Greg Gibson Vice President, Regulatory Affairs 750 East Pratt Street, Suite 1600 Baltimore, Maryland 21202



November 2, 2010

UN#10-262

Amanda Sigillito, Chief Non-Tidal Wetlands and Waterways Division Maryland Department of the Environment Water Management Administration 1800 Washington Boulevard Baltimore, Maryland 21230

Woody Francis, Project Manager U.S. Army Corps of Engineers – Baltimore District 10 S. Howard Street Baltimore, Maryland 21201

- Subject: Draft Final Phase II Nontidal Wetland and Stream Mitigation Plan for Calvert Cliffs Nuclear Power Plant, Unit 3 in Calvert County, Maryland, MDE Project Number 08-WL-1462 (T), 09-NT-0191 (NT), USACE Tracking No. NAB-2007-08123-M05
- References: 1) UN#10-037, Phase II Non-Tidal Wetlands and Stream Concept Plan and Tidal Wetlands Impacts for Calvert Cliffs Nuclear Power Plant, Unit 3, in Calvert County, Maryland, MDE Project Number 08-WL-1462 (T), 09-NT-0191 (NT), USACE Tracking No. NAB-2007-08123-M05, Dated March 18, 2010
 - UN#09-524, Summary Conceptual Phase II Non-Tidal Wetland and Stream Mitigation Plan for Calvert Cliffs Nuclear Power Plant, Unit 3 in Calvert County, Maryland, MDE Project Number 08-WL-1462 (T), 09-NT-0191 (NT), USACE Tracking No. NAB-2007-08123-M05, dated December 17, 2009.

Enclosed for review and approval please find the Draft Final Phase II Nontidal Wetland and Stream Mitigation Plan dated October 2010, for the proposed Calvert Cliffs Nuclear Power Plant, Unit 3 in Calvert County, Maryland (Enclosure 1). The Draft Final Phase II Nontidal Wetland and Stream Mitigation Plan ("Draft Final Plan") incorporates the philosophy of the Phase II Non-Tidal Wetlands and Stream Concept Plan ("Conceptual Plan") forwarded by Reference 1 and provides the details for implementing/constructing the Conceptual Plan. As such, the Draft Final Plan makes up the complete Phase II Nontidal Wetland and Stream Mitigation Plan by presenting the objective/scope/goal of the plan and the implementation (construction detail) aspect of the plan. The enclosed Draft Final Plan incorporates comments received from the Maryland Department of the Environment (MDE). UN#10-262 Page 2

Enclosure 2 provides an update to the summary of the Phase II Non-Tidal Wetland and Stream Mitigation Plan originally forwarded by Reference 2. UniStar understands that this summary document was the only outstanding item identified to the NRC that USACE needed to support the Final Environmental Impact Statement writing session scheduled for mid-November.

If you have any questions concerning the attached document, please call Mr. Jim Burkman at (410) 787-5130.

Sincerely,

Greg Gibson

- Enclosures 1) Calvert Cliffs Nuclear Power Plant, Unit 3 Draft Final Phase II Nontidal Wetland and Stream Mitigation Plan, October 2010
 - 2) Calvert Cliffs Nuclear Power Plant, Unit 3 Summary Draft Final Phase II Nontidal Wetland and Stream Mitigation Plan, October 2010
- cc: Laura Quinn NRC Project Manager, Environmental Projects Branch 2 (w/enclosure) Susan Gray – Power Plant Research Program (w/enclosure) Cheryl Kerr – MDE (w/enclosure) Kelly Neff – MDE (w/enclosure)

Enclosure 1

Calvert Cliffs Nuclear Power Plant, Unit 3 Draft Final Phase II Nontidal Wetland and Stream Mitigation Plan October 2010

Enclosure 2

Calvert Cliffs Nuclear Power Plant, Unit 3 Summary – Draft Final Phase II Nontidal Wetland and Stream Mitigation Plan October 2010



Summary – Draft Final Phase II Nontidal Wetland and Stream Mitigation Plan Calvert Cliffs Nuclear Power Plant, Unit 3 October 2010

The Draft Final Phase II Nontidal Wetland and Stream Mitigation Plan (henceforth referred to as the "Phase II Mitigation Plan") for the Calvert Cliffs Nuclear Power Plant (CCNPP), Unit 3 has been prepared in accordance with the Final Compensatory Mitigation Rule issued by the United States Army Corps of Engineers (USACE) and the Environmental Protection Agency (EPA), published 10 April 2008. This updated Phase II Mitigation Plan has been refined, in regard to expanding to provide more detail, from the Conceptual Phase II Mitigation Plan submitted to USACE and the Maryland Department of the Environment (MDE) in December 2009. The site vicinity is depicted in Figure 1.

The Phase II Mitigation Plan has been prepared in accordance with the Maryland Compensatory Mitigation Guidance (Interagency Mitigation Task Force [IMTF], 1994) and USACE Regulatory Guidance Letter (RGL) No. 08-03, dated 10 October 2008. The Plan addresses the 12 critical elements required by the Final Compensatory Mitigation Rule. The overall goal of the Phase II Mitigation Plan is to replace functions and values lost resulting from the proposed development, as well as to protect existing stream and wetland resources from potential impacts associated with changing land use from the Unit 3 expansion.

Nontidal Wetland Mitigation

The project proposes no more than 8,350 linear feet of stream impacts and no more than 11.72 acres of jurisdictional wetland and open water pond impacts. A comprehensive description of the impact sites has been provided in the wetland delineation report dated May 2007, Joint Permit Application (JPA) submitted on 16 May 2008, and subsequent revisions and addendums.

The limit of disturbance for the construction of the CCNPP Unit 3 facility has been designed to avoid and minimize impacts to natural resources to the greatest extent possible while still meeting the project needs. However, the construction of the project would not be possible without permanently impacting federally regulated wetlands and streams. To meet a "no net loss" goal for nontidal wetland mitigation, the mitigation strategy chosen for the CCNPP Unit 3 project proposes onsite, in-kind mitigation. This is accomplished through the creation or enhancement of several sites, depicted on Figure 2.

The proposed wetland creation and enhancement areas will be planted with native hydrophytic vegetation after excavation to final grades. The proposed species composition will be largely representative of the wetlands within the CCNPP property and native to the region. In addition, the plant material will include species that have been identified as suitable for installation on wetland mitigation projects by the Chesapeake Bay Critical Area Commission.

Dense stands of Phragmites have been observed in the sediment basins of the Lake Davies Dredged Material Disposal Area, Johns Creek, and other forested wetland areas on the CCNPP Unit 3 site. The control of Phragmites through herbicide application, mowing practices, and flooding of the sediment basins is proposed for the wetland creation and enhancement areas presently containing the invasive species. The following mitigation credit ratios and proposed total credits are proposed for the Phase II Mitigation Plan:

Wetland Mitigation Credit Summary

| Forested Creation | 12.26 | 1:2 | 6.13 |
|-----------------------------------|-------|------------------|-------------------|
| Emergent Creation | 1.61 | 1:1 | 1.61 |
| Wetland Enhancement | 19.62 | 1:4 | 4.91 |
| Total Impact Amount = 11.72 acres | | Total Credit Amo | unt = 12.65 acres |

Stream Mitigation

Stream mitigation credits will be achieved through various restoration and preservation techniques with the goal of protecting and improving aquatic resource functions and returning natural/historic functions to degraded aquatic resources. The Phase II Mitigation Plan includes 10,236 linear feet of stream restoration and 930 linear feet of stream preservation in order to obtain the required stream mitigation credits. This is measured based on valley distance and not sinuous length of channel. The Phase II Mitigation Plan is designed to reduce the potential of secondary impacts from proposed development and promote habitat and establishment of an American eel (*Anguilla rostrata*) population onsite. Stream impacts/credits are detailed below:

| | | Michigan Rais | Minication Credit |
|---|--------|-----------------|---------------------------|
| Stream Restoration | 10,236 | 1:1 | 10,236 |
| Stream Preservation | 930 | 1:2 | 465 |
| Total Impact Length = 8,350 linear feet | | Total Credit Am | ount = 10,701 linear feet |

Stream Mitigation Credit Summary

Stream mitigation work is designed to meet the goals and objectives of this Phase II Mitigation Plan in accordance with the guidance provided by the regulatory and resource agencies. Several sites are proposed and depicted on Figure 2. In-channel work will be performed in accordance with an approved Erosion and Sediment Control Plan and performed by a qualified contractor, experienced in the field of stream and wetland restoration. Work will be performed with sufficient construction oversight to ensure the specifications of the design are met, disturbance is minimized, and any in-field changes which may occur are conducted and documented appropriately. The supervisory aspects of the design will include an onsite engineer working in coordination with a biologist/ecologist, providing oversight of the contractor on a day-to-day basis to ensure the design approaches are field-fit according to changing existing conditions while limiting disturbance to existing vegetation and natural resources.

The restoration design on the project site utilizes a combination of natural channel design (NCD) and regenerative stormwater conveyance (RSC) principles. NCD techniques, as pioneered by Dr. David Rosgen, are utilized to ensure that the riffle grade control techniques of RSC, thalweg grading, and low flow water surface facet creation are coordinated with stable reference systems onsite. Additionally, the reference criteria provide a basis for judging the success of the proposed dynamic sand-bedded systems.

RSC is a groundwater recharge, storage, floodplain reconnection, and infiltration practice that use a series of open channel, sand seepage step pools and riffle grade controls, through which stormwater flows are conveyed. The silty sand soils on this site are particularly suited to allow lateral infiltration from RSC storage and maximize floodplain contact, storage, and runoff quantity and quality attenuation. The purpose of these systems is to reduce the commonly seen erosion in ordinary stormwater conveyances and convert stormwater to shallow groundwater, mitigating nutrient pollution and thermal impacts to the receiving waters. The riffle grade controls within RSC systems are sized to resist transport of their underlying material in the 100year storm, accreting sediment over top of them at lower discharges, and flushing at higher discharges without transporting the underlying grade control material.

To ensure that the stream-wetland system is successful and diverse into the future, with fresh sources of woody debris, the mitigation design does not propose the removal or management of beaver, nor is a timber management plan proposed. In this way, it is intended that the stream system receives a diverse mix of large and small woody debris and leaf litter without the channel destabilizing and becoming entrenched.

Site Maintenance and Protection

The Phase II Mitigation Plan includes the creation and enhancement of nontidal wetlands, as well as the restoration and enhancement/preservation of nontidal stream channels. The compensatory mitigation is proposed to be onsite and areas where mitigation efforts have taken place on the property shall be protected long-term protections in perpetuity through the use of a Declaration of Restrictive Covenants, following the conclusion of the Site Maintenance and Monitoring program and regulatory agency sign-off on the mitigation efforts compliance with the permit requirements.

After the onsite wetland creation and enhancement activities are complete, a 5-year annual monitoring program will be implemented in accordance with the Maryland Compensatory Mitigation Guidance (IMTF, 1994), and the guidance provided in RGL No. 08-03 (USACE, October 2008). Performance standards for monitoring will be within accepted guidelines.

Monitoring of the stream channels proposed within the mitigation plan will be performed in an effort to compare post-construction conditions to pre-construction baseline data and within the specifications set forth in the plan and by regulating agencies.





-



Calvert Cliffs Nuclear Power Plant, Unit 3 Draft Final Phase II Nontidal Wetland and Stream Mitigation Plan Lusby, Maryland

Prepared for:

UniStar Nuclear Energy Baltimore, Maryland

Prepared by:

EA Engineering, Science, and Technology, Inc. 15 Loveton Circle Sparks, Maryland 21152 (410) 771-4950

October 2010

EA Project Number: 14621.03

Calvert Cliffs Nuclear Power Plant, Unit 3 Draft Final Phase II Nontidal Wetland and Stream Mitigation Plan Lusby, Maryland

Prepared for:

UniStar Nuclear Energy Baltimore, Maryland

Prepared by:

EA Engineering, Science, and Technology, Inc. 15 Loveton Circle Sparks, Maryland 21152 (410) 771-4950

October 2010

TABLE OF CONTENTS

Page

| LIST OF FIGURESiii | | |
|--|--|--|
| LIST OF TABLES | | |
| LIST OF ACRONYMS AND ABBREVIATIONSiv | | |
| EXECUTIVE SUMMARYv | | |
| 1.0 INTRODUCTION1-1 | | |
| 2.0MITIGATION GOALS AND OBJECTIVES2-12.1Aquatic Resource Functions2-12.2Prevention of Secondary Impacts2-12.3Reduce Impacts to the American Eel2-2 | | |
| 3.0BASELINE INFORMATION FOR DEVELOPMENT AREA/IMPACTS3-13.1Nontidal Wetlands Proposed for Impact3-13.2Stream Channels Proposed for Impact3-2 | | |
| 4.0MITIGATION CREDIT ACCOUNTING4-14.1Nontidal Wetland Mitigation4-14.2Stream Mitigation4-24.3Additional Mitigation Credit Reserve4-3 | | |
| 5.0 EXISTING CONDITIONS / BASELINE DATA / BASIS OF DESIGN 5-1 5.1 Nontidal Wetland Mitigation Areas 5-1 5.2 Stream Mitigation Reaches 5-6 5.2.1 Stream Mitigation Reach Descriptions 5-106 5.2.2 FGM Investigationn 5-6 5.2.3 FGM Investigation Findings: General Findings and Reach Classification 5-6 5.2.4 FGM Investigation Findings: Degraded Reaches and Factors Influencing Channel 5-6 | | |
| 5.2.5FGM Investigation Findings:Reference Reaches and Basis or Design | | |
| 6.0WORK PLAN6-16.1Nontidal Wetland Mitigation6-16.1.1Wetland Mitigation Work Descriptions6-16.1.2Wetland Mitigation Planting Plan6-56.1.3Phragmites Management Plan6-56.2Stream Mitigation6-7 | | |
| 7.0 SITE PROTECTION INSTRUMENT | | |
| 8.0POST-CONSTRUCTION MONITORING AND PERFORMANCE STANDARDS8-1*8.1Nontidal Wetland Monitoring | | |

| 8.2 | Stream | Channel Monitoring | 8-2 |
|------|---------|---|------|
| 8.3 | Perform | nance Standards | 8-3 |
| 9.0 | LONG-TH | ERM MANAGEMENT RESPONSIBILITIES | 9-1 |
| 10.0 | ADAPTIV | E MANAGEMENT PLAN | 10-1 |
| 11.0 | FINANCI | AL ASSURANCE | 11-1 |
| 12.0 | REFEREN | VCES | 12-1 |
| APPE | NDIX A: | 12 CRITICAL ELEMENTS SUMMARY | |
| APPE | NDIX B: | DRAFT FINAL DESIGN PLANS | |
| APPE | NDIX C: | EXISTING CONDITIONS HYDROLOGY ANALYSIS REPORT | |
| APPE | NDIX D: | FLUVIAL GEOMORPHIC ASSESSMENT DATA | |
| APPE | NDIX E | CALCULATIONS FOR WEIR DESIGN | |

- APPENDIX F: LIST OF PLAN DETAILS AND STANDARD SPECIFICATIONS
- APPENDIX G: RSC SPECIFICATION

s?

LIST OF FIGURES

Number

<u>Title</u>

| 1 | Vicinity Map. |
|---|------------------|
| 2 | Mitigation Areas |

LIST OF TABLES

| <u>Number</u> | Title |
|---------------|--|
| 1 | Nontidal Wetland Impacts. |
| 2 | Stream Impact Summary. |
| 3 | Wetland Mitigation Credit Summary. |
| 4 | Stream Mitigation Credit Summary. |
| 5 | Phase I Stream Mitigation Areas. |
| 6 | Woodland Branch Reference Data. |
| 7 | Johns Creek Reference Data. |
| 8 | Summary of Wetland Mitigation Work Plan. |
| 9 | Detailed Stream Mitigation by Reach. |
| | |

LIST OF ACRONYMS AND ABBREVIATIONS

| EA | EA Engineering, Science, and Technology, Inc. |
|---------|---|
| EPA | Environmental Protection Agency |
| CCNPP | Calvert Cliffs Nuclear Power Plant |
| COMAR | Code of Maryland Regulations |
| FGM | Fluvial Geomorphic |
| FIDS | Forest Interior Dwelling Species |
| ft | Foot or Feet |
| IMTF | Interagency Mitigation Task Force |
| JPA | Joint Permit Application |
| LOD | Limit of Disturbance |
| MBSS | Maryland Biological Stream Survey |
| MDE | Maryland Department of the Environment |
| MHW | Mean High Water |
| mm | Millimeter(s) |
| NCD | Natural Channel Design |
| NRC | Nuclear Regulatory Commission |
| O.C. | On Center |
| ORAM | Ohio Rapid Assessment Method |
| RBP | Rapid Bioassessment Protocols |
| RGL | Regulatory Guidance Letter |
| RSC | Regenerative Stormwater Conveyance |
| SE | Stream Enhancement |
| SR | Stream Restoration |
| SWM | Stormwater Management |
| UniStar | UniStar Nuclear Energy |
| USACE | U.S. Army Corps of Engineers |
| WC | Wetland Creation |
| WE | Wetland Enhancement |

EXECUTIVE SUMMARY

The Draft Final Phase II Nontidal Wetland and Stream Mitigation Plan (henceforth referred to as the "Phase II Mitigation Plan") for the Calvert Cliffs Nuclear Power Plant (CCNPP), Unit 3 has been prepared in accordance with the Final Compensatory Mitigation Rule issued by the United States Army Corps of Engineers (USACE) and the Environmental Protection Agency (EPA), published 10 April 2008. This updated Phase II Mitigation Plan has been refined, in regard to expanding to provide more detail, from the Conceptual Phase II Mitigation Plan submitted to USACE and the Maryland Department of the Environment (MDE) in December 2009. The site vicinity is depicted in Figure 1.

The Phase II Mitigation Plan has been prepared in accordance with the Maryland Compensatory Mitigation Guidance (Interagency Mitigation Task Force [IMTF], 1994) and USACE Regulatory Guidance Letter (RGL) No. 08-03, dated 10 October 2008. The Plan addresses the 12 critical elements required by the Final Compensatory Mitigation Rule. The overall goal of the Phase II Mitigation Plan is to replace functions and values lost resulting from the proposed development, as well as to protect existing stream and wetland resources from potential impacts associated with changing land use from the Unit 3 expansion.

Nontidal Wetland Mitigation

The project proposes no more than 8,350 linear feet of stream impacts and no more than 11.72 acres of jurisdictional wetland and open water pond impacts. A comprehensive description of the impact sites has been provided in the wetland delineation report dated May 2007, Joint Permit Application (JPA) submitted on 16 May 2008, and subsequent revisions and addendums.

The limit of disturbance for the construction of the CCNPP Unit 3 facility has been designed to avoid and minimize impacts to natural resources to the greatest extent possible while still meeting the project needs. However, the construction of the project would not be possible without permanently impacting federally regulated wetlands and streams. To meet a "no net loss" goal for nontidal wetland mitigation, the mitigation strategy chosen for the CCNPP Unit 3 project proposes onsite, in-kind mitigation. This is accomplished through the creation or enhancement of several sites, depicted on Figure 2.

The proposed wetland creation and enhancement areas will be planted with native hydrophytic vegetation after excavation to final grades. The proposed species composition will be largely representative of the wetlands within the CCNPP property and native to the region. In addition, the plant material will include species that have been identified as suitable for installation on wetland mitigation projects by the Chesapeake Bay Critical Area Commission.

Dense stands of Phragmites have been observed in the sediment basins of the Lake Davies Dredged Material Disposal Area, Johns Creek, and other forested wetland areas on the CCNPP Unit 3 site. The control of Phragmites through herbicide application, mowing practices, and flooding of the sediment basins is proposed for the wetland creation and enhancement areas presently containing the invasive species. The following mitigation credit ratios and proposed total credits are proposed for the Phase II Mitigation Plan:

| Total Impact Amount = 11.72 acres | | Total Credit Amo | ount = 12.65 acrès |
|-----------------------------------|------------------------------|------------------|------------------------------|
| Wetland Enhancement | 19.62 | 1:4 | 4.91 |
| Emergent Creation | 1.61 | 1:1 | 1.61 |
| Forested Creation | 12.26 | 1:2 | 6.13 |
| Mitigation Type | Mitigation Amount (acres) | Mitigation Ratio | Mitigation Credit (acres) |

Wetland Mitigation Credit Summary

STREAM MITIGATION

Stream mitigation credits will be achieved through various restoration and preservation techniques with the goal of protecting and improving aquatic resource functions and returning natural/historic functions to degraded aquatic resources. The Phase II Mitigation Plan includes 10,236 linear feet of stream restoration and 930 linear feet of stream preservation in order to obtain the required stream mitigation credits. This is measured based on valley distance and not sinuous length of channel. The Phase II Mitigation Plan is designed to reduce the potential of secondary impacts from proposed development and promote habitat and establishment of an American eel (*Anguilla rostrata*) population onsite. Stream impacts/credits are detailed below:

| Mitigation Type | Mitigation Amount (linear feet) | Mitigation Ratio | Mitigation: Credit (linear feet) |
|---|------------------------------------|------------------|-------------------------------------|
| Stream Restoration | 10,236 | 1:1 | 10,236 |
| Stream Preservation | 930 | 1:2 | 465 |
| Total Impact Length = 8,350 linear feet | | Total Credit Am | ount = 10,701 linear feet |

Stream Mitigation Credit Summary

Stream mitigation work is designed to meet the goals and objectives of this Phase II Mitigation Plan in accordance with the guidance provided by the regulatory and resource agencies. Several sites are proposed and depicted on Figure 2. In-channel work will be performed in accordance with an approved Erosion and Sediment Control Plan and performed by a qualified contractor, experienced in the field of stream and wetland restoration. Work will be performed with sufficient construction oversight to ensure the specifications of the design are met, disturbance is minimized, and any in-field changes which may occur are conducted and documented appropriately. The supervisory aspects of the design will include an onsite engineer working in coordination with a biologist/ecologist, providing oversight of the contractor on a day-to-day basis to ensure the design approaches are field-fit according to changing existing conditions while limiting disturbance to existing vegetation and natural resources.

The restoration design on the project site utilizes a combination of natural channel design (NCD) and regenerative stormwater conveyance (RSC) principles. NCD techniques, as pioneered by Dr. David Rosgen, are utilized to ensure that the riffle grade control techniques of RSC, thalweg grading, and low flow water surface facet creation are coordinated with stable reference systems onsite. Additionally, the reference criteria provide a basis for judging the success of the proposed dynamic sand-bedded systems.

RSC is a groundwater recharge, storage, floodplain reconnection, and infiltration practice that use a series of open channel, sand seepage step pools and riffle grade controls, through which stormwater flows are conveyed. The silty sand soils on this site are particularly suited to allow lateral infiltration from RSC storage and maximize floodplain contact, storage, and runoff quantity and quality attenuation. The purpose of these systems is to reduce the commonly seen erosion in ordinary stormwater conveyances and convert stormwater to shallow groundwater, mitigating nutrient pollution and thermal impacts to the receiving waters. The riffle grade controls within RSC systems are sized to resist transport of their underlying material in the 100year storm, accreting sediment over top of them at lower discharges, and flushing at higher discharges without transporting the underlying grade control material.

To ensure that the stream-wetland system is successful and diverse into the future, with fresh sources of woody debris, the mitigation design does not propose the removal or management of beaver, nor is a timber management plan proposed. In this way, it is intended that the stream system receives a diverse mix of large and small woody debris and leaf litter without the channel destabilizing and becoming entrenched.

Site Maintenance and Protection

The Phase II Mitigation Plan includes the creation and enhancement of nontidal wetlands, as well as the restoration and enhancement/preservation of nontidal stream channels. The compensatory mitigation is proposed to be onsite and areas where mitigation efforts have taken place on the property shall be protected long-term protections in perpetuity through the use of a Declaration of Restrictive Covenants, following the conclusion of the Site Maintenance and Monitoring program and regulatory agency sign-off on the mitigation efforts compliance with the permit requirements.

After the onsite wetland creation and enhancement activities are complete, a 5-year annual monitoring program will be implemented in accordance with the Maryland Compensatory Mitigation Guidance (IMTF, 1994), and the guidance provided in RGL No. 08-03 (USACE, October 2008). Performance standards for monitoring will be within accepted guidelines.

Monitoring of the stream channels proposed within the mitigation plan will be performed in an effort to compare post-construction conditions to pre-construction baseline data and within the specifications set forth in the plan and by regulating agencies.

1.0 INTRODUCTION

UniStar Nuclear Energy (UniStar) has proposed construction of a new nuclear power plant (Unit 3) at the project site known as the Calvert Cliffs Nuclear Power Plant (CCNPP), located in the Lusby area of Calvert County, Maryland, along the shoreline of the Chesapeake Bay, about 45 miles southeast of Washington D.C. (Figure 1). CCNPP is being proposed for expansion to provide additional energy service to meet the growing regional demand. A joint permit application and proposal for onsite mitigation of wetlands and streams has previously been submitted. EA Engineering, Science, and Technology, Inc. (EA) has been retained to develop the Phase II Final Nontidal Wetland and Stream Mitigation Plan (henceforth referred to as the "Phase II Mitigation Plan") in accordance with the Final Compensatory Mitigation Rule issued by the U.S. Army Corps of Engineers (USACE) and the Environmental Protection Agency



⁽EPA), published 10 April 2008.

Federal and state regulations require that the losses be compensated through mitigation for activities that cause unavoidable losses of wetlands and streams. Wetland and stream mitigation is defined as the creation, restoration, enhancement, or preservation of wetlands or streams, to compensate for the wetlands and streams that will be lost. This document provides supporting details for the wetland and stream mitigation plan proposed for the Unit 3 project at CCNPP.

EA has prepared this Phase II Mitigation Plan to present the proposed design for the stream and wetland mitigation sites for review and approval by USACE and the Maryland Department of the Environment (MDE) in order to facilitate the final permit authorization for the proposed impacts to existing streams and wetlands as documented in the Joint Permit Application (JPA) submitted on 16 May 2008, and subsequent revisions and addendums. This Phase II Mitigation Plan has been developed from the Conceptual Phase II Nontidal Wetland and Stream Mitigation Plan, which was submitted to USACE and MDE on 8 December 2010 for review and comments. Prior to developing this Mitigation Plan, comments from MDE were received on the Conceptual Phase II Nontidal Wetland and Stream Mitigation Plan.

The Phase II Mitigation Plan has been prepared in accordance with the *Maryland Compensatory Mitigation Guidance* (Interagency Mitigation Task Force [IMTF], 1994) and the USACE Regulatory Guidance Letter (RGL) No. 08-03, dated 10 October 2008, and documents the 12 critical elements as required by the Final Compensatory Mitigation Rule. The 12 critical elements include the following:

- Objectives
- Site selection criteria
- Site protection instruments
- Baseline information (for impact and compensation sites)
- Credit determination methodology
- Mitigation work plan
- Maintenance plan
- Ecological performance standards
- Monitoring requirements
- Long-term management plan
- Adaptive management plan
- Financial assurances

The 12 critical elements have been addressed throughout the Draft Phase II Mitigation Plan, and a summary of the 12 critical elements is included in Appendix A.

2.0 MITIGATION GOALS AND OBJECTIVES

As part of the planning process for proposed Unit 3 and associated facilities, steps were taken to ensure avoidance and minimization of impacts to Wetland and Stream resources to the maximum extent practicable. A detailed description of the Avoidance and Minimization procedure has been included in the JPA (Section 4-F) as well as within Section 6.0 of the previously submitted *Supplemental Environmental Resource Report*. However, due to numerous safety, operational, and engineering requirements and restraints, the anticipated development would result in unavoidable permanent impacts to wetlands and stream resources.

2.1 AQUATIC RESOURCE FUNCTIONS

The overall goal of the Phase II Mitigation Plan is to replace functions and values lost due to proposed development, as well as protect existing stream and wetland resources from potential impacts associated with changing land use from the Unit 3 expansion. The wetland and stream impacts on the CCNPP Unit 3 site occur within the same hydrologic units as the proposed wetland enhancement and creation areas and the stream enhancement and restoration areas; i.e., the Patuxent River Lower and West Chesapeake Bay hydrologic units. The geographic relationship between the areas of nontidal wetland and stream losses and the proposed mitigation sites provides an opportunity to mitigate impacts at an upper watershed level. The watershed approach used in the design of the compensatory mitigation plan for CCNPP Unit 3 is consistent with the ongoing natural resource management activities that have been conducted at CCNPP over the years. The mitigation activities are also compatible with comprehensive watershed management plans for CCNPP.

Mitigation credits are required to compensate for the unavoidable nontidal wetland impacts and stream impacts associated with the proposed project. The creation and enhancement of nontidal wetlands are being proposed to enhance water quality and habitat, as well as provide functional replacement for impacted wetlands. The stream mitigation credits will be achieved through restoration, enhancement, and preservation techniques with the goal of protecting and improving aquatic resource functions and returning natural/historic functions to former or degraded aquatic resources. Similarly, through the establishment of headwater wetland and infiltration practices in head-cut and upland situations, restoration of historical channel functions, historical groundwater elevations, and increases in base flow will be achieved.

2.2 PREVENTION OF SECONDARY IMPACTS

The proposed Phase II Mitigation Plan has been designed to account for proposed development and stormwater discharges in order to minimize their potential impacts on the existing aquatic resources. This is accomplished through the utilization of energy dissipation structures, reconnection of the channel with the existing floodplain, and appropriate channel sizing. The addition of infiltration practices and planting of riparian trees and shrubs is intended to increase base flow propagation in the watershed as well as reduce the potential for thermal impacts from stormwater discharges. The mitigation design has been created to utilize construction techniques with minimal impact to existing water resources as well as existing vegetation. The design is intended to work with existing trees and shrubs to minimize canopy disturbance, and to utilize tree materials created through the clearing and grubbing phase of the construction of Unit 3.

Furthermore, the creation of headwater wetlands and infiltration practices are proposed to promote base flow, attenuate spikes in the hydrograph which may be erosive to stream channels, and compensate for existing and proposed impervious areas. These practices are proposed in order to have a successful mitigation outcome utilizing watershed approaches.

2.3 REDUCE IMPACTS TO THE AMERICAN EEL

The American eel has suffered extreme decline since European colonization of the region. The American eel is a catadromous species that begins its life by hatching from eggs in the Sargasso Sea, an area of the Atlantic Ocean north of the Bahamas. The eels then migrate to estuaries of the Atlantic Coast where they spend most of their lives before returning to the Sargasso Sea to spawn (Murdy et al. 1997). Historically, American eels were found throughout the East Coast streams, comprising more than 25 percent of the total fish biomass (Atlantic States Marine Fisheries Commission 2000]. As development of the rivers began and eel harvesting increased, the American eel populations began to decline throughout its range. During the upstream migration from the Sargasso Sea to the tributaries and estuaries of the Atlantic Ocean, American eels are forced to go through many obstacles in order to successfully reach their nursery grounds. Therefore, eels are susceptible to a variety of habitat, overfishing, and parasitic pressures. Changes in water quality and obstacles to fish passage present the two largest obstacles to their success in eastern freshwater streams. Eels mature in these freshwater streams for between 10 and 40 years. Since they live in a limited home range, the habitat must not be ephemeral (Ford and Mercer 1986).

American eel habitat enhancement and preservation has been identified as a priority for this project. This habitat includes undercut banks, crevices, hollow and overhanging logs, and sheltered areas. These areas coincide with roots, leaf mat, and partially and fully submerged woody debris in the channel.

The Phase II Mitigation Plan includes preservation of stream reaches identified as having known eel populations or potential habitat, and enhancements in other reaches to create suitable eel habitat. Enhancement of stream reaches to provide potential habitat for the American eel include placement of woody debris in the channel and work to raise the groundwater elevation to enhance base flow in the channels. At present, many channels exhibit excellent woody debris and cover elements; however, they lack base flow. Through enhancing base flow, additional habitat can be created for American eel. In addition, many reaches have head-cuts with large drops that may present migration barriers for American eel during their inland migration. These head cuts would be eliminated through creation of steps, or through other uplift techniques.



3.0 BASELINE INFORMATION FOR DEVELOPMENT AREA/IMPACTS

Jurisdictional wetlands and streams will be permanently impacted as a result of constructing the proposed Unit 3 project. The limit of disturbance (LOD) for the construction of the CCNPP Unit 3 facility has been designed to avoid and minimize impacts to natural resources to the greatest extent practical while still meeting the project needs. However, the construction of the project would not be possible without permanently impacting Waters of the United States, including federally regulated wetlands. The previously submitted permit application for the project proposes 8,350 linear feet of stream impacts and impacts to 11.72 acres of jurisdictional wetlands and open water ponds. A comprehensive description of the impact sites has been provided in the previously submitted wetland delineation report dated May 2007 and the JPA submitted on 16 May 2008.

3.1 NONTIDAL WETLANDS PROPOSED FOR IMPACT

The wetland areas to be impacted by the construction of Unit 3 include forested and emergent nontidal wetlands as well as open water ponds and are detailed in Table 1.

| Wetland Type | Area of Impact | Impact Type | |
|---|----------------|------------------------|--|
| Forested Wetland | 7.88 acres | Permanent Grading/Fill | |
| Emergent Wetland | 1.21 acres | Permanent Grading/Fill | |
| Open Water | 2.63 acres | Permanent Grading/Fill | |
| Total Area of Permanent Impacts = 11.72 acres | | | |

| Table 1. | Nontidal | Wetland | Impacts |
|----------|----------|---------|---------|
|----------|----------|---------|---------|

Common functions of the impacted wetlands were previously determined to be groundwater recharge, groundwater discharge, flood flow alteration, sediment/shoreline stabilization, sediment/toxicant retention, nutrient removal/transformation, production export, aquatic diversity/abundance, and wildlife habitat diversity/abundance. Common values were also determined to be recreation, uniqueness/heritage, education/scientific value, and visual quality/aesthetics. The Ohio Rapid Assessment Method (ORAM), as outlined in the Ohio Rapid Assessment Method for Wetlands (Mack 2001) was used to quantify the functions and values of wetland communities on the CCNPP Unit 3 project site to determine the appropriate level of mitigation. This was performed as part of the Phase I Mitigation Plan as developed for Unistar by MACTEC in 2009. The areas assessed not only consisted of the wetlands that would be impacted by the proposed development, but included the wetlands not being impacted, in order to determine the viability of mitigation sites. A majority of the wetland systems proposed for impacts appear to be degraded and exhibited moderate functions and values. The detailed results of the wetland evaluation have been included in Section 5.0 of the *Supplemental Environmental Resource Report*, which was previously submitted with the JPA.

3.2 STREAM CHANNELS PROPOSED FOR IMPACT

Approximately 8,350 linear feet of jurisdictional (perennial and intermittent) stream channels were identified within the proposed LOD on the CCNPP Unit 3 site development project site which will be impacted as described in Table 2. The stream identification numbers listed in Table 2 correspond to the USACE identification system used during the Jurisdictional Determination site inspection and documented in the Phase I Mitigation Plan (MACTEC 2009).

| Stream Reach Identification | Impact Length (linear feet) | |
|---|-----------------------------|--|
| RA-I-A | 729 | |
| RA-IVC-A | 1,595 | |
| RA-IVN-A | 102 | |
| RA-IVN-B | 2,943 | |
| RA-IVN-C | 555 | |
| RA-IVN-D | 1,342 | |
| RA-VIIN-A | 521 | |
| RA-VIIS-A | 563 | |
| Total Impact Length = 8,350 linear feet | | |

An onsite evaluation of the stream channels using the Rapid Bioassessment Protocols (RBP) (U.S. EPA 1999) was conducted, as well as a benthic macro-invertebrate assessment using the Maryland Biological Stream Survey (MBSS) guidelines (Kazyak 2001). Most of the stream reaches proposed for impact received scores of suboptimal, as based on the RBP. Detailed results from these stream assessments were provided in Section 6.0 of the *Supplemental Environmental Resource Report*, which was included in the previously submitted JPA.

As part of the Phase II Mitigation Plan, EA has calculated the anticipated temporary impacts to wetlands and stream channels that will be impacted during the mitigation construction activities. In addition to the permanent impacts to 11.72 acres of wetlands and 8,350 linear feet of stream channels, the mitigation activities are anticipated to temporarily impact no more than 1.75 acres of wetlands and 590 linear feet of stream channels. These impacts associated with the mitigation activity are temporary and will be removed upon completion of the mitigation construction. The anticipated temporary impacts are proposed for construction access, temporary crossings, and other activities associated with ongoing construction activities. Fill material placed within the streams and wetlands will be removed and restored to original grade upon completion of the mitigation construction activities and re-planted with appropriate hardwood vegetation. Mitigation construction laydown areas are proposed be placed to minimize wetland and stream impacts. A

detailed set of plans, including the proposed LOD are included in the Sediment and Erosion Control Plans and provided with the set of Draft Final Design Plans in Appendix B.

4.0 MITIGATION CREDIT ACCOUNTING

The LOD for the construction of the CCNPP Unit 3 facility has been designed to avoid and minimize impacts to natural resources to the greatest extent practical while still meeting the project needs. However, the construction of the project would not be possible without permanently impacting Waters of the United States, including federally regulated wetlands and streams.

To determine the required compensatory mitigation for wetland impacts, USACE–Baltimore District was consulted to determine the appropriate mitigation strategies for the project. The mitigation strategy chosen for the CCNPP Unit 3 project is onsite, in-kind mitigation. Therefore, no purchasing of mitigation bank credits is proposed to satisfy compensatory mitigation requirements. The Phase I Mitigation Plan (MACTEC 2009) was underway prior to issuance of the Final Compensatory Mitigation Rule issued by USACE and EPA and it was determined that there were no approved, State of Maryland, wetland/stream mitigation banks within the service area.

4.1 NONTIDAL WETLAND MITIGATION



To meet a "no net loss" goal of nontidal wetland mitigation, the 11.72 acres of nontidal wetland impacts caused by the construction of the proposed project must be mitigated by creating, restoring, or enhancing an equal area of nontidal wetlands. The Phase II Mitigation Plan for the Calvert Cliffs Unit 3 project includes the creation of new wetland areas onsite as well as enhancing existing wetlands. The wetland creation areas will include creation of both forested and emergent wetlands. A portion of open water creation is also proposed in order to replace functions and values lost from the impacted areas, as well as creating an ecologically diverse wetland mosaic within the mitigation area. The following mitigation credit ratios are proposed for the Phase II Mitigation Plan:

- Forested Wetland Creation = 1:2 credit ratio
- Wetland Enhancement = 1:4 credit ratio
- Emergent Wetland Creation = 1:1 credit ratio

Wetland enhancement will consist of the removal and control of common reed (*Phragmites australis*, commonly referred to as phragmites), along with planting of native bottomland hardwood species within existing wetlands where possible. Based on comments received by MDE on 2 December 2009, it has been determined that this technique will yield mitigation credits at a 1:4 ratio. A summary of wetland mitigation credits is described in Table 3.

| Mitigation Type | Mitigation Amount (acres) | Mitigation Ratio | Mitigation Credit (acres) |
|-----------------------------------|------------------------------|-----------------------------------|------------------------------|
| Forested Creation | 12.26 | 1:2 | 6.13 |
| Emergent Creation | 1.61 | 1:1 | 1.61 |
| Wetland Enhancement | 19.62 | 1:4 | 4.91 |
| Total Impact Amount = 11.72 acres | | Total Credit Amount = 12.65 acres | |

Table 3.Wetland Mitigation Credit Summary

4.2 STREAM MITIGATION

As previously stated, the construction of the project would not be possible without permanently impacting 8,350 linear feet of jurisdictional stream. As stated in the approved Phase I Mitigation Plan, the amount of stream mitigation proposed is based on a mitigation ratio of 1:1 for linear feet of stream impacts. Therefore, the Phase II Mitigation Plan includes greater than the required 8,350 linear feet of stream mitigation credits through restoration and preservation techniques as described in Table 4.

| Mitigation Type | Mitigation Amount (linear feet) | Mitigation Ratio | Mitigation Credit (linear feet) | |
|--|------------------------------------|------------------|------------------------------------|--|
| Stream Restoration | 10,236 | 1:1 | 10,236 | |
| Stream Preservation | 930 | 1:2 | 465 | |
| Total Credit Amount = 10,701 linear feet | | | | |

Table 4.Stream Mitigation Credit Summary

Restoration

The mitigation proposed for the project consists of restoration of aquatic resources through the manipulation of the physical, chemical, or biological characteristics of resources with the goal of returning natural/historic functions to a former or degraded aquatic resource. For the purpose of tracking net gains in aquatic resource area, restoration is divided into two categories: re-establishment and rehabilitation. Re-establishment results in rebuilding a former aquatic resource and results in a gain in aquatic resource area and functions. Rehabilitation has the goal of repairing natural/historic functions to a degraded aquatic resource. Rehabilitation results in a gain in aquatic resource and result in a gain in aquatic resource area.



Preservation

Preservation will minimize the threat to, or prevent the decline of, aquatic resources by future actions. This includes the protection and maintenance of aquatic resources through the implementation of appropriate legal and physical mechanisms. Deed restrictions will be utilized as protection mechanisms for preservation of the aquatic resources.

Enhancement

Stream enhancement is defined by manipulating the physical, chemical, or biological characteristics of the aquatic resources to heighten, intensify, or improve a specific aquatic resource function(s). Enhancement strategies proposed in the Phase II Mitigation Plan were coupled with restoration practices onsite and, therefore, were not counted as a standalone practice. Enhancement practices include the addition of vegetation to floodplain and riparian areas, as well as invasive species removal and other management practices.

The Final Mitigation Rule that has been adopted by USACE states that enhancement differs from restoration, rehabilitation, and re-establishment because the objective of enhancement is usually to improve one or two functions, which may result in a decrease in the performance of other functions. Increasing those particular functions does not change the amount of area occupied by the aquatic resource. In contrast, re-establishment and rehabilitation (which are forms of restoration) are intended to return most, if not all, natural and/or historic functions to a former or degraded aquatic resource. If a compensatory mitigation activity results in an increase in aquatic resource area, in addition to increases in one or more aquatic resource functions, then it is appropriately classified as restoration.

4.3 ADDITIONAL MITIGATION CREDIT RESERVE

During the development of the Phase II Mitigation Plan, it was determined that the potential exists to obtain more mitigation credits onsite than is required for the proposed impacts. The impacts for the development of CCNPP require the mitigation of 11.72 acres of wetlands and 10,701 linear feet of stream channels. However, the conceptual Phase II Mitigation Plan anticipates 12.65 acres of wetland credits and 10,701 linear feet of stream credits, creating a surplus of 0.93 acres of wetland credits and 2,351 linear feet of stream credits.

UniStar Nuclear Energy has elected to include the additional mitigation areas into this Phase II Mitigation Plan in an effort to create a reserve of mitigation credits for potential future use for impacts that may arise for future projects onsite. The reserve of mitigation credits would not be sold or transferred to any project located offsite. The purpose of this proposed reserve is to provide compensatory mitigation for future unavoidable impacts to Waters of the United States, including nontidal wetlands that result from activities authorized under Section 404 of the Clean Water Act and the Maryland Nontidal Wetlands Protection Act, provided such use has met all applicable requirements and is authorized by the appropriate authority(s). The credit reserve would be used to comply with the special condition mitigation requirements of permitted projects by providing in-kind compensation for authorized wetlands losses and may only be used for future projects after all appropriate and practical steps to avoid and minimize adverse impacts to aquatic resources, including nontidal wetlands and streams, have been taken.

The mitigation credit reserve does not provide ultimate Federal and/or State authorization for specific future projects impacting Waters of the United States, exclude such future projects from any applicable statutory or regulatory requirements, or preauthorize the use of credits from the reserve for any particular project.

5.0 EXISTING CONDITIONS / BASELINE DATA / BASIS OF DESIGN

The subject property consists of approximately 2,070 acres located in the Lusby area of Calvert County, Maryland, along the shoreline of the Chesapeake Bay, about 45 miles southeast of Washington, D.C. The site is bound to the north and south by wooded land, to the east by the Chesapeake Bay, and to the west by Maryland State Highway 2/4. The proposed Unit 3 development is primarily sited on the southern portion of the subject property.

The current site conditions consist primarily of forested areas along the northern and southern portion of the site around the existing development. The topography of the site consists of gently rolling slopes within the center of the site and stream valleys with narrow floodplains, adjoined by steep side slopes located within the forested undeveloped portions of the site. The streams and wetlands on the site were identified as nontidal, as the steep shoreline cliffs prevent tidal influence from extending beyond the sandy beaches.

The areas of potential mitigation were selected during the development of the Phase I Mitigation Plan and further studied prior to the development of the Phase II Mitigation Plan. After reviewing the Phase I Mitigation Plan, EA conducted multiple site visits of the project site in order to verify the Phase I findings and collect additional data to support the Phase II design. EA conducted field reviews from August 2009 through October 2009 in order to: (1) complete the delineation of remaining streams and wetlands within the project area, (2) perform a detailed Fluvial Geomorphology Investigation of the proposed stream mitigation sites, (3) perform an assessment of the proposed wetland mitigation areas, and (4) conduct a Baseline Conditions Assessment of the existing streams.

5.1 NONTIDAL WETLAND MITIGATION AREAS

Locations for potential wetland enhancement and wetland creation areas were identified within the approved Phase I Mitigation Plan (MACTEC 2009). These areas were determined after field reviews conducted in 2007 and 2008, in which specific locations were identified as having ecological lift potential for wetland enhancement or as being suitable for the creation of wetland communities from upland landscape. The Phase I concept included the creation and enhancement within the Lake Davies Disposal Area sediment basins (WC-2 and WE-1), the portion of Johns Creek to the south of the sediment basins (WE-2), as well as an upland grassed field at the Camp Conoy area (WC-1).

After review of the site conditions, and development layout, EA determined that the forested wetland creation area at Camp Conoy (previously WC-1 in the Phase I plan) may not be suitable for the previously proposed forested wetland. The area formerly proposed for WC-1 will be proposed for upland reforestation in order to close the canopy within the Critical Area and increase Forest Interior Dwelling Species (FIDS) habitat.

Additional changes were made to the proposed wetland mitigation areas from the Phase I Mitigation Plan. After review of existing data and field reconnaissance conducted by EA, some revisions to the locations for wetland creation have been proposed. The following is a list of the proposed wetland creation and wetland enhancement areas proposed to meet the mitigation requirements.

- WC-1 Creation of forested head water wetland system at the head of Woodland Branch, near the open field north of the old visitor center. Associated with stream restoration stationing along Woodland Branch (WB 0+00 3+75).
- WC-2 Creation of a forested/emergent wetland system with open water habitat, within the middle manmade sediment basin of the Lake Davies Disposal Area.
- WE-1 Enhancement of an existing wetland located within a smaller manmade, abandoned, sediment basin within the Lake Davies Disposal Area.
- WC-3 Creation of two small forested wetland areas adjacent to WE-1.
- WE-2 Enhancement of a portion of Johns Creek and a linear drainage way extension occurring to the south of the Lake Davies Disposal Area.
- WE-3 and WC-4 –Creation and enhancement of forested wetlands in the location of the old open water ponds located below Camp Conoy Pond. This wetland is associated with the stream restoration proposed for SE-4 (SE-4 0+00 10+44).



Wetland Creation Area #1 (WC-1)

Mitigation Site WC-1 is located at the head of Woodland Branch, near the open field north of the old visitor center. The majority of the proposed mitigation site exists within the forested area along Woodland Branch with a small portion extending into the existing open grass field. The uppermost portion of Woodland Branch is highly incised and degraded, with a large head-cut located at the origin of the stream. The visitor's center onsite directs stormwater runoff from the adjacent impervious surface towards the stream channel and has contributed to the identified degradation; however, aerial photography has indicated that the adjacent field has been cleared or in agricultural use since at least 1938. The existing vegetation and the soil profile within the WC-1 site were examined during field reconnaissance. The forested portion of this mitigation site consists predominantly of sweetgum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), tulip poplar (*Liriodendron tulipifera*), white oak (*Quercus alba*), American beech (*Fagus grandifolia*), and American holly (*Ilex opaca*). Meanwhile, the nearby open grass field appears to be a warm seasonal grass meadow area that is maintained on a low level. The topography in this area drains down to Woodland Branch and receives runoff from the existing development.

