



May 2020

PENNICHUCK WATER WORKS STUMP POND BMP EVALUATION



Prepared for:



PENNICHUCK

25 Manchester Street
Merrimack, NH 03054

MEMORANDUM

TO: Donald Ware, P.E., Chief Operating Officer
FROM: Eileen Pannetier, President
Nick Cristofori, P.E., Project Manager
DATE: May 5, 2020
SUBJECT: Craftsman Lane BMP Design and Stump Pond Brook BMP Assessment

1 Introduction

1.1 Project Background

The purpose of this memorandum is to expand on a previous study completed in 2002 under a Source Water Protection Grant (SWPG) titled “Study of Urban Non-Point Source Pollution – Stump Pond Brook Subwatershed”. This study, in part, developed a pre-conceptual design for a stormwater BMP along Craftsman Lane, in the vicinity of Stump Pond dam and the Stump Pond Brook culvert crossing.

Stump Pond and Stump Pond Brook are tributaries to the Pennichuck Water Works (PWW) water supply ponds, and tributary/groundwater sampling has been performed at this location for the past several years. Based on historical water quality data, groundwater phosphorus levels in this location have been in the mid to upper-range compared to all other sampling locations throughout Pennichuck Brook Watershed (PBW). Tributary phosphorus levels are in the mid-range compared to all other sampling locations throughout PBW. High phosphorus concentrations can be attributed to several sources, including agricultural fertilizers, soil/bank erosion, snow melt, and atmospheric deposition.

Historical water quality data shows that dissolved oxygen levels at this location are significantly lower compared to all other sampling locations throughout PBW. This can be caused by high phosphorus concentrations. Phosphorus is the limiting nutrient for algae and aquatic plant growth in waterbodies; high concentrations cause eutrophication and a reduction in dissolved oxygen.

1.2 Project Goal

The goal of this project was to advance the previously developed pre-conceptual design to a 50% conceptual design for a stormwater BMP that will capture and treat the immediate, uncontrolled stormwater runoff to Stump Pond Brook from the impervious areas of Craftsman Lane. Additionally, an assessment of the possibility of implementing a large-scale stormwater BMP that will treat the discharge from Stump Pond to Stump Pond Brook was conducted. Recommended next steps for the Craftsman Lane stormwater BMP and a potential Stump Pond Brook stormwater BMP are also summarized at the end of this memo.

2 Advancement of Craftsman Lane Stormwater BMP

2.1 Conceptual Design

Stump Pond dam and the Stump Pond Brook culvert crossing is approximately located at 11 Craftsman Lane, Merrimack, NH 03054. A site assessment was completed in November, 2019 during which the following information was obtained:

- Site photographs (*Appendix A*);

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- Detailed topographic survey within the limits of contributing impervious areas along Craftsman Lane;
- Limited topographic survey within the limits of pervious/wooded areas south of Craftsman Lane, or the location of the proposed BMP;
- Spot elevations and/or coordinates of important features, such as dam spillway, top of headwall, inlet/outlet elevation, edge of water, roadway centerline, edge of roadway, utility poles, guardrail, etc.; and,
- Location of known existing utilities (dig safe was contacted to verify the location of any utilities in the area – none exist with the exception of overhead wires).

The above information, along with information obtained from GIS/LiDAR (town/property lines, buildings, wetlands, topography, etc.) and aerial imagery (tree line, etc.), was incorporated into the base map used for the final 50% conceptual design of the Craftsman Lane stormwater BMP (*Appendix B*).

In general, Craftsman Lane slopes down towards the dam and culvert crossing from both sides (east and west). Currently, stormwater runoff from both sides of Craftsman Lane discharges uncontrolled into Stump Pond Brook via two paved spillways located directly above the downstream culvert headwall. The proposed conceptual design will eliminate both untreated stormwater discharges by constructing two BMPs, one BMP on either side of the paved spillway. The goal is to intercept and treat the stormwater runoff, which can contain various pollutants including sediment, salt, oils, and/or fuel, before it is discharged directly to Stump Pond Brook.

The proposed conceptual design for the west BMP consists of a sediment forebay for pretreatment and an infiltration basin for treatment. The proposed conceptual design for the east BMP consists of an infiltration basin for treatment; however, a pretreatment sediment forebay cannot be included due to a lack of available space. In addition to the west and east BMP, an optional inverted berm is proposed to be installed along a portion of the south side of Craftsman Lane to ensure stormwater runoff from Craftsman Lane is directed into the west BMP from the western subcatchment and into the east BMP from the eastern subcatchment. Should this design be infeasible (e.g. due to ownership issues), it can be replaced by a conventional asphalt berm, however, this is more likely to be damaged by winter plowing operations. The plan view and cross section view of the sediment forebay, west infiltration basin, east infiltration basin, and inverted berm are detailed in the 50% conceptual design plans (*Appendix B*).

Topographic survey collected by CEI, supplemented with available topography from LiDAR data, was used to estimate the western and eastern contributing subcatchment areas of Craftsman Lane. The topographic subcatchment areas and land use information were then used to estimate runoff volumes from impervious areas to be received by the west and east BMP, and was used to size the BMPs. The target pretreatment volume for a BMP is 0.1" per impervious acre and the target treatment volume for a BMP is 1" per impervious acre. The west BMP, forebay and infiltration basin, have been designed with sufficient capacity to account for the 0.1" pretreatment and 1" treatment volumes. The east BMP infiltration basin, however, has not due to the steep slope and limited space on the eastern side. Although the east BMP only has the capacity to treat approximately 70% of the 1" treatment volume from the eastern subcatchment, together with the west BMP, over 90% of runoff from the 1" storm from Craftsman Lane that is currently discharging uncontrolled to Stump Pond Brook would be treated. BMP component sizing calculations and pretreatment/treatment volume calculations are included at the end of this memo (*Appendix C*).

The Simple Method Model spreadsheet used to estimate the pollutant loadings to the Stump Pond Brook. Annual pollutant loading estimates are based on impervious area, annual runoff, and pollutant

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concentrations based on land use for each BMP's subcatchment. Pollutants that were analyzed included total suspended solids (TSS), total phosphorus (TP), and total nitrogen (TN). BMP pollutant removal efficiencies are based on the BMP type. Pollutant loading and removal calculations and methodology are included at the end of this memo (*Appendix D*). As shown in the calculations, if the Craftsman Lane stormwater BMPs are implemented, approximately 1,818 pounds of TSS, 2 pounds of TP, and 3 pounds of TN would be removed annually from stormwater currently discharging to Stump Pond Brook.

2.2 Permitting Requirements

Due to the location of the project, construction and installation of the BMPs might impact wetland and/or wetland buffer areas, therefore, anticipated permitting requirements are as follows:

- NHDES Wetland Permit Application (*RSA 482-A, Env-Wq 100-900*)
 - o NH Natural Heritage Bureau (NHB) Review
 - o NH Division of Historical Resources (DHR) Review
 - o NH Fish and Game Department (FGD) Review
 - o Designated River Check and National Wetland Inventory (NWI) Check
 - o Abutter Notifications

In addition to wetland permitting, PWW may have to work with the neighboring two properties to the west as the optional inverted berm extends off of PWW-owned property to the west. The parcel immediately to the west of the PWW parcel is owned by Merrimack Valley Baptist Church (7 Craftsman Lane, Amherst, NH 03031) and the parcel further west owned by St. Paul Lutheran Church (3 Craftsman Lane, Amherst, NH 03031). As noted previously, this feature may be removed and replaced with conventional asphalt berm located on property owned by the Town of Amherst.

