Chapter 3 - Documentation

TABLE OF CONTENTS

List of Appendices

Chapter 3 - Documentation

3.1 Overview

3.1.1 Introduction

An important part of the design or analysis of any hydraulic facility is the documentation. Appropriate documentation of the design of any hydraulic facility is essential because of:

- The importance of public safety
- Justification of expenditure of public funds
- Future reference by engineers (when improvements, changes, or rehabilitations are made to the highway facilities or adjacent property)
- Information leading to the development of defense in matters of litigation
- Information is available to public

Frequently, it is necessary to refer to plans, specifications, and analysis long after the actual construction has been completed. Documentation permits evaluation of the performance of structures after flood events to determine if the structures performed as anticipated or to establish the cause of unexpected behavior, if such is the case. In the event of a failure, it is essential that contributing factors be identified in order that recurring damage can be avoided.

3.1.2 Definition

The definition of hydrologic and hydraulic documentation as used in this chapter is the compilation and preservation of the design and related details, as well as all pertinent information related to the basis of design and decisions. This should include drainage area and other maps, field survey information, source references, photographs, engineering calculations and analyses, measured and other data, flood history including narratives from newspapers, individuals such as highway maintenance personnel, and local residents who witnessed or had knowledge of an unusual event.

3.1.3 Purpose

This chapter describes the documentation that should be included in the design files and on the construction plans. While the documentation requirements for existing and proposed drainage facilities are similar, the data retained for existing facilities are often slightly different from that for proposed facilities, and these differences are discussed. This chapter identifies a system for organizing the documentation of hydraulic designs and reviews to provide as complete a history of the design process as is practical.

The major purpose of providing good documentation is to define the design procedure that was used and to show how the final design and decisions were made. There is a myth that avoiding documentation will prevent or limit litigation losses as it supposedly precludes providing the plaintiff with incriminating evidence. This is seldom if ever the case and documentation should be viewed as the record of reasonable and prudent design analysis based on the best available technology. Thus, good documentation can provide the following:

- Protection for the Department by proving that reasonable and prudent actions, were in fact, taken (such proof should certainly not increase the potential court award, and may decrease it by disproving any claims of negligence by the plaintiff)
- Identifying the situation at the time of design which might be very important if legal action occurs in the future
- Documenting that rationally accepted procedures and analysis were used at the time of the design which were commensurate with the perceived site importance and flood hazard (this should further disprove any negligence claims)
- A continuous site history to facilitate future reconstruction
- The file data necessary to quickly evaluate any future site problems that might occur during the facilities service life
- Expediting plan development by clearly providing the reasons and rationale for specific design decisions

3.1.4 Types

Three basic types of documentation should be considered: preconstruction, design, and construction or operation.

1. Preconstruction documentation should include the following if available or within the budgetary constraints of the project.

    - Aerial photographs
    - Topographic mapping with contours
    - Watershed map or plan including
        - Flow directions
        - Watershed boundaries
        - Watershed areas quantified
        - Natural storage areas
        - Existing and proposed contours
    - Surveyed data reduced to include
        - Existing hydraulic facilities
        - Existing controls
        - Profiles - roadway, channel, driveways
        - Cross sections - roadway, channels, faces of structures

- Flood insurance studies (including any available hydraulic model data), and maps by FEMA
- Soil Conservation Service soil maps
- Field trip report(s) which may include:
  - Video cassette recordings
  - Audio tape recordings
  - Still camera photographs
  - Written analysis of findings with sketches
- Reports from other agencies (local, State or Federal), VDOT personnel, newspapers, and abutting property owners

2. Design documentation should include all the information used to justify the design, including:

   - Reports from other agencies
   - Hydrological report
   - Hydraulic report

3. Construction and operation documentation should include:

   - Plans
   - Revisions
   - As-built plans and subsurface borings
   - Photographs
   - Record of operation: during flooding events, complaints, and resolutions

It is very important to prepare and maintain, in a permanent file, any available as-built plans and plan revisions for every drainage structure to document subsurface foundation elements; such as, footing types and elevations, pile types, and (driven) tip elevations, etc. There may be other information which should be included or may become evident as the design or investigation develops. This additional information should be incorporated at the discretion of the designer.

3.1.5 Scheduling

Documentation should not be considered as occurring at specific times during the design or as the final step in the process, which could be long after the final design is completed. Documentation should be an ongoing process and part of each step in the hydrologic and hydraulic analyses and the design process. This will increase the accuracy of the documentation, provide data for future steps in the plan development process, and provide consistency and continuity in the design even when different designers are involved at different times of the plan development process.

3.1.6 Responsibility

The designer should be responsible for determining what hydrologic analyses, hydraulic design, and related information should be documented during the plan development process. This designer should make a determination that complete documentation has been achieved during the plan development process which will include the final design. To assist in this determination, refer to Appendix 3B for the following:

- Project Documentation Checklist (Appendix 3B-1)
- Suggested outline for a VDOT Hydrologic and Hydraulic Analysis Report (Appendix 3B-2)
- Field Engineer's Hydraulic Report (Appendix 3B-3)

3.2 Procedure

3.2.1 Introduction

The designer should maintain a complete hydrologic and hydraulic design and analysis documentation file for each waterway encroachment or crossing. Where practicable this file should include such items as:

- Identification and location of the facility
- Roadway functional classification data
- Photographs (ground and aerial)
- Engineering cost estimates
- Actual construction costs
- Hydrologic investigations
- Drainage area maps
- Vicinity maps and topographic maps
- Contour maps
- Interviews (local residents, adjacent property owners, and maintenance forces)
- Newspaper clippings
- Design notes and correspondence relating to design decisions
- History of performance of existing structure(s)
- Assumptions

The documentation file should contain design/analysis data and information that influenced the facility design and which may not appear in other project documentation.

3.2.2 Practices

Following are the practices related to documentation of hydrologic and hydraulic designs and analyses:

- Hydrologic and hydraulic data, preliminary calculations, analyses, and all related information used in developing conclusions and recommendations related to drainage requirements, including estimates of structure size and location should be compiled in a documentation file
- The designer should document all design assumptions and selected criteria including the decisions related thereto
- The amount of detail of documentation for each design or analysis should be commensurate with the risk and the importance of the facility. Typically, culverts would normally require less documentation, whereas bridges and other major drainage structures would require more
- Documentation should be organized to be concise and complete, so that knowledgeable designers can understand years hence what predecessors did

- Circumvent incriminating statements wherever possible by stating uncertainties in less than specific terms - (e.g.," the culvert may cause back water" rather than the "culvert will cause back water"). Be objective in your statements, and opinions
- Provide all related references in the documentation file to include such things as published data and reports, memos and letters, and interviews. Include dates and signatures where appropriate
- Documentation should include data and information from the conceptual stage of project development through service life to provide successors with all information
- Documentation should be organized to logically lead the reader from past history through the problem background, into the findings, and through the performance
- In the case of lengthy documentation assemblies, a summary and table of contents at the beginning of the documentation will provide an outline of the documentation file to assist users in finding detailed information

3.2.3 Storage

Where and how to store and preserve records is an important consideration. Ease of access, durability, legibility, storage space required, and cost are the prime factors to consider when evaluating alternative methods of storage and preservation.

The designer should maintain the documentation files including: microfilm, microfiche, digital media, magnetic media, etc. where it will be readily available for use during construction, for defense of litigation, and future replacement or extension. The designer should retain only documentation that is not retained elsewhere. Original plans, project correspondence files, construction modifications, and inspection reports are the types of documentation that usually do not need to be duplicated. Hydrologic and hydraulic documentation should be retained with the project plans or other permanent location at least until the drainage facility is totally replaced or modified as a result of a new drainage study or a minimum of 10 years after construction.

3.3 Documentation Procedures

3.3.1 Introduction

Documentation procedures for the major hydrologic and hydraulic chapters are in the Procedure section for the respective chapters. The items described should be in the documentation file. The intent is not to limit the data to only those items listed, but rather to establish a suggested minimum requirement consistent with the hydraulic design procedures as outlined in this manual. If circumstances are such that the drainage facility is sized by other than normal procedures or if the size of the facility is governed by factors other than hydrologic or hydraulic factors, a narrative summary detailing the design basis should appear in the documentation file. Additionally, the designer should include in the documentation file items not listed below but which are useful in understanding the analyses, design, findings, and final recommendations.

3.3.2 Computer Files

The following items should be included in the documentation file, and be clearly labeled:

- Input data listing
- Output results of alternatives
- Version of software
- Limitations and capabilities of software
- File names and dates
- Verification of methodology and solution /results
- Quality control practices
- Derivation of formulas for desktop applications (spreadsheets)

3.3.3 Schedule

The hydraulics designer shall refer to the following requirements for design milestone deliverables, unless otherwise waived by the respective District L&D Engineer:

Preliminary Field Inspection ("PFI") Milestone: Drainage Narrative – A preliminary drainage study should be conducted to the extent necessary to identify watersheds, drainage areas and determine SWM requirements based on the required Technical Criteria (per LD-IIM-195). A Drainage Narrative shall be submitted with Plans that states how Water Quality and Water Quantity will be met for this project. Also any potential stream relocations, restorations, or enhancements should be identified, if applicable. Any potential issues should be identified at this milestone and included in the narrative for documentation purposes (see appendix 3A-1 for example). Plans shall be completed to the minimum LD-436 requirements[*]

[*] Rev. 7/16

Public Hearing ("PH") (or Public Involvement) Milestone: Drainage Study – A preliminary drainage study should be conducted to the extent necessary to identify constructability issues and determine appropriate R/W limits to accommodate drainage features, including SWM facilities. Potential stream relocation, restoration, or enhancements should be identified, if applicable. All existing drainage structures shall be inspected for structural and functional adequacy. Any remediation measures should be identified and included in the Drainage Study for documentation purposes (see appendix 3A-2 for example). Plans shall be completed to the minimum LD-436 requirements.

Field Inspection ("FI") Milestone: Drainage, SWM, and ESC Design/Calculations shall be completed and submitted with the Plans. Design/Calculations shall meet VDOT requirements, unless a design waiver is requested and approved by VDOT (See Appendix 3A-3 for example). Plans shall be completed to the minimum LD-436 requirements.

Pre-Advertisement Conference ("PAC") Milestone: Drainage, SWM, and ESC Design/Calculations and Report shall be completed and submitted with the Plans. The Report shall be signed and sealed in accordance with IIM-LD-243, and all design waivers shall be completed, approved, and included in the Report (See Appendix 3A-4 for example). Plans shall be completed to the minimum LD-436 requirements.

All above deliverables shall be uploaded to Falcon as PDF files at the proper milestone and archived with that milestone. See VDOT CADD Manual Section E.2.2 Archiving Files for instructions on how to archive.*

3.3.4 Guidelines

Descriptions for hydraulic items shall be written in accordance with these instructional guidelines. General examples of basic drainage descriptions are shown for illustrative purposes. These examples are intended to assist the Drainage Designer in the consistent application of VDOT procedures and practices. The numerical values utilized in the descriptions are for illustration only. These examples are reflective of the VDOT Road and Bridge Standards.

3.3.4.1 Plan Measurements

The length of culverts and storm sewer pipe shall be shown to the nearest 1'.

Invert elevations for culverts and appurtenances shall be shown to the nearest 0.1'.

Invert elevations for storm sewer pipe and appurtenances shall be shown to the nearest 0.01'.

* Rev. 1/17

Linear footage of manholes and heights of junction boxes and drop inlets shall be shown to the nearest 0.1'.

The design height of cover for culverts and storm sewer pipe shall be shown to the nearest 1'.

The skew angle for culverts shall be shown to the nearest 5 degree increment.

3.3.4.2 Pipe Lengths

The actual scaled/measured value should be shown.*

Pipe lengths are typically determined based on the horizontal plan view distance between the ends of the pipe segment. Where pipes are specified to be laid on steep slopes, such as the outlet pipe from a shoulder slot inlet, the length of the pipe should be determined based on the length measured along the incline.

The location of the ends of a segment of drainage pipe will vary depending on the type of terminal structure specified. The ends of the pipe should be established based on the following:

- For terminal structures such as drop inlets, manholes, junction boxes, etc., the end of the pipe should be established based on the point at which the exterior walls of the pipe intersect the interior wall of the terminal structure. An exception to this would be where a terminal structure would have a base unit with an internal dimension less than the external dimension of the pipe. In this case the end of the pipe should be established based on that point at which the interior walls of the pipe intersect the interior wall of the terminal structure
- Where endwalls are specified as terminal structures, the end of the pipe and the location of the face of the endwall should be established based on that point at which the embankment slope intersects the interior wall at the crown (top) of the pipe
- Where end-sections are specified as terminal structures, the point at which the embankment slope intersects the exterior wall at the top of the end-section (at its full height) should be determined. Dimension "C" noted in the appropriate table on the Standard Drawings for ES-1, ES-1A or ES-2 (as applicable) should be subtracted from this point to establish the location (and pay line) for the end of pipe
- Where the pipe projects beyond the embankment with no type of terminal treatment specified, the end of the pipe should be established based on that point at which the embankment slope intersects the flow line (invert) of the pipe

* Rev. 7/14

3.3.4.3 Skew Angle of Culverts*

The angle of skew shown on the plans for a drainage culvert is the acute angle formed by the centerline of the structure and a line drawn perpendicular to the roadway baseline that the culvert crosses. Where the culvert crosses more than one roadway baseline and where the baselines at the opposite ends of the structure are not parallel, an angle of skew for each end of the structure shall be shown in the description and in the summaries.

3.3.4.4 Structure Numbers

A numbering system is to be used to identify all proposed drainage items on the plans and those existing items to be modified or adjusted with the proposed construction (Exception – Projects with minimal drainage items that will use a Streamline Summary). A two number designation is to be used. The first number will identify the number of the plan sheet that contains the item and the second number will designate the assigned item number (e.g., Structure 4-20 is item number 20 on plan sheet 4; Structure 11B-2 is item number 2 on sheet 11B).

Culverts shall be identified by a single designation (e.g., 15-9).

For storm drain systems, the structures (inlets, manholes, junction boxes, etc.) shall be individually numbered. The pipe connecting two such structures shall be identified as from point to point (e.g., 4-6 to 4-7 is the pipe between structures 4-6 and 4-7).

The structure designation numbers are to be shown within ellipses. The descriptions are to be shown, space permitting, on the corresponding plan sheet. If all of the descriptions cannot be shown on the plan sheet, a separate drainage description sheet should be provided.

3.3.4.5 Protective Coatings

Where a protective coating is required for culverts, storm sewers and concrete structures exposed to the normal ebb and flow of tidal water or a corrosive environment, the Drainage Designer should include the following notation in the drainage description for the specified structures:

- *Pipe or structure is to have protective coating applied in accordance with Section 404 of the VDOT Road and Bridge Specifications*

* Rev 7/14

3.3.4.6 Pipe Descriptions

Each description should list the categories of information, as may be appropriate in the following order:

- All data pertaining to the pipe or culvert barrel (material, length, size, skew, cover, inverts)
- The type of end treatment (including erosion control protection)
- The recommended foundation data and minor structure excavation quantities

The "Design Height of Cover" must be shown for each pipe description on the plans (including pipes under entrances) and on the Drainage Summary, see Appendix 3A-5. This allows the Engineer to determine the proper strength, sheet thickness, or class of pipe from VDOT's Road and Bridge Standard PC-1 drawings applicable to a particular location.
When specifying less than the standard minimum cover on concrete pipe, a reference to Drainage General Note D-14 should be included in the description for the structure.

When specifying the height of cover for the pipe culverts or the fill height for box culverts, normal practice is to specify the maximum cover that occurs along the entire length (run) of the culvert. Generally, as the height of cover (dead load) increases so does the required strength of the culvert. Therefore, specifying the maximum height of cover should ensure that the selected culvert is of sufficient strength to withstand the anticipated maximum dead load.

This, however, does not always hold true for culverts in low cover situations due to the greater influence of the live load. Two examples of this would be:

- Pipes or culverts, subject to traffic loading, with less than the standard Minimum cover called for in Standard PC-1 (2016* VDOT Road & Bridge Standards). In such cases, each type of pipe or culvert material will have its own specific requirements for absolute minimum heights of cover both during construction and in the finished condition. Refer to Standard PC-1 for requirements specific to material and size. For situations where the cover is less than the standard minimum, the designer is advised to contact the pipe manufacturer directly and discussing the anticipated loading with their Engineering Manager

- Concrete box culverts, of like size, with 0' to 2' of cover generally require more concrete and steel (greater strength) than those with 2' to 5' of cover

Therefore, if a portion of the culvert falls into one of the above categories, the plans should specify the minimum height of cover or fill height to ensure that we get the proper strength pipe or box culvert for the particular site conditions.

* Rev 1/17

In those cases where the Materials Division's Subsurface Investigation Report indicates a soft, yielding or otherwise unsuitable foundation material, the description would include the recommended excavation and backfill information and be noted as follows:*

Excavate 20" below bottom of culvert and backfill with Bedding Material Aggregate #25 or 26
200 CY Minor Structure Excavation
100 Tons Bedding Material Aggregate #25 or 26

- The specified bedding material quantity should be that required for backfilling the unsuitable material excavation below the normal 4" of bedding material and within the vertical limits shown in the Road and Bridge Standard PC-1 drawings.
- The specified minor structure excavation quantity should be measured from the top of the existing ground surface or bottom of the normal roadway excavation limit, whichever is lower, to the bottom of the foundation trench and within the vertical limits shown in the Road and Bridge Standard PC-1 drawings.
- The quantities specified for minor structure excavation and bedding material should include that required for endwalls, wingwalls, or other appurtenances. This quantity is based on the ratio of the plan area of the endwalls, wingwalls, or other appurtenances to the plan area of the culvert or pipe barrel. (See Section 8.4.4.4)

The strength, thickness, gage, class of pipe or method of bedding will be noted on the plans.

Pipe fittings such as tees, wyes, reducers, etc. are paid for as linear feet of pipe based on the largest dimension. Therefore, such items should be included in the description of the larger size pipe and their length included in the total length of that pipe segment.

In instances where a culvert must be countersunk to comply with environmental requirements a notation should also be included in the drainage description indicating that the invert elevations reflect countersinking, e.g., "The invert elevations noted reflect a minimum of "*" countersinking." (where "*" is either 3" or 6" as required for the culvert's size.) This will clearly communicates to the field personnel that the proposed invert elevations are intentionally set lower than the streambed. The fact that the culvert is to be countersunk should also be included in the remarks column of the Drainage Summary, see Appendix 3A-5.

* Rev 7/14

3.3.4.6.1 Typical Culvert Descriptions

These descriptions allow the Engineer* the option of selecting the pipe material and joint type for a particular project location Pipe material shall be specified in the description Reqd.

(2-3) 100'-48" Conc. Pipe Class III Req. (6' Cover) (20°Skew)
Leak Resistant Joint Type
Inv(In) = 435.0', Inv(Out) = 434.0'
2 Std. EW-2 Req.
21 CY Std. EC-1 Class 1 Req. Lt. Type B Installation
378 CY Minor Structure Excavation

(2-5) 100'-24" Aluminum Coated Type 2, 14 Gauge Pipe Req. (3'Cover)
Silt Tight Joint Type
Inv(In) = 435.0', Inv(Out) = 434.0'
1 Std. ES-1 or 2 Req. Lt.
1 Std. EW-11 Req. Rt. 4:1 Slope

3.3.4.6.2 Concrete Pipe on Radius

Concrete pipe may be installed on a radius using the open joint method or using the bevel pipe method with or without open joints. Concrete pipe that is installed on a radius using the open joint method is standard pipe and should not be specified as concrete radial pipe. See Section 9.4.8.8 for the minimum radius for each method for various pipe sizes.

