KIBBY WIND POWER PROJECT
TURBINE SERIES A & B
FRANKLIN COUNTY, MAINE

CONSTRUCTION AND STORMWATER NARRATIVE

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March 23, 2007

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1.0 PROJECT OVERVIEW

AMEC Industrial & Infrastructure, Inc. (AMEC), under agreement with TransCanada Energy Inc., is preparing preliminary engineering plans and specifications for final design and construction of a wind energy project in the Kibby Mountain region of Franklin County Maine. The project consists of two main areas, Turbine Series A and B which include 19 and 27 wind turbine sites, respectively.

To provide access to each turbine pad, preliminary horizontal and vertical geometric designs and associated grading plans were developed for access and turbine roads. The preliminary grading plans served as a basis for the development of preliminary erosion & sediment control plans and post-construction drainage and stormwater management plans.

A total of approximately 109 and 227 acres for Turbine Series A and B, respectively, of land will be disturbed for the construction of the wind turbines, storm water management measures and turbine lay-down areas. These areas do not include disturbed areas associated with temporary material storage sites, batch plants and pull-offs.

Note that the design information and calculations contained in this report are preliminary and are subject to change during final design. Site assessments and investigations need to be conducted for several support areas before proceeding with additional stormwater planning and design activities. These support areas include:

- Rock crusher and temporary material storage areas,
- Temporary laydown areas,
- Gold Brook Road and access road turnoffs (15 in total)
- Concrete batch plant and material handling storage area, and

More than one potential site has been identified for material storage areas, road turnoffs and the concrete plant. At each of these potential areas, site environmental assessments will be performed to determine whether the use of the area for the designated purpose is feasible. If sites are suitable based on environmental assessments, then site investigations will be performed as appropriate (water supply for batch plant area and mineral resource investigations for geological area).

2.0 ROADWAY AND TURBINE PAD CONSTRUCTION

To construct the wind power development, improvements to existing roads and construction of new roads will be required. Existing logging road improvements may include some grade adjustments, widening, clearing of brush growth that encroaches on the roadway

Existing road improvements may also include permanent or temporary widening of curves at intersections to allow turning radius for long loads required to deliver the wind turbine components.

New access roads will be required to access the wind turbine sites from the existing access roads. These new roads are required to suit construction purposes and will remain for maintenance access to the wind turbines. The most efficient routing of these roads will provide for access between turbines to allow the efficient movement of large cranes and equipment between the wind turbine sites.

To construct the wind power development improvements to existing roads and construction of new roads will be required. The site is located within Plum Creek lands and as such has a network of logging roads and planned future logging roads. The selected construction roads will use, to the extent practical existing and proposed logging road alignments coordinated with Plum Creek's road plans. Existing road improvements may include some grade adjustments, widening, clearing of brush growth that encroaches on the road ROW.

For the travel of the large cranes, temporary construction roads with a 34 foot width of traveled portion are required for crane movement between wind turbine sites. While there are exceptions, the measures required for the construction of access roads are covered in section 7 of this narrative, These measures cover a variety of situations which will occur on both access roads and ridge roads, and during construction, an on-site engineer will be available to advise which measures are most appropriate. The following basis has been used for the road layout and design:

Road Grade:

- Maximum allowable gradient of 6% with a well compacted sufficient road grip surface; unassisted
- Maximum allowable gradient of 10%; may require specialized trucks and assisted pulling power- FEL/tractor/etc
- In flat or slope terrain – 6-inch maximum rise or fall in 50 feet

Access road effective working width:

- Straight sections: 16-foot running surface plus shoulders
- Curves: 21-foot running surface plus 2-foot shoulders

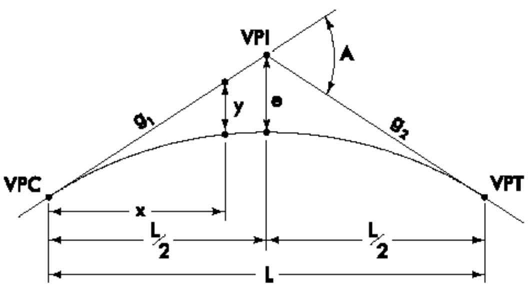
Between wind turbine locations:

- 16 feet for crane breakdown travel with maximum lateral slope of 0.5%
- 34 feet for crawler crane travel

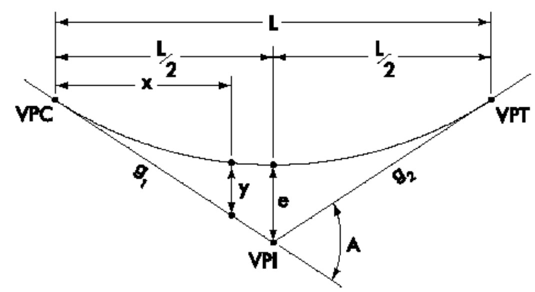
Road curves:

- Distance between curves: not less than 150 feet

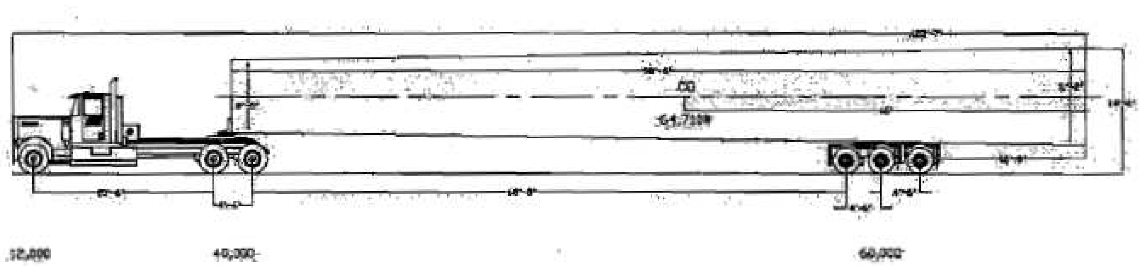
- Minimum allowable inner radius of curve: 150 feet
- Minimum vertical radius; not less than 1,600 feet
- Sag and crest vertical curve design – maintain minimum clearances to accommodate clearance requirements of transport vehicles. For crest vertical curves, a minimum 6” vertical clearance was used. For sag vertical curves, clearance requirements associated with truck overhangs were used (see below).



Crest



Sag



Required internal clear area for curves:

- Less than 20 degree: 0 feet
- 20 to 60 degree: 36 feet
- 60 to 90 degree: 50 feet

T-intersections (80m tower; 44m blade transport):

- Interior turn radius 160 feet preferred
- Tower longest (mid) section requires: interior turn radius of 100 feet
- 44-meter blade requires transport turn interior radius of 136 feet

Road "dead end/turn round":

- Radius: 110 feet for 16-foot wide road
- Turn spur: 210 feet

Wind turbine site:

- Refer to Drawing 11 – Typical Turbine Pad Layout (Page 32)

- Surface: suitable (may require gravel surfacing in some areas) for material lay down, preassembly, secondary/auxiliary crane access, and primary crane lifts, lift preparatory activities, wash/clean equipment, and preassembly of primary crane

Wind turbine site "erection crane pad":
- Refer to Drawing 11 – Typical Turbine Pad Layout (Page 32)
- Pad orientation dependant upon site configuration, location of access road, and erection plan
- Bearing support capacity requirement: crane plus Nacelle @ 80,000Kg
- Level – maximum lateral slope 0.5%

Road composition:
- Design based on fit for service during construction
- Compacted sub grade and granular base material
- Maximize use of local road bed materials such as shale and till materials existing at site
- Surface gravels as required using pit run materials to extent available supplemented with surfacing gravels.
- Ditching, drainage and sediment control

3.0 EROSION AND SEDIMENT CONTROLS DURING CONSTRUCTION

To the extent possible, overland flow will be maintained during and after construction. Accordingly, erosion and sediment control of construction related runoff will primarily be managed through the use of temporary sediment barriers, which essentially consists of mulch berms. Where concentrated flow is unavoidable, temporary sediment traps will be used to trap sediment laden runoff during construction. (Refer to Drawing 10 – Typical Erosion and Sediment Control Measures, Page 31)

Off-site runoff will be collected in diversion channels and conveyed around and through the construction site to minimize the quantity of runoff entering the construction site. Off-site runoff will be conveyed through cross-culverts and re-distributed with level spreaders to create a stable outfall.

All perimeter controls including off-site diversion channels and culverts, sediment barriers, and sediment traps will be installed before commencing earthwork activities. Temporary diversion berms will be used, as necessary, to temporarily direct construction runoff to the traps. Natural, undisturbed vegetative buffers will be maintained down-slope of sediment barriers and traps to further filter out the sediment-laden runoff.

Stabilization during construction will utilize erosion control mix or seeding, as appropriate to each location and weather condition. Detailed information about construction stabilization measures is also provided in Section 3.3. Erosion and sediment control measures will be designed in accordance with State of Maine, Department of Environmental Protection (DEP), Erosion and Sediment Control BMP Manual, March 2003.

3.1 Sediment Trap Design

3.1.1 Storage Requirements

Typically, sediment traps provide a means by which sediment is removed from sediment laden storm water runoff. Typically, storage volumes to trap sediment are 1800 cubic feet (cf) per acre of "wet" or "dry" storage.

Once the storage volumes are computed, the traps are graded out to establish a stage-storage relationship, computed using the following equation.

$$V_{pond} = \sum\left[\left(\frac{A_1 + A_2}{2}\right)\Delta h\right]$$

Where,

V_{pond} = Cumulative storage volume in pond (cf)
A = Contour area measured in AutoCAD for the graded pond (sf)
Δh = Change in elevation between contours (ft)

3.1.2 Spillway Design

To maintain overland flow, the outlets of the sediment traps will consist of a broad-crested weir overflow spillway. The crest of the weir is set at the wet storage elevation. The following equations would be used to compute weir flows at varying water elevations in the traps.

$$Q_{weir} = C_w L H^{3/2}$$

Where,

Q_{weir} = Flow over weir (cfs)
C_w = Discharge coefficient (typically 3.1)
L = Weir length (ft)
H = Head to the weir crest (ft)

3.2 Sediment Barriers (DEP Erosion Control Mix, Mulch Berms)

A sediment barrier is a berm installed across or at the toe of a slope and down gradient of disturbed earth. Its purpose is to intercept and retain small amounts of sediment from disturbed or unprotected areas of limited extent. (For other sediment barrier use, see MDEP BMP handbook section 14.0.) Refer to Drawing 10 – Typical Erosion and Sediment Control Measures, page 31.

The sediment barrier is used where:

- Sedimentation can pollute or degrade a wetland or any other water resource.
- Sedimentation will reduce the capacity of storm drainage systems or adversely flood adjacent areas.

The contributing drainage area does not exceed 1/4 acre per 100 ft of barrier length; the maximum length of slope above the barrier is 100 feet; and the maximum gradient behind the barrier is 50 percent (2:1). If the slope length is greater, additional measures such as diversions may be necessary to reduce that length.

Sediment barriers cannot be used in areas of concentrated flows. Under no circumstances should erosion control mix sediment barriers be constructed in streams or in swales.

SPECIFICATIONS

Erosion control mix can be manufactured on or off the project site. It consists primarily of organic material, separated at the point of generation, and may include: shredded bark, stump grindings, composted bark, or flume grit and fragmented wood generated from water-flume log handling systems. Wood chips, ground construction debris, reprocessed wood products or bark chips are not acceptable as the organic component of the mix. Erosion control mix contains a well-graded mixture of particle sizes and may contain rocks less than 4" in diameter. Erosion control mix must be free of refuse, physical contaminants, and material toxic to plant growth.

COMPOSITION

The mix should have the following composition:

- The organic matter content is between 80 and 100%, dry weight basis.
- Particle size by weight is 100 % passing a 6" screen and a minimum of 70 %, maximum of 85%, passing a 0.75" screen.
- The organic portion needs to be fibrous and elongated.
- Large portions of silts, clays or fine sands are not acceptable in the mix.
- Soluble salts content is less than 4.0 mmhos/cm.
- The pH should fall between 5.0 and 8.0.

INSTALLATION OF SEDIMENT BARRIERS

On slopes less than 5 % or at the bottom of steeper slopes (<2:1) up to 20 feet long, the barrier should be a minimum of 12" high, as measured on the uphill side of the barrier, and a minimum of two feet wide. On longer or steeper slopes, the barrier should be wider to accommodate the additional flow.

The barrier must be placed along a relatively level contour. It may be necessary to cut tall grasses or woody vegetation to avoid creating voids and bridges that would enable fines to wash under the barrier through the grass blades or plant stems.

Good locations for stand-alone use without reinforcement by other BMPs are:

- At toe of shallow slopes;
- On frozen ground, outcrops of bedrock and very rooted forested areas; and
- At the edge of gravel parking areas and areas under construction.

Locations where other BMPs should be used:

- At low points of concentrated runoff;
- Below culvert outlet aprons;
- Where a previous stand-alone erosion control mix application has failed;
- At the bottom of steep perimeter slopes that are more than 50 feet from top to bottom (i.e., a large up-gradient contributing watershed); and
- Around catchbasins and closed storm systems.

CONSIDERATIONS

Sediment barriers should not be used in streams and large drainage ways!
If there is evidence of end flow around installed barriers, extend barriers uphill or consider replacing them with temporary check dams.
Sediment barriers should be installed prior to disturbing soil in the drainage area above them.

MAINTENANCE

The erosion control mix barriers should be inspected regularly and after each large rainfall. Any required repairs should be made immediately, with additional erosion control mix placed on the berm to reach the desired height and width. Failure is typically not catastrophic and is more easily repaired than silt fencing.

If there is any sign of undercutting at the center or the edges, or any sign of impounding large volumes of water behind the barrier, it may be necessary to reinforce the barrier by adding another sediment barrier, such as a temporary rock check dam.
Sediment deposits should be removed when they reach approximately one-half the height of the barrier.

When the barrier is decomposed, clogged with sediment, eroded or ineffective, it must be replaced or repaired. The barrier should be reshaped as needed.

Erosion control mix barriers can be left in place. Any sediment deposits remaining in place after barrier is no longer required should be spread to conform to the existing grade and be seeded and mulched.

In the long-term, vegetation adds stability and will blend in the barrier to the natural environment. Woody vegetation can be planted into the barriers, or they can be over-seeded with legumes.

If the barrier needs to be removed, it can be spread out into the landscape.

3.3 Soil Stabilization

3.3.1 Seed Mixtures

The following seed mixes will be used in disturbed upland areas, as recommended by the Franklin County Soil and Water Conservation District:

For areas below 2300 ft in elevation, the following “conservation mix” is recommended:

Creeping red fescue	18%
Flat pea	52%
Tall fescue	26%
Redtop	4%

For areas greater than 2300 ft in elevation, the following “high elevation cover” seed mixtures is recommended:

Hard fescue	25%
Chewings fescue	17%
Creeping red fescue	17%
Creeping bentgrass	17%
Redtop	7%
Birdsfoot trefoil	14%
White clover (ladino type)	3%

Disturbed wetland areas will be seeded with annual winter rye at 1 lb/1,000 square feet, as necessary. Fertilizer or lime will not be used in wetlands.

3.3.2 Erosion Control Mix For Mulch

Erosion control mix is long-term mulch that creates a good buffer around disturbed sites such as buildings, roads and drainage ways. Erosion control mix can be used as a permanent ground cover, as an overwinter stabilization mulch, or left to naturalize. It is not designed to support grass vegetation, but legumes or woody vegetation may be established to add stability.

Erosion control mix must not be used in areas of concentrated water flows. Evidence of groundwater seepage on slopes may require the erosion control mix to be replaced with riprap.

