCHES OF SPAWNING GRAVEL. REFER TO THE ROCK RIFFLE DETAIL (SHEET 18) FOR SPAWNING GRAVEL PLACEMENT.



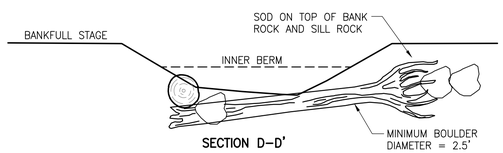
SECTION A-A'



SECTION B-B'

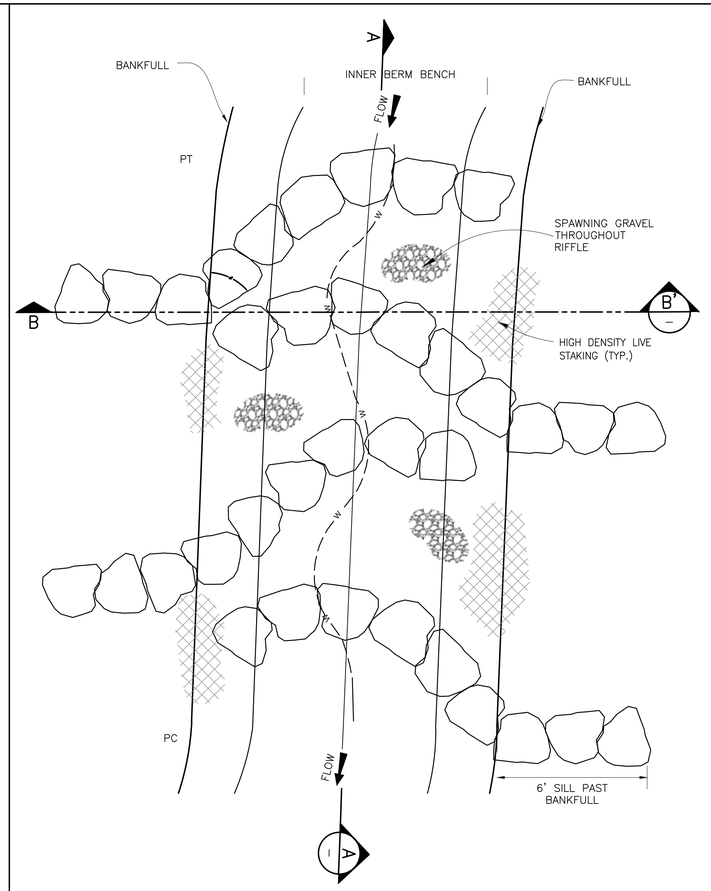


SECTION C-C'

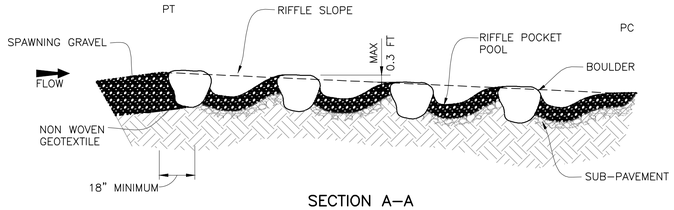


SECTION D-D'

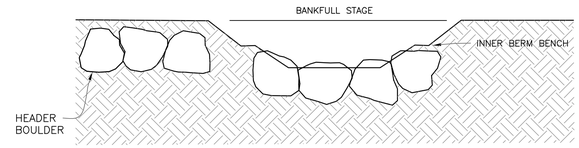
1/19 DETAIL – LOG/ROCK AND ROLL RIFFLE
NOT TO SCALE



PLAN VIEW



SECTION A-A



SECTION B-B

NOTES:

1. THE MAXIMUM AMOUNT OF DROP FROM ONE MINI-VANE TO THE NEXT SHALL BE NO GREATER THAN 0.3 FT. THE COMBINED AMOUNT OF DROP OVER ALL THE MINI-VANES SHALL NOT EXCEED THE TOTAL AMOUNT OF FALL IN THE RIFFLE SLOPE.
2. MINI-VANES SHALL BE EQUALLY SPACED IN THE RIFFLE AS A FUNCTION OF THE RIFFLE LENGTH.
3. A HYDRAULIC EXCAVATOR WITH A BUCKET THAT CONTAINS A HYDRAULIC THUMB SHALL BE USED TO PLACE BOULDERS AND LOGS.
4. THE BOULDERS SHALL SLOPE FROM THE BED ELEVATION, AT THE HEAD OF THE VANE, TO 1/2 TO 3/4 BANKFULL ELEVATION AT A SLOPE OF 3%-5%. HEADER AND FOOTER BOULDERS SHALL BE TIED SECURELY INTO THE BANK IN SUCH A WAY THAT IT ELIMINATES THE POSSIBILITY OF STREAMFLOW DIVERTING AROUND THEM.
5. ANY SOIL DISTURBED DURING THE PLACEMENT OF RIFFLE, SHALL BE SEEDED USING TEMPORARY AND PERMANENT SEEDING METHODS.
6. THE THALWEG OR LOW POINT SHALL ALTERNATE LEFT AND RIGHT OF ℄ BY 1.5 FT.
7. THE GAP BETWEEN THE HEADER AND FOOTER BOULDERS SHALL BE CHINKED BY HAND WITH GRAVEL AND COBBLE FROM THE UPSTREAM DIRECTION.
8. THE HORIZONTAL ANGLE OF THE HEADER BOULDERS OF THE MINI-VANE AND THE BANK SHALL BE BETWEEN 40-50 DEGREES.
9. THE ELEVATION OF THE STRUCTURES CAN BE INTERPOLATED FROM THE DESIGN PROFILE AT THE LOCATION AND STATIONING OF EACH INDIVIDUAL STRUCTURE
10. SUB-PAVEMENT CONSISTING OF KYTC CLASS II CHANNEL LINING SHALL BE PLACED 2 FEET BELOW SURFACE OF RIFFLE AND SHALL BE OVERLAIN WITH 6 INCHES OF SPAWNING GRAVEL. REFER TO THE ROCK RIFFLE DETAIL (SHEET 18) FOR SPAWNING GRAVEL PLACEMENT.

2/19 DETAIL – ROCK AND ROLL RIFFLE
NOT TO SCALE

DRAFT
NOT FOR CONSTRUCTION

DECEMBER 2013 - 75%

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HATCHERY CREEK DESIGN/BUILD PROJECT
RUSSELL COUNTY, KENTUCKY

AS BUILT DATE	TYPICAL DETAILS	DRAWING NO. 19
DRAWN BY MS	COMMONWEALTH OF KENTUCKY	SCALE AS SHOWN
CHECKED BY WL/GA	FINANCE AND ADMINISTRATION CABINET DEPARTMENT FOR FACILITIES MANAGEMENT DIVISION OF ENGINEERING FRANKFORT, KENTUCKY	REVIEWED DIV. OF ENGR.
A & E FILE NO. 175653030	ECOGRO/RIDGEWATER P.O. BOX 22273 Lexington, Kentucky 40522 859-231-0600 www.ecogro.net / Stantec Consulting Services Inc. 10909 Timberwood Circle, Suite 100 Louisville, Kentucky 40223-5301 502-212-5000 www.stantec.com	For Intent Only
DATE DEC 2013		ACCOUNT NO. ----