Wetland Creation Area #2 (WC-2)

Mitigation Site WC-2 is located within the middle sediment basin of the Lake Davies Disposal Area, which was created during the construction of the existing development. The basin is surrounded by earthen berms on all sides, with an outlet on the western side that drains to Goldstein Branch. During the site evaluation, EA observed a dense stand of common reed (*Phragmites australis*) which dominates the entire sediment basin. Native vegetation was observed around the outer perimeter of the basin and consisted of red maple, tulip poplar, and black willow (*Salix nigra*). The underlying soils were observed during the site evaluation to identify the presence of hydric soils. The upper layer of the underlying soils appears to consist of material and sediment from the dredge spoils which have formed a dense clay layer containing an abundance of phragmites rhizomes. Below the dense clay layer, EA identified hydric soils with the presence of saturation, oxidized root channels, and extensive mottling.

Wetland Enhancement Area #1 (WE-1)

Mitigation Site WE-1 is located within the lower basin of the Lake Davies Disposal Area, which is also surrounded by large earthen berms on all sides. This lower basin contains two drains located on the southern end, which appear to drain the basin and convey flow to the lower drainageway located to the south (WE-2). Similar to WC-2, this basin is dominated by phragmites with native vegetation along the perimeter. A small pocket of native vegetation was also observed within the center of the basin. Dominant native vegetation within this mitigation area consists of red maple, black willow, tulip poplar, and small spike false nettle (*Boehmeria cylindrica*). The underlying soils were observed during the site evaluation to identify the presence of hydric soils. The soils within this basin were similar to the soils observed at WC-2, in which the upper layer contained a dense clay layer containing an abundance of phragmites rhizomes. Below the dense clay layer, EA identified hydric soils with the presence of saturation, oxidized root channels, and extensive mottling.

Wetland Creation Area #3 (WC-3)

Mitigation Site WC-3 consists of two small topographic low areas adjacent to the lower basin of the Lake Davies Disposal Area (WE-1). These two areas are currently not identified as existing wetlands as they lack the presence of wetland hydrology. Dominant native vegetation within these creation areas consist of red maple, sweetgum, and tulip poplar, with some phragmites extending into these areas. The soils within the two creation areas were similar to the soils observed at WE-1. However, the dense clay observed in the adjacent sediment basin was only a few inches deep in these areas, and contained a more natural underlying soil matrix. Wetland hydrology was not observed in these areas.

Wetland Enhancement Area #2 (WE-2)

Mitigation Site WE-2 includes the existing linear drainageway that conveys flow from the aforementioned lower basin of the Lake Davies Disposal Area (WE-1), down to Johns Creek and the lower portion of the stream valley along Johns Creek. The enhancement area along Johns Creek includes approximately 3,000 linear feet of stream valley dominated by phragmites. The portions of the Johns Creek reach that are not infested with phragmites consist of a bottomland hardwood forest community dominated by red maple, sweetgum, and black gum (*Nyssa sylvatica*) with New York fern (*Thelypteris noveboracensis*), sensitive fern (*Onoclea sensibilis*), soft rush (*Juncus effusus*), and lizard tail (*Saururus cernuus*) dominating the understory. The linear drainageway extending down from WE-1 is dominated by phragmites. Wetland hydrology and hydric soils were identified throughout the area of WE-2.

Wetland Enhancement Area #3 and Creation Area #4 (WE-3 and WC-4)

Mitigation Sites WC-4 and WE-3 are located along the stream channel downstream of the existing Camp Conoy Pond. The proposed mitigation area is within a forested area between the developed camp area and the Chesapeake Bay and consists of a series of open water ponds located in-line to the existing stream channel proposed for restoration. A large head cut is located at the downstream portion of the stream channel. During the site investigation, it appeared that the water elevation in Camp Conoy Pond had been lowered and the hydrology within the wetlands downstream has been affected. The existing vegetation and the soil profile within this area were examined during field reconnaissance. The forested portion of this mitigation site consists predominantly of red maple, sweetgum, tulip poplar, white oak, American beech, and American holly. Meanwhile, the open water ponds predominately contain false nettle along the edges. The topography in this area drains down to the Chesapeake Bay and receives runoff from the existing camp area. This area is proposed to receive increased discharges from the proposed SWM plan for Unit 3.

5

5.2 STREAM MITIGATION REACHES

Locations for potential stream restoration and enhancement areas were previously identified within the approved Phase I Mitigation Plan (MACTEC 2009) and are described in Table 5 and identified on the figure above. These lengths have been revised during the development of the Phase II Mitigation Plan, and names have been replaced with baseline stationing. The total linear feet of valley distance is used to determine the length of the mitigation reach, rather than the stationing which follows the approximate sinuous channel centerline.

| Mitigation Area | Location | Length (linear feet) |
|--|----------------------------|----------------------|
| SR-1 WB 36+75-57+50 | Lower Woodland Branch | 2,100 |
| SR-2 WB 0+00-18+00 | Upper Woodland Branch | 1,700 |
| SR-3 | Chesapeake Bay Tributary 1 | 800 |
| SR-4 JC 11+50-25+00 | Johns Creek | 1,150 |
| SR-5 SE/R-5 0+00-17+50 | UT Johns Creek | 1,700 |
| SE-1 SE-1 0+00-14+14 | UT Lower Woodland Branch | 1,520 |
| SE-2 WB 18+00-36+75 | Woodland Branch | 900 |
| SE-3 SE-3 0+00-2+19, & UT 0+00- 2+86 | UT Upper Woodland Branch | 631 |
| SE-4 SE-4 0+00-10+44 | Chesapeake Bay Tributary 2 | 1,044 |
| SE-5 SE/R-5 0+00-17+50 | UT Johns Creek | 1,700 |

Table 5.Proposed Stream Mitigation Reaches

5.2.1 Stream Mitigation Reach Descriptions

Descriptions of stream reaches are based upon segmented breaks identified through the Phase I assessment for the project, as well as changes in constraints, stream type or valley gradient. Since the reaches are varied and the lengths of channel are large, reaches are broken into general units and characterized on a macro scale in most instances, rather than breaking down individual sections of varying degrees of entrenchment, vegetation, bed material, etc. Therefore, multiple
channel conditions are often within each reach. Their observed state is based on visual assessment as well as survey information, the process and site utilization of which is described in Section 5.2.2. These reaches have been further refined into general terms based on the average valley gradient within these reaches; similarly, reach characteristics are correlated with gradient of their respective valleys.

Upper Reach Woodland Branch – WB 0+00 – 18+00

The main stem of Woodland Branch originates at the open field north of the old visitors center. The upper reach of this stream corresponds to the proposed wetland creation site from WB 0+00 to WB 3+75, which consists of a highly incised and degraded gully, with a large head-cut located at the origin of the stream. The valley gradient is steep, varying from approximately 5-20% in portions of the reach. Channel depths exceed five feet throughout the reach. The visitor's center and adjoining parking areas direct stormwater runoff from the adjacent impervious surfaces towards an open field and stream channel and may contributed to the identified degradation. However, aerial photography has indicated that the adjacent field has been cleared or in agricultural use since at least 1938, so the majority of the long-term degradation in this reach likely began before the visitor center was constructed. The forested portion of this mitigation site consists predominantly of sweet gum, red maple, tulip poplar, white oak, American beech, and American holly. Meanwhile, the nearby open grass field appears to be a warm-season grass meadow area that is maintained periodically through mowing. The topography in this area drains down to Woodland Branch and receives runoff from the existing development. Incision and re-creation of a floodplain terrace within the channel has occurred within the stream banks from WB 0+00 - 18+00. However, the channel is not well connected to the historic floodplain and the banks exhibit dense vegetation growth, overhead cover, and root mass directly in the channel.

Middle Reach Woodland Branch – WB 18+00 – 36+75

The middle reach of the main stem of Woodland Branch (WB 18+00 – 36+75) was observed during minimal base flow. The lower portion of the reach is wide with a high width/depth ratio, and exhibits channels predominantly of clean, fine to medium sand. Numerous additional floodplain channels can be observed which are either abandoned or utilized only in high flow situations. The reach shows little evidence of significant erosion, block failures, or excessive shear stress. The valley gradient is approximately 1% and bank heights vary from 1-4' typically. Roots, logs, and leaf matter are present in the channel. The reach at its lower extent is controlled by an 18-inch metal pipe and stone fire road crossing which serves as grade control. At the lower extent of the reach there is evidence of connected wetlands and fresh sand on the floodplain, suggesting an aggradation situation; however, channel and wetland stability appears to be strong. Vegetation is dense, contributing to the floodplain and channel stability.

The upper half of this reach is characterized by a relatively stable sand channel, with high width/depth ratio, which emerges from an incised state at the top, and becomes slightly incised through the bottom portion before becoming a stable reach. Much of this reach is incised several feet and lacks habitat. There is less woody debris in the channel than is seen on other reaches; however, the channel contained base flow at the time of the assessment. The floodplain is

largely unconnected to the channel, although abandoned channels in the floodplain are present and may be active at higher flow stages. The floodplain exhibits mature upland species primarily with small pockets of adjacent wetlands.

Lower Reach Woodland Branch – WB 36+75 – 57+50

The lower reach of Woodland Branch was separated into two distinct portions. The upper half of this reach begins below an 18-inch corrugated steel pipe culvert, which appears to have caused instability downstream including channel entrenchment. The upper portions are moderately entrenched, and poorly connected to the adjacent floodplain. The floodplain is dominated by upland species, indicating the incision and resulting lowered water table have been present for an extended period of time. The floodplain has several abandoned channels that have similar dimension to the reference reaches onsite. This channel has a gravel content that appears to be limestone from fire road maintenance activities. Although this stone is seen in bar features, it is not considered the bed load of the reach, as riffles are populated with fine to medium sands, with a veneer of silt over top. Channel banks are silt and sand materials, further supporting this assumption. Banks are vertical and erosive over much of the reach with little overhead cover and poor root mass. At the time of the survey, there was no base flow in the upper assessment reach.

The lower portion of this reach is more incised than the upper portion. Tree roots are contained on only the uppermost foot of the banks, leaving vertical, erosive silt banks exposed. This reach, when surveyed, was also without base flow. Channel substrate is sand with silt, similar to upper reaches.

UT Upper Woodland Branch - SE-3 0+00 - 2+19 and UT 0+00 - 2+86

One unnamed tributary located on the upper reach of Woodland Branch was also identified as part of the stream restoration area. This tributary begins as a wetland complex and degrades into an incised channel, with low width/depth ratio and an entrenchment ratio approaching a value of 1.

UT Lower Woodland Branch – SE 0+00 – 14+14

One unnamed tributary located on the lower reach of Woodland Branch was also identified as part of the stream restoration area. This tributary was assessed in three individual sections including a short reference reach in between two incised reaches.

The upper reach of this tributary begins at a 24-inch concrete pipe culvert under an existing logging road. The culvert causes destabilization of the channel, due to excess downstream velocity and maintenance activities for approximately 110 feet downstream of the culvert. The channel has exposed silt banks and evidence of erosion throughout, indicating the beginning stages of channel incision.

The middle reach of this tributary was identified as a reference reach and is characterized by small, connected floodplain channels. This reach is the basis for restoration design used along this tributary as well as other portions of Woodland Branch. This reach requires enhancement or

restoration work in order to create transitions to impaired reach work areas as required at its upstream and downstream limits, and planting to create a continuous riparian buffer with the other restoration reaches.

The entrenched lower portion of this headwater tributary to Woodland Branch alternates between moderate to severe entrenchment with the occurrence of root wads and logs in the channel. The base flow of the channel becomes subsurface in several portions of the reach.

SR-3 – No Stationing

SR-3 was identified as having an abundance of American eels, which are targeted for preservation onsite. SR-3 is unique in that the majority of the entire reach is a hard-bottomed channel with imbricated fossilized *Chesapecten nefrens* scallops, now extinct, dating this geologic feature to approximately 12-15 millions years old. This consolidated clay layer serves as grade control of the reach, rendering it stable. Additionally, a gray consolidated clay layer is located above this layer, which is very stable and fairly resistant to erosion.

The upper portions of the reach are severely incised, with banks in excess of 10 vertical feet. The lower portions of the reach are less incised, with stable bench features and no visible grade control other than logs and root wads. Gravel beds are observed in the lower portions of the reach. The entire reach has large amounts of submerged and overhanging woody debris, undercut banks, and submerged roots. It appears that American eel heavily utilize these features for habitat.

SE-4 0+00 - 10+44

The SE-4 reach is located in the Camp Conoy area of the site and drains directly to the Chesapeake Bay. The reach is influenced by three impoundments. The watershed contains the present Camp Conoy Pond, and begins as the outfall from a pond, with another in-stream pond located immediately before a steep drop to the Chesapeake Bay. There is evidence in the reach that an additional in-stream pond once existed along the channel but was breached. The channel is fairly steep and moderately incised, with silt-sand bed and silt banks. There is little riparian vegetation but a fairly developed upland canopy over the site. At the time of the survey, the only water observed was in the ponds, and a minimal groundwater base flow in the portion of the reach which directly connects to the Chesapeake Bay. SE-4 is entrenched along its length, and as a result, flow does not regularly over top the stream bank inundating the floodplain under common flow events, nor is sediment regularly deposited onto the floodplain. Groundwater is shallow but normally below the invert of the existing channel, and base flow is usually absent from the reach in drier months. Additionally, the degree of entrenchment creates conditions of excess sediment transport, which result in deeper entrenchment through channel incision.

The lower portion of the reach cascades down a shear silt/clay bank onto a small stony beach adjacent to the Chesapeake Bay. The cliff face and incised channel banks are characterized by areas of bare earth and the presence of common reed as well as other invasive species, grasses, and small shrubs, all of which assist in partially stabilizing the slope.

SR-4 - JC 11+50 - 25+00

SR-4 is the main stem of Johns Creek. Prior to this restoration reach, the stream is considered to be a reference and becomes a highly connected wetland channel system with sparse trees and thick sedge floodplain and banks. The reach reference portion of the reach is extremely flat with little discernable movement of the water. Reference morphology is presented in Table 7 earlier in this report. Within the more channelized portion of the reference, slopes are approximately 1.1 percent with a sinuosity of approximately 1.5—the highest observed in the assessment of the site. Immediately downstream of the reference, the reach becomes deeply incised within approximately 50 channel feet, until uplifted through beaver activity backwatering in lower reaches. Evidence of abandoned floodplain channels is present within SR-4 floodplain areas, with the pattern and dimension of these abandoned channels matching closely with those of reference reaches. Below this reach, beaver have created additional wetlands and channel grade controls which have arrested channel incision, although wetlands are significantly impacted by phragmites.

SR-5/SE-5 0+00 - 17+50

The SE-5 and SR-5 reaches are a connected first order headwater tributary to Johns Creek. The reaches culminate in the Johns Creek Valley wetland complex with poorly defined channels. The reaches alternate between moderate and severe entrenchment, with many fluctuations between these states throughout. These reaches are incised with grade control provided by occasional logs or root sills. The reach at the time of assessment contained base flow throughout. The majority of the reach is low sinuosity, low slope, with the greatest amounts of slope occurring at log and root grade controls. Channel beds are fine to medium sand with silt components, most likely sourced from overland flow and stream bank erosion. The floodplain is moderately drained with upland and wetland species present.

5.2.2 FGM Investigation

EA performed a detailed Fluvial Geomorphologic Assessment during September and October 2009, in which approximately 2,900 linear feet of representative channel were surveyed utilizing differential leveling techniques to determine channel measurements and longitudinal profile in the formulation of the mitigation design. In addition, pebble counts, bar samples, cross sections, and protrusion measurements were utilized to quantify the key fluvial geomorphic (FGM) data to derive conclusions about the long-term stability of each reach. Total station survey along with field measurements were utilized to measure channel form factors such as radius of curvature, belt width, etc.

Survey of the site centered on channels which experience base flow conditions, and was taken not only in the context of the observed single-thread base flow channels, but how those channels interact with other channels within the valley of that base flow channel.

A longitudinal profile survey was conducted at locations that depicted the departure of the reach from stable to unstable conditions, comparing stable reference conditions in relation to upstream or downstream entrenchment or channel down-cutting conditions. Stable conditions were

defined as those reaches which exhibited riparian vegetation and habitat which appeared to persist, in addition to channel depth conditions which demonstrated frequent access to the floodplain. Frequent access to the floodplain was often identified through visual observation of fresh sand deposits, wash lines and fresh floodplain scour. Unstable or degrading conditions were defined as those channels which have entrenched themselves and no longer exhibit evidence of frequent floodplain access, and additionally, are actively down-cutting. Degrading channels also offer poor habitat quality and an absence of riparian vegetation, or presence of invasive species. Cross sections were also surveyed for the channel depicting unstable / degrading conditions as well as reference conditions.

In reference reaches, cross sections of representative thalweg facet features (riffle, run, pool, and glide facets) were surveyed. A minimum of one of each of these facets was surveyed at the top and bottom of the reaches to identify how cross sectional area changed through the reach. Cross sections were also surveyed to account for the dimension of the valley in which the reaches reside. In degraded reaches, only cross sections of riffles and pools were surveyed. These are the most easily identified features in these degraded reaches, and the main purpose was to show the contrasting entrenchment conditions between these reaches and reference or stable reaches. Many reaches were surveyed during the absence of base flow due to the intermittent nature of the streams and time of year of the survey. Where base flow was available, water surface elevations were recorded in the longitudinal profile. Bars (point, mid-channel, and transverse), berms, and other in-channel features were identified in longitudinal profiles, along with abandoned floodplain channels, channel sinuosity, valley cross sections, and other contextual features. Reference reaches are identified on the design drawings and are proposed only for minor enhancement work (planting and woody debris placement), or will remain undisturbed with the exception of transitions to the restoration areas.

Particular attention during survey was given to log features in the channel. Logs and woody debris in the channel are the primary observed factor for channel self-recovery. As woody debris enters the channel thalweg, backwatering occurs and organic matter (leaves, twigs, etc.) accumulates behind the debris. This in turn causes a lifting of the base elevation of the thalweg, thus allowing for thalweg re-connection with the floodplain. Survey of these debris and log features provided a baseline understanding of how these features influence channel profile, and was seen as essential to providing a template of acceptable slopes, inverts, and methodologies to construct similar features in restoration reaches. Channel stability onsite was not evaluated based on the static condition of channel facets, but rather the dynamic condition of the systems as a whole throughout a reach in maintaining floodplain functions and values.

5.2.3 FGM Investigation Findings: General Findings and Reach Classification

Speaking generally about the streams on site, these streams consist of sand bedded, sinuous thalweg channels with minor periodic grade controls usually composed of woody debris, limbs, or root mat. Larger changes" in grade are associated with beaver activity, backwater pools and aggregation, or channel degradation. Numerous "abandoned" (not exhibiting signs of frequent base flow) or dry channels exist throughout the floodplain, as well as wetland systems throughout the entire valley bottom. Abandoned terraces are rare; generally the valley bottoms

are flat and transition sharply within only a few feet to upland conditions. In this way, floodplains are sinks for sediments with sediment sources generally supplied by upland areas.

Through the evaluation process, EA surveyed multiple reaches within the site, including reference reaches were surveyed in conjunction with the transition areas to incised, degraded reaches. The Calvert Cliffs sites exhibit many instances of systems in flux, with observable changes in reaches between entrenched systems and stream systems connected to their floodplains. Reference reaches are present and discussed in detail in Section 5.2.5, Basis of Design.

Rosgen Stream Classification was performed for the base flow thalweg channels on site. This was selected because this classification system is the most widely accepted system available. This system was also used in the Phase I report. However, this classification is qualitative in that it relates channel classification properties to a bankfull or channel forming discharge. A classic example of how this bankfull stage miss-identification can change the classification of a reach is how many F-classified reaches are mis-characterized as C-classified reaches because bankfull elevation is estimated too high. In fact, evaluation of the Phase I report by EA found this to be the case on many of the assessment and reference reached indentified by the previous consultants. These reaches were in fact entrenched, based on their depth, lack of floodplain access, and conflict with the basis of understanding that sand bedded channels transport sediment during significant runoff events of practically any magnitude, but are low energy in that they do not exhibit substantive excess shear stress that precludes the presence of depositional features.

Therefore, EA developed a modified classification scheme in order to provide useful data and a basis of comparison between reaches. EA first looked at discharges, via regional curves and TR-55 modeling in order to understand the magnitude of discharges occurring on site. The 1-year, 2-year, and an approximate estimate of the 1.5-year discharge were examined and compared with regional curves for the Maryland Coastal Plain.

The base flow thalweg of each valley was surveyed and classified. EA utilized this information to identify the slope of the existing base flow thalweg, and the cross sectional area associated with the "top of floodplain" elevation.

The strict relation with traditional bankfull, however, ends there. EA utilized its best judgment to determine if traditional bankfull made any sense as a channel-forming discharge each reach. In many cases where excessive channel incision had occurred, there was no connection with the floodplain for any range of discharges which could be associated with a bankfull; therefore the channel entrenchment ratio was approximately calculated as a value of 1, and the channel was judged to be entrenched. These reaches also did not engage any other thalwegs or abandoned channels in the floodplain and were also the base flow channel. They serve as single, entrenched channels.

Other reaches on the site, however, contained only a small amount of the modeled or regional curve-estimated discharge. These reaches were highly connected to the floodplain and exhibited log grade controls, dense roots on channel banks and stable habitat. These reaches may or may not engage additional well-defined thalwegs within the valley. These reaches were classified as

according to the Rosgen classification system with the realization that discharges greater than top-of-bank stage engaged multiple channels in some cases, and therefore classification was related to a top of bank (single thread) condition, as well as a out of bank (multi-thread) condition. Additionally, EA realized that characterizing the top-of-bank condition would be useful in determining the acceptable parameters to with which to base proposed thalweg grading construction data upon.

Utilizing this methodology, the threshold for classification of majority of stream reaches requiring restoration classify as B5c channels with a low width/depth ratio (out of range of the typical B channels). Those channels classified in the B group are generally not so entrenched as prohibit self recovery, however channels classifying as F or G stream types are. B channels on site in many cases activate additional thalwegs in the valley, indicating that dedritic function had not been lost to channel incision. G and F channels exist on the site, and have lost all dendritic function and can be observed in the longitudinal profile series data, usually at the end of a profile, depicting departure from dendritic and otherwise stable channel states. A complete departure occurs in F and G thalwegs from any floodplain channels, meaning that multiplethread channels degrade to single thread entrenched channels. These channels mimic the sinuosity of stable stream types in most cases; however, head cuts, block bank failures, disturbed vegetation, and silt veneer over sandy beds dominate. Entrenchment ratios approach a value of 1, and bank heights exceed one foot and can be up to fifteen feet. Overall, the majority of channels are dominated by sandy bed materials and silt/clay banks. Impaired reaches often display a veneer of silt over a bed material of fine to medium sand, which is indicative of stream bank erosion in these reaches.

Additionally, the presence of floodplain wetlands is not evident in degraded reaches. Upland species such as tulip poplar dominate the floodplain, also indicating a system-wide lowering of the shallow groundwater table. This demonstrates that channel incision not only leads to the formation of single-thread channel systems, but a widespread lowering the shallow groundwater table.

5.2.4 FGM Investigation Findings: Degraded Reaches and Factors Influencing Channel Departure and Recovery

There are several main features which are seen as causing channel departure on the site. The main indicator of reduced floodplain function and channel degradation observed on site is channel incision. While portions of incised channel demonstrate the potential for self recovery, as incision increases in depth this potential is not observed. Through analysis of the transitions between reference and degraded reaches, it was observed that woody debris when coupled with channel depths of approximately one foot to 18 inches had strong potential for self recovery through the introduction of woody debris as grade control, and channel depths in excess of 18 inches did not demonstrate significant accretion of sediments behind grade controls and continued to down cut and widen. Incision was measures as the maximum riffle depth from the adjacent floodplain elevation. Within Woodland Branch, incised surveyed reaches varied between 15' and 3.67' of maximum riffle depth, and Johns Creek surveyed reaches varied between 3.88' and 1.17'. Reach SE-4 had a incision range of 6.21' to 1.21'.

Breaks in the riparian canopy and lack of woody debris introduction into the channel appear to be significant factors in channel departure. These breaks in canopy were assessed visually. As the fine silt/sand soils and bed material of the reaches is highly erosive, in situations where the channel is not situated on a hard compacted clay footing, logs and woody debris provide the grade control that prevents channel incision. Similarly observed, after channel incision has occurred, channel recovery or partial recovery is initiated through logs, leaf matter, and roots creating partial blockages and channel roughness. Through natural occurrence or beaver activity, the continual introduction of woody debris into the channel is seen as essential for preserving stability. Similarly, a vigorous riparian buffer is seen as essential to channel restoration. In some reaches, deer that are present in large numbers may be removing riparian vegetation and causing instability.

Previous agricultural disturbance and logging activity may also contribute to the channel degradation onsite. Although many portions of the site have been untouched since the 1960s when the facility was first developed, the effects of agricultural and logging activity can still be observed onsite, including erosion in many old logging roads and general floodplain disturbance including mounds, potholes, and other excavation activity. These influences may explain channel incision and disturbance at some portions of the site. The most prominent example is the headwater on Woodland Branch, which drain the watershed that includes the visitor center, associated parking lot, and a large cleared field that has been planted in a warm-season grass mix. The cleared field has been disturbed for the entire known photographic record, back to 1938. Due to flow concentration and runoff from impervious surfaces and cleared land, this reach quickly degrades into a 10- to 15-foot-deep head cut. This reach also lacks a strong base flow, which may be caused by excessive runoff and lack of infiltration due to the watershed land use. Other similar headwater areas onsite do not exhibit these traits, leading to the conclusion that impervious area and lack of forest cover result in stream channel destabilization. Trenching, straightening, and other factors may have also contributed to channel destabilization.

5.2.5 FGM Investigation Findings: Reference Reaches and Basis of Design

Evaluation of the FGM data has been used to determined that stable, unconfined stream forms onsite consist of low bankfull width, low bankfull depth, high width/depth ratio, low gradient (channel slope and valley slope is approximately 1 percent or less), and sand-silt bedded streams with relatively low sinuosity between 1.2 and 1.5. Valleys may single or multiple thread channels, but regardless of dedritic function, the channels utilize the floodplain frequently and for discharges well below the 1-year, 2-year, and regional curve-estimated bankfull discharges. Channels are well connected to floodplains, with floodplain elevation being such that the flooding and inundation of the floodplain occurs frequently (multiple times per year) and is driven via "typical" storm events as well as snowmelt and rain-on-snow events. The valley bottom serves as the belt width and flood-prone width in most cases. Reaches are characterized by logs and roots providing grade control and forming short, steep run facet features, resulting in scour pools immediately downstream. Without logs or root features concentrating shear stress, pools are relatively shallow, found in backwater areas, or are a result of beaver activity. Leaf matter is abundant in the channel bed in many locations. Channel thalwegs by themselves would classify as Rosgen C5 type, but when accounting for valleys with multiple thalwegs, classify as D5, with potential to evolve increased sinuosity and floodplain connectivity to a E/D5 stream

type (E systems in single-thread situations) over a prolonged time period through natural, stable states of erosion, accretion, and vegetation maturation. Not every valley has multiple thalwegs; headwater systems are C5 systems, although the potential exists for them to not be streams at all, but rather, vegetated wetland headwater seeps. A summary of Woodland Branch reference data, which was used as a basis of design, is presented in Table 6.

| Woodland Branch Reference Sediment – Riffle (values in millimeters [mm]) | | | | | |
|--|------|-------------------|----------|----------|------|
| D16 | D35 | D50 | D84 | D95 | D100 |
| 0.06 | 0.17 | 0.2 | 7.42 | 10.97 | 16.0 |
| SE-1 Reference Bar Sample – 100% sand, no particles exceeding 2.0 mm | | | | | |
| Bankfull (Average) Channel Slope | | | | | 1.1% |
| Thalweg Parameters | | Minimum | Average | Maximum | |
| Riffle Slope (Thalweg, Observed) | | 0.165% | 0.783% | 1.620% | |
| Run Slope (Thalweg, Observed) | | 1.499% | 4.327% | 8.166% | |
| Pool Slope (Thalweg, Observed) | | ~0.0% (backwater) | 0.124% | 0.337% | |
| Glide Slope (Thalweg, Observed) | | ~0.0% (backwater) | 0.134% | 0.321% | |
| Pool to Pool Spacing (Thalweg, Observed) | | 18.47 ft | 29.82 ft | 47.84 ft | |
| Pool Maximum Depth (Relative to Floodplain) | | 0.85 ft | 1.04 ft | 1.30 ft | |
| Riffle Maximum Depth (Relative to Floodplain) | | 0.56 ft | 0.63 ft | 0.87 ft | |

| Гable 6. | Woodland | Branch | Reference Data |
|----------|----------|--------|-----------------------|
| | | | |

Johns Creek watersheds are similar in their reference characteristics, although at a slightly lower slope. These reaches are a flatter valley slope with a more prevalent gravel fraction, although the streams still classify as sand bed. A summary of Johns Creek reference data, which was used as a basis of design, is presented in Table 7.

| Johns Creek Reference Sediment – Riffle (values in millimeters [mm]) | | | | | | |
|--|--|-------------------|----------|----------|---------|--|
| D16 | D35 | D50 | D84 | D95 | D100 | |
| 0.08 | 0.17 | 0.23 | 0.76 | 0.98 | 5.70 | |
| SE-1 Reference | SE-1 Reference Bar Sample – 92.78% sand, 7.22% gravel, D100 8 mm | | | | | |
| Bankfull (Average) Channel Slope | | | | | 0.54% | |
| Thalweg Parameters | | | Minimum | Average | Maximum | |
| Riffle Slope (Thalweg, Observed) | | 0.135% | 0.514% | 0.945% | | |
| Run Slope (Thalweg, Observed) | | 2.651% | 5.206% | 12.129% | | |
| Pool Slope (Thalweg, Observed) | | ~0.0% (backwater) | 0.015% | 0.055% | | |
| Glide Slope (Thalweg, Observed) | | 0.149% | 0.322% | 0.496% | | |
| Pool to Pool Spacing (Thalweg, Observed) | | 10.37 ft | 20.23 ft | 35.53 ft | | |
| Pool Maximum Depth (Relative to Floodplain) | | 1.02 ft | 1.53 ft | 2.03 ft | | |
| Riffle Maximum Depth (Relative to Floodplain) | | 0.81 ft | 0.90 ft | 1.02 ft | | |

| Table 7. | Johns | Creek | Reference Data |
|----------|-------|-------|-----------------------|
| Table /. | Jonns | Стеек | Reference Data |

5.2.6 Design Basis Discussion

The restoration methodology follows a combination of RSC and NCD principles. Some reaches follow a very close RSC methodology and others utilize the methodology only for the basic principles of design for riffle grade controls. The restoration basis of design utilizes reference data on site in the creation of riffle grade control facet slopes, the grading and shaping of thalweg features, and channel thalweg plan form parameters. The basis for design is discussed in full detail in section 6.2, however the portions relating to the reference conditions on site are discussed here.

Although several elements of natural channel design principles are not utilized for the design, reference parameters are utilized in the proposed design to develop parameters for thalweg grading, grade control slope design, and log structure size, slope, and spacing. Additionally, reference data is used in the development of the system-wide stability parameters which will gauge its long term stability through the mitigation monitoring period. Reference data is utilized to determine suitable connectivity and entrenchment ratios. Entrenchment of the system prevents the formation of any meaningful large-scale depositional zones, key to sequestering nutrients and fostering wetland habitat. Additionally, entrenchment creates a large scale lowering of the shallow groundwater table and reduction in the quantity and quality of floodplain wetlands. Arguably, the entire valley bottom of these systems should be the active channel, engaging single or multiple thalwegs and wetlands depending on woody debris present, the magnitude of the rain event and resulting runoff, or beaver activity within the floodplain.

5.2.7 Basis for Restoration Reach Selection

Given these observations of channel departure and its causes, the mitigation plan seeks to reduce channel incision within degraded reaches to acceptable levels of self recovery and channel connectivity with the floodplain, creating a large scale uplift of the shallow groundwater table and re-inundation of the floodplain with common runoff events. The mitigation plan identifies the reaches within the project site which have the best potential for restoration, and reaches in which restoration will arrest the migration of channel incision, protecting existing wetland and stream resources within the site. Additionally, the mitigation plan seeks to provide additional control of stormwater runoff from the proposed Unit 3 site development activities to reduce the potential for secondary impacts to existing wetland and stream resources on site.

Woodland Branch watershed is a proposed restoration reach because of the prevalence of incised stream resources within it. The restoration work here seeks to reverse three centuries of deforestation, agriculture, and site development which has incised its channels, drained its wetlands, and destroyed its benthic habitat. Similarly, the restoration work in Johns Creek seeks to create a continuum of connected floodplain / beaver wetlands from the intersection of MD Route 2/4 up to the discharges near the headwaters from the proposed site development, by removing phragmites, lifting incised portions of the channel, and preventing the migration of channel incision into sedge/rush floodplain wetlands already existing in the valley.

6.0 WORK PLAN

The proposed Draft Final Phase II Mitigation Plan accounts for proposed development and stormwater discharges in order to minimize their potential impacts on the existing aquatic resources. This is accomplished through the utilization of energy dissipation structures, reconnection of the channel with the existing floodplain, and appropriate channel sizing. The addition of infiltration practices and planting of riparian trees and shrubs is intended to increase base flow propagation in the watershed as well as reduce thermal impacts from stormwater discharges. EA has worked closely with the Unit 3 SWM design team in order to effectively design the Phase II Mitigation Plan to account for the changes in discharge locations and flows. The proposed wetland and stream mitigation concepts described below are proposed in accordance with our Goals and Objectives, as stated in Section 2.0.

6.1 NONTIDAL WETLAND MITIGATION

Onsite compensatory mitigation for unavoidable impacts to approximately 11.72 acres of jurisdictional, nontidal forested wetlands, emergent wetlands, and open water ponds is being proposed in order to meet a "no net loss" goal of nontidal wetland mitigation. The Phase II Mitigation for the CCNPP Unit 3 project includes the creation of new forested and emergent wetland areas onsite as well as enhancement of existing wetlands in areas previously described in Section 5.1 of this report. A portion of open water creation is also included in order to replace functions and values lost from the affected areas, as well as create a wetland mosaic within the mitigation area.

6.1.1 Wetland Mitigation Work Descriptions

WC-1: Upper Woodland Branch (WB 0+00 – 3+75 Drawings EX-1, G-1, and P-1)

Forested wetland creation is proposed for the upland areas at the origin of Woodland Branch, located north of the existing visitor's center. The existing head cut and incised stream channels at the head of Woodland Branch are unlikely to maintain stable conditions if proposed for restoration. Rather, EA has evaluated the potential to fill this head cut and replace it with headwater infiltration wetlands to enhance base flow, dissipate energy, promote stability, and allow for transition to the preservation reaches downstream.

The primary strategy for the creation of the headwater wetland is utilizing design techniques similar to regenerative stormwater conveyance (RSC) practices. RSC is an infiltration practice that uses a series of open channel, sand seepage step pools and riffle weirs, through which stormwater flows are conveyed. The purpose of these systems is to reduce the commonly seen erosion in ordinary stormwater conveyances and convert stormwater to shallow groundwater, mitigating nutrient pollution and thermal impacts to the receiving waters, while promoting base flow downstream.

Currently, Woodland Branch receives runoff from the surrounding development which would be utilized as a hydrology source for the created wetland system. Micropools and other microtopography features have been included in the system design to diversify habitat for wetland flora and fauna. This area will be planted with seedlings of native hydrophytic tree and shrub species to create a wetland hardwood forest community. Approximately 1.10 acres of forested wetlands will be created at a 1:2 mitigation credit ratio yielding approximately 0.55 acres of wetland credit. An increase in wetland function is anticipated through the creation of wildlife habitat, increase in groundwater recharge/discharge, and an increase in sediment retention and nutrient removal/uptake. This wetland is part of a larger restoration system described in further detail below as part of the Upper Woodland Branch Reach (WB 0+00 – 18+00).

WC-2: Lake Davies Upper Disposal Basin (Drawings EX-18, EX-19, EX-20, G-18, G-19, G-20, P-18, P-19, and P-20)

WC-2 consists of a wetland creation area proposed within the upper basin of the Lake Davies Disposal Area. Wetland creation will be established through the creation of three separate vegetative zones consisting of an interior open water pond planted with a minimal amount of aquatic species. The open water pond will be surrounded with an emergent fringe wetland that will be planted with herbaceous plant species. The remaining area will consist of a created bottomland hardwood forest with a system of low flow channels created from proposed outfall discharges.

Wetland fill material will be deposited within the sediment basin to create the different zones and provide microtopography features that will be included in the system design to diversify habitat for wetland flora and fauna. Soil material from the affected onsite wetland areas will be used for the WC-2 mitigation site; however, only wetlands that do not contain phragmites will be considered as a source of hydric soil material. A flow control structure will be utilized at the outfall point of the basin in order to manipulate and control hydrology within the wetland creation area. WC-2 will require the removal and control of phragmites prior to grading and planting the wetland creation area.

Through these mitigation activities, approximately 1.61 acres of emergent wetland will be created at a mitigation credit ratio of 1:1 and approximately 7.80 acres of forested wetland at a 1:2 credit ratio, yielding approximately 1.61 and 3.90 acres, respectively, of wetland credit. In addition, this design will include the creation of approximately 0.90 acres of open water habitat.

The creation of open water, emergent marsh, and bottomland hardwood forest will greatly increase wetland habitat diversity within this basin and be an improvement over the existing habitat conditions. Additionally, an increase in wetland function is anticipated through the increase in groundwater recharge/discharge, and an increase in sediment retention and nutrient removal/uptake.

WE-1: Lake Davies Lower Disposal Basin (Drawings EX-20, EX-21, G-20, G-21, P-20, and P-21)

WE-1 consists of a wetland enhancement area proposed within the lower basin of the Lake Davies Disposal Area. Enhancement of this area is proposed through the eradication of phragmites, by mowing and application of chemical herbicide, and the planting of native tree and

shrub wetland species. The enhancement proposed in this area consists of approximately 2.57 acres of existing wetlands at a mitigation credit ratio of 1:4. Therefore, approximately 0.64 acres of wetland credit is anticipated for WE-1. It is anticipated that the planting of native woody species within the enhancement area, along with phragmites eradication, will provide an increase in wetland function (habitat improvement) and values (visual quality/aesthetics).

WC-3: Lake Davies Lower Disposal Basin (Drawings EX-20, EX-21, G-20, G-21, P-20, and P-21)

Mitigation Site WC-3 consists of two small topographic low areas adjacent to the lower basin of the Lake Davies Disposal Area (WE-1). Wetland creation will be established through the grading of these two pockets to an elevation equal to WE-1 and provide microtopography features that will diversify habitat for wetland flora and fauna through planting of native hardwood wetland species. WC-3 will also require the removal and control of phragmites prior to grading and planting the wetland creation area.

Through these mitigation activities, approximately 0.44 acres of forested wetland will be created at a mitigation credit ratio of 1:2, yielding approximately 0.22 acres of wetland credit. It is anticipated that the planting of native woody species within this area, along with phragmites eradication, will provide an increase in wetland function (habitat improvement) and values (visual quality/aesthetics).

WE-2: Johns Creek Lower Reach (Drawings EX-15, EX-16, EX-17, EX-21, G-15, G-16, G-17, G-21, P-15, P-16, P-17, and P-21)

Mitigation Site WE-2 includes the existing linear drainageway that conveys flow from the aforementioned lower basin of the Lake Davies Disposal Area (WE-1), down to Johns Creek and the lower portion of the stream valley along Johns Creek. Enhancement of this area is proposed through the eradication of phragmites, by the application of chemical herbicide, and the planting of native tree and shrub wetland species where possible. The enhancement proposed in this area consists of approximately 16.01 acres of existing wetlands at a mitigation credit ratio of 1:4. Therefore, approximately 4.0 acres of wetland credit is anticipated for WE-2. It is anticipated that the planting of native woody species within the enhancement area, along with phragmites eradication, will provide an increase in wetland function (habitat improvement) and values (visual quality/aesthetics).

WC-4: SE-4 (SE-4 0+00 – 10+44 Drawings EX-25, EX-26, G-25, G-26, P-25, and P-26)

Wetland creation and enhancement is proposed along SE-4, which is located downstream of the existing Camp Conoy Pond. The proposed mitigation area exists within a forested area between the developed camp area and the Chesapeake Bay and consists of a series of open water ponds located in-line with the existing stream channel proposed for restoration. This area is proposed to receive increased discharges from the proposed SWM plan. Enhancement of the open water areas and creation of additional forested wetland areas along the existing stream channel is proposed for this reach, in addition to Priority 1 stream restoration within the existing channel.

The primary strategy for the creation and enhancement of the wetland areas is to utilize design techniques similar to RSC practices.

Modifications to the existing earthen berms and placement of water control structures will be utilized to enhance open water areas to encompass emergent wetland features. Microtopography features will be included in the system design to diversify habitat for wetland flora and fauna. This wetland area will be planted with seedlings of native hydrophytic tree and shrub species to create a wetland hardwood forest community as well as emergent plantings in and around the open water ponds. Approximately 2.86 acres of forested wetlands will be created at a 1:2 mitigation credit ratio yielding approximately 1.43 acres of wetland credit, and approximately 1.08 acres of wetlands will be enhanced at a 1:4 mitigation credit ratio yielding approximately 0.27 acres of wetland credit. An increase in wetland function is anticipated through the creation of wildlife habitat, increase in groundwater recharge/discharge, and an increase in sediment retention and nutrient removal/uptake. This wetland mitigation area is part of a larger restoration system and is described in further detail below as part of the SE-4 stream restoration reach (SE-4 0+00 – 10+44). The secondary purpose of these systems is to reduce impacts to the existing aquatic resources from the proposed SWM discharges while promoting base flow back into the existing channel downstream.

The previously described wetland mitigation work plan includes 1.61 acres of emergent and 12.56 acres of forested nontidal wetlands that will be created, as well as 19.62 acres of forested wetland enhancement in order to obtain 13.01 credits for the required wetland mitigation. Table 8 summarize the wetland mitigation work plan.

| | Multigation Avies. | Луре | Acreage | Ratio | Credit |
|----------------------|------------------------------|------------|---------|------------------|--------|
| | WC-1 | Forest | 1.1 | 1:2 | 0.55 |
| E | WC-2 | Forest | 7.8 | 1:2 | 3.90 |
| âtî: | WC-2 | Emergent | 1.61 | 1:1 | 1.61 |
| 0.12 0.12 0.12 | WC-2 | Open water | 0.9 | ** | ** |
| | WC-3 | Forest | 0.5 | 1:2 | 0.25 |
| | WC-4 | Forest | 2.86 | 1:2 ⁻ | 1.43 |
| ment | WE-1 | Forest | 2.53 | 1:4 | 0.63 |
| ince | WE-2 | Forest | 16.01 | 1:4 | 4.00 |
| Enha Balla | WE-3 | Emergent | 1.08 | · 1:4 | 0.27 |
| | Total wetland credit = 12.65 | | | | |

Table 8.Summary of Wetland Mitigation Work Plan

** Open water creation is proposed to replace lost functions of existing impacts. However, it is understood that no credit for wetland acreage is credited for open water creation areas.



6.1.2 Wetland Mitigation Planting Plan

The proposed wetland creation and enhancement areas will be planted with native hydrophytic vegetation as detailed on the attached Plant List (Appendix C) and as shown on the attached Draft Final Design Plans (P-27) provided in Appendix B. After excavation and the establishment of bottom elevations, the wetland creation areas will be planted. Overall tree and shrub spacing proposed for Forested Wetlands and Upland/Riparian Zones is approx. 8 feet on center (O.C.) (681 per acre) with trees averaging 16 feet O.C. (170 per acre) intermingled with shrubs at 9 feet O.C. (538 per acre). Emergent herbaceous species will be planted 3 feet O.C. (4,800 per acre). Canopy trees, understory trees, evergreens, and native shrubs shall be randomly intermingled (unless otherwise noted for clustering) throughout appropriate Zonation Concentration Areas noted and installed at the overall Spacing Range listed for each layer.

Plant spacing was determined to allow for anticipated mortality from wildlife depredation and defoliation by insects during early seedling establishment. The plant material will be predominantly representative of the species composition of the wetlands within the CCNPP property and native to the region. In addition, the plant material will include species that have been identified as suitable for installation on wetland mitigation projects by the Chesapeake Bay Critical Area Commission. However, final selection of plant stock will be determined to some extent by availability. The selected tree species will consist of containerized and/or bare root stock protected by tree shelters. The tree shelters will provide protection from wildlife depredation, wind, or other damaging influences.

6.1.3 Phragmites Management Plan

Phragmites is a large, coarse, perennial grass that usually forms large, dense stands reducing the diversity of plant and wildlife species. These stands exist in various locations within the CCNPP property. Phragmites identified onsite has been observed to be more than 10 feet in height. Flowering and seed set occur between July and September. Germination occurs in spring on exposed moist soils. Vegetative spread by belowground rhizomes (roots) can result in dense patches with up to 20 stems per square foot. Phragmites is capable of vigorous vegetative reproduction and often forms dense, nearly monospecific stands, as have been observed in the sediment basins of the Lake Davies Disposal Area, Johns Creek, and other forested wetland areas on the CCNPP Unit 3 site.

Phragmites is best controlled by application of herbicide treatment followed by mechanical removal (cutting and/or mowing) along with annual maintenance in order to prevent regrowth while native plants begin to re-colonize. For large, dense areas, prescribed burns can provide additional control after the initial herbicide treatment, but should only be performed by trained individuals.

Chemical Control

Glyphosate and imazapyr have been shown, through research and field tests, to be the most effective for phragmites control as an initial treatment. Both are non-selective, affecting any plant they come in contact with. With proper application, following the manufacturer's

instructions, impacts to native plants and animals can be minimized. Treatment in wetland areas requires the use of aquatic formulations. Use of a surfactant is recommended with aquatic treatment in order to increase effectiveness.

Imazapyr should be applied in early to late summer (June – September) or either glyphosate or a glyphosate/imazapyr mixture in late summer (August – September). Application methods vary depending on the size/density of the stand of phragmites and its location in the landscape. For small stands and scattered plants, methods include hand swiping, stem injections, or hand spraying. For large dense stands, the use of commercial equipment and a licensed or certified applicator will be necessary to meet safety requirements and to reduce impacts to native plants. According to the manufacturer's label, certification in pesticide application is required for use of imazapyr and recommended for use of glyphosate.

Mechanical Control

Mowing or cutting of the stand is the next step in phragmites control. It removes dead plant material after the herbicide treatment, encourages native plant growth, and allows for easier identification of phragmites regrowth, which can then be spot treated with herbicide.

Mowing or cutting should not be performed for at least 2 weeks after the herbicide treatment to allow for optimum plant exposure to the herbicide. Mowing or cutting should be done in late summer to fall (August – mid-November), but can be done in winter when the ground is frozen for wet sites. Mowing before treatment with herbicide or at the wrong time of year can actually stimulate growth of phragmites.

Hand cutting can be used for individual stems or small stands, whereas mowing with a brush cutter or flail-type mower is recommended for large, dense stands. Mowing should be done in two directions to adequately chop thatch. The cutting blades should be set to a mowing height greater than 4 inches to minimize impacts to small animals and native plants.

Equipment used to mow and cut phragmites should be cleared of all debris before removal from the site in order to reduce the chance of spreading seed to other sites. Plant material should be collected and bagged to control seed spread and also increase sunlight to the ground for the promotion of germination of native plants.

Long-Term Management

Phragmites will continue to re-establish from the existing seed bank and neighboring populations without annual maintenance. Follow-up spot treatments will most likely be required in order to allow native plants to successfully populate the wetland areas. Phragmites will be controlled and monitored for a length of time as described in Section 8.0, *Post-Construction Monitoring*, and Section 9.0, *Long-Term Management*, of this report.

6.2 STREAM MITIGATION

Stream mitigation work is designed to meet the goals and objectives of this Draft Final Phase II Mitigation Plan in accordance with the guidance provided by the regulatory and resource agencies. In-channel work will be performed in intermittent channels during periods of little or no base flow, and in all cases of flow, in accordance with an approved Erosion and Sediment Control Plan that allows for maintenance of stream flow during construction. Work will be performed by a qualified contractor, experienced in the field of stream and wetland restoration, with the specialized small and/or low ground-pressure equipment necessary to complete the job with minimal site disturbance. Work will be performed with sufficient construction oversight to ensure the specifications of the design are met and in-field changes which may occur are conducted and documented appropriately. Additionally, a strong construction supervision component of the design is proposed to minimize disturbance to existing vegetation, and relocate vegetation which can be practicably saved. The supervisory aspects of the design will include an onsite engineer working in coordination with a biologist/ecologist, providing oversight of the contractor on a day-to-day basis to ensure the design approaches are field-fit according to valley shape, profile, and existing vegetation, and that existing natural resources on site are impacted to the least extent possible.