SPECIFICATIONS

Erosion control mix can be manufactured on or off the project site. It consists primarily of organic material, separated at the point of generation, and may include: shredded bark, stump grindings, composted bark, or flume grit and fragmented wood generated from water-flume log handling systems. Wood chips, ground construction debris, reprocessed wood products or bark chips are not acceptable as the organic component of the mix. Erosion control mix is composed of a well-graded mixture of particle sizes and may contain rocks less than 4" in diameter. Erosion control mix must be free of refuse, physical contaminants, and material toxic to plant growth.

COMPOSITION

The mix composition should have the following composition:

- The organic matter content is between 80 and 100%, dry weight basis.
- Particle size by weight is 100 % passing a 6" screen and a minimum of 70 %, maximum of 85%, passing a 0.75" screen.
- The organic portion needs to be fibrous and elongated.
- Large portions of silts, clays or fine sands are not acceptable in the mix.
- Soluble salts content is less than 4.0 mmhos/cm.
- The pH should fall between 5.0 and 8.0.

INSTALLATION

When used as mulch, the length and steepness of the slope determines the appropriate thickness of the erosion control mix. Erosion control mix is not recommended for 2:1 slopes or greater. For other slopes, the following minimums apply:

- On slopes of 3:1 or less: 2 inches plus an additional 1/2 inch per 20 feet of slope up to 100 feet;
- On slopes between 3:1 and 2:1: 4 inches plus an additional 1/2 inch per 20 feet of slope up to 100 feet.

The thickness of the mulch at the bottom of the slope needs to be:

……………………….< 3:1 slope ....slopes between 3:1 and 2:1
< 20' of slope ....2.0" ....4.0"
< 60' of slope ....3.0" ....5.0"
< 100' of slope ....4.0" ....6.0"

The mulch may be placed with a hydraulic bucket or with a pneumatic blower or by hand. It should be placed evenly to provide 100 % soil coverage, with the soil totally invisible. It can be used as a stand alone reinforcement:

- On slopes 2 horizontal to 1 vertical or less.
- On frozen ground or forested areas.
- At the edge of gravel parking areas and areas under construction.

Other reinforcement BMPs (i.e. riprap) should be used:

- On slopes with groundwater seepage;
- At low points with concentrated flows and in gullies;
- At the bottom of steep perimeter slopes exceeding 100 feet in length (large up-gradient watershed);
- Below culvert outlet aprons; and
- Around catch basins and closed storm systems.

MAINTENANCE

The mulched area should be inspected regularly and after each large rainfall. Any required repairs should be made immediately, with additional erosion control mix placed on top of the mulch to reach the recommended thickness. When the mix is decomposed, clogged with sediment, eroded or ineffective, it must be replaced or repaired. Erosion control mix mulch should be left in place. Vegetation adds stability and should be promoted. If the mulch is removed, it should be spread out into the landscape.

OTHER USES

Besides use for temporary/semi-permanent stabilization of slopes, erosion control mix has been used successfully in many applications. It has been used on nature trails to establish a stable base that is resistant to foot traffic and to stabilize areas covered with snow and that may erode with the spring thaw. It has also been used in construction yards to mitigate the mud.
In these applications, the erosion control mix application rate will need to be adjusted for the site conditions, use and long-term effectiveness. With time, the organic component of the erosion control mix will decompose and become ineffective. Thus, the blanket of erosion control mix must be adjusted for composition and thickness. Any required

repairs should be made immediately, with additional erosion control mix placed on top to reach the desired thickness.

4.0 POST-CONSTRUCTION STORMWATER CONTROLS

4.1 Basic, General, and Flooding Standards

In accordance with the Maine DEP Chapter 500 Rules, there are five categories of stormwater standards that could apply to projects disturbing one (1) acre or more: basic, general, flooding, and/or urban impaired stream. There are no urban impaired streams in Franklin County so this standard would not apply. However, all three standards apply to projects involving 3 acres or more of impervious area or 20 acres or more of developed area.

The *Basic Standard* consists of erosion and sedimentation control measures during construction, inspection and maintenance, and housekeeping. Refer to Section 3.0. The *General Standard* applies best management practice (BMP) and phosphorus standards to address post-construction water quality. The *Flooding Standard* mitigates for post-construction increases in peak runoff flow rates for the 2-, 10-, and 25-year/24-hour storms.

The *"general"* standard will be applied for post-construction water quality by by directing on-site runoff through vegetated buffers via overland (sheet) flow where possible. Where concentration is unavoidable, flow will be re-distributed through level spreaders and released through vegetative buffers with the shortest practical spacing. Frequent release of off- and on-site runoff will sometimes not be feasible, particularly along roadway switchbacks and along longer sections of cut slopes on both sides of the road. In such cases, flow splitters/overflow weirs will be placed along the channels to distribute the concentrated flow before releasing the stormwater over level spreaders. (Refer to Drawing 4 – Typical Road Plan/Section – All Cut in Section 6.0). The general phosphorous standard is discussed in Section 4.2 below.

To address the *“flooding”* standard, a hydrologic analysis was conducted for the 2-, 10-, and 25-year/24-hour storms. Fifteen out of the seventeen study areas either had slight increases of approximately 1% or less or actually decreases in peak flow rates. Decreases in peak flow rates typically occurred due to increased time of concentration created by channel diversions. Preliminary modeling indicated that one area in Series A (Study Point A-4) and another area in Series B (Study Point B-12) had increases of approximately 4.6% and 9.1%, respectively. As the design progresses, time of concentrations will further increase by accounting for the re-distribution of flow through level spreaders; the affects of which on time of concentration and peak flow rates was not yet considered in the modeling. Furthermore, a portion of the 34-foot gravel turbine roads will be overlaid with a mixture of mulch and soil to promote vegetative growth and further reduce runoff. The affects of this reduced runoff on peak flow rates was also not yet considered in the modeling. It is anticipated that, once these two factors are included in the model, peak flow rates will further decrease to or below that for existing conditions.

The methodology and criteria for the stormwater components are provided below. The Natural Resources Conservation Service (NRCS) Technical Release 55 (TR-55), Urban Hydrology for Small Watersheds, was used to compute parameters, including *time of concentration* (Tc) and *runoff curve numbers* (RCN), needed to conduct the hydrologic analyses that was used to design the channels and culverts and to compute the pre- and post-development peak discharge values at design points.

Other parameters included *24-hour rainfall depths*, *temporal rainfall distribution*, and *drainage area*. 24-hour rainfall depths were obtained from the NRCS for Franklin County, Maine. The standard NRCS Type II rainfall distribution was applied in the model to establish the temporal distribution of each design storm. Drainage boundaries for existing conditions were obtained from existing topographic mapping. Drainage boundaries for developed conditions were obtained from the project site grading and drainage plan. *Antecedent moisture condition II* was assumed for both existing and developed conditions.

4.2 Phosphorous Removal

Ensuring appropriate phosphorus removal in project stormwater is important, especial when drainage contributes to lake watersheds. As noted in Section 8.1, the project Kibby Range (B-Series) ridgelines are within the watersheds of two lakes, Jim Pond and Flagstaff Lake, and therefore, the issue of phosphorus control has been specifically addressed.

The Jim Pond Watershed has a total watershed area of approximately 12,880 acres. The total project construction area within this watershed (excluding the 115 kV transmission line, discussed in Volume III) represents approximately 0.84 percent of the watershed area. The total acreage of land optioned by the project from Plum Creek (and, thus, over which TransCanada will have control) is approximately 7 percent of the watershed area.

The Flagstaff Watershed has a total watershed area of approximately 241,820 acres. The project construction area within this watershed is approximately 0.04 percent of the total watershed area, with the optioned property representing about 0.24 percent of the watershed area.

Although the project will not contribute significantly to flows within the watershed, the project has been designed with phosphorus control in mind through the use of vegetated buffers. Vegetated buffers are effective for phosphorus removal when designed in accordance with the BMP manual. For the Kibby Wind Power project, three types of vegetated buffers will be employed as part of the stormwater management plan, depending upon the specific location and use: a buffer with a stone-bermed level lip spreader; a buffer adjacent to the downhill side of a roadway; and a ditch turn-out buffer.

The effectiveness of these buffers depends on the buffer flow path length (or width), buffer slope, hydrologic soils class, size of drainage area, and density of vegetation (woods or meadow). Above all, the vegetated buffer dimensions must be protected and maintained. In order to successfully maintain these project buffers, adequate land must be available within the project property boundaries to provide buffer flow path length meeting the BMP Manual Design Standards. Any buffers that extend beyond the project property boundaries are at risk of being encroached by logging or development activities.

To determine if the Kibby Wind Power project property provides an adequate amount of land for effective vegetated buffers, an initial assessment was performed. For final design, the dimension and type of vegetated buffers will vary throughout the project site depending on the outfall conditions.

Preliminary calculations were conducted to determine the quantity of phosphorus (in pounds) available for algae growth in the Jim Pond and Flagstaff watersheds exported from the project. Standard export rates from DEP were used for grass and gravel roadway cover (Table 1).

Table 1-Standard Phosphorus Export Rates

LAND SURFACE (TYPE)	EXPORT PRE-TREATMENT (#/acre)
Lawn HSG A	0.30
Lawn HSG B	0.65
Lawn HSG C	0.97
Lawn HSG D	1.10
Road Ditch	1.00
Road Surface/Parking	3.50
Other Impervious Surfaces	2.00

A calculation was then performed to determine the weighted treatment factor for the vegetative buffers, a value from 0 to 1, located just down-slope of fill areas and level spreaders. The buffer treatment factor is a function of slope, soil type, and width. DEP provides standard treatment factors for slopes ranging from 0% - 3%, 3% - 8%, 8% - 15%, and 15% - 30% depending on the hydrologic soil group (HSG) and buffer width. Slopes over 30% do not provide a significant treatment of phosphorus. A slope analysis was conducted for a 250’ wide area adjacent to the project. Areas were computed for each of the above slope categories to determine an overall weighted treatment factor for Jim Pond and Flagstaff watersheds. Refer to Table 2 and Table 3 for respective detailed calculations and Figure 1 – Slope Map in Vegetative Buffer Areas (in support of the Phosphorus Export Calculation in Series B) in Section 7.0.

Table 2-Phosphorus Export Calculation for the Jim Pond Watershed (Series B)

LAND SURFACE (TYPE)	AREA acre(s)	EXPORT PRE-TREATMENT #/acre	WEIGHTED TREATMENT FACTORS* (buffers)	PHOSPHORUS EXPORT #
Gravel (permanent)	12.94	3.50	0.408	18.48
Grass & mulch stabilized areas	57.83	0.97	0.408	22.89
Roadside channels (riprap & grass)	5.50	1.00	0.408	2.24
Total	*76.27*		*Total*	*43.61*
* Weighted for slopes between 0% and 30% with HSG C, 250' width, and rock > 16" deep.			*Correction Available for Algae*	***21.81***
			Maximum Allowable	***30.10***

Table 3-Phosphorus Export Calculation for the Flagstaff Watershed (Series B)

LAND SURFACE (TYPE)	AREA acre(s)	EXPORT PRE-TREATMENT #/acre	WEIGHTED TREATMENT FACTORS* (buffers)	PHOSPHORUS EXPORT #
Gravel (permanent)	11.41	3.50	0.409	16.34
Grass & mulch stabilized areas	21.27	0.97	0.409	8.44
Roadside channels (riprap & grass)	4.83	1.00	0.409	1.98
Total	*37.52*		*Total*	*26.76*
* Weighted for slopes between 0% and 30% with HSG C, 250' width, and rock > 16" deep.			*Correction Available for Algae*	***13.38***
			Maximum Allowable	***26.44***

As indicated in Table 2 and Table 3, the computed export rates, after treatment, for Jim Pond and Flagstaff are 21.8 and 13.4 pounds, respectively. The corresponding allowable export rates provided by DEP are 30.1 and 26.4 pounds, respectively. Therefore, according to the preliminary calculations, the project is not exporting more phosphorus than is permitted.

4.3 Level Spreaders

As indicated previously, the use of level spreaders is a key component of the stormwater design. They have one of two functions:

1. Create a stable (non-erosive) outfall for conveying off-site runoff by re-distributing flow. This also provides some mitigation for impacts to peak flow rates due to increased runoff. To protect downstream areas from erosion, the lengths of the level spreaders with this function will be designed to pass flow between

approximately 0.3 cfs/ft to 1.0 cfs/ft, depending on the downstream slopes, corresponding to the 10-year peak flow rate.

2. Re-distribute concentrated flow from on-site areas through vegetative buffers to provide water quality treatment as required by the General and Phosphorus Standards. Beyond simply creating a stable outfall, as in the first function, the lengths of the level spreaders will be designed based on 100' per 1 acre of drainage area. A more distributed flow is needed to receive water quality treatment credit from the downstream vegetative buffer.

Where possible, the roadways and turbine pads were graded such that runoff from on-site areas would pass through the buffers via overland flow, minimizing the need for level spreaders. Where flow concentration could not be avoided, level spreaders will be designed to satisfy the criteria in item 2 above. Particular consideration was given to those areas where, due primarily to horizontal and vertical geometric constraints of the roadway design, longer runs of collector channels were needed because of long sections of road with cut slopes on both sides. Refer to Figure 2 – Cut and Fill Map (Series A) and Figure 3 – Cut and Fill Map (Series B) in Section 7.0. During final design, the roadway geometry will be fine tuned to reduce these occurrences. However, avoiding this condition completely is unlikely.

In such cases, cut limits generally range between 40 and 80 feet wide across the road section. Therefore, for 1-acre of runoff and 100' of level spreader, the channel length should be limited to approximately 500' to 700' before turning out into a level spreader. The width of the footprint in cut sections will likely be reduced by steepening cut slopes, pending a detailed geotechnical investigation; thus allowing the channels to extend longer before entering a level spreader. Nevertheless, if a long section of road with cut slopes on both sides is unavoidable, causing an accumulation of flow in the collection channel higher than what should go into a single level spreader, multiple level spreaders will be used. Overflow weirs will be installed along the channel to split off some of the flow to multiple level spreaders as illustrated in Drawing 4 – Typical Road Plan/Section – All Cut.

4.4 Conveyance Channels

Conveyance channels were designed for the 10-year peak discharge. Preliminary channel size and lining type were determined using the North American Green (NAG) channel design software, which is based on the Federal Highway Administration (FHWA), Hydraulic Engineering Circular No. 15 (HEC-15), "Design of Channels with Flexible Linings". The two primary objectives were to size the channels (i.e. bottom width and minimum depth at 0.25' of freeboard) and determine the appropriate lining type to protect the channel from erosion. Most of the channels are stable with un-reinforced vegetation or vegetation reinforced with synthetic lining.

4.5 Culverts

Several culverts are included in the project to help distribute off-site runoff across the roadways and convey runoff through embankments. The culverts should be corrugated metal (CMP) or high-density polyethylene (HDPE) circular pipe.

Culverts were designed for the 10-year storm using inlet/outlet control procedures defined in FHWA's Hydraulic Design Series No. 5 (HDS-5). The inlet and outlet control equations in HDS-5 were used to develop the culvert design spreadsheet in MS Excel. Culvert sizes were selected such that the 10-year headwater elevation is within approximately 1' from the top of culvert. Culverts that are crossing beneath access roads were designed assuming a minimum 18" to 24" of cover to the top of road. As such, they were sized to pass the 10-year storm providing a minimum 0.5' of freeboard to the top of road on the upstream side. That is, the maximum headwater depth over the crown would be no more than 12" to 18". Refer to Drawing 6 – Typical Culvert Outfall/Level Spreader (Page 27) and Drawing 9 – Typical Culvert Outlet Protection/Energy Dissipation(Page 30) regarding the design of the receiving drainage system downstream of culverts.