2.3 Cost Estimate

Estimated costs to implement the Craftsman Lane stormwater BMPs are as follows:

- Permitting: \$4,000 - \$6,000
- Final Design: \$8,000 - \$12,000
- Construction West BMP – Infiltration Basin and Sediment Forebay: \$30,000 - \$40,000
- Construction East BMP – Infiltration Basin: \$20,000 - \$30,000
- Construction of Optional Inverted Berm: \$8,000 - \$12,000

Total Estimated Cost: \$70,000 - \$100,000

3 Assessment of Stump Pond Brook Stormwater BMP

3.1 Existing Conditions

The downstream area of Stump Pond and Craftsman Lane (Stump Pond Brook) is located on a Pennichuck-owned parcel that is 1.9-acres in area, according to the Town of Merrimack New Hampshire Geographic Information System Data Portal. During field visits, a visual evaluation of the area surrounding Stump Pond Brook was conducted to determine existing site constraints pertaining to potential construction of a water quality treatment BMP. Stump Pond Brook is surrounded by a natural wetland area and densely wooded wetland buffers on all sides, including the entire Pennichuck-owned parcel. The elevation drop from Craftsman Lane to the bottom of the hill, or banks of Stump Pond Brook, is approximately 10 to 12 feet, including an area as steep as approximately 2:1 (horizontal to vertical) slope. The stream itself varies in

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width, however is approximately 6 feet wide along the majority of the channel. According to historical groundwater sampling data, the depth to groundwater on the upper banks of Stump Pond Brook is approximately 2.5 to 3.5 feet, depending on the time year. Based on groundwater recharge rates within Pennichuck's groundwater sampling well and due to high groundwater, it is anticipated that infiltration rates for this area are low, particularly close to the stream and within surrounding wetland areas.

3.2 Potential Treatment Designs

A description of treatment BMPs that could potentially be implemented to treat water from Stump Pond Brook are as follows:

- **Stormwater Wetland:** These BMPs are used to maximize pollutant removal through wetland vegetation uptake, retention, and settling. According to the New Hampshire Stormwater Manual, stormwater wetlands are capable of removing up to 80% TSS (when combined with a sediment forebay), 55% TN, and 45% TP.
 - Site Constraints: Inappropriate soil types, depth to groundwater, depth to bedrock, contributing drainage area, and available land area are all factors that can limit the suitability of a stormwater wetland in a particular area. Stormwater wetland cannot be located within a natural wetland area since they are not designed to have a full range of ecological functions of natural wetlands. Sufficient land area is required for stormwater wetlands, if space is limited, pocket wetlands may be implemented.
 - Site-Specific Considerations: The area surrounding Stump Pond Brook is generally located within a natural wetland area, has shallow groundwater, and slowly drained soils. Since stormwater wetlands should not be constructed within a natural wetland, this BMP type is not feasible.
- **Sand & Organic Filters:** These filters typically consist of a pretreatment component, which is usually a sediment forebay or vegetated filter strip, and a treatment component, which is usually a self-contained bed of sand and/or peat with perforated underdrains or cells/baffles with inlets/outlets. According to the New Hampshire Stormwater Manual, sand and organic filters are capable of removing up to 90% TSS (when combined with pretreatment device), 60% TN, and 65% TP.
 - Site Constraints: Sand and organic filters are adaptable to most locations; they can be installed in poor soil conditions, low infiltration rates, high evaporation rates, and limited space. Sand/organic filters may not provide treatment during cold weather due to freezing.
 - Site-Specific Considerations: Although the area surrounding Stump Pond Brook has shallow groundwater and slowly drained soils, a sand filter can be designed to work within these conditions. This BMP may be feasible at this location.
- **Stormwater Ponds:** Stormwater ponds consist of a permanent pool of water as the mechanism to remove pollutants. The pool allows suspended solids to settle, thus can remove solid and soluble pollutants. According to the New Hampshire Stormwater Manual, stormwater ponds are capable of removing up to 80% TSS (when combined with a sediment forebay), 55% TN, and 68% TP.
 - Site Constraints: Inappropriate soil types, depth to groundwater, depth to bedrock, contributing drainage area, and available land area are all factors that can limit the suitability of a wet basin in a particular area. Wet basins need to be located in less permeable soils, or else they will need to be lined to reduce infiltration. Wet basins should not be located within a natural wetland.

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- o Site-Specific Considerations: The area surrounding Stump Pond Brook is generally located within a natural wetland area, has shallow groundwater, and slowly drained soils. Since stormwater ponds should not be constructed within a natural wetland, this BMP type is not feasible.

3.3 Permitting Requirements

Due to the location and size of the project, construction and installation of any of these BMPs will have extensive impacts to wetland and/or wetland buffer areas, therefore, anticipated permitting requirements are as follows:

- U.S. Army Corp of Engineers State Programmatic General Permit (SPGP) or Individual Permit
- NHDES Alteration of Terrain Permit Application (*RSA 485-A:17, Env-Wq 1500*)
- NHDES Shoreland Permit Application (*RSA 483-9, Env-Wq 1400*)
- NHDES Wetland Permit Application (*RSA 482-A, Env-Wq 100-900*)
 - o Waste Management Division Review
 - o 401 Water Quality Certification Program
 - o NH Natural Heritage Bureau (NHB) Review
 - o NH Division of Historical Resources (DHR) Review
 - o NH Fish and Game Department (FGD) Review
 - o Designated River Check and National Wetland Inventory (NWI) Check
 - o Dredge Management Task Force (DMTF) Review

3.4 Analysis and Conclusions

In summary the following design and construction challenges exist at this site:

- The natural wetland areas and wooded wetland buffers surrounding Stump Pond Brook would need to be impacted and cleared for construction;
- The steep drop of approximately 10 vertical feet from Craftsman Lane makes construction access difficult and limits available space for the BMP because of sloping conditions;
- High groundwater, which is approximately 3-feet below the ground surface on average, limits the potential depth available for BMP construction;
- Extensive permitting would be required to conduct clearing and construction activities; and
- The large contributing watershed and associated drainage area would need to be addressed as part of BMP design and treatment characteristics.

Since the potential BMP would be treating water from Stump Pond rather than stormwater, typical BMP sizing criteria does not apply. However for the purposes of scale, the Stump Pond Brook watershed (1,310 acres in total) includes approximately 183 acres of impervious area based on available GIS records. The 1" water quality treatment volume, defined as 1" of runoff over the impervious area, for this watershed is approximately 665,000 CF (24,600 CY), therefore, a potential BMP with an average depth of 3 feet (approximate depth to groundwater) would need to be approximately 220,000 SF (5 acres), or more than 2.5-times larger than the entire 1.9-acre Pennichuck-owned parcel. Even a smaller BMP with an average depth of 3 feet that only treats the 0.1" pretreatment volume of approximately 66,500 CF (2,460 CY), would have to be approximately 22,200 SF (0.5 acres) in area.