6.2.1 Design Approach Methodology and Specifics

As discussed in Section 5.2.5, restoration design on the project site utilizes a combination of NCD and RSC principles. Section 5.2.5 discusses the reference data usage for the methodology and presents those design parameters. NCD techniques, as pioneered by Dr. David Rosgen, are utilized to ensure that the riffle grade control techniques of RSC, thalweg grading and low flow water surface facet creation are coordinated with stable reference systems onsite. Additionally, the reference criteria provide a basis for judging the success of the proposed dynamic sand-bedded systems.

Unlike gravel bed streams, the stream reaches which were used for the basis of design at the mitigation site, discussed in Section 5.2.5, do not follow the traditional "bankfull" channel design model of NCD, although some of the design principles are extremely similar. Bankfull-based NCD focuses on the net sediment flux through a reach being equal to zero, meaning that the amount of sediment delivered to the reach is equal to the amount transported away. These designs also focus on achieving a threshold critical shear stress. This is the shear stress value at which bed material of a certain size begins to move. Generally, significant amounts of bed material are not entrained below this value.

Traditional bankfull design also dictates that the vast majority of the sediment transport occurs during the bankfull discharge due to its magnitude and frequency. The bankfull discharge is often referred to as the "channel forming discharge" for this reason. Sand systems such as those found at the mitigation site apply these principles, but for a variety of discharges at which different channel thalwegs throughout the floodplain are engaged, therefore enabling the entire floodplain to become part of the active channel. Each thalweg within a reach has its own zone of shear stress concentration, with its own sediment regime. These systems, in their stable

condition, entrain bedload material at nearly every discharge, including the average daily discharge (less than 1 cubic foot per second in the observed cases). This is because the threshold for the movement of sand is negligible compared to the shear stress evolved from discharges created in runoff events. This stable system characterization is supported through observation of the identified reference reaches on Woodland Branch and Johns Creek from 2009 to the present day. The result is a dynamic state in which pools and riffles may change position through aggradation and erosion, but the morphological parameters which characterize the reach as a whole remain consistent. When evaluating the system on a larger level over time, expansive areas of long-term stable sediment transport and deposition can be observed. This is particularly evident in beaver dam complexes where backwater pools form depositional areas for all discharges experienced on the reach, and breaches of dams or the high-gradient areas associated with dam breaches represent reaches with overall erosive tendencies.

Areas of non-zero sediment flux are not accounted for in traditional natural channel design. This is in direct contrast with traditional regulatory driven performance requirements governing gravel bed stream restoration efforts, where the migration of riffles and pools is viewed as a channel alteration and a failure of the restoration approach, a view which may or may not be justified depending on the system and local geology involved.

The restoration approach proposed for this project also uses riffle grade control practices, and RSC techniques proposed in combination throughout the project. RSC has been pioneered by the Anne Arundel County, Maryland, Department of Public Works and various Maryland engineering consultants, and guidance for the design of RSCs has been issued through Anne Arundel County. Riffle grade control sizing criteria and calculations for each drainage area in which riffle grade controls are proposed are presented in Appendix E.

RSC is a groundwater recharge, storage, floodplain reconnection, and infiltration practice that uses a series of open channel, sand seepage step pools and riffle grade controls, through which stormwater flows are conveyed. The silty sand soils on this site are particularly suited to allow lateral infiltration from RSC storage and maximize floodplain contact, storage, and runoff quality and quantity attenuation. The purpose of these systems is to reduce the commonly seen erosion in ordinary stormwater conveyances and convert stormwater to shallow groundwater, mitigating nutrient pollution and thermal impacts to the receiving waters. The riffle grade controls within RSC systems are sized to resist transport of their underlying material in the 100-year storm, accreting sediment over top of them at lower discharges, and flushing at higher discharges without transporting the underlying grade control material. This approach is similar to a Priority 1 stream restoration, which replaces an incised channel with a re-dimensioned channel at a higher elevation and new alignment. Priority 1 restoration techniques are employed in this restoration plan, usually in re-establishing flow to the abandoned floodplain channel thalweg between weirs, so long as that channel meets the pattern and entrenchment criteria appropriate for the reach.

The riffle grade control techniques proposed for this project, however, vary when compared to other installations that utilize these design methodologies. Anne Arundel County, Maryland, Department of Public Works specifications call for equal-sized riffles through the project for a given design discharge. Throughout the proposed project, multiple weir dimensions vary to

accommodate different design discharges and natural variance in the floodplain and valley shape and slope. In order to limit disturbance and create a more natural system in appearance, the structures are designed to fit with the existing floodplain shape and grade where practicable. Although this presents an added level of complexity for the contractor and onsite engineer, it allows the installation to incorporate a higher degree of flow diversity into the project. Additionally, it is the intention of this mitigation plan to give the onsite engineer and the contractor the freedom to field-fit riffles and structures to meet existing conditions, so long as these changes meet the design criteria for the 100-year discharge, are documented fully in the asbuilt survey, are certified by the onsite engineer, and do not result in drastic alterations to the mitigation plan without the approval of the regulating agencies.

Additional deviation from accepted practices being proposed in this project includes allowing the contractor to substitute native topsoil and sod (i.e., sod mats) for mulch on the surfaces of riffle grade controls. As the riffle grade controls have a certain amount of excavation associated with them, this would result in a reuse of natural restoration materials which might otherwise be wasted. Additionally, if a source of riparian sedge/rush and shrub sod can be obtained, be it from site disturbance or from commercial sources, this material could be utilized to stabilize disturbed floodplain surfaces and re-establish floodplain wetland vegetation in areas of disturbance onsite.

RSC principles are employed in two distinct design situations at the mitigation site. Steep gradient reaches (those with floodplain gradients that exceed approximately 1 percent) employ weir/pool complexes with elevation drops as high as 1 foot through the riffles, and well defined deep pools immediately downstream. In low-gradient reaches, riffle grade control structures are installed for every 1 foot of fall, with between 3 and 6 inches of fall through each structure. The lowest upstream point of each riffle grade control structure is set at the approximate floodplain elevation at the structure location. No pools or pools with very minor depths are graded in between riffle structures. Reaches following each structure will be graded with a thalweg channel at negligible slope and with log grade controls making up the elevation difference between weir structures. These thalweg grading areas are designed to the same parameters, which are found in reference reach portions of the site. The log structures have small elevation drops across them, and over time they are intended to decay and be replaced by roots and other natural woody debris acting as grade control. It is anticipated that with new woody debris introduction, degradation of installed log grade controls, and establishment of vegetation, the low flow facet features will be free to move and self adjust between the stone riffle grade controls. The stone riffle grade controls therefore prevent large amounts of channel incision, and maintain any channel degradation within the tolerances for channel self-recovery.

The stone grade control structures are deployed to maintain grade as well as provide backwater areas, thus mimicking the function of natural beaver dam activity. In the coastal plain systems on site, there is no geologically present stone or cobble to act as grade control. Only small amounts of ferracrete are noted on site. The primary geologic and natural materials available for channel composition are silt, sand, clay in very deep formations, vegetation, and woody debris. Therefore, the only natural materials which would provide grade control on the site are woody debris and vegetation (root mat). One of the natural tools of grade control observed in nature in these types of systems is beaver dams, which are formed, breached, and rebuilt in stable complexes. Active beaver meadows and wetlands often display the presence of multiple dams,

active and abandoned, inundated and exposed, but all contributing to grade control and widespread areas of deposition and floodplain wetlands.

Although the spacing of the riffle grade control structures is much closer than most observed active beaver dam activity, these stone structures intend to replace the grade control element that multiple beaver dam placements create over time, and replicate the depositional zones associated with them. Although it would be ideal to create these structures with woody material, the abundance of such material and construction techniques to create stable grade controls are not available to the restoration contractor at this time. Woody debris structures, such as beaver dams, also quickly fail without maintenance from beaver. The placement of the proposed woody debris also intends to add brush piles, drift lines, and other woody features at various states of inundation to enhance the habitat for wildlife value, and add organic carbon to the soil for the purposes of building both diverse aerobic and anaerobic wetland soil chemistry and a vibrant ecological community. This woody debris is not intended to be a grade control and is distinct from the log grade control structures discussed above.

Additionally, installation of defined pools and backwater areas behind riffle grade control structures allows a unique opportunity to manage stormwater quantity on the site, and lift groundwater elevations to create low energy areas and floodplain wetland creation. In this way, a large-scale manipulation of the groundwater table is proposed to create incidental connected floodplain wetlands. While no new impervious area is proposed in the Woodland Branch watershed for the CCNPP Unit 3 project, the practices proposed mitigate for existing unmanaged stormwater draining into the watershed from land use changes due to prior clearing and agricultural use and from the current visitor's center parking lot. As these wetlands have a certain dynamic element to them, the wetlands that may be created as a result of the stream mitigation plan are not counted toward the wetland mitigation credit accounting.

To ensure that the stream-wetland system is successful and diverse into the future, with fresh sources of woody debris, the mitigation design does not propose the removal or management of beaver, nor is a timber management plan proposed. In this way, it is intended that the stream system receives a diverse mix of large and small woody debris and leaf litter without the channel destabilizing and becoming entrenched.

Upper Reach Woodland Branch (WB 0+00 – 18+00) and UT Upper Woodland Branch (SE-3 0+00 – 2+19 and UT 0+00 – 2+86 Drawings EX-1, EX-2, G-1, G-2, P-1, and P-2)

This reach has experienced incision and the re-creation of a floodplain within the channel. Given the steep gradient of the reach, RSC approaches with well-defined pools are proposed for the majority of the reach. The existing channel is not well connected to the floodplain; however, the banks exhibit dense vegetation growth, overhead cover, and root mass directly in the channel. The existing thalweg can be kept and reconnected with the floodplain or abandoned and preserved in many areas as oxbow wetlands. Therefore, emphasis has been placed on expanding base flow through the reach and preserving the connection for localized fish movement within the reach and to other reaches.

The primary strategy for the stabilization of SE-3 is the installation of watershed practices, such as headwater wetland creation and extensive headwater wetland creation practices using RSC methodologies. The goal is to raise the water table and promote base flow in Woodland Branch. The contractor will install regenerative fill media in the existing channel for the purposes of filtration and site access, minimizing disturbance to existing vegetation.

Middle Reach Woodland Branch – WB 18+00 – 36+75 (Drawings EX-3, EX-4, EX-5, G-3, G-4, G-5, P-3, P-4 and P-5)

The upper portion of this reach (WB 18+00 - 27+25) is proposed as a restoration and enhancement reach. Portions of the reach, once uplifted through the installation of log structures and riffle grade controls, will only require installation of riparian vegetation in the floodplain for stabilization. More advanced restoration will be required at the upper and lower extremes, where transition must be made to preservation reaches which will prevent the migration of incision through those preserved reaches. Steeper portions of the reach utilize RSC practices with defined pools, while low-gradient portions utilize riffle grade controls coupled with log structures and thalweg grading. Meanwhile the lower portion of this reach (WB 27+75-36+75) has a degree of entrenchment which allows for natural self-recovery; therefore, no grading is proposed. The only exception would be minimal stabilization or enhancement required in the floodplain as determined during construction oversight, since there will be contractor access available through this reach.

Lower Reach Woodland Branch (WB 36+75 – 57+50 Drawings EX-6, EX-7, G-6, G-7, P-6, and P-7)

Given the abundance of abandoned channel features in the floodplain, Priority 1 restoration of the reach includes re-use of these floodplain channels through uplift of the channel using riffle grade controls. Existing channels are proposed to be incorporated into thalweg grading areas between weirs at their existing elevations, with minimal disturbance wherever possible. Use of these channels will require that log grade controls be installed; however, grading and pattern adjustment is minimal, and this alternative is seen as a low-impact restoration alternative. Existing channels would be filled or turned into oxbow wetlands.

This method of restoration is expected to significantly raise groundwater elevations throughout the reach and provide a degree of wetland creation and enhancement within the active floodplain.

UT Lower Woodland Branch – SE-1 0+00 – 14+14 (Drawings EX-7, EX-8, EX-9, G-7, G-8, G-9, P-7, P-8, and P-9)

The upper portion of this reach (SE-1 0+00-2+25) proposes a pre-formed scour pool and alternating logs sills and log/root structures to be utilized to provide energy dissipation and channel uplift in this reach, correcting the conditions created by the existing culvert. The floodplain has trees and canopy cover and requires only minor planting improvements. No significant floodplain grading is anticipated; however, channel fill will accompany uplift activities.

The lower portion of this reach (SE-1 2+25 - 14+14) will require channel grade control and uplift. There is potential to utilize existing abandoned floodplain channels to provide this uplift as new thalweg is coupled with riffle grade controls. Presently abandoned channels have the similar dimensions and patterns as nearby stable reference reaches. This would lead to creation of oxbow wetlands and infiltration areas in existing entrenched locations, and an uplift of the water table creating floodplain wetlands. Minor floodplain grading is proposed in this reach as associated with channel relocation and the installation of stream restoration structures. Replacement and augmentation of riparian vegetation is proposed for this reach.

Stream Preservation Reach SR-3 (Not depicted on site construction drawings)

SR-3, because of its superior eel habitat, is targeted for preservation to allow existing habitat elements to continue to exist as they are. It also has unique bed features which cannot be replicated through construction activities, creating unique habitat within the site. The permittee proposes to preserve 930 linear feet of stream channel through the use of a Declaration of Restrictions.

SE-4 (SE-4 0+00-10+44 Drawings EX-25, EX-26, G-25, G-26, P-25, and P-26)

Restoration goals for this reach include work to improve the utilization of SE-4 by American eels, reconnect the channel with its floodplain, create and enhance wetlands, and promote base flow conditions by raising the shallow groundwater table within the reach.

The SE-4 restoration design applies RSC methodology with natural channel design principles of riffle/pool grade controls and headwater wetland creation to dissipate flow energy, lift the existing channel to connect with the existing floodplain, and filter stormwater runoff through a sand and woodchip channel-fill media. Additionally, recognizing the nature of this coastal plain system, restoration techniques will utilize woody grade controls to capture sandy bed load, and strive to mimic the natural series of grade controls and impoundments found in beaver dam systems, as found nearby onsite and throughout the region.

This proposed design utilizes the existing ponds as stilling basins to reduce flow velocity, with grading and planting proposed to reduce open water habitat in favor of creating emergent wetland habitat which, through natural succession, will shift towards forested wetland habitat.

Below the lowest pond, a series of stone step pools is proposed to provide American eel passage, grade stability, and connection to the Chesapeake Bay. The step pools are designed to prevent vertical channel incision and maintain channel profile stability. Additionally, energy dissipation is provided through the pools, limiting peak velocity of the flows and allowing refuge for American eels that may use this tributary.

The banks above the proposed step pools are currently vegetated with phragmites. Proposed grading on the banks above these step pools would eliminate the invasive reed, and when graded would allow natural erosion from slope sloughing and corresponding sediment deposition at the cliff base (colluvial processes). This would mimic the slope of the existing eroding silt/sand cliff faces rather than the existing conditions that occur through erosion of the channel bed from

stream flow. After restoration of SE-4, erosion of the sand cliff faces would be driven by natural processes such as wind, rain splash, freeze/thaw cycling, and natural slope instability, rather than through stream scour mechanisms.

While the Phase I plan proposed vegetative stabilization of the outfall of SE-4, the Draft Final Phase II plan does not include vegetative stabilization. The proposed design should result in enhancing the supply of sediment and, thus, potentially increasing available tiger beetle larval habitat in this area. Existing invasive and stabilizing plant species are proposed to be removed (through physical removal and limited chemical treatment) from the cliff vicinity and graded slopes. The graded and adjacent portions of the slope are designed to allow colluvial erosion and are not to be re-vegetated. In this way the design seeks to maintain a stable and natural erosion of sandy soils to mimic the specialized habitat critical to the life cycle of Puritan tiger beetles.

The step pool system would outfall to a small basin graded landward of the mean high water (MHW) line but graded to below the MHW elevation. The maximum width of the LOD in this area is less than 30 feet. This basin is designed to collect and flush sediment in accordance with existing near-shore sediment transport and wave action processes, and provide log habitat for American eel and other aquatic species.

Stream Restoration Reach SR-4 (Drawings EX-12, EX-13, G-12, G-13, P-12 and P-13, Construction Baseline Station JC 11+50 to JC 25+00)

The goals of SR-4 are to uplift the channel, replicating the floodplain wetlands observed upstream of the reach and also below the reach in the beaver dam influenced areas. A primary goal of the restoration is to arrest the incision occurring in this reach before it drains the reference reach and connected floodplain wetland areas upstream. Additionally, treatment using RSC practices at proposed stormwater outfalls to this reach and within the reach, as well as energy dissipation structures, are proposed to preserve stability within SR-4 and within the reference reach upstream.

Restoration practices throughout the reach include riffle grade control structures, log and root structures, Priority 1 restoration by introducing the channel into the abandoned floodplain, and planting of riparian and wetland species throughout the reach. As phragmites is observed adjacent to this reach, the Johns Creek restoration areas will require ongoing maintenance to control invasive species.

Stream Restoration Reach SR/SE-5 ,(Drawings EX-22, EX-23, EX-24, G-22, G-23, G-24, P-22, P-23, and P-24, Construction Baseline Station SE/SR-5 0+00 TO SE/SR-5 17+50)

Restoration practice throughout the reach includes riffle grade control / RSC systems, log and root structures, and planting of riparian and wetland species throughout the reach. RSC treatment in the upper portions of the reach are proposed to provide surface water infiltration and to support base flow within the reach.

The above stream mitigation work plan includes 10,236 linear feet of restoration and 930 linear of feet of stream preservation be performed on the existing stream channels (Table 9).

| | Mitigation Area | L.F. | | |
|---------------------------------|----------------------|-------|--|--|
| | Woodland Branch | 4354 | | |
| | SE-1 | 1376 | | |
| ution | SE-4 | 1036 | | |
| lora Uora | Johns Creek | 1525 | | |
| E. | SR/SE-5 | 1649 | | |
| | SE-3 | 296 | | |
| | Total Restoration = | 10236 | | |
| Préservation | SR-3 | 930 | | |
| | Total Preservation - | 030 | | |
| Total Stream Mitigation = 11166 | | | | |

Table 9.Detailed Stream Mitigation by Reach

The remainder of the stream restoration areas including the adjacent riparian areas will be revegetated using native seed mixtures as well as a mixture of plants identified in the attached Plant List for the wetland areas. Permanent seeding will be applied at a rate of approximately 15 pounds per acre and plants will be added as needed. Live stakes will also be placed along the disturbed stream banks, and the spacing and type of individual plantings will be determined based on the scale of disturbance, and the time of planting for successful establishment of the stage of development.

7.0 SITE PROTECTION INSTRUMENT

The Phase II Mitigation Plan includes the creation and enhancement of nontidal wetlands, as well as the restoration, enhancement, and preservation of nontidal stream channels. The compensatory mitigation is proposed to be onsite and shall be protected in perpetuity. Therefore, the mitigation areas will be protected in the future to prohibit activities including construction, grading, filling, excavating, ditching, draining, as well as the removal, cutting, mowing, burning, or harming of vegetation unless otherwise approved by USACE.

The permittee proposes to use a Declaration of Restrictive Covenants in order to ensure the protection of the streams and wetlands included in the Phase II Mitigation Plan. The protection document will allow for measures and accommodations required by the Nuclear Regulatory Commission (NRC) including but not limited to:

- The removal of dead and/or diseased trees,
- Management of wildlife, and
- Accommodation of possible future utility crossings.

Upon approval of the Final Phase II Mitigation Plan, the permittee will draft the appropriate protection document for approval by USACE prior to finalizing the document. Permits will generally require that the approved preservation mechanism be properly executed and recorded within 30 days of permit issuance unless the District exercises flexibility where it appears there is no immediate threat to the property; the terms of the preservation mechanism have been agreed to by necessary parties, and legitimate reasons for a limited extension of time exist.

In accordance with Code of Maryland Regulations (COMAR) 26.23.0403, the protection document utilized for the mitigation areas for the proposed project will also include language granting the recipient agency, or any successor agency, access to the mitigation sites for inspections during the monitoring period and for construction of the mitigation project. The protection documents will also include appropriate language to allow monitoring activities, as well as any remediation activities that may be required by the regulatory agencies. If the permittee or person conducting the proposed activity forfeits a bond and the recipient agency decides to complete construction of the mitigation project and shall also include language that the restriction is perpetual, binding on the grantor's personal representatives, heirs, successors, and assigns and runs with the land.

8.0 POST-CONSTRUCTION MONITORING AND PERFORMANCE STANDARDS

8.1 NONTIDAL WETLAND MONITORING

The permittee recognizes the concerns expressed by agencies that while the impacts proposed by the site development are permanent, the success of the mitigation areas in terms of their ecological functions and values is by no means certain in perpetuity.

Therefore, a comprehensive monitoring plan is proposed to monitor the implementation of this mitigation plan. After the onsite wetland creation and enhancement activities are complete, asbuilt design plans will be submitted to MDE and USACE within 120 days of completion and a monitoring program will be implemented for the project. The permittee is proposing a 5-year monitoring program in accordance with the *Maryland Compensatory Mitigation Guidance* (IMTF 1994), and the guidance provided in RGL No. 08-03 (USACE, October 2008). The mitigation monitoring effort will follow the MDE monitoring protocol for mitigation projects greater than ½ acre and include the collection of specific data for reporting, including the following:

- The growth and vitality of the planted hydrophytic species;
- Current site conditions at fixed photographic points;
- The species composition of recruited, desirable plant species;
- The species composition and areal cover of nuisance/non-native plant species;
- Wildlife utilization and depredation; and
- Measurements of surface inundation or groundwater.

The monitoring procedure will include a baseline monitoring event (Year 0), conducted immediately following the completion of the mitigation site construction activities and included in the submittal of the as-built design plans. Following the completion of the baseline monitoring event, a 5-year monitoring schedule will be conducted. Year 1 of the monitoring effort will be conducted during the fall of the same year of completion of the mitigation planting, unless the plantings are completed after July 1st. If the wetland mitigation areas are not completed prior to July 1st, the first year monitoring event will be performed the following year. Each monitoring event will be followed by an annual monitoring report which will be submitted before December 31st of each monitoring year.

Annual monitoring and sampling events will be performed in accordance with guidelines from the *Maryland Compensatory Mitigation Guidance* (IMTF 1994) between May and September of each year in order to appropriately measure vegetation. The success criteria for the monitoring program will include, at a minimum, the success of the planted vegetation, as measured through survivorship counts and observations of vitality and growth, and the existence of wetland hydrology for the created wetlands. Vegetation density measurement techniques outlined in the MDE guidance document will be utilized for both emergent and forested wetland mitigation areas and conducted during years 2, 3, and 5.

If success criteria have been satisfied at the completion of the 5-year monitoring program, a request for release from monitoring will be made to USACE and MDE.

If at any time the compensatory mitigation project cannot be maintained in accordance with the approved mitigation plan, it is the responsibility of the permittee to notify USACE and MDE.

8.2 STREAM CHANNEL MONITORING

Monitoring of the stream channels proposed within the mitigation plan will be performed in an effort to compare post-construction conditions and pre-construction baseline data, for the purposes of assessing the success of the mitigation project in relation to the mitigation plan goals and determine the degree of success the mitigation project has achieved in meeting the objectives of providing proper channel function and increased habitat quality. Success criteria will be gathered annually to document the success of the proposed mitigation plan to achieve its goals of no net loss of stream function. Mitigation reaches will be monitored annually for the duration of the monitoring period, which is proposed for 5 years. Monitoring reports will be submitted in accordance with the wetland mitigation monitoring requirements.

At the time of the as-built survey of the mitigation reaches, the project owner will survey and install monumented cross sections on the mitigation reaches as directed by the Contract Drawings and the Engineer. At a minimum, one cross section shall be installed per 300 linear feet of stream channel. Cross sections will capture the channel features at a maximum of 0.2-foot resolution and floodplain features at a minimum of 1-foot resolution. Cross sections should capture the thalweg and entire valley cross section. Thalweg facet features will be noted in the data collection. Monitoring reports will overlay these cross sections annually on a figure and annually calculate values of channel entrenchment, and note additional thalweg and wetland development, deposition or scour, and any associated notes or observations obtained through monitoring data collection. Cross sections will be collected for both restoration and portions of selected preservation reaches. Deposition and scour will be noted and expressed in terms to changes within the reach, with individual areas of deposition and scour not necessarily noted as failures so long as the reach maintains its new base level and floodplain connectivity.

Longitudinal profiles will be surveyed by the owner detailing the channel bed, water surface (if present), and floodplain elevation found on the restoration reaches. These survey areas will continue upstream and downstream of the reach for a minimum of 50 channel feet or until the limits of the restoration reach.

Wolman riffle pebble counts, point bar samples, and measurements of the largest and second largest particles found on the point bar surface will be collected annually from the restoration reaches. A minimum of one bar sample and one riffle pebble count will be obtained from each reach per year, and must be collected in the same approximate locations each monitoring year.

Furthermore, stone structures and treatments as identified on the as-built survey shall be monitored with photographs and evaluated for effectiveness annually. Monitors will note any noticeable failures or transport of structure material in the proximity of the structures. Installed

riparian trees and shrubs will also be monitored for survival (85 percent survival of planted species required after 5 years). Wood structures and woody debris will not be monitored.

Annual monitoring reports will be prepared in accordance with the *Mitigation and Monitoring Guidelines* (USACE 2004), the protocols presented in the *Maryland Compensatory Mitigation Guidance* (IMTF 1994), and the guidance provided in RGL No. 08-03 (USACE, October 2008). The monitoring program will be conducted pursuant to the MDE mitigation monitoring guidelines and protocols, and monitoring reports will contain a discussion of any deviations from as-built and an evaluation of the significance of these deviations and whether they are indicative of a stabilizing or destabilizing situation. At a minimum each annual monitoring report will include the following:

- Identification of parties responsible for monitoring;
- Location of monitoring stations depicted on an 11-inch by 17-inch map;
- Description of methods used for data collection;
- Photo documentation;
- Discussion of observed ecological function and floodplain connectivity with the channel;
- Pebble count data to determine size of bed material, and changes in composition; and
- Documentation of any change from the as-built drawings and proposed remedies, if required.

8.3 PERFORMANCE STANDARDS

Compensatory mitigation plans are required to provide written performance standards for assessing whether mitigation is achieving planned goals. The performance standards will become part of individual permits as special conditions and be used for performance monitoring. Project performance evaluations will be performed by USACE, as specified in the permits or special conditions, based upon monitoring reports. Adaptive management activities may be required to adjust to unforeseen or changing circumstances, and responsible parties may be required to adjust mitigation projects or rectify deficiencies. The project performance evaluations will be used to determine whether the environmental benefits or "credit(s)" for the entire project equal or exceed the environmental impact(s) or "debit(s)" of authorized activities. Performance standards for compensatory mitigation sites will be based on quantitative or qualitative characteristics that can be practicably measured. The performance standards will be indicators that demonstrate that the mitigation is developing or has developed into the desired habitat.

The success criteria for the CCNPP Unit 3 wetland creation/enhancement sites will include:

• 85 percent wetland vegetation coverage of the mitigation site (planted and naturally regenerated/recruited stems);

- The appearance of positive growth indicators for planted species, such as height and/or ground level diameter;
- A value of no more than 10 percent areal cover of phragmites and other invasive species within the treated wetland mitigation sites; and
- The establishment of appropriate inundation conditions or saturated soil conditions during the growing season and under normal yearly climatological conditions for the wetland creation mitigation sites.
 - Emergent saturated soil to the surface or presence of water on the surface for at least 21 consecutive days of the growing season.
 - Forested saturated soil to the surface and evidence of groundwater table within 10 inches of the surface long enough to develop hydric characteristics.

The performance standards established for the stream systems are more complicated than the typical gravel bed stream restoration, where channel facets are relatively fixed in position. As described in the previous design narrative, the sand bed systems proposed for Woodland Branch and Johns Creek are dynamic and changing, with the goal of connecting the channel thalweg to the floodplain. Therefore, channel function can be measured through a few key elements:

- Channel Thalweg Entrenchment: Between the installed riffle weirs, channel thalweg depth should not exceed 1 foot, except in localized pool facets. This is equal to the maximum proposed amount of valley fall between riffle grade control structures. This is also within range for natural logs and woody debris to act as grade controls, lifting the base level of channels back to a state of floodplain connection.
- Thalweg dimension, other than depth and the required cross sections, shall not be monitored, as it must be allowed dynamically to adjust to debris, vegetation, sediment flux, and debris.
- Riffle Grade Control Integrity: Stone riffle grade controls, riffle weirs, and installed stone structures should be monitored for movement and transport of the structure material. Riffle grade controls shall preserve their throat inverts and not significantly down cut or move their D50 material. Deposition within riffle grade controls is acceptable, as is scour of the surface mulch or topsoil over the cobble structure. Riffle grade controls shall not be circumvented by the formation of a new thalweg, bypassing their function.
- Log thalweg grade control structures shall not be monitored, as it is anticipated that they will decompose, be buried, cut-around, or otherwise degrade as part of natural channel evolution. It is also anticipated that they will be replaced by roots, new logs, and other natural debris acting in a similar capacity. Similarly, log debris placed in pools or the floodplain shall not be monitored as performance criteria as they are intended to decompose over time.

- Thalweg absolute position shall not be monitored, although channel thalweg survey coupled with corresponding water surface and floodplain elevations shall be monitored. Besides being impractical over such an extent of restoration, the system is intended to shift and change thalweg position, engaging thalwegs at multiple different discharges, abandoning and reforming thalweg features, and adjusting facet position between the confines of riffle grade controls. Profile survey is proposed as a means of gauging absolute entrenchment. Similarly, the presence of a channel thalweg will not be required as success criteria, since the valley bottom shall be allowed to evolve into a wetland or a braided stream system while still preserving floodplain function.
- Channel and floodplain vegetation should be monitored for the success of plantings and modified according to the adaptive management plan to adjust species composition and placement.
- Beaver Activity: Beaver activity within the mitigation reach shall not be considered a failure or detriment. Backwatering through beaver impoundments does not merit a structure failure or loss of floodplain function. Vegetation shall be monitored for effects of beaver activity, with adequate action being taken through the adaptive management plan to meet the reforestation goals of the site.
- Reach photos shall be collected at the approximately same photo position and perspective annually, during the same season.

9.0 LONG-TERM MANAGEMENT RESPONSIBILITIES

Long-term management and maintenance of the wetland mitigation sites will be assured through the placement of a Declaration of Restrictive Covenants on the mitigation area. If the mitigation area should ever be sold, all appropriate protective mechanisms (which will have been recorded) will remain in effect and will remain with the site into perpetuity. The permittee proposes that a Performance Bond be provided for the mitigation effort (COMAR 26.24.05.02).

Appropriate measures to address deficiencies identified during monitoring will be developed by USACE in consultation with MDE and the permittee. These appropriate measures will be part of the adaptive management plan discussed in Section 10, will ensure that the modification of the mitigation project provides ecological resource functions comparable to the project objectives.

10.0 ADAPTIVE MANAGEMENT PLAN

Due to the extensive breadth of mitigation proposed and complex ecological and geomorphological functions attempting to be replicated, as well as the uniqueness of the site and variability of weather, the permittee recognizes that the mitigation may require more advanced management and modification in order to be viable. Therefore, the permittee proposes an adaptive management and monitoring plan for use at this site.

In accordance with Final Mitigation Rule 332.7(c)(4), the performance standards outlined in Section 8.3 of this report can be revised through the adaptive management procedure to take into account appropriate measures implemented to address deficiencies. The performance standards may also be modified to reflect changes in management strategies and objectives so long as the modifications lead to ecological benefits comparable to or superior to the approved compensatory mitigation project. For example, the tree protection used onsite may not prevent deer grazing on the new plants, preventing the vegetation from establishing. The adaptive management to replace the plants using a new method to reduce grazing may be utilized. Adaptive management procedure can be implemented under any circumstances in which the function of the impacted wetlands and streams are not being performed by the mitigation project and secondary impacts are not being prevented.

Adaptive management would be managed and implemented by USACE. In the event that monitoring or other information identifies a deficiency in the compensatory mitigation project, at any time during or following construction of the project, USACE is to be notified within a month of the discovery of the deficiency. USACE is to be notified through a letter and formal report documenting the deficiencies to be addressed. USACE then has 4 weeks to assess the deficiencies and determine whether the ecological functions of the project are comparable to the approved performance standards.

If it is found that the deficiencies have significantly impaired the progress of the compensatory mitigation project, then the participating parties will consult to produce appropriate measures in coordination with the permittee. USACE and MDE have final approval over the measure implemented to address the mitigation project deficiencies. The proposal of appropriate measures should take place within 8 weeks following the USACE decision that the deficiencies need to be addressed and the final course of action decided on within 4 weeks following the presentation of appropriate measures. During the 4 weeks following the presentation of appropriate measures, the consulting stake-holders will participate in a review and revision process until the plans are approved by USACE and MDE. Corrective action will be taken as soon as possible following the adaptive management decision, within the constraints of growing seasons, closure periods, the special conditions of the permit, and weather conditions.

11.0 FINANCIAL ASSURANCE

If success criteria are not met within the proposed mitigation area by the 5th (or otherwise determined final) year of the monitoring program, some additional replanting, re-grading, or hydrologic modification may be necessary at the mitigation site and mitigation monitoring may be extended. USACE may require financial assurances on a permit-by-permit basis to ensure the initiation and successful completion of required compensatory mitigation. If required by USACE as a special condition of the permit, sufficient funding for this potential activity will be provided in the form of a Performance Bond or Letter of Credit to be posted before construction authorized by the permit commences. The amount of the Performance Bond or Letter of Credit will be determined and justified based on the required land management strategies and activities required to achieve ecological success. If the mitigation area(s) are not successful (i.e., do not provide adequate compensatory mitigation for authorized impacts and causing a net loss in wetland function), some form of contingency would need to be in place to assure that remedial activities can be funded to bring the site into compliance. Financial guarantees provide assurances to the permitting agencies that monies will be available to perform remedial activities should they be required. The financial assurances for the proposed mitigation plan will be established in accordance with the USACE RGL No. 05-1 (14 February 2005) Guidance on the Use of Financial Assurances and may be provided in the form of a Performance Bond or Letter of Credit.

12.0 REFERENCES

- Atlantic States Marine Fisheries Commission. 2000. Interstate Fisheries Management Plan for American Eel. April.
- Code of Maryland Regulations (COMAR). 1988. Office of the Secretary of the State, Volume XXIV, Title 26.
- Code of Maryland Regulations (COMAR). 2005. 26.23, Nontidal Wetlands Protection Act and Programs. Maryland Department of Natural Resources.
- Ford, Timothy, and Evan Mercer. 1986. Density, size distribution, and home range of American Eels, Anguilla rostra, in a Massachusetts Salt Marsh. Environmental Biology of Fishes. Springer, Netherlands.
- Interagency Mitigation Task Force (IMTF). 1994. Maryland Compensatory Mitigation Guidance. U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, National Marine Fisheries Service, Maryland Department of the Environment, Maryland Department of Natural Resources, and Maryland State Highway Administration. August.
- Kazyak, Paul F. 2001. *Maryland Biological Stream Survey Sampling Manual*. Maryland Department of Natural Resources. February.
- Mack, John J. 2001. Ohio Rapid Assessment Method for Wetlands, Manual for Using Version 5.0. Ohio EPA Technical Bulletin Wetland/2001-1-1. Ohio Environmental Protection Agency, Division of Surface Water, 401 Wetland Ecology Unit, Columbus, Ohio.
- MACTEC. 2009. Phase I Compensatory Mitigation Plan. 18 February.
- Maryland Department of the Environment (MDE). 2000. Maryland Stormwater Design Manual, Volumes I & II. Water Management Administration, Baltimore, Maryland.

Maryland Geological Survey Website. http://www.mgs.md.gov/

- Murdy, Edward, Ray Birdsong, and John Muswick. 1997. Fishes of the Chesapeake Bay. Smithsonian Institution.
- Rosgen, David L. 1994. A classification of natural rivers. *Catena* 22:169-199. Elsevier Science, B.C. Amsterdam.
- Rosgen, David L. 1996. Applied River Morphology. Wildland Hydrology Books, Pagosa Springs, Colorado.
- U.S. Army Corps of Engineers (USACE). 2004. Mitigation and Monitoring Guidelines: Baltimore District Regulatory Program.

- U.S. Army Corps of Engineers (USACE). 2005. Guidance on the Use of Financial Assurances, and Suggested Language for Special Conditions for Department of the Army Permits Requiring Performance Bonds. Regulatory Guidance Letter No. 05-1. 14 February.
- U.S. Army Corps of Engineers (USACE). 2008. Minimum Monitoring Requirements for Compensatory Mitigation Projects Involving the Restoration, Establishment, and/or Enhancement of Aquatic Resources. Regulatory Guidance Letter No. 08 03. 10 October.
- U.S. Army Corps of Engineers (USACE) and Environmental Protection Agency (EPA). 2008. Compensatory Mitigation for Losses of Aquatic Resources. Code of Federal Regulations (33 CFR Part 332). April.
- U.S. Environmental Protection Agency (EPA). 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish. Second edition. EPA 841-B-99-002. U.S. EPA Office of Water, Washington, D.C.
Appendix A

12 Critical Elements Summary

,

12 CRITICAL ELEMENTS SUMMARY

1. **Objectives**

The primary objective of the plan is to replace functions and values of nontidal wetlands and stream channels lost due to proposed development. The creation and enhancement of nontidal wetlands are being proposed to promote base flow in the existing channels, enhance water quality, improve wildlife habitat, and increase groundwater recharge functions. The stream mitigation credits will be achieved through restoration, enhancement, and preservation techniques with the goal of protecting and improving aquatic resource functions and returning natural/historic functions to former or degraded aquatic resources.

The proposed Draft Final Phase II Mitigation Plan has been designed to account for proposed development and stormwater discharges in order to minimize their potential impacts on the existing aquatic resources. This is accomplished through the utilization of energy dissipation structures, re-connection of the channel with the existing floodplain, and appropriate channel sizing. The addition of infiltration practices and planting of riparian trees and shrubs is intended to increase base flow propagation in the watershed as well as reduce the potential for thermal impacts from stormwater discharges.

The Draft Final Phase II Mitigation Plan includes preservation of stream reaches identified as having known eel populations or potential eel habitat, and enhancements in other reaches to create suitable eel habitat.

2. Site Selection Criteria

The Phase I Mitigation Plan was underway prior to issuance of the Final Compensatory Mitigation Rule issued by the U.S. Army Corps of Engineers (USACE) and U.S. Environmental Protection Agency (EPA), and it was determined that there were no approved, State of Maryland, wetland/stream mitigation banks within the service area. Therefore the mitigation strategy chosen for the Calvert Cliffs Nuclear Power Plant (CCNPP) Unit 3 project is onsite, in-kind mitigation. The areas proposed for mitigation were selected during the development of the Phase I Mitigation Plan and further studied prior to the development of the Draft Final Phase II Mitigation Plan. EA conducted field reviews from August 2009 through October 2009 in order to: (1) complete the delineation of remaining streams and wetlands within the project area, (2) perform a detailed Fluvial Geomorphology Investigation of the proposed stream mitigation areas, and (4) conduct a Baseline Conditions Assessment of the existing streams. Mitigation sites were finalized based on the results of these studies.

3. Site Protection Instruments

The permittee proposes to use a Declaration of Restrictive Covenants in order to ensure the protection of the streams and wetlands included in the Phase II Mitigation Plan. Mitigation areas will be protected in the future to prohibit activities including construction, grading, filling,

1

excavating, ditching, draining, as well as the removal, cutting, mowing, burning, or harming of vegetation unless otherwise approved by USACE.

The protection document will allow for measures and accommodations required by the Nuclear Regulatory Commission (NRC), including, but not limited to:

- The removal of dead and/or diseased trees,
- Management of wildlife, and
- Accommodation of possible future utility crossings.

4. **Baseline Information (for impact and compensation sites)**

Existing

The wetland areas to be impacted by the construction of Unit 3 include forested and emergent nontidal wetlands as well as open water ponds.

| Wetland Type | Area of Impact | Impact Type | | |
|---|----------------|------------------------|--|--|
| Forested Wetland | 7.88 acres | Permanent Grading/Fill | | |
| Emergent Wetland | 1.21 acres | Permanent Grading/Fill | | |
| Open Water | 2.63 acres | Permanent Grading/Fill | | |
| Total Area of Permanent Impacts = 11.72 acres | | | | |

Common functions of the impacted wetlands were previously determined to be groundwater recharge, groundwater discharge, flood flow alteration, sediment/shoreline stabilization, sediment/toxicant retention, nutrient removal/transformation, production export, aquatic diversity/abundance, and wildlife habitat diversity/abundance. A majority of the wetland systems proposed for impacts appear to be degraded and exhibited moderate functions and values.

In addition, 8,350 linear feet of streams are proposed for impact onsite. Most of the stream reaches proposed for impact received scores of suboptimal, as based on the Rapid Bioassessment Protocols (RBP, U.S. EPA 1999).

Proposed

Detailed descriptions of the baseline conditions of the proposed mitigation areas are provided in Section 6.0 of the Draft Final Phase II Mitigation Report and in the summary document.

5. Credit Determination Methodology

To meet a "no net loss" goal of nontidal wetland mitigation, the 11.72 acres of nontidal wetland impacts caused by the construction of the proposed project must be mitigated by creating,

restoring, or enhancing an equal area of nontidal wetlands. Based on comments received by MDE on 2 December 2009, it has been determined that this technique will yield mitigation credits as detailed below:

| Mitigation Type | Mitigation Amount/(acres) | Mitigation Ratio | Mitigation Credit |
|--|------------------------------|---------------------|---------------------|
| Forested Creation | 12.26 | 1:2 | 6.13 |
| Emergent Creation | 1.61 | 1:1 | 1.61 |
| Wetland Enhancement | 19.62 | 1:4 | 4.91 |
| Total Impact Amount = 11.72 acres | | Total Credit A | mount = 12.65 acres |

Stream mitigation proposed is based on a mitigation ratio of 1:1 for linear feet of stream impacts. Therefore, the Phase II Mitigation Plan includes greater than the required 8,350 linear feet of stream mitigation credits through restoration and preservation techniques.

| Mitigation Type | Mitigation Amount (linear feet) | Mitigation Ratio | Mitigation Credit (linear feet) |
|----------------------------------|------------------------------------|-----------------------------------|------------------------------------|
| Stream Restoration | 10,236 | 1:1 | 10,236 |
| Stream Preservation | 930 | 1:2 | 465 |
| Total Impact Amount = 8,350 l.f. | | Total Credit Amount = 10,701 l.f. | |

6. Mitigation Work Plan

Section 7.0 of the Draft Final Phase II Mitigation Report and the associated Design Plans contains a detailed description of the Work Plan proposed for the mitigation project.

7. Maintenance Plan

Maintenance within all mitigated areas will include the removal of invasive species. If the amount of areal cover of invasive species exceeds 10 percent areal cover, invasive species will be removed.

Based on the annual monitoring program to measure the progress of the mitigation sites, new maintenance procedures can be implemented through an adaptive management plan. This may include additional planting in any of the mitigation sites.

8. Ecological Performance Standards

The success criteria for the CCNPP Unit 3 wetland creation/enhancement sites will include:

- 85 percent wetland vegetation coverage of the mitigation site
- The appearance of positive growth indicators for planted species and/or recruited, desirable plant species that make-up the 85 percent coverage

- A value of no more than 10 percent areal cover of phragmites and other invasive species
- The establishment of appropriate inundation conditions or saturated soil conditions

The performance standards established for the stream systems are more complicated than typical gravel bed stream restoration efforts, where channel facets are relatively fixed in position. Refer to Section 8.3 of the Draft Final Phase II Mitigation Plan Report for a detailed description of these performance standards.

9. Monitoring Requirements

The permittee is proposing a 5-year monitoring program in accordance with the *Maryland Compensatory Mitigation Guidance* (IMTF, 1994), and the guidance provided in RGL No. 08-03 (USACE, October 2008). The wetland mitigation monitoring efforts will follow the MDE monitoring protocol for mitigation projects greater than one-half acre and will include the collection of specific data for reporting, including the following:

- The growth and vitality of the planted hydrophytic species;
- Current site conditions at fixed photographic points;
- The species composition of recruited, desirable plant species;
- The species composition and areal cover of nuisance/non-native plant species;
- Wildlife utilization and depredation; and
- Measurements of surface inundation or groundwater.

The monitoring procedure will include a baseline monitoring event and subsequent annual monitoring followed by an annual monitoring report which will be submitted before December 31^{st} of each monitoring year.

Monitoring of the stream channels proposed within the mitigation plan will be performed in an effort to compare post-construction conditions and pre-construction baseline data. Data will be used for the purposes of assessing the success of the mitigation project in relation to the mitigation plan goals, in order to determine the degree of success the mitigation project has achieved in meeting the objectives of providing proper channel function and increased habitat quality. Success criteria will be gathered annually to document the success of the proposed mitigation plan to achieve its goals of no net loss of stream function. Mitigation reaches will be monitored annually for the duration of the monitoring period which is proposed for 5 years. Monitoring reports will be submitted in accordance with the wetland mitigation monitoring requirements.

If success criteria have been satisfied at the completion of the 5-year monitoring program, a request for release from monitoring will be made to USACE and/or MDE.

10. Long-Term Management Plan

Long-term management and maintenance of the wetland mitigation sites will be assured through the placement of a Declaration of Restrictive Covenants on the mitigation area. Appropriate measures to address deficiencies identified during monitoring will be developed by USACE in consultation with MDE and the permittee. These appropriate measures will ensure that the modification of the mitigation project provides ecological resource functions comparable to the project objectives.

11. Adaptive Management Plan

The permittee, in order to meet the potential need for changing mitigation strategies or meeting with unexpected site conditions, has developed an adaptive management plan to ensure that mitigation goals are met for the site. Adaptive management would be supervised by USACE. In the event that monitoring or other information identifies a deficiency in the compensatory mitigation project, at any time during or following construction of the project, USACE is to be notified by the permittee within a month of the discovery of the deficiencies to be addressed. USACE will then assess the deficiencies and determine whether the ecological functions of the project are comparable to the approved performance standards.

If it is found that the deficiencies have significantly impaired the progress of the compensatory mitigation project, then the participating parties will consult to produce appropriate measures in coordination with the permittee. USACE and MDE have final approval over the measure implemented to address the mitigation project deficiencies. The proposal of appropriate measures should take place within 8 weeks following the USACE decision that the deficiencies need to be addressed and the final course of action decided on within 4 weeks following the presentation of appropriate measures. During the 4 weeks following the presentation of appropriate measures, the consulting stake-holders will participate in a review and revision process until the plans are approved by USACE and MDE. Corrective action will be taken as soon as possible following the adaptive management decision, within the constraints of growing seasons, closure periods, the special conditions of the permit, and weather conditions.

12. Financial Assurances

USACE may require financial assurances on a permit-by-permit basis to ensure the initiation and successful completion of required compensatory mitigation. If required by USACE as a special condition of the permit, sufficient funding for this potential activity will be provided in the form of a Performance Bond or Letter of Credit to be posted before construction authorized by the permit commences. The amount of the Performance Bond or Letter of Credit will be determined and justified based on the required land management strategies and activities required to achieve ecological success. If the mitigation area(s) are not successful (i.e., do not provide adequate compensatory mitigation for authorized impacts, thus causing a net loss in wetland or stream function), some form of contingency would need to be in place to assure that remedial activities can be funded to bring the site into compliance. The financial assurances for the proposed mitigation plan will be established in accordance with the USACE RGL No. 05-1 (14 February 2005) Guidance on the Use of Financial Assurances and may be provided in the form of a Performance Bond or Letter of Credit.