5.0 REFERENCES

- ✓ State of Maine, Department of Environmental Protection (DEP), Chapter 500 Rules, Stormwater Management, Revised November 16, 2005 and December 7, 2006.
- ✓ State of Maine, Department of Environmental Protection (DEP), Stormwater Management for Maine, Volume I – Stormwater Management Manual, January 2006.
- ✓ State of Maine, Department of Environmental Protection (DEP), Stormwater Management for Maine, Volume III – BMPs Technical Design Manual, January 2006.
- ✓ State of Maine, Department of Environmental Protection (DEP), "Phosphorous Control in Lake Watersheds: A Technical Guide for Evaluating New Development." 1992
- ✓ State of Maine, Department of Environmental Protection (DEP), Erosion and Sediment Control BMP Manual, March 2003.

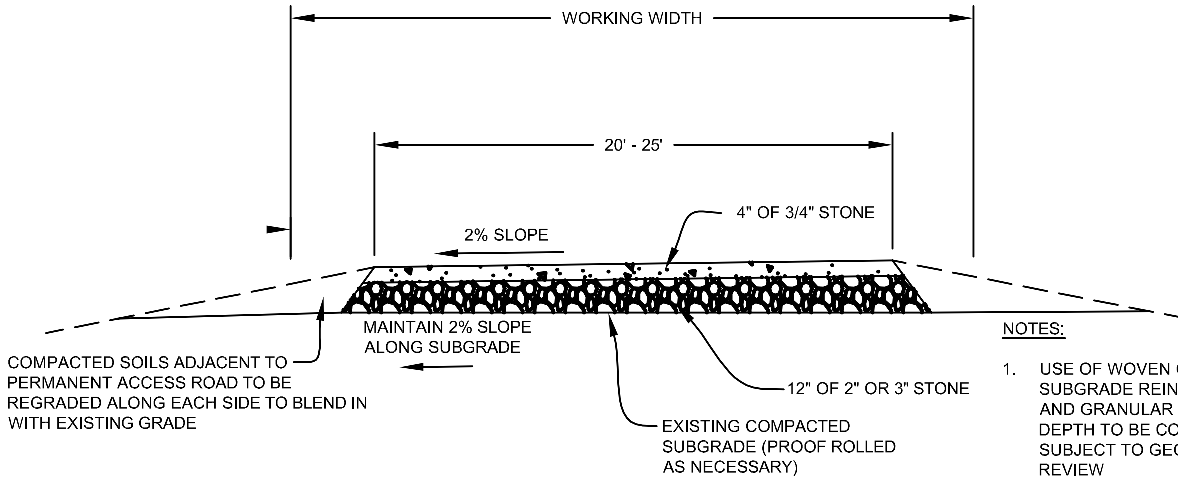
- ✓ Maine Land Use Regulation Commission, Chapter 10 of the Commission's Rules and Standards, November 7, 2005.
- ✓ US Department of Agriculture, National Resources Conservation Service, Technical Release 55, *Urban Hydrology for Small Watersheds*, June 1986
- ✓ US Department of Agriculture, Natural Resources Conservation Services – Maryland, *Conservation Practice Standard, Pond, Code 378*, January 2000
- ✓ Federal Highway Administration, Hydraulic Engineering Circular No. 15, *Design of Roadside Channels with Flexible Lining*
- ✓ Federal Highway Administration, Hydraulic Design Series No. 5, *Culvert Design*

6.0 CONSTRUCTION MEASURES

Given the hydrology of the site, special design emphasis was placed on handling of surface runoff and subsurface drainage. In general, surface runoff will be handled by maintaining overland flow where possible and re-establishing overland flow where concentration of surface runoff is necessary through the use of level spreaders. For subsurface drainage, measures are proposed to maintain subsurface drainage across the construction zone where cuts are occurring in areas of shallow groundwater to reduce potential for the creation of new seeps or springs. Such measures include a "rock sandwich" drainage blanket as well as a series of drainage trenches. Other construction measures are identified on the following Drawings 1 through 11, covering a variety of site conditions and these measures will be applied as required to suit the terrain.

Typical road sections as well as special fill and cut methods, typical roadway drainage controls, typical culvert details and stream crossing methods are illustrated herein. Typical erosion control measures are also shown.

An engineer will be present on site to determine the most appropriate measures to utilize based on both the terrain and the actual site conditions at the time of construction.

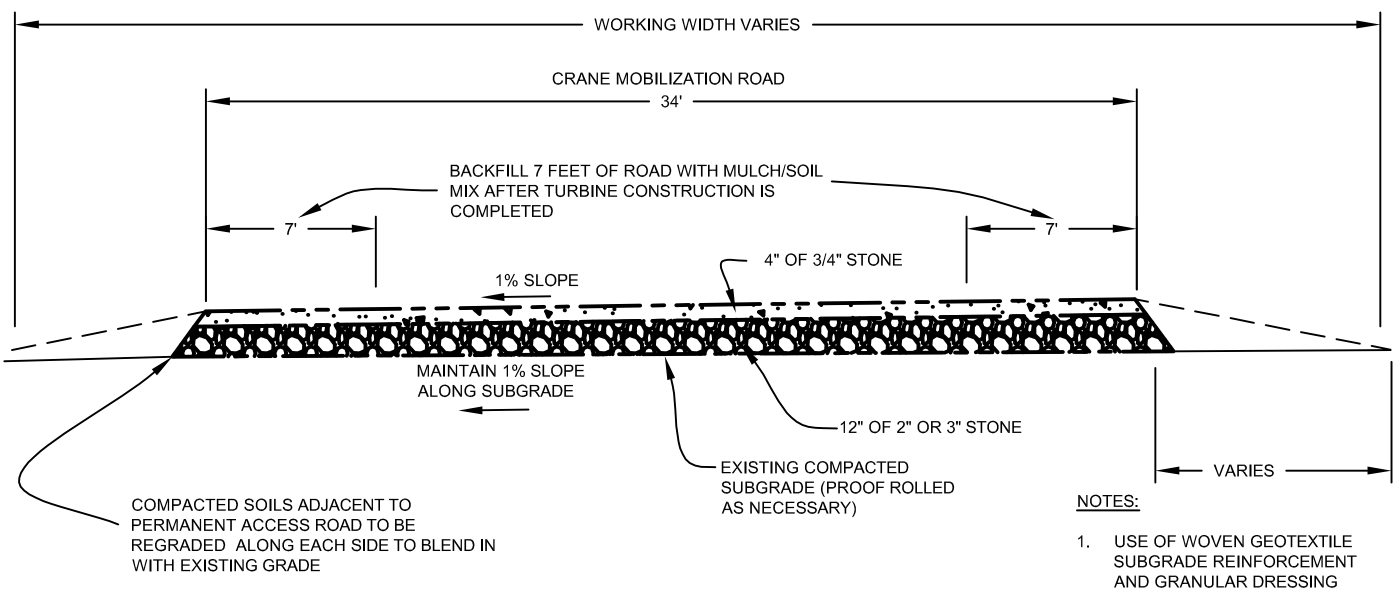


NOTES:

1. USE OF WOVEN GEOTEXTILE SUBGRADE REINFORCEMENT AND GRANULAR DRESSING DEPTH TO BE CONFIRMED SUBJECT TO GEOTECHNICAL REVIEW
2. ORIGINAL DRAINAGE PATTERNS WILL BE MAINTAINED TO THE SATISFACTION OF THE LANDOWNER.
3. ACCESS ROADS ARE TYPICALLY 20 FEET WIDE BUT MAY BE WIDER TO ACCOMODATE CURVES AND OTHER SPECIAL CONDITIONS.

TYPICAL ACCESS ROAD CROSS SECTION

(NOT TO SCALE)



NOTES:

1. USE OF WOVEN GEOTEXTILE SUBGRADE REINFORCEMENT AND GRANULAR DRESSING DEPTH TO BE CONFIRMED SUBJECT TO GEOTECHNICAL REVIEW
2. ORIGINAL DRAINAGE PATTERNS WILL BE MAINTAINED TO THE SATISFACTION OF THE LANDOWNER.

TYPICAL TURBINE ROAD CROSS SECTION

(NOT TO SCALE)

REF: WHITE CONSTRUCTION, INC., ROADS AND TRANSPORTATION SPECIFICATIONS, SECTION 6 (MODIFIED)

Kibby Wind Power Project
Franklin County, Maine

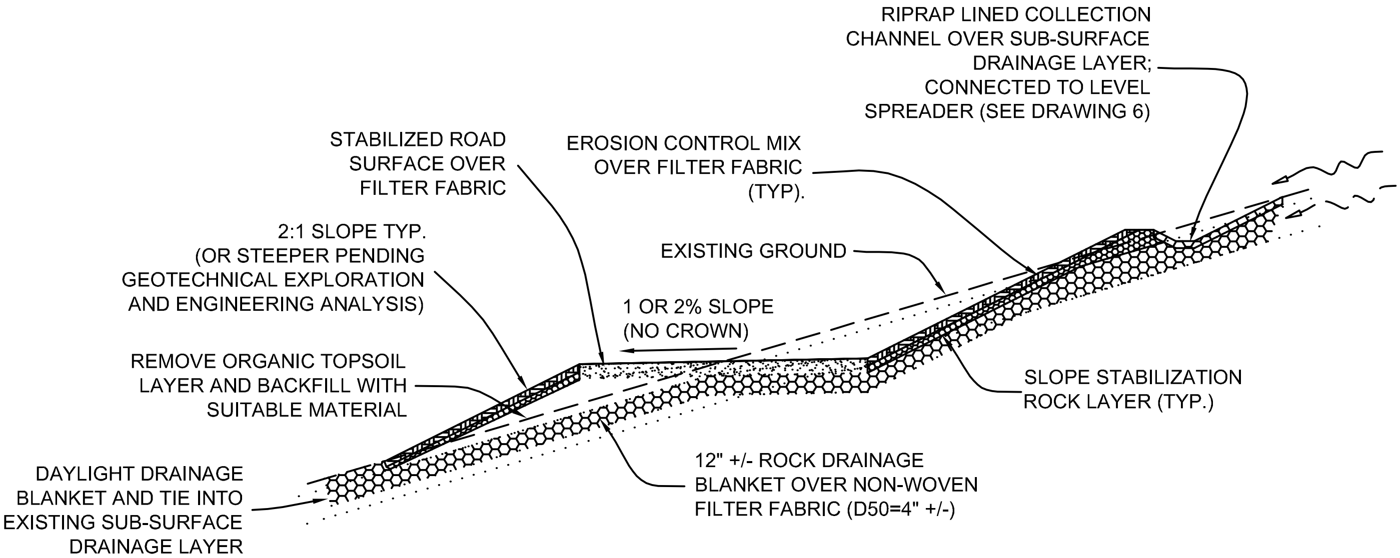
Original: 11-28-06
Revision 1: 12-05-06
Revision 2: 12-19-06
Revision 3: 03-23-07

Typical Road Sections

amec

EARTH & ENVIRONMENTAL, INC.
ONE PLYMOUTH MEETING, SUITE 850
PLYMOUTH MEETING, PA 19462-1308

Drawing 1



(NOT TO SCALE)

Note: The above drawing represents a situation where the roadway cuts into an existing slope with shallow groundwater; which may be managed using the drainage blanket or trench drains. These measures would not be necessary if the roadway does not cut into the subsurface drainage layer.

Kibby Wind Power Project

Franklin County, Maine

Original: 11-28-06
Revision 1: 12-05-06
Revision 2: 12-19-06

Road Traversing Existing Slope with Shallow Ground Water (Drainage Blanket)

amec

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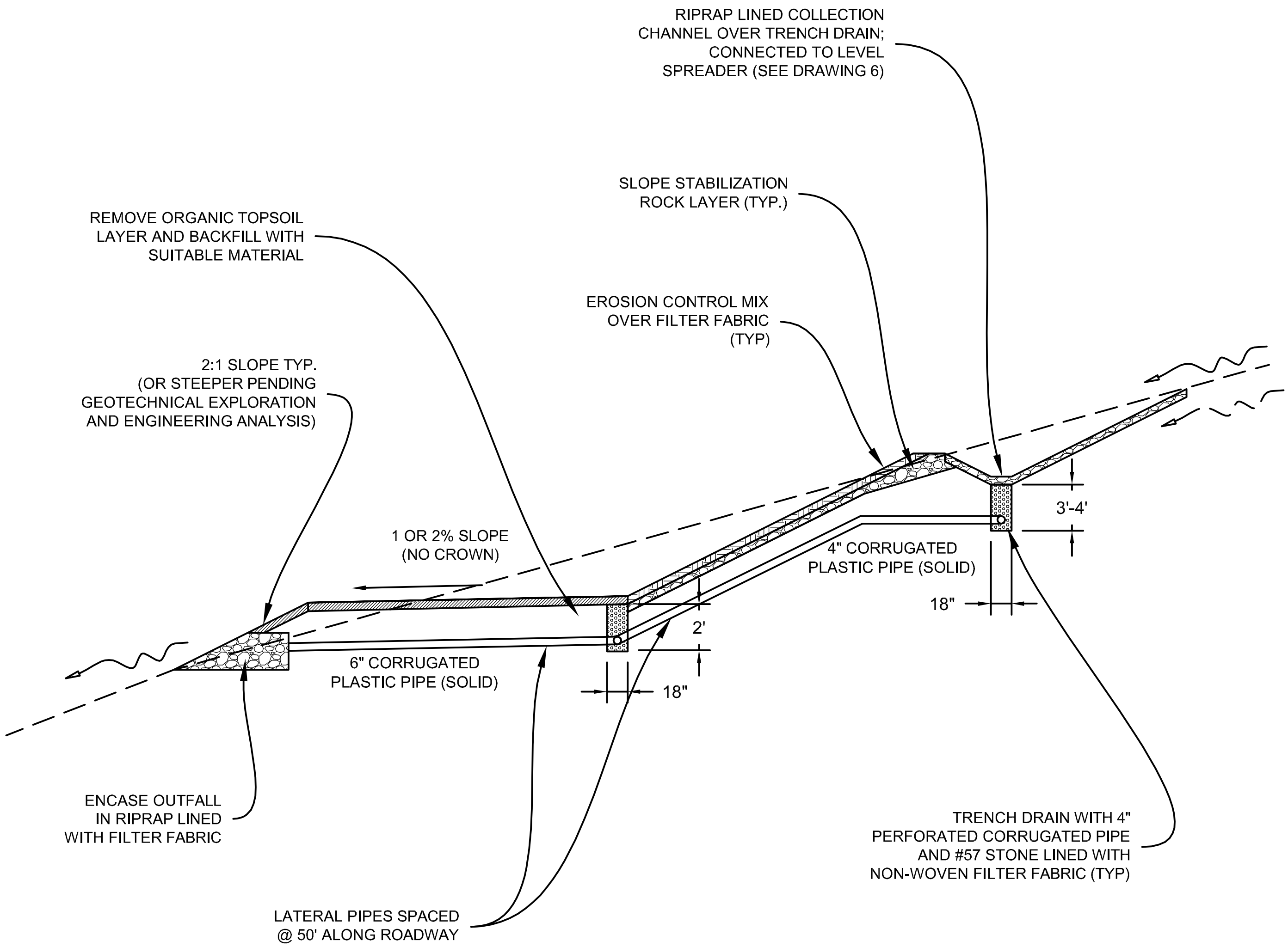
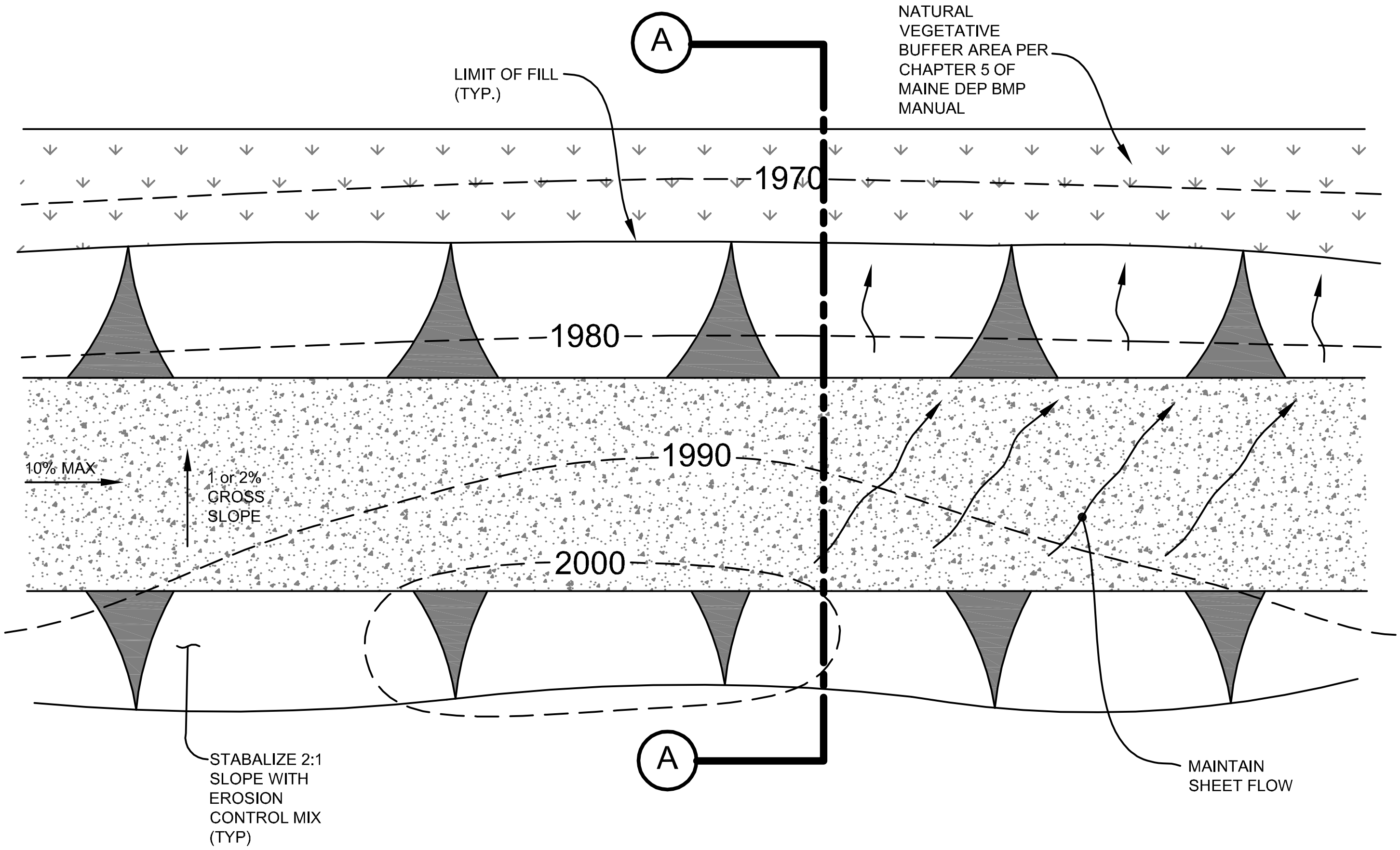
ONE PLYMOUTH MEETING, SUITE 850
PLYMOUTH MEETING, PA 19462-1308