- OPEN JOINT METHOD

  (2-3) 100'-48" Conc. Pipe Class III Req. (6' Cover)
  (530' Radius with open joints – using 8' pipe joint lengths)
  Joints are to be opened a maximum of 25% of the spigot or tongue length.
  Inv(In) = 435.0', Inv(Out) = 434.0'
  2 Std. EW-2 Req.
  21 CY Std. EC-1 Class 1 Req. Type B Installation
  378 CY Minor Structure Excavation

- BEVEL PIPE METHOD

  (3-1) 100'-48" Conc. Radial Pipe Class III Req. (6' Cover)
  (120' Radius – using 8' pipe joint lengths with full bevel)
  Inv(In) = 435.0', Inv(Out) = 434.0'
  2 Std. EW-2 Req. Lt.
  21 CY Std. EC-1 Class 1 Req. Type B Installation
  378 CY Minor Structure Excavation

* Rev. 7/16

- BEVEL PIPE WITH OPEN JOINT METHOD

  (6-7) 100'-48" Conc. Radial Pipe Class III* Req. (6' Cover)
  (95' Radius with open joints – using 8' pipe joint lengths with full bevel)
  Joints are to be opened a maximum of 25% of the spigot or tongue length.
  Inv(In) = 435.0', Inv(Out) = 434.0'
  2 Std. EW-2 Req.
  21 CY Std. EC-1 Class 1 Req. Type B Installation
  378 CY Minor Structure Excavation

3.3.4.6.3 Trenchless Applications

(5-6) 80'-48" Jacked Conc. Pipe Class IV Req. (25' Cover)
Leak Resistant Joint Type
Inv(In) = 197.6', Inv(Out) = 197.0'
2 Std. EW-2 Req.
21 CY Std. EC-1 Class 1 Req. Type B Installation

(5-8) 160'-36" Microtunnel Smooth Steel, 10 Gauge Pipe Req. (15' Cover)
Leak Resistant Joint Type
Inv(In) = 200.6', Inv(Out) = 198.0'
2 Std. EW-1 Req.
17 CY Std. EC-1 Class 1 Req. Type B Installation

3.3.4.6.4 Multiple Pipe Installation

(8-9) 300'-48" Galvanized Steel, 12 Gauge Pipe Req. (7' Cover)
(Triple Line – 100' each line)
Silt Tight Joint Type
Inv(In) = 164.8', Inv(Out) = 164.1'
2 Std. EW-7 Req.
41 CY Std. EC-1 Class 1 Req. Type B Installation
1,134 CY Minor Structure Excavation

3.3.4.6.5 Existing Pipe Extension

The vertical and horizontal alignment of the pipe extension should duplicate that of the existing pipe. The type of pipe specified for the extension should be the same as the existing pipe. The cover specified should be the maximum that occurs along the entire run of pipe, including the existing section.

* Rev. 7/16

(2-3) Existing Pipe To Be Extended with 50'-36" Corrugated Steel Pipe, 12 Gauge* Req. (7' Cover)
Inv(In) = 435.0', Inv(Out) = 434.0'
1 Std. EW-1 Req.

3.3.4.7 Box Culvert Descriptions

3.3.4.7.1 *Standard (Cast-In-Place)*

The standard description should be used where a cast in place structure can be used. However, the specifications allow the Contractor the option of substituting a precast structure with approval of the Engineer.

(4-3) 150'- 6' X 8' Box Culvert Req. (25' Cover)(15° Skew)
Inv(In) = 60.0', Inv(Out) = 57.0'
Std. BCS-DT, BCS-30, & BCW-21
4 Std. Type I Wings Req.
75 CY Std. EC-1 Class 1 Req. Rt. Type B Installation
527 CY Minor Structure Excavation

3.3.4.7.2 *Precast*

The precast description should be used where a precast structure only is desired.

(4-8) 150'- 6' X 8' Precast Box Culvert Req. (25' Cover)(15° Skew)
Inv(In) = 60.0', Inv(Out) = 57.0'
2 Headwalls Req. (Cost to be included in price bid for linear feet of box culvert) Reference Stds. BCS-DT & BCS-30
4 Wings Req. Reference Std. BCW-21, Type 1(K)
75 CY Std. EC-1 Class 1 Req. Rt. Type B Installation
527 CY Minor Structure Excavation

3.3.4.8 Structures

When specifying precast structures, it is not necessary to identify, in the description, the applicable precast standard base, riser, and top units, unless a particular type of component is desired. The Contractor should, wherever possible, be allowed the option of determining the most economical units to utilize to assemble the desired structure.

In addition to the standard information, the drainage description should include all information required to properly construct the structure. The description should be clear to the extent that there is no doubt as what is to be done at the location. Some examples of additional information to be included in a description would be:

- *Connect To Existing 18" Conc. Pipe*
- *Connect UD-4 TO DI*

* Rev. 7/16

Standard IS-1 Inlet Shaping should be specified for manholes, drop inlets, or junction boxes where the main trunk line of a storm sewer changes direction or pipes of approximately the same size intersect and are carried forward in a single pipe.

Standard SL-1 safety slabs shall be specified for manholes, drop inlets, or junction boxes in accordance with the guidance outlined in Section 9.4.5.2.2 and the standard drawing.

All drop inlets (both curb and median), catch basins, junction boxes and other such structures that require a frame and cover or grate at finished ground elevation, shall show the height dimension "H" on the plans and on the Drainage Summary, see Appendix 3A-5. This dimension is to be measured from the invert elevation to the top of the concrete or masonry structure and is to be shown to the nearest 0.1'.

Manholes should be shown as the number of linear feet required, measured from the invert to the top of the concrete or masonry structure. The linear feet of manhole specified should not include the height of the frame and cover.

3.3.4.8.1 *Curb Drop Inlets*[*]

The standard description assumes cast in place; however, the Contractor is allowed the option to substitute a precast structure.

(3-1) 1 Std. DI-4D Req.
L=8', H=5.2', Inv = 197.6'
Std. IS-1 Req.

When the required structure height is greater than the maximum allowed for a cast in place structure, or a precast structure is desired, the description would be:

(9-7) 1 Std. DI-4DD (Precast) Req.
L=8', H=25.0', Inv = 197.6'
2 Std. SL-1 Req.

[*] Rev 7/14

Standard IS-1 Inlet Shaping should be specified for manholes, drop inlets, or junction boxes where the main trunk line of a storm sewer changes direction or pipes of approximately the same size intersect and are carried forward in a single pipe.

Standard SL-1 safety slabs shall be specified for manholes, drop inlets, or junction boxes in accordance with the guidance outlined in Section 9.4.5.2.2 and the standard drawing.

All drop inlets (both curb and median), catch basins, junction boxes and other such structures that require a frame and cover or grate at finished ground elevation, shall show the height dimension "H" on the plans and on the Drainage Summary, see Appendix 3A-5. This dimension is to be measured from the invert elevation to the top of the concrete or masonry structure and is to be shown to the nearest 0.1'.

Manholes should be shown as the number of linear feet required, measured from the invert to the top of the concrete or masonry structure. The linear feet of manhole specified should not include the height of the frame and cover.

3.3.4.8.1 *Curb Drop Inlets*[*]

The standard description assumes cast in place; however, the Contractor is allowed the option to substitute a precast structure.

(3-1) 1 Std. DI-4D Req.
L=8', H=5.2', Inv = 197.6'
Std. IS-1 Req.

When the required structure height is greater than the maximum allowed for a cast in place structure, or a precast structure is desired, the description would be:

(9-7) 1 Std. DI-4DD (Precast) Req.
L=8', H=25.0', Inv = 197.6'
2 Std. SL-1 Req.

[*] Rev 7/14

3.3.4.8.2 *Grate Drop Inlets*

Descriptions for Standard DI-5, DI-7, and DI-12 series grate drop inlets should specify the type of grate required, i.e., a Type I grate for areas where pedestrian access is unlikely or a Type III (DI-5 & 7) or Type II (DI-12) for pedestrian accessible areas. When a DI-7 inlet is to be located in areas subject to occasional traffic (e.g., shoulders, parking areas, etc.), a load carrying Grate B should be specified.

(9-16) 1 Std. DI-7 Req. Grate A Type II Req.
H=5.3', Inv = 23.6'

Descriptions for Standard DI-5 inlets should include the type of cover. The Standard PG-2A cover type most closely matching the ditch configuration should be specified. The height of the structure is measured from the invert to the top of the concrete cover.

(4-5) 1 Std. DI-5 Req. Type I Grate Req.
Std. PG-2A Type E Cover
H=4.8', Inv = 13.6'

3.3.4.8.3 *Manholes*

If a cast in place structure only is to be allowed, show only the MH-1 designation. Show only the MH-2 designation if a precast unit only is to be allowed. The option of utilizing cast in place as well as precast manholes should be allowed at all locations except for those where placement is limited due to existing pipelines, utilities, the size of pipe, etc. Most locations should permit the Contractor the option to utilize either and the descriptions should specify both the cast in place and precast standard.

(3-1) 14.6 LF Std. MH-1 or 2 Req.
1 Std. MH-1 Frame & Cover Req.
Inv = 83.4'
1 Std. SL-1 Req.

3.3.4.8.4 *Junction Boxes*[*]

(8-3) 1 Std. JB-1 Req.
H=12.8', W=4', D=5'
Type A Tower Req.
1 Std. MH-1 Frame & Cover Req.
Inv = 121.4'
1 Std. SL-1 Req.

[*] Rev 7/14

3.3.4.8.5 *Stormwater Management Structures*

In those instances where the stormwater management basin is to be utilized as a temporary sediment basin, the description should be so noted with a reference to Standard SWM-DR for details.

- SWM DRAINAGE STRUCTURE
  (14-7) 6.7' Std. SWM-1 Req.
  Bottom Elev = 23.8'
  3" Diameter Water Quality Orifice Req., Inv = 26.8'
  10" Diameter Orifice Req., Inv = 28.8'
  See Sheet 2G For Details

- STORMWATER MANAGEMENT DAM
  (11-9) 1 SWM Dam Req
  See sheet 2E for details

- MANUFACTURED WATER QUALITY STRUCTURES
  (7-7) 1 Water Quality Structure Req.
  Top Elevation = 26.3'
  Inv. Pipe(In) = 20.3', Inv. Pipe(Out) = 20.0'

3.3.4.8.6 *Existing Structures*

The Drainage Designer will determine if existing pipe and box culverts and storm sewer pipe will remain and be utilized in the proposed design or removed or abandoned.

Pipes to be removed, abandoned or cleaned out are to be indicated on the plans for bidding purposes and labeled "To Be Removed", "To Be Abandoned", or "To Be Cleaned Out".

Any large amount of pipe and appurtenances to be removed, such as an existing storm sewer system[*], should be set up as a separate bid item and summarized in a separate column in the Incidental Summary.

When not set up as a separate pay item, small amounts of pipe and appurtenances to be removed are included in the cost of Clearing and Grubbing (See Section 105.15 of the Road & Bridge Specifications) or may be included in the cost of Regular Excavation. (See latest IIM-LD-110 & General Note G-4)

[*] Rev 7/14

Any drainage pipe that is abandoned and left in place shall be backfilled and plugged in accordance with VDOT's Road and Bridge Standard PP-1. These pipes are to be labeled on the plans "To Be Abandoned". The pay item for abandoning existing structures is "Flowable Backfill, CY" and includes furnishing and placing backfill material and plugging both ends of the drainage pipe.

The quantity for Flowable Backfill (includes flowable backfill or fine aggregate) is to be estimated in accordance with Standard PP-1. This estimated quantity is to be summarized in the Drainage Summary, see Appendix 3A-5. The pipe location/structure number should be shown in the Drainage Summary, see Appendix 3A-5 and the pipe size should be noted in the remarks column.

General Note D-12 (See latest IIM LD-110) is to be included on the General Note Sheet in all applicable project assemblies.

"Modify" should be used when a major work effort is required (e.g., connecting or removing pipes, adjusting height more than 1', etc.).*

(4-11) Modify Existing Drop Inlet
Adjust To Grade, Raise 2.3'
Add DI-3B, L=6'
Proposed Top Elev = 153.6'
See Sheet 2K For Details.

"Adjust" should be used when a minor work effort is required (e.g., adjusting height 1' or less).

(5-18) Adjust Existing MH
Adjust To Grade, Raise 0.5'
1 Std. MH-1 Frame & Cover Req.
Proposed Top Elev = 234.3'

All work to be performed to modify the structure should be clearly stated in the drainage description. Other such information would be:

- *Modify To (Accept/Remove) 15" Conc. Pipe*
- *Connect UD-4 To Structure*
- *Convert Existing DI to Manhole*
- *To Be Cleaned Out*

* Rev 7/14

The necessary standard items for completing the work should be specified (e.g., precast units, manhole frame and cover, etc.). The structural condition of an existing structure should be field evaluated to determine the suitability for modification. Those structures found to be structurally deficient or in poor condition should be replaced in lieu of being modified. The cost of total replacement versus modification should also be evaluated to make sure the most economical solution is being proposed.

3.3.4.9 Drainage Summaries and Type of Pipe Selection*

A Standard (Detailed) Summary is to be used on normal construction (C) projects.

A Streamlined Summary may be used on Minimum Plan (M), No Plan (N) and Safety projects.

When the Drainage Summary sheets are compiled, the drainage items in the Drainage Summary are to be referenced by their assigned structure numbers with no further reference to sheet number, station, or location needed.

The total linear feet of all like size pipe shall be summarized by material.

The methods of listing pipe in the Standard Summary, see Appendix 3A-5 and the Streamlined Summary are to be used to eliminate a possible contractor's error when ordering the pipe.

- Streamline Summary Example:

  800 LF 15" Aluminum Coated, Type 2, Pipe
  40 LF 15" Galvanized Corrugated Steel Pipe
  200 LF 15" Conc. Pipe
  100 LF 24" Polyethylene (PE) Corrugated, Type S Pipe
  200 LF 72" Special Design Conc. Pipe

The total linear feet of all like size pipe, are generally combined by material for the purposes of the estimate.

Projects on which the new pipe installations require end sections, the Drainage Summary, see Appendix 3A-5 shall have a column indicating the optional standard, "Std. ES-1 or Std. ES-2", for the end sections. A separate column on the Drainage Summary, see Appendix 3A-5 is required when specifying only a Std. ES-1 or Std. ES-2 end section for pipes of a particular material.

Example tabulations for a Route 64 project in York County are as follows:
(The template for the following tables can be found in the CADD Cell Library)

* Rev. 7/16

PIPE CULVERT EXAMPLE

Allowable Pipe Types Standard PC-1 as shown below will still be included in the Plan Sets.*

ALLOWABLE TYPE OF PIPE CULVERTS (UNLESS SHOWN ON PLANS) (SEE ROAD AND BRIDGE STANDARD PC-1 FOR HEIGHT OF COVER LIMITATIONS FOR EACH TYPE)											
LOCATION	CONCRETE	ALUMINUM COATED TYPE 2 CORRUGATED STEEL	POLYMER COATED 10/10 CORRUGATED STEEL	UNCOATED GALVANIZED CORRUGATED STEEL	GALVANIZED STEEL STRUCTURALPLATE	GALVANIZED STEEL STRUCTURALPLATE WITH CONCRETE INVERT	CORRUGATED ALUMINUM ALLOY	CORRUGATED ALUMINUM ALLOY STRUCTURAL PLATE	POLYVINYLCHLORIDE (PVC) CORRUGATED RIBBED PIPE (SMOOTH INTERIOR)	POLYETHYLENE (PE) CORRUGATED TYPE C	POLYETHYLENE (PE) CORRUGATED TYPE S
Rte. 64 & Ramps	X		X				X	X	X	X	X
Route 635 (Rural Local Road)	X	X	X		X	X	X	X	X	X	X
Entrances	X	X	X	X	X	X	X	X	X		X
Shoulder Slot Inlet		X	X	X			X		X	X	

* Rev. 7/16

STORM SEWER PIPE EXAMPLE*

ALLOWABLE TYPE OF STORM SEWER PIPE (UNLESS OTHERWISE SHOWN ON PLANS) (SEE ROAD AND BRIDGE STANDARD PC-1 FOR HEIGHT OF COVER LIMITATIONS FOR EACH TYPE)								
LOCATION	CONCRETE	CORRUGATED STEEL ALUMINUM COATED TYPE 2 FULLY CONCRETE LINED	ALUMINUM COATED TYPE 2 SPIRAL RIB PIPE	POLYMER COATED (10/10) CORRUGATED STEEL SPIRAL RIB PIPE	POLYMER COATED (10/10) CORRUGATED STEEL DOUBLE WALL (SMOOTH INTERIOR)	ALUMINUM SPIRAL RIB PIPE	POLYVINYLCHLORIDE (PVC) RIBBED PIPE (SMOOTH INTERIOR)	POLYETHYLENE (PE) CORRUGATED TYPE S
Rte. 64 & Ramps	X				X		X	X
Route 635 (Rural Local Road)	X			X	X	X	X	X

3.3.4.10 Post Installation Pipe Inspection

A post installation visual/video camera inspection shall be conducted by the Contractor on all pipes identified on the plans as storm sewer pipe and a select number of pipe culverts.

For pipe culverts, a minimum of one pipe installation for each size of each material type will be inspected or ten percent of the total amount for each size and material type summarized. All pipe installations on the plans not identified as storm sewer pipe shall be considered as culvert pipe for inspection purposes.

For multiple-line pipe installations, each line of pipe should be counted and quantified individually when determining the overall post installation pipe inspection quantity.

* Rev 7/14

The drainage summary, see Appendix 3A-5 is to include a quantity for the total linear feet of Post Installation Inspection (to include both pipe culverts and storm sewer pipe).

These requirements shall not be applicable to pipes that are being rehabilitated.
See sample Post Installation Summary Table in Appendix 3A-5 for No Plans(N):*

Example for “No Plan”:

POST INSTALLATION INSPECTION						
Storm Sewer Pipe		Pipe (All pipe installation on plans not identified as storm sewer pipe)				
Size	LF	Size	LF	10% of Total	Individual Installation	Quantity to Inspect (LF)
12"		12"	788	79	24,24,24,32,48,24,32,24,24,44,24, 40,24,24,24,24,24,24,24,24,24,36,24, 24,24,24,24,24,24,24,24	48
15"	228					
18"	36	15"	898	90	40,24,24,24,24,24,24,24,24,24,32, 24,24,48,24,24,24,32,24,24,36,24, 24,24,24,48,24,12,110,12,24	110
		18"	258	26	24,40,24,36,24,24,24,32,24,6	24
		23"x14"	2394	239	30,34,98,148,180,110,252,200,100,98, 68,32,94,48,28,164,76,176,32,40,44, 204,32,24,24,34,24	252
		30"x19"	106	11	36,36,34	34
		45"x29"	40	4	40	40
Subtotals	264					508
Totals to be Inspected			772			

* Rev 7/14

3.4 References

American Association of State Highway and Transportation Officials. (2014). *AASHTO Drainage Manual (*First Edition). Washington, D.C.: American Association of State Highway and Transportation Officials.

American Association of State Highway and Transportation Officials. (2007). *AASHTO Highway Drainage Guidelines (*Fourth Edition). Washington, D.C.: American Association of State Highway and Transportation Officials.*

*Rev 1/17

Appendix 3A-1 PFI Milestone Deliverable

Hydraulics Narrative

UPC 123456 - Rte 111 Safety Improvements

Stormwater Management

This project utilizes the technical criteria of Part IIB (9VAC25-870-62) for determining its post-development stormwater management design. Nutrient credits shall be purchased to meet the water quality requirements of the technical criteria. The total pollutant removal requirement for this project is 0.37 lb/year. Calculations for the quantity of nutrient credits required can be found at the end of this report.

The water quantity requirements for this project are also governed by the technical criteria of Part IIB (9VAC25-870-66). The limits of analysis for analyzing the downstream channel for channel and flood protection will be to the point where the contributing drainage area from the project is less than 1% of the total drainage area to that point. Therefore, channel and flood protection requirements will not be governed by the energy balance equation, but rather by showing that the channel is adequate for the 10-year storm for capacity and for the 2-year storm for resisting erosion. In order to meet the requirements of the 1% rule, the downstream channel will be analyzed to a point approximately 500 linear feet downstream of the project site. A map demonstrating compliance with the 1% rule can be found at the end of this narrative.