5

Appendix B

Draft Final Design Plans

Appendix C

Existing Conditions Hydrology Analysis Report



Existing Conditions Hydrology Analysis for the Calvert Cliffs Nuclear Power Plant, Unit 3 Phase II Nontidal Wetland and Stream Mitigation Plan Lusby, Maryland

Prepared for:

Unistar Nuclear Energy Baltimore, Maryland

Prepared by:

EA Engineering, Science, and Technology, Inc. 15 Loveton Circle Sparks, Maryland 21152 (410) 771-4950

October 2010

EA Project Number: 14621.03

TABLE OF CONTENTS

Page

| LIST | OF FIGURES | ii |
|------|-------------------------------|-----|
| LIST | OF TABLES | ii |
| LIST | OF ACRONYMS AND ABBREVIATIONS | iii |
| 1.0 | INTRODUCTION | 1-1 |
| 2.0 | PROCEDURES | 2-1 |
| 3.0 | CONCLUSIONS | 3-1 |
| | | |

APPENDIX A:TR-55 CHANNEL AND RESERVOIR ROUTING SCHEMATICSAPPENDIX B:TR-55 RESULTS FOR POIs 1-13APPENDIX C:SOILS TYPE



EA Engineering, Science, and Technology, Inc.

LIST OF FIGURES

Number

<u>Title</u>

1

Locations of Flow Estimates.

LIST OF TABLES

<u>Number</u>

<u>Title</u>

1 Woodland Branch, TR-55 Drainage Area Characteristics Data.

- 2 Johns Creek and Chesapeake Bay Streams, TR-55 Drainage Area Characteristics Data.
- 3 Woodland Branch, Channel Routing Data.

4 Johns Creek and Chesapeake Bay Streams, Channel Routing Data.

5 Flow Results at Woodland Branch, Johns Creek, and Chesapeake Bay Streams Points of Interest (POIs).

LIST OF ACRONYMS AND ABBREVIATIONS

| | cfs | Cubic Feet Per Second |
|---|------|---|
| | CN | Curve Number |
| | DA | Drainage Area |
| | EA | EA Engineering, Science, and Technology, Inc. |
| | ft | Foot or Feet |
| ? | NRCS | Natural Resources Conservation Service |
| | POI | Point of Interest |
| | Tc | Time of Concentration |

Calvert Cliffs Unit 3 Stream Restoration Project

`

EA Engineering, Science, and Technology, Inc.

1.0 INTRODUCTION

EA Engineering, Science, and Technology, Inc. (EA) has completed the hydrologic analysis to estimate peak flows in Woodland Branch tributaries, Johns Creek tributaries, and un-named streams contributing to the Chesapeake Bay, in support of the steam restoration project associated with Unit 3 development (see Figure 1: Locations of Flow Estimates). The hydrologic analysis focuses on the existing conditions, prior to development, and peak flows associated with the 1-, 2-, 10-, and 100-yr storm events.

2.0 PROCEDURES

EA utilized the Natural Resources Conservation Service (NRCS) TR-55 software to conduct the flow estimates. The TR-55 software includes methodologies that provide peak flow estimates resulting from drainage area characteristics in pre-development conditions and channel and reservoir routing to transfer the resulting flows from the drainage area to a location downstream, which are necessary computation procedures to conduct the analysis.

Drainage Area: Peak Flow Estimate

Drainage area characteristics required for TR-55 computation are listed as follows:

- A. Size of drainage area in Acres (sources: Unistar topography and U.S. Geological Survey 2009 topography);
- B. Land use (source: Google aerial photography [Google Imagery 2010 / Terrametrics Map Data 2010);
- C. Soils type (source: Department of Agriculture, NRCS, web soil survey, http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx);
- D. Time of concentration (sources: same as size drainage area); and
- E. Rainfall (source: TR-55, Calvert County of Maryland, type II).

EA delineated drainage areas contributing to the locations identified in the stream channel (see Figure 1), which are points of interest (POIs) using the topography (listed by Item A). Estimated peak flows from TR-55 are expected to occur at POIs. Topography was also used to determine time of concentration (Tc) path. Specific Tc data required include flow length and slope-related sheet and shallow concentrated flows. The land use characteristic for all delineated drainage areas was identified to be forested type in good condition. The hydrologic soil group (HSG) for the drainage areas were identified using NRCS soils data as referenced in Item C (see Appendix C for identified soil types). Rainfall data were provided by TR-55. The following Tables 1 and 2 show data utilized for TR-55 coding.

| Table 1. | Woodland Branch, | TR-55 Drainage Ar | ea Characteristics Data |
|----------|------------------|--------------------------|-------------------------|
| | , | | |

| Drainage Area Identification | Area | Curve Number (CN) | Time of Concentration |
|---------------------------------|----------------|----------------------|--------------------------|
| | acres) | (no units) | (hrs) |
| 1 | 28.69 48.10 | 55 55 | 0.275 0.517 |
| 3 4 | 67.59 38.86 | 55 55 | 0.356 0.467 |
| 5 5 | 71.35 | 55 55 | 0.451 |
| 0 7 | 16.05 | 55 55 | 0.475 |
| 8 | 29.65 | 55 | 0.377 |

Table 2.Johns Creek and Chesapeake Bay Stream, TR-55 Drainage AreaCharacteristics Data

| Drainage Area Identification | Area | Curve Number (CN) | Time of Concentration |
|---------------------------------|---------------|----------------------|--------------------------|
| • | - (acres) | (no units) | (hrs) |
| - 10 | 192.35 | 55 55 | 0.688 |
| 11 12 13 | 65.81 61.4 | 55 55 55 | 0.393 0.394 0.754 |

Channel and Reservoir Routing Procedures

Six POIs in Woodland Branch and Johns Creek required channel routing, which are POIs 1, 3, 4, 5, 6, 7, and 9. POIs 2, 8, 10, 11, and 13 did not require channel or reservoir routing. Only POI 12 required both channel and reservoir routing.

Channel routing methodology in TR-55 requires input data such as reach length, manning's coefficient, friction slope, and channel geometry (bottom width and side slope). Channel cross-sectional area is assumed to be trapezoidal.

For reservoir routing, TR-55 requires spillway or pipe data from principal channels. Specifically, the spillway data requires pond surface area and vertical distance above spillway crest and associated surface area. Pipe principal channel requires surface area information

similarly to spillway data with an additional input which is pipe vertical distance from the invert elevation to the spillway crest. Tables 3 and 4 illustrate channel and reservoir data.

| Channel | Reach Length | Manning's n | Friction | Bottom | Side Slope |
|---------------------|--------------|-------------|----------|--------|---------------|
| Identification | | | Slope | Width | - |
| (from upstream POI | [2] - (ft) | no units | (ft/ft) | (ft) | H (ft):V (ft) |
| to downstream POI | | | | | |
| 2-1 | 1464 | 0.125 | 0.0200 | 110 | 4:1 |
| 8-7 | 155 | 0.125 | 0.0010 | 20 | 5:1 |
| 7-6 | 426 | 0.125 | 0.0164 | 20 | 4:1 |
| 6-5 di | 1352 | 0.125 | 0.0081 | 35 | 4:1 |
| 5-4 | 1295 | 0.125 | 0.0077 | 100 | 8:1 |
| 4-3' and the second | 1759 | 0.125 | 0.0068 | 210 | 5:1 |

Table 3.Woodland Branch, Channel Routing Data

 Table 4.
 Johns Creek and Chesapeake Bay Streams, Channel Routing Data

| Channel | Reach Length | Manning's n | Friction | Bottom | Side Slope |
|--------------------|--------------|-------------|----------|---------|-----------------|
| Identification | | | Slope | Width | |
| (from upstream POI | (ft) | no units | (ft/ft) | 2, (ft) | ⊡ H (ft):V (ft) |
| to downstream POI) | | | | | |
| 10-9 | 1116 | 0.015 | 0.0094 | 135 | 2:1 |
| 12a-12b | 1000 | 0.025 | 0:001 | 20 | 2:1 |
| 12b-12c | 800 | 0.025 | 0.01 | 20 | 2:1 |
| 12c-12d | 500 | 0.025 | 0.02 | 10 | 1:1 |

Note: DA 12 has two channels (12a-12b and 12b-12c) connecting three reservoirs and one channel (12c-12d) discharging to the Chesapeake Bay.

Channel and reservoir routing schematics are provided in Appendix A.



EA Engineering, Science, and Technology, Inc.

3.0 CONCLUSIONS

EA utilized NRCS TR-55 software to estimate peak flows at established POIs for the 1-, 2-, 10-, and 100-yr storm events. The results are shown in Table 5 below.

Table 5.Flow Results at Woodland Branch, Johns Creek, and Chesapeake Bay
Streams Points of Interest (POIs)

| <u> </u> | | Fle | ows (cfs) | . , |
|----------|------|-------|-----------|--------|
| POI | 1-yr | 2-yr | 10-yr | 100-yr |
| 1 | 2.18 | 8.19 | 47.50 | 122.03 |
| 2 | 1.44 | 6.07 | 38.54 | 98.31 |
| 3 | 6.31 | 20.57 | 138.64 | 390.85 |
| 4 | 5.07 | 18.01 | 130.68 | 363.67 |
| 5 | 4.26 | 16.16 | 118.47 | 321.46 |
| 6 | 2.48 | 10.65 | 72!54 | 186.56 |
| 7 | 1.37 | 5.86 | 42.65 | 111.00 |
| 8 | 0.96 | 4.55 | 29:27 | 73.58 |
| 9 | 5.74 | 21.47 | 129.70 | 334.80 |
| 10 | 5:28 | 20.46 | -126:12 | 324.21 |
| 11 | 9.30 | 32.74 | 191.16 | 492.52 |
| 12 | 1.22 | 3.89 | 22.09 | 44:82 |
| 13 | 1.64 | 6.19 | 37.72 | 97.07 |

See Appendix B for TR-55 outputs.



Appendix A TR-55 Channel and Reservoir Routing Schematics

Woodland Branch TR-55 Channel Routing Schematic



Woodland Branch TR-55 Channel Routing Schematic

🕷 Reach Flow Path **Reach Flow Path** Project (Unistar, Calvert Cliffs) Flow Path Outlet --- RCH 2-1 {Length=1464 ft} DA-2 {Area = 48.1 ac, CN = 55, Tc = .517} Green Subareas Blüe - Reaches Red - Structures Click on 'Outlet' for more information Help Detaili



Johns Creek TR-55 Channel Routing Schematic

| E. Reach Flow Path | <u></u> |
|--|---|
| Project (Unistar: Calvert Cliffs) Flow Path | |
| Conten RCH 10-9 {Length=1116 ft} DA-10 {Area = 192.35 ac. CN = 55. Tc = 688} | |
| DA-9 {Area = 20.72 ac, CN = 55, Tc = .282} | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| Blue - Reaches | Red - Sifuctures: |
| Click on 'Outlet' for more information | <u> </u> |
| Click on 'Outlet' for more information | <u>Pibetail</u> <u>Hep</u> <u>Close</u> r |

Johns Creek TR-55 Reservoir Routing Schematic

| (Unistar: Calvert Cliffs);Flow;Path | Reach Flow Path | an a | |
|--|--------------------|--|-----|
| | | | |
| RCH North (Length=500 ft) | | | |
| North Pd (Structure=North Pd) | | | |
| Middle Pd (Structure=Middle Pd) | | | |
| RCH South {Length=1000 ft} | | | |
| South Pd (Structure=South Pond) | | | |
| DA-12a {Area = 24.36 ac, CN | N = 55, Tc = .226} | | |
| D.A-12b {Area = 25.9 ac, CN = 55, Tc = .145 |) | | |
| DA-12c {Area = 7 ac, CN = 55, Tc = .105} | | | • |
| DA-120 (Area = 0.53 ac, CN = 55, 16 = 0.100) | · | N | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | ; | |
| | | 4 | |
| | ` | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| leaches | Green - Subareas | | Red |
| | | | |
| n Uutiet Torimore intermation | | | |

Appendix **B**

1

TR-55 Results for POIs 1-13 (for 1-, 2-, 10-, and 100-yr storm events)

.

Woodland Branch

· ·

WinTR-55 Current Data Description

--- Identification Data ---

User: qn Date: 9/27/2010 Project: Unistar, Calvert Cliffs Units: English SubTitle: Flow estimate at designated points Areal Units: Acres State: Maryland County: Calvert Filename: C:\Documents and Settings\qnguyen\My Documents\Unistar\Report\Existing Conditions\TR-55

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Тс |
|------|-------------|---------|----------|-----|------|
| DA-1 | | Outlet | 28.69 | 55 | .275 |
| DA-2 | | RCH 2-1 | 48.1 | 55 | .517 |

Total area: 76.79 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr | 5-Yr | 10-Yr | 25-Yr | 50-Yr | 100-Yr | l-Yr |
|------|-------|-------|-------|-------|--------|------|
| (in) | (in) | (in) | (in) | (in) | (in) | (in) |
| 3.4 | 4 . 4 | 5.3 | 6.1 | 6.7 | 7,6 | 2.8 |

Storm Data Source:Calvert CoRainfall Distribution Type:Type IIDimensionless Unit Hydrograph:<standard>

Calvert County, MD (NRCS) Type II <standard>

9/27/2010 11

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr | 5-Yr | 10-Yr | 25-Yr | 50-Yr | 100-Yr | l-Yr |
|------|------|-------|-------|-------|--------|------|
| (in) | (in) | (in) | (in) | (in) | (in) | (in) |
| 3.4 | 4.4 | 5,3 | 6,1 | 6.7 | 7.6 | 2.8 |

Storm Data Source:Calvert CoRainfall Distribution Type:Type IIDimensionless Unit Hydrograph:<standard>

Calvert County, MD (NRCS) Type II

qn

WinTR-55, Version 1 00,09

Page 1

9/27/2010

10 11:28:11 AM

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak ANALYSIS: (cfs) | Flow by 10-Yr (cfs) | Rainfall 100-Yr (cfs) | Return Period 1-Yr (cfs) | |
|------------------------------------|----------------------------|---------------------------|-----------------------------|--------------------------------|--|
| SUBAREAS DA-1 | 5.40 | 33.86 | 83.51 | 1.04 | |
| DA-2 | 6.07 | 38.54 | 98.31 | 1.44 | |
| REACHES RCH 2-1 Down | 6.07 6.03 | 38.54 38.19 | 98.31 97.47 | 1.44 1.44 | |
| OUTLET | 8.19 | 47.50 | 122.03 | 2.18 | |

qn

WinTR-55, Version 1.00.09

9/27/2010

0 11:28:11 AM

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak ANALYSIS: (cfs) (hr) | Flow and 10-Yr (cfs) (hr) | Peak Time 100-Yr (cfs) (hr) | (hr) by Rainfall 1-Yr (cfs) (hr) | Return Period |
|------------------------------------|------------------------------------|------------------------------------|--------------------------------------|---|---------------------------------------|
| SUBAREAS DA-1 | 5.40 12.13 | 33.86 12.09 | 83,51 12,07 | 1.04 12,21 | · · · · · · · · · · · · · · · · · · · |
| DA-2 | 6.07 12.33 | 38.54 12.22 | 98.31 12,20 | 1.44 12.47 | |
| REACHES RCH 2-1 Down | 6.07 12.33 6.03 12.56 | 38,54 12.22 38,19 12.49 | 98.31 12,20 97.47 12.40 | 1.44 12.47 1.44 12.67 | |
| OUTLET | 8,19 | 47,50 | 122.03 | 2.18 | |

Page 1

9/27/2010

11:28:11 AM

qn

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description | |
|------------------------|--------------------------|----------------------------------|-----------------|--------------------|-------------------------|--|
| DA-1 DA-2 | 28.69 48.10 | 0.275 0.517 | 55 55 55 | Outlet RCH 2-1 | | |

Total Area: 76.79 (ac)

qn

WinTR-55, Version 1.00.09

Page 1

9/27/2010 11:28:11 AM

Reach Summary Table

| Reach Identifier | Receiving Reach Identifier | Reach Length (ft) | Routing Method |
|---------------------|----------------------------------|-------------------------|-------------------|
| RCH 2-1 | Outlet | 1464 | CHANNEL |

WinTR-55, Version 1.00.09

Page 1

9/27/2010 11

qn

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|-------------------------|------------------------|------------------|-----------------|------------------------|-----------------------------|----------------------|------------------------|
| DA-1 | | | | | | | |
| SHEET | 100 | 0.0878 | 0.150 | | | | 0.088 |
| SHALLOW | 153 | 0.1691 | 0.050 | | | | 0.006 |
| SHALLOW | 616 | 0.0608 | 0.050 | | | | 0.043 |
| CHANNEL | 1242 | | | | | 2.500 | 0.138 |
| | | | | Ti | me of Conce | entration | <u>,</u> 275 |
| DA-2 | | | | | | | |
| SHEET | 100 | 0.0165 | 0.150 | | | | 0.171 |
| SHALLOW | 592 | 0.0219 | 0,050 | | | | 0,069 |
| CHANNEL | 1997 | | | | | 2.000 | 0,277 |
| | | | | Ti | me of Conce | ntration | 517 |

qn

WinTR-55, Version 1.00.09

Page 1 9/27/2010

11:28:11 AM

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifie | r Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|-----------------------|------------------------------------|-------|-----------------------------|--------------------------|-----------------|
| DA-1 | Woods | (good |) B | 28.687 | 55 |
| | Total Area / Weighted Curve Number | | | 28.69 | 55 == |
| DA-2 | Woods | (good |) В | 48.098 | 55 |
| | Total Area / Weighted Curve Number | | | 48.1 | 55 |

qn

WinTR-55, Version 1 00.09

Page l

9

9/27/2010 11:28:11 AM

1.001

ζ

Reach Channel Rating Details

| Reach Identifier | Reach Length (ft) | Reach Manning's n | Friction Slope (ft/ft) | Bottom Width (ft) | Side Slope |
|---------------------|---|--|--|---|------------------------------|
| RCH 2-1 | 1464 | 0.125 | 0,02 | 110 | 4 :1 |
| Reach Identifier | Stage (ft) | Flow (cfs) | End Area (sq ft) | Top Width (ft) | Friction Slope (ft/ft) |
| RCH 2-1 | 0.0 0.5 1.0 2.0 5.0 10.0 20.0 | 0.000 58.572 187.043 601.313 2888.808 9913.166 36794.913 | 0 56 114 236 650 1500 3800 | 110 114 118 126 150 190 270 | 0.02 |

qn

WinTR-55 Current Data Description

--- Identification Data ---

User: qn Date: 9/27/2010 Project: Unistar, Calvert Cliffs Units: English SubTitle: Flow estimate at designated points Areal Units: Acres State: Maryland County: Calvert Filename: C:\Documents and Settings\qnguyen\My Documents\Unistar\Report\Existing Conditions\TR-55

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | TC |
|------|-------------|---------|----------|-----|-------|
| DA-5 | | RCH 5-4 | 71.35 | 55 | ,451 |
| DA-6 | , | RCH 6-5 | 36.68 | 55 | 0.475 |
| DA-7 | | RCH 7-6 | 16.05 | 55 | ,228 |
| DA-8 | | RCH 8-7 | 29.65 | 55 | .377 |
| DA-4 | | RCH 4-3 | 36.86 | 55 | 0.467 |
| DA-3 | | Outlet | 67.59 | 55 | 0.356 |

Total area: 258,18 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr | 5-Yr | 10-Yr | 25-Yr | 50-Yr | 100-Yr | l-Yr |
|------|------|-------|-------|-------|--------|------|
| (in) | (in) | (in) | (in) | (in) | (in) | (in) |
| 3.4 | 4.4 | 5.3 | 6.1 | 6.7 | 7.6 | 2.8 |

Storm Data Source:Calvert CoRainfall Distribution Type:Type IIDimensionless Unit Hydrograph:<standard>

Calvert County, MD (NRCS) Type II <standard>

WinTR-55, Version 1.00.09

9/27/2010 11:21:54 AM

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr | 5-Yr | 10-Yr | 25-Yr | 50-Yr | 100-Yr | 1-Yr |
|------------------|------|-------|-------|-------|--------|-------|
| (in) | (in) | (in) | (in) | (in) | (in) | (in) |
| 3 _r 4 | 4,4 | 5 " 3 | 6.1 | , 6.7 | 7.6 | 2 , 8 |

Storm Data Source: Rainfall Distribution Type: Type II Dimensionless Unit Hydrograph: <standard>

qn

Calvert County, MD (NRCS)

WinTR-55, Version 1.00.09

Page 1

9/27/2010

11:21:54 AM
Watershed Peak Table

| Sub-Area or Reach Identifier | Peak ANALYSIS: (cfs) | : Flow by 10-Yr (cfs) | Rainfall 100-Yr (cfs) | Return Period 1-Yr (cfs) | |
|------------------------------------|----------------------------|-----------------------------|-----------------------------|--------------------------------|------|
| SUBAREAS DA-5 | 9.79 | 62.76 | 158.84 | 2.20 | |
| DA-6 | 4.87. | 31.15 | 78.96 | 1.12 | |
| DA-7 | 3.39 | 20,62 | 50.25 | 0,63 | |
| DA-8 | 4.55 | 29.27 | 73.58 | 0.96 | |
| DA-4 | 4.95 | 31,61 | 80.55 | 1.13 | |
| DA-3 | 10,.77 | 68.97 | 173.24 | 2.23 | |
| REACHES RCH 8-7 Down | 4.55 3.59 | 29.27 25.47 | 73.58 67.18 | 0.96 0.90 | ! |
| RCH 7-6 Down | 5.86 5.84 | 42,65 42,45 | 111.00 110.32 | 1,37. 1,37 | |
| RCH 6-5 Down | 10.65 10.31 | 72.54 69.54 | 186.56 179.40 | 2.48 2.47 | |
| RCH 5-4 Down | 16.16 15.93 | 118.47 114.91 | 321.46 311.37 | 4.26 4.26 | |
| RCH 4-3 Down | 18.01 17.83 | 130.68 126.06 | 363.67 350.99 | 5.07 5.07 | |
| OUTLET | 20.57 | 138.64 | 390.85 | 6,31 | |

WinTR-55, Version 1,00,09

Page 1

9/27/2010

11:21:54 AM

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak ANALYSIS: (cfs) (hr) | Flow and 10-Yr (cfs) (hr) | Peak Time 100-Yr (cfs) (hr) | (hr) by Ra: 1-Yr (cfs) (hr) | infall Return | Period |
|------------------------------------|------------------------------------|------------------------------------|--------------------------------------|--------------------------------------|---------------|--------|
| SUBAREAS DA-5 | 9.79 12,26 | 62 .76 12 .20 | 158.84 12.18 | 2.20 12.40 | | |
| DA-6 | 4.87 12.29 | 31.15 12.20 | 78.96 12,17 | 1.12 12.43 | | |
| DA-7 | 3,39 12.10 | 20,62 12.06 | 50.25 12.04 | 0.63 12.15 | | |
| DA-8 . | 、4,55 12,22 | 29,27 12,15 | 73.58 12 [°] "13 | 0.96 12.32 | | |
| DA-4 | 4.95 12.28 | 31.61 12,19 | 80.55 12.18 | 1.13 12.42 | | |
| DA-3 | 10,77 12.20 | 68.97 12.14 | 173.24 12.12 | 2.23 12.30 | | |
| REACHES RCH 8-7 Down | 4.55 12.22 3.59 12.29 | 29.27 12.15 25.47 12,18 | 73.58 12.13 67.18 12.13 | 0.96 12,32 0.90 12.56 | | |
| RCH 7-6 Down | 5.86 12.15 5.84 12.24 | 42.65 12.11 42.45 12.15 | 111.00 12.08 110.32 12.13 | 1.37 12,49 1.37 12.57 | | |
| RCH 6-5 Down | 10 65 12.27 10.31 12.66 | 72.54 12.18 69.54 12.37 | 186.56 12 14 179.40 12.29 | 2.48 12,55 2.47 12,91 | | |
| RCH 5-4 Down | 16.16 12.61 15.93 12.97 | 118.47 12,31 114.91 12.54 | 321.46 12.24 311.37 12.40 | 4.26 12.82 4.26 13.18 | | |
| RCH 4-3 Down | 18,01 12.97 17,83 13,46 | 130,68 12.51 126,06 12,87 | 363.67 12.37 350.99 12.62 | 5.07 13.16 5.07 13.65 | , | |
| OUTLET | 20.57 | 138.64 | 390.85 | 6.31 | | |

WinTR-55, Version 1.00.09

9/27/2010 11:

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description | |
|------------------------|--------------------------|----------------------------------|-----------------|--------------------|-------------------------|--|
| DA-5 | 71.35 | 0,451 | 55 | RCH 5-4 | | |
| DA-6 | 36.68 | 0.475 | 55 | RCH 6-5 | | |
| DA-7 | 16.05 | 0,228 | 55 | RCH 7-6 | | |
| DA-8 | 29.65 | 0.377 | 55 | RCH 8-7 | | |
| DA-4 | 36.86 | 0,467 | 55 | RCH 4-3 | | |
| DA-3 | 67.59 | 0_356 | 55 | Outlet | | |
| | | | | | | |

Total Area: 258.18 (ac)

qn

WinTR-55, Version 1.00.09

Page 1

9/27/2010

Reach Summary Table

| Reach Identifier | Receiving Reach Identifier | Reach 'Length (ft) | Routing Method |
|---------------------|----------------------------------|--------------------------|-------------------|
| RCH 8-7 | RCH 7-6 | 155 | CHANNEL |
| RCH 7-6 | RCH 6-5 | 426 | CHANNEL |
| RCH 6-5 | RCH 5-4 | 1352 | CHANNEL |
| RCH 5-4 | RCH 4-3 | 1295 | CHANNEL |
| RCH 4-3 | Outlet | 1759 | CHANNEL |

qn

WinTR-55, Version 1.00.09

١

Page 1

9/27/2010

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wet Peri (f | ted meter t) | Velocity (ft/sec) | Travel Time (hr) |
|---|---------------------------------|----------------------------|-------------------------|------------------------|-------------------|--------------------|----------------------|---|
| DA-5 SHEET SHALLOW CHANNEL | 100 612 1631 | 0.0174 0.0238 | 0.150 0,050 | | | | 2,100 | 0.167 0.068 0.216 |
| | | | | Tin | ne of | Concen | tration | .451 |
| DA-6 SHEET SHALLOW CHANNEL | 100 413 1748 | 0.0100 0.0422 | 0.150 0.050 | | | | 2,100 | 0.209 0,035 0,231 |
| • | | | | Tin | ne of | Concen | tration | 0.475 |
| DA-7 SHEET SHALLOW CHANNEL | 100 603 816 | 0.1645 0.0492 | 0.150 0.050 | | | | 2.000 | 0.068 0.047 0.113 |
| | | | | Tin | ne of | Concen | tration | .228 |
| DA-8 SHEET SHALLOW SHALLOW CHANNEL CHANNEL | 100 90 568 1211 431 | 0.0813 0.1297 0.0314 | 0.150 0.050 0.050 | Tim | e of | Concent | 2.000 2.000 | 0.090 0.004 0.055 0.168 0.060 |
| | | | | | | concern | : | , 3, , |
| DA-4 User-provide | ed | | | | | | | 0.467 |
| | | | | Tim | e of | Concent | tration - | 0.467 |
| DA-3 User-provide | d | | | | | | | 0.356 |
| | | | · | Tim | e of | Concent | ration = | 0.356 |

WinTR-55, Version 1.00.09

Page 1

9/27/2010

11:21:54 AM

qn

1

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifie | r | Land Use | | | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|-----------------------|-------------|--------------|-------|--------|--------|-----------------------------|--------------------------|-----------------|
| DA-5 | Woods | | | | (good) | В | 71.349 | 55 |
| | Total Area | / Weighted | Curve | Number | | | 71,35 | 55 == |
| DA-6 | Woods | | | | (good) | В | 36.684 | 55 |
| | Total Area | / Weighted | Curve | Number | | | 36.68 | 55 |
| DA-7 | Woods | | | | (good) | В | 16.052 | 55 |
| | Total Area | / Weighted | Curve | Number | | · | 16.05 | 55 == |
| DA-8 | Woods | | | | (good) | В | 29.655 | 55 |
| | Total Area | / Weighted | Curve | Number | | | 29.,65 ==== | 55 == |
| DA-4 | Woods | | | | (good) | В | 36.86 | 55 |
| | Total Area | / Weighted | Curve | Number | | | 36.86 ===== | 55 == |
| DA-3 | CN directly | y entered by | user | | | - | 67,59 | 55 |
| | Total Area | / Weighted | Curve | Number | | | 67,59 ===== | 55 == |

WinTR-55, Version 1,00.09

Page 1

9/27/2010 11

11:21:54 AM

Reach Channel Rating Details

| Reach Identifier | Reach Length (ft) | Reach Manning's n | Friction Slope (ft/ft) | Botto Widt (ft | om Side th Slope t) |
|---|---|---|--|---|--|
| RCH 8-7 RCH 7-6 RCH 6-5 RCH 5-4 RCH 4-3 | 155 426 1352 1295 1759 | 0.125 0.125 0.125 0.125 0.125 0.125 0.125 | 0.001 0.0164 0.0081 0.0077 0.0068 | 20 20 35 10 21 | 0 5:1 0 4:1 0 4:1 00 8:1 0 5:1 |
| Reach Identifier | Stage (ft) | Flow (cfs) | End Area (sq ft) | Top Width (ft) | Friction Slope (ft/ft) |
| RCH 8-7 | 0.0 0.5 1.0 2.0 5.0 10.0 20.0 | 0.000 2.477 8.286 29.363 182.508 843.488 4385.437 | 0 11.3 25 60 225 700 2400 | 20 25 30 40 70 120 220 | 0.001 |
| RCH 7-6 | 0.0 0.5 1.0 2.0 5.0 10.0 20.0 | 0.000 9.921 32.778 113.425 670.295 2967.613 14890.805 | 0 11 24 56 200 600 2000 | 20 24 28 36 60 100 180 | 0.0164 |
| RCH 6-5 | 0.0 0.5 1.0 2.0 5.0 10.0 20.0 | 0.000 12.014 38.949 129.525 692.072 2761.774 12540.670 | 0 18.5 39 86 275 750 2300 | 35 39 43 51 75 115 195 | 0.0081 |
| RCH 5-4 | 0 0 0.5 1.0 2 0 5 0 10 0 20.0 | 0.000 33.310 107.344 352.024 1801.646 6798.966 28916.689 | 0 52 108 232 700 1800 5200 | 100 108 116 132 180 260 420 | 0.0077 |
| RCH 4-3 | 0.0 0.5 1.0 2.0 5.0 10.0 20.0 | 0.000 65.086 207.436 663.948 3140.583 10476.928 36929.770 | 0 106.3 215 440 1175 2600 6200 | 210 215 220 230 260 310 410 | 0.0068 |

WinTR-55, Version 1,00.09

Page

1

9/27/2010

11:21:54 AM

Johns Creek

WinTR-55 Current Data Description

--- Identification Data ---

User: qn Date: 9/27/2010 Project: Unistar, Calvert Cliffs Units: English SubTitle: Areal Units: Acres State: Maryland County: Calvert Filename: C:\Documents and Settings\qnguyen\My Documents\Unistar\Report\Existing Conditions\TR-55

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|-------|-------------|----------|----------|-----|------|
| DA-9 | | Outlet | 20.72 | 55 | ,282 |
| DA-10 | | RCH 10-9 | 192.35 | 55 | ,688 |

Total area: 213.07 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr | 5-Yr | 10-Yr | 25-Yr | 50-Yr | . 100-Yr | 1-Yr |
|------|------|-------|-------|-------|----------|------|
| (in) | (in) | (in) | (in) | (in) | (in) | (in) |
| 3.4 | 4.4 | 5.3 | 6.1 | 6.7 | 7.6 | 2.8 |

Storm Data Source:Calvert County, MD (NRCS)Rainfall Distribution Type:Type IIDimensionless Unit Hydrograph:<standard>

<

Page 1 🔨

9/27/2010

0 11:30:44 AM

Calvert County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr | 5-Yr | 10-Yr | 25-Yr | 50-Yr | 100-Yr | l-Yr |
|------|-------|-------|-------|-------|--------|------|
| (in) | (in) | (in) | (in) | (in) | (in) | (in) |
| 3.4 | 4 , 4 | 5,3 | 6,1 | 6.7 | 7,6 | 2.8 |

Storm Data Source:Calvert CorRainfall Distribution Type:Type IIDimensionless Unit Hydrograph:<standard>

Calvert County, MD (NRCS) Type II

qn

WinTR-55, Version 1.00.09

9/27/2010

Calvert County, Maryland

Watershed Peak Table

| Sub-Area or Reach Identifier | ANALYSIS: (cfs) | Peak Flow by 10-Yr (cfs) | Rainfall 100-Yr (cfs) | Return Period 1-Yr (cfs) | | |
|------------------------------------|--------------------|--------------------------------|-----------------------------|--------------------------------|--|--|
| SUBAREAS DA-9 | 3.84 | 24.15 | 59.68 | 0.74 | | |
| DA-10 | 20.46 | 126.12 | 324.21 | 5.28 | | |
| REACHES RCH 10-9 Down | 20.46 20.35 | 126.12 124.44 | 324.21 319.83 | 5.28 5.27 | | |
| OUTLET | 21.47 | 129.70 | 334.80 | 5,74 | | |

qn

WinTR-55, Version 1.00.09

Page 1

9/27/2010

11:30:44 AM

Calvert County, Maryland

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak ANALYSIS: (cfs) (hr) | Flow and 10-Yr (cfs) (hr) | Peak Time 100-Yr (cfs) (hr) | (hr) by Rainfall 1-Yr (cfs) (hr) | Return Period |
|------------------------------------|------------------------------------|------------------------------------|--------------------------------------|---|---------------|
| SUBAREAS DA-9 | 3.84 12.14 | 24.15 12.08 | 59.68 12.07 | 0.74 12.22 | |
| DA-10 | 20.46 12.49 | 126.12 12.34 | 324.21 12.31 | 5.28 12.66 | |
| REACHES | | | | | |
| RCH 10-9 Down | 20.46 12.49 20.35 | 126.12 12.34 124.44 | 324.21 12.31 319,83 | 5.28 12.66 5.27 | |
| OUTLET | 21.47 | 129.70 | 334.80 | 5.74 | |

qn

WinTR-55, Version 1.00.09

Page 1

9/27/2010 11:30:44 AM

Calvert County, Maryland

Sub-Area Summary Table

| Sub~Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|------------------------|--------------------------|----------------------------------|-----------------|--------------------|-------------------------|
| DA-9 | 20.72 | 0.282 | 55 | Outlet | |
| DA-10 | 192.35 | 0,688 | 55 | RCH 10-9 | |

Total Area: 213.07 (ac)

WinTR-55, Version 1.00.09

Page 1

9/27/2010

11:30:44 AM

Calvert County, Maryland

Reach Summary Table

| Reach Identifier | Receiving Reach Identifier | Reach Length (ft) | Routing Method | |
|---------------------|----------------------------------|-------------------------|-------------------|--|
| RCH 10-9 | Outlet | 1116 | CHANNEL | |

qn

Page 1

9/27/2010

Calvert County, Maryland

Sub-Area Flow Mannings's End Wetted Travel Slope . Perimeter Identifier/ Length n Area Velocity Time (ft/ft) (sq ft) (ft/sec) (hr) (ft) (ft) ---------______ ----------____ ---------_____ DA-9 SHEET 0,0863 100 0.150 0.088 SHALLOW 0.050 0.028 526 0,1045 CHANNEL 1197 2.000 0.166 Time of Concentration .282 _____ DA-10 SHEET 100 0.0264 0.150 0.142 SHALLOW 1111 0.0324 0,050 0.106 0.050 SHALLOW 977 0.0220 0.113 CHANNEL 2351 2.000 0.327 .688 Time of Concentration ----

Sub-Area Time of Concentration Details

WinTR-55, Version 1.00.09

Page 1 9/27/2010

11:30:44 AM

Calvert County, Maryland

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifie | r Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|-----------------------|------------------------------------|--------|-----------------------------|--------------------------|-----------------|
| DA-9 | Woods | (good) |) B | 20.72 | 55 |
| | Total Area / Weighted Curve Number | | | 20.72 | 55 == |
| DA-10 | Woods | (good) |) В | 192.35 | 55 |
| | Total Area / Weighted Curve Number | | | 192.35 | 55 == |

qn

WinTR-55, Version 1.00.09 Page 1

Calvert County, Maryland

Reach Channel Rating Details

| Reach Identifier | Reach Length (ft) | Reach Manning's n | Friction Slope (ft/ft) | Bottom Width (ft) | Side Slope |
|---------------------|---|--|--|---|------------------------------|
| RCH 10-9 | ^{.(} 1116 | 0,15 | 0.0094 | 135 | 2 :1 |
| Reach Identifier | Stage (ft) | Flow (cfs) | End Area (sq ft) | Top Width (ft) | Friction Slope (ft/ft) |
| RCH 10-9 | 0.0 0.5 1.0 2.0 5.0 10.0 20.0 | 0.000 40.897 130.027 414.098 1928.075 6261.012 20983.014 | 0 68 137 278 725 1550 3500 | 135 137 139 143 155 175 215 | 0.0094 |

qn

WinTR-55, Version 1.00.09

Page 1

9/27/2010 11:30:44 AM

WinTR-55 Current Data Description

--- Identification Data ---

User: 9/27/2010 qn -Date: Project: Unistar, Calvert Cliffs Units: English SubTitle: Areal Units: Acres State: Maryland County: Calvert Filename: C:\Documents and Settings\qnguyen\My Documents\Unistar\Report\Existing Conditions\TR-55

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Тс |
|-------|-------------|--------|----------|-----|------|
| DA-11 | | Outlet | 380.23 | 55 | .993 |

Total area: 380,23 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr | 5-Yr | 10-Yr | 25-Yr | 50-Yr | 100-Yr | l-Yr |
|------|------|-------|-------|-------|--------|------|
| (in) | (in) | (in) | (in) | (in) | (in) | (in) |
| 3.4 | 4.4 | 5.3 | 6.1 | 6,7 | 7.6 | 2.8 |

Storm Data Source:Calvert County, MD (NRCS)Rainfall Distribution Type:Type II Dimensionless Unit Hydrograph: <standard> +

WinTR-55, Version 1.00.09

Page 1

Calvert County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr | 5-Yr | 10-Yr | 25-Yr | 50-Yr | 100-Yr | l-Yr |
|------|------|-------|-------|-------|--------|------|
| (in) | (in) | (in) | (in) | (in) | (in) | (in) |
| 3.4 | 4.4 | 5.3 | 6.1 | 6.7 | 7.6 | 2.8 |

Storm Data Source:Calvert CoRainfall Distribution Type:Type IIDimensionless Unit Hydrograph:<standard>

۰,

Calvert County, MD (NRCS) Type II <standard>

qn

WinTR-55, Version 1,00,09

Page l

9/27/2010

12:08:57 PM

Calvert County, Maryland

Watershed Peak Table

| Sub-Area or Reach Identifier | ANALYSIS: (cfs) | Peak Flow by 10-Yr (cfs) | Rainfall 100-Yr (cfs) | Return Period 1-Yr (cfs) | • |
|------------------------------------|--------------------|--------------------------------|-----------------------------|--------------------------------|---|
| SUBAREAS DA-11 | 32.74 | 191.16 | 492.52 | 9,30 | |
| REACHES | | | | | |
| OUTLET | 32.74 | 191.16 | 492.52 | 9,30 | |

WinTR-55, Version 1.00.09

9/27/2010 12:08:57 PM

Calvert County, Maryland

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak ANALYSIS: (cfs) (hr) | Flow and 10-Yr (cfs) (hr) | Peak Time 100-Yr (cfs) (hr) | (hr) by Rainfall 1-Yr (cfs) (hr) | Return | Period | |
|------------------------------------|------------------------------------|------------------------------------|--------------------------------------|---|--------|--------|--|
| SUBAREAS DA-11 | 32,74 12.71 | 191.16 12.61 | 492.52 12,52 | . 9,30 12,98 | | | |

REACHES

OUTLET 32.74 191.16 492.52 9.30

WinTR-55, Version 1,00.09

Page 1

9/27/2010

12:08:57 PM

Calvert County, Maryland

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|------------------------|--------------------------|----------------------------------|-----------------|--------------------|-------------------------|
| DA-11 | 380,23 | 0,993 | 55 | Outlet | |

Total Area: 380.23 (ac)

WinTR-55, Version 1.00.09

9/27/2010

Calvert County, Maryland

| Sub~Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|-------------------------|------------------------|------------------|-----------------|------------------------|-----------------------------|----------------------|------------------------|
| DA-11 | | | | | | | |
| SHEET | 100 | 0,0922 | 0.150 | | | | 0,086 |
| SHALLOW | 1062 | 0.0224 | 0.050 | | | | 0.122 |
| CHANNEL | 5653 | | | | | 2.000 | 0,785 |
| | | | | Ti | me of Concer | ntration | .993 |

Sub-Area Time of Concentration Details

WinTR-55, Version 1.00.09

.

Page 1

9/27/2010

12:08:57 PM

qn

Calvert County, Maryland

Sub-Area Land Use and Curve Number Details

| Sub-Are Identifi | a er Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---------------------|------------------------------------|--------|-----------------------------|--------------------------|-----------------|
| DA-11 | Woods | (good) | B | 380.225 | 55 |
| | Total Area / Weighted Curve Number | | | 380,23 | 55 |

qn

WinTR-55, Version 1,00,09

9/27/2010

Streams Discharging to Chesapeake Bay

WinTR-55 Current Data Description

--- Identification Data ---

User: qn Date: 9/27/2010 Project: Unistar, Calvert Cliffs Units: English SubTitle: Areal Units: Acres State: Maryland County: Calvert Filename: C:\Documents and Settings\qnguyen\My Documents\Unistar\Report\Existing Conditions\TR-55

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Тс |
|--------|-------------|-----------|----------|-----|-------|
| DA-12b | | Middle Pd | 25.9 | 55 | .145 |
| DA-12c | | North Pd | 7 | 55 | ,105 |
| DA-12a | | South Pd | 24.36 | 55 | ,226 |
| DA-12d | | Outlet | 0,53 | 55 | 0.100 |

Total area: 57.79 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr | 5-Yr | 10-Yr | 25-Yr | 50-Yr | 100-Yr | 1-Yr |
|------|------|-------|-------|-------|--------|------|
| (in) | (in) | (in) | (in) | (in) | (in) | (in) |
| 3.4 | 4.4 | 5.3 | 6.1 | 6.7 | 7.6 | 2.8 |

| Storm Data Source: | Calvert County, MD (NRCS) |
|--------------------------------|---------------------------|
| Rainfall Distribution Type: | Type II |
| Dimensionless Unit Hydrograph: | <standard></standard> |

WinTR-55, Version 1,00,09

9/27/2010

Calvert County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr | 5-Yr | 10-Yr | 25-Yr | 50-Yr | 100-Yr | l-Yr |
|-------|------|-------|-------|-------|--------|------|
| (in) | (in) | (in) | (in) | (in) | (in) | (in) |
| 3 . 4 | 4,4 | 5.3 | 6.1 | 6 " 7 | 7,6 | 2.8 |

Storm Data Source:Calvert CouRainfall Distribution Type:Type IIDimensionless Unit Hydrograph:<standard>

Calvert County, MD (NRCS) Type II

qn

9/27/2010

11:32:43 AM



Calvert County, Maryland

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak ANALYSIS: (cfs) | Flow by 10-Yr (cfs) | Rainfall 100-Yr (cfs) | Return Period 1-Yr (cfs) | |
|------------------------------------|----------------------------|---------------------------|-----------------------------|--------------------------------|--|
| SUBAREAS DA-12b | 6.98 | 38.09 | 90.41 | 1.32 | |
| DA-12c | 2.15 | 10.71 | 25.92 | 0.43 | |
| DA-12a | 5.17 | 31.43 | 76.58 | 0.97 | |
| DA-12d | 0.17 | 0.82 | 1.99 | .00 | |
| REACHES | н Т | | | | |
| South Pd | 5.17 | 31.43 | 76.58 | 0.97 | |
| Down | 4.22 | 26.96 | 67.16 | 0.83 | |
| Middle Pd | 6.98 | 47.09 | 125.77 | 1.62 | |
| Down | 3.59 | 21.00 | 34.12 | 1.08 | |
| North Pd | 3.95 | 22.61 | 49.77 | 1.22 | |
| Down | 3.89 | 22.00 | 44.05 | 1.22 | |
| RCH South | 4.22 | 26.96 | 67.16 | 0.83 | |
| Down | 3.94 | 23.68 | 60,58 | 0.83 | |
| RCH Middle | 3.59 | 21.00 | 34.12 | 1.08 | |
| Down | 3.59 | 20.99 | 34.12 | 1.09 | |
| RCH North | 3.89 | 22.00 | 44.05 | 1.22 | |
| Down | 3.89 | 22.00 | 44.04 | 1.22 | |
| | | 22.00 | 44.00 | 1 00 | |
| OUTLET | 3.89 | 22.09 | 44.82 | 1.22 | |

qn

Page 1

.

9/27/2010 11:3

11:32:43 AM

N

Calvert County, Maryland

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak ANALYSIS: (cfs) (hr) | Flow and 10-Yr (cfs) (hr) | Peak Time 100-Yr (cfs) (hr) | (hr) by Rainfal l-Yr (cfs) (hr) | ll Return Period | |
|------------------------------------|------------------------------------|------------------------------------|--------------------------------------|--|------------------|---|
| SUBAREAS DA-12b | 6.98 12.05 | 38.09 12.02 | 90.41 11,99 | 1.32 12.07 | | |
| DA-12c | 2.15 12.03 | 10.71 12.01 | 25.92 11.95 | 0.43 12.05 | | |
| DA-12a | 5.17 12 _* 09 | 31.43 12.06 | 76.58 12.04 | 0.97 12.15 | | |
| DA-12d | 0.17 12.03 | 0.82 12,01 | 1.99 11.94 | .00 n/a | · | |
| REACHES South Pd Down | 5.17 12.09 4.22 12.17 | 31.43 12.06 26.96 12.12 | 76.58 12.04 67.16 12.10 | 0.97 12.15 0.83 12.27 | | |
| Middle Pd Down | 6.98 12.05 3.59 12.65 | 47.09 12.04 21.00 12.44 | 125.77 12.04 34.12 12.52 | 1,62 12.38 1.08 13.12 | | |
| North Pd Down | 3.95 12.66 3.89 12.80 | 22.61 12.45 22.00 12.57 | 49,77 12.04 44.05 12.08 | 1.22 13.12 1.22 13.24 | | |
| RCH South Down | 4.22 12.17 3.94 12.34 | 26.96 12.12 23.68 12.23 | 67.16 12.10 60.58 12.19 | 0.83 12.27 0,83 12.45 | | |
| RCH Middle Down | 3.59 12.65 3.59 12.69 | 21.00 12.44 20,99 12.48 | 34.12 12.52 34.12 12.55 | 1.08 13,12 1,08 13,15 | | |
| RCH North Down | 3,89 12,80 3,89 12.81 | 22,00 12.57 22,00 12.59 | 44 .05 12.08 44 .04 12.09 | 1.22 13.24 1.22 13.26 | | · |
| OUTLET | 3,89 | 22,09 | 44.82 | 1.22 | | |

WinTR-55, Version 1.00.09

Page 1

9/27/2010 11:

11:32:43 AM

Calvert County, Maryland

Structure Output Table

| each Peak Flow (PF), Storage Volume (SV), Stage (STG) Identifier by Rainfall Return Period | | | | | | |
|---|---------|-------|--------|------|--|---|
| Structure | | | | | | |
| Identifier ANA | ALYSIS: | 10-Yr | 100-Yr | l-Yr | | |
| Reach: South Po | 1 1 | | | | | |
| Weir : South Po 250(ft) | ond | | | | | |
| PF (cfs) | 4,22 | 26,96 | 67,16 | 0.83 | | * |
| SV (ac ft) | .03 | .18 | .44 | .01 | | |
| STG (ft) | ,01 | .05 | .14 | .00 | | |
| Reach: Middle H | 2d | | | | | |
| Pipe : Middle H | 2d | | | | | |
| 24(in) | | | | | | |
| PF (cfs) | 3.59 | 21.00 | 34.12 | 1.08 | | · |
| SV (ac ft) | .17 | 1.00 | 3.18 | .05 | | |
| STG (ft) | ,12 | .70 | 2.13 | .04 | | |
| Reach: North Pc | ł | | | | | |
| Weir : North Pd | 1 | | | | | |
| 24(ft) | | | | | | |
| PF (cfs) | 3.89 | 22.00 | 44.05 | 1.22 | | |
| SV (ac ft) | .03 | .19 | . 32 | .01 | | |
| STG (ft) | .08 | .46 | .73 . | .03 | | |

qn

WinTR-55, Version 1.00.09

.