AGENCY AUTHORIZED AGENT _____ DATE _____
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DIVISION OF ENGINEERING _____ DATE _____
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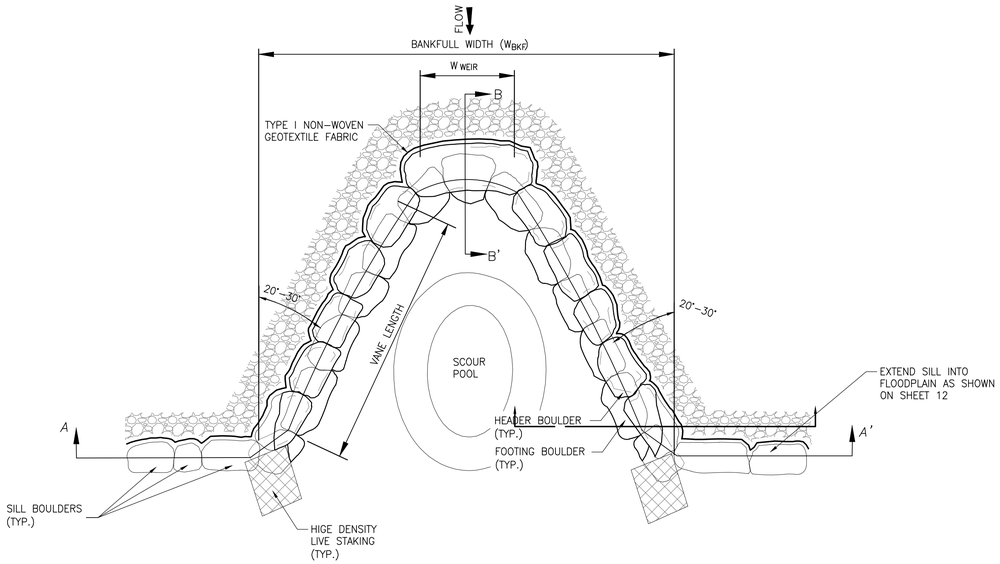
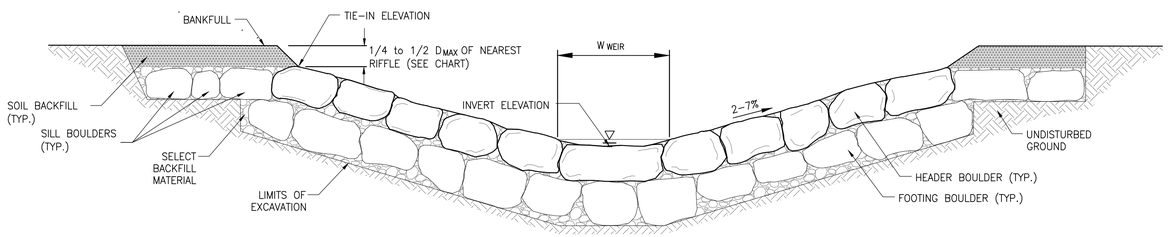
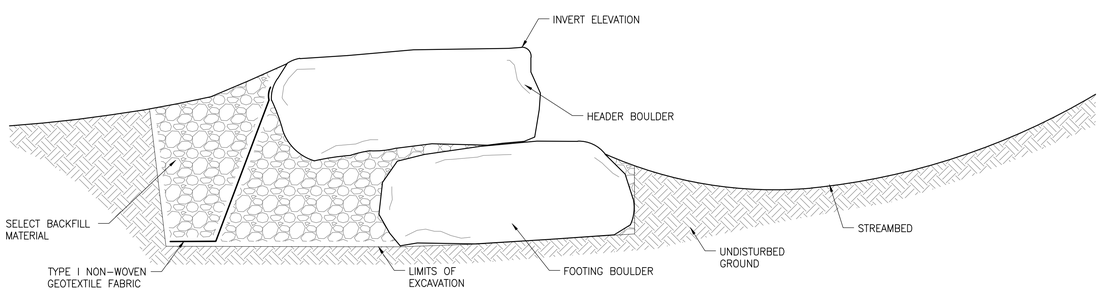


PLANVIEW – CROSS VANE (WITHOUT STEP)



SECTION A–A'



SECTION B–B'

NOTES:

1. BOULDERS SHALL BE OF LIMESTONE OR DOLOMITE WITH A MINIMUM DIAMETER OF 3 FEET.
2. FOOTING BOULDERS ARE BOULDERS PLACED TO PROVIDE A FOUNDATION AND SCOUR PROTECTION FOR THE HEADER BOULDERS.
3. HEADER BOULDERS SHALL BE UNDERLAIN BY FOOTING BOULDERS UNLESS OTHERWISE DIRECTED BY THE ENGINEER.
4. HEADER BOULDERS ARE THE TOP MOST ROCKS USED IN EACH BOULDER STRUCTURE. ALL HEADER BOULDERS CAN BE SEEN PROTRUDING FROM THE WATER SURFACE DURING EXTREMELY LOW FLOWS.
5. HEADER BOULDERS SHALL BE OFFSET SLIGHTLY UPSTREAM OF FOOTING BOULDERS SUCH THAT A MINIMUM 6 INCHES OF THE FOOTING BOULDERS IS VISIBLE ON THE DOWNSTREAM SIDE OF THE HEADER BOULDERS.
6. HEADER AND FOOTING BOULDERS SHALL BE ANGLED SLIGHTLY DOWNWARD IN THE UPSTREAM DIRECTION AS PER SECTION B–B'.
7. SILL BOULDERS SHALL BE PLACED PERPENDICULAR TO THE BANKFULL FLOW DIRECTION.
8. SET INVERT AT ELEVATION SHOWN IN REACH PROFILE.
9. ALL GAPS/VOIDS LARGER THAN 2 INCHES BETWEEN THE HEADER AND FOOTING BOULDERS SHALL BE CHINKED WITH SELECT BACKFILL MATERIAL.
10. ON THE UPSTREAM SIDE OF THE BOULDERS A LAYER OF NON-WOVEN GEOTEXTILE FABRIC SHALL BE PLACED AS SHOWN IN THE GEOTEXTILE PLACEMENT DETAIL THE ENTIRE LENGTH OF THE BOULDER STRUCTURE.
11. BACKFILL STRUCTURE WITH SELECT BACKFILL MATERIAL AS SHOWN AND DEFINED IN THE GEOTEXTILE PLACEMENT DETAIL.
12. SELECT BACKFILL AND SOIL BACKFILL MATERIAL SHALL BE COMPACTED SUCH THAT FUTURE SETTLEMENT OF THE MATERIAL IS KEPT TO A MINIMUM.
13. THE SURFACE OF THIS STRUCTURE SHALL BE FINISHED TO A SMOOTH AND COMPACT SURFACE IN ACCORDANCE WITH THE LINES, GRADES, AND CROSS-SECTIONS OR ELEVATIONS SHOWN ON THE DRAWINGS. THE DEGREE OF FINISH FOR INVERT ELEVATIONS SHALL BE WITHIN 0.1 FT OF THE GRADES AND ELEVATIONS INDICATED, PROVIDED ANY HEIGHT DOES NOT EXCEED 0.2 FT.
14. RE-DRESSING OF CHANNEL AND BANKFULL BENCH/FLOODPLAIN WILL LIKELY BE REQUIRED FOLLOWING INSTALLATION OF IN-STREAM STRUCTURES AND SHALL BE CONSIDERED INCIDENTAL TO CONSTRUCTION.
15. SEE THE PLANTING TABLE FOR DETAILS ON HIGH DENSITY LIVE STAKING.