The survey information provided for the downstream channel does not appear to match observations from the field visit. Photos and observations from the field show the downstream channel as a stream with a wide trapezoidal channel, while the survey data shows a v-shaped channel. Additional survey data or a field visit may be necessary to confirm the characteristics of the downstream channel; however, based on photos and field observations, the channel is adequate for channel and flood protection.

Appendix 3A-1 PFI Milestone Deliverable

Hydraulics Narrative

UPC 123456 - Rte 111 Safety Improvements

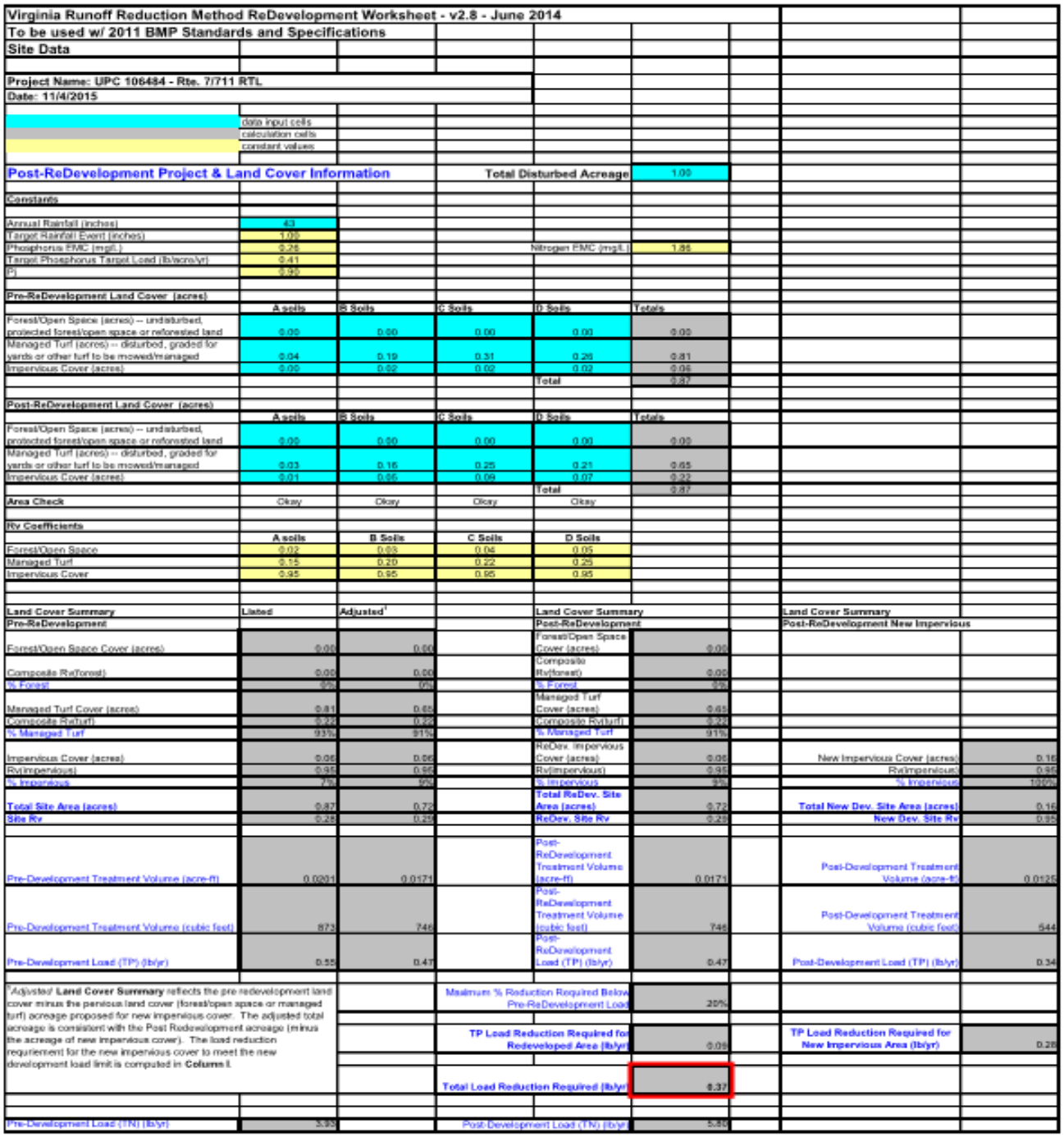
Stormwater Management

This project utilizes the technical criteria of Part IIB (9VAC25-870-62) for determining its post-development stormwater management design. Nutrient credits shall be purchased to meet the water quality requirements of the technical criteria. The total pollutant removal requirement for this project is 0.37 lb/year. Calculations for the quantity of nutrient credits required can be found at the end of this report.

The water quantity requirements for this project are also governed by the technical criteria of Part IIB (9VAC25-870-66). The limits of analysis for analyzing the downstream channel for channel and flood protection will be to the point where the contributing drainage area from the project is less than 1% of the total drainage area to that point. Therefore, channel and flood protection requirements will not be governed by the energy balance equation, but rather by showing that the channel is adequate for the 10-year storm for capacity and for the 2-year storm for resisting erosion. In order to meet the requirements of the 1% rule, the downstream channel will be analyzed to a point approximately 500 linear feet downstream of the project site. A map demonstrating compliance with the 1% rule can be found at the end of this narrative.

The survey information provided for the downstream channel does not appear to match observations from the field visit. Photos and observations from the field show the downstream channel as a stream with a wide trapezoidal channel, while the survey data shows a v-shaped channel. Additional survey data or a field visit may be necessary to confirm the characteristics of the downstream channel; however, based on photos and field observations, the channel is adequate for channel and flood protection.

Appendix 3A-1 PFI Milestone Deliverable



Virginia Runoff Reduction Method ReDevelopment Worksheet - v2.8 - June 2014

To be used w/ 2011 BMP Standards and Specifications

Site Data

Project Name: UPC 106484 - Rte. 7/711 RTL

Date: 11/4/2015

	data input cells
	calculation cells
	constant values

Post-ReDevelopment Project & Land Cover Information — **Total Disturbed Acreage** 1.00

Constants

Annual Rainfall (inches)	43		
Target Rainfall Event (inches)	1.00		
Phosphorus EMC (mg/L)	0.26	Nitrogen EMC (mg/L)	1.86
Target Phosphorus Target Load (lb/acre/yr)	0.41		
(P)	0.90		

Pre-ReDevelopment Land Cover (acres)

	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.04	0.19	0.31	0.26	0.81
Impervious Cover (acres)	0.00	0.02	0.02	0.02	0.06
				Total	0.87

Post-ReDevelopment Land Cover (acres)

	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.03	0.16	0.25	0.21	0.65
Impervious Cover (acres)	0.01	0.05	0.09	0.07	0.22
				Total	0.87
Area Check	Okay	Okay	Okay	Okay	

Rv Coefficients

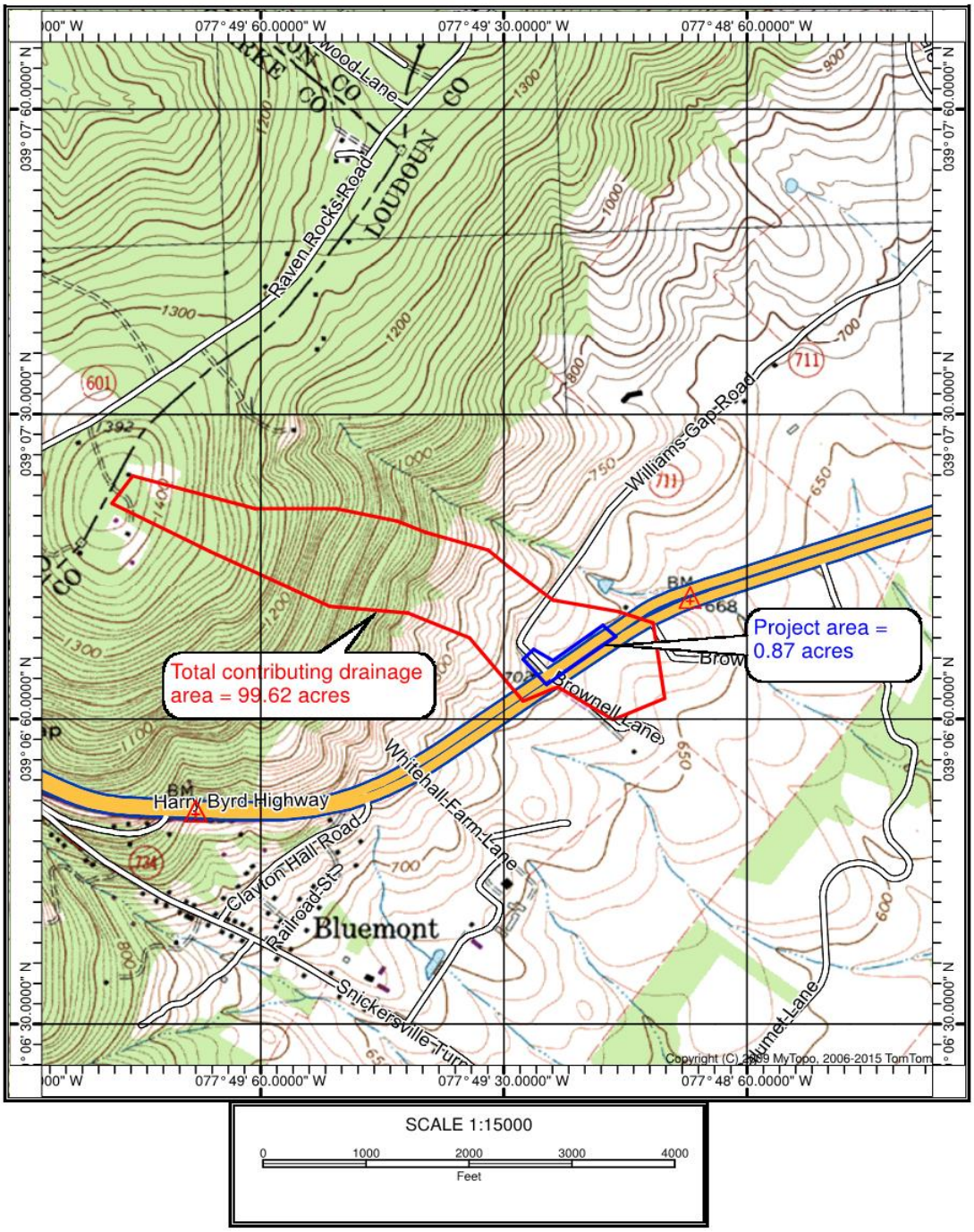
	A soils	B Soils	C Soils	D Soils
Forest/Open Space	0.02	0.03	0.04	0.05
Managed Turf	0.15	0.20	0.22	0.25
Impervious Cover	0.95	0.95	0.95	0.95

Land Cover Summary	Listed	Adjusted[1]		**Land Cover Summary**			**Land Cover Summary**	
Pre-ReDevelopment				**Post-ReDevelopment**			**Post-ReDevelopment New Impervious**	
Forest/Open Space Cover (acres)	0.00	0.00		Forest/Open Space Cover (acres)	0.00			
Composite Rv(forest)	0.00	0.00		Composite Rv(forest)	0.00			
% Forest	0%	0%		% Forest	0%			
Managed Turf Cover (acres)	0.81	0.65		Managed Turf Cover (acres)	0.65			
Composite Rv(turf)	0.23	0.23		Composite Rv(turf)	0.23			
% Managed Turf	93%	91%		% Managed Turf	91%			
Impervious Cover (acres)	0.06	0.06		ReDev. Impervious Cover (acres)	0.06		New Impervious Cover (acres)	0.16
Rv(impervious)	0.95	0.95		Rv(impervious)	0.95		Rv(impervious)	0.95
% Impervious	7%	9%		% Impervious	9%		% Impervious	100%
Total Site Area (acres)	0.87	0.72		**Total ReDev. Site Area (acres)**	0.72		**Total New Dev. Site Area (acres)**	0.16
Site Rv	0.28	0.28		**ReDev. Site Rv**	0.28		**New Dev. Site Rv**	0.95
Pre-Development Treatment Volume (acre-ft)	0.0201	0.0171		Post-ReDevelopment Treatment Volume (acre-ft)	0.0171		Post-Development Treatment Volume (acre-ft)	0.0125
Pre-Development Treatment Volume (cubic feet)	873	746		Post-ReDevelopment Treatment Volume (cubic feet)	746		Post-Development Treatment Volume (cubic feet)	544
Pre-Development Load (TP) (lb/yr)	0.55	0.47		Post-ReDevelopment Load (TP) (lb/yr)	0.47		Post-Development Load (TP) (lb/yr)	0.34

[1]Adjusted **Land Cover Summary** reflects the pre redevelopment land cover minus the pervious land cover (forest/open space or managed turf) acreage proposed for new impervious cover. The adjusted total acreage is consistent with the Post Redevelopment acreage (minus the acreage of new impervious cover). The load reduction requirement for the new impervious cover to meet the new development load limit is computed in **Column I**.

	Maximum % Reduction Required Below Pre-ReDevelopment Load	28%	
	TP Load Reduction Required for Redeveloped Area (lb/yr)	0.09	**TP Load Reduction Required for New Impervious Area (lb/yr)** 0.28
	Total Load Reduction Required (lb/yr)	0.37	
Pre-Development Load (TN) (lb/yr)	Post-Development Load (TN) (lb/yr)	5.80	

Appendix 3A-1 PFI Milestone Deliverable



Appendix 3A-2 PH Milestone Deliverable

Hydraulics Design Study

UPC 123456 – Rte. 111 Safety Improvements

Project Description:

VDOT Central Office Hydraulic Section has prepared a drainage design and associated computations for the Route 611 (Spring Creek Road) project located in Washington County. The purpose of this project is to replace the bridge over Spring Creek, widen the roadway and make safety improvements to the horizontal and vertical alignments.

Existing Conditions:

The project is small urban (5,000-49,999) in nature. Route 611 is a two lane roadway with graded shoulders. Roadside ditches and pipe culverts direct stormwater runoff to Spring Creek. There are no wetlands or water quality structures in the project area.

Proposed Drainage System:

The project will maintain the same general flow patterns. Stormwater runoff will sheet flow or drain to a roadside ditch and ultimately discharge into Spring Creek. A stream channel relocation will be required at two separate locations on the project.

Hydrology:

The Rational Method of calculating discharge is used exclusively on this project because all of the drainage areas are less than 200 acres in size.

Culvert Design:

All proposed culverts on the project were designed to accommodate the 10-year storm event and maintain a minimum 18” headwater freeboard to the roadway shoulder point. However, several existing culverts in good condition that are to remain within project limits do not meet the minimum freeboard and will require a design waiver.

Regulations:

The project is grandfathered under the provisions of Section 4VAC50-60-48 of the VSMP Regulations adopted September 13, 2011, and utilizes the technical criteria of Part IIC (4VAC50-60-93.1 et. seq.) for determining its post-development stormwater management design.

Appendix 3A-2 PH Milestone Deliverable

Compliance:

The project is in compliance with DEQ by acquiring the required removal lbs/year from basins at the I-81 Exit 14 Modifications Project. Attached are the performance based water quality calculations for both projects. The performance based calculations for this project (UPC#60792) show a required removal of 1.63lbs/year of phosphorous and the performance based calculations for the I-81 Exit 14 Project (UPC#97856) show removing an additional 1.65 lbs/year of phosphorous. A letter from DEQ agreeing that the required removal for this project can be done with the I-81 Exit 14 Project will be submitted with the next milestone submittal.

Appendix 3A-2 PH Milestone Deliverable

Performance Based Water Quality

60792 Route 611

Project No.	60792	Date:	04/07/14	
Calc. By:	RJW	Check By:		
County Number:	95	County:	Washington	Ver. 2/06/13

PERFORMANCE-BASED WATER QUALITY CALCULATIONS

WORKSHEET 1

STEP 1: Determine the applicable area (A) and the post-developed impervious cover (I_{post}).

Applicable area (A) = 7.41 acres

Post-development impervious cover:

structures	=	0.00	acres
parking lot	=	0.00	acres
roadway	=	1.98	acres
other:			
(input description)	=	0.00	acres
(input description)	=	0.00	acres
	Total =	1.98	acres

I_{post} = (total post-development impervious cover ÷ A) x 100 = 26.72 %

STEP 2: Determine the avg. land cover condition ($I_{watershed}$) or the exist. impervious cover (I_{exist})

1. Average land cover condition ($I_{watershed}$):
If the locality has determined land cover conditions for individual watersheds within its jurisdiction, use the watershed specific value determined by the locality as $I_{watershed}$.

$I_{watershed}$= _____ **%** (input locality value or leave blank if one does not apply)

Otherwise, use the Chesapeake Bay default value:

$I_{watershed}$= 16.00 %

Page 1 of 3

Appendix 3A-2 PH Milestone Deliverable

Performance Based Water Quality

60792 Route 611

Project No.	60792	Date:	04/07/14	
Calc. By:	RJW	Check By:	01/00/00	
County Number:	95	County:	Washington	Ver. 2/06/13

PERFORMANCE-BASED WATER QUALITY CALCULATIONS

WORKSHEET 1

2. Existing impervious cover ($I_{existing}$):

Determine the existing impervious cover of the development site if present.

Existing impervious cover:

structures	=	0.00	acres
parking lot	=	0.00	acres
roadway	=	1.13	acres
other:			
(input description)	=	0.00	acres
(input description)	=	0.00	acres
	Total =	**1.13**	**acres**

$I_{existing}$ = (total existing impervious cover ÷ A*) x 100 = 15.25 %

* The applicable area (A) should be the same as used in STEP 1.

STEP 3: Determine the appropriate development situation.

The site information determined in STEP 1 and STEP 2 provide enough information to determine the appropriate development situation under which the performance criteria will apply. The appropriate development situation will marked by an "X" except situation 4 that will require user input if it applies.

_____ **Situation 1:**
Situation 1 Not Applicable

This consists of land development where the existing percent impervious cover ($I_{existing}$) is less than or equal to the average land cover condition ($I_{watershed}$) and the proposed improvements will create a total percent impervious cover (I_{post}) which is less than or equal to the average land cover condition ($I_{watershed}$).

I_{post} 26.72 % <= $I_{watershed}$ 16.00 %

Page 2 of 3

Appendix 3A-2 PH Milestone Deliverable

Performance Based Water Quality

60792 Route 611

Project No.	60792	Date:	04/07/14	
Calc. By:	RJW	Check By:	01/00/00	
County Number:	95	County:	Washington	Ver. 2/06/13

PERFORMANCE-BASED WATER QUALITY CALCULATIONS

WORKSHEET 1

X Situation 2:
Use Worksheet 2

This consists of land development where the existing percent impervious cover ($I_{existing}$) is less than or equal to the average land cover condition ($I_{watershed}$) and the proposed improvements will create a total percent impervious cover (I_{post}) which is greater than the average land cover condition ($I_{watershed}$).

$I_{existing}$ 15.25 % <= $I_{watershed}$ 16.00 % ;and

I_{post} 26.72 % > $I_{watershed}$ 16.00 %

Situation 3:
Worksheet 3 Not Applicable

This consists of land development where the existing percent impervious cover (Iexisting) is greater than the average land cover condition (Iwatershed).

$I_{existing}$ 15.25 % > $I_{watershed}$ 16.00 %

Situation 4:
Worksheet 4 Not Applicable

This consists of land development where the existing percent impervious cover (Iexisting) is served by an existing stormwater management BMP (s) that addresses water quality.

If the proposed development meets the criteria for development situation 1, then the low density development is considered to be the BMP and no pollutant removal is required. The calculation procedure for situation 1 stops here. If the proposed development meets the criteria for development situations 2,3, or 4, then proceed to STEP 4 on the appropriate worksheet.