9/27/2010 11:

Sub-Area Summary Table

Calvert County, Maryland

Sub-Area Drainage Time of Curve Receiving Sub-Area Identifier Concentration Number Area Reach Description (ac) (hr) _____ _~____ -----25,90 DA-12b 0.145 55 Middle Pd 7,00 24.36 DA-12c 0.105 55 North Pd 55 55 DA-12a 0.226 South Pd DA-12d , 53 0.100 Outlet

Total Area: 57.79 (ac)

9/27/2010

11:32:43 AM

WinTR-55, Version 1,00.09

Page 1

Calvert County, Maryland

Reach Summary Table

| Reach Identifier | Receiving Reach Identifier | Reach Length (ft) | Routing Method | |
|---|---|-------------------------|--|---|
| South Pd Middle Pd North Pd RCH South RCH Middle RCH North | RCH South RCH Middle RCH North Middle Pd North Pd Outlet | 1000 800 500 | STRUCTURE (South Pond) STRUCTURE (Middle Pd) STRUCTURE (North Pd) CHANNEL CHANNEL CHANNEL | - |

qn

WinTR-55, Version 1.00.09

9/27/2010

11:32:43 AM

Calvert County, Maryland

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|----------------------------|------------------------|------------------|-----------------|------------------------|-----------------------------|----------------------|------------------------|
| DA-12b SHEET SHALLOW | 100 725 | 0.0675 0.0675 | 0.150 0.050 | | | | 0.097 0.048 |
| | | | | Ťi | me of Conce | ntration | .145 |
| DA-12c SHEET SHALLOW | 100 125 | 0.0675 0.0675 | 0.150 0.050 | Tir | ne of Concer | ntration | 0.097 0.008 .105 |
| . 12. | | | | | | · . | ******* |
| SHEET SHALLOW | 100 957 | 0.0187 0.0675 | 0.150 0.050 | | | | 0.163 0.063 |
| | | | | Tir | ne of Concer | ntration | . 226 |
| DA-12d | | | | | | | • |
| User-provide | đ | | | | | | 0.100 |
| | | | | Tin | ne of Concer | ntration | 0,100 |

WinTR-55, Version 1.00.09

Page l

9/27/2010

0 11:32:43 AM

Calvert County, Maryland

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifie | r Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|-----------------------|------------------------------------|--------|-----------------------------|--------------------------|-----------------|
| DA-12b | Woods | (good) | В | 25 " 9 | 55 |
| | Total Area / Weighted Curve Number | | | 25.9 ==== | 55 == |
| DA-12c | Woods | (good) | В | 7 | 55 |
| | Total Area / Weighted Curve Number | | | 7 | 55 == |
| DA-12a | Woods | (good) | В | 24.36 | 55 |
| | Total Area / Weighted Curve Number | | | 24.36 | 55 == |
| DA-12d | CN directly entered by user | | - | .53 | 55 |
| | Total Area / Weighted Curve Number | | | <u>,</u> 53 === | 55 == |

WinTR-55, Version 1.00.09

Page 1

9/27/2010

Calvert County, Maryland

Reach Channel Rating Details

| Reach Identifier | Reach Length (ft) | Reach Manning's n | Friction Slope (ft/ft) | Bottom Width (ft) | Side Slope |
|---|---|---|--|--|------------------------------|
| South Pd Middle Pd North Pd RCH South RCH Middle RCH North | (This rea (This rea (This rea 1000 800 500 | ch is a struct ch is a struct ch is a struct 0.025 0.025 0.025 | ture: South Pond ture: Middle Pd) ture: North Pd) 0.001 0.01 0.02 | d) 20 20 10 | 2 :1 1 :1 1 :1 |
| Reach Identifier | Stage (ft) | Flow (cfs) | End Area (sq ft) | Top Width (ft) | Friction Slope (ft/ft) |
| South Pd | (This rea | ch is a struct | ure: South Pond | 1) | |
| Middle Pd | (This read | ch is a struct | ure: Middle Pd) | | |
| North Pd | (This rea | ch is a struct | ure: North Pd) | | |
| RCH South | 0,0 0,5 1.0 2,0 5.0 10,0 20,0 | 0.000 11.968 38.518 126.407 655.022 2532.097 | · 0 10.5 22 48 150 400 | 20 22 24 28 40 60 | 0.001 |
| RCH Middle | 0,0 0,5 1.0 2.0 510 10,0 20,0 2 | 0.000 37.281 118.067 374.712 1764.961 6026.666 22726.289 | 0 10.3 21 44 125 300 800 | 20 21 22 24 30 40 60 | 0.01 |
| RCH North | 0.0 0.5 1.0 2.0 5.0 10.0 20.0 2 | 0.000 26,296 83,458 268.211 1342,287 5061,705 1844.051 | 0 5.3 11 24 75 200 600 | 10 11 12 14 20 30 50 | 0.02 |

WinTR-55, Version 1 00.09

Page 1

9/27/2010

11:32:43 AM

Calvert County, Maryland

Structure Description - User Entered

| Reach Identifier | Surface Area @ Crest (ac) | Height Above Crest (ft) | Surface Area @ Ht Above (ac) | Pipe Diameter (in) | Head on Pipe (ft) | Weir Length (ft) | _ |
|---------------------|------------------------------------|----------------------------------|---------------------------------------|--------------------------|-------------------------|------------------------|---|
| South Pd | 3.1 | 5 | 5.88 | | | 250 | |
| Middle Pd | 1,4 | 2 | 1.57 | 24 | 4 | | |
| North Pd | . 4 | 2 | .57 | | | 24 | |
| | | | | | | | |

WinTR-55, Version 1.00.09

Page 1

9/27/2010

10 11:32:43 AM
Calvert County, Maryland

Structure Rating Details - Computed

| Reach Idendifier | Stage (ft) | Pool Storage (ac ft) | Flows Length #1 250ft | (cfs) @ Weir Length #2 ft | Length Length #3 ft |
|---------------------|-------------------------------------|--|---|---------------------------------|---------------------------|
| South Pond | 0 0,5 1 2 5 10 20 | 0,00 1,62 3.38 7.31 22.45 58.80 173.20 | 0.000 247.487 700.000 1979.899 7826.238 22135.944 62609.903 | | |
| Reach | | Pool | Flows | (cfs) @ Pipe | Diameter |
| Idendifier | Stage | Storage | Dia #1 | Dia #2 | Dia #3 |
| | (ft) | (ac ft) | 24in | in | in |
| Middle Pd | 0 1 2 4 10 20 | 0,00 1,44 2,97 6,28 18,25 45,00 | 0.000 30.159 33.719 39.897 54.370 72.319 | | |
| Reach | | Pool | Flows | (cfs) @ Weir | Length |
| Idendifier | Stage (ft) | Storage (ac ft) | Length #1 24ft | Length #2 ft | Length #3 ft |
| North Pd | 0 0.5 1 2 5 10 20 | 0,00 0,21 0.44 0.97 3,06 8,25 25,00 | 0,000 23,759 67.200 190.070 751,319 2125.051 6010.551 | | |

WinTR-55, Version 1,00.09

9/27/2010 1

11:32:43 AM

WinTR-55 Current Data Description

--- Identification Data ---

User: qn Date: 9/27/2010 Project: Unistar, Calvert Cliffs Units: English SubTitle: Areal Units: Acres State: Maryland County: Calvert Filename: C:\Documents and Settings\qnguyen\My Documents\Unistar\Report\Existing Conditions\TR-55

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Тс | • |
|-------|-------------|--------|----------|-----|------|---|
| DA-13 | | Outlet | 61.4 | 55 | .754 | |

Total area: 61.40 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr | 5-Yr | 10-Yr | 25-Yr | 50-Yr | 100-Yr | l-Yr |
|------|------|-------|-------|-------|--------|------|
| (in) | (in) | (in)) | (in) | (in) | (in) | (in) |
| 3.4 | 4.4 | 5.3 | 6.1 | 6.7 | 7.6 | 2.8 |

Storm Data Source:Calvert ConRainfall Distribution Type:Type IIDimensionless Unit Hydrograph:<standard>

Calvert County, MD (NRCS) Type II <standard>

Page 1

9/27/2010

Calvert County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr | 5-Yr | 10-Yr | 25-Yr | 50-Yr | 100-Yr | 1-Yr |
|------|------|-------|-------|-------|--------|------|
| (in) | (in) | (in) | (in) | (in) | (in) | (in) |
| 3.4 | 4.4 | 5.3 | 6.1 | 6.7 | 7.6 | 2.8 |

Storm Data Source:Calvert ConRainfall Distribution Type:Type IIDimensionless Unit Hydrograph:<standard>

Calvert County, MD (NRCS) Type II

qn

WinTR-55, Version 1.00.09

Page 1

9/27/2010

12:07:32 PM

Calvert County, Maryland

Watershed Peak Table

| Sub-Area or Reach Identifier | ANALYSIS: (cfs) | Peak Flow by 10-Yr (cfs) | Rainfall 100-Yr (cfs) | Return Period 1-Yr (cfs) | | |
|------------------------------------|--------------------|--------------------------------|-----------------------------|--------------------------------|------|--|
| SUBAREAS DA-13 | 6.19 | 37.72 | 97.07 | 1.64 | | |
| REACHES | | | | | | |
| OUTLET | 6.19 | 37.72 | 97.07 | 1.64 | | |

WinTR~55, Version 1,00,09

9/27/2010

12:07:32 PM

Calvert County, Maryland

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak ANALYSIS: (cfs) (hr) | Flow and 1 10-Yr (cfs) (hr) | Peak Time 100-Yr (cfs) (hr) | (hr) by Rainfall 1-Yr (cfs) (hr) | Return Period |
|------------------------------------|------------------------------------|--------------------------------------|--------------------------------------|---|---------------|
| SUBAREAS | 6.19 | 37.72 | 97.07 | 1.64 | |
| DA-13 | 12.55 | 12.41 | 12 ₂ 37 | 12.73 | |

REACHES

OUTLET

6.19

37.72 97.07 1.64

WinTR-55, Version 1,00,09

9/27/2010

0 12:07:32 PM

Calvert County, Maryland

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description | |
|------------------------|--------------------------|----------------------------------|-----------------|--------------------|-------------------------|--|
| DA-13 | 61.40 | 0.754 | 55 | Outlet | | |

Total Area: 61.40 (ac)

WinTR-55, Version 1.00.09

Page 1

9/27/2010

Calvert County, Maryland

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|-------------------------|------------------------|------------------|-----------------|------------------------|-----------------------------|----------------------|------------------------|
| DA-13 | | | ********** | | | | |
| SHEET | 100 | 0.0026 | 0.150 | | | | 0.358 |
| SHALLOW | 857 | 0.0576 | 0,050 | 1 | | | 0.061 |
| CHANNEL | 2411 | | | | | 2.000 | 0.335 |
| | | | | | | | |

Time of Concentration .754

Page 1

9/27/2010 12:

12:07:32 PM



Calvert County, Maryland

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifie | r Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|-----------------------|------------------------------------|--------|-----------------------------|--------------------------|-----------------|
| DA-13 | Woods | (good) | ·B | 61.401 | 55 |
| | Total Area / Weighted Curve Number | | | 61.4 ==== | 55 |

Page 1

9/27/2010 12:07:32 PM

Appendix C

Soils Type

| 4ap Unit Symbol | Map Unit Name | Acres in AOI | Percent of AOI | Map unit symbol | : Map unit name | Rating | Acres in AOI | Percent of AOI | Map unit symbol | Map unit name | Rating | Acres in AOI | Percent of AOI | |
|--------------------|---|-----------------|-------------------|--------------------|---|----------------------------|-----------------|-------------------|--------------------|--|--------|-----------------|-------------------|--|
| 3IB2 | Beltsville silt loam, 2 to 5 percent slopes, moderately eroded | 17 | 0.30% | BIB2 | Beltsville silt loam, 2 to 5 percent slopes, moderately eroded | Moderately well drained | 1.2 | 0.00% | BIB2 | Beltsville silt loam, ⁻ 2 to 5 percent slopes, moderately eroded | с | 1.2 | 0.00% | |
| | | • • | | | | | | | | | | | | |
| N | Water | 1,726.50 | 25.90% | SrE | Sassafras and Westphalia soils, steep | Well drained | 809.6 | 30.20% | SrE | Sassafras and Westphalia soils, | В | 809.6 | 30.20% | |
| SrE | Sassafras and Westphalia soils, | 1,711.60 |) 25.70% | w | Water | | 334.9 | 12.50% | w | Water | | 334.9 | 12.50% | |
| ĒrE | Eroded land, steep | 448.6 | 6.70% | MnB2 | Matapeake silt loam, 2 to 5 percent slopes, moderately eroded | Well drained | 241.6 | 9.00% | MnB2 | Matapeake silt loam, 2 to 5 percent slopes, moderately | В | 241.6 | 9.00% | |
| MnB2 | Matapeake silt loam, 2 to 5 percent slopes, moderately eroded | 388.7 | 7 5.80% | ErE | Eroded land, steep | Wełl drained | 228.9 | 8.50% | ErE | eroded land, steep | В | 228.9 | 8.50% | |
| Му | Mixed alluvial land | 341.6 | 5 5.10% | My | Mixed alluvial land | Poorly | 169.7 | 6.30% | My | Mixed alluvial land | D | 169.7 | 6.30% | |
| ReD | Rumford-Evesboro gravelly loamy sands, 12 to 20 percent slopes | 248.3 | 3 3.70% | MnC3 | Matapeake silt loam, 5 to 10 percent slopes, severely eroded | Well drained | 144.3 | 5.40% | MnC3 | Matapeake silt Ioam, 5 to 10 percent slopes, severely eroded | В | 144.3 | 5.40% | |
| SaB2 | Sassafras loamy fine sand, 2 to 5 percent slopes, moderately eroded | 229.2 | 2 3.40% | ReD | Rumford-Evesboro gravelly loamy sands, 12 to 20 percent slopes | Well drained | 123.2 | 4.60% | ReD | Rumford-Evesboro gravelly loamy sands, 12 to 20 percent slopes | A | 123.2 | 4.60% | |
| ShC3 | Sassafras fine sandy loam, 5 to 10 percent slopes, severely eroded | 227.2 | 2 3.40% | ReC | Rumford-Evesboro gravelly loamy sands, 6 to 12 percent slopes | Well drained | 80.6 | 3.00% | ReC | Rumford-Evesboro gravelly loamy sands, 6 to 12 percent slopes | В | 80.6 | 3.00% | |
| ShD3 | Sassafras fine sandy loam, 10 to 15 percent slopes severely eroded | 180.9 | 2.70% | MnD3 | Matapeake silt loam, 10 to 15 percent slopes, severely eroded | Well drained | 74.8 | 2.80% | MnD3 | Matapeake silt loam, 10 to 15 percent slopes, severely eroded | В | 74.8 | 2.80% | |
| MnC3 | Matapeake silt loam, 5 to 10 percent slopes, | 17. | 2 2.60% | ShC3 | Sassafras fine sandy loam, 5 to 10 percent slopes, severely | Well drained | 67.7 | 2.50% | ShC3 | Sassafras fine sandy loam, 5 to 10 percent slopes, | В | 67.7 | 2.50% | |
| ReC | severely eroded Rumford-Evesboro gravelly loamy sands, 6 to 12 percent slopes | 144.; | 2 2.20% | SaC2 | eroded Sassafras loamy fine sand, 5 to 10 percent slopes, moderately eroded | Well drained | 64.6 | 2.40% | SaC2 | severely eroded Sassafras loamy fine sand, 5 to 10 percent slopes, moderately eroded | В | 64.6 | 2.40% | |

•

5

| ShB2 | Sassafras fine sandy loam, 2 to 5 percent slopes. | 114. 2 | 1.70% | SaB2 | Sassafras loamy fine sand, 2 to 5 percent | Well drained | 55.9 | 2.10% | SaB2 | Sassafras loamy fine sand, 2 to 5 | B55 | i.9 |
|------|---|---------------|-------|------|--|------------------------|------|-------|------|--|--------|-------------|
| | moderately eroded | | | | eroded | | | | | percent slopes, moderately eroded | | |
| SaC2 | Sassafras loamy fine sand, 5 to 10 percent slopes, | 80.1 | 1.20% | ShD3 | Sassafras fine sandy loam, 10 to 15 percent slopes severely eroded | Well drained | 41.7 | 1.60% | ShD3 | Sassafras fine sandy loam, 10 to 15 percent slopes | / B 41 | l. 7 |
| | moderately eroded | | | | | | | | | severely eroded | | |
| MnD3 | Matapeake silt loam, 10 to 15 percent slopes, | 75.9 | 1.10% | ShB2 | Sassafras fine sandy loam, 2 to 5 percent slopes, moderately | Well drained | 29 | 1.10% | ShB2 | Sassafras fine sandy loam, 2 to 5 percent slopes, moderately | / B | 29 |
| Co | Coastal beaches | 65.9 | 1.00% | RdD2 | eroded Rumford loamy sand, 10 to 15 percent slopes, moderately | Well drained | 27.6 | 1.00% | RdD2 | eroded Rumford loamy sand, 10 to 15 percent slopes, | В 27 | 7.6 |
| BtB2 | Butlertown silt loam, 2 to 5 percent slopes, moderately eroded | 50.9 | 0.80% | BtB2 | eroded Butlertown silt loam, 2 to 5 percent slopes, moderately eroded | Well drained | 25.3 | 0.90% | BtB2 | moderately eroded Butlertown silt Ioam, 2 to 5 percent slopes, moderately | C 25 | 5.3 |
| MnC2 | Matapeake silt loam, 5 to 10 percent slopes, moderately eroded | 51.9 | 0.80% | MnC2 | Matapeake silt loam, 5 to 10 percent slopes, moderately eroded | Well drained | 24.7 | 0.90% | MnC2 | eroded Matapeake silt Ioam, 5 to 10 percent slopes, | B 24 | ł.7 |
| Sx | Swamp | 48.1 | 0.70% | ShD2 | Sassafras fine sandy loam, 10 to 15 percent slopes moderately | Well drained | 24.9 | 0.90% | ShD2 | moderately eroded Sassafras fine sandy loam, 10 to 15 | · B 24 | 1.9 |
| ShC2 | Sassafras fine sandy loam, 5 to 10 percent slopes, moderately eroded | 38.9 | 0.60% | Co | eroded Coastal beaches | Poorly drained | 19.2 | 0.70% | Co | moderately eroded Coastal beaches | D 19 |).2 |
| ShD2 | Sassafras fine sandy loam, 10 to 15 percent slopes moderately eroded | 39.2 | 0.60% | HoB2 | Howell fine sandy loam, 2 to 6 percent slopes, moderately eroded | Well drained | 13.2 | 0.50% | HoB2 | Howell fine sandy loam, 2 to 6 percent slopes, moderately eroded | C 13 | 3.2 |
| Tm | Tidal marsh | 35.6 | 0.50% | Ma | Made land | | 13.9 | 0.50% | Ma | Made land | 17 | 2 0 |
| RdD2 | Rumford loamy sand, 10 to 15 percent slopes, moderately eroded | 29.4 | 0.40% | Es | Escarpments | Well drained | 9.8 | 0.40% | Ës | Escarpments | В 9 | 1.8 |
| Ev₿ | Evesboro loamy sand, 0 to 6 | 17.2 | 0.30% | EvB | Evesboro loamy sand, 0 to 6 percent slopes | Excessively drained | 10.3 | 0.40% | E∨B | Evesboro loamy sand, 0 to 6 percent | A 10 |).3 |
| HoB2 | Howell fine sandy loam, 2 to 6 percent slopes, | 18.5 | 0.30% | EvE | Evesboro loamy sand, 12 to 35 percent slopes | Excessively drained | 7.5 | 0.30% | EvE | slopes Evesboro loamy sand, 12 to 35 percent slopes | A 7 | '.5 |

-

| BtC3 | Butlertown silt loam, 5 to 10 percent slopes, | 13.1 | 0.20% | HwB2 | Howell silt loam, 2 to 6 percent slopes, moderately eroded | Well drained | 8.2 | 0.30% | HwB2 | Howell silt loam, 2 to 6 percent slopes, moderately eroded | с | 8.2 | 0.30% |
|------|---|------|-------|------------|---|----------------------------|----------|-----------|-----------|--|---|----------|---------|
| Es | Escarpments | 14.6 | 0.20% | Tm | Tidal marsh | Very poorly drained | 8.3 | 0.30% | Tm | Tidal marsh | D | 8.3 | 0.30% |
| HoD2 | Howell fine sandy loam, 12 to 20 percent slopes, moderately eroded | 10.9 | 0.20% | НуС3 | Howell clay loam, 6 to 12 percent slopes, severely eroded | Well drained | 5.5 | 0.20% | НуСЗ | Howell clay loam, 6 to 12 percent slopes, severely eroded | с | 5.5 | 0.20% |
| HwB2 | Howell silt loam, 2 to 6 percent slopes, moderately eroded | 11.4 | 0.20% | SIC3 | Sassafras loam, 5 to 10 percent slopes, severely eroded | Well drained | 4.2 | 0.20% | SIC3 | Sassafras loam, 5 to 10 percent slopes, severely eroded | В | 4.2 | 0.20% |
| HyD3 | Howell clay loam, 12 to 20 percent slopes, severely eroded | 10.8 | 0.20% | BtC3 | Butlertown silt loam, 5 to 10 percent slopes, severely eroded | Well drained | 1.7 | 0.10% | BtC3 | Butlertown silt loam, 5 to 10 percent slopes, | с | 1.7 | 0.10% |
| Ма | Made land | 13.9 | 0.20% | EvC | Evesboro loamy sand, 6 to 12 percent slopes | Excessively drained | 2.7 | 0.10% | EvC | Eversive robed Evesboro loamy sand, 6 to 12 | A | 2.7 | 0.10% |
| ReB | Rumford-Evesboro gravelly loamy sands, 2 to 6 percent slopes | 14.2 | 0.20% | ReB | Rumford-Evesboro graveliy loamy sands, 2 to 6 percent slopes | Well drained | 2.5 | 0.10% | ReB | Rumford-Evesboro gravelly loamy sands, 2 to 6 percent slopes | В | 2.5 | 0.10% |
| EvE | Evesboro loamy sand, 12 to 35 percent slopes | 9.8 | 0.10% | ImB | Iuka fine sandy loam, local alluvium, 2 to 5 percent slopes | Moderately well drained | 0.6 | 0.00% | ImB | Iuka fine sandy Ioam, local alluvium, 2 to 5 | с | 0.6 | 0.00% |
| HoC2 | Howell fine sandy loam, 6 to 12 percent slopes, moderately eroded | 8.3 | 0.10% | WaD3 | Westphalia fine sandy loam, 12 to 20 percent slopes severely eroded | Well drained | 0.5 | 0.00% | WaD3 | Westphalia fine sandy loam, 12 to 20 percent slopes severely eroded | В | 0.5 | 0.00% |
| НуС3 | Howell clay loam, 6 to 12 percent slopes, severely | 5.5 | 0.10% | WoA | Woodstown fine sandy loam, 0 to 2 percent slopes | Moderately well drained | 0.9 | 0.00% | WoA | Woodstown fine sandy loam, 0 to 2 percent slopes | с | 0.9 | 0.00% |
| MIB2 | Marr fine sandy loam, 2 to 6 percent slopes, moderately eroded | 3.5 | 0.10% | WoB | Woodstown fine sandy loam, 2 to 5 percent slopes | Moderately well drained | 2.2 | 0.10% | WoB | Woodstown fine sandy loam, 2 to 5 percent slopes | с | 2.2 | 0.10% |
| SIB2 | Sassafras loam, 2 to 5 percent slopes, moderately eroded | 4.9 | 0.10% | Totals for | r Area of Interest | | 2,681.30 | .00.00% . | Totals fo | r Area of Interest | | 2,681.30 | 100.00% |
| SIC3 | Sassafras loam, 5 to 10 percent | 5.1 | 0.10% | | | | | | | | | | |

.

.

slopes, severely eroded WoA Woodstown fine 6.6 0.10% sandy loam, 0 to 2 percent slopes

.

1

| WoB | Woodstown fine | 5.5 | 0.10% |
|-------------|----------------------|----------|---------|
| | sandy loam, 2 to 5 | | |
| BIC3 | Beltsville cilt loam | 1 4 | 0.000/ |
| 0.00 | 5 to 10 percent | 1.4 | 0.00% |
| | slopes severaly | | |
| | eroded | | |
| Ek | Elkton silt loam | 2.9 | 0.00% |
| FvC | Evesboro loamy | 2.7 | 0.00% |
| 2.0 | sand 6 to 12 | 2.7 | 0.00% |
| | percent slopes | | |
| ImB | Iuka fine sandy | 19 | 0.00% |
| | loam, local | | 0.00 /0 |
| | alluvium, 2 to 5 | | |
| | percent slopes | | - |
| MIC3 | Marr fine sandy | 0.5 | 0.00% |
| | loam, 6 to 12 | | |
| | percent slopes, | | |
| | severely eroded | | |
| OcB | Ochlockonee fine | 3.1 | 0.00% |
| | sandy loam, local | | |
| | alluvium, 2 to 5 | | |
| | percent slopes | | |
| OtB | Othello silt loam, | 1.6 | 0.00% |
| | 2 to 5 percent | | |
| CL 4 | slopes | _ | |
| SNA | Sassafras fine | 0.1 | 0.00% |
| | sandy loam, 0 to 2 | | |
| WaD2 | Dercent slopes | <u> </u> | |
| Wabs | westphalia rine | 0.5 | 0.00% |
| | Sandy loam, 12 to | • • | · . |
| | 20 percent slopes | | |
| | severely eroded | | |
| | | | |

Totals for Area of Interest 6,654.00 100.00%

• •

Appendix D

Fluvial Geomorphic Assessment Data

· ·

. .

: 1

SE 1

. .

. . .

.

| Basin: | Woodland Branch Drainage Area: 48 acres | 0.075 | mi ² |
|------------|---|-------------|------------------|
| ocation: | Calvert Cliffs Nuclear Plant | | |
| | | | |
| wp.arge | Lusby, Sec.adii, | | 40/04/0 |
| pross-Sect | ion Monuments (Lat./Long.): 0 Lat / 0 Long | | 10/01/0 |
| Deservers | | Valley Type | |
| | Bankfull WIDTH (W _{bkf}) | |] |
| | WIDTH of the stream channel at bankfull stage elevation, in a riffle section. | 5.86 | ſt |
| | Bankfull DEPTH (d _{bkf}) | | 7 |
| | Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a | | |
| | $a_{bkl} = A / v_{bkl}.$ | 0.38 | ∫ft |
| | Bankfull X-Section AREA (A _{bkf}) | | 1 |
| | AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle | | 1 |
| | section. | 2.25 | _ft ² |
| | Width/Depth Ratio (White / dhite) | | T |
| | Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section. | 15.42 | ft/ft |
| | Maximum DEPTH (d) | · . | - |
| | Maximum depth of the bankfull channel cross-section, or distance between the | | |
| | bankfull stage and Thalweg elevations, in a riffle section. | 0.89 | ft |
| | WIDTH of Flood-Prone Area (W ₍) | | ו |
| | Twice maximum DEPTH, or $(2 \times d_{mbkl})$ = the stage/elevation at which flood-prone area | | |
| | WIDTH is determined in a riffle section. | 75 | ft |
| | Entrenchment Ratio (ER) | |] |
| | The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkl}) | | |
| | (riffle section). | 12.8 | ft/ft |
| | Channel Materials (Particle Size Index) D _{so} | |] |
| | The D_{50} particle size index represents the mean diameter of channel materials, as | | |
| | sampled from the channel surface, between the bankfull stage and Thalweg elevations. | 0.40 | |
| | | 0.18 | Jmm |
| | Water Surface SLOPE (S) | |] |
| | Channel slope = "rise over run" for a reach approximately 20-30 bankfull channel | | |
| | at bankfull stage. | 0 01104 | ft /ft |
| | | 0.01104 | Pion |
| | Channel SINUOSITY (k) | | |
| | Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by | | |
| | channel slope (VS / S). | 1.2 | |
| | | | י ר |
| | Stream Stream (See Figure 2- | - 14) | |
| | Type | / | |

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

Copyright © 2006 Wildland Hydrology

WARSSS page 5-29

RIVERMORPH PROFILE SUMMARY

River Name:Calvert CliffsReach Name:Woodland SE-1Profile Name:Refference OnlySurvey Date:10/01/2009

Survey Data

| DIST | СН | WS | B | KF P | 1 | P2 | P3 | P4 | |
|--------|------|------|------|------|---|----|----|----|--|
| 96 | 6.74 | 6.66 | 6.11 | | | | | | |
| 97 | 7.29 | 6.79 | | | | | | | |
| 98 | 7.09 | 6.81 | 6.03 | | | | | | |
| 102 | 6.99 | 6.82 | 6.22 | | | | | | |
| 105 | 6.94 | 6.82 | 6.19 | | | | | | |
| 109 | 6.98 | 6.85 | 6.14 | | | | | | |
| 111 | 6.99 | 6.85 | | | | | | | |
| 113.5 | 7.14 | 6.89 | | | | | | | |
| 115 | 7.26 | 6.87 | 6.33 | | | | | | |
| 118 | 7.17 | 6.89 | | | | | | | |
| 120 | 6.98 | 6.89 | 6.09 | | | | | | |
| 123 | 7.03 | 6.91 | | | | | | | |
| 128 | 7.06 | 6.92 | 6.32 | | | | | | |
| 134 | 7.06 | 6.96 | 6.27 | | | | | | |
| 137 | 7.08 | 6.97 | 6.47 | | | | | | |
| 140 | 7.09 | 6.96 | | | | | | | |
| 145 | 7.1 | 6.98 | 6.43 | | | | | | |
| 147 | 7.38 | 6.97 | | | | | | | |
| 148.6 | 7.13 | 6.97 | 6.43 | 6.38 | | | | | |
| 150 | 7.09 | 6.97 | | | | | | | |
| 151.5 | 7.06 | 6.98 | 6.49 | | | | | | |
| 154 | 7.24 | 7.09 | 6.39 | | | | | | |
| 158 | 7.25 | 7.12 | 6.55 | | | | | | |
| 163 | 7.28 | 7.12 | | | | | | | |
| 169 | 7.29 | 7.18 | 6.56 | | | | | | |
| 173 | 7.43 | 7.23 | | · | | | | | |
| 176 | 7.71 | 7.3 | | | | | | | |
| 178 | 7.97 | 7.49 | | | | | | | |
| 179 | 7.6 | 7.51 | | | | | | | |
| 182 | 7.71 | 7.67 | 7.04 | | | | | | |
| 184 | 7.77 | 7.67 | | | | | | | |
| 187 | 7.84 | 7.68 | | | | | | | |
| 189 | 7.94 | 7.69 | | | | | | | |
| 191 | 8.03 | 7.74 | | | | | | | |
| 194 | 8 | 7.75 | | | | * | | | |
| 195 | 8.12 | 7.82 | | | | | | | |
| 197 | 8.1 | 7.89 | 7.14 | 7.09 | | | | | |

| 200 | 8.39 | 7.94 | 7.12 |
|-------|------|------|------|
| 202 | 8.25 | 7.93 | |
| 206 | 8.29 | 7.93 | |
| 209 | 8.27 | 7.92 | |
| 216 | 8.29 | 7.92 | |
| 226 | 8.27 | 7.92 | |
| 231 | 8.32 | 7.92 | |
| 233 | 8.34 | 7.99 | 7.32 |
| 235 | 8.62 | 8.27 | |
| 238 | 8.56 | 8.29 | 7.38 |
| 240 | 8.45 | 8.29 | 7.38 |
| 246 | 8.4 | 8.3 | 7.54 |
| 250 | 8.42 | 8.31 | |
| 255 | 8.45 | 8.31 | |
| 264 | 8.47 | 8.37 | |
| 267 | 8.67 | 8.4 | 7.91 |
| 271 | 8.64 | 8.43 | |
| 275 | 8.57 | 8.46 | |
| 280 | 8.6 | 8.45 | |
| 283 | 8.99 | 8.45 | |
| 288 | 8.82 | 8.43 | |
| 293 | 9.1 | 8.77 | |
| 297 | 8.94 | 8.74 | |
| 300 | 8.98 | 8.75 | 8.42 |
| 305 | 6.44 | 6.06 | 5.61 |
| 312 . | 6.33 | 6.11 | 5.76 |
| 315 | 6.38 | 6.14 | |
| 319 | 6.21 | 6.13 | 5.72 |

Cross Section / Bank Profile Locations

| Туре | Profile Station |
|-----------|---|
| | |
| Other XS | 20 |
| Glide XS | 150 |
| Riffle XS | 158 |
| Run XS | 233 |
| Pool XS | 235 |
| Riffle XS | 445 |
| Riffle XS | 364 |
| Riffle XS | S 486 |
| | Type Other XS Glide XS Riffle XS Run XS Pool XS Riffle XS Riffle XS Riffle XS |

Measurements from Graph

Bankfull Slope: 0.01104

| Variable | Min | Avg | Max | |
|--------------------|--------------|--------------------|-------------------|--|
| S riffle S pool | 0.00165 0 | 0.00783 0.00124 | 0.0162 0.00337 | |
| S run | 0.01499 | 0.04327 | 0.08166 | |
| S glide | 0 | 0.00134 | 0.00321 | |
| P_P | 18 47 | 29.82 | 47 84 | |

| • | |
|---|---|
| | |
| | |
| | |
| 1 | |
| | 7 |
| • | |

| Pool length | 4.23 | 12.46 | 28.71 |
|---------------|------------|------------|-------------|
| Riffle length | 7.57 | 18.87 | 30.93 |
| Dmax riffle | 0.56 | 0.63 | 0.7 |
| Dmax pool | 0.85 | 1.04 | 1.3 |
| Dmax run | 0.73 | 0.9 | 1.01 |
| Dmax glide | 0.59 | 0.77 | 0.87 |
| Low bank ht | 0.2 | 0.2 | 0.2 |
| enoth and d | enth measu | rements in | feet slones |

Length and depth measurements in feet, slopes in ft/ft.

RIVERMORPH PROFILE SUMMARY

Notes

River Name: Calvert Cliffs Reach Name: Woodland SE-1 Profile Name: Refference Only Survey Date: 10/01/2009

DIST Note

| 96 | left / begin ref |
|-------|-------------------|
| 98 | left |
| 102 | right |
| 105 | left |
| 109 | right |
| 111 | Run |
| 113.5 | Pool |
| 115 | mid pool |
| 118 | Glide |
| 120 | Riffle |
| 128 | right |
| 134 | left |
| 137 | right |
| 145 | left |
| 148.6 | Glide L/R |
| 151.5 | right |
| 154 | left |
| 158 | Riffle (left) |
| 169 | RIGHT |
| 182 | right |
| 197 | right/left |
| 200 | left |
| 233 | Run Right |
| 238 | right |
| 240 | right |
| 246 | left |
| 267 | right |
| 280 | large downed tree |
| 293 | DEBRIS JAM AT 292 |
| 300 | RIGHT BANK |
| 305 | left bank |
| 312 | left bank |



RIVERMORPH CROSS SECTION SUMMARY

| Cross S | Section Dat | a Entry | | | , | |
|-------------------|------------------------|-----------------------|--------|--------------|---|----------|
| BM Ele Backsig | evation: ght Rod Re | 99 ft ading: 1 | ft | | | |
| ГАРЕ | FS | ELEV | NO | TE | | |
| ·25 | 6.4 | 93.6 | | | | - |
| 7 | 6.62 | 93.38 | | | | |
|) | 6.56 | 93.44 | LEP | | | |
| 2 | 6.45 | 93.55 | | | | |
| 3 | 6.45 | 93.55 | | | | |
| 1 | 6.46 | 93.54 | BKF | | | |
| 5 | 6.61 | 93.39 | | | | |
| 5.3 | 7.1 | 92.9 | LEW | | | |
| 5.7 | 7.18 | 92.82 | | | | |
| ; ; | 7.24 | 92.76 | | | | |
| 5.5 | 7.35 | 92.65 | | | | |
| 7 | 7.21 | 92.79 | | | | |
| '.4 | 7.09 | 92.91 | REW | | | |
| • | 6.76 | 93.24 | | | | |
| • | 6.49 | 93.51 | | | | |
| 1 | 6.42 | 93.58 | | | | |
| 8 | 6.82 | 93.18 | | | | |
| 0 | 6.4 | 93.6 | | | | |
| ross S | ectional G | eometrv | | | | |
| ross S | Sectional G | eometry hannel Lef | t Righ | t 3 94.43 | | |
| Bankfu | Il Elevation | 1(ft) 93.54 | 93 54 | 93.54 | | |
| Floodn | rone Width | (ff) 75 | | | | |
| lankfu | 11 Width (fi | (1, 7, 5) | 5 13 | 2.93 | | |
| ntrenc | hment Rat | 12 9.00 | 5.15 | 2.95 | | |
| Innelle Ioon F | Junioni Kal | 10 12.8 0.20 | 0.5 | 0 27 | | |
| Agent L | vepin (II) | U.38 | 0.0 | 0.27 | | |
| /1ax1m | um Depth (| $(\Pi) 0.89$ | 0.89 | 0.77 | | |
| wiath/l | Depin Ratio | o 15.42 | 10.26 | 10.85 | | |
| sanktu | II Area (sq | (f) 2.25 | 1.46 | 0.79 | 6 | |
| vetted | rerimeter | $(\Pi) 6.33$ | 4.03 | 5.84 | | |
| iydrau | lic Radius | (tt) 0.36 | 0.36 | 0.2 | | |

| Begin BKF Station | 1.8 | 1.8 | 6.93 |
|-------------------|------|------|------|
| End BKF Station | 9.86 | 6.93 | 9.86 |

Entrainment Calculations

Entrainment Formula: Shields Curve

| C | hanne | el Le | ft Side | Righ | t Side |
|---------------------|-------|-------|---------|------|--------|
| Slope | 0.01 | 1 0 | .011 | 0.01 | 1 |
| Shear Stress (lb/sc | ft) | 0.25 | 0.25 | 0 | .14 |
| Movable Particle (| (mm) | 13. | 7 1 | 3.7 | 8.6 |

RIVERMORPH CROSS SECTION SUMMARY

| River Name: | Calvert Cliffs |
|-----------------|----------------|
| Reach Name: | Woodland SE-1 |
| Cross Section N | ame: Pool_235 |
| Survey Date: | 09/23/2009 |

Cross Section Data Entry

BM Elevation:99 ftBacksight Rod Reading:1 ft

| TAPE | FS | ELEV | NOTE | |
|------|------|-------|---------------|--|
| 0 | 7.48 | 92.52 | LEP | |
| 3 | 7.32 | 92.68 | | |
| 4 | 7.41 | 92.59 | BKF | |
| 5 | 7.64 | 92.36 | | |
| 5.5 | 8.29 | 91.71 | LEW | |
| 6 | 8.42 | 91.58 | | |
| 7 | 8.82 | 91.18 | | |
| 7.5 | 8.75 | 91.25 | | |
| 8 | 8.57 | 91.43 | vertical bank | |
| 8.3 | 7.67 | 92.33 | | |
| 9 | 7.41 | 92.59 | | |
| 11 | 7.31 | 92.69 | | |
| 13 | 7.38 | 92.62 | | |
| | | | | |

Cross Sectional Geometry

| Chann | el Lef | t Rig | ht |
|-------------------------|--------|-------|-------|
| Floodprone Elevation (| ft) 94 | 94 | 94 |
| Bankfull Elevation (ft) | 92.59 | 92.59 | 92.59 |
| Floodprone Width (ft) | 13 | | |
| Bankfull Width (ft) | 5 | 2.5 | 2.5 |
| Entrenchment Ratio | 2.6 | | |
| Mean Depth (ft) | 0.74 | 0.57 | 0.91 |
| Maximum Depth (ft) | 1.41 | 1.21 | 1.41 |
| Width/Depth Ratio | 6.76 | 4.39 | 2.75 |
| Bankfull Area (sq ft) | 3.69 | 1.42 | 2.27 |
| Wetted Perimeter (ft) | 6.17 | 4.11 | 4.48 |
| Hydraulic Radius (ft) | 0.6 | 0.35 | 0.51 |
| Begin BKF Station | 4 | 4 ' | 6.5 |
| End BKF Station | 9 | 6.5 | 9 |
| | | | |

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

RIVERMORPH CROSS SECTION SUMMARY

River Name:Calvert CliffsReach Name:Woodland SE-1Cross Section Name:Run 233Survey Date:09/23/2009

. _____

Cross Section Data Entry

| BM Elevation: | 99 ft |
|------------------------|-------|
| Backsight Rod Reading: | 1 ft |

| TAPE | FS | ELEV | NOTE | |
|------|------|-------|------|--|
| 0 | 7.41 | 92.59 | LEP | |
| 2 | 7.4 | 92.6 | | |
| 4 | 7.42 | 92.58 | bkf | |
| 4.2 | 7.99 | 92.01 | LEW | |
| 5 | 8.06 | 91.94 | | |
| 5.5 | 8.06 | 91.94 | | |
| 6 | 8.02 | 91.98 | | |
| 6.5 | 8.04 | 91.96 | | |
| 7 | 7.99 | 92.01 | REW | |
| 7.5 | 7.71 | 92.29 | | |
| 8 | 7.61 | 92.39 | | |
| 9 | 7.35 | 92.65 | | |
| 13 | 7.34 | 92.66 | | |

Cross Sectional Geometry

| Chann | el Left | Righ | nt |
|-------------------------|-----------|--------|---------|
| Floodprone Elevation (| ft) 93.22 | 2 93.2 | 2 93.22 |
| Bankfull Elevation (ft) | 92.58 | 92.58 | -92.58 |
| Floodprone Width (ft) | 13 | | |
| Bankfull Width (ft) | 4.73 | 2.37 | 2.36 |
| Entrenchment Ratio | 2.75 | | |
| Mean Depth (ft) | 0.46 | 0.59 | 0.33 |
| Maximum Depth (ft) | 0.64 | 0.64 | 0.62 |
| Width/Depth Ratio | 10.28 | 4.02 | 7.15 |
| Bankfull Area (sq ft) | 2.18 | 1.4 | 0.78 |
| Wetted Perimeter (ft) | 5.25 | 3.39 | 3.08 |
| Hydraulic Radius (ft) | 0.41 | 0.41 | 0.25 |
| Begin BKF Station | 4 | 4 | 6.37 |
| End BKF Station | 8.73 | 6.37 | 8.73 |

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

ChannelLeft SideRight SideSlope000Shear Stress (lb/sq ft)VVVMovable Particle (mm)VVV

RIVERMORPH CROSS SECTION SUMMARY

River Name:Calvert CliffsReach Name:Woodland SE-1Cross Section Name:Glide 150Survey Date:09/23/2009

Cross Section Data Entry

BM Elevation:99 ftBacksight Rod Reading:1 ft

| TAPE | FS | ELEV | NOTE | |
|------|--------|-------|------|--|
| -7 | 6.19 | 93.81 | | |
| 0 | 6.34 | 93.66 | LEP | |
| 2 | 6.28 | 93.72 | | |
| 3 | 6.33 | 93.67 | | |
| 4 | 6.46 | 93.54 | | |
| 4.8 | 7.06 | 92.94 | LEW | |
| 5 | 7.15 | 92.85 | | |
| 5.5 | . 7.16 | 92.84 | | |
| 6 | 7.05 | 92.95 | | |
| 6.5 | 7.05 | 92.95 | | |
| 7 | 6.99 | 93.01 | | |
| 7.5 | 6.53 | 93.47 | | |
| 8 | 6.55 | 93.45 | | |
| 9 | 6.39 | 93.61 | BKF | |
| 12 | 6.42 | 93.58 | | |
| 18 | 6.7 | 93.3 | | |

.