Due to the challenges at this site, it is estimated that permitting and design of a stormwater BMP will be in excess of \$100,000 (permitting \$25,000+, design \$75,000+). Construction will depend on the selected BMP

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design and final sizing, however, construction of a BMP sized to hold even part of the 1" water quality treatment volume is estimated to cost in the range of \$500,000 to greater than \$1M.

In light of the above, CEI does not recommend moving forward with one of the aforementioned stormwater BMPs to treat the flow from Stump Pond Brook. Alternatively, CEI recommends proceeding with the items discussed in the following section.

4 Recommendations and Next Steps

This report and associated attachments represent the 50% conceptual design for the Craftsman Lane stormwater BMP and a feasibility assessment for a Stump Pond Brook stormwater BMP. The following are recommendations for next steps:

4.1 Advance Design and Construction of Craftsman Lane BMP

CEI recommends that PWW proceed with final design and permitting of the Craftsman Lane stormwater BMP. Next steps towards implementing the Craftsman Lane stormwater BMP would be to complete necessary wetland permitting and reviews, complete construction plans, and then bid and construct the project. This should include working with private property owners and/or NHDES when undergoing implementation of the Craftsman Lane stormwater BMP to incorporate optional design elements that could impact privately-owned and Town-owned land.

4.2 Evaluate Sediment and Phosphorus Cycling within Stump Pond

CEI recommends completion of a bathymetric survey of Stump Pond and collection of in-pond water and sediment samples at various depths to further understand the eutrophic conditions, potential sediment loads, and accumulated sediment depths within Stump Pond. If the pond has internal phosphorus cycling, the phosphorus load to downstream areas may become extreme. The evaluation will help determine potential impacts on phosphorus loading to downstream waters due to internal phosphorus cycling in the pond.

4.3 Evaluate Stump Pond Dam and Culvert

CEI recommends completion of an assessment of the condition of Stump Pond dam and culvert, and remove the debris from the dam/weir structure that was observed during field visits to reduce the potential for debris to impact functionality and potentially cause sediment washout downstream. One potential option may be to lower the dam at the Stump Pond outlet, or remove it entirely to improve water quality in the pond and thus in downstream waterbodies such as the PWW supply ponds. Alternatively, it may be possible to alter or reconstruct the existing dam outlet structure to allow for discharge of water from the base of the dam rather than over the spillway. Depending on the results of Item 4.2 above, this could allow for releasing "cleaner" water into Stump Pond Brook and improving downstream water quality. This could be further enhanced by allowing water to cascade over riprap or other similar feature, thus providing an aeration component that is currently lacking within deeper areas of Stump Pond.

APPENDIX A

Site Photographs

Appendix A – Site Photographs



Appendix A – Site Photographs



Appendix A – Site Photographs



Appendix A – Site Photographs



Appendix A – Site Photographs



Appendix A – Site Photographs



Appendix A – Site Photographs



APPENDIX B

50% Conceptual Design Plans

LEGEND

- BENCHMARK
- TOWN LINE
- PROPERTY LINE
- EDGE OF PAVEMENT
- GUARDRAIL
- BUILDING
- OVERHEAD WIRES
- CULVERT/DAM
- EDGE OF WATER
- TREELINE
- MAJOR CONTOUR
- MINOR CONTOUR
- LIMIT OF WORK
- PROPOSED CONTOUR
- LIMIT OF CLEARING
- INVERTED CURB
- DRAINAGE FEATURE
- UNDERGROUND DRAIN
- EROSION CONTROLS