Page 3 of 3

Appendix 3A-2 PH Milestone Deliverable

Performance Based Water Quality

60792 Route 611

Project No.	60792	Date:	04/07/14	
Calc. By:	RJW	Check By:	01/00/00	
County Number:	95	County:	Washington	Ver. 2/06/13

PERFORMANCE-BASED WATER QUALITY CALCULATIONS

WORKSHEET 2 : SITUATION 2

SUMMARY OF SITUATION 2 CRITERIA: FROM CALCULATION PROCEDURE STEP 1 THRU STEP 3, WORKSHEET 1:

Applicable area (A)*= 7.41 acres

I_{post} = (total post-development impervious cover / A) x 100 = 26.72 %

$I_{watershed}$ = 16.00 %

$I_{existing}$ 15.25 % <= $I_{watershed}$ 16.00 % ;and

I_{post} 26.72 % > $I_{watershed}$ 16.00 %

STEP 4: Determine the relative pre-development pollutant load (L_{pre}).

$L_{pre(watershed)}$ = [0.05 + (0.009 x $I_{watershed}$)] x A x 2.28 (Equation 5-16)

$L_{pre(watershed)}$ = relative pre-development total phosphorous load (pounds per year)

$I_{watershed}$ = average land cover condition for specific watershed or locality or the Chesapeake Bay default value of 16% (percent expressed in whole numbers)

A = applicable area (acres)

$I_{watershed}$ = 16.00 %

A = 7.41 acres

$L_{pre(watershed)}$ = 3.28 lbs/year

Page 1 of 4

Appendix 3A-2 PH Milestone Deliverable

Performance Based Water Quality

60792 Route 611

Project No.	60792	Date:	04/07/14	
Calc. By:	RJW	Check By:	01/00/00	
County Number:	95	County:	Washington	Ver. 2/06/13

PERFORMANCE-BASED WATER QUALITY CALCULATIONS

WORKSHEET 2 : SITUATION 2

SUMMARY OF SITUATION 2 CRITERIA: FROM CALCULATION PROCEDURE STEP 1 THRU STEP 3, WORKSHEET 1:

Applicable area (A)*= 7.41 acres

I_{post} = (total post-development impervious cover / A) x 100 = 26.72 %

$I_{watershed}$ = 16.00 %

$I_{existing}$ 15.25 % <= $I_{watershed}$ 16.00 % ;and

I_{post} 26.72 % > $I_{watershed}$ 16.00 %

STEP 4: Determine the relative pre-development pollutant load (L_{pre}).

$L_{pre(watershed)}$ = [0.05 + (0.009 x $I_{watershed}$)] x A x 2.28 (Equation 5-16)

$L_{pre(watershed)}$ = relative pre-development total phosphorous load (pounds per year)

$I_{watershed}$ = average land cover condition for specific watershed or locality or the Chesapeake Bay default value of 16% (percent expressed in whole numbers)

A = applicable area (acres)

$I_{watershed}$ = 16.00 %

A = 7.41 acres

$L_{pre(watershed)}$ = 3.28 lbs/year

Page 1 of 4

Appendix 3A-2 PH Milestone Deliverable

Performance Based Water Quality

60792 Route 611

Project No.	60792	Date:	04/07/14	
Calc. By:	RJW	Check By:	01/00/00	
County Number:	95	County:	Washington	Ver. 2/06/13

PERFORMANCE-BASED WATER QUALITY CALCULATIONS

WORKSHEET 2 : SITUATION 2

STEP 5: Determine the relative post-development pollutant load (L_{post}).

L_{post} = [0.05 + (0.009 x I_{post})] x A x 2.28 (Equation 5-21)

L_{post} = relative post-development total phosphorous load (pounds per year)

I_{post} = post-development percent impervious cover (percent expressed in whole numbers)

A = applicable area (acres)

L_{post} = 4.91 pounds per year

STEP 6: Determine the relative pollutant removal requirement (RR) .

RR = Lpost - Lpre(watershed)

RR= 1.63 pounds per year

STEP 7: Identify best management practice (BMP) for site.

1. Determine the required pollutant removal efficiency for site:

EFF = (RR ÷ L_{post}) x 100 (Equation 5-22)

L_{post} = relative post-development total phosphorous load (pounds per year)

EFF = required pollutant removal efficiency (percent in whole numbers)

RR = pollutant removal requirement (pounds per year)

EFF = 33.20 %

Page 2 of 4

Appendix 3A-2 PH Milestone Deliverable

Performance Based Water Quality

60792 Route 611

Project No.	60792	Date:	04/07/14	
Calc. By:	RJW	Check By:	01/00/00	
County Number:	95	County:	Washington	Ver. 2/06/13

PERFORMANCE-BASED WATER QUALITY CALCULATIONS

WORKSHEET 2 : SITUATION 2

2. Select BMP(s) from Table 5-14 and locate on the site:

BMP 1: Sta: / offset	
BMP 2: Sta: / offset	
BMP 3: Sta: / offset	
BMP 4: Sta: / offset	
BMP 5: Sta: / offset	

L_{BMP} = [0.05 + (0.009 x I_{bmp})] x A x 2.28 (Equation 5-23)
$L_{removed}$ = EFF_{BMP} x L_{BMP} (Equation 5-24)

L_{BMP} = relative post-development total phosphorous load entering proposed BMP (pounds per year)
I_{BMP} = Post-development percent impervious cover of BMP drainage area (percent expressed in whole numbers
A = drainage area of proposed BMP (acres)
$L_{removed}$ = Post-development pollutant removed by proposed BMP (pounds per year)
EFF_{BMP} = pollutant removal efficiency of BMP (expressed in decimal form)

3. and 4. Determine the pollutant load entering the proposed BMP (s) and Calculate the pollutant load removed by the proposed BMP(s):

BMP Str.#	BMP "A" (acres)	BMP Imp. Area (ac.)	I_{BMP} (%)	L_{BMP}	EFF_{BMP}	$L_{removed}$ (Lbs/YR)	Comments
						0.00	
						0.00	
						0.00	
						0.00	
						0.00	

Page 3 of 4

Appendix 3A-2 PH Milestone Deliverable

Performance Based Water Quality

60792 Route 611

Project No.	60792	Date:	04/07/14	
Calc. By:	RJW	Check By:	01/00/00	
County Number:	95	County:	Washington	Ver. 2/06/13

PERFORMANCE-BASED WATER QUALITY CALCULATIONS

WORKSHEET 2 : SITUATION 2

5. Calculate the total pollutant load removed by the BMP (s):

$L_{removed/total} = L_{removed/BMP1} + L_{removed/BMP2} + Etc....$ **(equation 5-25)**

where:

$L_{removed/total}$ =	Total pollutant load removed by proposed BMP's
$L_{removed/BMP1}$ =	pollutant load removed by BMP1
$L_{removed/BMP2}$ =	pollutant load removed by BMP2

See chart on sheet 3 of 4 for individual BMP removal

$L_{removed/total}$ = **0.00** **Pounds/year**

6. Verify compliance:

Lremoved/total ≥ RR

0.00 ≥ **1.63** ADD MEASURES

Page 4 of 4

Appendix 3A-3 FI Milestone Deliverable

Hydraulic Design Study

UPC 987654 – Rte. 643 Safety Improvements

Hydraulic Design Narrative

General Description:

VDOT Central Office Hydraulic Section has prepared a drainage design and associated computations for the Route 643 (Back Hampden Sydney Road) project located in Prince Edward County. The purpose of this project is to make improvements to the horizontal and vertical alignments and widen shoulders for safety purposes. The drainage plans and computations address the hydraulic changes to the roadway and comply with all regulatory requirements.

Existing Conditions:

The project is rural in nature. Route 643 is a two lane roadway with narrow graded shoulders. Roadside ditches and pipe culverts direct stormwater runoff to an unnamed live stream, which crosses the existing roadway through a box culvert. There are no wetlands or water quality structures in the project area.

Proposed Drainage System:

The project will maintain the same general flow patterns. Stormwater runoff will sheet flow or drain to a roadside ditch and ultimately discharge into the unnamed tributary to Wilck's Lake. Stream channel relocations will be required at three locations on the project.

Erosion and Sediment Control (ESC):

This ESC Plan has been designed, prepared, reviewed, and approved in accordance with the VDOT's approved ESC & Stormwater Management (SWM) Program Standards and Specifications. A copy of the Certification Form is part of this document.

Hydrology:

TR-55 Method of calculating discharge is used for Culvert 4-5, due to the size of the drainage area. The Rational Method of calculating discharge is used for all other aspects of this project because the drainage areas are less than 200 acres in size. Drainage areas were calculated with the use of electronic survey and design data.

Appendix 3A-3 FI Milestone Deliverable

Culvert Design:

All culverts on the project were designed and sized based on criteria outlined in Chapter 8 of the *VDOT Drainage Manual.* The culverts were designed to accommodate the 10-year storm event and maintain a minimum 18" headwater freeboard to the roadway shoulder point. Culvert computations are part of this document in Appendix __.

Inlet & Pipe Design:

There are no proposed inlets or proposed pipe systems on the project.

Ditch Design:

All ditches on the project were designed and sized based on criteria outlined in Chapter 7 of the *VDOT Drainage Manual.* The ditches on the project are designed to convey the 10-year discharge, and to resist erosion from the 2-year discharge. Computations for the ditches are part of this document in Appendix __.

Minimum Standard-19 (MS-19):

The Virginia ESC Regulation MS-19 for an adequate receiving channel governs requirements for stream channel erosion. The natural outfall channel has been analyzed for adequacy for conveying the 2-year storm while resisting erosion of the bed and banks. Computations for channel adequacy are part of this document in Appendix__.

Appendix 3A-3 FI Milestone Deliverable

Regulations:

The project is grandfathered under the provisions of Section 4VAC50-60-48 of the VSMP Regulations adopted September 13, 2011, and utilizes the technical criteria of Part IIC (4VAC50-60-93.1 et. seq.) for determining its post-development stormwater management design. In accordance with the performance-based criteria, this project is considered a Situation 3 because the existing percent impervious cover is greater than the average land cover condition. However, when initially developed, water quality requirements were based on the net increase of impervious cover and did not require treatment. The requirements changed to require treatment of the total post-development impervious area after the project had completed the public involvement stage.

The applicable percent impervious cover of the site is less than the statewide average land cover condition of 16% and therefore a water quality BMP is not required. At the time of public hearing, the applicable post construction impervious cover was defined as the net increase in impervious area of the site divided by the total post-development area of the site.

- Post-development impervious area = 2.20 acres
- Pre-development impervious area = 1.43 acres
- Net increase impervious area = 2.20 – 1.43 = 0.77 acres
- Total post-development area of site = 5.51 acres
- Applicable percent impervious cover = 0.77 ÷ 5.51 = 13.97% < 16%

PROJECT	Back Hampden Sydney Road				CULVERT DESIGN FORM LD-269
ROAD	Back Hampden Sydney	COUNTY	Prince Edward	SHEET	OF
CULVERT	3-4		VA	UNITS	ENGLISH
	106+75			DESIGNER:	SS/RJW DATE: 8/21/2014
				REVIEWER:	VAB DATE: 8/21/2014

HYDROLOGICAL DATA

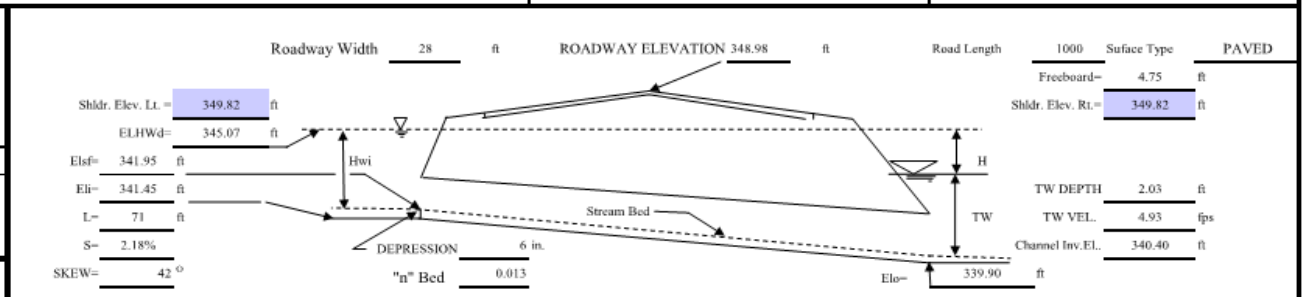
Method: INPUT
Drainage Area: 75.985
Time of Concentration 33.438

DESIGN FLOWS

R.I. (years)	FLOW (cfs)	
10	Design	80.88
2	Check	58.44
25	Max.	100.44

CULVERT DESCRIPTION:

TYPE: Single/Multiple Conforming



Inlet Edge Description:

Square edge w/headwall

Single / Multiple Conforming / Broken Back Culverts

MATERIAL	SHAPE	Size (in)	N	Mannings n	TOTAL FLOW Q cfs	FLOW PER BARREL Q/N cfs	HEADWATER CALCULATIONS: INLET CONTROL HWi/D	HWi ft	FALL ft	ELHWi ft	OUTLET CONTROL TW ft	dc ft	(dc+D)/2 ft	ho ft	ke	H ft	ELHWo ft	CONTROL HEADWATER ELEV ft	OUTLET VEL fps	MINIMUM SHOULDER ELEV. ft	COMMENTS
CMPSmCorr	Circular	54	1	0.02	80.88	80.9	0.80	2.97	0.00	344.42	2.03	2.34	3.42	3.17	0.50	1.01	345.07	345.07	11.47		
					58.44	58.4	0.65	2.24	0.00	343.69	1.73	1.93	3.22	2.97	0.50	0.52	344.38	344.38	10.70		
					100.44	100.4	0.96	3.65	0.00	345.10	2.26	2.64	3.57	3.32	0.50	1.57	345.79	345.79	11.96		

Broken Back Culvert

LENGTH	Elev.	SKEW °

TAILWATER DATA:

Channel Shape	Trapezoidal		
Bottom Width, ft	4.00	"n" =	0.035
Side Slope Lt. (H:1V)	2.00		
Side Slope Rt. (H:1V)	2.00		
Channel Slope, ft/ft	0.0100		

Distance										
Elevation										
"n" =										

TAILWATER RESULTS:

	Discharge cfs	Elevation ft	Flow depth ft	Velocity fps	Shear force PSF
Design	342.43	2.03	4.93	1.27	
Check	342.13	1.73	4.52	1.08	
Max.	342.66	2.26	5.22	1.41	

ROADWAY DATA:

Roadway Width, ft	28
Surface Type	PAVED
Top of Road Elevation, ft	348.98
Length of Road, ft	1000

ROADWAY OVERTOPPING:

	Discharge cfs	Overtopping Discharge cfs	Overtopping Elevation ft
Design	0		0.00
Check	0		0.00
Max.	0		0.00

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS
(2) HWi/D = HW/D OR HWi/D FROM DESIGN CHARTS
(3) FALL = HWI - (ELHWd - ELsf); FALL IS ZERO FOR CULVERTS ON GRADE
(4) ELhi = HWi + ELi (INVERT OF INLET CONTROL SECTION)
(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL
(6) ho = TW or (dc + D/2) (WHICHEVER IS GREATER)
(7) $H = [1 + ke + (29n^2L)/R^{1.33}]v^2/2g$

SUBSCRIPT DEFINITIONS:

HWd	DESIGN HEADWATER	i	INLET
HWi	HW IN INLET CONTROL	o	OUTLET
HWo	HW IN OUTLET CONTROL	sf	Streambed @ culvert face

COMMENTS / DISCUSSION:

CULVERT BARREL SELECTED

SIZE: n:
SHAPE: MATERIAL:
ENTRANCE:

PROJECT	Back Hampden Sydney Road				CULVERT DESIGN FORM LD-269
ROAD	Back Hampden Sydney	COUNTY	Prince Edward	SHEET	OF
CULVERT	3-4		VA	UNITS	ENGLISH
	106+75			DESIGNER:	SS/RJW DATE: 8/21/2014
				REVIEWER:	VAB DATE: 8/21/2014

HYDROLOGICAL DATA

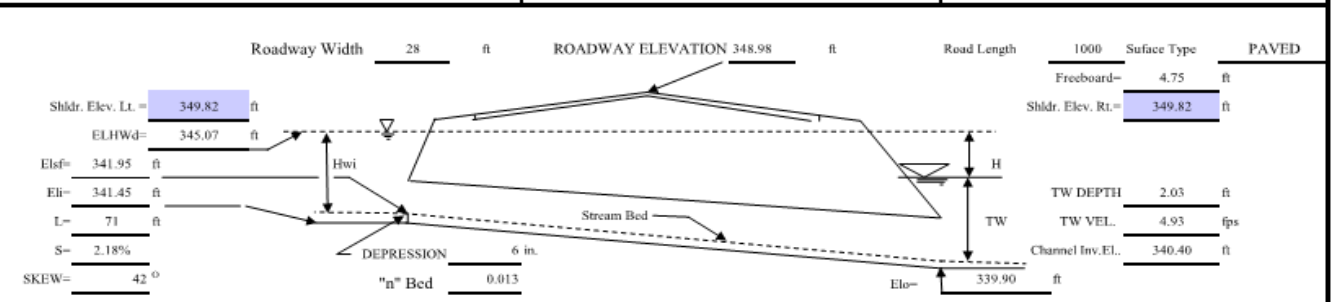
Method: INPUT
Drainage Area: 75.985
Time of Concentration 33.438

DESIGN FLOWS

R.I. (years)	FLOW (cfs)	
10	Design	80.88
2	Check	58.44
25	Max.	100.44

CULVERT DESCRIPTION:

TYPE: Single/Multiple Conforming



Inlet Edge Description:

Square edge w/headwall

Single / Multiple Conforming / Broken Back Culverts

MATERIAL	SHAPE	Size (in)	N	Mannings n	TOTAL FLOW Q cfs	FLOW PER BARREL Q/N cfs	HEADWATER CALCULATIONS: INLET CONTROL HWi/D	HWi ft	FALL ft	ELHWi ft	OUTLET CONTROL TW ft	dc ft	(dc+D)/2 ft	ho ft	ke	H ft	ELHWo ft	CONTROL HEADWATER ELEV ft	OUTLET VEL fps	MINIMUM SHOULDER ELEV. ft	COMMENTS
CMPSmCorr	Circular	54	1	0.02	80.88	80.9	0.80	2.97	0.00	344.42	2.03	2.34	3.42	3.17	0.50	1.01	345.07	345.07	11.47		
					58.44	58.4	0.65	2.24	0.00	343.69	1.73	1.93	3.22	2.97	0.50	0.52	344.38	344.38	10.70		
					100.44	100.4	0.96	3.65	0.00	345.10	2.26	2.64	3.57	3.32	0.50	1.57	345.79	345.79	11.96		

Broken Back Culvert

LENGTH	Elev.	SKEW °

TAILWATER DATA:

Channel Shape	Trapezoidal	
Bottom Width, ft	4.00	"n" = 0.035
Side Slope Lt: (H:1V)	2.00	
Side Slope Rt: (H:1V)	2.00	
Channel Slope, ft/ft	0.0100	

Distance										
Elevation										
"n" =										

TAILWATER RESULTS:

Discharge cfs	Elevation ft	Flow depth ft	Velocity fps	Shear force PSF
Design	342.43	2.03	4.93	1.27
Check	342.13	1.73	4.52	1.08
Max.	342.66	2.26	5.22	1.41

ROADWAY DATA:

Roadway Width, ft	28
Surface Type	PAVED
Top of Road Elevation, ft	348.98
Length of Road, ft	1000

ROADWAY OVERTOPPING:

Discharge cfs	Overtopping Discharge cfs	Overtopping Elevation ft
Design	0	0.00
Check	0	0.00
Max.	0	0.00

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS
(2) HWi/D = HW/D OR HWi/D FROM DESIGN CHARTS
(3) FALL = HWI - (ELHWd - ELsf); FALL IS ZERO FOR CULVERTS ON GRADE
(4) ELhi = HWi + ELi (INVERT OF INLET CONTROL SECTION)
(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL
(6) ho = TW or (dc + D/2) (WHICHEVER IS GREATER)
(7) $H = [1 + ke + (29n^2L)/R^{1.33}]v^2/2g$

SUBSCRIPT DEFINITIONS:

HWd	DESIGN HEADWATER	i	INLET
HWi	HW IN INLET CONTROL	o	OUTLET
HWo	HW IN OUTLET CONTROL	sf	Streambed @ culvert face

COMMENTS / DISCUSSION:

CULVERT BARREL SELECTED

SIZE: n:
SHAPE: MATERIAL:
ENTRANCE:

PROJECT: Back Hampden Sydney Road
LOCATION:

OUTLET PROTECTION

Designed SS/RJW

UNITS ENGLISH

CULVERT & TAILWATER DATA

Culvert No:	3-4		2-Year Outlet Velocity:	13.97	Ft/Sec.
Culvert Dia. / Rise:	4.50	Ft.	Tailwater Channel Flow Depth:	2.03	Ft.
Design Discharge:	80.88	CFS.			
Depth of Flow @ Outlet:	1.37	Ft.	Natural Channel Bed Material:	Fine Sand	
Brink Velocity:	15.36	Ft/Sec.	Mean Particle size of Bed Material:	0.00082 - 0.00041	
Froude No.:	2.31		Non-scour Velocity for Soil Type:	1.00	Ft/Sec.