Cross Sectional Geometry

| Chann | el Left | Righ | nt |
|-------------------------|-----------|-------|---------|
| Floodprone Elevation (| ft) 94.38 | 94.3 | 8 94.38 |
| Bankfull Elevation (ft) | 93.61 | 93.61 | 93.61 |
| Floodprone Width (ft) | 25 | | * |
| Bankfull Width (ft) | 6.54 | 1.52 | 5.02 |
| Entrenchment Ratio | 3.82 | | |
| Mean Depth (ft) | 0.33 | 0.29 | 0.35 |
| Maximum Depth (ft) | 0.77 | 0.75 | 0.77 |
| Width/Depth Ratio | 19.82 | 5.24 | 14.34 |
| Bankfull Årea (sq ft) | 2.19 | 0.44 | 1.75 |
| Wetted Perimeter (ft) | 6.98 | 2.49 | 5.99 |
| Hydraulic Radius (ft) | 0.31 | 0.18 | 0.29 |
| Begin BKF Station | 3.46 | 3.46 | 4.98 |
| End BKF Station | 10 | 4.98 | 10 |
| | | | |

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

Channel Left Side Right Side Slope 0 0 0 Shear Stress (lb/sq ft) Movable Particle (mm)

RIVERMORPH REACH SUMMARY

River Name: Calvert Cliffs Reach Name: Woodland SE-1

Stream Type Valley Type D50(mm)Val SlopeBKF Q(cfs)DA(sq mi)C 5IX0.180.01325.20.075

Dimension Summary

Database based on the following Cross Sections:

| Variable | Min Avg Max |
|---|---|
| Floodprone Width (ft) Riffle Area (Sq ft) Max Riffle Depth (ft) Mean Riffle Depth (ft) Riffle Width (ft) Pool Area (Sq ft) Max Pool Depth (ft) Mean Pool Depth (ft) Pool Width (ft) Run Area (Sq ft) Max Run Depth (ft) Mean Run Depth (ft) Run Width (ft) Glide Area (Sq ft) Max Glide Depth (ft) Mean Glide Depth (ft) | $\begin{array}{cccccccccccccccccccccccccccccccccccc$ |
| Pattern Summary | 0.54 0.54 0.54 |
| Variable | Min Avg Max |
| Sinuosity Meander Wavelength (f Radius of Curvature (ft) Belt Width (ft) Profile Summary | 1.2 a) $36 49.25 66$ 3 6.65 9.5 50 55 70 |
| Data Based on the follo | wing: |
| Variable | Min Avg Max |
| S riffle (ft/ft) S pool (ft/ft) | 0.00165 0.00783 0.0162 0 0.00124 0.00337 |

| S run (ft/ft) | 0.0149 | 9 0.0432 | 0.08166 |
|--------------------------|--------|----------|---------|
| S glide (ft/ft) | 0 | 0.00134 | 0.00321 |
| P - P(ft) | 18.47 | 29.82 | 47.84 |
| Pool length (ft) | 4.23 | 12.46 | 28.71 |
| Riffle length (ft) | 7.57 | 18.87 | 30.93 |
| Dmax riffle (ft) | 0.89 | 0.89 | 0.89 |
| Dmax pool (ft) | 1.41 | 1.41 | 1.41 |
| Dmax run (ft) | 0.64 | 0.64 | 0.64 |
| Dmax glide (ft) | 0.77 | 0.77 | 0.77 |
| Low bank ht start-end (f | Ì) (| 0.2 0. | 2 0.2 |
| Bankfull slope (ft/ft) | | 0.0110 | 4 |

Hydraulic Summary

| Variable | Min | Avg | Max | |
|--|------|---------------------|------|--|
| Discharge (cfs) Velocity (fps) Hyd Radius (ft) | 0.36 | 5.2 2.31 0.36 | 0.36 | |

| | Str | eam: Calvert Cliffs, Re | each - Woodla | nd SE-1 | L | ocation: Calv | ert Clif | fs Nuclear P | lant | | |
|---|----------|--|------------------------------------|------------------------------|--|------------------|------------------------------|---|--------------------------|---------------------------------------|---------------------|
| 1 | Ob | <u>servers: Jim Morris, Tom</u> | King | Date: 10/01 | /09 | Val | еу Туре | : IX Exercised data | Strea | т Туре: С 5 | Simo |
| | | | | € € | Ri | ver Reac | h Sun | mary Da | ta. | | |
| ŕ | n. | Mean Riffle Depth (d _{bkf}) | 0.38, ft | <u> </u> | 111 | | | | | | str ² |
| | | Mean Pool Depth (d _{bkfp}) | 0.74 ft | Pool Width (\ | N _{bkfp}) | 5 | ift | Pool Area (A | _{bkíp}) | 3:69 | ۴t ² |
| | ion | Mean Pool Depth/Mean Riffle Depth | 1.95 d _{bkfp} / | Pool Width/R | iffle Widt | h 0:8 | W _{bkfp} / | Pool Area / F | Riffle Area | 1.64 | A _{bkfp} / |
| | ens | Max Riffle Depth (d _{maxrif}) | 0.89 ft | Max Pool De | pth (d _{maxp} |) 14 | ft | Max Riffle De | epth/Mean f | Riffle Depth | 2.342 |
| - | Ĕ | Max Pool Depth/Mean Riffle | Depth 3.711 | Point Bar Slo | ре | Ō | ft/ft | Inner Berm V | Vidth (W _{ib}) | 0 | 麜 ft |
| - | ם ה | Inner Berm Depth (d _{ib}) | 0 ft | Inner Berm W | vidth/Dep | th Ratio | 0 | W _{ib} /d _{ib} Inn | er Berm Ar | ea (A _{ib}) | ∰ ft ² |
| Post and the | Ē | Streamflow: Estimated Mea | n Velocity at Ba | nkfull Stage (u | _{bkí}) | 2.31 | ft/s | Estimation M | ethod | | |
| - | , na | Streamflow: Estimated Disc | harge at Bankfu | Il Stage (Q _{bkf}) | | 5.2 | cfs | Drainage Are | a | 0.075 | a mi² |
| | _ | Geometry | Mean Min | Max | | Dimensio | nless Gi | ometry Ratio | S | Mean Mir | i Maxe |
| L | | Meander Wavelength (L _m) | 49.3 36 | 66n ft | Meande | r Length Rati | o (L _m /W | _{okf}) | <u> </u> | 8.40 6.1 | 4 11.26 |
| | 6 | Radius of Curvature (R _c) | 6.65 3 | 9:5 ft | Radius | of Curvature/ | Riffle Wi | dth (R _c /W _{bkf}) | - , | 1.13 0.5 | 1 1.62 |
| <u>ا</u> | | Belt Width (W _{bit}) | 55 50 | 70 ft | Meande | r Width Ratio | (W _{blt} /W | ькі) | | 9:39 8.5 | 3 11.95 |
| HAND BANK | _ | Individual Pool Length | 12.5 4.23 | 28.7 ft | Pool Lei | ngth/Riffle Wi | dth | | | 2.13 0.7 | 2 4.90 |
| HALL ST | Ger | Pool to Pool Spacing | 29.8 18.5 | 47.8 ft | Pool to I | Pool Spacing | /Riffle W | idth | | 5.09 3.1 | 5 8.16 |
| 1000 | rat I | Riffle Length | 18.9 7.57 | 30.9 ft | Riffle Le | ngth/Riffle W | idth | | | 3.22 1.2 | 9 5.28. |
| | nel | Valley Slope (VS) | 0132 ft/ft | Average Wate | er Surfac | e Slope (S) | 0.0 | 1104 ft/ft | Sinuosity | (VS/S) | 1.2. |
| | uar | Stream Length (SL) | 0 | Valley Length | (VL) | | | 0 | Sinuosity | (SL/VL) | |
| Care of the | 5 | Low Bank Height sta | rt 0.2 ft | Max Rit | ffle | start 0 | ft | Bank-Hei | ght Ratio (E | 3HR) sta | n See |
| | | Facet Slopes | Mean Min | Max | | Dimensioni | ess Slo | e Ratios | | Mean Mir | Max |
| | [| Riffle Slope (S _{rif}) | 0.008 0.002 | 0.016 ft/ft | Riffle Slo | ope/Average | Water S | urface Slope (| S _{rif} / S) | 0.709 0.14 | 9 1.467 |
| ard stands | | Run Slope (S _{run}) | 0.043 0.015 | 0.082 ft/ft | Run Slo | pe/Average V | Vater Su | rface Slope (S | run / S) | 3.919 1.35 | 8 7.397 |
| ana an | | Pool Slope (S _p) | 0.001 0.000 | 0.003 ft/ft | Pool Sio | pe/Average V | Vater Su | rface Slope (S | S _p / S) | 0.112 0.00 | 0 0.305 |
| ALCORD STOR | | Glide Slope (S _g) | 0.001 0.000 | 0.003 ft/ft | Glide Slo | ope/Average | Water S | urface Slope (| S _g / S) | 0.121 0.00 | 0 0.291 |
| 100 C | | Feature Midpoint a | Mean Min | Max | | Dimension | ess Dep | th Ratios | | Méan Min | Max |
| Gizte en | | Max Riffle Depth (d _{maxrif}) | 0.89 0.89 | .0.89 ft | Max Riff | le Depth/Mea | n Riffle I | Depth (d _{maxrif} / | d _{bkf}) | 2.34 2.34 | 2.34 |
| hara peri | e | Max Run Depth (d _{maxrun}) | 0.64 0.64 | 0.64 ft | Max Rur | Depth/Mean | Riffle D | epth (d _{maxrun} / | d _{bkf}) | 1.68 1.68 | 3 1.68 |
| 2.48% X-> | 5 | Max Pool Depth (d _{maxp}) | 1.41 1.41 | 1.41 ft | Max Poo | l Depth/Mear | n Riffle D | epth (d _{maxp} / d | _{bkf}) | 3.71 3.7 | 3.71 |
| -465569 | ר ב | Max Glide Depth (d _{maxg}) | 0.77 0.77 | 0.77 ft | Max Glid | le Depth/Mea | n Riffle I | Depth (d _{maxg} / d | d _{bkí}) | 2.03 2.03 | 2.03 |
| a state of | | P | ach ^b Dif | na ^c . E | Sar ¹ | Pa | b | Diffic ^C | Bar | Broteinian | Laist d |
| 1000 | | % Silt/Clay | 5.7,1 1 1 | 6 | | D ₁₆ | .03 | 0.06 | 0 | | mm |
| at the second | | % Sand | 2.86 5 | 8 | 00 | D ₃₅ | .06 | 0.17 | Ó. | 0 | mm |
| 10000 | 2 | % Gravel | 1.43 2 | 622 (|) | D ₅₀ | .18 | 0.2 | O S | 0 | mm |
| | | % Cobble | 0 0 | | | D ₈₄ | .14 | 7.42 | 0 | · 0 | mm |
| 観察のからい | | % Boulder | 0 | | | D ₉₅ | .64 | 10.97 | 0 | 0 | mm |
| 12.00 | | 6 Bedrock | 0 | | | D ₁₀₀ | 1:3 | 16 . | 2. | 0 | mm |
| a | - 6 | the anti- strange provide the associate the second strange and associations. | na na salita ang kana kana sala sa | | تقري^ي «يوني دريز برسي». • • • • • • • • • • • • • • • • • | server and a set | 1.54949 (1.100) (1.100) 1 | | AND TRUE ALL AND SHARE A | and a substant and take of high and - | ADD 1 |

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2005).

nax, mean depths are ave. mid-point values except pools: taken at deepest part of pool. ^b Composite sample of riffles and pools within the designated reach.

^c Active bed of a riffle.

^d Height of roughness feature above bed.

SR 1 Imp

.



| Stream: | Calvert Cliffs, Reach - Woodland Top of SR-1 Uplift | | |
|-----------|--|-------------|------------------|
| Basin: | Drainage Area: 0 acres | 0 | mi ² |
| Location: | | | |
| Twp.&Rge | Sec.&Qtr.: ; | | |
| Cross-Sec | tion Monuments (Lat./Long.): 0 Lat / 0 Long | Date | : 10/05/0 |
| Observers | · · · · · · · · · · · · · · · · · · · | Valley Type | : IX |
| | Bankfull WIDTH (W _{bkf}) | | ٦ |
| | WIDTH of the stream channel at bankfull stage elevation, in a riffle section. | 5.25 | ft |
| | Bankfull DEPTH (desc) | | ר |
| | Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a | | |
| | riffle section ($d_{bkt} = A / W_{bkt}$). | 0.46 | ft |
| | Bankfull X-Section AREA (A _{bk}) | | 7 |
| | AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle | · · | |
| | section. | 2.43 | _ft ² |
| | Width/Depth Ratio (W _{bkf} / d _{bkf}) | | ר |
| | Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section. | 11.41 | ft/ft |
| | Maximum DEPTH (d) | | 7 |
| | Maximum depth of the bankfull channel cross-section, or distance between the | | |
| | bankfull stage and Thalweg elevations, in a riffle section. | 0.56 | ft |
| , | WIDTH of Flood-Prone Area (W _{fna}) | - | 7 |
| | Twice maximum DEPTH, or (2 x d _{mbkl}) = the stage/elevation at which flood-prone area | | |
| | WIDTH is determined in a riffle section. | 8.06 | ft |
| | Entrenchment Ratio (ER) | | 7 |
| | The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W _{tpa} / W _{bkl}) | | |
| | (rime section). | 1.54 | _ft/ft |
| | Channel Materials (Particle Size Index) D ₅₀ | | |
| | The D_{50} particle size index represents the mean diameter of channel materials, as | | |
| | elevations. | 0.13 | mm |
| | | | ייייים. ר |
| | Water Surface SLOPE (S) | | |
| | widths in length, with the "riffle-to-riffle" water surface slope representing the gradient | | |
| | at bankfull stage. | 0.0124 | ft/ft |
| | Channel SINUOSITY (k) | | 7 |
| | Sinuosity is an index of channel pattern, determined from a ratio of stream length | | |
| | divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S). | | |
| İ | | 1.1 | |
| | Stream B5c | | |
| | Type (See Figure 2- | 14) | |

RIVERMORPH PROFILE SUMMARY

River Name: Calvert Cliffs Reach Name: Woodland Top of SR-1 Uplift Profile Name: Main Reach Survey Date: 10/02/2009

Survey Data

DIST WS CH BKF **P1** P2 P3 P4 1 7.14 5 5 7.04 6.94 8 7.04 6.94 12 7.28 7.03 5.22 17 7.55 7.72 19 23 7.77 5.36 5.28 27 7.49 5.49 6.92 30 7.28 33 7.13 6.83 7.03 5.46 36 7.13 7.03 40 7.22 7.07 45 7.42 7.29 5.97 47 7.5 7.37 6.07 51 7.78 7.37 6.61 5.57 53 7.72 7.37 57 8.09 7.55 5.78 61 8.15 64 7.52 5.46 5.67 7.47 7.37 67 71 7.54 7.39 5.46 5.78 76 7.55 7.45 78 7.69 81 7.73 6.03 6.23 7.61 83 8.16 7.62 7.77 7.62 84 86 7.98 89 7.87 91 7.92 93 7.87 7.77 6.32 6.22 95 8.44 97 8.44 8.16 100 8.48 8.16 6.3 103 8.3 8.16 106 8.28 8.17 108 8.4 6.24 6.27 111 8.44

file:///lovetonfp/...itigation/Design%20Data/all%20rivermorph%20reports/SR-1%20Imp/sr-1%20main%20channel%20profile%20report.txt[10/5/2010 10:11:19 AM]



| 115 | 8.38 | | | | |
|-----|------------|------|------|------|------|
| 119 | 8.35 | | | | |
| 122 | 8.4 | | | , | |
| 125 | 8.29 | 8.19 | 6.65 | 6.62 | |
| 128 | 8.32 | | | | |
| 133 | 8.35 | | 6.69 | 6.58 | |
| 138 | 8.38 | | 6.87 | 6.84 | 7.44 |
| 142 | 8.39 | | | | |
| 146 | 8.33 | 8.23 | 7.02 | | |
| 149 | 8.44 | | | | |
| 150 | 8.53 | | | | |
| 152 | 8.57 | | | | |
| 154 | 8.43 | | | | |
| 156 | 8.39 | | 6.9 | | |
| 159 | 8.61 | | 6.7 | 6.9 | |
| 163 | 8.53 | | | | |
| 166 | 8.44 | | | | |
| 170 | 8.57 | | 6.95 | 6.84 | |
| 174 | 8.47 | | | | |
| 176 | 8.35 | 8.25 | | | |
| 177 | 8.6 | | | | |
| 179 | 8.47 | | | | |
| 182 | 8.47 | | | | |
| 185 | 8.45 | 8.35 | 7.49 | 7.02 | |
| 190 | 8.74 | | | | |
| 193 | 8.62 | 8.52 | | | |
| 197 | 8.67 | | | | |
| 199 | 8.71 | | | | |
| 202 | 8.84 | | 7.58 | 7.36 | |
| 205 | 8.73 | | | | |
| 208 | 8.66 | 8.56 | | | |
| 211 | 8.69 | 8.59 | | | |
| 213 | 8.76 | 8.66 | 7.86 | | |
| 216 | 8.91 | 8.76 | | | |
| 218 | 9 | 8.76 | 7.73 | 7.76 | |
| | | | | | |

Cross Section / Bank Profile Locations

| Name | Туре | Profile Stat | ion |
|-------------------------|-----------|--------------|-----|
| Pool at 21 | Pool XS | 21 | |
| Riffle 142 | Riffle XS | 142 | |
| Abandonned Riffle at 11 | Riffle | XS 11 | |
| Abandonned Pool at 60 | Pool | XS 60 | |

Measurements from Graph

Bankfull Slope: 0.0124

| Variable | Min | Avg | | Max | |
|----------|-----|-----|---|-----|--|
| S riffle | 0 | 0 | 0 | | |
| S pool | 0 | 0 | 0 | | |

| | 0 | 0 | |
|---|--------------------------------------|---|--|
|) | 0 | 0 | |
| | 0 | 0 | |
| 0 | 0 | 0 | |
| 0 | 0 | 0 | |
| 0 | 0 | 0 | |
| 0 | 0 | 0 | |
| 0 | 0 | 0 | |
| 0 | 0 | 0 | |
| 0 | 0 | 0 | |
| | 0 0 0 0 0 0 0 0 | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | $\begin{array}{cccccccccccccccccccccccccccccccccccc$ |

Length and depth measurements in feet, slopes in ft/ft.

RIVERMORPH PROFILE SUMMARY

Notes

River Name: Calvert Cliffs Reach Name: Woodland Top of SR-1 Uplift Profile Name: Main Reach Survey Date: 10/02/2009

DIST Note

| 1 | left- note - entire reach shot in the dry! |
|-----|--|
| 8 | gravel bar present |
| 12 | left |
| 23 | left/right |
| 27 | left, inner berm |
| 33 | left, inner berm |
| 40 | mid riffle |
| 45 | left |
| 51 | right / top bar |
| 57 | left / top berm |
| 71 | left/right |
| 81 | l/r - lots of woody debris |
| 93 | l/r |
| 100 | left |
| 108 | right |
| 111 | left |
| 125 | right/left |
| 133 | right/left |
| 138 | r/l tw of ab channel start at 153 |
| 146 | left |
| 156 | right |
| 159 | right/left |
| 170 | RIGHT/LEFT |
| 182 | start gravel bar |
| 185 | left/right |
| 202 | left/right |
| 213 | right |
| 218 | right/left |
River Name:Calvert CliffsReach Name:Woodland Top of SR-1 UpliftCross Section Name:Riffle 142Survey Date:10/02/2009

·-----

Cross Section Data Entry

BM Elevation:98 ftBacksight Rod Reading:2 ft

| TAPE | FS | ELEV | NOTE | · |
|------|------|-------|------|----|
| 0 | 6.28 | 93.72 | LEP | ** |
| 2 | 6.86 | 93.14 | | |
| 3 | 7.07 | 92.93 | | |
| 3.5 | 7.21 | 92.79 | | |
| 3.88 | 0 | 92.2 | BKF | |
| 4 | 8.01 | 91.99 | | |
| 4.5 | 8.21 | 91.79 | | |
| 5 | 8.24 | 91.76 | | |
| 6 | 8.36 | 91.64 | | |
| 7 | 8.36 | 91.64 | | |
| 8 | 8.34 | 91.66 | | |
| 9 | 8.1 | 91.9 | | |
| 9.5 | 6.96 | 93.04 | | |
| 10 | 6.84 | 93.16 | | |
| 11 | 7.01 | 92.99 | | |
| 12 | 7.17 | 92.83 | | |
| 12.5 | 7.39 | 92.61 | | |
| 13 | 7.42 | 92.58 | | |
| 14 | 7.29 | 92.71 | | |
| 15 | 7.15 | 92.85 | | |
| 16 | 6.78 | 93.22 | | |
| 18 | 6.44 | 93.56 | | |
| 20 | 6.26 | 93.74 | | |
| 22 | 6.13 | 93.87 | | |
| 24 | 6.07 | 93.93 | | |

Cross Sectional Geometry

| Channe | el Left | | Right | |
|-------------------------|-----------|----|-------|-------|
| Floodprone Elevation (1 | ft) 93.92 | 2 | 93.92 | 93.92 |
| Bankfull Elevation (ft) | 92.78 | 92 | 2.78 | 92.78 |
| Floodprone Width (ft) | 23.67 | - | | |
| Bankfull Width (ft) | 8.27 | 3 | 7. | 99 |

| Entrenchment Ratio | 2.86 | | |
|-----------------------|-------|------|-------|
| Mean Depth (ft) | 0.72 | 0.93 | 0.6 |
| Maximum Depth (ft) | 1.14 | 1.14 | 1.14 |
| Width/Depth Ratio | 11.49 | 3.23 | 13.32 |
| Bankfull Area (sq ft) | 5.94 | 2.8 | 3.14 |
| Wetted Perimeter (ft) | 9.4 | 4.63 | 7.06 |
| Hydraulic Radius (ft) | 0.63 | 0.6 | 0.44 |
| Begin BKF Station | 3.51 | 3.51 | 6.51 |
| End BKF Station | 14.5 | 6.51 | 14.5 |

Entrainment Calculations

·

Entrainment Formula: Rosgen Modified Shields Curve

Channel Left Side Right Side Slope 0 0 0 Shear Stress (lb/sq ft) Movable Particle (mm)

River Name:Calvert CliffsReach Name:Woodland Top of SR-1 UpliftCross Section Name:Pool at 21Survey Date:10/02/2009

Cross Section Data Entry

BM Elevation:98 ftBacksight Rod Reading:2 ft

| TAPE | FS | ELEV | NOTE | |
|------|------|-------|----------|--|
| 0 | 5.33 | 94.67 | LEP | |
| 2 | 5.33 | 94.67 | | |
| 4 | 5.32 | 94.68 | | |
| 5 | 5.37 | 94.63 | | |
| 6 | 5.85 | 94.15 | | |
| 7 | 6.04 | 93.96 | BKF | |
| 8 | 6.7 | 93.3 | | |
| 10 | 7.53 | 92.47 | | |
| 11 | 7.82 | 92.18 | | |
| 12 | 7.8 | 92.2 | | |
| 13 | 7.19 | 92.81 | vertical | |
| 13.2 | 5.53 | 94.47 | | |
| 15 | 5.24 | 94.76 | | |
| 18 | 4.98 | 95.02 | | |
| | | | | |

Cross Sectional Geometry

| Chann | el Left | Righ | it |
|-------------------------|-----------|--------|---------|
| Floodprone Elevation (| ft) 95.74 | 4 95.7 | 4 95.74 |
| Bankfull Elevation (ft) | 93.96 | 93.96 | 93.96 |
| Floodprone Width (ft) | 18 | | |
| Bankfull Width (ft) | 6.14 | 3.07 | 3.07 |
| Entrenchment Ratio | 2.93 | | |
| Mean Depth (ft) | 1.21 | 0.84 | 1.58 |
| Maximum Depth (ft) | 1.78 | 1.51 | 1.78 |
| Width/Depth Ratio | 5.07 | 3.65 | 1.94 |
| Bankfull Area (sq ft) | 7.42 | 2.59 | 4.83 |
| Wetted Perimeter (ft) | 7.73 | 4.95 | 5.81 |
| Hydraulic Radius (ft) | 0.96 | 0.52 | 0.83 |
| Begin BKF Station | 7 | 7 | 10.07 |
| End BKF Station | 13.14 | 10.07 | 13.14 |

Entrainment Formula: Rosgen Modified Shields Curve

ChannelLeft SideRight SideSlope000Shear Stress (lb/sq ft)00Movable Particle (mm)00

RIVERMORPH REACH SUMMARY

River Name: Calvert Cliffs Reach Name: Woodland Top of SR-1 Uplift

Stream Type Valley Type D50(mm)Val SlopeBKF Q(cfs)DA(sq mi)B 5cIX0.130.013600

Dimension Summary

Database based on the following Cross Sections:

| Variable | Min | Avg | Max | |
|--------------------------|-------|---------|---------|--|
| Floodprone Width (ft) | 8 | .06 8.0 |)6 8.06 | |
| Riffle Area (Sq ft) | 2.43 | 3 2.43 | 2.43 | |
| Max Riffle Depth (ft) | 0. | 56 0.5 | 6 0.56 | |
| Mean Riffle Depth (ft) | 0 | .46 0. | 46 0.46 | |
| Riffle Width (ft) | 5.25 | 5.25 | 5.25 | |
| Pool Area (Sq ft) | 7.42 | 2 7.42 | 7.42 | |
| Max Pool Depth (ft) | 1. | 78 1.7 | /8 1.78 | |
| Mean Pool Depth (ft) | 1 | .21 1.1 | 21 1.21 | |
| Pool Width (ft) | 6.14 | 6.14 | 6.14 | |
| Run Area (Sq ft) | 0 | 0 | 0 | |
| Max Run Depth (ft) | 0 | 0 | 0 | |
| Mean Run Depth (ft) | 0 | 0 | 0 | |
| Run Width (ft) | 0 | 0 | 0 | |
| Glide Area (Sq ft) | 0 | 0 | 0 | |
| Max Glide Depth (ft) | 0 | . 0 | 0 | |
| Mean Glide Depth (ft) | 0 | 0 | 0 | |
| Glide Width (ft) | 0 | 0 | 0 | |
| Pattern Summary | | | | |
| Variable | Min | Avg | Max | |
| Sinuceity | 1 | 1 | | |
| Meander Wavelength (f | i) I | 0 0 | 0 | |
| Radius of Curvature (ft) | ., 0 | 0 | 0 | |
| Belt Width (ft) | 0 | 0 0 |) | |
| | Ū | 0 | , , | |
| Profile Summary | | | | |
| | | | | |
| Data Based on the follow | wing: | | | |
| Variable | Min | Δνα | Max | |
| • and the | | | | |
| S riffle (ft/ft) | 0 0 | 0 | | |
| S pool (ft/ft) | 0 | 0 0 | | |

| S run (ft/ft) | 0 | | 0 | | 0 | | | |
|-------------------------|-----|----|----|-----|------|---|------|--|
| S glide (ft/ft) | 0 | | 0 |) | 0 |) | | |
| P - P (ft) | 0 | | 0 | | 0 | | | |
| Pool length (ft) | | 0 | | 0 | | 0 | | |
| Riffle length (ft) | | 0 | | 0 | | 0 | | |
| Dmax riffle (ft) | | 0 | | 0.5 | 56 | 0 | | |
| Dmax pool (ft) | | 1. | 78 |] | 1.78 | } | 1.78 | |
| Dmax run (ft) | | 0 | | 0 | | 0 | | |
| Dmax glide (ft) | | 0 | | 0 | | 0 | | |
| Low bank ht start-end (| ft) | | 0 | | 0 | | 0 | |
| Bankfull slope (ft/ft) | | | | 0. | 012 | 4 | | |

Hydraulic Summary

| Variable | Min | Avg | Max | |
|-----------------------------------|------|--------|------|--|
| Discharge (cfs) Velocity (fps) | | 0 0 | | |
| Hyd Radius (ft) | 0.43 | 0.43 | 0.43 | |

RIVERMORPH PROFILE SUMMARY

River Name: Calvert Cliffs

Reach Name: Woodland Top of SR-1 Uplift Profile Name: Abandoned Channel Survey Date: 10/02/2009

Survey Data

| DIST | CH CH | WS | BKF | P1 | P2 | P3 | P4 | |
|------|-------|------|------|----|----|----|----|--|
| 2 | 6.46 | | | | | | | |
| 5 | 6.55 | 5.83 | 5.93 | | | | | |
| 8 | 6.65 | | | | | | | |
| 11 | 6.75 | 5.95 | 5 | | | | | |
| 13 | 6.77 | 6.01 | 5.96 | | | | | |
| 16 | 6.93 | | | | | | | |
| 18 | 6.8 | | | | | | | |
| 21 | 6.87 | 5.95 | 6.4 | | | | | |
| 23 | 6.84 | | | | | | | |
| 25 | 6.84 | | | | | | | |
| 28 | 6.84 | | | | | | | |
| 30 | 6.87 | | | | | | | |
| 32 | 6.95 | | | | | | | |
| 36 | 7.08 | | | | | | | |
| 38 | 7.12 | | | | | | | |
| 40 | 7.14 | | | | | | | |
| 42 | 7.29 | | | | | | | |
| 44 | 7.22 | | | | | | | |
| 46 | 7.29 | | | | | | | |
| 48 | 7.33 | | | | | | | |
| 50 | 7.38 | | | | | | | |
| 52 | 7.26 | | | | | | | |
| 54 | 7.31 | | | | | | | |
| 56 | 7.37 | | | | | | | |
| 58 | 7.54 | | | | | | | |
| 60 | 7.53 | 6.58 | | | | | | |
| 62 | 7.47 | | | | | | | |
| 64 | 7.45 | | | | | | | |
| 66 | 7.5 | | | | | | | |
| 68 | 7.58 | | | | | | | |
| 70 | 7.58 | | | | | | | |
| 72 | 7.67 | | | | | | | |
| 74 | 7.71 | | | | | | | |
| 76 | 7.69 | | | | | | | |
| 78 | 7.68 | | | | | | | |
| 80 | 7.62 | | | | | | | |
| 82 | 767 | | | | | | | |

 84
 7.59

 86
 7.53

 88
 7.66

 90
 7.77

 92
 8.91
 7.02

Cross Section / Bank Profile Locations

| Name | Туре | Profile S | Station |
|-------------------------|-----------|-----------|---------|
| Pool at 21 | Pool XS | 21 | |
| Riffle 142 | Riffle XS | 142 | |
| Abandonned Riffle at 11 | Riffle X | KS | 11 |
| Abandonned Pool at 60 | Pool X | S | 60 |

Measurements from Graph

Bankfull Slope: 0

| Avg | Max |
|-----|--|
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| | Avg 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |

Length and depth measurements in feet, slopes in ft/ft.

RIVERMORPH PROFILE SUMMARY

Notes

River Name: Calvert Cliffs Reach Name: Woodland Top of SR-1 Uplift Profile Name: Abandoned Channel Survey Date: 10/02/2009

DIST Note

5 l/r

13 right/left

21 left/right

92 bottom of main channel at end

.

River Name:Calvert CliffsReach Name:Woodland Top of SR-1 UpliftCross Section Name:Abandonned Riffle at 11Survey Date:10/02/2009

Cross Section Data Entry

BM Elevation:98 ftBacksight Rod Reading:2 ft

| TAPE | FS | ELEV | NOTE | |
|------|------|-------|------|---|
| 0 | 5.98 | 94.02 | BKF | |
| 1 | 6.18 | 93.82 | | |
| 1.5 | 6.43 | 93.57 | | |
| 2 | 6.63 | 93.37 | | |
| 2.5 | 6.74 | 93.26 | | |
| 3 | 6.72 | 93.28 | | |
| 3.5 | 6.72 | 93.28 | | |
| 4 | 6.63 | 93.37 | | |
| 5 | 6.48 | 93.52 | | |
| 6 | 6.14 | 93.86 | 1 | |
| 7 | 5.95 | 94.05 | | |
| 8 | 5.89 | 94.11 | | |
| 9 | 5.94 | 94.06 | | |
| 10 | 5.95 | 94.05 | | |
| | | | - | 1 |

Cross Sectional Geometry

, ______

| Chann | el Left | Rigl | nt |
|-------------------------|-----------|--------|---------|
| Floodprone Elevation (| ft) 94.78 | s 94.7 | 8 94.78 |
| Bankfull Elevation (ft) | 94.02 | 94.02 | 94.02 |
| Floodprone Width (ft) | 10 | | |
| Bankfull Width (ft) | 6.84 | 3.42 | 3.42 |
| Entrenchment Ratio | 1.46 | | |
| Mean Depth (ft) | 0.43 | 0.46 | 0.4 |
| Maximum Depth (ft) | 0.76 | 0.76 | 0.74 |
| Width/Depth Ratio | 15.91 | 7.43 | 8.55 |
| Bankfull Area (sq ft) | 2.95 | 1.58 | 1.38 |
| Wetted Perimeter (ft) | 7.06 | 4.29 | 4.25 |
| Hydraulic Radius (ft) | 0.42 | 0.37 | 0.32 |
| Begin BKF Station | 0 | 0 | 3.42 |
| End BKF Station | 6.84 | 3.42 | 6.84 |

file:///lovetonfp/...20Mitigation/Design%20Data/all%20rivermorph%20reports/SR-1%20Imp/sr-1%20fp%20channel%20riffle%20report.txt[10/5/2010 10:11

~

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

ChannelLeft SideRight SideSlope000Shear Stress (lb/sq ft)00Movable Particle (mm)

River Name: Calvert Cliffs Reach Name: Woodland Top of SR-1 Uplift Cross Section Name: Abandonned Pool at 60 Survey Date: 10/02/2009 Cross Section Data Entry BM Elevation: 98 ft Backsight Rod Reading: 2 ft

| TAPE | FS | ELEV | NOTE | |
|------|------|-------|------|---|
| 0 | 6.97 | 93.03 | | |
| 2 | 6.93 | 93.07 | | |
| 5 | 6.79 | 93.21 | | |
| 8 | 6.59 | 93.41 | | |
| 10 | 6.59 | 93.41 | | |
| 11 | 6.59 | 93.41 | | |
| 12 | 6.66 | 93.34 | BKF | |
| 14 | 7.26 | 92.74 | | |
| 15 | 7.44 | 92.56 | | |
| 15.5 | 7.46 | 92.54 | | |
| 16 | 7:5 | 92.5 | | • |
| 16.5 | 7.5 | 92.5 | | |
| 17 | 7.39 | 92.61 | | |
| 18 | 6.97 | 93.03 | | |
| 19 | 6.59 | 93.41 | | |
| 20 | 6.42 | 93.58 | REP | |

Cross Sectional Geometry

| Chann | el Left | Righ | nt |
|-------------------------|-----------|--------|---------|
| Floodprone Elevation (| ft) 94.18 | 3 94.1 | 8 94.18 |
| Bankfull Elevation (ft) | 93.34 | 93.34 | 93.34 |
| Floodprone Width (ft) | 20 | | |
| Bankfull Width (ft) | 6.82 | 3.41 | 3.41 |
| Entrenchment Ratio | 2.93 | | |
| Mean Depth (ft) | 0.52 | 0.47 | 0.57 |
| Maximum Depth (ft) | 0.84 | 0.8 | 0.84 |
| Width/Depth Ratio | 13.12 | 7.26 | 5.98 |
| Bankfull Area (sq ft) | 3.55 | 1.61 | 1.94 |
| Wetted Perimeter (ft) | 7.08 | 4.31 | 4.36 |
| Hydraulic Radius (ft) | 0.5 | 0.37 | 0.45 |
| Begin BKF Station | 12 | 12 | 15.41 |
| End BKF Station | 18.82 | 15.41 | 18.82 |

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

Channel Left Side Right Side Slope 0 0 0 Shear Stress (lb/sq ft) Movable Particle (mm)

SR 1 Middle Imp

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

| Basin: | Drainage Area: 0 acres | 0 | mi ² | | | |
|-----------|---|--------------|-----------------|--|--|--|
| Location: | | | | | | |
| Twp.&Rge | :; Sec.&Qtr.:; | | | | | |
| Cross-Sec | tion Monuments (Lat./Long.): 0 Lat / 0 Long | Date: | 10/15/09 | | | |
| Observers | : | Valley Type: | IX | | | |
| | Bankfull WIDTH (W _{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section. | 7 | ft | | | |
| | | | 1 | | | |
| | Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section (d_{bkf} = A / W_{bkf}). | 1.01 | ft | | | |
| | Bankfull X-Section AREA (A _{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section. | 7.06 | ft ² | | | |
| | Width/Depth Ratio (W _{bkf} / d _{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section. | | | | | |
| | Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section. | 1.6 | ft | | | |
| | WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or (2 x d _{mbkl}) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section. | 8.5 | ft | | | |
| | Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W _{fpa} / W _{bkl}) (riffle section). | 1.21 | ft/ft | | | |
| | Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations. | 0.12 | mm | | | |
| . • | Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage. | 0.00395 | ft/ft | | | |
| | Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S). | 1.12 | | | | |
| | Stream Type (See Figure 2- | 14) | 2 | | | |

Copyright © 2006 Wildland Hydrology

٦,

1

RIVERMORPH PROFILE SUMMARY

River Name: Calvert Cliffs Reach Name: Woodland SR-1 Middle Profile Name: Reach SR-1 Mid Survey Date: 10/15/2009

Survey Data

| DIST | CH | WS | S BKF | P1 | P2 | P3 | P4 | |
|------|------|------|----------|----|----|----|-----|--|
| 0 | 8.34 | 8.24 | 5.35 | | | | ``` | |
| 4 | 8.33 | 8.23 | | | | | | |
| 8 | 8.36 | 8.26 | 5.09 | | | | | |
| 11 | 8.39 | 8.29 | | | | | | |
| 15 | 8.47 | 8.33 | 5.18 | | | | | |
| 17 | 8.43 | 8.33 | | | | | | |
| 19 | 8.46 | 8.36 | | | | | | |
| 22 | 8.46 | 8.36 | 5.17 | | | | | |
| 25 | 8.47 | 8.37 | | | | | | |
| 31 | 8.49 | 8.39 | | | | | | |
| 34 | 8.54 | 8.44 | | | | | | |
| 37 | 8.59 | 8.45 | | | | | | |
| 40 | 8.55 | 8.45 | | | | | | |
| 43 | 8.56 | 8.46 | | | | | | |
| 45 | 8.56 | 8.46 | | | | | | |
| 48 | 8.85 | 8.62 | | | | | | |
| 50 | 8.72 | 8.62 | | | | | | |
| 59 | 8.9 | 8.76 | 5.58 | | | | | |
| 62 | 8.9 | 8.76 | | | | | | |
| 64 | 8.97 | 8.75 | | | | | | |
| 68 | 8.87 | 8.75 | | | | | | |
| 71 | 8.85 | 8.75 | | | | | | |
| 73 | 8.9 | 8.8 | | | | | | |
| 75 | 8.93 | 8.83 | | | | | | |
| 77 | 8.94 | 8.84 | | | | | | |
| 80 | 8.97 | 8.87 | | | | | | |
| 83 | 8.97 | 8.87 | | | | | | |
| 86 | 8.97 | 8.87 | 7.74 5.3 | 4 | | | | |
| 87 | 9.1 | 8.93 | | | | | | |
| 89 | 9.06 | 8.93 | | | | | | |
| 91 | 9.03 | 8.93 | | | | | | |
| 93 | 9.11 | 8.93 | | | | | | |
| 95 | 9.03 | 8.93 | | | | | | |
| 97 | 9.05 | 8.95 | | | | | | |
| 101 | 9.09 | 8.99 | 5.68 | | | | | |
| 103 | 9.17 | 9.06 | | | | | | |
| 105 | 9.29 | 9.06 | | | | | | |

. _ _ _

| 109 | 9.37 | 9.06 | | | | | | |
|-------|----------|----------|------------------|-----------------|---|---|--|--|
| 113 | 9.16 | 9.06 | | | | | | |
| 117 | 9.19 | 9.09 | | | | | | |
| 122 | 9.24 | 9.14 | | | | | | |
| 125 | 9.35 | 9.17 | 5.7 | | | | | |
| 132 | 9.4 | 9.17 | | | | | | |
| 134 | 9.29 | 9.17 | | | | | | |
| 137 | 9.49 | 9.17 | 7.94 | | | • | | |
| 139 | 9.64 | 9.17 | | | | | | |
| 140 | 9.78 | 9.17 | | | | | | |
| 143 | 9.81 | 9.17 | 5.26 | | | | | |
| 148 | 9.51 | 9.17 | | | | | | |
| 151 | 9.27 | 9.17 | | | | | | |
| 155 | 9.28 | 9.18 | | | | | | |
| 158 | 9.38 | 9.28 | | | | | | |
| 162 | 9.39 | 9.29 | 5.59 | | | | | |
| 168 | 9.42 | 9.29 | | | | | | |
| 172 | 9.38 | 9.29 | 5 (7 | | | | | |
| 1/8 | 9.32 | 9.29 | 5.67 | | | | | |
| 182 | 9.5 | 9.29 | | | | | | |
| 185 | 9.35 | 9.29 | | | · | | | |
| 100 | 9.37 | 9.5 | | | | | | |
| 195 | 9.51 | 9.50 | | | | | | |
| 203 | 9.41 | 9.33 | 5.03 | | | | | |
| 203 | 9.39 | 9.35 | 5.95 | | | | | |
| 212 | 9.55 | 9.50 | · | | | | | |
| 215 | 9.55 | 9.45 | | | | | | |
| 220 | 9.55 | 9.45 | 6.23 | | | | | |
| 224 | 9.62 | 95 | 0.25 | | | | | |
| 228 | 9.79 | 9.54 | | | | | | |
| 231 | 9.6 | 9.53 | 6.62 | | | | | |
| 234 | 9.65 | 9.55 | | | | | | |
| 237 | 9.61 | 9.54 | | | | | | |
| 241 | 9.61 | 9.54 | | | | | | |
| 244 | 9.66 | 9.56 | 6.57 | | | | | |
| 248 | 9.67 | 9.57 | | | | | | |
| 252 | 9.67 | 9.57 | | | | | | |
| 255 | 9.74 | 9.64 | | | | | | |
| 257 | 9.82 | 9.7 | | | | | | |
| Cross | Section | / Bank | Profile Location | ns | | | | |
| Name | | | Туре | Profile Station | | | | |
| POOL | AT 14 | 0 | Pool XS | 5 140 | | | | |
| KIFFI | LE AT 7 | 15 | Riffle X | .8 75 | | | | |
| Measu | irements | s from (| Graph | | | | | |
| Bankf | ull Slop | e: 0.0 | 00395 | | | | | |

Variable Min Avg Max



| S riffle | 0.00407 | 0.00733 | [،] 0.00998 | | | |
|--------------|---|---------|----------------------|--|--|--|
| S pool | 0 | 0.00044 | 0.00084 | | | |
| S run | 0.00808 | 0.02179 | 0.05075 | | | |
| S glide | 0 | 0.0013 | 0.00234 | | | |
| P - P | 34.98 | 59.9 | 84.65 | | | |
| Pool length | 2.67 | 12.11 | 26.17 | | | |
| Riffle lengt | h 10.68 | 18.1 | 41.92 | | | |
| Dmax riffle | e 1 | 1.2 | 1.36 | | | |
| Dmax pool | 1.24 | 1.46 | 1.85 | | | |
| Dmax run | 1.02 | 1.24 | 1.35 | | | |
| Dmax glide | e 1.21 | 1.37 | 1.53 | | | |
| Low bank l | nt 3.26 | 3.37 | 3.49 | | | |
| Length and | Length and depth measurements in feet, slopes in ft/ft. | | | | | |

RIVERMORPH PROFILE SUMMARY

Notes

River Name: Calvert Cliffs Reach Name: Woodland SR-1 Middle Profile Name: Reach SR-1 Mid Survey Date: 10/15/2009

| DIST | Note |
|------|-------------------------|
| 0 | LEFT |
| 4 | THIS REACH WAS SHOT DRY |
| 8 | RIGHT |
| 15 | LEFT |
| 59 | LEFT |
| 75 | RIFFLE SECTION HERE |
| 86 | BENCH / HIGH LEFT BANK |
| 101 | LEFT |
| 125 | LEFT |
| 137 | LEFT |
| 140 | POOL SECTION HERE |
| 143 | LEFT |
| 162 | LEFT |
| 178 | LEFT |
| 203 | LEFT |
| 220 | LEFT |
| 231 | LEFT |
| 244 | LEFT |

257 END OF PROFILE



| River N Reach N Cross S Survey | ame: Jame: ection Nar Date: | Calvert Clif Woodland S ne: RIFFLE 10/15/2009 | fs SR-1 Middle AT 75 | |
|---|--------------------------------------|--|----------------------------|---|
| Cross S | ection Dat | a Entry | | |
| BM Ele | vation: | 98 ft | | |
| Backsig | ht Rod Re | ading: 2 | It | |
| TAPE | FS | ELEV | NOTE | |
| 0 | 5.39 | 94.61 | LEP | |
| 1 | 5.51 | 94.49 | | |
| 4 | 5.5 | 94.5 | | |
| 8 | 5.47 | 94.53 | | |
| 10 | 5.46 | 94.54 | | |
| 11 | 5.28 | 94.72 | | |
| 12 | 5.17 | 94.83 | | |
| 13 | 5.47 | 94.53 | | |
| 14 | 5.57 | 94.43 | | |
| 15 | 5.59 | 94.41 | | |
| 17 | 5.31 | 94.69 | | |
| 19 | 5.24 | 94.76 | | |
| 21 | 5.22 | 94.78 | | |
| 22 | 5.49 | 94.51 | | |
| 23 | 5.97 | 94.03 | | , |
| 24.5 | 7.14 | 92.86 | | |
| 25 | 7.92 | 92.08 | | |
| 26 | 8.21 | 91.79 | | |
| 27 | 8.75 | 91.25 | | |
| 28 | 8.95 | 91.05 | | |
| 29 | 8.91 | 91.09 | | |
| 30 | 8.65 | 91.35 | | |
| 31 | 7.7 | 92.3 | BKF | |
| 32 | 5.48 | 94.52 | | |
| 35 | 5.27 | 94.73 | | |
| 39 | 5.33 | 94.67 | | |
| 44 | 5.39 | 94.61 | | |
| 50 | 5.59 | 94.41 | | |
| 53 | 5.23 | 94.77 | | |
| 59 | 5.36 | 94.64 | | |
| 51 | 5.33 | 94.67 | | |
| | 4 1 7 | 05.02 | | |

Cross Sectional Geometry

file:///lovetonfp/...0Mitigation/Design%20Data/all%20rivermorph%20reports/SR-1%20Middle%20Imp/sr-1%20mid%20riffle%20report.txt[10/5/2010 10:25:23 AM]



Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

ChannelLeft SideRight SideSlope000Shear Stress (lb/sq ft)00Movable Particle (mm)00

River Name:Calvert CliffsReach Name:Woodland SR-1 Middle Cross Section Name: POOL AT 140 Survey Date: 10/15/2009

Cross Section Data Entry

Width/Depth Ratio

BM Elevation: 98 ft Backsight Rod Reading: 2 ft

| TAPE | FS | ELEV | NOTE | | |
|--------------------------------|--------------|------------------|---------------|---|--|
| 0 | 5.95 | 94.05 | LEP | | |
| 3 | 6.14 | 93.86 | | | |
| 5 | 6.09 | 93.91 | | | |
| 7 | 5.85 | 94.15 | | | |
| 8 | 5.78 | 94.22 | | | |
| 9 | 5.86 | 94.14 | | | |
| 9.5 | 7.73 | 92.27 | | | |
| 10 | 8.21 | 91.79 | BKF | | |
| 11 | 8.83 | 91.17 | | | |
| 12 | 9.43 | 90.57 | | - | |
| 13.5 | 9.81 | 90.19 | | | |
| 14 | 9.78 | 90.22 | | | |
| 15 | 9.39 | 90.61 | | | |
| 16 | 9.17 | 90.83 | | | |
| 17 | 8.21 | 91.79 | | | |
| 18 | 5.93 | 94.07 | | | |
| 19 | 5.74 | 94.26 | | | |
| 20 | 5.56 | 94.44 | | | |
| 25 | 5.66 | 94.34 | | | |
| 29 | 5.72 | 94.28 | | | |
| 35 | 5.59 | 94.41 | | | |
| | | | | | |
| Cross S | ectional G | eometry | | | |
| | | | | | |
| | C | hannel Left | Right | | |
| Floodpr | one Elevat | ion (ft) 93.39 | 93.39 93.39 | | |
| Bankful | II Elevation | (ft) 91.79 | 91.79 91.79 | | |
| Floodpr | one Width | (II) 8.5 | | | |
| Bankful | li Width (ft |) / 1 | 5.5 5.5 | | |
| Entrenc | nment Kati | 0 1.21 | 0.06 1.06 | | |
| Mean D | epin (II) | | 0.90 1.00 | | |
| Maximum Depth (ft) 1.6 1.6 1.6 | | | | | |

3.65

6.93

3.3

| Bankfull Area (sq ft) | 7.06 | 3.35 | 3.7 |
|-----------------------|------|------|------|
| Wetted Perimeter (ft) | 7.87 | 5.49 | 5.5 |
| Hydraulic Radius (ft) | 0.9 | 0.61 | 0.6 |
| Begin BKF Station | 10 | 10 | 13.5 |
| End BKF Station | 17 | 13.5 | 17. |
| | | | |

_____ Entrainment Calculations ------------

3.72 5.58 0.67 13.5

Entrainment Formula: Rosgen Modified Shields Curve

Channel Left Side Right Side Slope 0 0 0 Shear Stress (lb/sq ft) Movable Particle (mm)

RIVERMORPH REACH SUMMARY

River Name: Calvert Cliffs Reach Name: Woodland SR-1 Middle

Stream Type Valley Type D50(mm)Val SlopeBKF Q(cfs)DA(sq mi)G 5cIX0.120.005600

Dimension Summary

Database based on the following Cross Sections:

| Variable | Min | Avg | Max |
|--------------------------|---------|---------|-----------|
| Floodprone Width (ft) | 7 | .95 7.9 | 95 7.95 |
| Riffle Area (Sq ft) | . 5.1 | 5.1 | 5.1 |
| Max Riffle Depth (ft) | 1 | .25 1.2 | 1.25 |
| Mean Riffle Depth (ft) | C | .83 0.8 | 33 0.83 |
| Riffle Width (ft) | 6.14 | 6.14 | 6.14 |
| Pool Area (Sq ft) | 7.0 | 6 7.06 | 7.06 |
| Max Pool Depth (ft) | 1 | .6 1.6 | 1.6 |
| Mean Pool Depth (ft) | 1 | .01 1.0 | 01 1.01 |
| Pool Width (ft) | 7 | 7 | 7 |
| Run Area (Sq ft) | 0 | 0 | 0 |
| Max Run Depth (ft) | 0 | 0 | 0 |
| Mean Run Depth (ft) | 0 | 0 | 0 |
| Run Width (ft) | 0 | 0 | 0 |
| Glide Area (Sq ft) | 0 | 0 | 0 |
| Max Glide Depth (ft) | 0 | 0 | 0 |
| Mean Glide Depth (ft) | 0 | 0 | 0 |
| Glide Width (ft) | 0 | 0 | 0 |
| Pattern Summary | | | |
| Variable | Min | Avg | Max |
| Sinuosity | | 12 | |
| Meander Wavelength (ft |) | 0 0 | 0 |
| Radius of Curvature (ft) | ́0 | 0 | 0 |
| Belt Width (ft) | 0 | 0 0 | |
| Profile Summary | | | |
| Data Based on the follow | ving: | | |
| Variable | Min | Avg | Max |
| S riffle (ft/ft) | 0 00407 | 0.00733 | 3 0 00998 |
| S pool (ft/ft) | 0 0 | 0.00044 | 0.00084 |
| 1 / / | - | | |



| S run (ft/ft) | 0.0080 | 0.02 | 2179 (| 0.05075 |
|--------------------------|--------|--------|--------|---------|
| S glide (ft/ft) | 0 | 0.0013 | 0.00 |)234 |
| P - P(ft) | 34.98 | 59.9 | 84.6 | 5 |
| Pool length (ft) | 2.67 | 12. | 1 20 | 6.17 |
| Riffle length (ft) | 10.6 | 8 18. | 1 4 | 1.92 |
| Dmax riffle (ft) | 0 | 1.6 | 0 | |
| Dmax pool (ft) | 1.6 | 1.6 | 1.6 | 5 |
| Dmax run (ft) | 0 | 0 | 0 | |
| Dmax glide (ft) | 0 | 0 | 0 | |
| Low bank ht start-end (f | t) | 3.26 | 3.37 | 3.49 |
| Bankfull slope (ft/ft) | | 0.00 | 395 | |