No.	Revision/Issue	Date



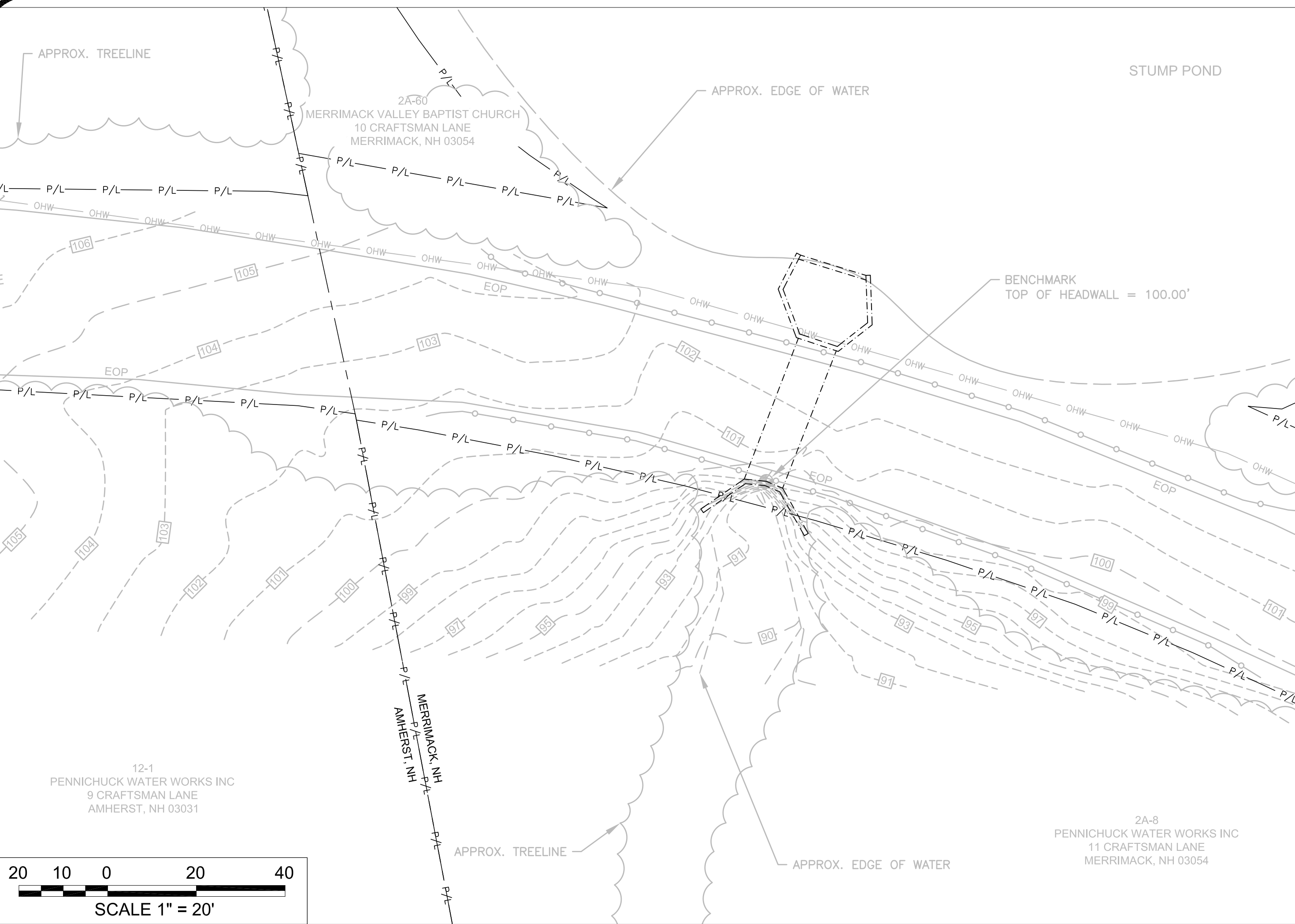
COMPREHENSIVE ENVIRONMENTAL
INCORPORATED
21 DEPOT STREET
MERRIMACK, NH 03054

STUMP POND BMPS
PLAN VIEW
PENNICHUCK WATER WORKS
25 MANCHESTER STREET
MERRIMACK, NH 03054

Project: 131-66
Date: APRIL 2020
Drawn by: PD
Checked by: NC
Scale: As Shown

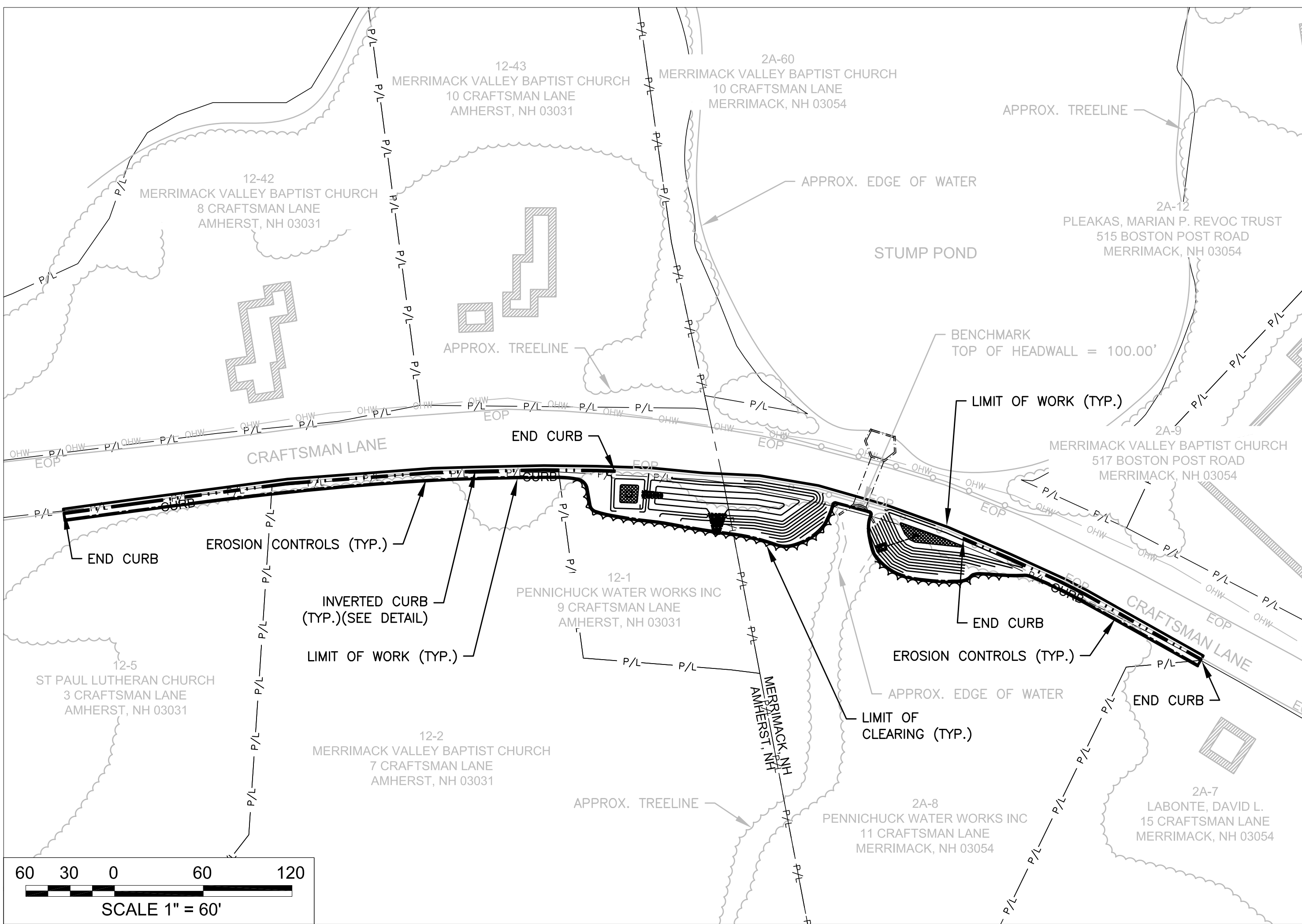
Sheet:

1



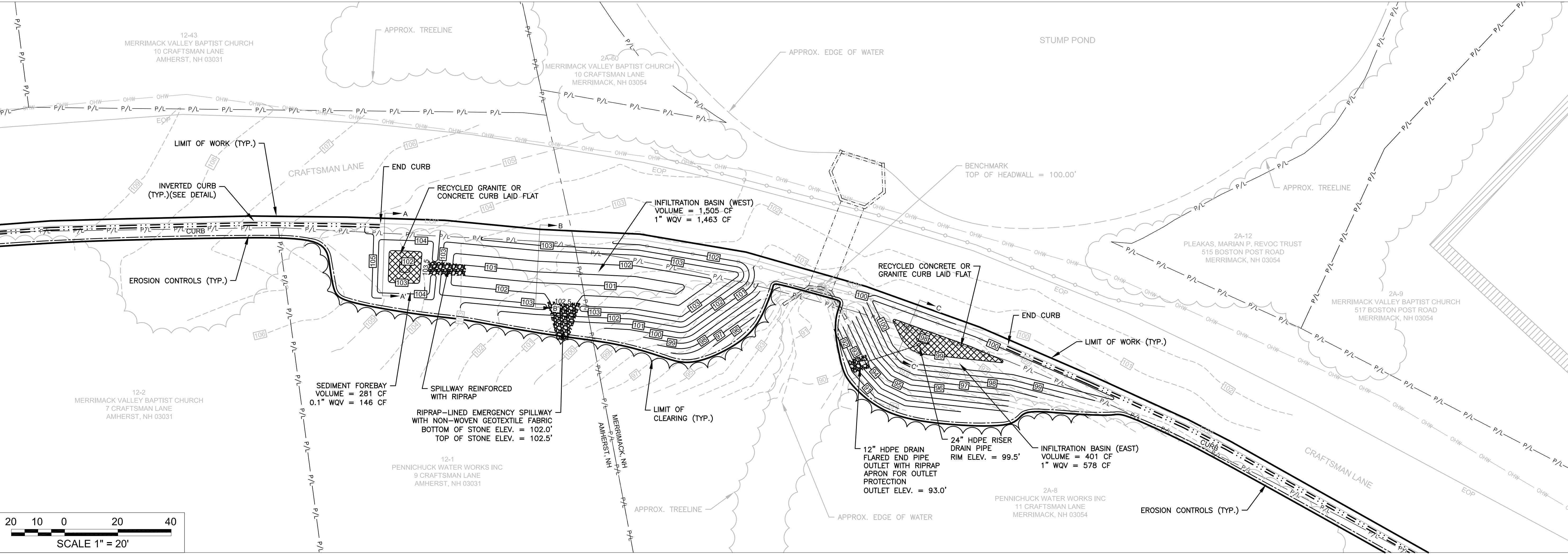
EXISTING PLAN VIEW

SCALE: 1"=20'