Drawing 2A



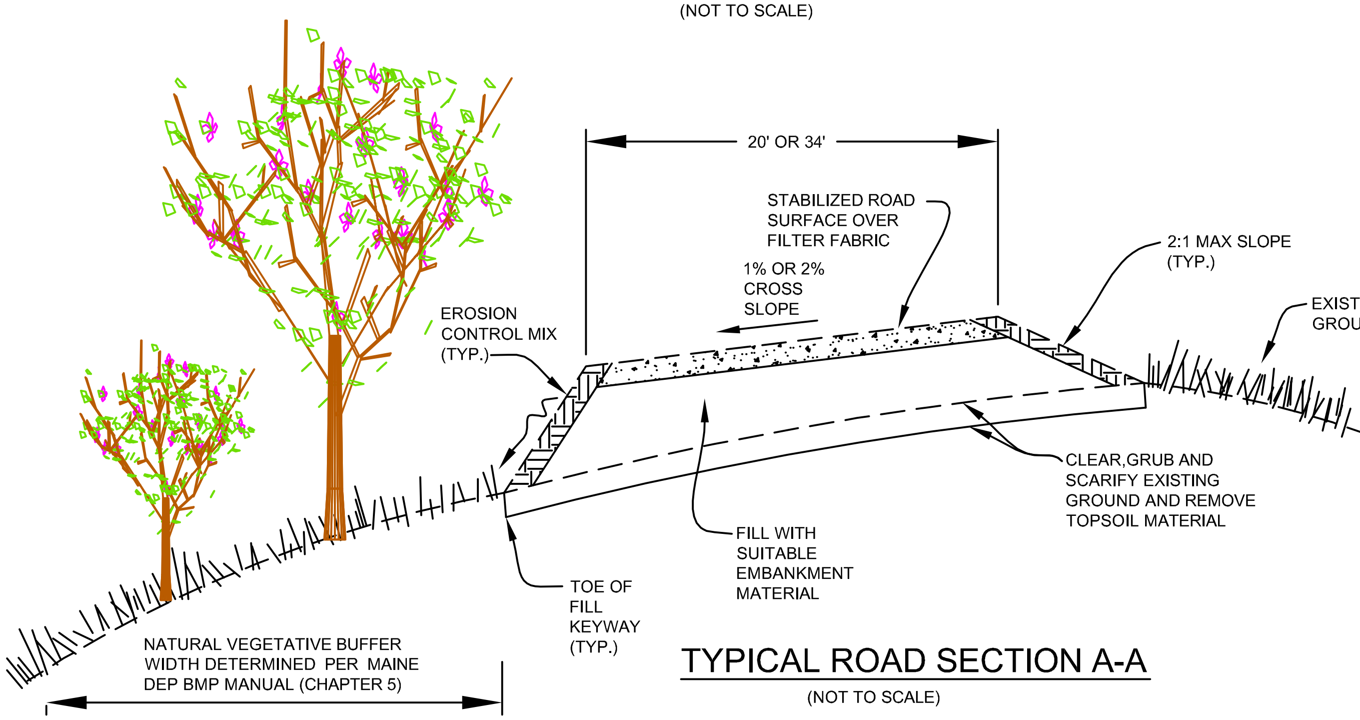
Note: The above drawing represents a situation where the roadway cuts into an existing slope with shallow groundwater; which is managed using the drainage blanket or trench drains. These measures would not be necessary if the roadway does not cut into the subsurface drainage layer.

Kibby Wind Power Project **Franklin County, Maine** Original: 12-19-06	**Road Traversing Existing Slope with Shallow Ground Water (Trench Drains)**	amec EARTH & ENVIRONMENTAL, INC. ONE PLYMOUTH MEETING, SUITE 850 PLYMOUTH MEETING, PA 19462-1308 Drawing 2B



TYPICAL ROAD PLAN

(NOT TO SCALE)

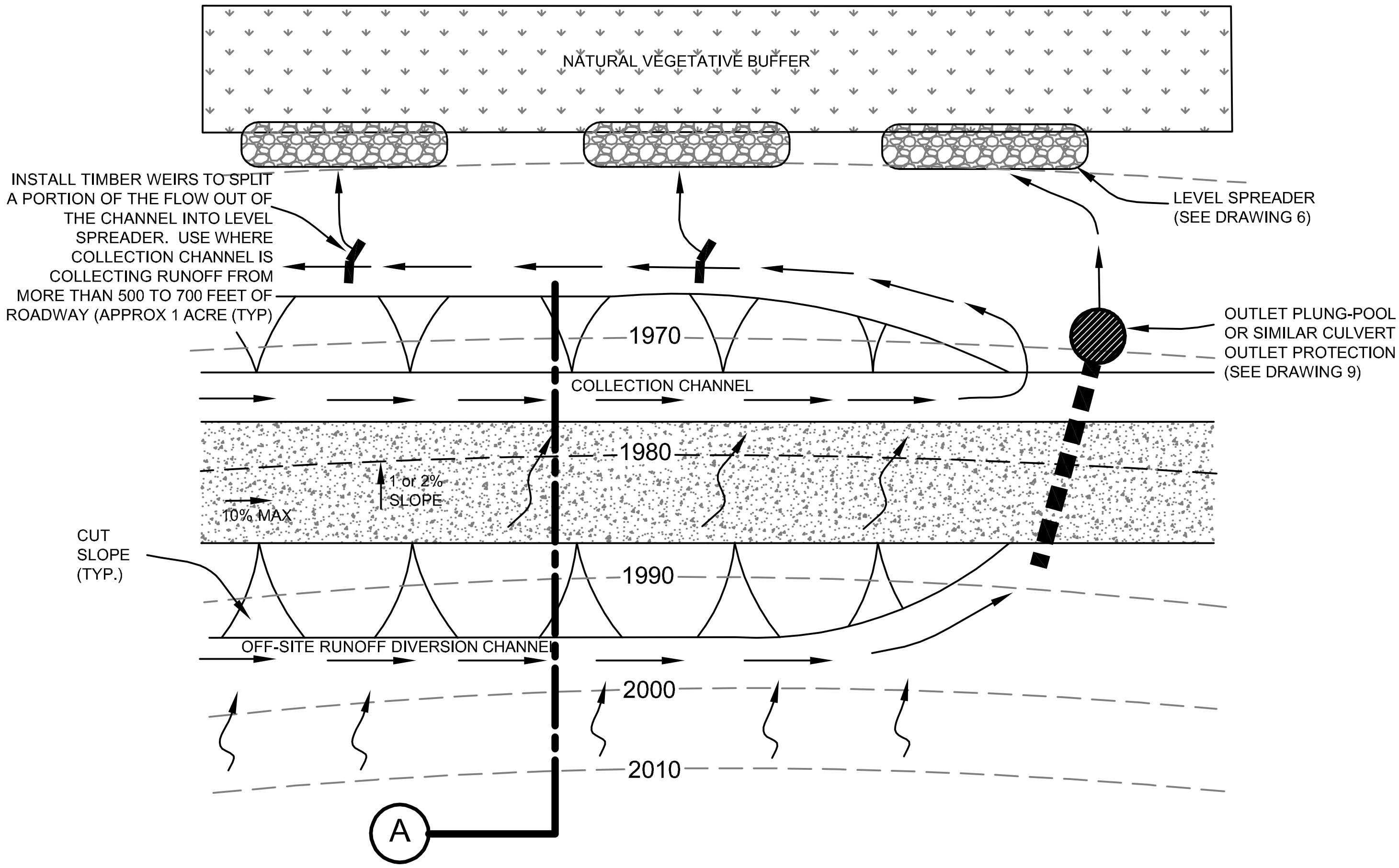


TYPICAL ROAD SECTION A-A

(NOT TO SCALE)

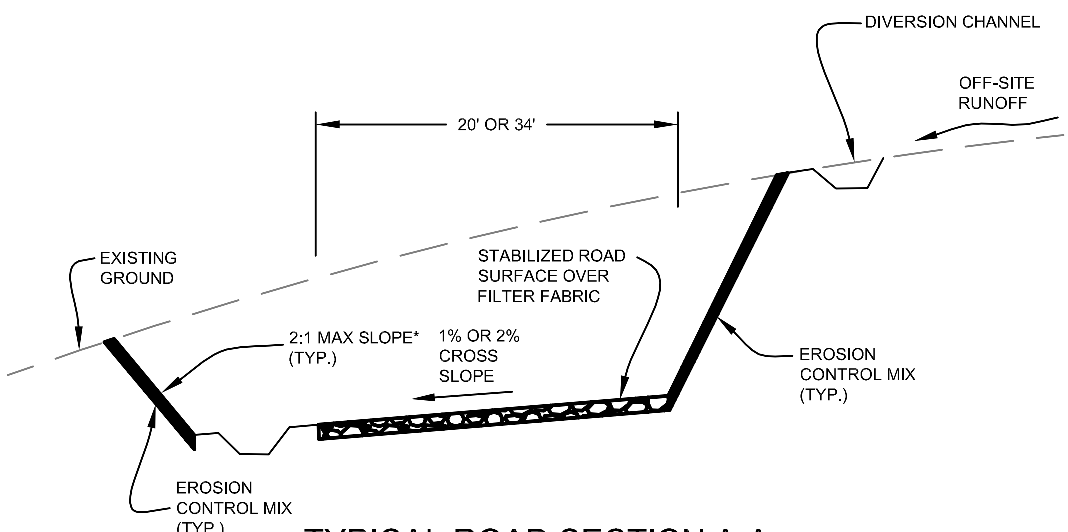
*FILL STROKES CAN BE MADE STEEPER PENDING GEOTECHNICAL EXPLORATION AND ENGINEERING ANALYSIS

Kibby Wind Power Project **Franklin County, Maine** Original: 11-28-06 Revision 1: 12-05-06	**Typical Road Plan/ Section - All Fill**	amec EARTH & ENVIRONMENTAL, INC. ONE PLYMOUTH MEETING, SUITE 850 PLYMOUTH MEETING, PA 19462-1308 Drawing 3



TYPICAL ROAD PLAN

(NOT TO SCALE)



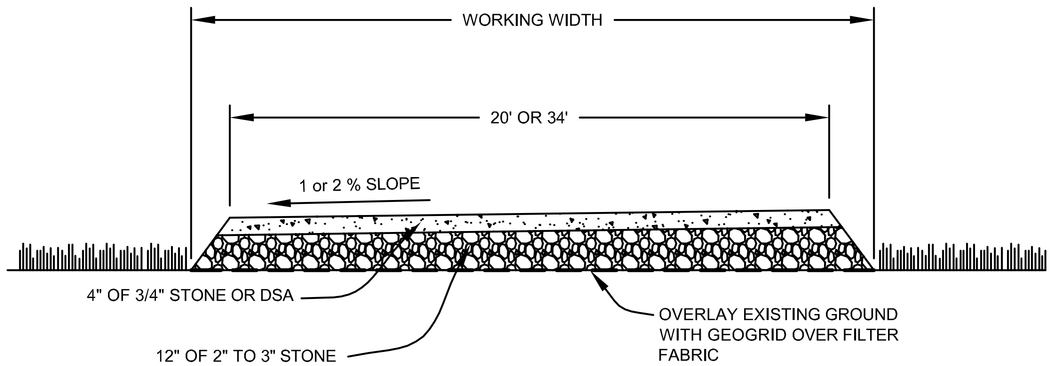
TYPICAL ROAD SECTION A-A

(NOT TO SCALE)

*CUT SLOPES MAY BE MADE STEEPER PENDING GEOTECHNICAL EXPLORATION AND ENGINEERING ANALYSIS

**IF ROADWAY CUTS INTO GROUNDWATER, MEASURES TO CONTROL / MANAGE SUBSURFACE DRAINAGE MAY BE REQUIRED

Kibby Wind Power Project **Franklin County, Maine** Original: 11-28-06 Revision 1: 12-05-06 Revision 2: 03-23-07	**Typical Road Plan/ Section - All Cut**	amec EARTH & ENVIRONMENTAL, INC. ONE PLYMOUTH MEETING, SUITE 850 PLYMOUTH MEETING, PA 19462-1308 Drawing 4