Hydraulic Summary

| Variable | Min | Avg | Max |
|-----------------------------------|------|--------|------|
| Discharge (cfs) Velocity (fps) | | 0 0 | |
| Hyd Radius (ft) | 0.74 | 0.74 | 0.74 |

SE 2 Imp

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

| Stream: | | | ;2 |
|-----------|---|---------------------|-----------------|
| Basin: | Drainage Area: 0 acres | 0 | mı⁻ |
| Location: | | | |
| Twp.&Rge | Sec.&Qtr.: ; | | |
| Cross-Sec | ction Monuments (Lat./Long.): 0 Lat / 0 Long | Date | : 12/15/0 |
| Observers | 5: | Valley Type | : IX |
| | Bankfull WIDTH (W _{bkf}) | | ר |
| | WIDTH of the stream channel at bankfull stage elevation, in a riffle section. | 11.78 | ft |
| | Bankfull DEPTH (d) | | Г |
| | Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a | | |
| | riffle section $(d_{bkf} = A / W_{bkf})$. | 0.47 | ft |
| | Bankfull X-Section AREA (Asse) | | ן . |
| | AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle | | |
| | section. | 5.56 | ft ² |
| | Width/Depth Ratio (White/ dhite) | | ٦ |
| | Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section. | 25.06 | ft/ft |
| | | | ב ר |
| | Maximum depth of the bankfull channel cross-section, or distance between the | | |
| | bankfull stage and Thalweg elevations, in a riffle section. | 0.77 | ft |
| | WIDTH of Flood-Prope Area (W,) | | - - |
| | Twice maximum DEPTH, or $(2 \times d_{mbkl})$ = the stage/elevation at which flood-prone area | | |
| | WIDTH is determined in a riffle section. | 37 | ft |
| | Entrenchment Ratio (ER) | | 7 |
| | The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa}/W_{bkl}) | | |
| | (riffle section). | 3.14 | ft/ft |
| | Channel Materials (Particle Size Index) D ₅₀ | • | ٦ |
| | The D_{50} particle size index represents the mean diameter of channel materials, as | | |
| | sampled from the channel surface, between the bankfull stage and Thalweg | ~ 4 - | |
| | | 0.17 | _mm |
| | Water Surface SLOPE (S) | |] |
| | Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length with the "riffle to riffle" water surface slope representing the gradient | | |
| | at bankfull stage. | 0.00384 | ft/ft |
| | | 0.0004 | -)'''' 7 |
| | Channel SINUOSITY (k) | | |
| | Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by | | |
| | channel slope (VS / S). | 1.1 | |
| | | | - |
| | Stream C 5 (See Figure 2- | 14) | |
| | Туре | | |

Copyright © 2006 Wildland Hydrology

WARSSS page 5-29

RIVERMORPH PROFILE SUMMARY

River Name: Calvert Cliffs Reach Name: Woodland SE-2, Low SR-2 Profile Name: SE-2 Reach Survey Date: 10/06/2009

Survey Data

٠,

| DIST | Cŀ | 4 W | S I | 3KF | P1 | P2 | P3 | P4 | |
|------------------|------|------|-------|------|----|----|----|----|--|
| 0 | 6.4 | 6.32 | 4.67 | | | | | | |
| 3 | 6.4 | 6.33 | | | | | | | |
| 6 | 6.45 | 6.35 | 4.8 | | | | | | |
| 10 | 6.42 | 6.37 | | | | | | | |
| 17 | 6.42 | 6.37 | | | | | | | |
| 20 | 6.42 | 6.37 | | | | | | | |
| 23 | 6.43 | 6.39 | 5.1 | | | | | | |
| 25 | 6.51 | 6.4 | | | | | • | | |
| 28 | 6.51 | 6.42 | | | | | | | |
| 31 | 6.49 | 6.43 | 4.64 | | | | | | |
| 34 | 6.49 | 6.46 | | _ | | | | | |
| 36 | 6.53 | 6.46 | 4.86 |) | | | | | |
| 40 | 6.55 | 6.54 | | | | | | | |
| 45 | 6.59 | 6.58 | 5.16 |) | | | | | |
| 55 | 6.67 | 6.59 | | 5.79 | | | | | |
| 62 | 6.73 | 6.69 | | | | | | | |
| 64 | 6.85 | 6.73 | | | | | | | |
| 6/ | 6.8 | 6.73 | | | | | | | |
| /0 | 1.31 | 6.73 | | | | | | | |
| 73 | 1.32 | 6.73 | | | | | | | |
| /6 70 | 0.99 | 6.73 | | | | | | | |
| /9 | 7.44 | | 5 21 | 6 27 | | | | | |
| 82 85 | 1.21 | | 5.51 | 0.57 | | | | | |
| 8 <i>3</i> 00 | 0.03 | 6 72 | | | | | | | |
| 90 | 6.81 | 673 | | | | | | | |
| 95 | 6.8 | 673 | | | | | | | |
| 90 | 6.82 | 673 | 5 4 8 | | | | | | |
| 102 | 6 78 | 673 | 5.40 | | | | | | |
| 102 | 6.87 | 6.8 | | | | | | | |
| 113 | 6.93 | 6.81 | | | | | | | |
| 115 | 7 07 | 6.93 | | | | | | | |
| 117 | 7.61 | 6.87 | | | | | | | |
| 120 | 7.18 | 6.87 | | | | | | | |
| 123 | 7.25 | 6.89 | | | | | | | |
| 127 | 7.03 | 6.85 | | | | | | | |
| 131 | 6.99 | 6.83 | 5.69 |) | | | | | |
| | - | | | | | | | | |

| 136 | 6.99 | 6.88 | • | | |
|-----|-------|-------|-----------|------|-------|
| 140 | 6.91 | 6.85 | | | |
| 142 | 6.9 | 6.88 | | | |
| 144 | 7 59 | 6 88 | | | |
| 148 | 7.09 | 0.00 | | | |
| 150 | 6.07 | 69 | | | |
| 154 | 6.05 | 6.02 | 5.06 | | |
| 154 | 0.95 | 0.92 | 5.90 | | |
| 105 | 7.04 | 0.90 | | | |
| 172 | 7.06 | 6.96 | | | |
| 177 | /.08 | 6.99 | | | |
| 183 | 7.11 | 7.04 | 6.1.5 | | |
| 189 | 7.14 | 7.08 | 6.15 | | |
| 193 | 7.13 | 7.1 | | | |
| 197 | 7.3 | 7.12 | | | |
| 200 | 7.68 | 7.12 | | | |
| 203 | 7.72 | 7.12 | 6.13 | | |
| 219 | 7.29 | 7.21 | | | |
| 225 | 7.32 | 7.25 | · · · • • | 5.37 | |
| 227 | 7.55 | 7.26 | | | |
| 231 | 8.11 | 7.26 | | | |
| 238 | 7.56 | 7.21 | | | |
| 240 | 7.27 | 7.2 | | | |
| 245 | 7.24 | 7.2 | | | |
| 253 | 7.6 | 7.24 | | | |
| 256 | 7.38 | 7.26 | | | |
| 265 | 5.89 | 5.86 | 4.95 | | |
| 270 | 5.95 | 5.89 | | | |
| 275 | 5.98 | 5.91 | | | |
| 279 | 6 | 5.91 | | | |
| 286 | 5.97 | 5.92 | | | |
| 292 | 6.03 | 5.96 | | | |
| 300 | 6.05 | 5.93 | | | |
| 311 | 6.05 | 5.99 | 5.15 | 5.72 | |
| 321 | 6.13 | 6.07 | | | |
| 328 | 6.15 | 6.09 | 5.42 | 5.25 | |
| 333 | 6.19 | 6.17 | ••••= | • • | |
| 337 | 6.23 | 6.17 | | | |
| 343 | 6.25 | 6.17 | | | |
| 350 | 6.25 | 6.19 | 5.62 | 5.53 | |
| 356 | 6.29 | 6.26 | 0.02 | 0.00 | |
| 365 | 6 34 | 6.29 | 5 68 | 5 72 | |
| 372 | 6.41 | 6 3 5 | 5.80 | 0.72 | |
| 372 | 6 4 5 | 637 | 5.04 | | |
| 281 | 6.40 | 6.43 | | | |
| 286 | 6.52 | 6.44 | 5 0/ | | 5 51 |
| 205 | 6.52 | 6 52 | 5.24 | | 6.52 |
| 373 | 6.66 | 6.55 | 5 57 | 6.07 | 5 5 5 |
| 400 | 6 70 | 6.60 | 5.51 | 67 | 5.55 |
| 407 | 6 00 | 672 | 5.15 | 0.2 | 5.50 |
| 413 | 0.00 | 6 92 | 2.00 | | |
| 421 | 0.89 | 0.03 | 6 22 | | |
| 4/1 | 7.01 | 0.01 | 0.72 | | |

Cross Section / Bank Profile Locations

.

| Name | Туре | Profile Station | |
|--|--|--|--|
| Entr Riffle at 14 Entr Pool at 73 Glide at 208.5 Pool at 233 Run at 249 Riffle at 300 | Riffle XS Pool XS Glide XS Riffle XS Run XS Riffle XS | 14 73 208.5 233 249 300 | |
| | | | |

Measurements from Graph

Bankfull Slope: 0.00384

| Variable | Min | Avg | Max | |
|-------------|------------|--------------|------------------------|----|
| S riffle | 0.00354 | 0.0048 | 0.00643 | |
| S pool | 0 | 0.00205 | 0.0025 | |
| S run | 0.00602 | 0.00995 | 0.01606 | |
| S glide | 0.00281 | 0.00468 | 0.00562 | · |
| P - P | 26.26 | 40.95 | 60.08 | |
| Pool lengt | h 8.9 | 16.29 | 24.92 | |
| Riffle leng | gth 21.81 | 34.72 | 47.18 | |
| Dmax riff | le 0.65 | 1.05 | 1.39 | |
| Dmax poc | ol 1.22 | 1.72 | 2.1 | |
| Dmax run | 1.19 | 1.34 | 1.47 | |
| Dmax glic | le 0.92 | 1.24 | 1.46 | |
| Low bank | ht 0.6 | 1 | 1.45 | |
| Length an | d depth me | asurements i | n feet, slopes in ft/f | t. |

RIVERMORPH PROFILE SUMMARY

Notes

River Name: Calvert Cliffs Reach Name: Woodland SE-2, Low SR-2 Profile Name: SE-2 Reach Survey Date: 10/06/2009

DIST Note

| 0 | right | |
|-----|-------------------|--|
| 6 | right | |
| 23 | right | |
| 31 | right | |
| 36 | right | |
| 45 | right | |
| 55 | r bank bench | |
| 62 | log | |
| 82 | 6.37 = top of bar | |
| 99 | right | |
| 131 | left | |

ż



- log 142 154 left 189 left 203 left 225 top of point bar 265 left big tree high bank high bank 337 386 395
- 415 block failure right bank

River Name: Calvert Cliffs Reach Name: Woodland SE-2, Low SR-2

Cross Section Name: Entr Riffle at 14 Survey Date: 10/14/2009

Cross Section Data Entry

BM Elevation:98 ftBacksight Rod Reading:2 ft

| TAPE | FS | ELEV | NOTE |
|------|------|-------|------|
| 0 | 4.52 | 95.48 | lep |
| 2 | 4.8 | 95.2 | 1 |
| 3 | 5.03 | 94.97 | |
| 4 | 5.29 | 94.71 | BKF |
| 4.5 | 5.73 | 94.27 | |
| 5 | 6.38 | 93.62 | |
| 5.2 | 6.46 | 93.54 | |
| 5.8 | 6.36 | 93.64 | lew |
| 7 | 6.32 | 93.68 | |
| 9 | 6.15 | 93.85 | |
| 10 | 6.12 | 93.88 | |
| 10.5 | 5.48 | 94.52 | |
| 11 | 5.08 | 94.92 | |
| 11.5 | 4.98 | 95.02 | |
| 13 | 4.9 | 95.1 | |
| 15 | 4.9 | 95.1 | |
| 16 | 4.52 | 95.48 | |
| 17 | 4.32 | 95.68 | |
| | | | |

Cross Sectional Geometry

| | | , | |
|-------------------------|----------|--------|-------|
| Chann | el Left | t Rig | ht |
| Floodprone Elevation (| ft) 95.8 | 8 95.8 | 95.88 |
| Bankfull Elevation (ft) | 94.71 | 94.71 | 94.71 |
| Floodprone Width (ft) | 17 | | |
| Bankfull Width (ft) | 6.74 | 3.37 | 3.37 |
| Entrenchment Ratio | 2.52 | | |
| Mean Depth (ft) | 0.84 | 0.9 | 0.78 |
| Maximum Depth (ft) | 1.17 | 1.17 | 1 |
| Width/Depth Ratio | 8.02 | 3.74 | 4.32 |
| Bankfull Area (sq ft) | 5.66 | 3.03 | 2.64 |
| Wetted Perimeter (ft) | 7.63 | 4.88 | 4.75 |
| Hydraulic Radius (ft) | 0.74 | 0.62 | 0.56 |

 Begin BKF Station
 4
 4
 7.37

 End BKF Station
 10.74
 7.37
 10.74

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

ChannelLeft SideRight SideSlope000Shear Stress (lb/sq ft)00Movable Particle (mm)

River Name: Calvert Cliffs Reach Name: Woodland SE-2, Low SR-2 Cross Section Name: Entr Pool at 73 Survey Date: 10/15/2009

Cross Section Data Entry

BM Elevation: 98 ft Backsight Rod Reading: 2 ft

| TAPE | FS | ELEV | NOTE | |
|------|------|-------|------|--|
| 0 | 4.5 | 95.5 | LEP | |
| 3 | 4.62 | 95.38 | | |
| 4 | 4.75 | 95.25 | | |
| 6 | 5.2 | 94.8 | | |
| 6.5 | 6.7 | 93.3 | | |
| 7 | 6.88 | 93.12 | | |
| 8 | 7.02 | 92.98 | | |
| 9 | 7.22 | 92.78 | | |
| 10 | 7.46 | 92.54 | | |
| 11 | 7.29 | 92.71 | | |
| 12 | 6.93 | 93.07 | | |
| 12.5 | 6.7 | 93.3 | REW | |
| 13 | 6 | 94 | BKF | |
| 13.4 | 5.95 | 94.05 | | |
| 14 | 5.32 | 94.68 | | |
| 15 | 5.18 | 94.82 | | |
| 17 | 5.18 | 94.82 | | |
| 18 | 5.34 | 94.66 | | |
| 21 | 5.01 | 94.99 | | |
| 24 | 4.6 | 95.4 | | |

Cross Sectional Geometry

| Chann | el Lef | t Rig | ght |
|-------------------------|----------|-------|----------|
| Floodprone Elevation (| ft) 95.4 | 6 95. | 46 95.46 |
| Bankfull Elevation (ft) | 94 | 94 | 94 |
| Floodprone Width (ft) | 23 | | |
| Bankfull Width (ft) | 6.73 | 3.36 | 3.37 |
| Entrenchment Ratio | 3.42 | | |
| Mean Depth (ft) | 1.03 | 1 | 1.07 |
| Maximum Depth (ft) | 1.46 | 1.37 | 1.46 |
| Width/Depth Ratio | 6.53 | 3.36 | 3.15 |
| Bankfull Area (sq ft) | 6.95 | 3.36 | 3.59 |

| Wetted Perimeter (ft) | 7.82 | 5.32 | 5.24 |
|-----------------------|------|------|------|
| Hydraulic Radius (ft) | 0.89 | 0.63 | 0.69 |
| Begin BKF Station | 6.27 | 6.27 | 9.63 |
| End BKF Station | 13 | 9.63 | 13 |
| | | | |

file:///lovetonfp/...hase%20II%20Mitigation/Design%20Data/all%20rivermorph%20reports/SE-2%20Imp/se-2%20pool%201%20report.txt[10/5/2010 10:29:

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

ChannelLeft SideRight SideSlope000Shear Stress (lb/sq ft)---Movable Particle (mm)---

River Name:Calvert CliffsReach Name:Woodland SE-2, Low SR-2Cross Section Name:Run at 249Survey Date:10/15/2009

Cross Section Data Entry

BM Elevation:93.66 ftBacksight Rod Reading:4.93 ft

| TAPE | FS | ELEV | NOTE | |
|------|----------|-------|------|--|
| 0 | 4 97 | 93 62 | I FP | |
| 1 | 5.07 | 93.52 | | |
| 2 | 5.26 | 93.33 | | |
| 3 | 5.51 | 93.08 | | |
| 3.4 | 5.83 | 92.76 | LEW | |
| 4 | 5.86 | 92.73 | | |
| 5 | 5.75 | 92.84 | | |
| 6 | 5.54 | 93.05 | | |
| 7 | 5.58 | 93.01 | | |
| 8 | 5.61 | 92.98 | | |
| 9 | 5.75 | 92.84 | | |
| 10 | 5.69 | 92.9 | | |
| 11 | 5.58 | 93.01 | | |
| 12 | 5.51 | 93.08 | | |
| 13 | 5.36 | 93.23 | | |
| 15 | 5.32 | 93.27 | | |
| 18 | 5.23 | 93.36 | | |
| 21 | 5.19 | 93.4 | | |
| 25 | 5.18 | 93.41 | BKF | |
| 29 | 4.97 | 93.62 | | |

Cross Sectional Geometry

| Chann | el Left | Righ | nt |
|-------------------------|-----------|--------|---------|
| Floodprone Elevation (| ft) 94.09 | 9 94.0 | 9 94.09 |
| Bankfull Elevation (ft) | 93.41 | 93.41 | 93.41 |
| Floodprone Width (ft) | 29 | | |
| Bankfull Width (ft) | 23.42 | 11.71 | 11.71 |
| Entrenchment Ratio | 1.24 | | |
| Mean Depth (ft) | 0.24 | 0.42 | 0.06 |
| Maximum Depth (ft) | 0.68 | 0.68 | 0.17 |
| Width/Depth Ratio | 97.58 | 27.88 | 195.17 |
| Bankfull Area (sq ft) | 5.53 | 4.87 | 0.66 |

| Wetted Perimeter (ft) | 23.63 | 12.1 | 11.89 |
|-----------------------|-------|-------|-------|
| Hydraulic Radius (ft) | 0.23 | 0.4 | 0.06 |
| Begin BKF Station | 1.58 | 1.58 | 13.29 |
| End BKF Station | 25 | 13.29 | 25 |

Entrainment Calculations

file:///lovetonfp/...P% 20 Phase% 20 II% 20 Mitigation/Design% 20 Data/all% 20 rivermorph% 20 reports/SE-2% 20 Imp/se-2% 20 run% 20 report.txt [10/5/2010 10:29 Mitigation/Design% 20 Data/all% 20 rivermorph% 20 reports/SE-2% 20 Imp/se-2% 20 run% 20 report.txt [10/5/2010 10:29 Mitigation/Design% 20 Data/all% 20 rivermorph% 20 reports/SE-2% 20 Imp/se-2% 20 run% 20 report.txt [10/5/2010 10:29 Mitigation/Design% 20 Data/all% 20 rivermorph% 20 reports/SE-2% 20 Imp/se-2% 20 run% 20 report.txt [10/5/2010 10:29 Mitigation/Design% 20 Data/all% 20 rivermorph% 20 reports/SE-2% 20 Imp/se-2% 20 run% 20 report.txt [10/5/2010 10:29 Mitigation/Design% 20 Phase% 2

Entrainment Formula: Rosgen Modified Shields Curve

ChannelLeft SideRight SideSlope000Shear Stress (lb/sq ft)00Movable Particle (mm)

River Name:Calvert CliffsReach Name:Woodland SE-2, Low SR-2Cross Section Name:Glide at 208.5Survey Date:10/15/2009

Cross Section Data Entry

BM Elevation:93.66 ftBacksight Rod Reading:4.93 ft

| TAPE | FS | ELEV | NO | TE | |
|--|-------------|---------------|----------|-------|--|
| 0 | | 93 66 | I FP | | |
| 2 | 4.75 | 93.85 | LLI | | |
| 3 | 4 85 | 93 74 | | | |
| 4 | 5.08 | 93.51 | | | |
| 5 | 5 35 | 93.24 | | | |
| 6 | 5.16 | 93.43 | | | |
| 7 | 5.38 | 93.21 | | | |
| 8 | 5.51 | 93.08 | | • | |
| 8.5 | 5.63 | 92.96 | LEW | | |
| 9 | 5.68 | 92.91 | | | |
| 10 | 5.69 | 92.9 | | | |
| 11 | 5.63 | 92.96 | | | |
| 12. | 5.49 | 93.1 | | | |
| 13 | 5.4 | 93.19 | ` | | |
| 14 | 5.35 | 93.24 | | | |
| 15 | 5.51 | 93.08 | | | |
| 16 | 5.45 | 93.14 | | | |
| 16.5 | 5.08 | 93.51 | BKF | | |
| 18 | 4.76 | 93.83 | | | |
| 20 | 4.65 | 93.94 | | | |
| 27 | 4.65 | 93.94 | | , | |
| | | | | | |
| | | | | | |
| Cross Sectional Geometry | | | | | |
| | | | | | |
| | Cl | hannel Left | Right | ł | |
| Floodpr | one Elevati | on (ft) 94.12 | 2 94.12 | 94.12 | |
| Bankful | l Elevation | (ft) 93.51 | 93.51 | 93.51 | |
| Floodpr | one Width | (ft) 27 | | | |
| Bankfull Width (ft) $12.5 - 6.25 - 6.25$ | | | | | |
| Entrencl | hment Rati | 0 2.16 | | | |
| Mean Depth (ft) 0.37 0.34 0.39 | | | | | |
| Maximu | m Depth (| ft) 0.61 | 0.61 | 0.59 | |
| Width/D | epth Ratio | 33.78 | 18.38 | 16.03 | |

file:///lovetonfp/...%20Phase%20II%20Mitigation/Design%20Data/all%20rivermorph%20reports/SE-2%20Imp/se-2%20glide%20report.txt[10/5/2010 10:29:13 AM]
| Bankfull Area (sq ft) | 4.57 | 2.15 | 2.41 |
|-----------------------|-------|-------|-------|
| Wetted Perimeter (ft) | 12.76 | 6.95 | 7 |
| Hydraulic Radius (ft) | 0.36 | 0.31 | 0.34 |
| Begin BKF Station | 4 | 4 | 10.25 |
| End BKF Station | 16.5 | 10.25 | 16.5 |
| | | | |

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

ChannelLeft SideRight SideSlope000Shear Stress (lb/sq ft)---Movable Particle (mm)---

| Cross Se | ection Dat | a Entry | | | | |
|------------------|------------|-----------|-------|-----|---|--|
| BM Elev | vation: | 93.66 | ft | | | |
| Backsig | ht Rod Re | ading: 4. | 93 ft | | | |
| TAPE | FS | ELEV | NOTE | | | |
| 0 | 5 13 | 93 46 | LEP | | | |
| 2 | 5.24 | 93 35 | | | 1 | |
| - | 5.21 | 93 38 | | | | |
| 4 | 5.27 | 93.32 | BKF | | | |
| 4.2 | 5.64 | 92.95 | A 24 | | | |
| 5 | 5.93 | 92.66 | LEW. | | | |
| 6.2 | 6.04 | 92.55 | | | | |
| e. <u>-</u> 7 | 5.97 | 92.62 | | | | |
| 8 | 5.96 | 92.63 | | · · | - | |
| 9 | 5.81 | 92.78 | | | | |
| 11 | 5:76 | 92.83 | _ | | | |
| 13 | 5.68 | 92.91 | | | | |
| 14 | 5.43 | 93.16 | | | | |
| 16 | 5.25 | 93.34 | | | | |
| 17 | 5.29 | 93.3 | | | | |
| 19 | 5.58 | 93.01 | | | | |
| 20 | 5.72 | 92.87 | | | | |
| 21 | 5.82 | 92.77 | : | | | |
| 22 | 5.72 | 92.87 | | | | |
| 23 | 5.46 | 93.13 | | | | |
| 24 | 5.3 | 93.29 | | | | |
| 26 | 5.37 | 93.22 | | | | |
| 28 | 5.46 | 93.13 | | | | |
| 31 | 5.27 | 93.32 | | | | |
| 34 27 | 5.09 | 93.5 | | | | |
| 5/ | 4.92 | 93.67 | | | | |
| | | | | : | | |
| | | | | | | |

file:///lovetonfp/...hase%20II%20Mitigation/Design%20Data/all%20rivermorph%20reports/SE-2%20Imp/se-2%20riffle%202%20report.txt [10/5/2010 10:29:16 AM]



| | | , | |
|-----------------------|-------|------|-------|
| Bankfull Width (ft) | 11.78 | 5.71 | 6.07 |
| Entrenchment Ratio | 3.14 | | |
| Mean Depth (ft) | 0.47 | 0.63 | 0.33 |
| Maximum Depth (ft) | 0.77 | 0.77 | 0.52 |
| Width/Depth Ratio | 25.06 | 9.06 | 18.39 |
| Bankfull Area (sq ft) | 5.56 | 3.58 | 1.98 |
| Wetted Perimeter (ft) | 12.11 | 6.52 | 6.63 |
| Hydraulic Radius (ft) | 0.46 | 0.55 | 0.3 |
| Begin BKF Station | 4 | 4 | 9.71 |
| End BKF Station | 15.78 | 9.71 | 15.78 |
| | | | |
| | | | |

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

| River Name:Calvert CliffsReach Name:Woodland SE-2, Low SR-2Cross Section Name:Pool at 233Survey Date:10/15/2009 | | | | | | | |
|---|-----------------------|--------------------------|-----------------|---------------|---|--|--|
| Cross Se | ction Data | Entry | | | | | |
| BM Elev Backsigh | ation: at Rod Read | 93.66 ing: 4. | ft 93 ft | | | | |
| TAPE | FS | ELEV | NC | DTE | | | |
| 0 | 1 03 | 03 66 | | | | | |
| 2 | 4.95 | 93.60 | LLI | | | | |
| 5 | 4.91 | 03 71 | | • | | | |
| 6 | 4.00 | 93.66 | | | | | |
| 7 | 5 38 | 93 21 | | | • | | |
| 8 | 5.50 | 92 89 | LEW | | | | |
| 9 | 6.15 | 92.44 | | | | | |
| 10 | 6.42 | 92.17 | | | | | |
| 11 | 6.28 | 92.31 | | | | | |
| 12 | 6.31 | 92.28 | | | | | |
| 13 | 5.98 | 92.61 | | | | | |
| 13.5 | 5.17 | 93.42 | BKF | | | | |
| 18 | 4.95 | 93.64 | | | | | |
| 25 | 4.85 | 93.74 | | | | | |
| | | | | | | | |
| Cross Se | ctional Geo | metry | | | | | |
| | | | | | | | |
| | Cha | nnol Loft | Pial | at | | | |
| Floodpro | ne Flevetic | (ff) 0/6' | 1 Kigi 7 0/6 | .n 57 0/67 | , | | |
| Rankfull | Flevation (| f(11) 94.0 f(11) 94.0 | 03 42 | 03 42 | | | |
| Floodpro | ne Width (f | 11) 75.42 | | | | | |
| Rankfull | Width (ft) | 697 | 3 40 | 3 48 | | | |
| Entrench | ment Ratio | 3 59 | | 5.40 | | | |
| Mean De | nth (ft) | 0.83 | 0.66 | 0.99 | | | |
| Maximur | n Denth (ft) | 1 25 | 1 25 | 1 25 | | | |
| Width/De | enth Ratio | 84 | 5 29 | 3 52 | | | |
| Bankfull | Area (so ft) | 577 | 2.31 | 3.46 | | | |
| Wetted P | erimeter (ft | 771 | 4 96 | 5 24 | | | |
| Hydraulie | Radius (ff | 075 | 0.47 | 0.66 | | | |
| Begin Rk | (F Station | 6 53 | 6 53 | 10.02 | | | |
| End RKF | Station | 13.5 | 10.02 | 13.5 | | | |
| Div Divi | Junion | 10.0 | 10.02 | 10.0 | | | |
| | | | | | | | |
| | | | | | | | |

file:///lovetonfp/...hase%20II%20Mitigation/Design%20Data/all%20rivermorph%20reports/SE-2%20Imp/se-2%20pool%202%20report.txt[10/5/2010 10:29:12 AM]

Entrainment Calculations _____

Slope

Entrainment Formula: Rosgen Modified Shields Curve

Channel Left Side Right Side 0 0 0 Shear Stress (lb/sq ft) Movable Particle (mm)

SR 3 Lower Imp

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

| Basin: | Drainage Area: 27.52 acres | 0.043 | mi² |
|------------|--|-------------|----------------------|
| _ocation: | | | |
| Twp.&Rge: | ; Sec.&Qtr.: ; | | |
| Cross-Sect | ion Monuments (Lat./Long.): 0 Lat / 0 Long | Date | : 10/06 |
| Observers: | | Valley Type | : VIÌI |
| | | | ר |
| | WIDTH of the stream channel at bankfull stage elevation, in a riffle section. | 8.53 | `_ft |
| | Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section (d _{bkf} = A / W _{bkf}). | 0.72 |] _{ft} |
| | Bankfull X-Section AREA (A _{bkf}) | | ٦ |
| | AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section. | 6.14 | ft ² |
| | Width/Depth Ratio (W _{bkf} /d _{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section. | 11.85 |] ft/ft |
| | Maximum DEPTH (d _{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section. | 0.88 | ft |
| | WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or (2 x d _{mbkl}) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section. | 17.14 | ft |
| | Entrenchment Ratio (ER) | | 1 |
| | The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkl}) (riffle section). | 2.01 | _ft/ft |
| ľ | Channel Materials (Particle Size Index) D ₅₀ | | 1 |
| | The D ₅₀ particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations. | 0.65 | |
| I | | 9.00 | յտո |
| | Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage. | 0 00843 | £4.)[[] |
| i | | 0.00045 | - Jivit |
| | Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S). | 1.1 | |
| | Stream B4c (See Figure 2- | 14) |] |

Copyright © 2006 Wildland Hydrology

RIVERMORPH PROFILE SUMMARY

River Name: Calvert Cliffs Reach Name: SR-3 Lower Reach Profile Name: Lower Survey Date: 10/05/2009

Survey Data

| DIST | CH | I WS | BKF | P1 | TOB | P3 | P4 | |
|------|------|--------|------|------|-----|----|----|--|
| 0 | 5.1 | 4.86 | | | | | | |
| 3 | 5.1 | 4.86 | | | | | | |
| 8 | 5.1 | 4.85 | 3.73 | | | | | |
| 13 | 5.08 | 4.92 | | | | | | |
| 20 | 5.08 | 4.97 | | | | | | |
| 22 | | 4.21 | | | | | | |
| 25 | 5.37 | 4.98 | | | | | | |
| 30 | 5.48 | 5.04 | | | | | | |
| 33 | 5.44 | 5.08 | | | | | | |
| 37 | 5.28 | 5.09 | | | | | | |
| 41 | 5.26 | 5.11 4 | 1.57 | 2.23 | | | | |
| 46 | 5.39 | 5.16 | | | | | | |
| 51 | 5.46 | 5.26 | | | | | | |
| 55 | 5.39 | 5.3 4. | .47 | 2.5 | | | | |
| 57 | 5.82 | 5.42 | | | | | | |
| 63 | 5.93 | 5.42 | | | | | | |
| 77 | 5.62 | 5.42 | | | | | | |
| 81 | 5.57 | 5.44 | | | | | | |
| 88 | 5.63 | 5.47 | | | | | | |
| 93 | 5.6 | 5.47 | | | | | | |
| 96 | 5.56 | 5.47 4 | .61 | | | | | |
| 100 | 5.64 | 5.47 | | | | | | |
| 107 | 5.66 | 5.59 | | | | | | |
| 108 | | 4.82 | 3.69 | | | | | |
| 114 | 5.72 | 5.59 | | | | | | |
| 120 | | 5.02 | 4.21 | | | | | |
| 121 | 5.8 | 5.67 | | | | | | |
| 127 | 5.86 | 5.73 | | | | | | |
| 133 | 5.94 | 5.78 | | | | | | |
| 136 | | 5.22 | 4.31 | 3. | .77 | | | |
| 138 | 6.21 | 5.79 | | | | | | |
| 143 | 6.06 | 5.81 | | | | , | | |
| 149 | 5.94 | 5.78 | | | | | | |
| 153 | 5.99 | 5.89 | 3.66 | | | | | |
| 157 | 6.07 | 5.91 | 4.67 | | | | | |
| 160 | 6.12 | 5.92 | | | | | | |
| 165 | 6.07 | 5.92 | | | | | | |
| | • | | | | | | | |

file:///lovetonfp/...Mitigation/Design%20Data/all%20rivermorph%20reports/SR-3%20Lower%20Imp/sr-3%20low%20profile%20report.txt[10/5/2010 10:33:22 AM]



| 171 | 6.17 | 6.12 | | | |
|-------|------|------|------|------|-----|
| 171.3 | 6.82 | | | | |
| 172 | 6.84 | 6.46 | | | |
| 178 | 6.88 | 6.45 | | | |
| 189 | 7.05 | 6.45 | | | |
| 194 | 6.96 | 6.46 | | | |
| 201 | 6.75 | 6.52 | | | |
| 205 | 6.63 | 6.5 | 5.92 | 3.59 | 3.3 |
| 212 | 6.64 | 6.5 | | | |
| 220 | 6.73 | 6.62 | | | |
| 226 | 6.85 | 6.72 | | | |
| 233 | 6.96 | 6.77 | 5.92 | 3.73 | |

Cross Section / Bank Profile Locations

| Name | Туре | Profile Station |
|--------------|-----------|-----------------|
| Riffle at 96 | Riffle XS | 0 |
| Pool at ~172 | Pool XS | 0 |

Measurements from Graph

Bankfull Slope: 0.00843

| Variable | Min | Avg | Max | |
|-------------|----------|---------|---------|-----|
| S riffle | 0.00243 | 0.00906 | 0.01497 | |
| S pool | 0 | 0.00485 | 0.01453 | |
| S run | 0.00657 | 0.03665 | 0.07862 | |
| S glide | 0.0025 | 0.00625 | 0.00946 | . / |
| P - P | 33.64 | 53.09 | 74.62 | |
| Pool lengt | h 6.91 | 14.31 | 22.72 | |
| Riffle leng | ,th 8.24 | 17.43 | 33.64 | |
| Dmax riff | le 0.73 | 0.87 | 1 | |
| Dmax poo | 1 1.03 | 1.26 | 1.45 | |
| Dmax run | 0.71 | 0.85 | 0.96 | |
| Dmax glid | le 0.74 | 0.94 | 1.04 | |
| Low bank | ht 0.73 | 0.87 | 1 | |

Length and depth measurements in feet, slopes in ft/ft.

RIVERMORPH PROFILE SUMMARY

Notes

.....

River Name: Calvert Cliffs Reach Name: SR-3 Lower Reach Profile Name: Lower Survey Date: 10/05/2009

DIST Note

| 8 | small log |
|-----|-------------------|
| 22 | right bank |
| 41 | left/right |
| 46 | start eel habitat |
| 96 | RIGHT BANK |
| 108 | LEFT/RIGHT |
| 120 | LEFT/RIGHT |
| 127 | lod at 129 |
| 157 | RIGHT/LEFT |
| 171 | log present |
| 205 | tob l/r |
| 233 | l/l fence |

River Name:Calvert CliffsReach Name:SR-3 Lower ReachCross Section Name:Riffle at 96Survey Date:10/06/2009

.

Cross Section Data Entry

BM Elevation:98 ftBacksight Rod Reading:2 ft

| TAPE | FS | ELEV | NOTE | |
|------|------|-------|------|----------|
| 0 | 2.67 | 97.33 | LEP | |
| 3 | 3.02 | 96.98 | | |
| 5 | 3.72 | 96.28 | | |
| 7 | 4 | 96 | | |
| 9 | 4.02 | 95.98 | | |
| 9 | 4.44 | 95.56 | | |
| 11 | 4.57 | 95.43 | | |
| 13 | 4.68 | 95.32 | BKF | |
| 14 | 5.21 | 94.79 | | |
| 14.5 | 5.45 | 94.55 | LEW | |
| 15 | 5.5 | 94.5 | | ` |
| 17 | 5.56 | 94.44 | | |
| 19 | 5.49 | 94.51 | | |
| 21 | 5.43 | 94.57 | REW | |
| 22 | 4.02 | 95.98 | | |
| 35 | 0 | 100 | | |

Cross Sectional Geometry

·

| Chann | el Left | Righ | nt |
|-------------------------|----------|-------|-------|
| Floodprone Elevation (| ft) 96.2 | 96.2 | 96.2 |
| Bankfull Elevation (ft) | 95.32 | 95.32 | 95.32 |
| Floodprone Width (ft) | 17.14 | | |
| Bankfull Width (ft) | 8.53 | 4.27 | 4.26 |
| Entrenchment Ratio | 2.01 | | |
| Mean Depth (ft) | 0.72 | 0.68 | 0.75 |
| Maximum Depth (ft) | 0.88 | 0.88 | 0.87 |
| Width/Depth Ratio | 11.85 | 6.28 | 5.68 |
| Bankfull Area (sq ft) | 6.14 | 2.92 | 3.21 |
| Wetted Perimeter (ft) | 9.11 | 5.33 | 5.52 |
| Hydraulic Radius (ft) | 0.67 | 0.55 | 0.58 |
| Begin BKF Station | 13 | 13 | 17.27 |
| End BKF Station | 21.53 | 17.27 | 21.53 |

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

ChannelLeft SideRight SideSlope000Shear Stress (lb/sq ft)00Movable Particle (mm)00

River Name:Calvert CliffsReach Name:SR-3 Lower ReachCross Section Name:Pool at ~172Survey Date:10/06/2009

Cross Section Data Entry

BM Elevation:98 ftBacksight Rod Reading:2 ft

| TAPE | FS | ELEV | NOTE | |
|------|------|-------|------|------|
| 0 | 1.83 | 98.17 | LEP | |
| 2 | 2.92 | 97.08 | | |
| 5 | 6.47 | 93.53 | LEW | |
| 6 | 7.02 | 92.98 | | |
| 7 | 6.86 | 93.14 | | |
| 8 | 6.73 | 93.27 | | |
| 9 | 6.47 | 93.53 | | |
| 10 | 6.02 | 93.98 | | |
| 12 | 5.59 | 94.41 | BKF | |
| 13 | 5.2 | 94.8 | | |
| 19 | 3.07 | 96.93 | | |
| 27 | 2.4 | 97.6 | | |
| 30 | 1.6 | 98.4 | | |
| | | | | |

Cross Sectional Geometry

| Chann | el Left | Righ | nt |
|-------------------------|------------|--------|---------|
| Floodprone Elevation (| (ft) 95.84 | 4 95.8 | 4 95.84 |
| Bankfull Elevation (ft) | 94.41 | 94.41 | 94.41 |
| Floodprone Width (ft) | 12.88 | | |
| Bankfull Width (ft) | 7.74 | 3.87 | 3.87 |
| Entrenchment Ratio | 1.66 | | |
| Mean Depth (ft) | 0.79 | 1.08 | 0.5 |
| Maximum Depth (ft) | 1.43 | 1.43 | 1.11 |
| Width/Depth Ratio | 9.8 | 3.58 | 7.74 |
| Bankfull Area (sq ft) | 6.13 | 4.18 | 1.95 |
| Wetted Perimeter (ft) | 8.49 | 5.56 | 5.15 |
| Hydraulic Radius (ft) | 0.72 | 0.75 | 0.38 |
| Begin BKF Station | 4.26 | 4.26 | 8.13 |
| End BKF Station | 12 | 8.13 | 12 |
| | | | |

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

ChannelLeft SideRight SideSlope000Shear Stress (lb/sq ft)00Movable Particle (mm)00

SR 3 Lower Imp

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

| Basin: | Drainage Area: 0 acres | 0 | mi ² |
|--------------|---|------------|-----------------|
| Location: | | | |
| | Sec &Otr | | * |
| Cross-Sod | tion Monuments (Lat / Long): 0 Lat / 0 Long | Data | 10/05/0 |
| Obconversion | | | · 1\/ |
| Juservers: | | vaney Type | . IV _ |
| | Bankfull WIDTH (W _{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section. | 7.42 |] _{ft} |
| • | Bankfull DEPTH (d _{bkf}) | | 7 |
| | Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkl} = A / W_{bkl}$). | 0.95 | ft |
| | Bankfull X-Section AREA (A _{bk}) | | 7 |
| | AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle | | , |
| | | 7.02 | ft ² |
| | Width/Depth Ratio (W _{bkf} / d _{bkf}) | |] |
| | Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section. | 7.81 | ft/ft |
| | Maximum DEPTH (d _{mbkf}) | | 7 |
| | Maximum depth of the bankfull channel cross-section, or distance between the | | |
| | bankfull stage and Thalweg elevations, in a riffle section. | 1.23 | _ft |
| | WIDTH of Flood-Prone Area (W _{fpa}) | | |
| | Twice maximum DEPTH, or $(2 \times d_{mbkl})$ = the stage/elevation at which flood-prone area | | |
| | WIDTH is determined in a riffle section. | 10.19 | ∫ft |
| | Entrenchment Ratio (ER) | |] |
| | The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W _{fpa} / W _{bkl}) (riffle section) | 4 27 | <i>6.10</i> |
| | | 1.37 | Jivit |
| | Channel Materials (Particle Size Index) D ₅₀ | | |
| | The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg | | |
| | elevations. | 8 | mm |
| | Water Surface SLOPE (S) | | י ו |
| | Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel | | 1 |
| | widths in length, with the "riffle-to-riffle" water surface slope representing the gradient | | |
| | | 0.01606 |]ft/ft |
| | Channel SINUOSITY (k) | • |] |
| | Sinuosity is an index of channel pattern, determined from a ratio of stream length | | |
| | divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S). | 4 4 | |
| l | | 1.1 |] |
| | Stream G 4/1c (See Figure 2- | 14) | |

Copyright © 2006 Wildland Hydrology

;

WARSSS page 5-29

RIVERMORPH PROFILE SUMMARY

River Name: Calvert Cliffs Reach Name: SR-3 Upper Reach Profile Name: Upper SR-3 Survey Date: 10/05/2009

-----<u>-</u>------

Survey Data

| DIST | CH | WS | BKF | P1 | P2 | P3 | P4 | |
|----------|-------|-------|------|------|----|----|----|--|
| 0 | 3.65 | 3.53 | | | | | | |
| 4 | 3.68 | 3.63 | | | | | | |
| 6 | 3.74 | 3.63 | | | | | | |
| 8 | 3.74 | 3.68 | | | | | | |
| 10 | 4.21 | 4.04 | | | | | | |
| 13 | 4.4 | 4.15 | | | | • | | |
| 15 | 4.22 | 4.13 | | | | | | |
| 17 | 4.4 | 4.14 | | | | | | |
| 20 | 4.33 | 4.17 | | | | | | |
| 24 | 4.52 | 4.29 | | | | | | |
| 26 | | | 3.87 | | | | | |
| 27 | 4.62 | | | | | | | |
| 29 | 4.55 | 4.33 | | | | | | |
| 30 | | 4.33 | | | | | | |
| 32 | 4.47 | 4.33 | | | | | | |
| 34 | 4.38 | 4.33 | | | | | | |
| 37 | 4.55 | 4.33 | | | | | | |
| 41 | 4.58 | 4.48 | | | | | | |
| 45 | 4.75 | 4.48 | | | | | | |
| 52 57 | 4.54 | 4.44 | | | | | | |
| 57 62 | 4.00 | 4.47 | | | | | | |
| 66 | 4.05 | 4.40 | | | | | | |
| 73 | 4.05 | 4.40 | | | | | | |
| 77 | 4.02 | 4 4 8 | | | | | | |
| 82 | 4 65 | 4 56 | | | | | | |
| 83 | 5 4 5 | 5.23 | | | | | | |
| 85 | 5.45 | 5.26 | | | | | | |
| 88 | 5.48 | 5.4 | | | | | | |
| 90 - | 6.42 | 6.26 | | | | | | |
| 93 | 7.56 | 7.44 | | | | | | |
| 96 | | 7.44 | 6.26 | | | | | |
| 98 | 8.02 | 7.44 | | | | | | |
| 104 | 8.06 | 7.47 | | | | | | |
| 108 | 7.74 | 7.48 | | | | | | |
| 110 | | | 6.88 | 7.13 | | | | |
| 114 | 7.59 | 7.49 | | | | | | |

| 7.63 | 7.49 | 6.3 |
|------|---|--|
| 7.78 | 7.57 | 6.18 |
| 7.74 | 7.58 | 6.34 |
| | 6.0 | 55 |
| 7.79 | 7.63 | 6.74 |
| 7.79 | 7.65 | 6.5 |
| 8 | 7.77 | |
| 8.16 | 7.91 | |
| 8.09 | 7.94 | |
| 8.56 | 8.24 | |
| 8.64 | 8.28 | |
| 8.54 | 8.4 | |
| 8.96 | 8.52 | |
| 8.82 | 8.54 | |
| 9.03 | 8.87 | |
| 9.37 | 9.15 | |
| | 7.63 7.78 7.74 7.79 7.79 8 8.16 8.09 8.56 8.64 8.54 8.54 8.96 8.82 9.03 9.37 | $\begin{array}{cccccccccccccccccccccccccccccccccccc$ |

Cross Section / Bank Profile Locations

| Name | | Туре | Prof | ile Station | |
|------------------------|----------------------|-------------|----------------|-------------|---|
| XS Pool U XS Riffle | Upper 104 Top 127 | Poo Riff | ol XS le XS | 104 127 | |
| Measurem | ents from | Graph | | , | |
| Bankfull S | lope: 0.0 |)1606 | | | |
| Variable | Min | Avg | Max | , | |
| S riffle | 0.00059 | 0.00351 | 0.0064 | 2 | |
| S pool | 0.00198 | 0.00432 | 0.008 | 03 | |
| S run | 0.02944 | 0.09676 | 0.2494 | 4 | |
| S glide | 0.00321 | 0.00446 | 0.0064 | 42 | • |
| P - P | 2.67 | 22.21 | 61.24 | | |
| Pool length | h 2.49 | 7 | 15.13 | | |
| Riffle leng | th 17.09 | 21.01 | 24.92 | | |
| Dmax riffl | e 1.28 | 1.32 | 1.35 | | |
| Dmax poo | l 0.74 | 1.07 | 1.69 | | |
| Dmax run | 1.7 | 1.7 | 1.7 | | |
| Dmax glid | e 1.32 | 1.51 | 1.7 | | |
| Low bank | ht 3.16 | 4.39 | 5.61 | | |

Length and depth measurements in feet, slopes in ft/ft.