OUTLET PROTECTION **REQUIRED!**

SCOUR HOLE SIZE

D_{16} Stone Size	0.01	Ft.	Depth:	1.21	Ft.
D_{50} Stone Size	0.10	Ft.	Width:	4.08	Ft.
Plasticity Index	5.00		Length:	9.00	Ft.
			Location of Max. Scour:	3.60	Ft.

VDOT METHOD

Outlet Protection Type	Class II	Length of Apron:	22.50	Ft.
(See VDOT Design Standards for Details)		Width of Apron:	13.50	Ft.
		Thickness of Apron:	3.00	Ft.

RECOMMENDATIONS:

PROJECT	Back Hampden Sydney Road				
ROAD	Back Hampden Sydney	COUNTY	Prince Edward	SHEET	OF
CULVERT	4-2		VA	UNITS	ENGLISH
	112+10				

CULVERT DESIGN FORM LD-269

DESIGNER: SS/RJW DATE: 8/21/2014

REVIEWER: VAB DATE: 8/21/2014

HYDROLOGICAL DATA

Method: INPUT

Drainage Area: 15.656

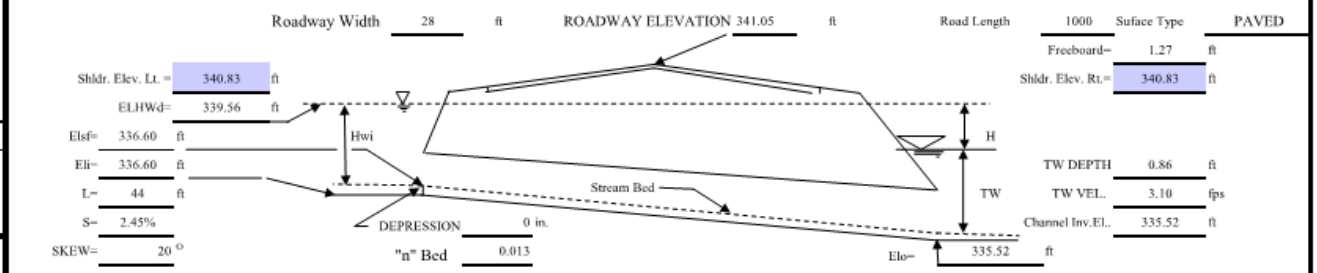
Time of Concentration 20.472

DESIGN FLOWS

R.I. (years)	FLOW (cfs)	
10	Design	20.17
2	Check	14.86
25	Max.	24.72

CULVERT DESCRIPTION:

TYPE: Single/Multiple Conforming



Inlet Edge Description:

Square edge w/headwall

Single / Multiple Conforming / Broken Back Culverts

MATERIAL	SHAPE	Size (in)	N	Mannings n	TOTAL FLOW Q cfs	FLOW PER BARREL Q/N cfs	HEADWATER CALCULATIONS: INLET CONTROL HWi/D	HWi ft	FALL ft	ELHWi ft	OUTLET CONTROL TW ft	dc ft	(dc+D)/2 ft	ho ft	ke	H ft	ELHWo ft	CONTROL HEADWATER ELEV ft	OUTLET VEL fps	MINIMUM SHOULDER ELEV. ft	COMMENTS
Concrete	Circular	24	1	0.01	20.17	20.2	1.48	2.96	0.00	339.56	0.86	1.61	1.81	1.81	0.50	1.31	338.63	339.56	11.64		
					14.86	14.9	0.96	1.93	0.00	338.53	0.73	1.39	1.70	1.69	0.50	0.71	337.92	338.53	10.78		
					24.72	24.7	1.89	3.78	0.00	340.38	0.96	1.75	1.88	1.88	0.50	1.96	339.36	340.38	12.20		

Broken Back Culvert

LENGTH	Elev.	SKEW °

TAILWATER DATA:

Channel Shape	Trapezoidal	
Bottom Width, ft	5.00	"n" = 0.035
Side Slope Lt: (H:1V)	2.00	
Side Slope Rt: (H:1V)	4.00	
Channel Slope, ft/ft	0.0100	

Distance						
Elevation						
"n" =						

TAILWATER RESULTS:

	Discharge cfs	Elevation ft	Flow depth ft	Velocity fps	Shear force PSF
Design	336.38	0.86	3.10	0.54	
Check	336.25	0.73	2.83	0.46	
Max.	336.48	0.96	3.28	0.60	

ROADWAY DATA:

Roadway Width, ft	28
Surface Type	PAVED
Top of Road Elevation, ft	341.05
Length of Road, ft	1000

ROADWAY OVERTOPPING:

	Discharge cfs	Overtopping Discharge cfs	Overtopping Elevation ft
Design	0	0	0.00
Check	0	0	0.00
Max.	0	0	0.00

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HWi/D = HW/D OR HWi/D FROM DESIGN CHARTS

(3) FALL = HWI - (ELHWd - ELsf); FALL IS ZERO FOR CULVERTS ON GRADE

(4) ELhi = HWi + ELi (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL

(6) ho = TW or (dc + D/2) (WHICHEVER IS GREATER)

(7) $H = [1 + ke + (29n^2L)/R^{1.33}]v^2/2g$

SUBSCRIPT DEFINITIONS:

HWd	DESIGN HEADWATER	i	INLET
HWi	HW IN INLET CONTROL	o	OUTLET
HWo	HW IN OUTLET CONTROL	sf	Streambed
			@ culvert face

COMMENTS / DISCUSSION:

CULVERT BARREL SELECTED

SIZE: n:

SHAPE: MATERIAL:

ENTRANCE:

PROJECT	Back Hampden Sydney Road				CULVERT DESIGN FORM LD-269
ROAD	Back Hampden Sydney	COUNTY	Prince Edward	SHEET	OF
CULVERT	4-2		VA	UNITS	ENGLISH
	112+10			DESIGNER:	SS/RJW DATE: 8/21/2014
				REVIEWER:	VAB DATE: 8/21/2014

HYDROLOGICAL DATA

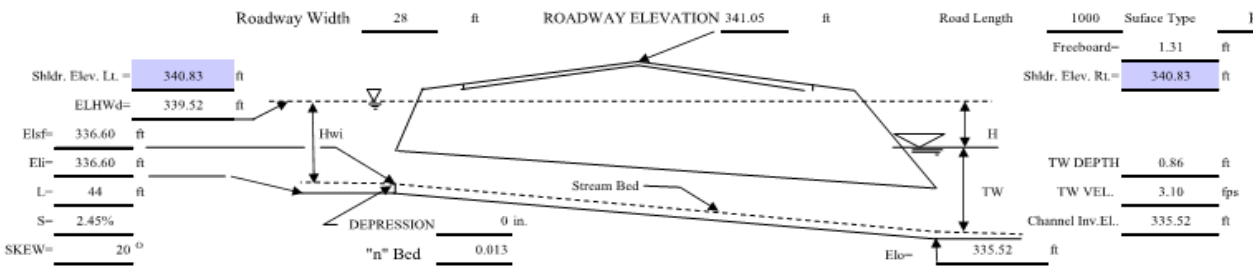
Method: INPUT
Drainage Area: 15.656
Time of Concentration 20.472

DESIGN FLOWS

R.I. (years)	FLOW (cfs)	
10	Design	20.17
2	Check	14.86
25	Max.	24.72

CULVERT DESCRIPTION:

TYPE: **Single/Multiple Conforming**



Inlet Edge Description:

Square edge w/headwall

Single / Multiple Conforming / Broken Back Culverts

MATERIAL	SHAPE	Size (in)	N	Mannings n	TOTAL FLOW Q cfs	FLOW PER BARREL Q/N cfs
CMPSmCorr	Circular	24	1	0.02	20.17	20.2
					14.86	14.9
					24.72	24.7

HEADWATER CALCULATIONS

INLET CONTROL HWi/D	HWi ft	FALL ft	ELHWi ft	OUTLET CONTROL TW ft	dc ft	(dc+D)/2 ft	ho ft	ke	H ft	ELHWo ft	CONTROL HEADWATER ELEV ft	OUTLET VEL fps	MINIMUM SHOULDER ELEV. ft	COMMENTS
1.46	2.92	0.00	339.52	0.86	1.61	1.81	1.81	0.50	2.15	339.47	339.52	6.92		
0.94	1.89	0.00	338.49	0.73	1.39	1.70	1.69	0.50	1.16	338.38	338.49	6.74		
2.01	3.70	0.00	340.30	0.96	1.75	1.88	1.88	0.50	3.22	340.62	340.62	7.87		

Broken Back Culvert

LENGTH	Elev.	SKEW °

TAILWATER DATA:

Channel Shape	Trapezoidal	
Bottom Width, ft	5.00	"n" = 0.035
Side Slope Lt: (H:1V)	2.00	
Side Slope Rt: (H:1V)	4.00	
Channel Slope, ft/ft	0.0100	
Distance		
Elevation		
"n" =		

TAILWATER RESULTS:

	Discharge cfs	Elevation ft	Flow depth ft	Velocity fps	Shear force PSF
Design	336.38	0.86	3.10	0.54	
Check	336.25	0.73	2.83	0.46	
Max.	336.48	0.96	3.28	0.60	

ROADWAY DATA:

Roadway Width, ft	28
Surface Type	PAVED
Top of Road Elevation, ft	341.05
Length of Road, ft	1000

ROADWAY OVERTOPPING:

	Discharge cfs	Overtopping Discharge cfs	Overtopping Elevation ft
Design	0	0	0.00
Check	0	0	0.00
Max.	0	0	0.00

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS
(2) HWi/D = HW/D OR HWi/D FROM DESIGN CHARTS
(3) FALL = HWI - (ELHWd - ELsf); FALL IS ZERO FOR CULVERTS ON GRADE
(4) ELhi = HWi + ELi (INVERT OF INLET CONTROL SECTION)
(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL
(6) ho = TW or (dc + D/2) (WHICHEVER IS GREATER)
(7) $H = [1 + ke + (29n^2L)/R^{1.33}]v^2/2g$

SUBSCRIPT DEFINITIONS:

HWd	DESIGN HEADWATER	i	INLET
HWi	HW IN INLET CONTROL	o	OUTLET
HWo	HW IN OUTLET CONTROL	sf	Streambed
			@ culvert face

COMMENTS / DISCUSSION:

CULVERT BARREL SELECTED

SIZE: n:
SHAPE: MATERIAL:
ENTRANCE:

PROJECT: Back Hampden Sydney Road
LOCATION:

OUTLET PROTECTION

Designed SS/RJW

UNITS ENGLISH

CULVERT & TAILWATER DATA

Culvert No:	4-2		2-Year Outlet Velocity:	10.78	Ft/Sec.
Culvert Dia. / Rise:	2.00	Ft.	Tailwater Channel Flow Depth:	0.86	Ft.
Design Discharge:	20.17	CFS.			
Depth of Flow @ Outlet:	1.08	Ft.	Natural Channel Bed Material:	Fine Sand	
Brink Velocity:	11.64	Ft/Sec.	Mean Particle size of Bed Material:	0.00082 - 0.00041	
Froude No.:	1.97		Non-scour Velocity for Soil Type:	0.96	Ft/Sec.
OUTLET PROTECTION		**REQUIRED!**			

SCOUR HOLE SIZE

			Depth:	0.72	Ft.
D_{16} Stone Size	0.01	Ft.	Width:	2.42	Ft.
D_{50} Stone Size	0.10	Ft.	Length:	5.33	Ft.
Plasticity Index	5.00		Location of Max. Scour:	2.13	Ft.

VDOT METHOD

Outlet Protection Type	Class AI	Length of Apron:	6.00	Ft.
(See VDOT Design Standards for Details)		Width of Apron:	6.00	Ft.
		Thickness of Apron:	2.00	Ft.

RECOMMENDATIONS:

PROJECT	Back Hampden Sydney Road				
ROAD	Back Hampden Sydney	COUNTY	Prince Edward	SHEET	OF
CULVERT	4-5		VA	UNITS	ENGLISH
	122+50				

CULVERT DESIGN FORM LD-269

DESIGNER: SS/RJW DATE: 9/2/2014

REVIEWER: VAB DATE: 9/2/2014

HYDROLOGICAL DATA

Method: TR-55

Drainage Area: 0.743 Sq. Mi.

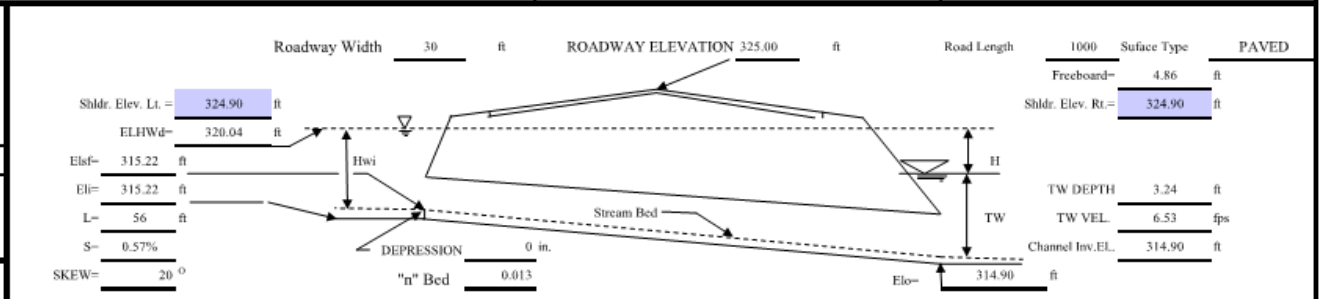
Time of Concentration 1.231 Hours

DESIGN FLOWS

R.I. (years)	FLOW (cfs)	
10	Design	243.07
2	Check	60.12
25	Max.	403.16

CULVERT DESCRIPTION:

TYPE: Single/Multiple Conforming



Inlet Edge Description:

Wingwall 30deg-75deg flare

Single / Multiple Conforming / Broken Back Culverts

MATERIAL	SHAPE	Size (in)	N	Mannings n	TOTAL FLOW Q cfs	FLOW PER BARREL Q/N cfs	HEADWATER CALCULATIONS: INLET CONTROL HWi/D	HWi ft	FALL ft	ELHWi ft	OUTLET CONTROL TW ft	dc ft	(dc+D)/2 ft	ho ft	ke	H ft	ELHWo ft	CONTROL HEADWATER ELEV ft	OUTLET VEL fps	MINIMUM SHOULDER ELEV. ft	COMMENTS
Concrete	Box	72 X 96	1	0.01	243.07	243.1	0.80	3.76	0.00	318.98	3.24	3.06	4.53	4.53	0.40	0.61	320.04	320.04	11.70		
					60.12	60.1	0.55	1.29	0.00	316.51	1.62	1.21	3.61	3.60	0.40	0.04	318.54	318.54	7.47		
					403.16	403.2	1.08	5.90	0.00	321.12	4.10	4.29	5.15	5.14	0.40	1.68	321.72	321.72	13.42		

Broken Back Culvert

LENGTH	Elev.	SKEW °

TAILWATER DATA:

Channel Shape	Trapezoidal	
Bottom Width, ft	5.00	"n" = 0.035
Side Slope Lt: (H:1V)	2.00	
Side Slope Rt: (H:1V)	2.00	
Channel Slope, ft/ft	0.0100	
Distance		
Elevation		
"n" =		

TAILWATER RESULTS:

	Discharge cfs	Elevation ft	Flow depth ft	Velocity fps	Shear force PSF
Design	318.14	3.24	6.53	2.02	
Check	316.52	1.62	4.50	1.01	
Max.	319.00	4.10	7.44	2.56	

ROADWAY DATA:

Roadway Width, ft	30
Surface Type	PAVED
Top of Road Elevation, ft	325
Length of Road, ft	1000

ROADWAY OVERTOPPING:

	Discharge cfs	Overtopping Discharge cfs	Overtopping Elevation ft
Design	0		0.00
Check	0		0.00
Max.	0		0.00

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HWi/D = HW/D OR HWi/D FROM DESIGN CHARTS

(3) FALL = HWI - (ELHWd - ELsf); FALL IS ZERO FOR CULVERTS ON GRADE

(4) ELhi = HWi + ELi (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL

(6) ho = TW or (dc + D/2) (WHICHEVER IS GREATER)

(7) $H = [1 + ke + (29n^2L)/R^{1.33}]v^2/2g$

SUBSCRIPT DEFINITIONS:

HWd	DESIGN HEADWATER	i	INLET
HWi	HW IN INLET CONTROL	o	OUTLET
HWo	HW IN OUTLET CONTROL	sf	Streambed @ culvert face

COMMENTS / DISCUSSION:

CULVERT BARREL SELECTED

SIZE: n:

SHAPE: MATERIAL:

ENTRANCE:

PROJECT: Back Hampden Sydney Road — Designed SS/RJW
LOCATION: **OUTLET PROTECTION**
UNITS: ENGLISH

CULVERT & TAILWATER DATA

Culvert No:	4-5		2-Year Outlet Velocity:	11.16	Ft/Sec.
Culvert Dia. / Rise:	8.00	Ft.	Tailwater Channel Flow Depth:	3.55	Ft.
Design Discharge:	295.17	CFS.			
Depth of Flow @ Outlet:	2.99	Ft.	Natural Channel Bed Material:	Fine Sand	
Brink Velocity:	12.35	Ft/Sec.	Mean Particle size of Bed Material:	0.00082 - 0.00041	
Froude No.:	1.26		Non-scour Velocity for Soil Type:	1.24	Ft/Sec.

OUTLET PROTECTION **REQUIRED!**

SCOUR HOLE SIZE

			Depth:	1.91	Ft.
D_{16} Stone Size	0.01	Ft.	Width:	5.98	Ft.
D_{50} Stone Size	0.10	Ft.	Length:	13.63	Ft.
Plasticity Index	5.00		Location of Max. Scour:	5.45	Ft.

VDOT METHOD

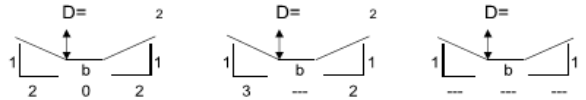
Outlet Protection Type	Class I	Length of Apron:	30.00	Ft.
(See VDOT Design Standards for Details)		Width of Apron:	24.00	Ft.
		Thickness of Apron:	2.00	Ft.