DRAFT
NOT FOR CONSTRUCTION

DECEMBER 2013 - 75%

1/20 DETAIL – BOULDER CROSS VANE
NOT TO SCALE

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HATCHERY CREEK DESIGN/BUILD PROJECT
RUSSELL COUNTY, KENTUCKY

AS BUILT DATE

TYPICAL DETAILS

DRAWING NO. 20

DRAWN BY MS
CHECKED BY WL/GA
A & E FILE NO. 175653030
DATE DEC 2013

COMMONWEALTH OF KENTUCKY
FINANCE AND ADMINISTRATION CABINET
DEPARTMENT FOR FACILITIES MANAGEMENT
DIVISION OF ENGINEERING
FRANKFORT, KENTUCKY

ECOGRO/RIDGEWATER
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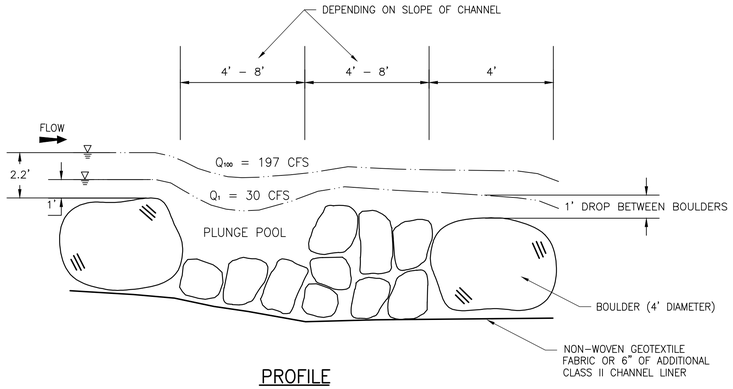
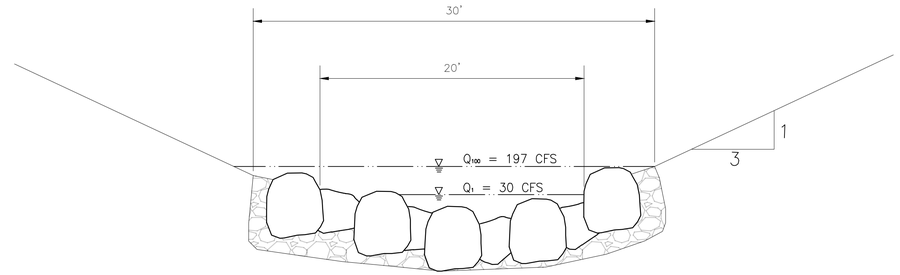
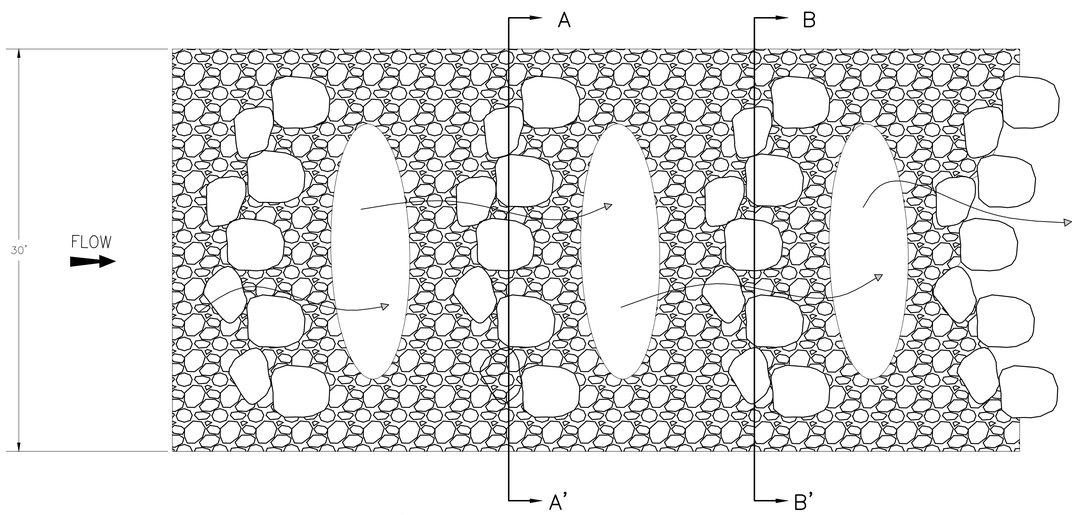


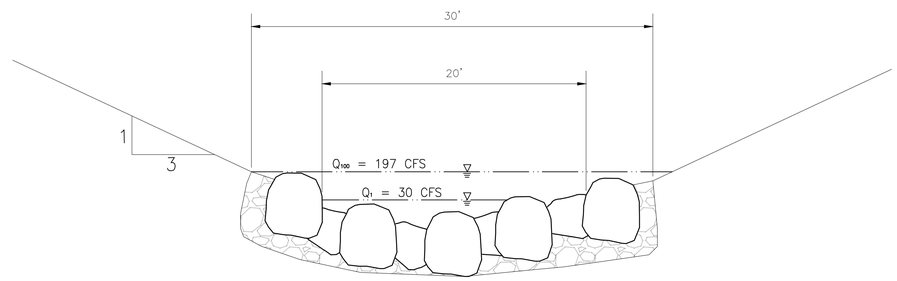
PROFILE



SECTION
A–A'



PLANVIEW



SECTION
B–B'

1/21 DETAIL – BOULDER JAM STEP
NOT TO SCALE

DRAFT
NOT FOR CONSTRUCTION

DECEMBER 2013 - 75%

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HATCHERY CREEK DESIGN/BUILD PROJECT
RUSSELL COUNTY, KENTUCKY

AS BUILT DATE	TYPICAL DETAILS	DRAWING NO. 21
DRAWN BY MS	COMMONWEALTH OF KENTUCKY	
CHECKED BY WL/GA	FINANCE AND ADMINISTRATION CABINET DEPARTMENT FOR FACILITIES MANAGEMENT DIVISION OF ENGINEERING FRANKFORT, KENTUCKY	SCALE AS SHOWN
A & E FILE NO. 175653030		REVIEWED DIV. OF ENGR.
DATE DEC 2013	ECOGRO/RIDGEWATER 1000 JEFFERSON Lexington, Kentucky 40502 859-231-0505 www.ecogro.net / Stantec Consulting Services Inc. 10175 Harrison Ridge Blvd, Suite 100 Louisville, Kentucky 40223-5301 502-212-5000 www.stantec.com	For Intent Only ACCOUNT NO. ----

AGENCY AUTHORIZED AGENT — Approved for Program Concept Only — DATE
DIVISION OF ENGINEERING — Approved for Program Concept Only — DATE