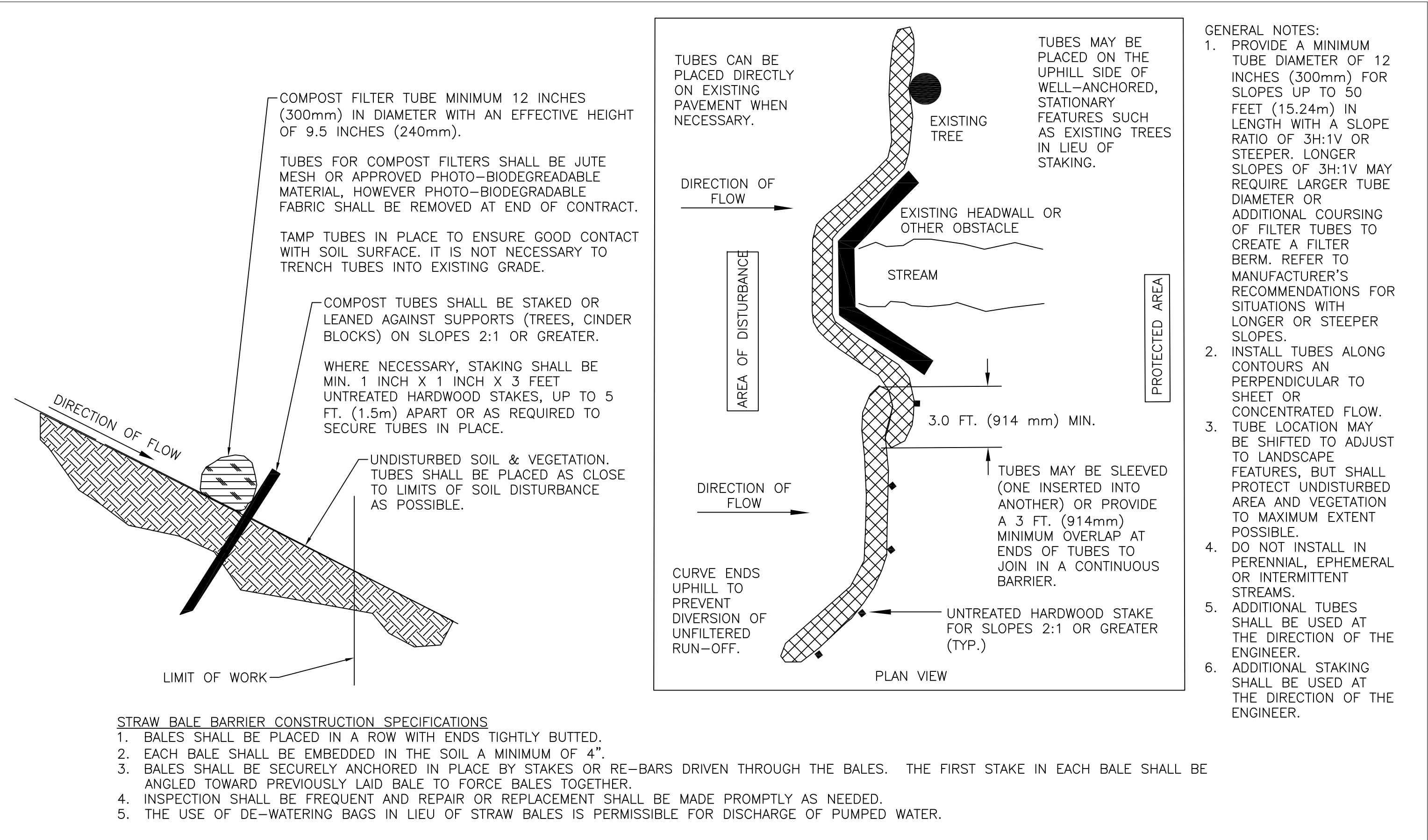
PROPOSED PLAN VIEW – LIMITS OF CAPE COD BERM

SCALE: 1"=60'



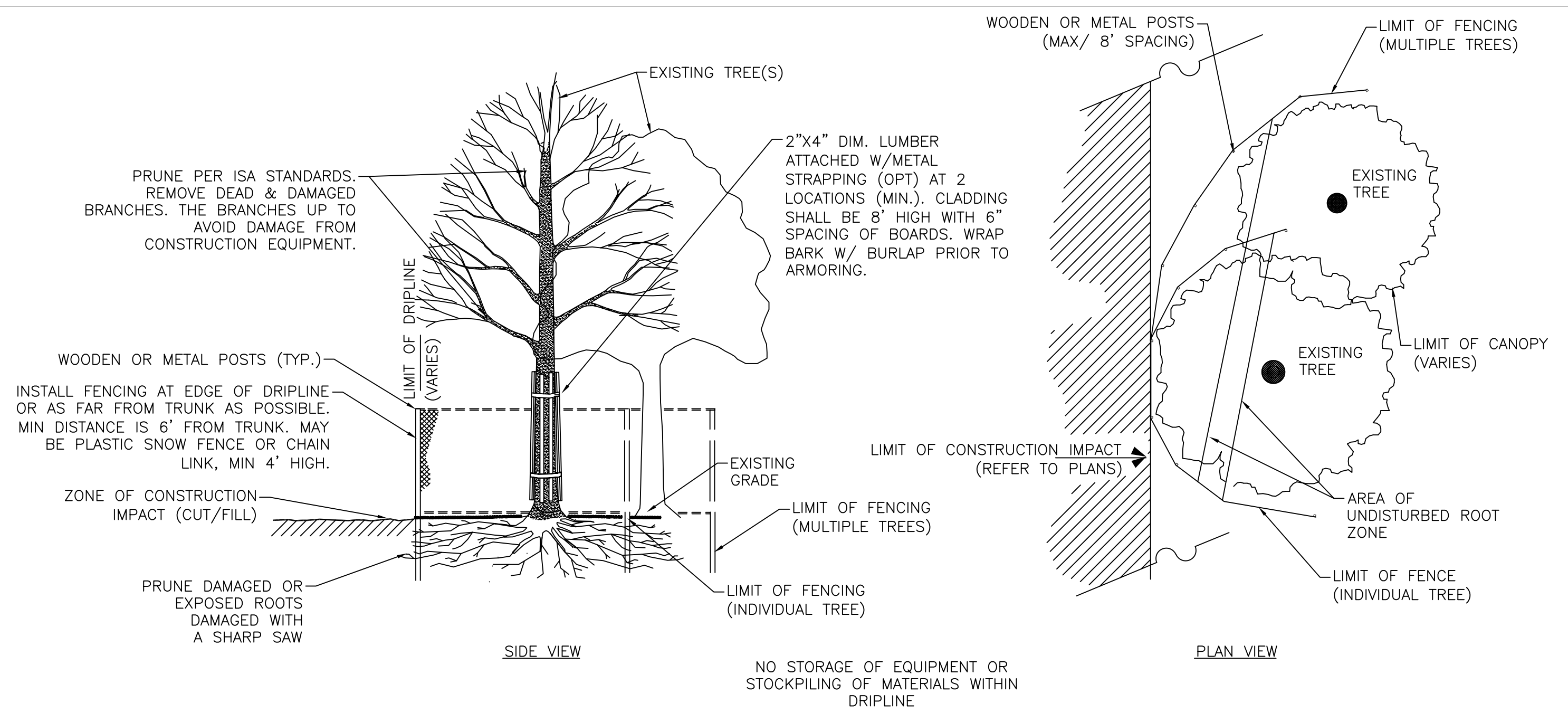
PROPOSED PLAN VIEW

SCALE: 1"=20'