(NOT TO SCALE)

Kibby Wind Power Project

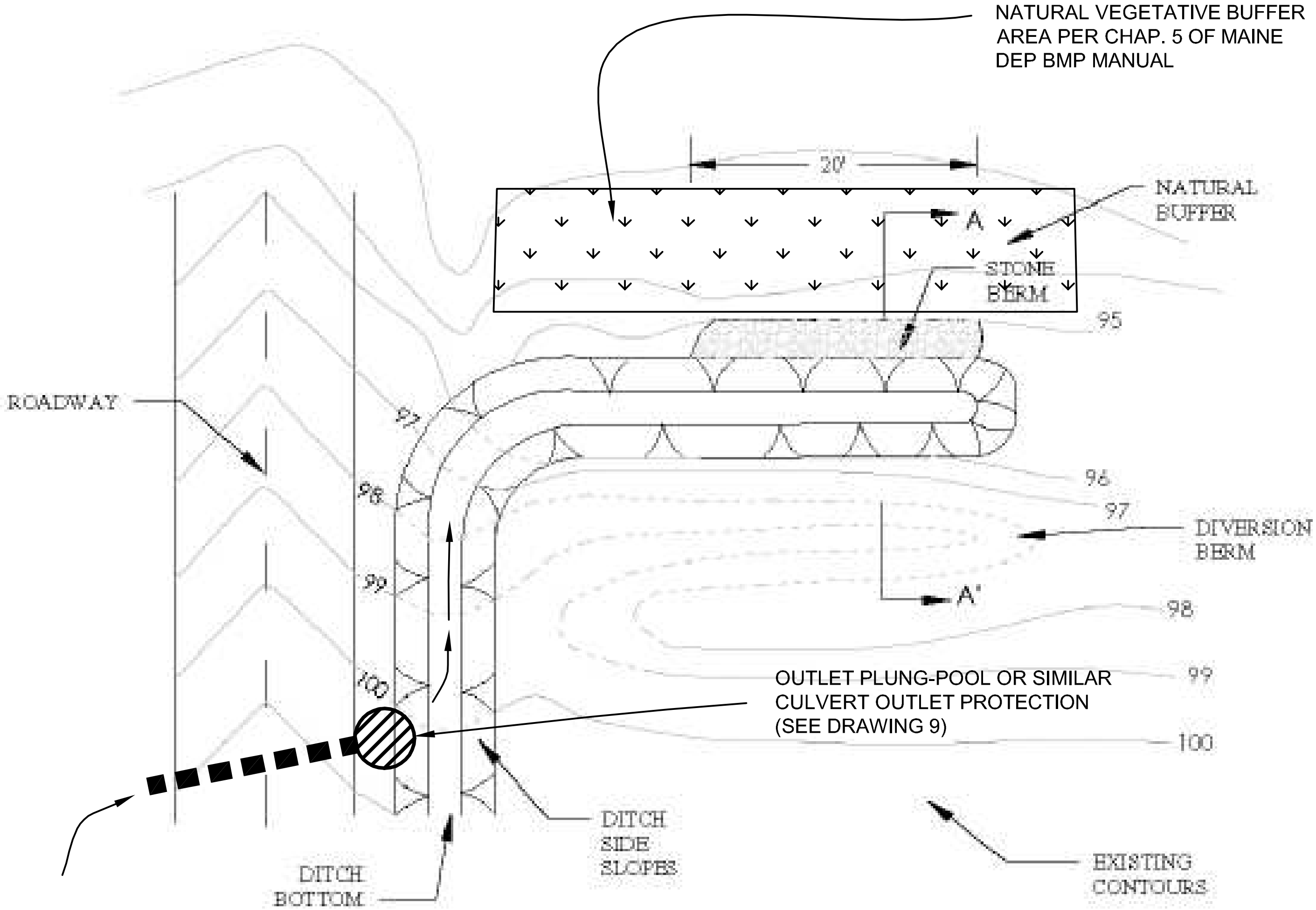
Franklin County, Maine

Original: 11-28-06
Revision 1: 12-05-06

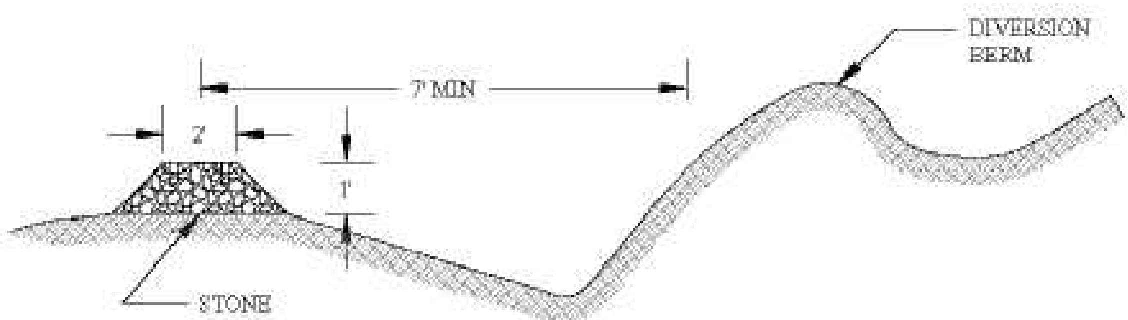
Typical Road Section when Crossing Wet Areas

EARTH & ENVIRONMENTAL, INC.
ONE PLYMOUTH MEETING, SUITE 850
PLYMOUTH MEETING, PA 19462-1308

Drawing 5



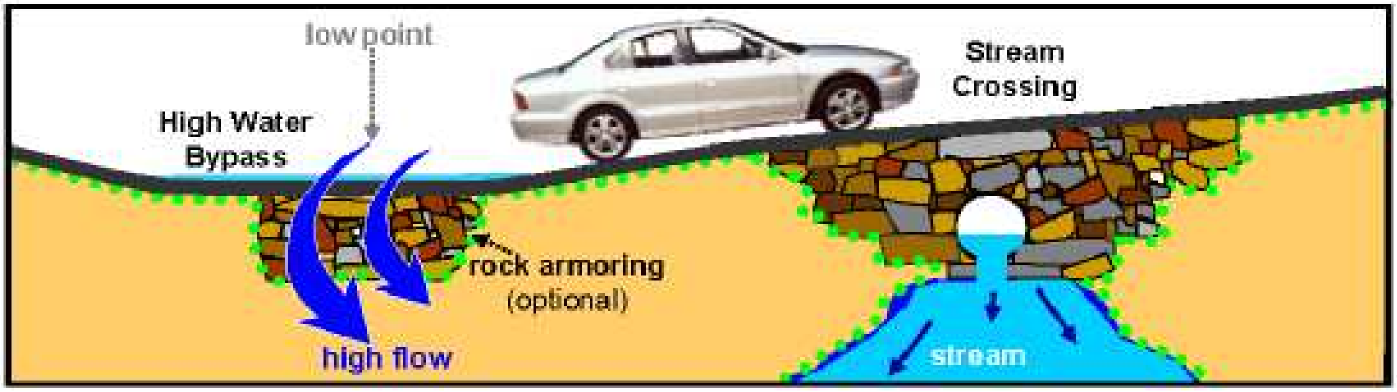
PLAN VIEW
(NOT TO SCALE)



CROSS SECTION A-A
(NOT TO SCALE)

REF: MAINE DEPT. OF ENVIRONMENTAL PROTECTION, BMP TECHNICAL DESIGN MANUAL VOLUME 3 CHAPTER 5.

Kibby Wind Power Project **Franklin County, Maine** Original: 11-28-06 Revision 1: 12-05-06	**Typical Culvert Outfall/ Level Spreader**	amec EARTH & ENVIRONMENTAL, INC. ONE PLYMOUTH MEETING, SUITE 850 PLYMOUTH MEETING, PA 19462-1308 Drawing 6



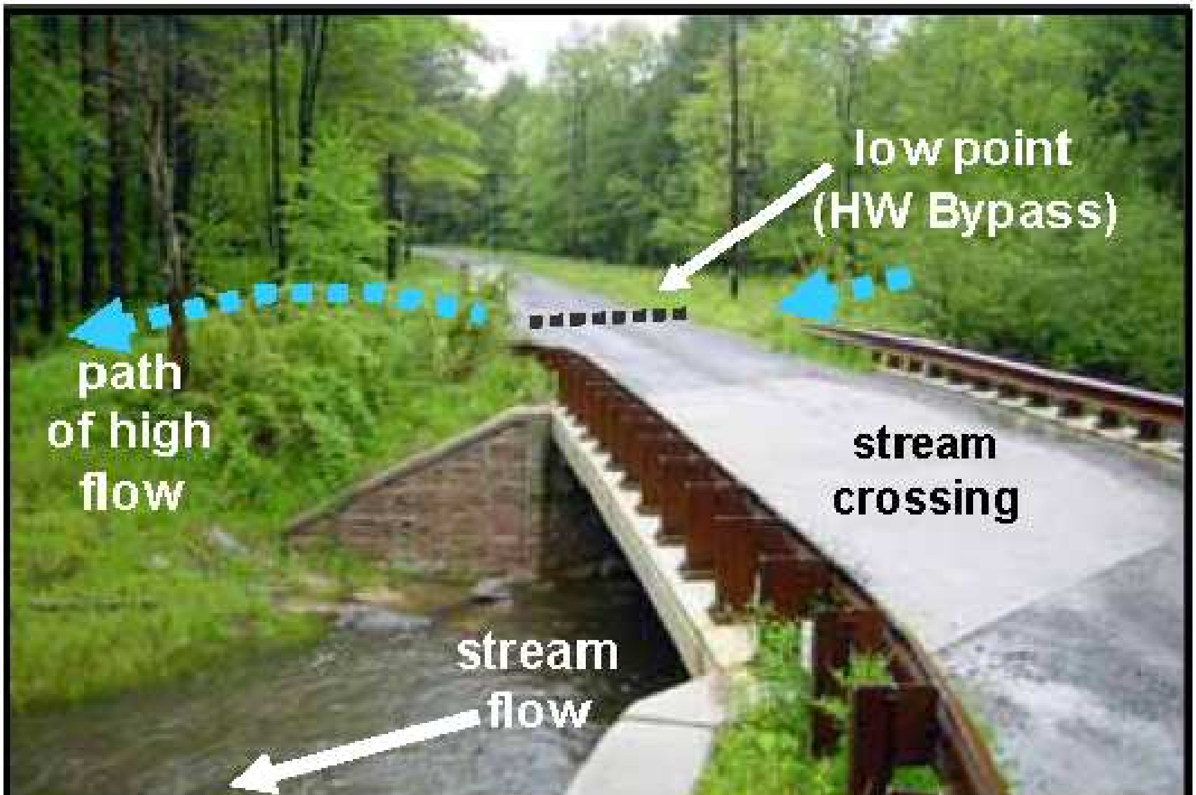
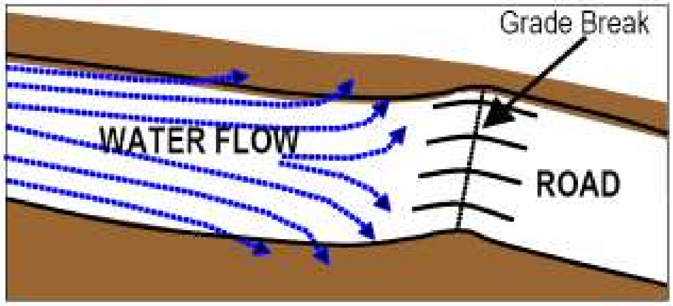
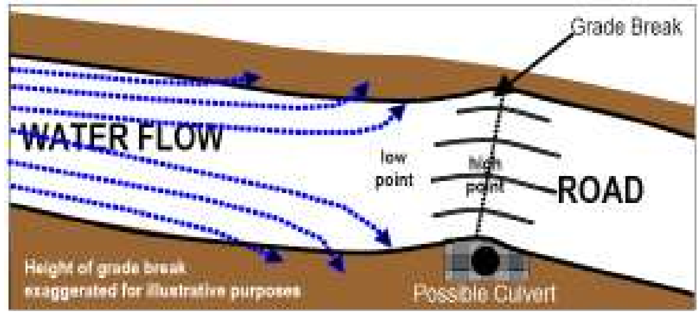


Photo 1: The low point in the above site is away from the stream. Little reinforcement was needed at this site because of the relatively flat terrain.

REF: PENN STATE CENTER FOR DIRT GRAVEL ROAD STUDIES, TECHNICAL BULLETIN.

Kibby Wind Power Project **Franklin County, Maine** Original: 11-28-06 Revision 1: 12-05-06	**Typical Stream Crossing**	amec EARTH & ENVIRONMENTAL, INC. ONE PLYMOUTH MEETING, SUITE 850 PLYMOUTH MEETING, PA 19462-1308 Drawing 7

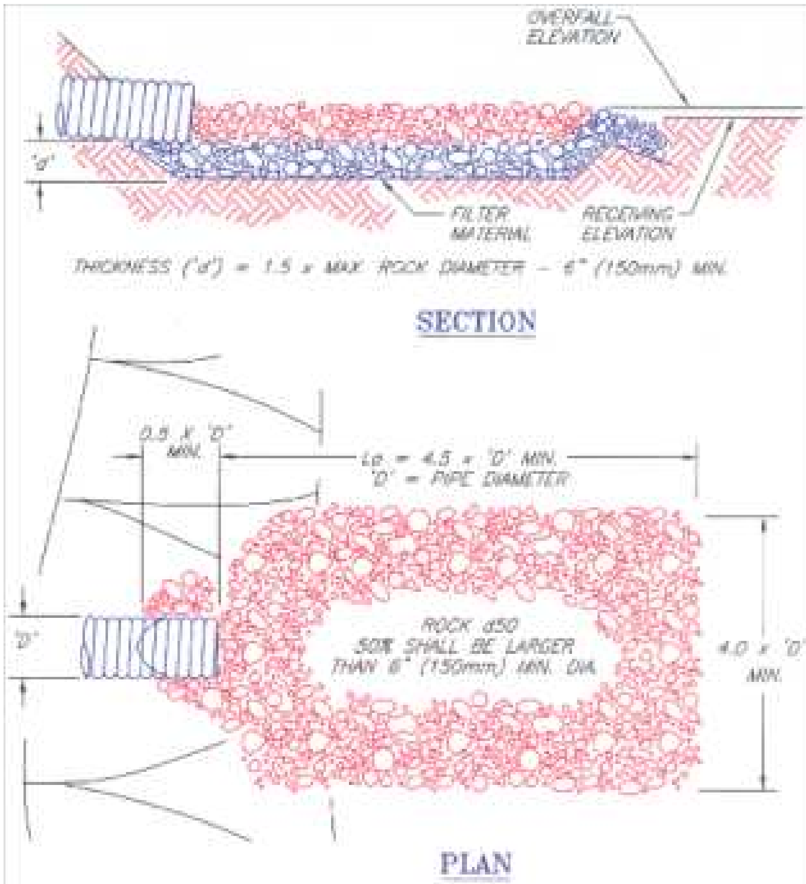




GRADE BREAK – Interruption in slope redirects flow and causes water to leave road area.