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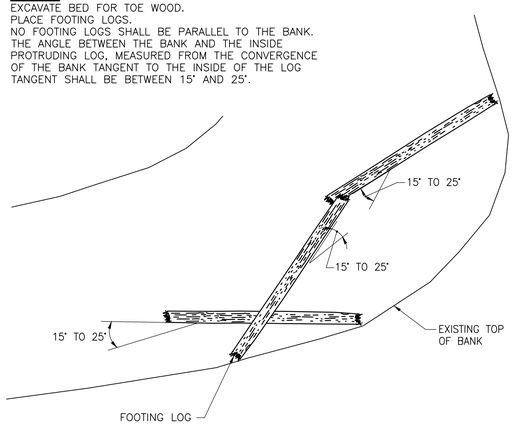
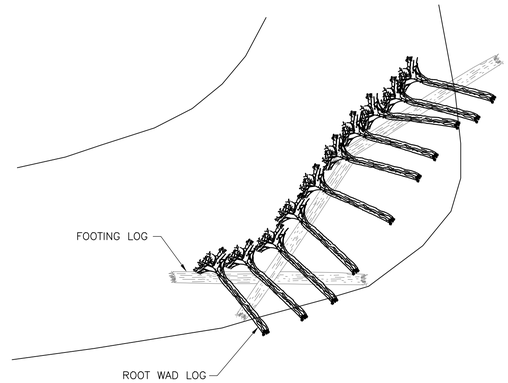
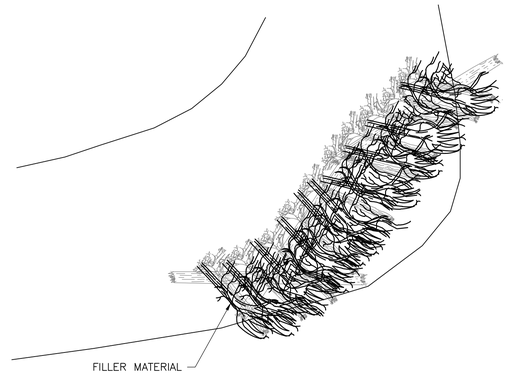
STEP 1.
EXCAVATE BED FOR TOE WOOD.
PLACE FOOTING LOGS.
NO FOOTING LOGS SHALL BE PARALLEL TO THE BANK.
THE ANGLE BETWEEN THE BANK AND THE INSIDE PROTRUDING LOG, MEASURED FROM THE CONVERGENCE OF THE BANK TANGENT TO THE INSIDE OF THE LOG TANGENT SHALL BE BETWEEN 15° AND 25°.



STEP 2.
PLACE ROOT WAD LOGS CANTILEVERED OVER FOOTING LOGS.



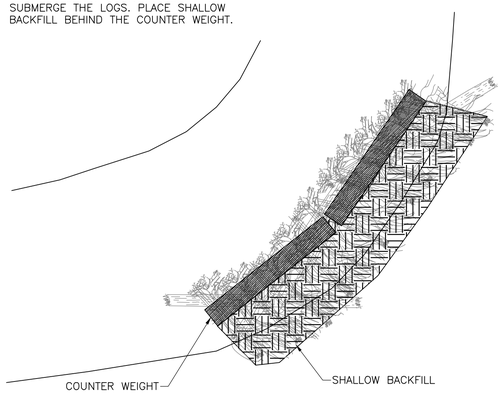
STEP 3.
PLACE FILLER MATERIAL (SMALL LOGS, LIMBS, TREE TOPS AND BRUSH) PARALLEL TO AND BETWEEN THE ROOT WADS



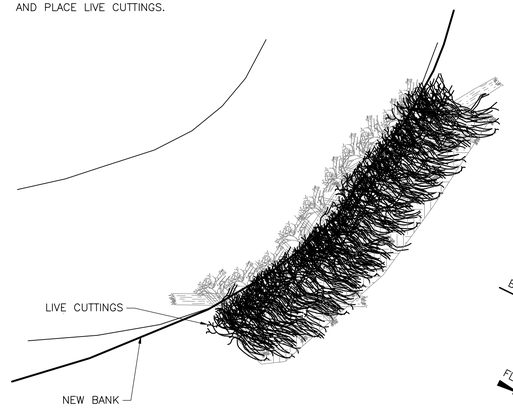
NOTES:

1. EXCAVATE FOR WOODY DEBRIS AT WIDTH AND DEPTH GIVEN IN THE TABLE.
2. WOODY DEBRIS SHALL BE COMPRISED OF LOGS, ROOTWADS, LIMBS, BRANCHES, TOPS, STUMPS AND OTHER LARGE WOODY MATERIAL HARVESTED FROM THE SITE. ONLY DOWNED TREES OR TREES APPROVED FOR REMOVAL MAY BE USED FOR THIS ITEM.
3. SMALLER LIMBS AND TOPS/BRANCHES SHALL BE FORCED INTO THE LARGE VOIDS. WOODY DEBRIS SHALL NOT PROTRUDE MORE THAN 6-INCHES BEYOND THE TOE OF THE SLOPE INTO THE STREAM CHANNEL. THE WOODY DEBRIS SHALL NOT BE PLACED PARALLEL TO THE THE DIRECTION OF FLOW
4. WHEN CONSTRUCTING WOOD TOE, USE SOME SMALLER BRANCHES AND WOOD MATERIAL TOWARD THE TOP TO PREPARE FOR SOIL AND PLANTING SURFACE.
5. SOD MATS SHALL BE STACKED TO MATCH SLOPE OF PROPOSED CHANNEL.
6. IF SOD IS NOT AVAILABLE, LIVE BRUSH LAYERING MAY BE USED ABOVE THE WOOD TOE AS DETERMINED BY THE ENGINEER.
7. WOOD TOE/SOD MAT SHALL EXTEND FROM P.C. + 10 TO P.T. + 10 UNLESS SHOWN OTHERWISE ON DRAWINGS.

STEP 4.
ADD TEMPORARY COUNTER WEIGHT TO SUBMERGE THE LOGS. PLACE SHALLOW BACKFILL BEHIND THE COUNTER WEIGHT.

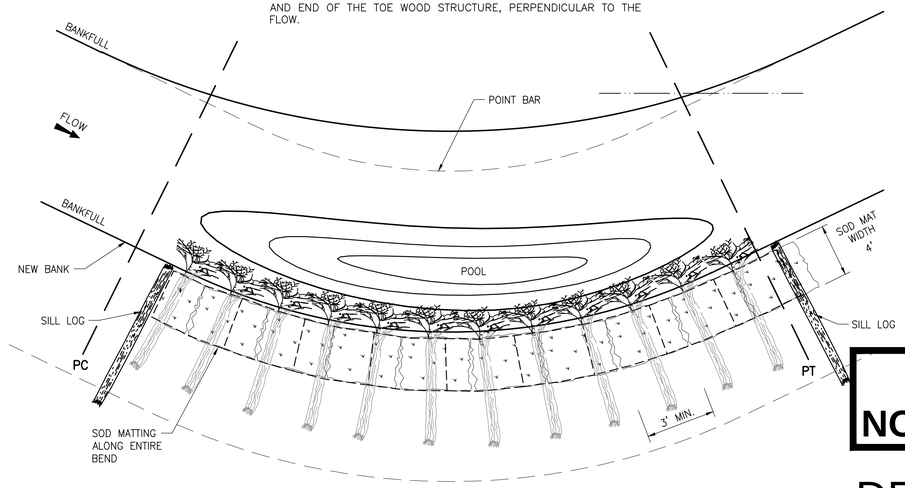


STEP 5.
REMOVE TEMPORARY COUNTER WEIGHT AND PLACE LIVE CUTTINGS.

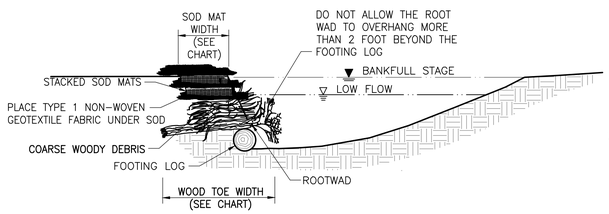


STEP 6.
INSTALL STACKED SOD MATS OR WRAPPED SOIL LIFTS AND LAYERS OF CUTTINGS BETWEEN SOIL LIFTS UP TO BANKFULL STAGE.

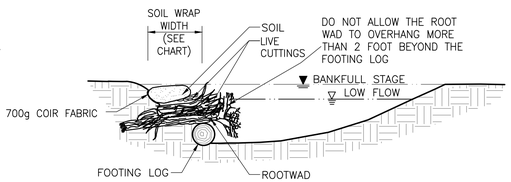
STEP 7.
SILL LOGS ARE BURIED FLUSH OR 6 INCHES BELOW THE TOP OF THE BANKFULL BENCH. PLACE THE SILL LOGS AT THE BEGINNING AND END OF THE TOE WOOD STRUCTURE, PERPENDICULAR TO THE FLOW.