RECOMMENDATIONS:

LD-268

Lt

101+00 to 106+50



PROJECT 0643-073-214,M50
BY RJW
LOCATION Prince Edward
DATE 8/21/2014
SHEET 1

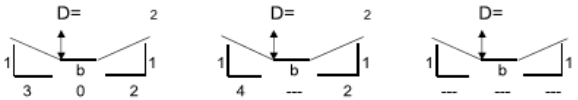
STA. TO STA.		FLOW LENGTH (ft)	0.9		0.5		0.3		CA		Tc	I2	Q2	TYP. SECTION	Slope	Earth n= 0.03 ALLOW VEL.	VEL.	Protective Lining n=0.05 VEL	n=0.05 DEP	n=0.015 VEL	n=0.015 DEP	I10	Q10	DEP	REMARKS
			A (ac)	CA	A (ac)	CA	A (ac)	CA	INCR.	ACC.	(min)		(cfs)		(Ft/Ft)		(ft/sec)	(ft/sec)	(ft)	(ft/sec)	(ft)		(cfs)	(ft)	
100+00	100+50	50	0.41	0.369	0.322	0.161	2.955	0.887	1.417	1.417	12.0	3.83	5.43	2	0.030	2.0	4.14	2.82	0.88	0.00		5.13	7.27	0.98	EC-2
100+50	101+00	50	0.02	0.018	0.021	0.01	0.095	0.029	0.056	1.473	12.7	3.74	5.509	2	0.030	2.0	4.18	2.85	0.88	0.00		5.01	7.39	0.98	EC-2
101+00	101+50	50	0.02	0.018	0.021	0.01	0.095	0.029	0.056	1.53	13.5	3.64	5.566	2	0.019	2.0	3.58	2.44	0.96	0.00		4.89	7.47	1.07	EC-2
101+50	102+00	50	0.02	0.018	0.021	0.01	0.095	0.029	0.056	1.586	14.1	3.57	5.658	2	0.034	2.0	4.36	2.97	0.87	0.00		4.79	7.60	0.98	EC-2
102+00	102+50	50	0.02	0.018	0.021	0.01	0.095	0.029	0.056	1.643	14.7	3.50	5.747	2	0.035	2.0	4.44	3.03	0.87	0.00		4.71	7.73	0.97	EC-2
102+50	103+00	50	0.02	0.018	0.021	0.01	0.095	0.029	0.056	1.699	15.4	3.42	5.815	2	0.027	2.0	4.03	2.75	0.92	0.00		4.61	7.83	1.03	EC-2
103+00	103+50	50	0.02	0.018	0.021	0.01	0.095	0.029	0.056	1.756	16.1	3.35	5.881	2	0.031	2.0	4.28	2.92	0.90			4.52	7.93	1.00	EC-2
103+50	104+00	50	0.02	0.018	0.021	0.01	0.095	0.029	0.056	1.812	16.8	3.28	5.945	1	0.025	2.0	4.10	2.79	1.03			4.43	8.03	1.15	EC-2
104+00	104+50	50	0.02	0.018	0.021	0.01	0.095	0.029	0.056	1.869	17.5	3.21	6.008	1	0.027	2.0	4.24	2.89	1.02			4.35	8.12	1.14	EC-2
104+50	105+00	50	0.02	0.018	0.021	0.01	0.095	0.029	0.056	1.925	18.0	3.17	6.102	1	0.056	2.0	5.61	3.82	0.89			4.29	8.25	1.00	EC-2
105+00	105+50	50	0.02	0.018	0.021	0.01	0.095	0.029	0.056	1.982	18.5	3.13	6.194	1	0.064	2.0	5.92	4.04	0.88	0.00		4.23	8.39	0.98	EC-2
105+50	106+00	50	0.02	0.018	0.021	0.01	0.095	0.029	0.056	2.038	19.0	3.08	6.284	1	0.059	2.0	5.74	3.91	0.90	0.00		4.18	8.51	1.00	EC-2
106+00	106+50	50	0.02	0.018	0.021	0.01	0.095	0.029	0.056	2.095	19.4	3.05	6.389	1	0.099	2.0	7.01	4.78	0.82	0.00		4.14	8.66	0.92	EC-3A
DI(XX)																									
107+00	106+50	50	0.014	0.013	0.071	0.036	0	0	0.048	0.048	5.0	5.19	0.251	1	0.035	2.0	2.10	1.44	0.30	0.00		6.84	0.33	0.33	EC-2

Page 28

LD-268

Lt.

107+50 to 112+00 24" pipe



PROJECT 0643-073-214, M501
BY RJW
LOCATION Prince Edward
DATE 8/21/2014
SHEET 1

Earth n= 0.03

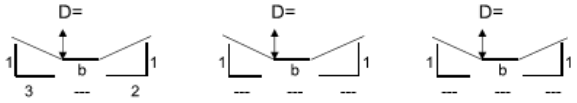
STA. TO STA.		FLOW LENGTH (ft)	0.9		0.5		0.3		CA		Tc	I2	Q2	TYP. SECTION	Slope	ALLOW VEL.	VEL.	Protective Lining n=0.05		Protective Lining n=0.015		I10	Q10	DEP	REMARKS
			A (ac)	CA	A (ac)	CA	A (ac)	CA	INCR.	ACC.	(min)		(cfs)		(Ft/Ft)		(ft/sec)	VEL (ft/sec)	DEP (ft)	VEL (ft/sec)	DEP (ft)		(cfs)	(ft)	
107+50	108+00	50	0.024	0.022	0.014	0.007	0.219	0.066	0.094	0.094	15.0	3.47	0.326	1	0.026	2.0	1.94	1.32	0.31	0.00		4.67	0.44	0.35	EC-2
108+00	108+50	50	0.024	0.022	0.014	0.007	0.219	0.066	0.094	0.188	15.6	3.40	0.639	1	0.026	2.0	2.31	1.57	0.40	0.00		4.58	0.86	0.45	EC-2
108+50	109+00	50	0.024	0.022	0.014	0.007	0.219	0.066	0.094	0.282	16.2	3.34	0.944	1	0.021	2.0	2.32	1.58	0.49	0.00		4.51	1.27	0.55	EC-2
109+00	109+50	50	0.024	0.022	0.014	0.007	0.219	0.066	0.094	0.376	16.7	3.29	1.239	1	0.022	2.0	2.53	1.73	0.54	4.26	0.34	4.44	1.67	0.60	EC-2
109+50	110+00	50	0.024	0.022	0.014	0.007	0.219	0.066	0.094	0.47	16.9	3.27	1.54	1	0.017	2.0	2.43	1.66	0.61	4.09	0.39	4.42	2.08	0.68	EC-2
110+00	110+50	50	0.024	0.022	0.014	0.007	0.219	0.066	0.094	0.564	17.1	3.25	1.837	1	0.012	2.0	2.27	1.55	0.69	0.00		4.40	2.48	0.77	EC-2
110+50	111+00	50	0.024	0.022	0.014	0.007	0.219	0.066	0.094	0.659	17.6	3.20	2.11	1	0.010	2.0	2.20	1.50	0.75	0.00		4.33	2.85	0.84	EC-2
111+00	111+50	50	0.024	0.022	0.014	0.007	0.219	0.066	0.094	0.753	18.2	3.15	2.374	1	0.012	2.0	2.37	1.61	0.77	0.00		4.27	3.21	0.86	EC-2
111+50	112+00	50	0.024	0.022	0.014	0.007	0.219	0.066	0.094	0.847	18.7	3.11	2.632	1	0.012	2.0	2.43	1.66	0.80	0.00		4.21	3.57	0.89	EC-2
112+00	112+19	18.93	0.009	0.008	0.005	0.003	0.083	0.025	0.036	0.882	19.2	3.07	2.706	1	0.073	2.0	4.85	3.30	0.57	0.00		4.16	3.67	0.64	EC-2

Page 29

LD-268

643_LANE

Left SIDE



PROJECT 80008
BY RJW
LOCATION Prince Edward
DATE 8/21/2014
SHEET 1

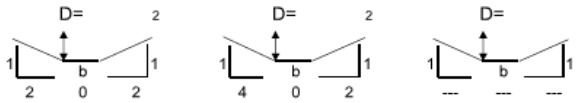
STA. TO STA.		FLOW LENGTH (ft)	0.9		0.5		0.3		CA		Tc	I2	Q2	TYP. SECTION	Slope	Earth n= 0.03 ALLOW VEL.	VEL.	Protective Lining n=0.05 VEL	DEP	n=0.015 VEL	DEP	I10	Q10	DEP	REMARKS
			A (ac)	CA	A (ac)	CA	A (ac)	CA	INCR.	ACC.	(min)		(cfs)		(Ft/Ft)		(ft/sec)	(ft/sec)	(ft)	(ft/sec)	(ft)		(cfs)	(ft)	
115+00	114+50	50	0.029	0.026	0.016	0.008	0.208	0.062	0.096	0.096	5.0	5.19	0.5	1	0.006	2.0	1.22	0.00		0.00		6.84	0.66	0.45	
114+50	114+00	50	0.029	0.026	0.016	0.008	0.208	0.062	0.096	0.193	6.1	4.91	0.945	1	0.008	2.0	1.64	0.00		0.00		6.49	1.25	0.53	
114+00	113+50	50	0.029	0.026	0.016	0.008	0.208	0.062	0.096	0.289	7.2	4.66	1.345	1	0.008	2.0	1.80	0.00		0.00		6.17	1.78	0.61	
113+50	113+00	50	0.029	0.026	0.016	0.008	0.208	0.062	0.096	0.385	8.3	4.43	1.707	1	0.008	2.0	1.89	0.00		0.00		5.89	2.27	0.67	
113+00	112+50	50	0.029	0.026	0.016	0.008	0.208	0.062	0.096	0.481	9.4	4.23	2.038	1	0.027	2.0	3.10	2.11	0.62	0.00		5.64	2.71	0.69	EC-2
112+50	112+19	31.07	0.018	0.016	0.01	0.005	0.13	0.039	0.06	0.541	9.9	4.15	2.246	1	0.077	2.0	4.74	3.23	0.53	0.00		5.53	2.99	0.59	EC-2

Page 30

LD-268

Left of Road

115+00-122+50 & 131+00-122+50



PROJECT 0643-073-124,M501
BY RJW
LOCATION Prince Edward
DATE 8/21/2014
SHEET 1

Earth n= 0.03 | Protective Lining

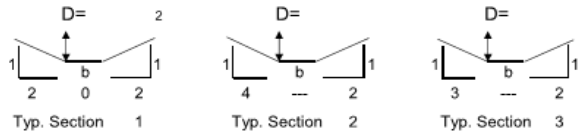
STA. TO STA.		FLOW LENGTH (ft)	0.9		0.5		0.3		CA		Tc	I2	Q2	TYP. SECTION	Slope	ALLOW VEL.	VEL.	n=0.05		n=0.015		I10	Q10	DEP	REMARKS
			A (ac)	CA	A (ac)	CA	A (ac)	CA	INCR.	ACC.	(min)		(cfs)		(Ft/Ft)		(ft/sec)	VEL (ft/sec)	DEP (ft)	VEL (ft/sec)	DEP (ft)		(cfs)	(ft)	
115+00	115+50	50	0.032	0.029	0.018	0.009	0.265	0.079	0.117	0.117	6.0	4.93	0.578	1	0.000	2.0	0.38	0.26	1.06	0.00		6.52	0.76	0.97	EC-2
115+50	116+00	50	0.032	0.029	0.018	0.009	0.265	0.079	0.117	0.235	9.3	4.26	0.999	1	0.006	2.0	1.50	1.02	0.70	2.52	0.44	5.67	1.33	0.64	EC-2
116+00	116+50	50	0.032	0.029	0.018	0.009	0.265	0.079	0.117	0.352	9.6	4.20	1.479	1	0.011	2.0	2.16	1.47	0.71	3.64	0.45	5.60	1.97	0.79	EC-2
116+50	117+00	50	0.032	0.029	0.018	0.009	0.265	0.079	0.117	0.469	9.8	4.16	1.953	1	0.018	2.0	2.75	1.88	0.72	4.63	0.46	5.55	2.60	0.80	EC-2
117+00	117+50	50	0.032	0.029	0.018	0.009	0.265	0.079	0.117	0.587	10.0	4.13	2.424	1	0.023	2.0	3.17	2.16	0.75	5.34	0.48	5.51	3.23	0.83	EC-2
117+50	118+00	50	0.032	0.029	0.018	0.009	0.265	0.079	0.117	0.704	10.2	4.11	2.892	2	0.028	2.0	3.34	2.28	0.65	5.62	0.41	5.48	3.86	0.72	EC-2
118+00	118+50	50	0.032	0.029	0.018	0.009	0.265	0.079	0.117	0.821	10.3	4.08	3.354	2	0.034	2.0	3.72	2.54	0.66	6.25	0.42	5.45	4.48	0.74	EC-2
118+50	119+00	50	0.032	0.029	0.018	0.009	0.265	0.079	0.117	0.938	10.4	4.06	3.813	2	0.037	2.0	3.94	2.69	0.69	6.63	0.44	5.42	5.09	0.77	EC-2
119+00	119+50	50	0.032	0.029	0.018	0.009	0.265	0.079	0.117	1.056	10.6	4.04	4.269	1	0.037	2.0	4.37	2.98	0.85	7.34	0.54	5.40	5.70	0.94	EC-3A
119+50	120+00	50	0.032	0.029	0.018	0.009	0.265	0.079	0.117	1.173	10.7	4.03	4.723	1	0.037	2.0	4.48	3.05	0.88	7.53	0.56	5.38	6.31	0.98	EC-3A
120+00	120+50	50	0.032	0.029	0.018	0.009	0.265	0.079	0.117	1.29	10.8	4.01	5.174	1	0.036	2.0	4.57	3.12	0.91	7.69	0.58	5.36	6.91	1.02	EC-3A
120+50	121+00	50	0.032	0.029	0.018	0.009	0.265	0.079	0.117	1.408	10.9	3.99	5.621	1	0.039	2.0	4.77	3.25	0.93	8.02	0.59	5.33	7.51	1.04	EC-3A
121+00	121+50	50	0.032	0.029	0.018	0.009	0.265	0.079	0.117	1.525	11.0	3.98	6.065	1	0.050	2.0	5.37	3.66	0.91	9.02	0.58	5.31	8.10	1.02	EC-3A
121+50	122+00	50	0.032	0.029	0.018	0.009	0.265	0.079	0.117	1.642	11.1	3.96	6.509	1	0.049	2.0	5.43	3.70	0.94	9.13	0.60	5.30	8.70	1.05	EC-3A
122+00	122+50	50	0.032	0.029	0.018	0.009	0.265	0.079	0.117	1.76	11.2	3.95	6.95	1	0.134	2.0	8.01	5.46	0.80	13.48	0.51	5.28	9.29	0.89	EC-3A (Box)

Page 31

LD-268

Lt.

130+00 to 122+50



PROJECT 0643-073-214,M501
BY RJW
LOCATION Prince Edward
DATE 8/21/2014
SHEET 1

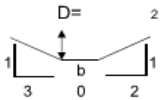
STA. TO STA.		FLOW LENGTH (ft)	0.9		0.5		0.3		CA		Tc	I2	Q2	TYP. SECTION	Slope	Earth n= 0.03 ALLOW VEL.	VEL.	Protective Lining n=0.05 VEL	DEP	n=0.015 VEL	DEP	I10	Q10	DEP	REMARKS
			A (ac)	CA	A (ac)	CA	A (ac)	CA	INCR.	ACC.	(min)		(cfs)		(Ft/Ft)		(ft/sec)	(ft/sec)	(ft)	(ft/sec)	(ft)		(cfs)	(ft)	
130+00	129+50	50	0.033	0.03	0.028	0.014		0	0.044	0.246	6.7	4.40	1.082	2	0.016	2.0	2.10	1.43	0.50	3.53	0.32	6.31	1.55	0.57	EC-2
129+50	129+00	50	0.033	0.03	0.028	0.014		0	0.044	0.29	7.5	4.59	1.331	2	0.012	2.0	1.98	1.35	0.57	3.33	0.36	6.09	1.76	0.64	EC-2
129+00	128+50	50	0.033	0.03	0.028	0.014		0	0.044	0.333	8.2	4.45	1.484	2	0.018	2.0	2.37	1.62	0.55	3.99	0.35	5.91	1.97	0.61	EC-2
128+50	128+00	50	0.033	0.03	0.028	0.014		0	0.044	0.377	8.6	4.38	1.65	2	0.024	2.0	2.75	1.87	0.54	4.62	0.35	5.82	2.19	0.60	EC-2
128+00	127+50	50	0.033	0.03	0.028	0.014		0	0.044	0.421	8.9	4.32	1.819	2	0.028	2.0	2.96	2.02	0.55	4.98	0.35	5.75	2.42	0.61	EC-2
127+50	127+00	50	0.033	0.03	0.028	0.014		0	0.044	0.465	9.1	4.29	1.991	2	0.028	2.0	3.03	2.06	0.57	5.09	0.36	5.70	2.65	0.63	EC-2
127+00	126+50	50	0.033	0.03	0.028	0.014		0	0.044	0.508	9.3	4.25	2.16	1	0.033	2.0	3.56	2.43	0.67	5.98	0.42	5.66	2.88	0.74	EC-2
126+50	126+00	50	0.033	0.03	0.028	0.014		0	0.044	0.552	9.5	4.22	2.327	1	0.040	2.0	3.87	2.64	0.66	0.00		5.62	3.10	0.74	EC-2
126+00	125+50	50	0.033	0.03	0.028	0.014		0	0.044	0.596	9.7	4.18	2.491	1	0.031	2.0	3.57	2.43	0.72	0.00		5.57	3.32	0.80	EC-2
125+50	125+00	50	0.033	0.03	0.028	0.014		0	0.044	0.639	10.0	4.13	2.642	1	0.020	2.0	3.10	2.11	0.79	0.00		5.51	3.52	0.88	EC-2
125+00	124+50	50	0.033	0.03	0.028	0.014		0	0.044	0.683	10.3	4.08	2.79	1	0.016	2.0	2.88	1.96	0.84	0.00		5.45	3.72	0.94	EC-2
124+50	124+00	50	0.033	0.03	0.028	0.014		0	0.044	0.727	10.5	4.05	2.946	1	0.008	2.0	2.21	1.50	0.99	0.00		5.41	3.93	1.10	EC-2
124+00	123+50	50	0.033	0.03	0.028	0.014		0	0.044	0.771	10.7	4.02	3.099	1	0.003	2.0	1.66	1.13	1.17	0.00		5.37	4.14	1.30	EC-2
123+50	123+00	50	0.033	0.03	0.028	0.014		0	0.044	0.814	10.9	3.99	3.25	1	0.057	2.0	4.81	3.28	0.70	0.00		5.33	4.34	0.78	EC-2
123+00	122+50	50	0.033	0.03	0.028	0.014		0	0.044	0.858	11.2	3.95	3.386	1	0.040	2.0	4.27	2.91	0.76	0.00		5.28	4.53	0.85	EC-2
DI(XX)																									
130+00	130+50	50	0.017	0.015	0.008	0.004	0.01	0.003	0.022	0.022	5.0	5.19	0.117	3	0.006	2.0	0.88	0.00		0.00		6.84	0.15	0.26	
130+50	131+00	50	0.017	0.015	0.008	0.004	0.01	0.003	0.022	0.045	6.2	4.88	0.219	3	0.006	2.0	1.02	0.00		0.00		6.46	0.29	0.33	

Page 32

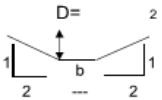
LD-268

RT.

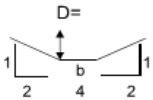
109+00 to 112+00



Typ. Section 1



Typ. Section 2



Typ. Section 3

PROJECT 80008
BY RJW
LOCATION Prince Edward
DATE 8/21/2014
SHEET 1

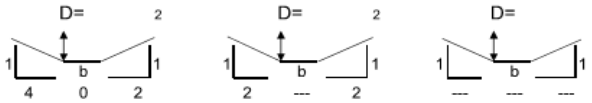
STA. TO STA.		FLOW LENGTH (ft)	0.9		0.5		0.3		CA		Tc	I2	Q2	TYP. SECTION	Slope	Earth n= 0.03 ALLOW VEL.	VEL.	Protective Lining n=0.05 VEL	n=0.05 DEP	n=0.015 VEL	n=0.015 DEP	I10	Q10	DEP	REMARKS
			A (ac)	CA	A (ac)	CA	A (ac)	CA	INCR.	ACC.	(min)		(cfs)		(Ft/Ft)		(ft/sec)	(ft/sec)	(ft)	(ft/sec)	(ft)		(cfs)	(ft)	
109+00	109+50	50	0.023	0.021	0.017	0.009		0	0.029	0.029	5.0	5.19	0.152	1	0.009	2.0	1.09	0.00		0.00		6.84	0.20	0.26	
109+50	110+00	50	0.023	0.021	0.017	0.009		0	0.029	0.059	5.8	4.99	0.293	1	0.021	2.0	1.74	0.00		0.00		6.59	0.39	0.29	
110+00	110+50	50	0.023	0.021	0.017	0.009		0	0.029	0.088	6.2	4.87	0.429	1	0.021	2.0	1.91	0.00		0.00		6.44	0.57	0.33	
110+50	111+00	50	0.023	0.021	0.017	0.009		0	0.029	0.117	6.7	4.77	0.559	2	0.018	2.0	2.00	0.00		0.00		6.31	0.74	0.42	
111+00	111+50	50	0.023	0.021	0.017	0.009		0	0.029	0.147	7.1	4.68	0.686	2	0.018	2.0	2.12	1.44	0.49	0.00		6.20	0.91	0.54	EC-2
111+50	112+00	50	0.023	0.021	0.017	0.009		0	0.029	0.176	7.7	4.56	0.802	2	0.018	2.0	2.19	1.50	0.52	0.00		6.05	1.06	0.58	EC-2
DI(XX)																									

Page 33

LD-268

RT.