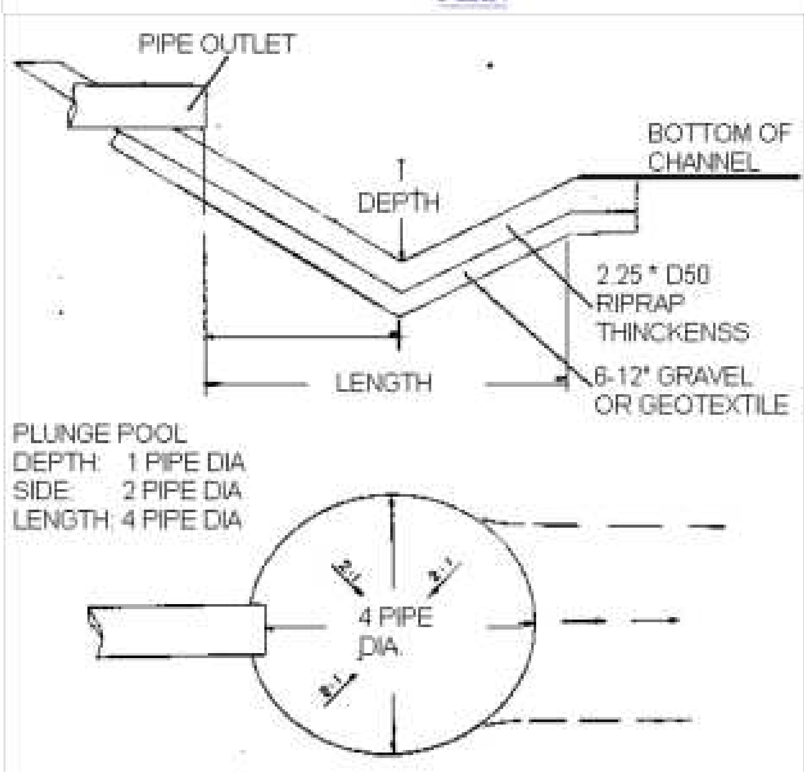
REF: PENN STATE CENTER FOR DIRT GRAVEL ROAD STUDIES, TECHNICAL BULLETIN.

Kibby Wind Power Project **Franklin County, Maine** Original: 11-28-06 Revision 1: 12-05-06	**Typical Roadway Runoff Drainage Controls**	amec EARTH & ENVIRONMENTAL, INC. ONE PLYMOUTH MEETING, SUITE 850 PLYMOUTH MEETING, PA 19462-1308 Drawing 8



TYPICAL ENERGY DISSIPATOR

(NOT TO SCALE)



TYPICAL PLUNGE-POOL

(NOT TO SCALE)

REF: MAINE EROSION AND SEDIMENT CONTROL BMP MANUAL

Kibby Wind Power Project

Franklin County, Maine

Original: 11-28-06
Revision 1: 12-05-06

Typical Culvert Outlet Protection/ Energy Dissipation

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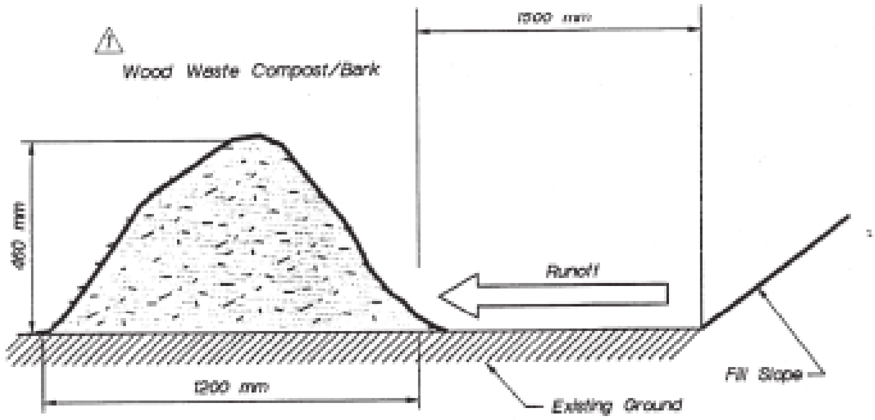
EARTH & ENVIRONMENTAL, INC.
ONE PLYMOUTH MEETING, SUITE 850
PLYMOUTH MEETING, PA 19462-1308

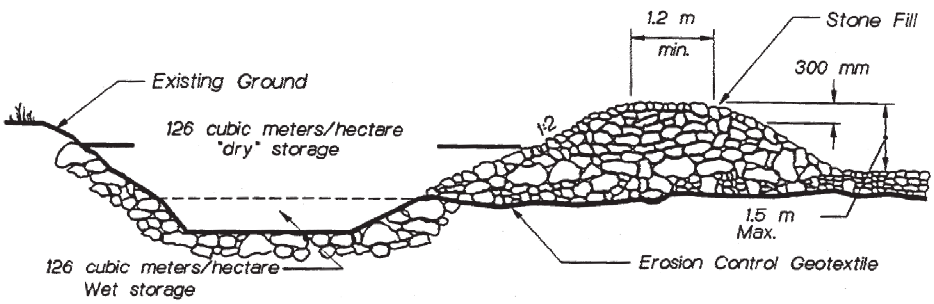
Drawing 9



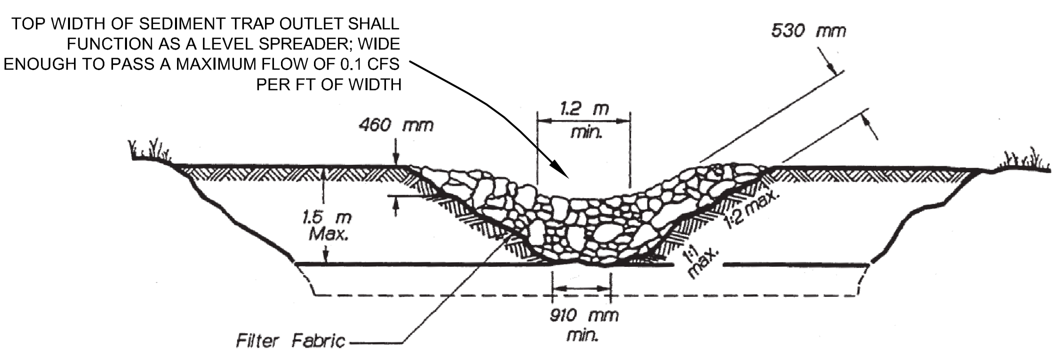
NOTE:

Wood Waste Compost/Bark Filter Berms may be used in combination with Silt Fence to improve sediment removal and prevent clogging of the Wood Waste Composte/Bark Berm by larger sediment particles. (Silt fence placed to filter runoff before Wood Waste Compost/Bark)

FILTER BERMS



CROSS SECTION
(@ ℄ of Outlet)

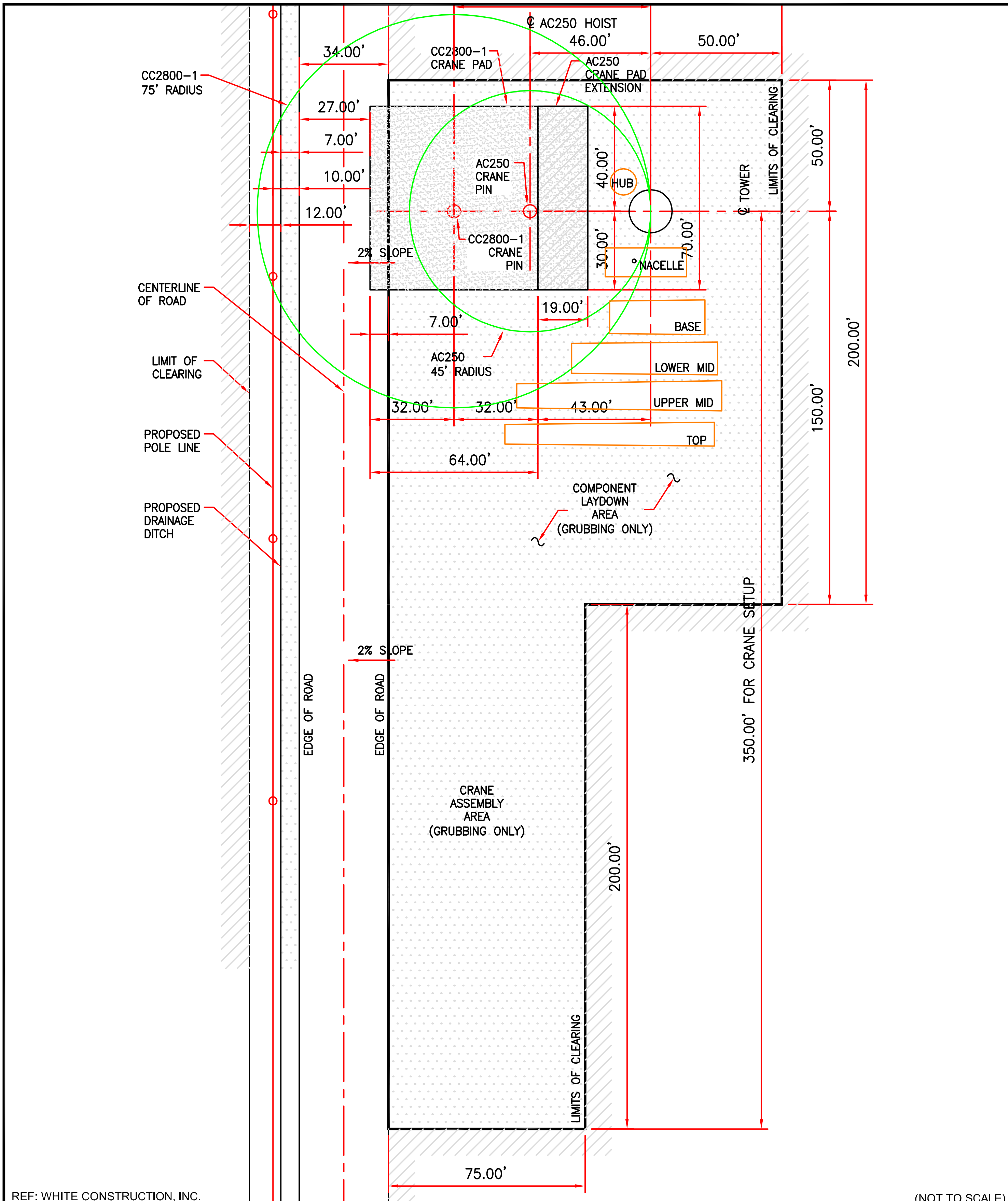


Outlet

SEDIMENT TRAP @ LEVEL SPREADERS

REF: MAINE DEPT. OF TRANSPORTATION, EROSION AND SEDIMENT CONTROL STANDARDS.

Kibby Wind Power Project **Franklin County, Maine** Original: 11-28-06 Revision 1: 12-05-06	**Typical Erosion and Sediment Control Measures**	amec EARTH & ENVIRONMENTAL, INC. ONE PLYMOUTH MEETING, SUITE 850 PLYMOUTH MEETING, PA 19462-1308 Drawing 10



REF: WHITE CONSTRUCTION, INC.

(NOT TO SCALE)

Kibby Wind Power Project

Franklin County, Maine

Original: 11-28-06
Revision 1: 12-05-06

Typical Turbine Pad Layout

EARTH & ENVIRONMENTAL, INC.
ONE PLYMOUTH MEETING, SUITE 850
PLYMOUTH MEETING, PA 19462-1308

Drawing 11

Chapter 5
Vegetated Buffers

5.1 General Criteria

5.1.1 General Description

Buffer strips are natural, undisturbed strips of natural vegetation or planted strips of close-growing vegetation adjacent to and downslope of developed areas.

IMPORTANT

There are four types of BMP buffers approved by DEP:

- Buffer adjacent to residential, largely pervious or small impervious areas: This buffer is for smaller areas where the flow enters the buffer as sheet flow.
- Buffer with stone bermed level lip spreaders: This buffer is used for larger, developed areas and uses a level spreader to create sheet flow onto the buffer.
- Buffer adjacent to the down hill side of a road: This buffer is used for flow from a roadway when it directly enters the buffer as sheet flow.
- Ditch turn-out buffer: This buffer is used to divert roadway runoff collected in a ditch into a buffer as sheet flow.

As stormwater runoff travels over the buffer area, vegetation slows the runoff and traps particulate pollutants. They are also effective for phosphorus removal when designed in accordance with this manual. The effectiveness of buffers for pollutant removal depends on the flow path length and slope of the buffer berm length, the soil permeability, the size of drainage area, and the type and density of vegetation. Also

Chapter Contents:

critical to the performance of buffer strips is the distribution of water flowing over it. If water is allowed to concentrate because of poor grading or uneven runoff distribution, the buffer will be short-circuited and have only minimal benefit. The irregular microtopography of undisturbed buffers provides small areas within which runoff can pool, encouraging infiltration and reducing the amount of runoff.

Buffers are used to treat runoff from relatively small amounts of impervious area, as typically found in residential developments and small commercial and industrial sites. This type of BMP requires minimal maintenance and provides an aesthetically pleasing area.

This manual describes four different BMP buffers, each of which is appropriate for specific situations. This chapter is set up to present general design, construction and maintenance criteria applicable to all buffers up front, followed by specific design criteria for each buffer type.

5.1.2 General Size Suitability Criteria

IMPORTANT
Design Tips - All Buffers

- Buffers shall be directly adjacent to areas being treated.
- Buffer slope must be less than 15%.
- Runoff must enter the buffer as sheet flow.
- Manipulate sites to maximize buffer flow path length.
- Only continuous flow path length may be counted for treatment.
- Flow paths of runoff through a buffer must be parallel or diverging; they must not converge.

1. **Drainage Area:** The required size and type of buffer used is dependent on the size and land use characteristics of the area draining to it. Generally speaking, the smaller the area draining to a buffer, the more effective it is likely to be.

IMPORTANT

Use the buffer sizing tables in this Chapter to size buffers to meet BMP standards. When used to meet phosphorus allocations in lake watersheds, adjust the sizing of the buffers in accordance with Volume II of this manual.

2. **Location:** Buffers are located downslope of developed areas and along waterways. They should be located directly adjacent to areas for which they are providing treatment. Use of buffers may be limited by location of suitable septic areas, building sites, roads, and driveways. Site planning should provide for the location of buffers as part of the overall development scheme, with consideration of the design criteria listed below. In sensitive lake watersheds requiring phosphorus controls, preliminary planning will need to include determination of the allowable phosphorus export from the site.

5.1.3 General Design and Construction Criteria

1. **Maximum Slope:** The buffer's slope must be less than 15% to be included in the calculation of buffer flow path length. Areas with slopes greater than 15% are too steep to be effective as a treatment buffer but should be left undisturbed. The buffer must have a relatively uniform slope so that stormwater does not concentrate in channels.

2. **Distribution of runoff over the buffer:** To be treated, runoff must enter the buffer as sheet flow and cannot be allowed to channelize.

   Buffers will not treat shallow concentrated or channelized flow. In most cases wooded and non-wooded natural buffers take advantage of the natural micro topography, (the small depressions and mounds of natural ground) to store runoff and allow for maximum infiltration.

3. **Separation from streams:** Buffers must not be interrupted by intermittent or perennial stream channels or other drainage ways.

4. **Restabilization of buffers used for sediment control during construction:** If a buffer has been used to trap sediment during construction, the sediment must be removed and the original topography, ground cover and vegetation reestablished. Otherwise, sediment accumulations may cause runoff to concentrate in certain locations. It is advisable to protect buffer strips with wood waste berm sedimentation barriers during the construction process.

5. **Pretreatment for buffers with "bare soil" contributing areas:** To prevent a heavy sed-iment loading from damaging the buffer, sites that will have areas of bare soil for a long time can not utilize this BMP without first pre-treating the runoff with a sediment control BMP.