PLAN VIEW



SOD MAT WITH WOOD TOE SECTION VIEW



LIVE BRUSH LAYER WITH WOOD TOE SECTION VIEW

1 / 22 **DETAIL – WOOD TOE/SOD MAT STRUCTURE**
NOT TO SCALE

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HATCHERY CREEK DESIGN/BUILD PROJECT
RUSSELL COUNTY, KENTUCKY

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TYPICAL DETAILS

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FRANKFORT, KENTUCKY

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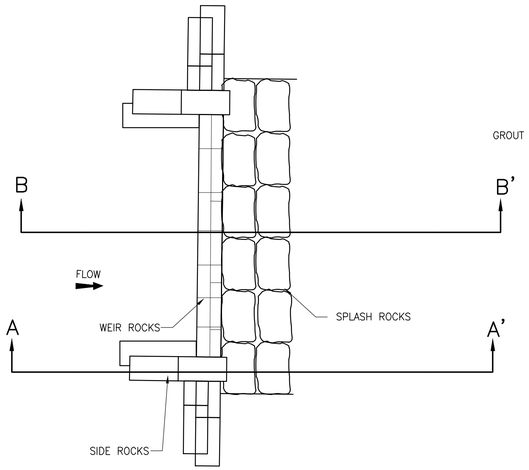
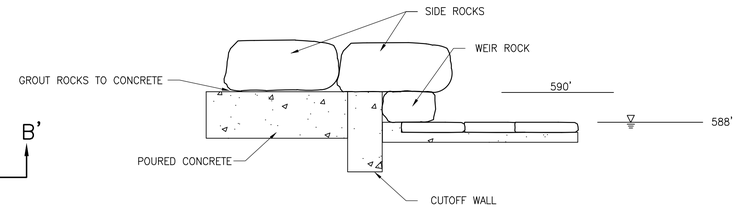
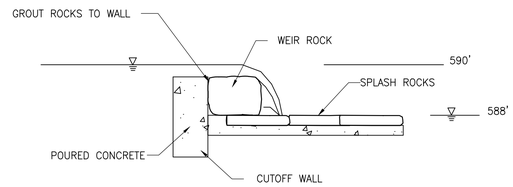


PLANVIEW

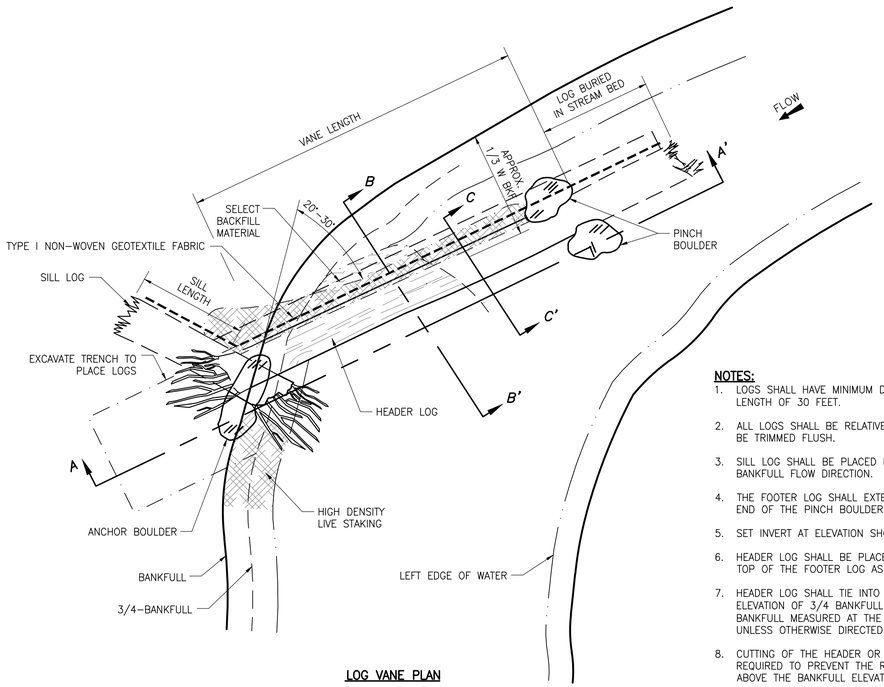


SECTION
A–A'

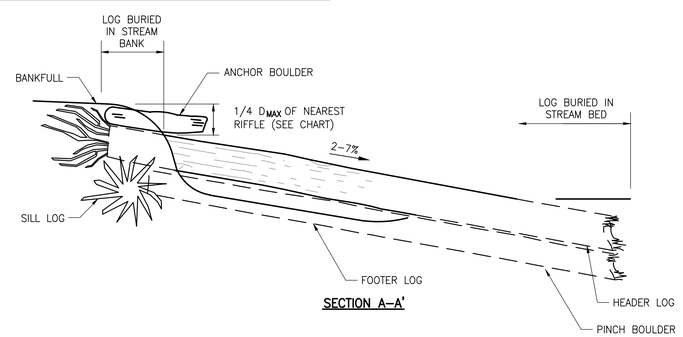


SECTION
B–B'

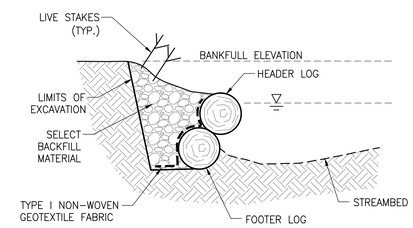
1/23 DETAIL – MIGRATION BARRIER
NOT TO SCALE



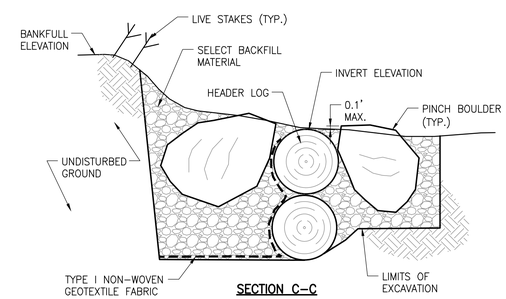
LOG VANE PLAN



SECTION A–A'



SECTION B–B



SECTION C–C

NOTES:

1. LOGS SHALL HAVE MINIMUM DIAMETER OF 18" WITH A MINIMUM LENGTH OF 30 FEET.
2. ALL LOGS SHALL BE RELATIVELY STRAIGHT AND LIMBS SHALL BE TRIMMED FLUSH.
3. SILL LOG SHALL BE PLACED PERPENDICULAR TO THE BANKFULL FLOW DIRECTION.
4. THE FOOTER LOG SHALL EXTEND FROM THE SILL LOG TO THE END OF THE PINCH BOULDER.
5. SET INVERT AT ELEVATION SHOWN IN REACH PROFILE.
6. HEADER LOG SHALL BE PLACED SLIGHTLY DOWNSTREAM ON TOP OF THE FOOTER LOG AS SHOWN IN THE DETAIL.
7. HEADER LOG SHALL TIE INTO THE STREAM BANK AT A MAXIMUM ELEVATION OF 3/4 BANKFULL AND MINIMUM ELEVATION OF 1/2 BANKFULL MEASURED AT THE NEXT DOWNSTREAM RIFFLE UNLESS OTHERWISE DIRECTED BY THE ENGINEER.
8. CUTTING OF THE HEADER OR SILL LOG ROOTWAD MAY BE REQUIRED TO PREVENT THE ROOTWAD FROM PROTRUDING ABOVE THE BANKFULL ELEVATION.
9. ALL GAPS LARGER THAN 2 INCHES BETWEEN THE HEADER AND FOOTER LOGS SHALL BE CHINKED WITH LIMBS AND/OR BRUSH ON THE UPSTREAM SIDE PRIOR TO PLACEMENT OF THE GEOTEXTILE.
10. ON THE UPSTREAM SIDE OF THE LOGS A LAYER OF NON-WOVEN GEOTEXTILE FABRIC SHALL BE PLACED AS SHOWN IN THE GEOTEXTILE PLACEMENT DETAIL THE ENTIRE LENGTH OF THE LOG.
11. NAIL NON-WOVEN GEOTEXTILE TO EDGE OF HEADER LOG AS SHOWN IN THE GEOTEXTILE PLACEMENT DETAIL.
12. TWO PINCH BOULDERS ARE REQUIRED AT THE UPSTREAM END OF THE HEADER LOG.
13. PINCH BOULDERS SHALL NOT PROTRUDE MORE THAN 0.1 FOOT ABOVE THE INVERT ELEVATION UNLESS OTHERWISE DIRECTED BY THE ENGINEER.
14. SEE THE PLANTING TABLE FOR DETAILS ON HIGH DENSITY LIVE STAKING.