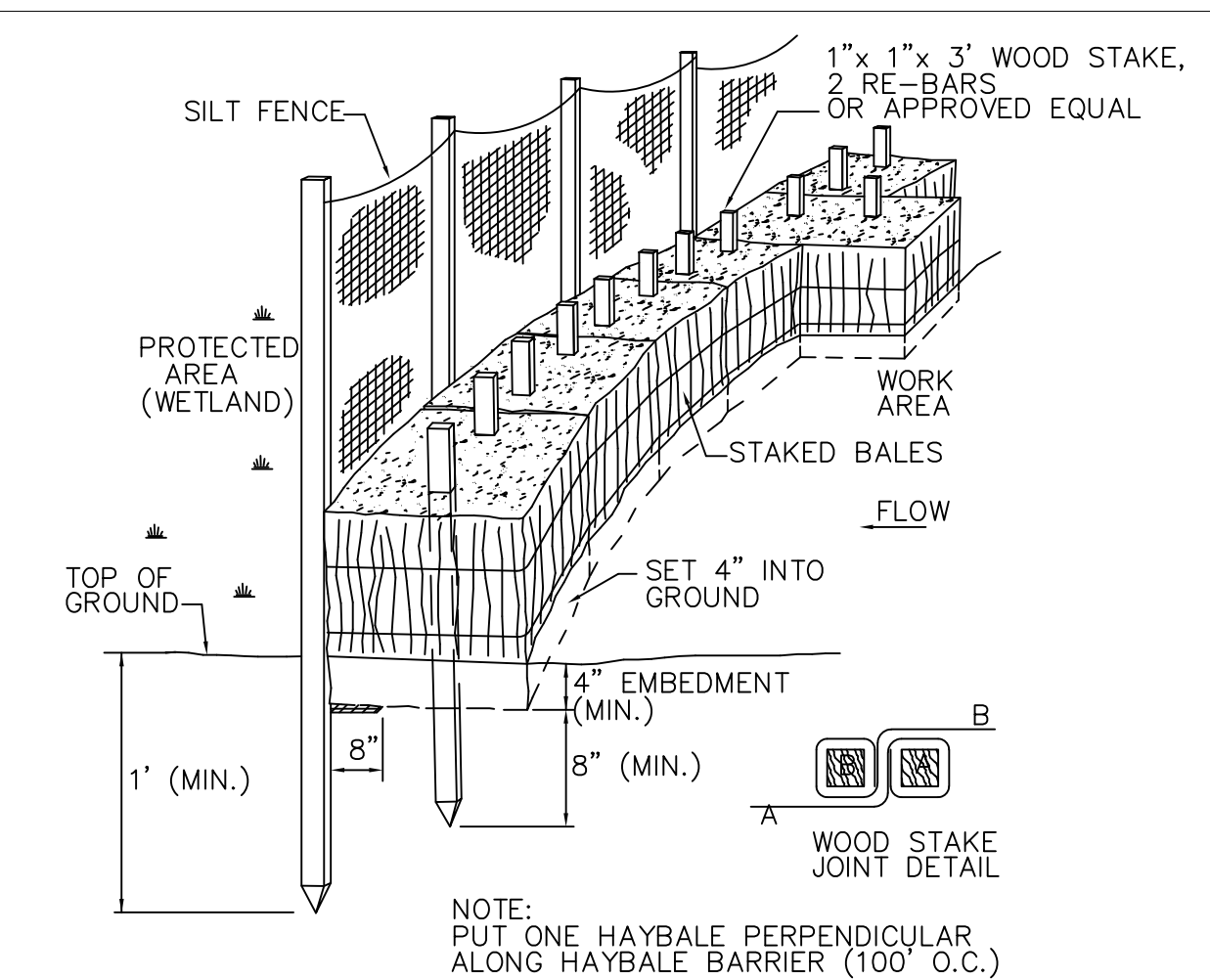
PERIMETER EROSION CONTROLS – COMPOST FILTER TUBE (TYP.)

NOT TO SCALE



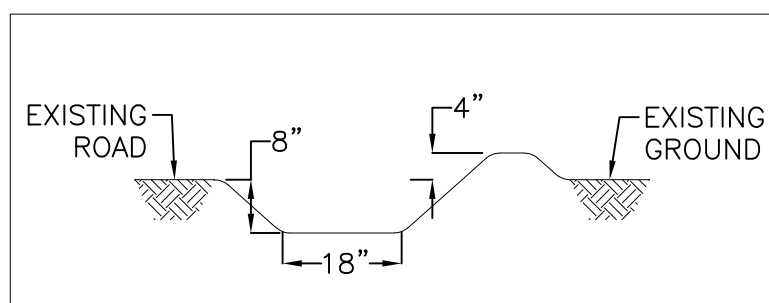
TREE PROTECTION (TYP.)

NOT TO SCALE



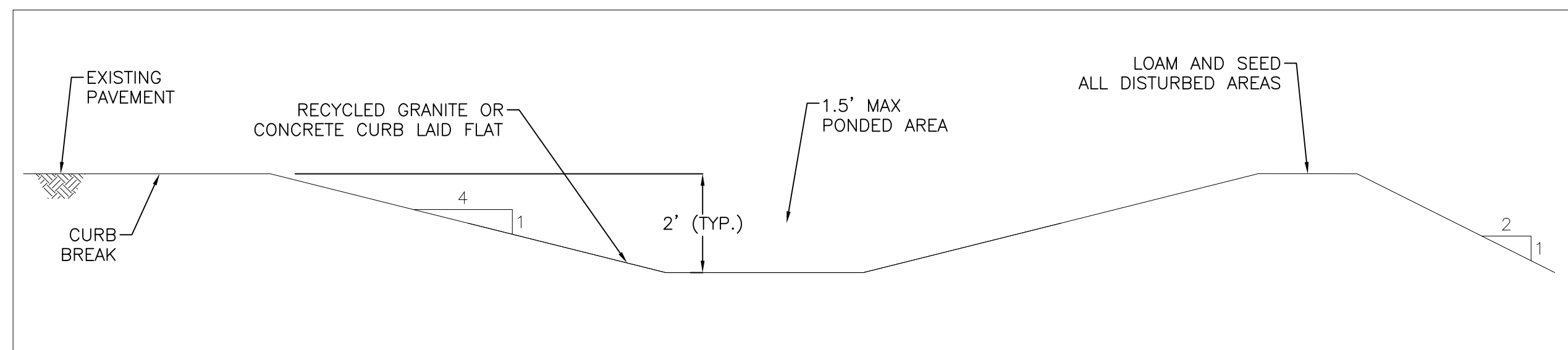
SILT FENCE (TYP.)