6. **Buffer dimensions:** Buffer flow path length depends to some extent on the proposed layout, and may be limited by the location of roads, driveways, building sites, and suitable septic system locations. Overall site design and individual lot configuration can be manipulated to maximize buffer flow-path length while minimizing interference with developed areas. The longer the buffer flow path length, the more effective the buffer is. Only continuous flow path length may be counted. A second buffer separated from the first by a developed area may not be included. The buffer berm length will vary depending on the soil type and vegetative cover of the buffer. Buffer sizing is addressed under each of the four buffer BMPs discussed in this manual.

7. **Topography:** The topography of a buffer area must be such that stormwater runoff will not concentrate as it flows across a buffer, but will remain well distributed. Flow paths of runoff through a buffer must not converge, but must be essentially parallel or diverging. This should be confirmed in the field for each area designated as a buffer.

8. **Vegetative cover:** The vegetative cover type of a buffer must be either forest or meadow. In most instances the sizing of a buffer varies depending on vegetative cover type.

a. *Forest buffer:* A forest buffer must have a well distributed stand of trees with essentially complete canopy cover, and must be maintained as such. A forested buffer must also have an undisturbed layer of duff covering the mineral soil. Activities that may result in disturbance of the duff layer are prohibited in a buffer.

b. *Meadow buffer:* A meadow buffer must have a dense cover of grasses, or a combination of grasses and shrubs or trees. A buffer must be maintained as a meadow with a generally tall stand of grass, not as a lawn. It must not be mown more than twice per calendar year. If a buffer is not located on natural soils, but is constructed on fill or reshaped slopes, a buffer surface must either be isolated from stormwater discharge until a dense sod is established, or must be protected by a three inch layer of erosion control mix or other wood waste material approved by the department before stormwater is directed to it. Vegetation must be established using an appropriate seed mix.

c. *Mixed meadow and forest buffer:* If a buffer is part meadow and part forest, the required sizing of a buffer must be determined as a weighted average, based on the percent of a buffer in meadow and the percent in forest, of the required sizing for meadow and forest buffers.

9. **Deed restrictions and covenants:** Areas designated as buffers must be clearly identified on site plans and protected from disturbance by deed restrictions and covenants. Refer to Appendix D for suggested templates for deed restrictions and conservation easements.

5.1.4 General Maintenance Criteria

1. **Mowing:** Meadow buffers may be mown no more than twice per year. They may not be maintained as a lawn.

2. **Inspection Frequency:** Buffers should be inspected annually for evidence of erosion or concentrated flows through or around the buffer. All eroded areas should be repaired, seeded and mulched. A shallow stone trench should be installed and maintained as a level spreader to distribute flows evenly in any area showing concentrated flows.

3. **Access and Use:** Buffers should not be traversed by all-terrain vehicles or other vehicles. Activities within buffers should be conducted so as not to damage vegetation, disturb any organic duff layer, and expose soil.

4. **Model Maintenance Plan:** The following techniques should be followed to maintain the integrity of buffers from initial planning through post-construction (Schueler, 1994):

   a. <u>Planning Stage</u>

   i. Require buffer limits to be present on all clearing/grading and erosion control plans

   ii. Record all buffer boundaries on official maps and site plans.

   iii. Clearly establish acceptable and unacceptable uses for the buffer, and include in deed restrictions and conservation easements.

   iv. Establish clear vegetation targets and management rules for the buffer.

   v. Provide incentives for owners to protect buffers through perpetual conservation easements rather than deed restrictions.

   b. <u>Construction Stage</u>

   i. Pre-construction stakeout of buffers to define the Limit of Disturbance (LOD).

   ii. Set LOD based on drip-line of the forested buffer.

   iii. Conduct pre-construction meeting to familiarize contractors and foremen with LOD and buffer limit.

   iv. Mark the LOD with silt fence barrier, signs or other methods to exclude construction equipment.

   c. <u>Post-Development Stage</u>

   i. Mark buffer boundaries with permanent signs (or fences) describing allowable uses.

   ii. Educate property owners/homeowner associations on the purpose, limits and allowable uses of the buffer.

   iii. Conduct periodic "buffer walks" to inspect the condition of the buffer network (using volunteers, where possible).

   iv. Replant unused meadow buffers with trees and shrubs, if possible.

5.2 Types of Buffers

5.2.1 Buffer Adjacent to Residential, Largely Pervious or Small Impervious Areas

A buffer adjacent to residential, largely pervious or small impervious areas is for small developments where runoff enters the buffer as sheet flow without the aid of a level spreader. Figure 5-1 shows a typical buffer of this type. It may only be used when it is located immediately downhill of the developed area and runoff enters as sheet flow. This design is not appropriate for treating large impervious areas because, even if pavement is graded evenly, it is likely that some concentration of runoff will occur as the stormwater travels across large areas of pavement. Only runoff from the following areas may be treated using this type of buffer:

- A single family residential lot draining to buffer;
- A developed area with less than 10% imperviousness where the flow path over the portion of the developed area for which treatment is being credited does not exceed 150 feet; or
- An impervious area of less than one acre, where the flow path across the impervious area does not exceed 100 feet.

In addition to the general design and construction criteria, provided in the beginning of this Chapter, the following criteria must also be applied in the design and construction of a buffer adjacent to residential, largely pervious or small impervious areas.

IMPORTANT
Design Tips–Buffer Adjacent to Residential, Largely Pervious or Small Impervious Areas

- Buffers adjacent to residential, largely pervious or small impervious areas are for small developments. They are not appropriate for treating large impervious areas.
- Runoff must enter the buffer as sheet flow without the aid of a level spreader.
- The buffer must be located downhill of the developed area.

1. **Slope:** A buffer meeting this standard is not allowed on natural slopes in excess of 15%.

2. **Soil Restrictions:** A buffer meeting this stan-dard is not allowed on Hydrologic Soil Group D soils except that a forested buffer is allowed if the D soils in a buffer are not wetland soils.

3. **Buffer Sizing:** Sizing depends only on the soil type and vegetative cover type of a buffer. Tables 5-1 and 5-2 indicate the required buffer flow path length based on soil types and vegetative cover types. Buffers described by this Chapter must be located downhill of the entire developed area for which it is providing stormwater treatment, such that all runoff from the entire developed area has a flow path through the buffer at least as long as the required length of flowpath.

Table 5-1
Required Buffer Flow Path Length Per Soil and Vegetative Cover Types with 0-8% Buffer Slope

Hydrologic Soil Group of Soil in Buffer	Length of Flow Path for a Forested Buffer (feet)	Length of Flow Path for a Meadow Buffer (feet)
A	45	75
B	60	85
C Loamy Sand or Sandy Loam	75	100
C Silt Loam, Clay Loam or Silty Clay Loam	100	150
D Non-Wetland	150	Not Applicable

Table 5-2
Required Buffer Flow Path Length Per Soil and Vegetative Cover Types with 9-15% Buffer Slope

Hydrologic Soil Group of Soil in Buffer	Length of Flow Path for a Forested Buffer (feet)	Length of Flow Path for a Meadow Buffer (feet)
A	54	90
B	72	102
C Loamy Sand or Sandy Loam	90	120
C Silt Loam, Clay Loam or Silty Clay Loam	120	180
D Non-Wetland	180	Not Applicable

5.2.2 Buffer with Stone Bermed Level Lip Spreader

A buffer with stone bermed level lip spreaders consists of a bermed level spreader followed by a buffer. Runoff is directed behind the stone berm, which is constructed along the contour at the upper margin of a buffer area. The runoff then spreads out behind the berm so that it seeps through the entire length of the berm and is evenly distributed across the top of a buffer as sheet flow. Figure 5-2 shows a typical buffer with stone bermed level lip spreader. This type of buffer must be used when treating stormwater runoff from any of the following:

- An impervious area greater than one acre;
- Impervious areas where the flow path across the impervious area exceeds 150 feet; or
- Developed areas, including lawns and impervious surfaces, where runoff is concentrated, intentionally or unintentionally, so that it does not run off in well-distributed sheet flow when it enters the upper end of a buffer, except that road ditch runoff may be treated using a ditch turn out buffer.

In addition to the general design and construction criteria, provided in the beginning of this Chapter, the following criteria must also be applied in the design and construction of a buffer with stone bermed level lip spreaders.

IMPORTANT
Design Tips - Buffer with Stone Bermed Level Lip Spreader

- Stone berm must be well-graded and contain small stone and gravel to force flows to spread out behind the berm.
- Stone berm must be at least 1.5' high and 2.0' across the top with 2:1 side slopes.
- Provide a shallow, 6" deep trapezoidal trough with a minimum bottom width of 3' along uphill edge of berm.
- Buffer with stone berm not allowed on Hydrologic Soil Group D soils identified as wetland soils.
- Required berm length varies by the Hydrologic Soil Group of the soils in a buffer and by the length of flow path.

1. **Stone berm specifications:** The berm must be well-graded and contain some small stone and gravel so that flow through the berm will be restricted enough to cause it to spread out behind the berm. The stone berm must be at least 1.5 feet high and 2.0 feet across the top with 2:1 side slopes constructed along the contour and closed at the ends. Unless otherwise approved by the department, the design must include a shallow, 6-inch deep trapezoidal trough with a minimum bottom width of three feet, and with a level downhill edge excavated along the contour on the uphill edge of the stone berm.

2. **Stone size:** The stone must be coarse enough that it will not clog with sediment. Stone for stone bermed level lip spreaders must consist of sound durable rock that will not disintegrate by exposure to water or weather. Fieldstone, rough quarried stone, blasted ledge rock or tailings may be used. The rock must be well-graded within the limits provided in Table 5-3, or as otherwise approved by the department.

Table 5-3 Berm Stone Size		
Sieve Designation (Metric)	**Sieve Designation (US Customary)**	**Percent By Weight Passing Square Mesh Sieves**
300 mm	12 in	100
150 mm	6 in	84-100
75 mm	3 in	68-83
25.4 mm	1 in	42-55
4.75 mm	No. 4	8-12

3. **Slope:** A buffer meeting this standard is not allowed on natural slopes in excess of 15% unless a buffer has been evaluated using a site specific hydrologic buffer design model approved by the department, and measures have been included to ensure that runoff remains well-distributed as it passes through a buffer.

4. **Soil Restrictions:** A buffer meeting this stan-dard is not allowed on Hydrologic Soil Group D soils that are identified as wetland soils.

5. **Buffer sizing:** The required size of a buffer area below the stone bermed level lip spreader varies with the size and impervi-ousness of the developed area draining to a buffer, the type of soil in a buffer area, the slope of a buffer, and the vegetative cover type. Tables 5-4 and 5-5 indicate the required berm length per acre of impervious area and lawn draining to a buffer for a given length of flow path through a buffer. Required berm length varies by the Hydrologic Soil Group of the soils in a buffer and by the length of flow path through a buffer. If more than one soil type is found in a buffer, the required sizing of a buffer must be determined as weighted average, based on the percent of a buffer in each soil type, of the required sizing for each soil type buffer. Alternative sizing may be allowed if it is determined by a site-specific hydrologic buffer design model approved by the department.

NOTE: The following tables were developed using a 1.25 inch, 24 hour storm of type III distribution, giving a maximum unit flow rate of less than 0.009 cfs per foot.

Table 5-4
Required Berm and Flow Path Length of a Buffer with 0-8% Slope and a Stone Bermed Level Lip Spreader

Hydrologic Soil Group	Length of Flow Path through Buffer (feet)	Berm Length for a Forested Buffer (feet)		Berm Length for a Meadow Buffer (feet)	
		Per acre of impervious area	Per acre of lawn	Per acres of impervious area	Per acre of lawn
Soil Group A	75	75	25	125	35
	100	65	20	75	25
	150	50	15	60	20
Soil Group B	75	100	30	150	45
	100	80	25	100	30
	150	65	20	75	25
Soil Group C sandy loam or loamy sand	75	125	35	150	45
	100	100	30	125	35
	150	75	25	100	30
Soil Group C silt loam, clay loam or silty clay loam	100	150	45	200	60
	150	100	30	150	45
Soil Group D non-wetland	150	150	45	200	60

Table 5-5
Required Berm and Flow Path Length of a Buffer with 9-15% Slope and a Stone Bermed Level Lip Spreader

Hydrologic Soil Group	Length of Flow Path through Buffer (feet)	Berm Length for a Forested Buffer (feet)		Berm Length for a Meadow Buffer (feet)	
		Per acre of impervious area	Per acre of lawn	Per acre of impervious area	Per acre of lawn
Soil Group A	75	90	30	150	42
	100	78	24	90	30
	150	60	18	72	24
Soil Group B	75	120	36	180	54
	100	96	30	120	36
	150	78	24	90	30
Soil Group C sandy loam or loamy sand	75	150	42	180	54
	100	120	36	150	42
	150	90	30	120	36
Soil Group C silt loam, clay loam or silty clay loam	100	180	54	240	72
	150	120	36	180	54
Soil Group D non-wetland	150	180	54	240	72

5.2.3 Buffer Adjacent to the Down Hill Side of a Road

A buffer adjacent to the down hill side of a road consists of a buffer directly adjacent to a roadway. The road must be parallel to the contour of the slope. It may only be used when the runoff from the road surface and shoulder sheets immediately into the buffer. In no instance may runoff from areas other than the adjacent road surface and shoulder be directed to these buffers. Figure 5-3 shows a typical buffer adjacent to the down hill side of a road.

In addition to the general design and construction criteria, provided in the beginning of this Chapter, the following criteria must also be applied in the design and construction of buffers adjacent to the down hill side of a road.

1. **Slope:** A buffer meeting this standard is not allowed on natural slopes in excess of 20%.

2. **Soil Restrictions:** A buffer meeting this stan-dard is not allowed on soils identified as wet-land soils.

3. **Buffer Sizing:** Sizing depends only on the vegetative cover type of a buffer and the num-ber of travel lanes draining to a buffer. Table 5-6 indicates the required buffer flow path length based on the number of travel lanes draining to the buffer and whether the buffer is forested or meadow.

4. **Inclusion of inslope:** The inslope of the roadbed may be included as part of a meadow buffer only if it is designed and constructed to allow infiltration. Design and construction to allow infiltration includes, but is not limited to, the inslope fill material being a sandy loam or coarser soil texture having slopes no steeper than 4:1; loaming and seeding to meadow grasses; and maintaining a buffer area as a meadow buffer.

> **IMPORTANT**
> **Design Tips - Buffer Adjacent to the Down Hill Side of a Road**
>
> The in slope of the roadbed may only be included as part of a meadow buffer if it is designed and constructed to allow infiltration.

Table 5-6
Required Buffer Flow Path Adjacent to the Down Hill Side of a Road

	Length of Flow Path for a Forested Buffer (feet)	Length of Flow Path for a Meadow Buffer (feet)
One travel lane draining to buffer	35	50
Two travel lanes draining to buffer	55	80

5.2.4 Ditch Turn Out Buffer

A ditch turn-out buffer is used to divert runoff collected in a roadside ditch into a buffer. It consists of a combination of checkdams and bermed level lip spreaders used to divert concentrated ditch flows into a buffer as sheet flow. Runoff backs up behind the checkdam and is directed over a stone berm that spreads flows out so that it is evenly distributed across the top of a buffer as sheet flow. Figure 5-4 shows a typical ditch turn-out buffer.

IMPORTANT
Design Tips - Ditch Turn-Out Buffer

- A ditch turn-out buffer uses a combination of checkdams and bermed level lip spreaders to divert concentrated ditch flows into a buffer as sheet flow.
- Refer to buffer sizing tables in this section.

In addition to the general design and construction criteria, provided in the beginning of this Chapter, the following criteria must also be applied in the design and construction of a ditch turn-out buffer.