2/23 DETAIL – LOG VANE/ROOTWAD
NOT TO SCALE

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HATCHERY CREEK DESIGN/BUILD PROJECT
RUSSELL COUNTY, KENTUCKY

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TYPICAL DETAILS

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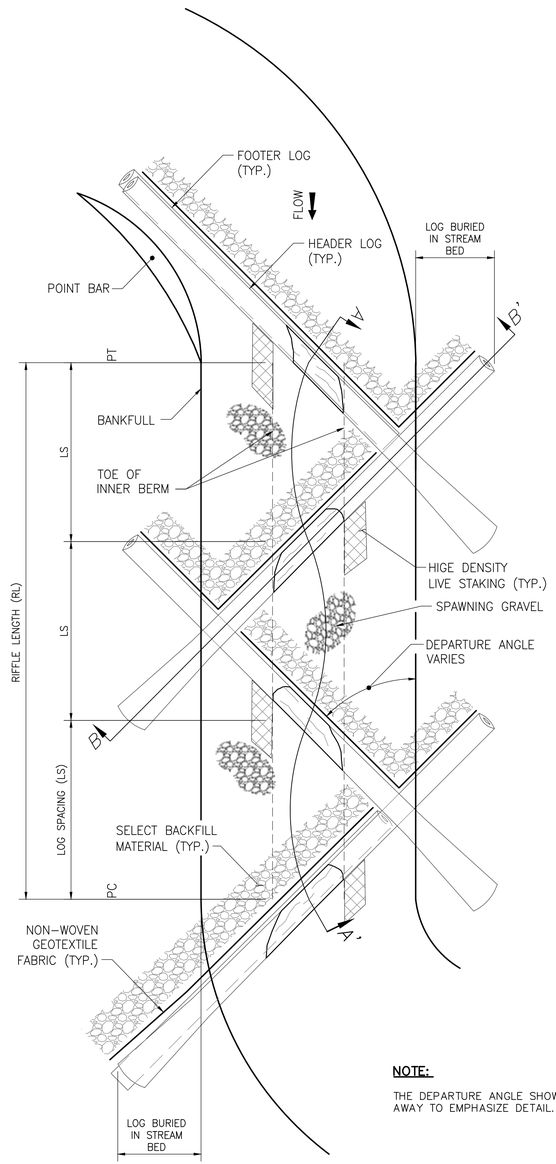
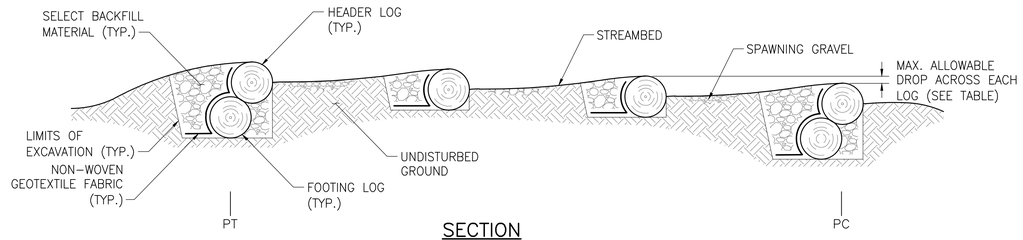


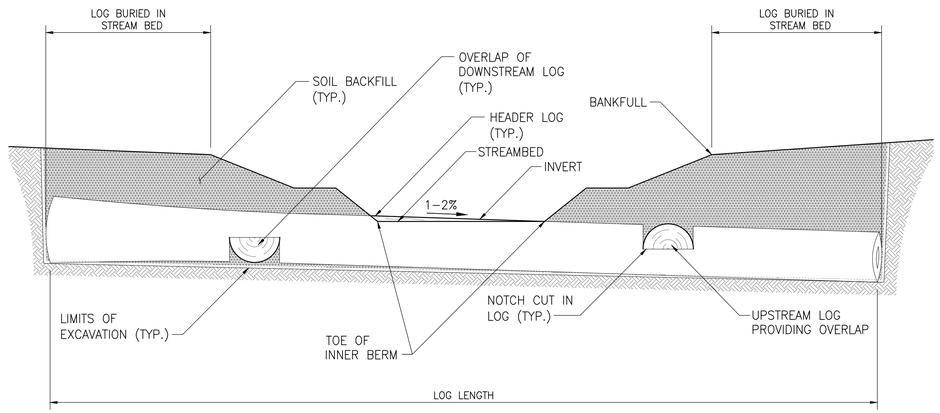
NOTE:

THE DEPARTURE ANGLE SHOWN ABOVE IS DEPICTED IN SUCH AWAY TO EMPHASIZE DETAIL.

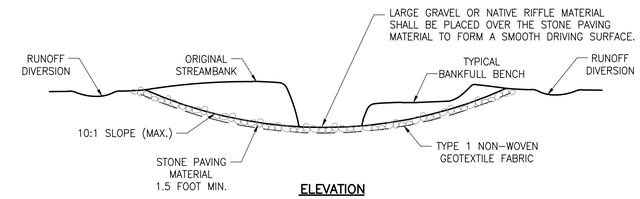
1 / 24 DETAIL – LOG RIFFLE
NOT TO SCALE



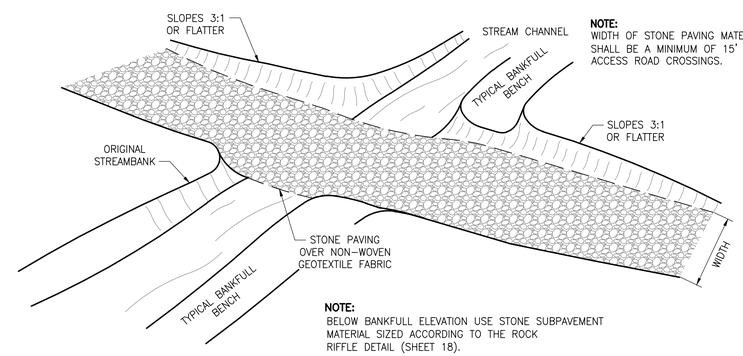
SECTION
A–A'



SECTION
B–B'



ELEVATION



NOTE:
WIDTH OF STONE PAVING MATERIAL SHALL BE A MINIMUM OF 15' FOR ACCESS ROAD CROSSINGS.