130+00 to 122+50



PROJECT 80008
BY RJW
LOCATION Prince Edward
DATE 8/21/2014
SHEET 1

Earth n= 0.03

STA. TO STA.		FLOW LENGTH (ft)	0.9		0.5		0.3		CA		Tc	I2	Q2	TYP. SECTION	Slope	ALLOW VEL.	VEL.	Protective Lining n=0.05 VEL	n=0.05 DEP	n=0.015 VEL	n=0.015 DEP	I10	Q10	DEP	REMARKS
			A (ac)	CA	A (ac)	CA	A (ac)	CA	INCR.	ACC.	(min)		(cfs)		(Ft/Ft)		(ft/sec)	(ft/sec)	(ft)	(ft/sec)	(ft)		(cfs)	(ft)	
130+00	129+50	50	0.007	0.007	0.022	0.011	0.236	0.071	0.089	0.089	8.0	4.49	0.398	1	0.026	2.0	1.97	1.34	0.31	0.00		5.96	0.53	0.29	
129+50	129+00	50	0.007	0.007	0.022	0.011	0.236	0.071	0.089	0.177	8.1	4.47	0.792	1	0.012	2.0	1.74	1.19	0.47	0.00		5.94	1.05	0.43	
129+00	128+50	50	0.007	0.007	0.022	0.011	0.236	0.071	0.089	0.266	8.2	4.45	1.183	1	0.013	2.0	1.97	1.34	0.54	0.00		5.91	1.57	0.50	
128+50	128+00	50	0.007	0.007	0.022	0.011	0.236	0.071	0.089	0.354	8.3	4.43	1.571	2	0.019	2.0	2.65	1.81	0.66	4.45	0.42	5.89	2.09	0.73	EC-2
128+00	127+50	50	0.007	0.007	0.022	0.011	0.236	0.071	0.089	0.443	8.4	4.41	1.955	2	0.032	2.0	3.42	2.33	0.65	0.00		5.87	2.60	0.72	EC-2
127+50	127+00	50	0.007	0.007	0.022	0.011	0.236	0.071	0.089	0.532	8.5	4.40	2.336	2	0.024	2.0	3.19	2.17	0.73	0.00		5.84	3.11	0.82	EC-2
127+00	126+50	50	0.007	0.007	0.022	0.011	0.236	0.071	0.089	0.62	8.6	4.38	2.714	2	0.028	2.0	3.53	2.40	0.75	0.00		5.82	3.61	0.84	EC-2
126+50	126+00	50	0.007	0.007	0.022	0.011	0.236	0.071	0.089	0.709	8.7	4.36	3.089	2	0.025	2.0	3.48	2.37	0.81	0.00		5.80	4.11	0.90	EC-2
126+00	125+50	50	0.007	0.007	0.022	0.011	0.236	0.071	0.089	0.797	9.1	4.29	3.424	2	0.018	2.0	3.19	2.18	0.89	0.00		5.72	4.56	0.99	EC-2
125+50	125+00	50	0.007	0.007	0.022	0.011	0.236	0.071	0.089	0.886	9.4	4.23	3.745	2	0.017	2.0	3.14	2.14	0.94	0.00		5.63	4.99	1.04	EC-2
125+00	124+50	50	0.007	0.007	0.022	0.011	0.236	0.071	0.089	0.975	9.8	4.16	4.056	2	0.015	2.0	3.08	2.10	0.98	0.00		5.55	5.41	1.09	EC-2
124+50	124+00	50	0.007	0.007	0.022	0.011	0.236	0.071	0.089	1.063	10.2	4.10	4.356	2	0.008	2.0	2.53	1.72	1.12	0.00		5.47	5.81	1.25	EC-2
124+00	123+50	50	0.007	0.007	0.022	0.011	0.236	0.071	0.089	1.152	10.7	4.02	4.632	2	0.049	2.0	4.96	3.38	0.83	0.00		5.37	6.19	0.92	EC-2
123+50	123+00	50	0.007	0.007	0.022	0.011	0.236	0.071	0.089	1.24	11.0	3.98	4.942	2	0.026	2.0	3.97	2.71	0.96	0.00		5.32	6.60	1.06	EC-2
123+00	122+50	50	0.007	0.007	0.022	0.011	0.236	0.071	0.089	1.329	11.3	3.94	5.234	2	0.067	2.0	5.77	3.93	0.82	0.00		5.27	7.00	0.91	EC-2
																									Page 34

Appendix 3A-4 PAC Milestone Deliverables

COMMONWEALTH of VIRGINIA

DEPARTMENT OF TRANSPORTATION
LOCATION AND DESIGN DIVISION

REPORT COVER SHEET

Final Hydraulic Design Computations
03/01/2016

Drainage Report Prepared By: Rebecca J. Worley, P.E.
Drainage Report Checked By: Victoria A. Bains, P.E.

VDOT Location and Design Division
Richmond, VA
Hydraulic Engineer

Responsible for Pages 1 to 18

Project Description: Route 17/Hook Road Signalization; sidewalk construction
From: Intersection of Route 17/Route 1216
To: 0.05 Mi. South of Intersection of Route 17/1216
Project UPC No.: 98806

Appendix 3A-4 PAC Milestone Deliverables

TABLE OF CONTENTS

Appendix 3A-4 PAC Milestone Deliverables

Hydraulic Design Narrative

General Description:

VDOT Central Office Hydraulics Section has prepared a drainage design and associated computations for the Route 17/Route 1216 intersection project located in Gloucester County. The purpose of this project is to coordinate signals to improve traffic flow and safety and reduce congestion. Additionally, sidewalk will be constructed. The drainage plans and computations address the hydraulic changes to the roadway and comply with all regulatory requirements. A detailed description of Water Quantity and Water Quality compliance is shown in Appendix A and Appendix B respectively.

Existing Conditions:

The project site is located in Gloucester County. The properties along Route 17 are businesses. The southwest corner of the intersection currently drains via sheet flow, eventually draining to the Route 17 roadway storm sewer system. The southeast corner of the intersection currently drains via sheet flow, eventually draining to the Route 216 roadway storm sewer system. The median to the south of the intersection currently drains via a graded swale which outfalls into the Route 17 roadway storm sewer system. Both storm sewer systems ultimately outfall to Sarah Creek. There are no wetlands or water quality structures located within the project limits.

Proposed Drainage System:

The project will maintain the same general flow patterns. Runoff from both the southeast and southwest corners of the intersection will sheet flow from the project limits. Runoff from the median will flow through a graded grass swale and tie into the existing concrete median ditch approximately 250 feet south of the intersection. All runoff from the project limits will ultimately outfall to Sarah Creek.

Erosion and Sediment Control (ESC):

This ESC Plan has been designed, prepared, reviewed, and approved in accordance with the VDOT's approved ESC & Stormwater Management (SWM) Program Standards and Specifications. A copy of the Certification Form is part of this document.

Appendix 3A-4 PAC Milestone Deliverables

Hydrology:

The Rational Method of calculating discharge is used exclusively on this project because all drainage areas are less than 200 acres in size. Drainage areas were calculated with the use of electronic survey and design data.

Hydraulic Design Software:

The design software utilized on this project includes:

- Virginia Runoff Reduction Method Spreadsheet

Appendix 3A-4 PAC Milestone Deliverables

EROSION & SEDIMENT CONTROL/ STORMWATER MANAGEMENT CERTIFICATION

Appendix 3A-4 PAC Milestone Deliverables

LD-445C
(10/20/14)

VIRGINIA DEPARTMENT OF TRANSPORTATION
LOCATION AND DESIGN
EROSION AND SEDIMENT CONTROL (ESC) AND STORMWATER MANAGEMENT (SWM) CERTIFICATION FORM

From: Plan Reviewer Rebecca Worley

To: Project Manager Nathan Huber

District: Fredericksburg Residency: Saluda

UPC Number: 98806 VDOT Project Number: 0017-036-577, M-501

Area to be Disturbed (to the nearest one-hundredth acre): 0.17

This form shall be completed by the Plan Reviewer and provided to the ESC/SWM Plan Designer. The ESC & SWM Plan Designer shall forward this form to the Project Authority for use in completing the application for a VPDES Construction Permit (if applicable).

This form serves to ensure that a project specific ESC Plan and SWM Plan has been designed/prepared, reviewed, and approved in accordance with the Virginia Department of Transportation's approved ESC & SWM Standards and Specifications.

ESC Plan Reviewer*

The ESC Plan for the project listed above has been reviewed and approved in accordance with the VDOT's approved ESC Standards and Specifications.

Signature: Rebecca J. Worley Title: **Hydraulics Engineer**

Printed name: Rebecca Worle Date: **3/1/2016**

*DEQ Certified Plan Reviewer for ESC or Professional Engineer, Land Surveyor, Landscape Architect or Architect with expertise in the field of ESC.

SWM Plan Reviewer**

The SWM Plan for the project listed above has been reviewed and approved in accordance

Signature: Rebecca J. Worley Title: Hydraulics Engineer

Printed name: Rebecca Worley Date: **3/1/2016**

**DEQ Certified Plan Reviewer for SWM: Individuals seeking SWM certification will be considered provisionally certified for two Years from the date they complete their first required training course.

Appendix 3A-4 PAC Milestone Deliverables

APPENDIX A: WATER QUANTITY

Appendix 3A-4 PAC Milestone Deliverables

Water Quantity:

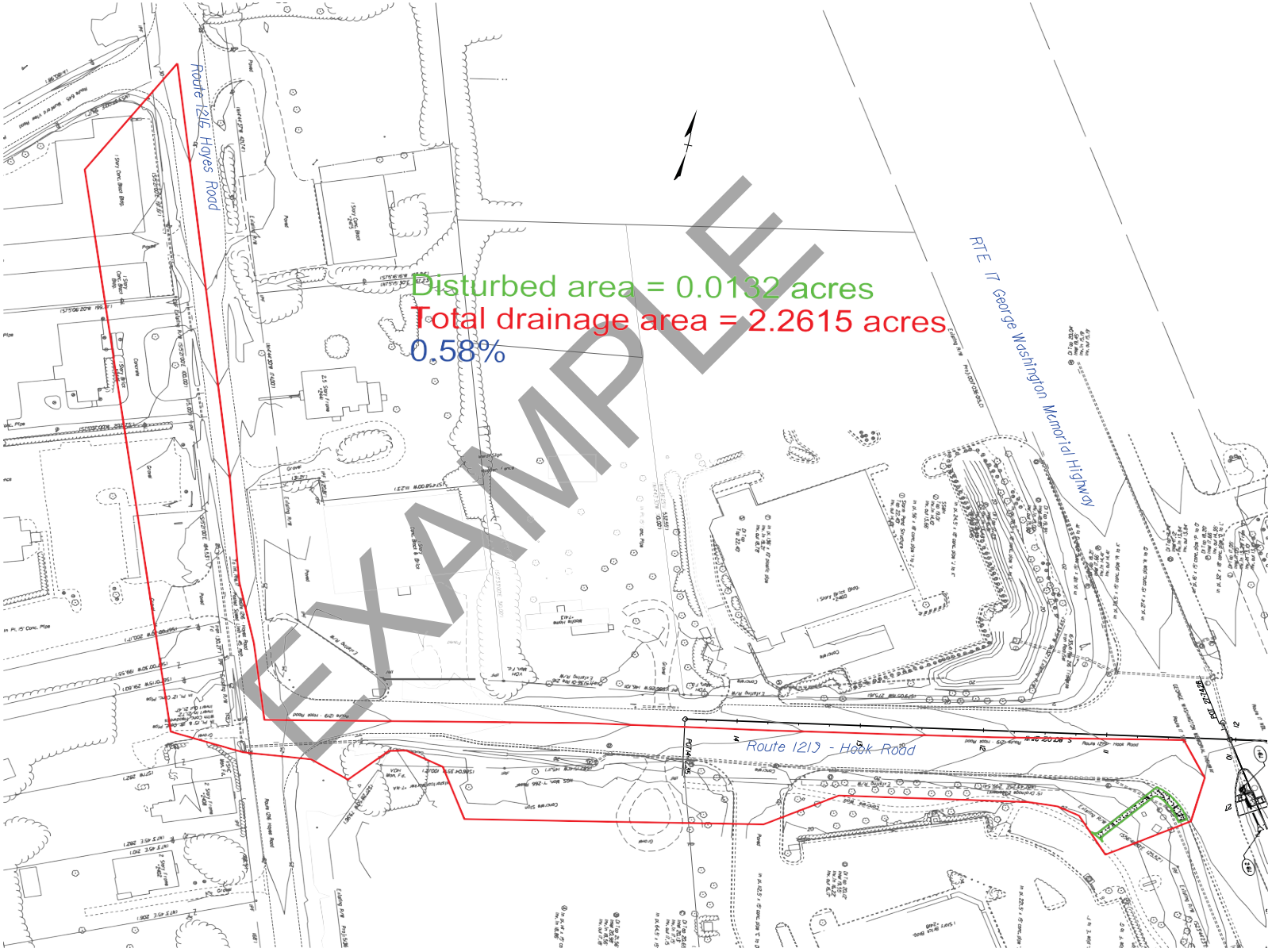
This project utilizes the technical criteria of Part IIB (9VAC25-870-62) for determining its post- development stormwater management design. Using the DEQ Runoff Reduction spreadsheet for redevelopment, the total phosphorus load reduction required was found to be 0.07 lb/yr. Nutrient credits will be purchased to meet the water quality criteria.

Each outfall was analyzed individually for compliance with the water quantity criteria. Detailed information about each outfall analysis follows.

Outfall 1 – Southwest corner (Route 17 George Washington Memorial Highway & Route 1219 Hook Road)

Land disturbance at this outfall is associated with the construction of sidewalk and totals 0.0132 acres. The project area will flow into the gutter pan on Route 17, where the total drainage area is 2.2615 acres. Because the disturbed area is less than one-percent ($\frac{0.0132}{2.2615} * 100$ = 0.58%) of the total drainage area at the outfall and the spread from the gutter pan does not exceed the allowable, no water quantity controls are required for channel or flood protection. Calculated spread from the gutter pan at the limits of disturbance is 5.37', which is less than the allowable spread of 8'. The drainage area map on the following page demonstrates compliance with the one-percent rule.

Appendix 3A-4 PAC Milestone Deliverables



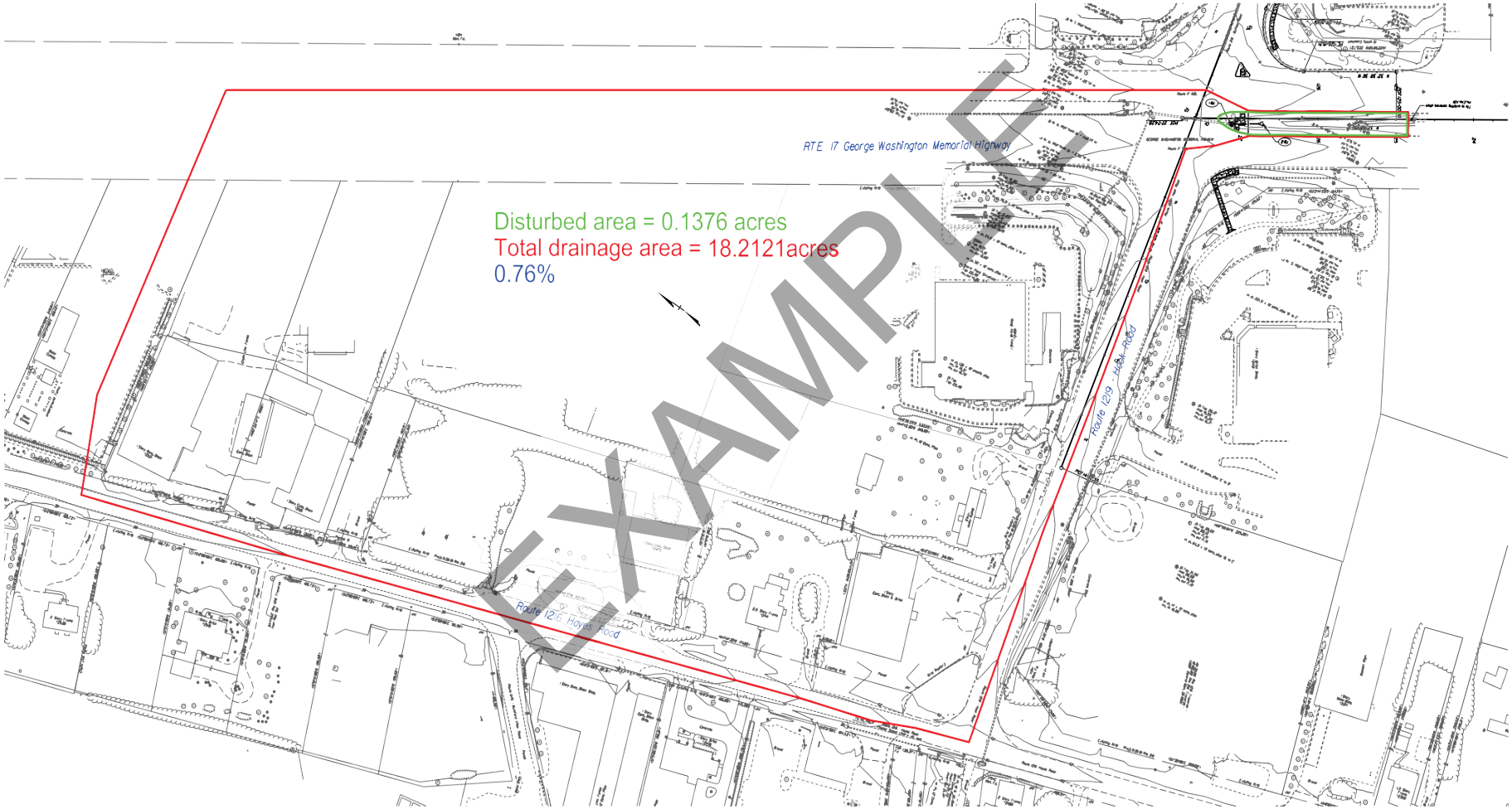
Appendix 3A-4 PAC Milestone Deliverables

Outfall 2 – Route 17 George Washington Memorial Highway Median (South of intersection)

Land disturbance at this outfall is associated with the construction of a raised concrete median and pipe extension. Additionally, the grass channel downstream of the outfall pipe will be graded approximately 250 feet to tie into the existing concrete ditch. The total land disturbance is 0.1376 acres and the total drainage area at the outfall is 18.2121 acres. Because the disturbed area is less than one-percent ($\frac{0.1376}{18.2121} * 100$ = 0.76%) of the total drainage area at the outfall, no water quantity controls are required for channel or flood protection. The drainage area map on the following page demonstrates compliance with the one-percent rule.

.