NOT TO SCALE



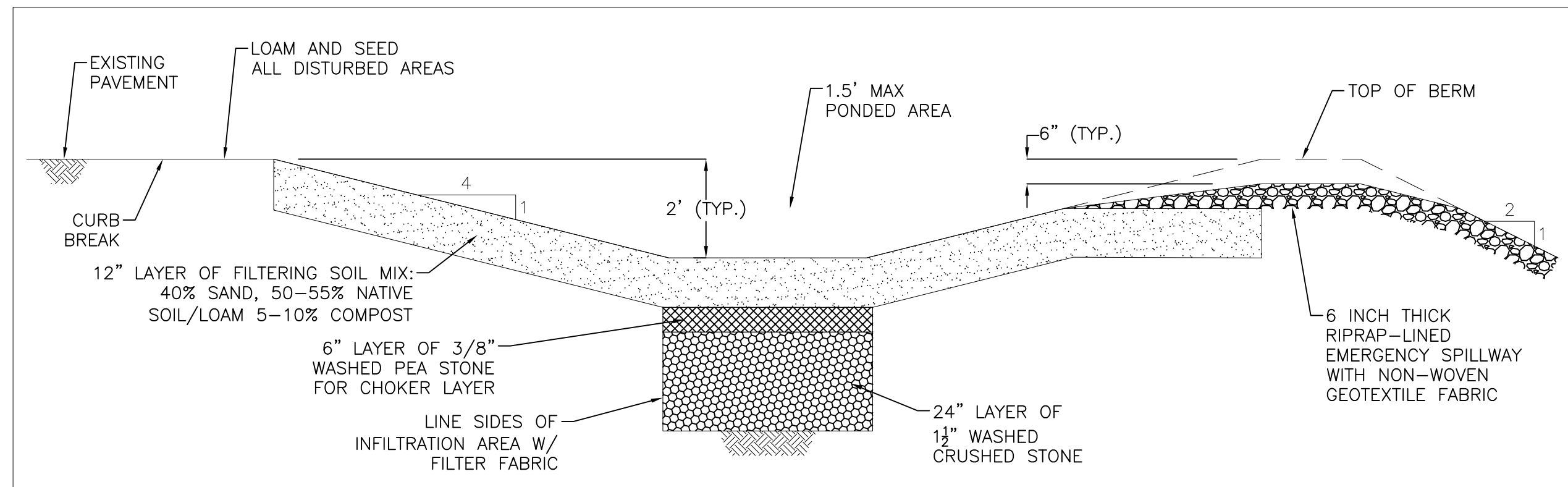
INVERTED CURB DETAIL (TYP.)

NOT TO SCALE



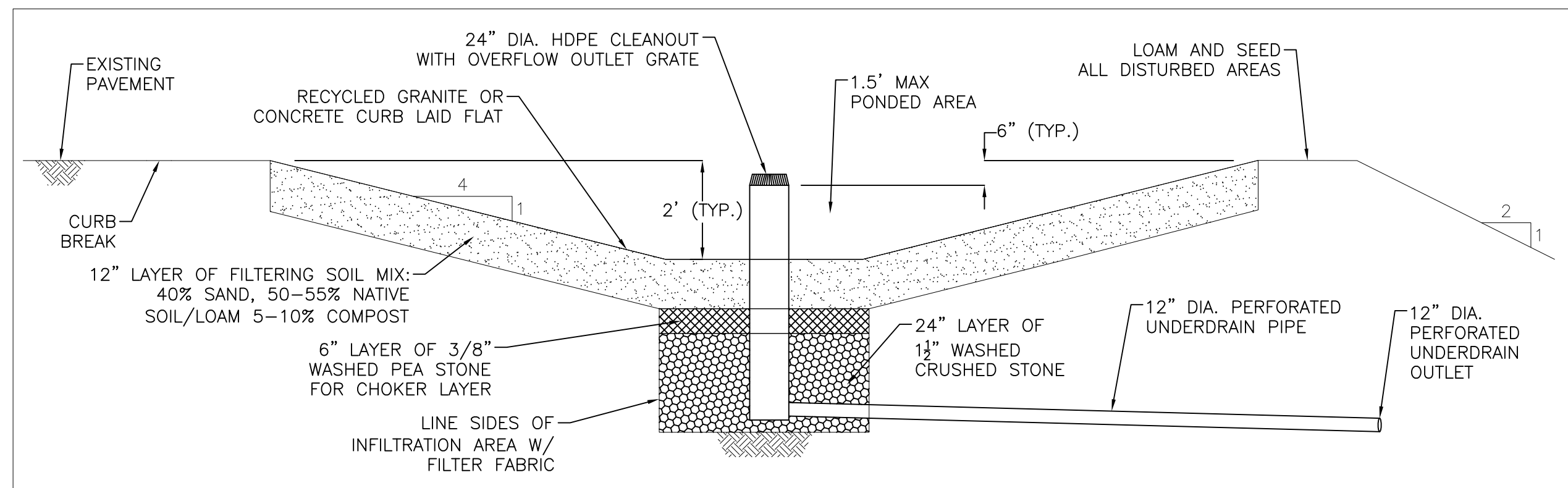
WEST BMP: SEDIMENT FOREBAY – CROSS SECTION A–A'

NOT TO SCALE



WEST BMP: INFILTRATION BASIN – CROSS SECTION B–B'

NOT TO SCALE



EAST BMP: INFILTRATION BASIN – CROSS SECTION C–C'

NOT TO SCALE

No.	Revision/Issue	Date

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

21 DEPOT STREET
MERRIMACK, NH 03054

STUMP POND BMPS DETAILS

PENNICHUCK WATER WORKS
25 MANCHESTER STREET
MERRIMACK, NH 03054

Project: 131–66 Date: APRIL 2020	Sheet: 2
Drawn by: PD Checked by: NC	Scale: As Shown

APPENDIX C

BMP Sizing Calculations

Appendix C - BMP Volume Calculations

West Subcatchment Area = 17,560 SF
 0.1" Pretreatment Volume = 146 CF
 1" Treatment Volume = 1463 CF

West Forebay - 0.1" Pretreatment Volume = 146 CF				
Elevation	Area (sf)	Avg Surface Area	Incremental Storage (cf)	Accumulated Storage (cf)
102.00	16	0	0	0
103.00	144	80	80	80
103.50	401	209	281	281
Total Volume				281
Percentage of 0.1" Pretreatment Volume Treated				100%

West BMP - 1" Treatment Volume = 1,463 CF				
Elevation	Area (sf)	Avg Surface Area	Incremental Storage (cf)	Accumulated Storage (cf)
101.00	329	0	0	0
102.00	1,107	718	718	718
102.50	2,039	1,573	787	1,505
Total Volume				1,505
Percentage of 1" Treatment Volume Treated				100%

East Subcatchment Area = 6,940 SF
 0.1" Pretreatment Volume = 58 CF
 1" Treatment Volume = 578 CF