NOTE:
BELOW BANKFULL ELEVATION USE STONE SUBPAVEMENT MATERIAL SIZED ACCORDING TO THE ROCK RIFFLE DETAIL (SHEET 18).

PLAN VIEW

2 / 24 DETAIL – PERMANENT LOW WATER CROSSING
NOT TO SCALE

NOTES:

1. LOGS SHALL HAVE MINIMUM DIAMETER OF 18" AND MINIMUM LENGTH OF 30'.
2. ALL LOGS SHALL BE RELATIVELY STRAIGHT AND LIMBS SHALL BE TRIMMED FLUSH.
3. FOOTING LOGS ARE LOGS PLACED TO PROVIDE A FOUNDATION AND SCOUR PROTECTION FOR THE HEADER LOGS.
4. THE UPSTREAM AND DOWNSTREAM HEADER LOGS SHALL BE UNDERLAIN BY FOOTING LOGS UNLESS OTHERWISE DIRECTED BY THE ENGINEER.
5. HEADER LOGS ARE THE TOP MOST LOGS USED IN EACH LOG STRUCTURE. HEADER LOGS FOR THIS STRUCTURE ARE ONLY VISIBLE BETWEEN THE INNER BERMS.
6. HEADER LOGS SHALL BE OFFSET SLIGHTLY DOWNSTREAM OF THE FOOTING LOGS.
7. SET INVERTS AT ELEVATION SHOWN IN REACH PROFILE.
8. THE DROP IN ELEVATION ACROSS THE STRUCTURE SHALL NOT EXCEED 6 INCHES UNLESS OTHERWISE DIRECTED BY THE ENGINEER.
9. THE MOST UPSTREAM LOG SHALL BE PLACED SUCH THAT THE BANK TIE IN IS ON THE SAME SIDE AS THE NEXT UPSTREAM OUTSIDE BEND IN ORDER TO HELP DIRECT STREAM FLOW AWAY FROM THE PREVIOUS OUTSIDE BEND.
10. THE MOST DOWNSTREAM LOG SHALL BE PLACED SUCH THAT THE HIGH POINT IS ON THE SAME SIDE AS THE NEXT DOWNSTREAM OUTSIDE BEND IN ORDER TO HELP DIRECT STREAM FLOW FROM THE NEXT OUTSIDE BEND.
11. ALL LOGS ARE PLACED SUCH THAT THEY OVERLAP THE NEXT DOWNSTREAM LOG; THEREFORE, IT IS RECOMMENDED THAT THIS STRUCTURE BE CONSTRUCTED FROM DOWNSTREAM TO UPSTREAM.
12. THE VERTICAL SLOPE OF EACH LOG SHALL NOT EXCEED 2% UNLESS OTHERWISE DIRECTED BY THE ENGINEER.
13. IT IS LIKELY THAT EACH LOG WILL REQUIRE NOTCHING WHERE THEY OVERLAP IN ORDER TO NOT EXCEED THE MAXIMUM VERTICAL SLOPE SPECIFICATIONS AND SHALL BE CONSIDERED INCIDENTAL TO CONSTRUCTION.
14. THE NOTCH DEPTH FOR ANY LOG SHALL NOT EXCEED HALF THE DIAMETER OF THE LOG BEING NOTCHED UNLESS OTHERWISE DIRECTED BY THE ENGINEER
15. ALL GAPS/VOIDS LARGER THAN 2 INCHES BETWEEN THE HEADER AND FOOTING LOGS SHALL BE CHINKED WITH LIMBS AND/OR BRUSH ON THE UPSTREAM SIDE PRIOR TO PLACEMENT OF THE GEOTEXTILE.
16. ON THE UPSTREAM SIDE OF THE LOGS A LAYER OF NON-WOVEN GEOTEXTILE FABRIC SHALL BE PLACED AS SHOWN IN THE GEOTEXTILE PLACEMENT DETAIL THE ENTIRE LENGTH OF THE LOG.
17. BACKFILL STRUCTURE WITH SUBPAVEMENTL MATERIAL AS SHOWN ON THE DETAIL.
18. SELECT BACKFILL AND SOIL BACKFILL MATERIAL SHALL BE COMPACTED SUCH THAT FUTURE SETTLEMENT OF THE MATERIAL IS KEPT TO A MINIMUM.
19. NAIL NON-WOVEN GEOTEXTILE TO EDGE OF HEADER LOG AND BACKFILL AS SHOWN IN THE GEOTEXTILE PLACEMENT DETAIL.
20. THE SURFACE OF THIS STRUCTURE SHALL BE FINISHED TO A SMOOTH AND COMPACT SURFACE IN ACCORDANCE WITH THE LINES, GRADES, AND CROSS-SECTIONS OR ELEVATIONS SHOWN ON THE DRAWINGS. THE DEGREE OF FINISH FOR INVERT ELEVATIONS SHALL BE WITHIN 0.1 FT OF THE GRADES AND ELEVATIONS INDICATED, PROVIDED ANY HEIGHT DOES NOT EXCEED MAX. ALLOWABLE DROP INDICATED IN TABLE.
21. RE-DRESSING OF CHANNEL AND BANKFULL BENCH/FLOODPLAIN WILL LIKELY BE REQUIRED FOLLOWING INSTALLATION OF IN-STREAM STRUCTURES AND SHALL BE CONSIDERED INCIDENTAL TO CONSTRUCTION.
22. SEE THE PLANTING TABLE FOR DETAILS ON HIGH DENSITY LIVE STAKING.
23. NO LIVE STAKES SHALL BE INSTALLED ON THE UPSTREAM SIDE OF THE LOG VANE AT OR BELOW THE TIE-IN ELEVATION OF THE HEADER LOG WITH THE STREAM BANK UNLESS OTHERWISE DIRECTED BY THE ENGINEER.
24. PLACE SPAWNING GRAVEL THROUGHOUT RIFFLE. REFER TO THE ROCK RIFFLE DETAIL (SHEET 18) FOR SPAWNING GRAVEL PLACEMENT.

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HATCHERY CREEK DESIGN/BUILD PROJECT
RUSSELL COUNTY, KENTUCKY

AS BUILT DATE	TYPICAL DETAILS	DRAWING NO. 24
DRAWN BY MS	COMMONWEALTH OF KENTUCKY FINANCE AND ADMINISTRATION CABINET DEPARTMENT FOR FACILITIES MANAGEMENT DIVISION OF ENGINEERING FRANKFORT, KENTUCKY	SCALE AS SHOWN
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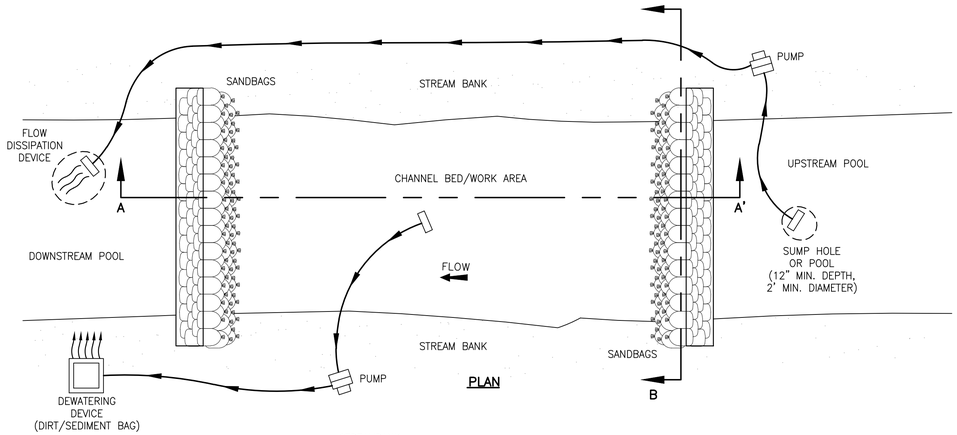
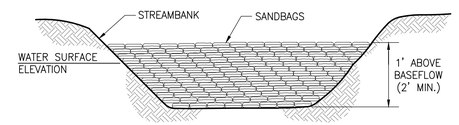
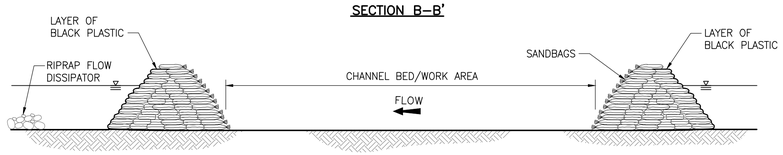