1. **Drainage Area:** No areas other than the road surface, road shoulder and road ditch may be directed into the buffer. No more than 400 ft of road and ditch may be treated in any ditch turn-out buffer, and no more than 250 feet may be treated if more than one travel lane is draining to the ditch.

2. **Distribution of runoff over the buffer:** The turnout should extend into the side ditch or cut slope in a manner that it intercepts the ditch runoff and carries it into the buffer area. The buffer end of the turnout must be level and equipped with a stone bermed level spreader.

3. **Stone berm specifications:** The stone berm to which the ditch turn-out delivers the runoff must be at least 20 feet in length and must be constructed along the contour. It must be at least one- foot high and two feet across the top with 2:1 side slopes.

4. **Stone size:** Stone for the berm must consist of sound durable rock that will not disintegrate by exposure to water or weather. Fieldstone, rough quarried stone, blasted ledge rock or tailings may be used. The rock must be well graded with a median size of approximately 3 inches and a maximum size of 6 inches.

5. **Slope:** A buffer meeting this standard is not allowed on natural slopes in excess of 15%.

6. **Soil Restrictions:** A buffer meeting this stan-dard is not allowed on Hydrologic Soil Group D soils with wetlands.

7. **Buffer sizing:** The required size of a buffer area below the turnout's stone bermed level lip spreader varies with the type of soil in a buffer area, the slope of a buffer, the length of road ditch draining to a buffer and the vegetative cover type within a buffer. Tables 5-7 and 5-8 indicate the required length of the flow path through a buffer for various vegetative covers and ditch lengths. If two travel lanes drain to the ditch, as in the case of a super elevated road, the length of flow path indicated for 400 feet of road must be used, but no more than 250 feet of ditch may drain to each turn-out.

Table 5-7 Required Buffer Flow Path Length Per Length of Road or Ditch with 0-8% Buffer Slope			
Hydrologic Soil Group of Soil in Buffer	**Length of Road or Ditch Draining to a Buffer (feet)**	**Length of Flow Path for a Forested Buffer (feet)**	**Length of Flow Path for a Meadow Buffer (feet)**
A	200	50	70
	300	50	85
	400	60	100
B	200	50	70
	300	50	85
	400	60	100
C **Loamy Sand or Sandy Loam**	200	60	100
	300	75	120
	400	100	Not applicable
C **Silt Loam, Clay Loam or Silty Clay Loam**	200	75	120
	300	100	Not applicable
D **Non-wetland**	200	100	150

Table 5-8 Required Buffer Flow Path Length Per Length of Road or Ditch with 9-15% Buffer Slope			
Hydrologic Soil Group of Soil in Buffer	**Length of Road or Ditch Draining to a Buffer (feet)**	**Length of Flow Path for a Forested Buffer (feet)**	**Length of Flow Path for a Meadow Buffer (feet)**
A	200	60	84
	300	60	102
	400	72	120
B	200	60	84
	300	60	102
	400	72	120
C Loamy Sand or Sandy Loam	200	72	120
	300	90	144
	400	120	Not applicable
C Silt Loam, Clay Loam or Silty Clay Loam	200	90	144
	300	120	Not applicable
D Non-wetland	200	120	180

Selected References

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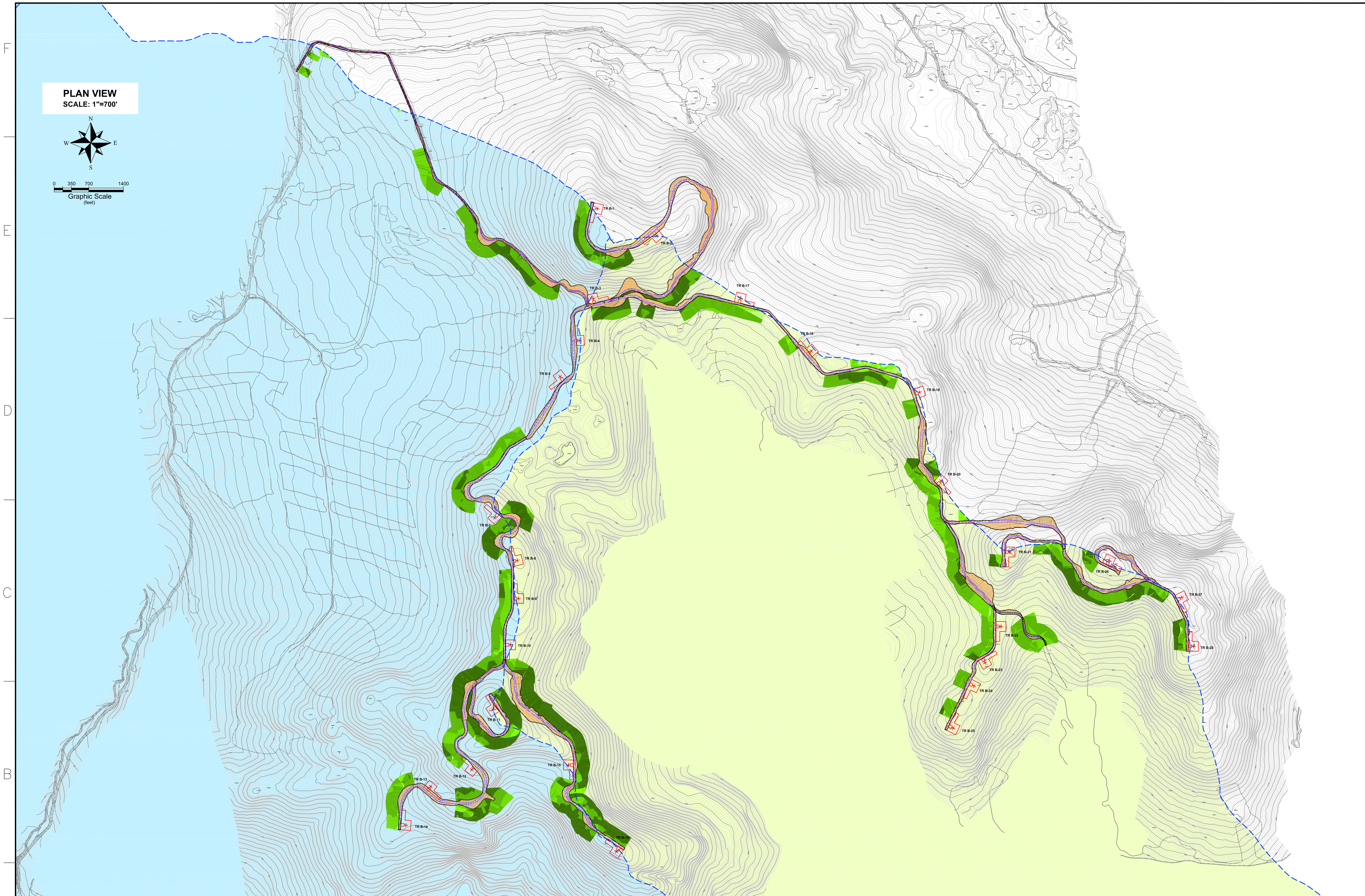
7.0 FIGURES



NOTES

LEGEND

SLOPE ANALYSIS WITHIN POTENTIAL VEG. BUFFER (250')			
ID	MINIMUM SLOPE	MAXIMUM SLOPE	COLOR
1	0.00%	3.00%	
2	3.00%	8.00%	
3	8.00%	15.00%	
4	15.00%	30.00%	
5	30.00%	Over 30.00%	

Jim Pond Watershed

Flagstaff Watershed

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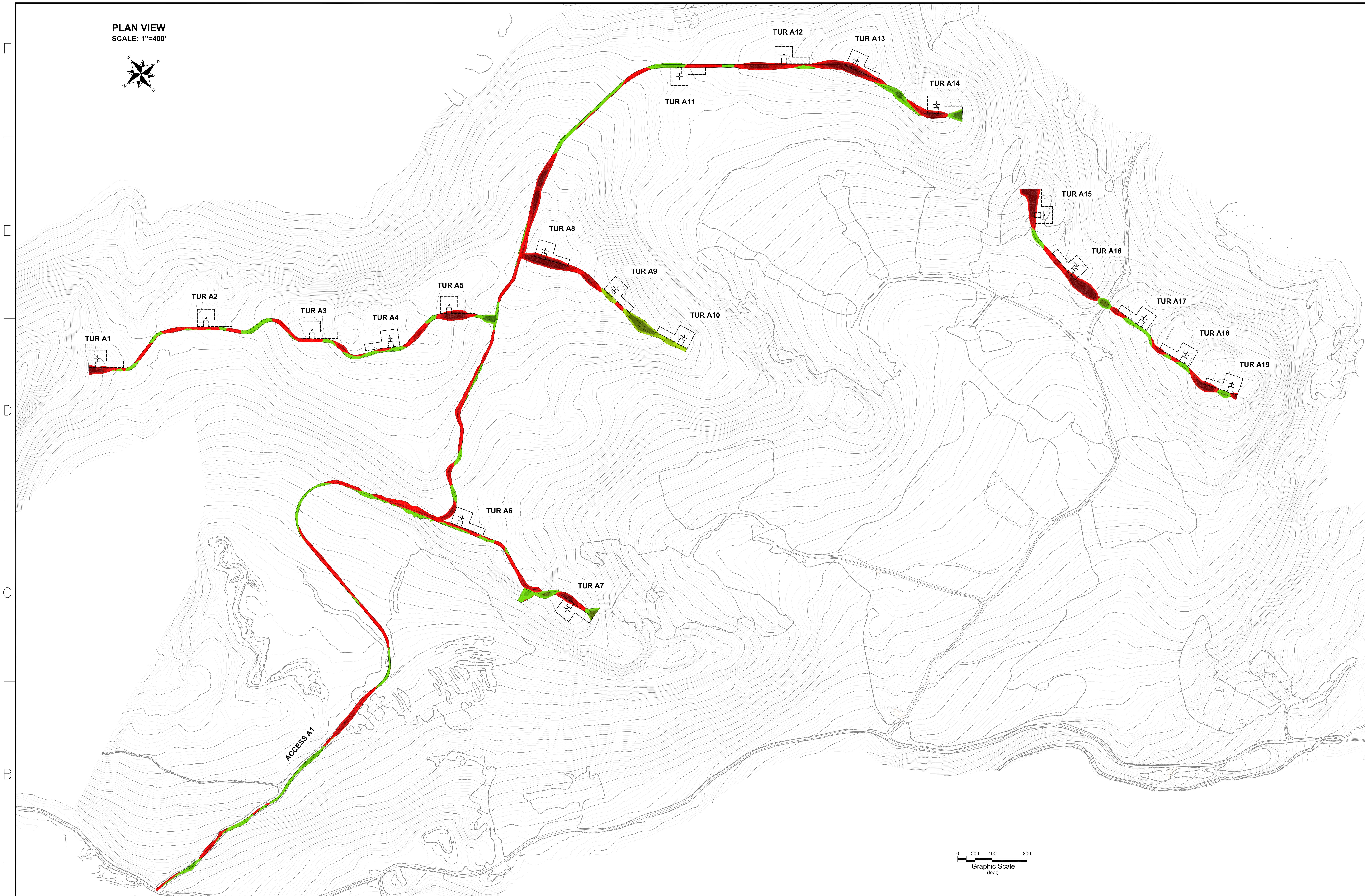

NOTES

LEGEND

Cut Area Analysis

Zone	Min. Depth (feet)	Max. Depth (feet)
	0.00	5.00
	5.00	10.00
	10.00	Over 10.00

Fill Area Analysis

Zone	Min. Depth (feet)	Max. Depth (feet)
	0.00	5.00
	5.00	10.00
	10.00	Over 10.00

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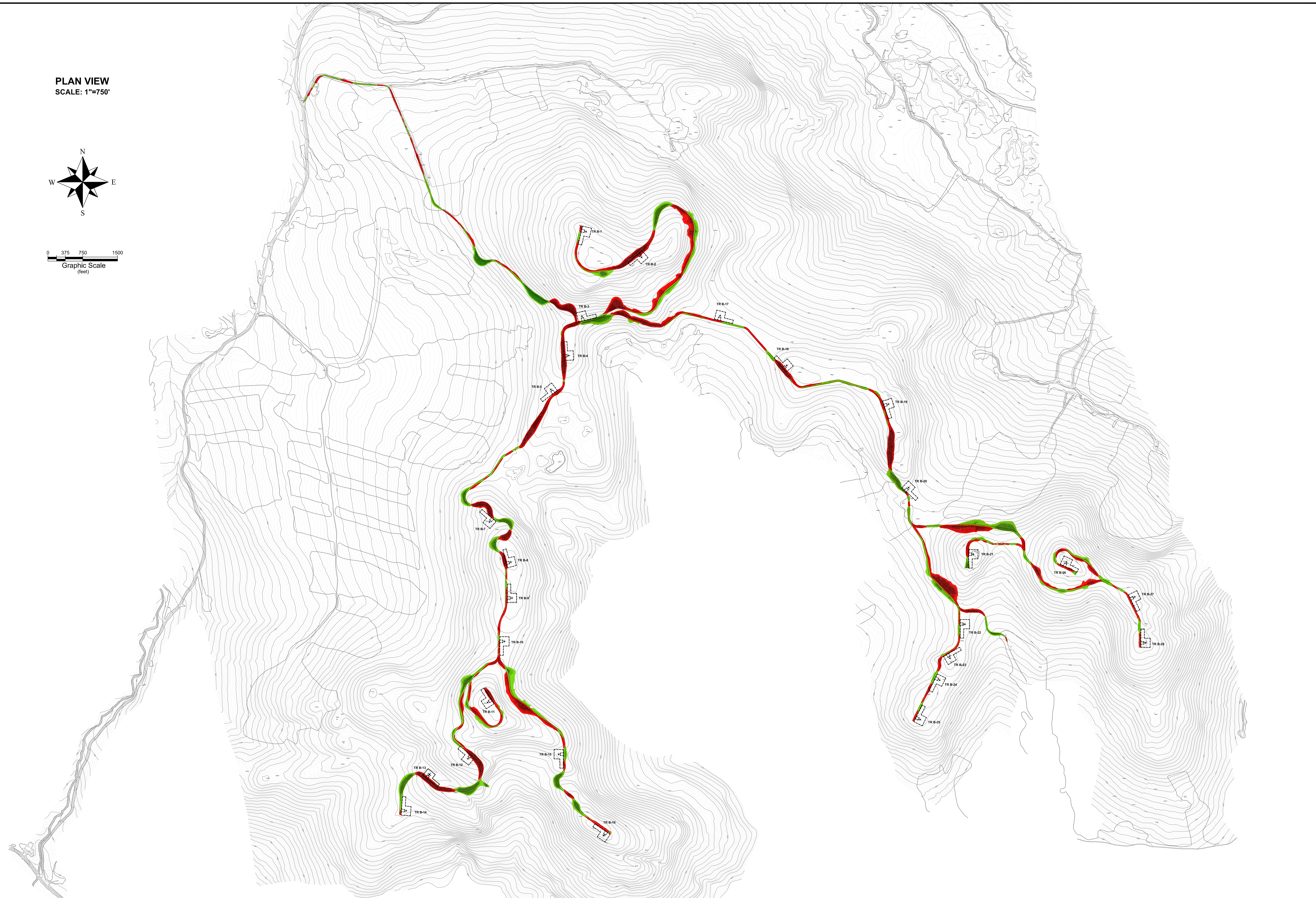

NOTES

LEGEND

Cut Area Analysis

Zone	Min. Depth (feet)	Max. Depth (feet)
	0.00	5.00
	5.00	10.00
	10.00	Over 10.00

Fill Area Analysis

Zone	Min. Depth (feet)	Max. Depth (feet)
	0.00	5.00
	5.00	10.00
	10.00	Over 10.00

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