Appendix 3A-4 PAC Milestone Deliverables

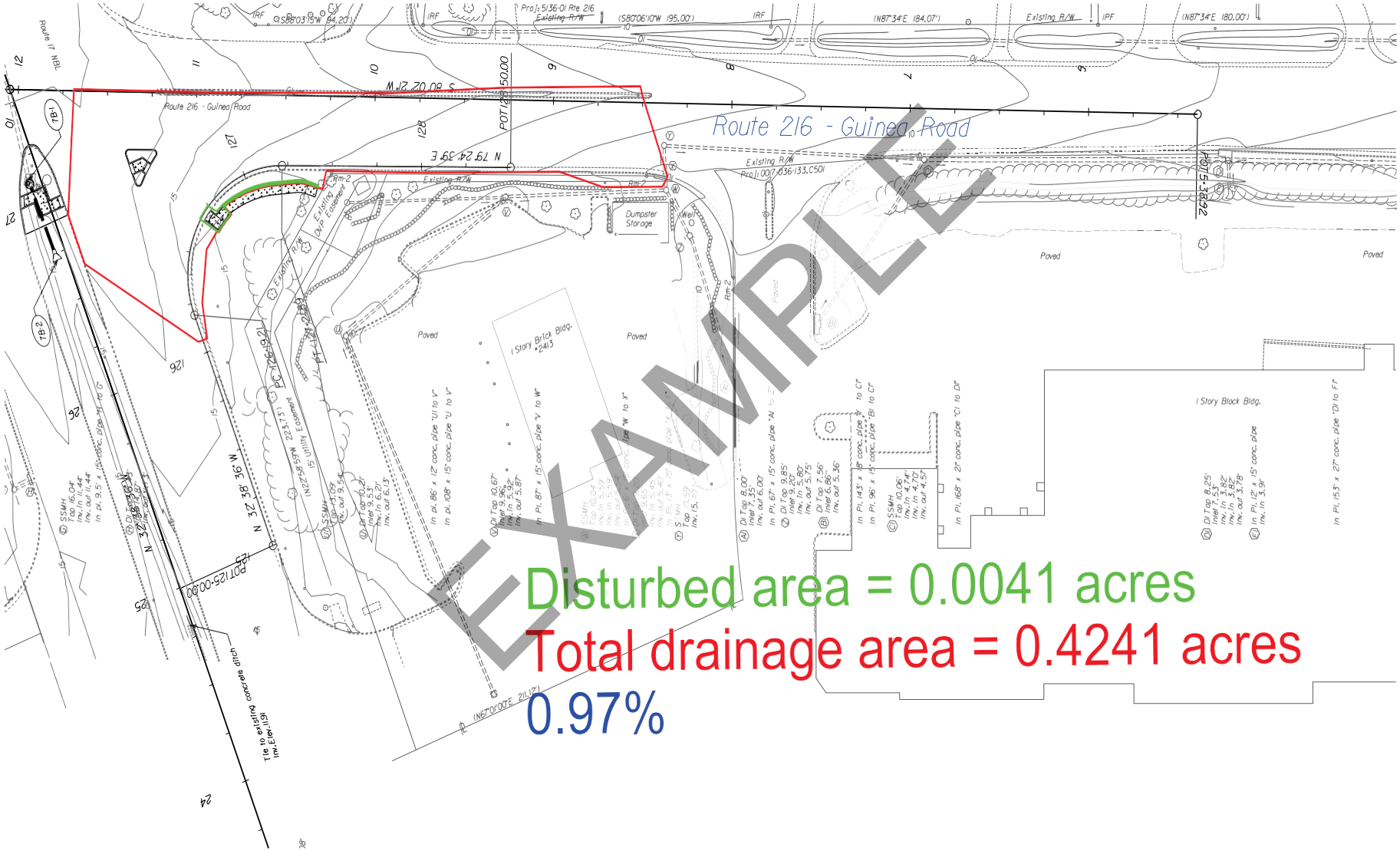


Appendix 3A-4 PAC Milestone Deliverables

Outfall 3 – Southeast corner pedestrian ramp (Route 17 George Washington Memorial Highway & Route 216 Guinea Road)

Land disturbance at this outfall is associated with the construction of a pedestrian ramp and totals 0.0041 acres. The disturbed area outfalls to the gutter and drains along Guinea Road, where the total drainage area at the first drop inlet is 0.4241 acres. Because the disturbed area is less than one-percent ($\frac{0.0041}{0.4241} * 100 = 0.97\%$) of the total drainage area at the outfall and the spread does not exceed the allowable from the disturbed area to the first drop inlet, no water quantity controls are required for channel or flood protection. Calculated spread at the first drop inlet along Guinea Road is 4.91', which is less than allowable spread of 8'. The drainage area map on the following page demonstrates compliance with the one-percent rule.

Appendix 3A-4 PAC Milestone Deliverables



Appendix 3A-4 PAC Milestone Deliverables

Outfall 4 – Southeast corner sidewalk construction (Route 17 George Washington Memorial Highway & Route 216 Guinea Road)

Land disturbance at this outfall is associated with the construction of sidewalk and totals 0.0131 acres. Runoff draining from this land disturbance will not be concentrated, but will maintain runoff as sheet flow from the sidewalk area. Due to the limited increase in impervious area leading to a very slight increase in runoff, it is not anticipated that the project will cause flooding, erosion, or sedimentation to the downstream area. Therefore, this outfall is in compliance with the guidance in section D of the water quantity regulations for sheet flow.

Appendix 3A-4 PAC Milestone Deliverables

Appendix 3A-4 PAC Milestone Deliverables

APPENDIX B: WATER QUALITY

Appendix 3A-4 PAC Milestone Deliverables

Water Quality:
This project utilizes the technical criteria of Part IIB (9VAC25-870-62) for determining its post- development stormwater management design. Using the DEQ Runoff Reduction spreadsheet for redevelopment, the total phosphorus load reduction required was found to be 0.07 lb/yr. Nutrient credits will be purchased to meet the water quality requirements for this project.

The DEQ Runoff Reduction spreadsheet below demonstrates compliance with the water quality requirements for this project.

Appendix 3A-4 PAC Milestone Deliverables

Virginia Runoff Reduction Method ReDevelopment Worksheet - v2.8 - June 2014

To be used w/ 2011 BMP Standards and Specifications

Site Data

Project Name: 98806 Rte. 17 at Hook Road

Date: 2/17/2016

	data input cells
	calculation cells
	constant values

Post-ReDevelopment Project & Land Cover Information

Total Disturbed Acreage 0.17

Constants

Annual Rainfall (inches)	43		
Target Rainfall Event (inches)	1.00		
Phosphorus EMC (mg/L)	0.26	Nitrogen EMC (mg/L)	1.86
Target Phosphorus Target Load (lb/acre/yr)	0.41		
Pj	0.90		

Pre-ReDevelopment Land Cover (acres)

	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.17	0.00	0.00	0.00	0.17
Impervious Cover (acres)	0.00	0.00	0.00	0.00	0.00
				Total	0.17

Post-ReDevelopment Land Cover (acres)

	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.13	0.00	0.00	0.00	0.13
Impervious Cover (acres)	0.04	0.00	0.00	0.00	0.04
				Total	0.17
Area Check	Okay	Okay	Okay	Okay	

Rv Coefficients

	A soils	B Soils	C Soils	D Soils
Forest/Open Space	0.02	0.03	0.04	0.05
Managed Turf	0.15	0.20	0.22	0.25
Impervious Cover	0.95	0.95	0.95	0.95

Land Cover Summary	**Listed**	**Adjusted[1]**
Pre-ReDevelopment		
Forest/Open Space Cover (acres)	0.00	0.00
Composite Rv(forest)	0.00	0.00
% Forest	0%	0%
Managed Turf Cover (acres)	0.17	0.13
Composite Rv(turf)	0.15	0.15
% Managed Turf	99%	99%
Impervious Cover (acres)	0.00	0.00
Rv(impervious)	0.95	0.95
% Impervious	1%	1%
Total Site Area (acres)	0.17	0.13
Site Rv	0.16	0.16
Pre-Development Treatment Volume (acre-ft)	0.0026	0.0017
Pre-Development Treatment Volume (cubic feet)	97	76
Pre-Development Load (TP) (lb/yr)	0.06	0.05

Land Cover Summary	
Post-ReDevelopment	
Forest/Open Space Cover (acres)	0.00
Composite Rv(forest)	0.00
% Forest	0%
Managed Turf Cover (acres)	0.13
Composite Rv(turf)	0.15
% Managed Turf	99%
ReDev. Impervious Cover (acres)	0.00
Rv(impervious)	0.95
% Impervious	1%
Total ReDev. Site Area (acres)	0.13
ReDev. Site Rv	0.16
Post-ReDevelopment Treatment Volume (acre-ft)	0.0017
Post-ReDevelopment Treatment Volume (cubic feet)	76
Post-ReDevelopment Load (TP) (lb/yr)	0.05

Land Cover Summary	
Post-ReDevelopment New Impervious	
New Impervious Cover (acres)	0.04
Rv(impervious)	0.95
% Impervious	100%
Total New Dev. Site Area (acres)	0.04
New Dev. Site Rv	0.95
Post-Development Treatment Volume (acre-ft)	0.0030
Post-Development Treatment Volume (cubic feet)	130
Post-Development Load (TP) (lb/yr)	0.09

[1]Adjusted **Land Cover Summary** reflects the pre-redevelopment land cover minus the pervious land cover (forest/open space or managed turf) acreage proposed for new impervious cover. The adjusted total acreage is consistent with the Post Redevelopment acreage (minus the acreage of new impervious cover). The load reduction requirement for the new impervious cover to meet the new development load limit is computed in **Column I**.

Maximum % Reduction Required Below Pre-ReDevelopment Load	10%
TP Load Reduction Required for Redeveloped Area (lb/yr)	0.00
TP Load Reduction Required for New Impervious Area (lb/yr)	0.07
Total Load Reduction Required (lb/yr)	0.07

Pre-Development Load (TN) (lb/yr)	0.43	Post-Development Load (TN) (lb/yr)	0.35

Appendix 3A-5 Drainage Summary

DRAINAGE SUMMARY

		Storm Sewer Pipe			Pipe			End Sections						Endwalls						Manholes		Junction Box JB-1		Box Culverts		Drop Inlets									Erosion Control Stone St'd EC-1						
	Cover	12" Aluminum Coated Type 2, 14 Gauge Pipe	15" Conc., Class III Pipe	18" Galvanized Corrugated Steel, 12 Gauge Pipe	15" Polyethylene (PE) Corrugated, Type S Pipe	24" Conc., Class IV Pipe	30" Polymer Coated (10/10) Corrugated Steel Spiral Rib Pipe	12" ES-1	15" ES-1	18" ES-1	24" ES-1	12" ES-2	18" ES-2	EW-1	EW-2	EW-11	Reinf. Steel	A3 Concrete	A3 Concrete for PG-5	MH-1 or 2	MH-1 Frame & Cover	Reinf. Steel	A4 Concrete	Reinf. Steel	A4 Concrete	DI-3B	DI-3C	DI-7	DI-7A	Structure Height	Structure Length	No. 57 Stone	No. 25 or 26 Aggregate*	Geotextile Drainage Fabric	Class A1	Class I	Class II	Flowable Backfill	Minor Structure Exc.	Post Installation Pipe Inspection	Remarks
Structure	ft	ft	ft	ft	ft	ft	ft	Ea	Ea	Ea	Ea	Ea	Ea	Ea	Ea	Ea	Lbs	CY	SY	LF	Ea	Lbs	CY	Lbs	CY	Ea	Ea	Ea	Ea	ft	ft	TON	TON	SY	Tons	Tons	Tons	CY	CY	ft	
3-1	4.0		13						1																															13.0	Existing pipe to be extended
4-01	5.0			24									1																											24	Existing pipe to be extended
4-03	2.0				25				2																			1		12											Grate A, Type III Req'd.
4-03 to 4-04	12.0	80																																						80	
4-04																										1								2.5			3				
4-05	8.0	41										1																												41	Existing pipe to be extended
4C-01	10.0						91							2				4.4																6.3		9				91	Min. 6" countersinking; Type A installation
4C-02																1	1997	11.8																							
4C-02 to 4C-03	4.0																																							95	Min. 6" countersinking
4C-03																													1	7.6											Grate B Req'd.
4C-03 to 4C-04	4.0																																								Min. 6" countersinking
4C-04															1			4.5																34.1		51					Type B installation
5-01	7.0					102					2																							4	4.5						Min. 6" countersinking; Type A installation
5-02																												1													Grate B Req'd.
5-02 to 5-11	4.0	11																																						11	
5-03																														5.5											Type III w/ MB-7D
5-03 to 5-09	5.0	4																																						4	
5-04																														4.9											Type III w/ MB-7D
5-04 to 5-03	4.0																																							15	
5-05																														5.7	6										Type III w/ MB-7D
5-05 to 5-07	3.0																																							7	
5-06																														5.3	6										Type III w/ MB-7D; Connect to UD-4
5-06 to 5-07	3.0																																							27	
5-07																				4.7	1																				
5-07 to 5-08	2.0																																							191	
5-08																				4.8	1																				Connect to UD-4
5-08 to 4C-03	2.0																																							141	
5-09																				5.8	1																				
5-09 to 5-10	3.0																																							156.0	
5-10																				5.6	1																				Connect to UD-4
5-10 to 5-05	5.0																																							4.0	
5-11																				4.9	1																				
5-11 to 5-09	3.0																																							38.0	
5-12																																									
5-13																																									
5-14																																									
5-15																																									
6-01																			3																						St'd PG-5 Req'd; W = 1.0'; Grade downstream ditch from trapezoidal to v-shaped
6-03																										1				3.5	8										
6-03 to 6-04	2.0			49																																				49.0	
6-04													1																					2.3	2.7						Type A installation
6-06																			2.3																						St'd PG-5 Req'd; W = 2.0'; Grade downstream ditch from trapezoidal to v-shaped
EX-01																																						61.7			48" Conc. Pipe to be abandoned
Incidental																			916																						For trapezoidal ditch from Lewistown Sta. 26+25 to Ramp B Sta. 15+25; W=4', D=2', t=4"
Totals		136	13	73	25	102	91	0	3	0	2	1	2	2	1	1	1997	20.70	921.3	26	5	0	0	0	0	2	0	2	1			0	0	49.2	7.2	60	3	61.7	0	987	

* No. 25 or 26 aggregate quantity is the 2" of depth not included in the cost of the pipe. (VDOT Spec 302.04)

Appendix 3A-5 Drainage Summary

Example for “No Plan”

POST INSTALLATION INSPECTION						
Storm Sewer Pipe		Pipe (All pipe installation on plans not identified as storm sewer pipe)				
Size	LF	Size	LF	10% of Total	Individual Installation	Quantity to Inspect (LF)
12"		12"	788	79	24,24,24,32,48,24,32,24,24,44,24, 40,24,24,24,24,24,24,24,24,36,24, 24,24,24,24,24,24,24,24	48
15"	228					
18"	36	15"	898	90	40,24,24,24,24,24,24,24,24,24,24,32, 24,24,48,24,24,24,32,24,24,36,24, 24,24,24,48,24,12,110,12,24	110
		18"	258	26	24,40,24,36,24,24,24,32,24,6	24
		23"x14"	2394	239	30,34,98,148,180,110,252,200,100,98, 68,32,94,48,28,164,76,176,76,32,40,44, 204,32,24,24,34,24	252
		30"x19"	106	11	36,36,34	34
		45"x29"	40	4	40	40
Subtotals	264					508
Totals to be Inspected			772			

Appendix 3B-1 Documentation Data Sheet for Hydrologic and Hydraulic Computations

SUBMITTAL:	***FIELD INSPECTION***	**SUBMITTAL DATE:**	***10/21/01***
Project:	*Route 33 West Point Bridges over Pamunkey and Mattaponi Rivers*	Scheduled Advertisement: Revised:	*~~May 2002~~* *May 2003*
Project Nos.	*0033-333-102, PE-101* *0033-333-103, PE-101*	Drainage Manual Revision:	*6/86*
		Agreement Date:	*10/23/99*
		Earliest Date of Calculations:	*11/99*
Location:	*New Kent County* *King William County* *Town of West Point* *King and Queen County*		
From:	*New Kent County*	Scheduled / actual milestones	
		Preliminary Field Review:	
To:	*King William County*	Field Inspection:	
		Public Hearing Plans:	
Other Info:			
		Public Hearing:	
Submitted	*Company/Agency*		
By:	*address*	Right-of-Way	
Submitted	*VDOT C.O.*	Pre-Final:	
To:	*Richmond, VA*		
		Final:	
Submitted			
To:		Construction Completion:	
Submitted			
To:			
Design Assignments			
	Project Manager	Hydraulics Task Leader	

Note: Sheet to be filled out and included in H&H Report. Blank sheet provided on next page.

Appendix 3B-1 Documentation Data Sheet for Hydrologic and Hydraulic Computations

SUBMITTAL:	***FIELD INSPECTION***	**SUBMITTAL DATE:**	
Project:		Scheduled Advertisement: Revised:	
Project Nos.		Drainage Manual Revision:	
		Agreement Date:	
		Earliest Date of Calculations:	
Location:			
From:		Scheduled / actual milestones	
		Preliminary Field Review:	
To:		Field Inspection:	
		Public Hearing Plans:	
Other Info:			
		Public Hearing:	
Submitted			
By:		Right-of-Way	
Submitted		Pre-Final:	
To:			
		Final:	
Submitted			
To:		Construction Completion:	
Submitted			
To:			
Design Assignments			
	Project Manager	Hydraulics Task Leader	

Note: This sheet to be filled out and included in H&H Report.

Appendix 3B-2 Suggested Outline for VDOT Hydrologic and Hydraulic Analysis Reports

Cover for H&HA Report describing project, submittal, and schedule

Section I - Project Description and Requirements

Section II - **Hydrology**

A. Criteria
B. Methodology
C. Peak Discharge Computations and Summary Table
D. FEMA Flood Maps
E. Previous Studies
F. Data Gathering

Section III - Open Channel Hydraulics

A. Criteria
B. Methodology
C. Typical Roadway Ditch Sections
D. Roadway Ditch Computations and Summary Table
E. Existing Stream Inventory
F. Data Gathering

Section IV - Culverts Hydraulics

A. Criteria
B. Methodology
C. Culvert Computations and Summary Table
D. Data Gathering

Section V - Storm Sewer Hydraulics

A. Criteria
B. Methodology
C. Spread Computations
D. Storm Sewer and Hydraulic Grade Line Computations
E. Data Gathering

Section VI - Stormwater Management

A. Criteria
B. Methodology
C. Stormwater Management Plan Summary
D. Detention Basin Computations
E. Data Gathering

Section VII – Erosion and Sediment Control

A. Criteria
B. Methodology
C. Sediment Basin Plan Summary
D. Phase I Narrative
E. Phase II Narrative
F. Data Gathering

Note: This a suggested format and does not attempt to identify all the elements necessary for adequate analysis or documentation

Appendix 3B-3 Field Engineer's Hydraulic Report

Survey by _____

To :
Attention:
From :

Rte._____ Proj. _____

Stream Name _____

Subject : Field Engineers
Hydraulic Report

Sta._____

A separate form should be submitted for each appropriate site on this project.

I. Hydrologic History of Site (District Drainage Engineer)

State any unusual hydrologic occurrences of which you have or can acquire knowledge.

_____

_____

_____

II. Hydraulic History of Site (District Bridge & Drainage Engrs.)

_____

_____

_____

_____

III. Comment of the relative importance and/or value of private or public property adjacent to this site (up and downstream) and the general affect of floods thereon. (Dist. Drainage Engr.)

_____

_____

_____

_____

Appendix 3B-3 Field Engineer's Hydraulic Report

IV. State rip rap and/or scour protection recommendations and justification for these recommendations. (Dist. Bridge Engr.).

_____

_____

_____

_____

V. Provide a basic assessment of the environmental, ecological, historical and economic considerations, which may exert an influence on this site. (District Drainage Engineer)

_____

_____

_____

_____

VI. Make note of any flood plain zoning and/or flood plain studies in existence or eminently proposed. (Dist. Drainage Engr.)

_____

_____

_____

_____

VII. Other Special Considerations and Remarks (District Bridge and Drainage Engineers)

_____

_____

_____

_____