PLAN



SECTION B–B'



SECTION A–A'

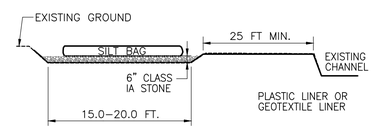
SEQUENCE OF CONSTRUCTION FOR TYPICAL WORK AREA

1. INSTALL SILT BAGS WITH ROCK PADS.
2. INSTALL UPSTREAM PUMP AND TEMPORARY FLEXIBLE HOSE.
3. PLACE UPSTREAM IMPERVIOUS DIKE AND BEGIN PUMPING OPERATIONS FOR STREAM DIVERSION.
4. PLACE DOWNSTREAM IMPERVIOUS DIKE AND PUMPING APPARATUS. DEWATER ENTRAPPED AREA. AREA TO BE DEWATERED SHALL BE EQUAL TO ONE DAY'S WORK.
5. PERFORM STREAM RESTORATION WORK IN ACCORDANCE WITH THE PLANS.
6. EXCAVATE ANY ACCUMULATED SILT AND DEWATER BEFORE REMOVAL OF IMPERVIOUS DIKES. REMOVE IMPERVIOUS DIKES, PUMPS, AND TEMPORARY FLEXIBLE HOSE. (DOWNSTREAM IMPERVIOUS DIKES FIRST).
7. ALL GRADING AND STABILIZATION MUST BE COMPLETED IN ONE DAY WITHIN THE PUMP AROUND AREAS BETWEEN THE IMPERVIOUS DIKES. THE IMPERVIOUS DIKE LOCATIONS AS SHOWN ON THIS SHEET ONLY SHOW THE UPPER AND LOWER EXTENT OF WORK FOR EACH STREAM SEGMENT. THE CONTRACTOR IS RESPONSIBLE FOR DETERMINING THE LOCATION OF THE IMPERVIOUS DIKE(S) FOR EACH DAY'S WORK.
8. REMOVE SILT BAGS WITH ROCK PADS AND BACKFILL.
9. STABILIZE DISTURBED AREA WITH SEED AND MULCH.

NOTES:

1. ALL EXCAVATION SHALL BE PERFORMED IN ONLY DRY OR ISOLATED SECTIONS OF CHANNEL.
2. IMPERVIOUS DIKES ARE TO BE USED TO ISOLATE WORK FROM STREAM FLOW WHEN NECESSARY.
3. ALL GRADED AREAS SHALL BE STABILIZED WITHIN 24 HOURS.
4. MAINTENANCE OF STREAM FLOW OPERATIONS SHALL BE INCIDENTAL TO THE WORK. THIS INCLUDES POLYETHYLENE SHEETING, DIVERSION PIPES, PUMPS AND HOSES.
5. PUMPS AND HOSES SHALL BE OF SUFFICIENT SIZE TO DEWATER THE WORK AREA.
6. SIDESLOPES OF RESTORED CHANNEL SHALL BE BLANKETED PRIOR TO TURNING WATER INTO CHANNEL. SEE TYPICAL BLANKETED LOCATION DETAIL.
7. CONTRACTOR IS RESPONSIBLE FOR DETERMINING & ACQUIRING THE PROPER SIZED PUMP.

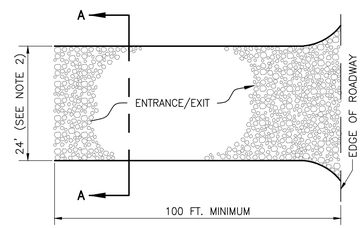
   * PUMP AROUND IS NOT REQUIRED WHEN NEW CHANNEL WORK IS DONE IN THE DRY OR OFF–LINE.



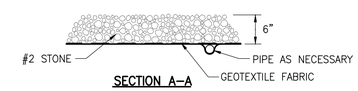
NOTE:
PROVIDE STABILIZED OUTLET

SILT BAG WITH ROCK PAD

1/25 DETAIL – PUMP AROUND
NOT TO SCALE



PLAN

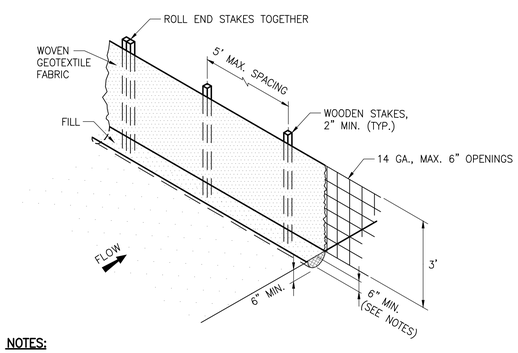


SECTION A–A

NOTES:

1. ALL THE DIMENSIONS IN THE DRAWING ARE RECOMMENDED MINIMUMS.
2. THE CONTRACTOR SHALL INSTALL 6 INCHES OF KYTC NO. 2 STONE WITH GEOTEXTILE FABRIC LAYER UNDERNEATH. THE ENTRANCE/EXIT SHOULD BE A MINIMUM OF 100 FEET IN LENGTH AND 24 FEET IN WIDTH.
3. THE CONTRACTOR SHALL MAKE EVERY EFFORT TO MINIMIZE THE AMOUNT OF SOIL AND MUD LEAVING THE CONSTRUCTION SITE. STONE IN THE ENTRANCE SHOULD BE ADDED OR CLEANED WHENEVER THE ENTRANCE FAILS TO PREVENT MUD TRACKING ON THE PUBLIC ROADWAY.
4. PIPING SHALL BE OF SUFFICIENT DIAMETER AND SLOPE TO PASS ROADSIDE DITCH FLOWS.

3/25 DETAIL – TEMPORARY CONSTRUCTION ENTRANCE/EXIT
NOT TO SCALE



NOTES:

1. SILT FENCE SHALL BE INSTALLED ACROSS SLOPES ON THE CONTOUR LINE.
2. ATTACH FILTER FABRIC TO WOODEN STAKES WITH STAPLES, HOGRINGS OR OTHER MATERIALS APPROVED BY THE ENGINEER.
3. WOODEN STAKES SHALL BE INSTALLED ON THE DOWNHILL SIDE OF FILTER FABRIC.
4. BURY THE BOTTOM 12 INCHES OF FILTER FABRIC IN A 6"X6" TRENCH (TO PREVENT SEDIMENT FROM ESCAPING UNDER THE FENCE) AND BACK FILL WITH SOIL.
5. JOIN SILT FENCE SECTIONS BY ROLLING END STAKES TOGETHER TO CREATE AN UNBROKEN SEDIMENT BARRIER.
6. MULCH BERMS MAY BE APPROVED BY THE ENGINEER ON A CASE–BY–CASE BASIS.

2/25 DETAIL – SILT FENCE
NOT TO SCALE

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TYPICAL DETAILS

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