East BMP - 1" Treatment Volume = 578 CF				
Elevation	Area (sf)	Avg Surface Area	Incremental Storage (cf)	Accumulated Storage (cf)
98.00	4	0	0	0
99.00	243	124	124	124
99.50	868	556	278	401
Total Volume				401
Percentage of 1" Treatment Volume Treated				69%

APPENDIX D

Pollutant Loading and Removal Calculations

Site		Proposed BMP Type(s)	Appendix D - Stump Pond Proposed Pollutant Loading and Removal Summary											
			<u>Total Subcatchment Area</u>	<u>Total Subcatchment Area</u>	<u>Commercial</u>	<u>Forested</u>	<u>Open Urban Land</u>	<u>Residential - High Density</u>	<u>Residential - Med Density</u>	<u>Residential - Low Density</u>	<u>Industrial</u>	<u>Roadway/ Parking Lot</u>	<u>Pasture</u>	<u>Total Area</u>
			(SF)	(acres)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
BMP 1	West Subcatchment	Sediment Forebay	17,560	0.40	0%	0%	0%	0%	0%	0%	0%	100%	0%	100%
		Infiltration Basin												
BMP 2	East Subcatchment	Infiltration Basin	6,940	0.16	0%	0%	0%	0%	0%	0%	0%	100%	0%	100%
Total Subcatchment Area			24,500	0.56	0%	0%	0%	0%	0%	0%	0%	100%	0%	100%

Site		Proposed BMP Type(s)	Appendix D - Stump Pond Proposed Pollutant Loading and Removal Summary															
			<u>Commercial</u>	<u>Forested</u>	<u>Open Urban Land</u>	<u>Residential - High Density</u>	<u>Residential - Med Density</u>	<u>Residential - Low Density</u>	<u>Industrial</u>	<u>Roadway/ Parking Lot</u>	<u>Pasture</u>	<u>Total Area</u>	<u>Impervious Area</u>	<u>Sanded Area</u>	<u>Pretreatment Volume</u> (0.1"/Imp acre)	<u>Treatment Volume</u> (1"/Imp Acre)	<u>Annual Runoff</u>	Annual Runoff
			(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(cf)	(cf)	(in)	(cf)
BMP 1	West Subcatchment	Sediment Forebay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.4	0.4	0.3	146	1,463	38	56,302
		Infiltration Basin																
BMP 2	East Subcatchment	Infiltration Basin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.2	0.1	58	578	38	22,251
Total Subcatchment Area			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.6	0.6	0.4	204	2,042	38	78,553

Site		Proposed BMP Type(s)	Appendix D - Stump Pond Proposed Pollutant Loading and Removal Summary												
			Annual TSS Loading	Annual TP Loading	Annual TN Loading	Annual FC Loading	BMP Pollutant Removal Efficiencies						Annual TSS Removed	Annual TP Removed	Annual TN Removed
			(lbs)	(lbs)	(lbs)	(bil.colonies)	BMP Volume	Volume Treated	TSS	TP	TN	Fecal Coliform	(lbs)	(lbs)	(lbs)
BMP 1	West Subcatchment	Sediment Forebay	2,222	2	5	27	281	100.00%	25%	0%	0%	N/A	556	0	0
		Infiltration Basin					1,505	100%	80%	65%	55%	N/A	1,333	1	3
BMP 2	East Subcatchment	Infiltration Basin	878	1	2	11	401	69%	80%	65%	55%	N/A	485	0	1
Total Subcatchment Area			3,101	3	7	38							1,818	2	3
			Total Loading to Stump Pond Brook										Total Removed Proposed BMPs		

Appendix D - Stump Pond Proposed Pollutant Loading and Removal Summary

Annual Rainfall	45	inches; user specified
Pj	0.9	%; default
Sanding Rate	70	lbs/acre; default
Sanding Applications	10	times/year; default

References:

Pitt, Robert. (2004, February 16). The National Stormwater Quality Database (NSQD, version 1.1). Retrieved July 22, 2005 from the World Wide Web: <http://unix.eng.ua.edu/~rpitt/Research/ms4/Paper/recentpaper.htm>
The New York Stormwater Management Design Manual Appendix A. Retrieved July 22, 2005 from the World Wide Web: <http://www.dec.state.ny.us/website/dow/toolbox/simple.pdf>
The Simple Method to Calculate Urban Stormwater Loads. Retrieved July 22, 2005 from the World Wide Web: <http://www.stormwatercenter.net/monitoring%20and%20assessment/simple%20meth/simple.htm>
*Table H-2 of the 2010 Rhode Island Storm Water Manual

Land use	TSS (mg/L)	TP (mg/L)	TN (mg/L)	Fecal Coliform (mg/L)	% Impervious
Commercial	77	0.33	2.97	4600	85
Forested	51	0.11	1.78	300	5
Open Urban Land	51	0.11	1.74	300	9
Residential - High Density	100	0.4	2.2	7000	40
Residential - Med Density	100	0.4	2.2	7000	10
Residential - Low Density	100	0.4	2.2	7000	30
Industrial	149	0.32	3.97	2400	75
Roadway/Parking Lot	172	0.55	1.4	1700	100
Pasture	145	0.37	5.98	300	5

Pollutant Loading Formulas (Simple Method Equations):

TSS, TP, TN

$L = 0.226 * R * C * A$

Where:

L = Annual Load (lbs)

R = Annual Runoff (inches)

C = Pollutant Concentration (mg/l)

A = Area (acres)

0.226 = Unit Conversion Factor

Fecal Coliform

$L = .00103 * R * C * A$

Where:

L = Annual Load (Billion Colonies)

R = Annual Runoff (inches)

C = Pollutant Concentration (#col/100mL)

A = Area (acres)

0.00103 = Unit Conversion Factor

Annual Rainfall

$R = P * P_j * R_v$

Where:

R = Annual Runoff (inches)

P = Annual Rainfall (inches)

P_j = % of rainfall events producing runoff

R_v = Runoff Coefficient = 0.05+0.9 * I_a

I_a = Impervious Fraction (%)

Notes:

- Sanding applications assume 66% (2/3) of the impervious area is sanded.
- Pollutant Concentrations (C) are derived from Volume 1 Appendix D of the New Hampshire Stormwater Manual (December 2008)

BMP Type	TSS Removal (%)	TP Removal (%)	TN Removal (%)	Fecal Coliform Removal (%)	Pretreatment / Treatment
25-FT Wide Vegetated Filter Strip	10%	0%	0%	N/A	Pretreatment
50-FT Wide Vegetated Filter Strip	45%	0%	0%	N/A	Pretreatment
Plunge Pool / Forebay	25%	0%	0%	N/A	Pretreatment
Bioretention/Raingarden	90%	40-90%	30-50%	N/A	Treatment
Constructed Stormwater Wetland	80%	40-60%	20-55%	75%	Treatment
Extended Dry Detention Basin	50%	10-30%	15-50%	10%	Treatment
Wet Basins	80%	30-70%	10-50%	40-90%	Treatment
Water Quality Swale	70%	20-90%	10-90%	N/A	Treatment
Infiltration Trench	80%	40-70%	40-70%	90%	Treatment
Infiltration Basin	80%	60-70%	50-60%	90%	Treatment