RIVERMORPH PROFILE SUMMARY

Notes

River Name: Calvert Cliffs Reach Name: SR-3 Upper Reach Profile Name: Upper SR-3

Survey Date: 10/05/2009

| DIST | Note |
|------|-----------------------|
| 13 | mid pool |
| 30 | LOD |
| 90 | shell layer elevation |
| 96 | begin shell layer |
| 104 | pool section here |
| 110 | top point bar / bench |
| 118 | bench |
| 124 | bench |
| 127 | riffle section |
| 132 | top of shells |
| 143 | left |

file:///lovetonfp/...itigation/Design% 20 Data/all% 20 rivermorph% 20 reports/SR-3% 20 Upper% 20 Imp/sr-3% 20 upper% 20 profile% 20 report.txt [10/5/2010 10:36:10.10] to 10.10 to 10

| River Name: | Calvert Cliffs |
|----------------------|-------------------------|
| Reach Name: | SR-3 Upper Reach |
| Cross Section | Name: XS Riffle Top 127 |
| Survey Date: | 10/05/2009 |

Cross Section Data Entry

BM Elevation:100 ftBacksight Rod Reading:3.2 ft

| TAPE | FS | ELEV | NOTE |
|------|-------|--------|---------------|
| 0 | 2.23 | 100.97 | LEP |
| 6 | 3.43 | 99.77 | |
| 8 | 4.65 | 98.55 | |
| 10 | 6.98 | 96.22 | |
| 11.5 | 9.44 | 93.76 | BNKPN |
| 13 | 9.73 | 93.47 | BKF |
| 14 | 10.68 | 92.52 | |
| 15 | 10.76 | 92.44 | LEW |
| 16 | 10.81 | 92.39 | |
| 18 | 10.96 | 92.24 | |
| 19 | 10.84 | 92.36 | REW |
| 19.5 | 10.78 | 92.42 | |
| 20.5 | 9.64 | 93.56 | TOP OF SHELLS |
| 24 | 3.14 | 100.06 | |
| 26 | 2.45 | 100.75 | |
| 29 | 1.82 | 101 38 | |

Cross Sectional Geometry

| Chann | el Left | Righ | ıt |
|-------------------------|----------|-------|-------|
| Floodprone Elevation (| ft) 94.7 | 94.7 | 94.7 |
| Bankfull Elevation (ft) | 93.47 | 93.47 | 93.47 |
| Floodprone Width (ft) | 10.19 | | |
| Bankfull Width (ft) | 7.42 | 3.77 | 3.65 |
| Entrenchment Ratio | 1.37 | | |
| Mean Depth (ft) | 0.95 | 0.89 | 1 |
| Maximum Depth (ft) | 1.23 | 1.14 | 1.23 |
| Width/Depth Ratio | 7.81 | 4.24 | 3.65 |
| Bankfull Area (sq ft) | 7.02 | 3.37 | 3.65 |
| Wetted Perimeter (ft) | 8.3 | 5.29 | 5.28 |
| Hydraulic Radius (ft) | 0.85 | 0.64 | 0.69 |
| Begin BKF Station | 13 | 13 | 16.77 |
| End BKF Station | 20.42 | 16.77 | 20.42 |

Entrainment Calculations

- - - -

Entrainment Formula: Rosgen Modified Shields Curve

ChannelLeft SideRight SideSlope000Shear Stress (lb/sq ft)00Movable Particle (mm)00

River Name:Calvert CliffsReach Name:SR-3 Upper ReachCross Section Name:XS Pool Upper 104Survey Date:10/05/2009

Cross Section Data Entry

BM Elevation:100 ftBacksight Rod Reading:3.19 ft

| TAPE | FS | ELEV | NOTE |
|------|-------|--------|---------------------|
| 0 | 1.91 | 101.28 | LEP |
| 5 | 2.65 | 100.54 | |
| 6 | 3.03 | 100.16 | |
| 7 | 3.45 | 99.74 | |
| 8 | 6.87 | 96.32 | |
| 8.5 | 8.58 | 94.61 | top of shells |
| 9.5 | 10.69 | 92.5 | lew |
| 11 | 10.84 | 92.35 | |
| 12 | 11.15 | 92.04 | |
| 13 | 11.29 | 91.9 | |
| 14.5 | 11.13 | 92.06 | |
| 16 | 10.72 | 92.47 | |
| 18 | 10.64 | 92.55 | rew |
| 18.5 | 10.42 | 92.77 | |
| 19 | 9.66 | 93.53 | BKF - top of shells |
| 22 | 2.78 | 100.41 | |
| 25 | 1.55 | 101.64 | |
| 27 | 0.07 | 103.12 | |

Cross Sectional Geometry

| Channe | el Left | Righ | nt |
|---------------------------|-----------|--------|---------|
| Floodprone Elevation (| ft) 95.16 | 5 95.1 | 6 95.16 |
| Bankfull Elevation (ft) | 93.53 | 93.53 | 93.53 |
| Floodprone Width (ft) | 11.37 | | |
| Bankfull Width (ft) | 9.99 | 4.24 | 5.75 |
| Entrenchment Ratio | 1.14 | | |
| Mean Depth (ft) | 1.17 | 1.23 | 1.13 |
| Maximum Depth (ft) | 1.63 | 1.63 | 1.6 |
| Width/Depth Ratio | 8.54 | 3.45 | 5.09 |
| Bankfull Area (sq ft) | 11.69 | 5.21 | 6.48 |
| Wetted Perimeter (ft) | 11.23 | 6.56 | 7.87 |
| Hydraulic Radius (ft) | 1.04 | 0.79 | 0.82 |

Begin BKF Station9.019.0113.25End BKF Station1913.2519

Entrainment Calculations

Entrainment Formula: Shields Curve

ChannelLeft SideRight SideSlope000Shear Stress (lb/sq ft)000Movable Particle (mm)000

SE 4 Lower Imp

RIVERMORPH PROFILE SUMMARY

River Name: Calvert Cliffs Reach Name: Bay SE-4 Bottom Profile Name: Headcut to Beach Survey Date: 09/23/2009

Survey Data

| DIST | СН | WS | BKF | P 1 | P2 | Р3 | P4 |
|------|-------|------|-----|------------|----|----|----|
| 0 | 8.65 | 8.2 | | | | | |
| 9 | 8.78 | | | | | | |
| 16 | 8.8 | 8.35 | | | | | |
| 23 | 9.06 | 8.3 | | | | | |
| 30 | 8.95 | | | | | | |
| 49 | 9.1 | 8.65 | | | | | |
| 58 | 9.48 | | | | | | |
| 62 | 9.74 | | | | | | |
| 69 | 10.7 | | | | | | |
| 70 | 14.8 | | | | | | |
| 78 | 14.53 | | | | | | • |
| 85 | 15.04 | | | | | | |
| 90 | 15.64 | | | | | | |
| 103 | 16.1 | | | | | | |
| 112 | 16.5 | | | | | | |
| 120 | 17.78 | | | | | | |
| 135 | 18.52 | | | | | | |
| 142 | 18.72 | | | | | | |
| 148 | 18.83 | | | | | | |
| 156 | 20.25 | | | | | | |
| 169 | 21.95 | | | | | | |
| 172 | 23.22 | | | | | | |
| 175 | 27.2 | | | | | | |
| 185 | 28.41 | | | | | | |

Cross Section / Bank Profile Locations

NameTypeProfile StationXS-3 @ 0+75Riffle XS0

Measurements from Graph

Bankfull Slope: 0

Variable Min Avg Max

| S riffle | 0 | | 0 | | 0 | | | | | |
|-------------|------|------|-------|------|------|-------|---------|-------|--------|-----|
| S pool | 0 | | 0 | | 0 | | | | | |
| S run | 0 | | 0 | | 0 | | | | | |
| S glide | 0 | | 0 | | 0 | | | | | |
| P - P | 0 | | 0 | | 0 | | | | | |
| Pool length | 3 | 0 | | 0 | | 0 | | | | |
| Riffle leng | th | 0 | | 0 | | 0 | | | | |
| Dmax riffle | e | 0 | | 0 | | 0 | | | | |
| Dmax pool | | 0 | | 0 | | 0 | | | | |
| Dmax run | | 0 | | 0 | | 0 | | | | |
| Dmax glide | e | 0 | | 0 | | 0 | | | | |
| Low bank | ht | 0 | | 0 | | 0 | | | | |
| Length and | l de | epth | meası | ırem | ents | in fe | et, slo | pes i | n ft/1 | ft. |

RIVERMORPH PROFILE SUMMARY

Notes

River Name: Calvert Cliffs Reach Name: Bay SE-4 Bottom Profile Name: Headcut to Beach Survey Date: 09/23/2009

DIST Note

- 0 theo bkf
- 16 right tob
- 23 right tob
- 30 channel is 5' wide here
- 49 theo bkf
- 175 upper beach elevation
- 185 beach added in office

| River Name: | Calvert Cliffs |
|---------------|-------------------|
| Reach Name: | Bay SE-4 Bottom |
| Cross Section | Name: XS-3 @ 0+75 |
| Survey Date: | 09/23/2009 |

·····

Cross Section Data Entry

BM Elevation: 96.41 ft Backsight Rod Reading: 0 ft

| TAPE | FS | ELEV | NOTE | |
|------|-------|-----------|---------|-----|
| 0 | 5.54 | 90.87 | | • • |
| 7 | 6.06 | 90.35 | | |
| 18 | 7.4 | 89.01 | <i></i> | |
| 20 | 8.3 | 88.11 | | |
| 21 | 11.8 | 84.61 | | |
| 23.2 | 14.15 | 82.26 | | |
| 26 | 14.4 | 82.01 | | |
| 29 | 14.08 | 82.33 | | |
| 30.5 | 12.43 | 83.98 | | |
| 31 | 8.43 | 87.98 | | |
| 37 | 7.38 | 89.03 | | |
| 43 | 5.15 | 91.26 | | |
| | | | | |

Cross Sectional Geometry

| Chann Electrone Election (| el] | Left | Rig | ht | 00.00 |
|-------------------------------|------|------|-------|------|-------|
| Floodprone Elevation (| n) 9 | 9.99 | 99.5 | 01 | 99.99 |
| Bankfull Elevation (ff) | 91 | | 91 · | 91 | |
| Floodprone Width (ft) | 43 | 5 | | | |
| Bankfull Width (ft) | 42.3 | 3 | 21.15 | 21 | .15 |
| Entrenchment Ratio | 1.0 | 02 | | | |
| Mean Depth (ft) | 3.05 | | 1.31 | 4.8 | |
| Maximum Depth (ft) | 8 | .99 | 6.55 | 8 | 3.99 |
| Width/Depth Ratio | 13 | .87 | 16.15 | 4 | .41 |
| Bankfull Area (sq ft) | 129 | 9.19 | 27.74 | 1 | 01.45 |
| Wetted Perimeter (ft) | 51 | .12 | 30.83 | 3 | 3.38 |
| Hydraulic Radius (ft) | 2.5 | 3 | 0.9 | 3.0 | 4 |
| Begin BKF Station | 0 | | 0 | 21.1 | 5 |
| End BKF Station | 42. | 3 | 21.15 | 42 | 2.3 |
| | | | | | |

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

SE 4 Upper Imp

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

| Basin: | SE-4 Dr | ainage Area: | 70.4 | acres | 0.11 | mi ² |
|-----------|---|---|--------------|--|---------------------------------------|-----------------|
| .ocation: | | | | | | |
| wp.&Rge | • • | Se | ec.&Qtr. | · ; | | |
| Cross-Sec | tion Monuments (Lat./Long.): 0 Lat | / 0 Long | | - | Date: | 09/15/0 |
| Observers | · · · · · · · · · · · · · · · · · · · | ¥ | | | Valley Type: | VIII |
| | | | | | 1 | 1 |
| | Banktuli WIDTH (W _{bkf}) | le elevation in a ri | iffle sectio | n an | 2.28 | f4 |
| | | | | | 2.50 |]'']'' |
| | Bankfull DEPTH (d _{bkf}) | ation at boold due | | - 4' | | |
| | riffle section ($d_{bkl} = A / W_{bkl}$). | Ction, at banktull s | tage elev | ation, in a | 0.42 | ft |
| | | | | | <u> </u> |] |
| | AREA of the stream channel cross-section at | hankfull stage ele | evation in | a riffle | | |
| | section. | oonnan orago ora | | | 1.01 | ft ² |
| | Width/Dopth Patio (W / d) | | | ····· | · · · · · · · · · · · · · · · · · · · | -] |
| | Bankfull WIDTH divided by bankfull mean DEI | PTH, in a riffle sec | ction. | | 5.67 | ft/ft |
| | | | | | 1 | 1 |
| | Maximum DEP I H (0 _{mbkf}) | section or distance | re hetwee | on the | | |
| | bankfull stage and Thalweg elevations, in a rif | fle section. | | | 0.56 | ft |
| | WIDTH of Flood-Prone Area (W _{(re}) | | | | | |
| | Twice maximum DEPTH, or $(2 \times d_{mbkf}) =$ the s | tage/elevation at v | vhich floo | d-prone area | | |
| | WIDTH is determined in a riffle section. | | | | 4.24 | ft |
| | Entrenchment Ratio (ER) | | | | | |
| | The ratio of flood-prone area WIDTH divided b | y bankfull channe | I WIDTH | (W _{fpa} / W _{bkf}) | | |
| | (riffle section). | | | | 1.78 | ft/ft |
| | Channel Materials (Particle Size Inc | dex)D ₅₀ | | | | |
| | The D ₅₀ particle size index represents the mean sampled from the channel surface, between the | n diameter of cha | nnel mate | erials, as | | |
| | elevations. | e Dankiuli Slaye a | inu maiw | ey | 0,19 | mm |
| | | | | | | |
| | Channel slope = "rise over run" for a reach apr | proximately 20-30 | bankfull | channel | | |
| | widths in length, with the "riffle-to-riffle" water s | surface slope repre | esenting t | he gradient | | |
| | at banktull stage. | | | <u>-</u> | 0.01178 | ft/ft |
| | Channel SINUOSITY (k) | | | | | |
| | Sinuosity is an index of channel pattern, deterr | nined from a ratio | of stream | length | | |
| | civided by valley length (SL / VL); or estimated channel slope (VS / S). | from a ratio of va | ney slope | divided by | | |
| | | ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ | | | | |
| | Stream B5c |] | (500 | Figure 2 | .14) | |
| | Туре / шиление толо то стал | | (366 | i igule Z | 17) | |

Copyright © 2006 Wildland Hydrology

Ń

WARSSS page 5-29

RIVERMORPH PROFILE SUMMARY

River Name:Calvert CliffsReach Name:Bay SE-4 TopProfile Name:TopSurvey Date:09/16/2009

Survey Data

| DIST | CH | WS | BKF | P1 | P2 | P3 | P4 | | 1) 1 | |
|----------|--------------|------|----------|----|----|----|----|------|---------|--|
| 0 | 7.32 | 7.32 | | | | | | | | |
| 4 | 7.35 | | 6.39 | | | | | | | |
| 6 | 7.27 | - | | | | | | | | |
| 10 | 7.37 | | | | | | | | | |
| 14 | 7.41 | | 6.69 | | | | | | | |
| 19 | 7.52 | | | | | | | · | | |
| 25 | 7.55. | | | | | | | | | |
| 27 | | | 5.87 | | | | | | | |
| 35 | 7.78 | | | | | | | | | |
| 42 | 7.91 | | | | | | | | | |
| 46 | 7.89 | | | | | | | | | |
| 51 | 7.96 | | | | | | | | | |
| 56 | 8.19 | 7.3 | 4 | | | | | | | |
| 59 | 8.25 | | | | | | | | | |
| 62 | 8.24 | | | | | | | | | |
| 65 | 8.3 | | | | | | | | | |
| 74 | 8.34 | 7 (| <i>(</i> | | | | | | | |
| /8 | 8.34 | /.0 | 0 | | | | | | | |
| 83 99 | 0.41 9.47 | . 77 | Q | | | | | | | |
| 00 | 0.47 8.60 | 1.1 | 0 | | | | | | | |
| 92 07 | 8.09 | | | | | | | | | |
| 101 | 8 74 | | | | | | | | | |
| 101 | 8 74 | | | | | | | | | |
| 108 | 8 88 | 8.1 | 6 | | | | | | | |
| 113 | 9.02 | | | | | | | | | |
| 119 | 9.27 | 8.3 | 86 | | | | | | | |
| 125 | 9.36 | | | | | | | | | |
| 131 | 9.4 | | | | | | | | | |
| 137 | 9.47 | | 6.99 | | | | | | | |
| 141 | 9.39 | | • | | | | | | | |
| 148 | 9.7 | | | | | | | | | |
| 153 | 9.75 | 8.9 | 3 7 | | | | | | | |
| 162 | 9.69 | | | | | | | | | |
| 167 | 9.73 | | | | | | | | | |
| 171 | 9.71 | 8.9 |) | | | | | | | |
| 179 | 9.79 | | | | | | | | | |



| 186 | 9.95 | |
|-----|-------|-----------|
| 189 | 10 | |
| 193 | 10.03 | 9.14 7.89 |
| 199 | 10.1 | |
| 205 | 10.19 | |
| 209 | 10.21 | 9.51 |
| 215 | 10.42 | |
| 219 | 10.34 | 8.75 |
| 226 | 10.3 | |
| 231 | 10.43 | 9.57 |
| 237 | 10.45 | |
| 240 | 10.5 | |
| 242 | 10.47 | |
| 244 | 10.61 | |
| 250 | 10.71 | 8.7 |
| 256 | 10.72 | |
| 261 | 10.81 | |
| 264 | 10.99 | |
| 269 | 11 | |
| 274 | 11.07 | |
| 278 | | 9.77 |
| 284 | 11.24 | |
| 289 | 11.15 | |
| 292 | 11.32 | |
| 296 | | 10.27 |
| 330 | 11.37 | |
| | | |

Cross Section / Bank Profile Locations

| Name | Туре | Profile Station |
|------------|-----------|-----------------|
| Riffle 231 | Riffle XS | 0 |
| Pool 219 | Pool XS | 0 |

Measurements from Graph

Bankfull Slope: 0

| Variable | Min | Avg | Ma | х |
|---------------|---------|--------|-------------|-----------------|
| S riffle 0 |) | 0 | 0 | |
| S pool | 0 | 0 | 0 | |
| S run (|) | 0 | 0 | |
| S glide |) | 0 | 0 | |
| P-P 0 | | 0 2 | 0 | |
| Pool length | 0 | 0 | 0 | |
| Riffle length | 0 | 0 | 0 | |
| Dmax riffle | 0 | 0 | 0 | |
| Dmax pool | 0 | 0 | 0 | |
| Dmax run | 0 | 0 | 0 | |
| Dmax glide | 0 | 0 | 0. | |
| Low bank ht | 0 | 0 | 0 | |
| Langth and | lanth m | ~~~~~~ | ata in fact | alamaa in ft/ft |

Length and depth measurements in feet, slopes in ft/ft.

RIVERMORPH PROFILE SUMMARY

Notes

River Name: Calvert Cliffs Reach Name: Bay SE-4 Top Profile Name: Top Survey Date: 09/16/2009

DIST Note

| 4 | tob left |
|-----|-----------|
| 14 | bench |
| 27 | tob right |
| 51 | pool |
| 56 | bench |
| 62 | riffle |
| 65 | riffle |
| 78 | bench |
| 92 | log |
| 108 | bench |
| 137 | left bank |
| 153 | tob right |
| 215 | р |
| 231 | r |
| 242 | run |
| 244 | ทาท |

| River Name:Calvert CliffsReach Name:Bay SE-4 TopCross Section Name:Riffle 231Survey Date:09/23/2009 | | | | | | | | | | |
|--|--------------|----------|-----------|--|--|--|--|--|--|--|
| Cross Section Data Entry | | | | | | | | | | |
| BM Elevation: 0 ft Backsight Rod Reading: 0 ft | | | | | | | | | | |
| TAPE | FS | ELEV | NOTE | | | | | | | |
| 0 | ۰۰۰۰۰ ۱ | 100 | | | | | | | | |
| 0 | 81 | 01.6 | IED | | | | | | | |
| 2 | 0.4 9.70 | 91.0 | LEF | | | | | | | |
| 2 0 | 0.72 8 70 | 91.20 | | | | | | | | |
| 10 | 8 08 | 01.02 | | | | | | | | |
| 10 | 0.20 | 90.79 | | | | | | | | |
| 11 5 | 0.25 | 90.65 | | | | | | | | |
| 11.5 | 10.25 | 89.75 | | | | | | | | |
| 12.2 | 10.25 | 89.64 | | | | | | | | |
| 12.2 | 10.50 | 89.56 | TW | | | | | | | |
| 13.6 | 10.44 | 89.50 | 1 ** | | | | | | | |
| 12.0 | 9.88 | 90.12 | BKF | | | | | | | |
| 14 6 | 9.63 | 90.12 | DIXI | | | | | | | |
| 14.0 | 9.05 | 90.79 | | | | | | | | |
| 29 | 9.21 8 1 | 91.9 | | | | | | | | |
| 50 | 0.1 | 100 | | | | | | | | |
| Cross Sec | ctional Ge | ometry | | | | | | | | |
| | | | | | | | | | | |
| Channel Left Right Floodprone Elevation (ft) 90.68 90.68 90.68 Bankfull Elevation (ft) 90.12 90.12 90.12 Floodprone Width (ft) 4.24 Bankfull Width (ft) 2.38 1.19 1.19 | | | | | | | | | | |
| Entrenchi | ment Ratio | 1.78 | | | | | | | | |
| Mean De | pth (ft) | 0.42 | 0.45 0.4 | | | | | | | |
| Maximun | n Depth (1 | (1) 0.56 | 0.54 0.56 | | | | | | | |
| Width/De | epin Ratio | 3.0/ | 2.04 2.97 | | | | | | | |
| Banktull Area (sq ft) 1.01 0.54 0.47 | | | | | | | | | | |
| Wetted Perimeter (ft) $2.88 \ 2.05 \ 1.92$ | | | | | | | | | | |
| Hydraulic Kadlus (II) 0.35 0.26 0.25 | | | | | | | | | | |
| Begin BKF Station 11.62 11.62 12.81 | | | | | | | | | | |
| End BKF Station 14 12.81 14 | | | | | | | | | | |

file:///lovetonfp/...20Mitigation/Design%20Data/all%20rivermorph%20reports/SE-4%20Upper%20Imp/se-4%20up%20riffle%20report.txt[10/5/2010 10:40:59 AM]

Entrainment Calculations

Entrainment Formula: Shields Curve

Channel Left Side Right Side Slope 0.01178 0 0 Shear Stress (lb/sq ft) 0.26 Movable Particle (mm) 14.2

| River Name:Calvert CliffsReach Name:Bay SE-4 TopCross Section Name:Pool 219Survey Date:09/23/2009 | | | | | | | | | | | |
|---|-----------------------|-----------------|--------|---------|---|--|--|--|--|--|--|
| Cross Section Data Entry | | | | | | | | | | | |
| BM Elev Backsigh | vation: nt Rod Rea | 0 ft ding: 0 | ft | | | | | | | | |
| TAPE | FS | ELEV | N | DTE | | | | | | | |
| 0 | 84 | 91.6 | LEP | | | | | | | | |
| 4 | 8.5 | 91.5 | | | | | | | | | |
| 9 | 8.3 | 91.7 | | | | | | | | | |
| 13 | 8.64 | 91.36 | | | | | | | | | |
| 14 | 8.9 | 91.1 | | • | | | | | | | |
| 14.5 | 9.1 | 90.9 | BKF | | | | | | | | |
| 15.7 | 10.11 | 89.89 | | • | | | | | | | |
| 16.4 | 10.29 | 89.71 | | | | | | | | | |
| 17 | 10.31 | 89.69 | | | | | | | | | |
| 17.4 | 10.31 | 89.69 | TW | | | | | | | | |
| 18 | 10.27 | 89.73 | | | | | | | | | |
| 18.2 | 9.29 | 90.71 | | | | | | | | | |
| 19 | 8.76 | 91.24 | | | | | | | | | |
| 24 | 8.5 | 91.5 | | | | | | | | | |
| 34 | 8.4 | 91.6 | | | | | | | | | |
| Cross Se | ctional Ge | ometry | | | | | | | | | |
| | Ch | annel Lefi | t Rigl | nt | | | | | | | |
| Floodpro | ne Elevatio | on (ft) 92.1 | 1 92.1 | 1 92.11 | | | | | | | |
| Bankfull | Elevation | (ft) 90.9 | 90.9 | 90.9 | | | | | | | |
| Floodpro | ne Width (| (ft) 34 | | | | | | | | | |
| Bankfull | Width (ft) | 3.99 | 1.99 | 2 | | | | | | | |
| Entrenchment Ratio 8.53 | | | | | | | | | | | |
| Mean De | pth (ft) | 0.87 | 0.75 | 0.99 | • | | | | | | |
| Maximun | n Depth (f | t) 1.21 | 1.19 | 1.21 | | | | | | | |
| Width/De | epth Ratio | 4.59 | 2.65 | 2.02 | | | | | | | |
| Bankfull | | | | | | | | | | | |
| Wetted P | erimeter (f | it) 5.24 | 3.57 | 4.05 | | | | | | | |
| Hydraulic | c Radius (f | t) 0.66 | 0.41 | 0.49 | | | | | | | |
| Begin Bk | CF Station | 14.5 | 14.5 | 16.49 | | | | | | | |
| End BKF | Station | 18.49 | 16.49 | 18.49 | | | | | | | |

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

1

SR 4 Imp

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

| Basin: | Drainage Area: 0 acres | 0 | mi ² | | |
|-----------|---|-------------|------------------|--|--|
| Location: | | | | | |
| Twp.&Rge | e:; Sec.&Qtr.:; | | | | |
| Cross-Sec | ction Monuments (Lat./Long.): 0 Lat / 0 Long | Date | : 10/15/0 | | |
| Observers | 5. | Valley Type | : IX | | |
| | Bankfull WIDTH (West) | | ٦ | | |
| × | WIDTH of the stream channel at bankfull stage elevation, in a riffle section. | 8.5 | ft | | |
| | Bankfull DEPTH (d) | | - - | | |
| | Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a | | | | |
| | riffle section ($d_{bkt} = A / W_{bkt}$). | 0.58 | ft | | |
| | Bankfull X-Section AREA (Abbf) | | 7 | | |
| | AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle | | | | |
| | section. | 4.96 | _ft ² | | |
| | Width/Depth Ratio (W _{bkf} / d _{bkf}) | | 7 | | |
| | Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section. | 14.66 | ft/ft | | |
| | Maximum DEPTH (d _{mbkf}) | | 1 | | |
| | Maximum depth of the bankfull channel cross-section, or distance between the | | | | |
| | bankfull stage and Thalweg elevations, in a riffle section. | 1.09 | _ft | | |
| | WIDTH of Flood-Prone Area (W _{fpa}) | ····· |] | | |
| | Twice maximum DEPTH, or $(2 \times d_{mbd}) \approx$ the stage/elevation at which flood-prone area | | | | |
| | This determined in a nine section. | 25 | _itt | | |
| | Entrenchment Ratio (ER) | |] | | |
| | The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section). | 2 01 | ft/ft | | |
| | | 2.34 | יייינ ח | | |
| | Channel Materials (Particle Size Index) D ₅₀ | | | | |
| | sampled from the channel surface, between the bankfull stage and Thalweg | | | | |
| | elevations. | 0.23 | mm | | |
| ò | Water Surface SLOPE (S) | | | | |
| | Channel slope = "rise over run" for a reach approximately 20-30 bankfull channel | | | | |
| | widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage. | 0.0054 | 6. /G | | |
| | | 0.0054 | | | |
| | Channel SINUOSITY (k) | · | | | |
| | Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by | | | | |
| | channel slope (VS / S). | 1.54 | | | |
| | Stream C 5 | | 7 | | |
| | Type (See Figure 2- | 14) | | | |

Copyright © 2006 Wildland Hydrology

RIVERMORPH PROFILE SUMMARY

River Name: Calvert Cliffs Reach Name: Johns SR-4 Profile Name: Reference Survey Date: 11/02/2009

Survey Data

| DIST | CH | I W | S BK | LF P1 | P2 | P3 | P4 | |
|------|------|------|------|-------|----|----|----|---|
| 0 | 6.61 | 6.37 | 6. | .25 | | | | - |
| 3 | 6.42 | 6.37 | 5.72 | | | | | |
| 5 | 6.4 | 6.38 | 5.49 | | | | | |
| 9 | 6.45 | 6.39 | 5.71 | | | | | |
| 11 | 6.53 | 6.41 | | | | | | |
| 13 | 6.56 | 6.43 | 5.28 | 5.7 | 8 | | | |
| 15 | 6.6 | 6.42 | | | | | | |
| 18 | 6.68 | 6.42 | | | | | | |
| 21 | 6.53 | 6.43 | 5.62 | | | | | |
| 24 | 6.47 | 6.44 | 5.62 | | | | | |
| 26 | 6.65 | 6.49 | | | | | | |
| 29 | 6.59 | 6.51 | | | | | | |
| 31 | 6.75 | 6.61 | | | | | | |
| 32 | 6.89 | 6.67 | | | | | | |
| 35 | 6.98 | 6.71 | 6.04 | | | | | |
| 37 | 7.29 | 6.68 | | | | | | |
| 39 | 7.78 | 6.68 | | | | | | |
| 41 | 7.73 | 6.68 | | | | | | |
| 42 | 7.45 | 6.68 | | | | | | |
| 43 | 7.15 | 6.69 | 6.03 | | | | | |
| 45 | 7.01 | 6.69 | | | | | | |
| 47 | 6.78 | 6.7 | | | | | | |
| 48 | 6.88 | 6.71 | | | | | | |
| 50 | 7 | 6.79 | | | | | | |
| 51 | 7.73 | 6.79 | | | | | | |
| 52 | 7.75 | 6.79 | | | | | | |
| 53 | 7.21 | 6.79 | | | | | | |
| 57 | 7.23 | 6.78 | 5.98 | 5.98 | 8 | | | |
| 60 | 7.15 | | | | | | | |
| 62 | 7.13 | | | | | | | |
| 64 | 7.11 | 4 | 5.81 | 6.14 | | | | |
| 65 | 7.03 | 6.78 | | | | | | |
| 67 | 6.89 | 6.78 | | | | | | |
| 69 | 6.94 | 5 | 5.94 | | | | | |
| 70 | 7.2 | | | | | | | |
| 71 | 7.53 | | | | | | | |
| 72 | 7.3 | | | | | | | |

| 6 |
|---|
| |
| |
| |

| 74 | 7.03 | 6.79 | 6.07 |
|-----|--------|------------|------|
| 77 | 7.02 | | |
| 79 | 7.02 | 4 | 5.63 |
| 82 | 6.95 | 6.79 | |
| 84 | 6.93 | | |
| 85 | 7.12 | ϵ | 5.07 |
| 88 | 7.09 | 6.79 | |
| 91 | 6.97 | 5 | 5.79 |
| 94 | 6.89 | 6.79 | |
| 100 | 6.88 | 6.8 | 5.82 |
| 103 | 6.99 | 6.81 | |
| 107 | 6.97 | 6.85 | |
| 110 | 7.02 | 6.87 | 6.19 |
| 115 | 6.99 | 6.86 | 5.83 |
| 118 | 6.95 | 6.86 | |
| 120 | 7.15 | 6.89 | |
| 121 | 7.24 | 6.99 | |
| 122 | 7.31 | | |
| 125 | 7.12 | (| 5.13 |
| 129 | 7.02 | 6.97 | |
| 130 | 7.13 | 6.99 | |
| 131 | 7.29 | 7.04 | |
| 132 | 7.42 | | |
| 134 | 7.25 | | |
| 135 | 7.19 | 7.01 | |
| 138 | • 7.15 | 7.02 | 6.28 |
| 140 | 7.26 | e | 5.22 |
| 144 | 7.18 | 7.03 | |
| 147 | 7.1 | 7.04 | |
| 150 | 7.39 | 7.1 | |
| 152 | 7.24 | 7.11 | |
| 155 | 7.31 | 7.13 | |
| 156 | 7.47 | 7.25 | |
| 158 | 7.56 | 7.27 | |
| 160 | 7.71 | 6 | 5.26 |
| 161 | 7.58 | 7.29 | |
| 163 | 7.34 | 7.29 | |
| 165 | 7.41 | 6 | 5.7 |
| 167 | 7.4 | 7.29 | |
| 170 | | 6.5 | 52 |
| 173 | 7.38 | 7.31 | |
| 174 | 7.52 | 7.37 | |
| 178 | 7.5 | 7.39 | |
| 180 | 7.45 | 6 | .76 |
| | | | |

Cross Section / Bank Profile Locations

| Name | Туре | Profile Station | |
|------------------|-----------|-----------------|--|
| Pool at 38 | Pool XS | 38 | |
| Glide at 44 | Glide XS | 44 | |
| Valley Run at 49 | Run XS | 49 | |
| Riffle at 100 | Riffle XS | 100 | |
| Riffle at 220 | Riffle XS | 220 | |

6.63

file:///lovetonfp/...0Mitigation/Design%20Data/all%20rivermorph%20reports/SR-4%20Imp%20Johns/sr-4%20ref%20profile%20report.txt[10/5/2010 10:43:

| Pool at 238 | Pool XS | 238 |
|-------------------|-----------|-----|
| Riffle Valley 100 | Riffle XS | 0 |

Measurements from Graph

Bankfull Slope: 0.0054

| Variable | Min | Avg | Max | |
|-------------|---------|---------|---------|--|
| S riffle | 0.00135 | 0.00514 | 0.00945 | |
| S pool | 0 | 0.00156 | 0.00559 | |
| S run | 0.02651 | 0.05206 | 0.12129 | |
| S glide | 0.00149 | 0.00322 | 0.00496 | |
| P - P | 10.37 | 20.23 | 35.53 | |
| Pool length | n 3.41 | 10.35 | 16.34 | |
| Riffle leng | th 3.13 | 7.5 | 10.23 | |
| Dmax riffle | e 0.81 | 0.9 | 1.02 | |
| Dmax pool | 1.02 | 1.53 | 2.03 | |
| Dmax run | 0.83 | 0.99 | 1.16 | |
| Dmax glid | e 0.87 | 1.02 | 1.23 | |
| Low bank | ht 0.83 | 0.89 | 0.97 | |
| | | | | |

Length and depth measurements in feet, slopes in ft/ft.

RIVERMORPH PROFILE SUMMARY

Notes

River Name: Calvert Cliffs Reach Name: Johns SR-4 Profile Name: Reference Survey Date: 11/02/2009

DIST Note

| 2.0. | |
|------|----------------|
| | |
| 0 | GLIDE |
| 3 | RIGHT |
| 5 | LEFT |
| 9 | RIGHT |
| 13 | GLIDE |
| 21 | RIGHT |
| 24 | RIGHT |
| 35 | RIGHT |
| 37 | POOL |
| 39 | POOL SECTION |
| 45 | GLIDE SECTION |
| 48 | RUN SECTION |
| 79 | LEFT |
| 91 | RIGHT |
| 100 | RIGHT |
| 110 | RIFFLE SECTION |
| 125 | LEFT |

| 140 | LEFT |
|-----|-------|
| 160 | RIGHT |
| 180 | RIGHT |

RIVERMORPH PROFILE SUMMARY

River Name: Calvert Cliffs Reach Name: Johns SR-4 Profile Name: reach Survey Date: 10/15/2009

Survey Data

| DIST | CH | I W | S BKI | F BAR | BENCH | P3 | P4 | |
|------|-------------------|------|-------|-------|-------|----|----|--|
| 0 | 6.61 | 6.37 | 6.2 | 25 | | | | |
| 3 | 6.42 | 6.37 | 5.72 | | | | | |
| 5 | 6.4 | 6.38 | 5.49 | | | | | |
| 9 | 6.45 | 6.39 | 5.71 | | | | | |
| 11 | 6.53 | 6.41 | | | | | | |
| 13 | 6.56 | 6.43 | 5.28 | 5.78 | | | | |
| 15 | 6.6 | 6.42 | | | | | | |
| 18 | 6.68 | 6.42 | | | | | | |
| 21 | 6.53 | 6.43 | 5.62 | | | | | |
| 24 | [·] 6.47 | 6.44 | 5.62 | | | | | |
| 26 | 6.65 | 6.49 | | | | | | |
| 29 | 6.59 | 6.51 | | | | | | |
| 31 | 6.75 | 6.61 | | | | | | |
| 32 | 6.89 | 6.67 | | | | | | |
| 35 | 6.98 | 6.71 | 6.04 | | | | | |
| 37 | 7.29 | 6.68 | | | | | | |
| 39 | 7.78 | 6.68 | | | | | | |
| 41 | 7.73 | 6.68 | | | | | | |
| 42 | 7.45 | 6.68 | | | | | | |
| 43 | 7.15 | 6.69 | 6.03 | | | | | |
| 45 | 7.01 | 6.69 | | | | | | |
| 47 | 6.78 | 6.7 | | | | | | |
| 48 | 6.88 | 6.71 | | | - | | | |
| 50 | 7 | 6.79 | | | | | | |
| 51 | 7.73 | 6.79 | | , | | | | |
| 52 | 7.75 | 6.79 | | | | | | |
| 53 | 7.21 | 6.79 | | | | | | |
| 57 | 7.23 | 6.78 | 5.98 | 5.98 | | | | |
| 60 | 7.15 | | | | | | | |
| 62 | 7.13 | | | | | | | |
| 64 | 7.11 | 4 | 5.81 | 6.14 | | | | |
| 65 | 7.03 | 6.78 | | | | | | |
| 67 | 6.89 | 6.78 | | | | | | |
| 69 | 6.94 | 4 | 5.94 | | | | | |
| 70 | 7.2 | | | | | | | |
| 71 | 7.53 | | | | | | | |
| 72 | 73 | | | | | | | |

| 74 | 7.03 | 6.79 | 6.07 | 6.63 |
|-------|--------|------|------|------|
| 77 | 7.02 | | | |
| 79 | 7.02 | - | 5.63 | |
| 82 | 6.95 | 6.79 | | |
| 84 | 6.93 | | | |
| 85 | 7.12 | (| 5.07 | |
| 88 | 7.09 | 6.79 | | |
| 91 | 6.97 | 4 | 5.79 | |
| 94 | 6.89 | 6.79 | | |
| 100 | 6.88 | 6.8 | 5.82 | |
| 103 | 6.99 | 6.81 | | |
| 107 | 6.97 | 6.85 | | |
| 110 | 7.02 | 6.87 | 6.19 | |
| 115 | 6.99 | 6.86 | 5.83 | |
| 118 | 6.95 | 6.86 | | |
| 120 | 7.15 | 6.89 | | |
| 121 | 7.24 | 6.99 | | |
| 122 | 7.31 | | | |
| 125 | 7.12 | | 6.13 | |
| 129 | 7.02 | 6.97 | | |
| 130 | 7.13 | 6.99 | | |
| 131 | 7.29 | 7.04 | | |
| 132 | 7.42 | | | |
| 134 | 7.25 | | | |
| 135 | 7.19 | 7.01 | | |
| 138 | 7.15 | 7.02 | 6.28 | |
| 140 | 7.26 | (| 5.22 | |
| 144 | 7.18 | 7.03 | | |
| 147 | 7.1 | 7.04 | | |
| 150 | 7.39 | 7.1 | | |
| 152 | 7.24 | 7.11 | | |
| 155 | . 7.31 | 7.13 | | |
| 156 | 1.47 | 7.25 | | |
| 158 | 7.50 | 1.27 | | |
| 160 | 7.71 | 7 20 | 5.26 | |
| 101 | 7.30 | 7.29 | | |
| 105 | 7.54 | 1.29 | . 7 | |
| 167 | 7.41 | 7 20 | 5.7 | |
| 170 | 7.4 | 1.25 | 52 | |
| 173 | 7 38 | 7 31 | | |
| 174 | 7.52 | 7 37 | | |
| 178 | 7.5 | 7 39 | | |
| 180 | 7.45 | (| 5.76 | |
| 181 | 7.74 | 7.37 | | |
| 184 | 7.63 | 7.37 | 6.77 | |
| 186 | 7.47 | 6 | 5.68 | |
| 189 | 7.48 | 7.38 | | |
| 192 | 7.55 | 7.41 | | |
| 192.5 | 7.63 | 7.58 | | |
| 194 | 7.78 | 7.6 | 6.43 | |
| 200 | 7.73 | 7.73 | 6.46 | 1 |
| 201 | 10.08 | 9.78 | | |
| 202 | 11.43 | 9.78 | | |

6.09

ę

204 11.38 9.78 210 10.03 10.07 9.78 6.66 213 218 9.86 224 10.07 230 10.01 9.78 236 9.8 9.8 6.8 236.2 10.68 9.9 10.55 9.9 237 241 10.22 9.9 10.02 9.94 7.2 242 9.17 246 10.23 9.96 253 10.22 10.08 6.91 258 10.17 10.08 262 10.22 10.09 265 10.6 10.11 270 10.44 10.15 6.87 5.3

Cross Section / Bank Profile Locations

| Name | Туре | Profile Station |
|-------------------|-----------|-----------------|
| Pool at 38 | Pool XS | 38 |
| Glide at 44 | Glide XS | 44 |
| Valley Run at 49 | Run XS | 49 |
| Riffle at 100 | Riffle XS | 100 |
| Riffle at 220 | Riffle XS | 220 |
| Pool at 238 | Pool XS | 238 |
| Riffle Valley 100 | Riffle XS | 0 |

Measurements from Graph

Bankfull Slope: 0

| Variable | Min | Avg | | Max |
|--------------|---------|------------|----------|-----------------------|
| | | | | |
| S riffle | 0 | 0 | 0 | |
| S pool | 0 | 0 | 0 | |
| S run | 0 | 0 | 0 | |
| S glide | 0 | 0 | 0 | |
| P - P | 0 | 0 | 0 | |
| Pool length | 0 | 0 | · 0 | |
| Riffle lengt | th 0 | 0 | 0 | |
| Dmax riffle | e 0 | * 0 | 0 | |
| Dmax pool | 0 | 0 | 0 | |
| Dmax run | 0 | 0 | 0 | |
| Dmax glide | e 0 | 0 | 0 | |
| Low bank | ht 0 | 0 | 0 | |
| Length and | depth m | easuremer | nts in f | eet, slopes in ft/ft. |

RIVERMORPH PROFILE SUMMARY

Notes

River Name: Calvert Cliffs Reach Name: Johns SR-4 Profile Name: reach Survey Date: 10/15/2009

DIST Note

| 0 | GLIDE |
|-----|-----------------------|
| 3 | RIGHT |
| 5 | LEFT |
| 9 | RIGHT |
| 13 | GLIDE |
| 21 | RIGHT |
| 24 | RIGHT |
| 35 | RIGHT |
| 37 | POOL |
| 39 | POOL SECTION |
| 45 | GLIDE SECTION |
| 48 | RUN SECTION |
| 79 | LEFT |
| 91 | RIGHT |
| 100 | RIGHT |
| 110 | RIFFLE SECTION |
| 125 | LEFT |
| 140 | LEFT |
| 160 | RIGHT |
| 180 | RIGHT |
| 184 | RIGHT |
| 236 | LEFT |
| 242 | LEFT |
| 253 | LEFT |
| 270 | benchmark at ele 5.3 |
| | |

| River Na Reach N Cross Se Survey I | ame: ame: ection Nar Date: | Calvert Cliff Johns SR-4 ne: Riffle at 10/15/2009 | îs 100 |
|--|--|--|--|
| Cross Se | ction Dat | a Entry | |
| BM Elev Backsigh | vation: nt Rod Re | 98 ft ading: 2 | ft |
| TAPE | FS | ELEV | NOTE |
| 0 | 6.07 | 03 03 | |
| 2 | 5.94 | 94.06 | |
| 5 | 5.24 | 94.00 | |
| 56 | 5.05 | 94 21 | len |
| 8 | 5.8 | 94 2 | BKF |
| 9 | 6.01 | 93.99 | |
| 10 | 6.58 | 93.42 | |
| 104 | 6.8 | 93.2 | |
| 11 | 6.88 | 93.12 | |
| 12 | 6.89 | 93.11 | |
| 12.5 | 6.77 | 93.23 | |
| 13 | 6.74 | 93.26 | |
| 14 | 6.61 | 93.39 | |
| 14.5 | 6.08 | 93.92 | |
| 15 | 5.88 | 94.12 | |
| 16 | 5.82 | 94.18 | |
| 18 | 5.97 | 94.03 | |
| 20 | 6.18 | 93.82 | |
| 22 | 5.99 | 94.01 | |
| 24 | 5.68 | 94.32 | |
| 25 | 5.71 | 94.29 | |
| Cross See | ctional Ge | cometry | |
| | | | |
| | | | |
| Floodprog Bankfull Floodprog Bankfull Entrench Mean Dep | Cl ne Elevati Elevation ne Width Width (ft) ment Ration pth (ft) | hannel Left ion (ft) 95.29 (ft) 94.2 (ft) 25) 15.23 o 1.64 0.42 | Right 95.29 95.29 94.2 94.2 0.79 14.44 0.08 0.44 |
| Maximun Width/De | n Depth (: pth Ratio | ft) 1.09 36.26 | 0.17 1.09 9.88 32.82 |

file:///lovetonfp/... I% 20 Mitigation/Design% 20 Data/all% 20 rivermorph% 20 reports/SR-4% 20 Imp% 20 Johns/sr-4% 20 riffle% 201% 20 report.txt [10/5/2010 10:43:16 AM]

| Bankfull Area (sq ft) | 6.37 | 0.07 | 6.31 |
|-----------------------|-------|------|-------|
| Wetted Perimeter (ft) | 15.79 | 0.97 | 15.15 |
| Hydraulic Radius (ft) | 0.4 | 0.07 | 0.42 |
| Begin BKF Station | 8 | 8 | 8.79 |
| End BKF Station | 23.23 | 8.79 | 23.23 |
| | | | |

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

ChannelLeft SideRight SideSlope000Shear Stress (lb/sq ft)Movable Particle (mm)

| River Name:Calvert CliffsReach Name:Johns SR-4Cross Section Name:Pool at 38Survey Date:10/15/2009 | | | | | | |
|---|------------------------|--------------------|-------|---------|--|--|
| Cross Se | ction Data | Entry | | | | |
| BM Elev Backsigł | vation: nt Rod Read | 98 ft ing: 2 f | t | | | |
| TAPE | FS | ELEV | NC | DTE | | |
| 0 | 5.43 | 94.57 | | | | |
| 2.5 | 5.49 | 94.51 | lep | | | |
| 4 | 5.72 | 94.28 | 1 | | | |
| 5 | 5.87 | 94.13 | | | | |
| 6 | 6.16 | 93.84 | | | | |
| 7 | 6 47 | 93.53 | | | | |
| , 7 5 | 6 69 | 93 31 | LEW | | | |
| 8 | 7 68 | 92 32 | | | | |
| 88 | 7 71 | 92.22 | | | | |
| 9.5 | 7.63 | 92.27 | | | | |
| 10 | 7 | 93 | | | | |
| 10 2 | 671 | 93.29 | | | | |
| 10.2 | 6.22 | 93.78 | | | | |
| 10.5 | 5.08 | 93.76 | BKE | | | |
| 12 | 5.90 | 94.02 | DKI | | | |
| 20 | 5.69 | 94.31 | | | | |
| 20 | 5.07 | J 4 .31 | | | | |
| | | | | | | |
| Cross Se | ctional Geo | metry | | | | |
| | | | | | | |
| | C1- | | D:-1 | - 4 | | |
| F1 1 | Cha | nnel Left | Kigr | | | |
| Floodpro | ne Elevation | n (ff) 95.75 | 95.7 | 5 95.75 | | |
| Bankfull | Elevation (| tt) 94.02 | 94.02 | 94.02 | | |
| Floodpro | one Width (f | t) 20 | | | | |
| Bankfull | Width (ft) | 6.62 | 2.97 | 3.65 | | |
| Entrench | ment Ratio | 3.02 | | | | |
| Mean De | epth (ft) | 0.76 | 0.64 | 0.86 | | |
| Maximu | m Depth (ft) | 1.73 | 1.71 | 1.73 | | |
| Width/D | epth Ratio | 8.71 | 4.64 | 4.24 | | |
| Bankfull | Area (sq ft) | 5.02 | 1.89 | 3.13 | | |
| Wetted P | Perimeter (ft |) 8.1 | 5.41 | 6.12 | | |
| Hydrauli | c Radius (ft) |) 0.62 | 0.35 | 0.51 | | |
| Begin BI | KF Station | 5.38 | 5.38 | 8.35 | | |
| End BKF | F Station | 12 | 8.35 | 12 | | |

file:////lovetonfp/...I%20Mitigation/Design%20Data/all%20rivermorph%20reports/SR-4%20Imp%20Johns/sr-4%20pool%201%20report.txt[10/5/2010 10:43:18 AM]

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

ChannelLeft SideRight SideSlope000Shear Stress (lb/sq ft)00Movable Particle (mm)00

River Name:Calvert CliffsReach Name:Johns SR-4Cross Section Name:Glide at 44Survey Date:10/15/2009

Cross Section Data Entry

BM Elevation:98 ftBacksight Rod Reading:2 ft

| TAPE | FS | ELEV | NOTE |
|------|------|-------|------|
| 0 | 5.4 | 94.6 | |
| 2 . | 5.35 | 94.65 | |
| 3 | 6.07 | 93.93 | |
| 4 | 5.94 | 94.06 | lep |
| 5 | 5.82 | 94.18 | |
| 5.5 | 6.12 | 93.88 | |
| 6 | 6.26 | 93.74 | |
| 7 | 6.6 | 93.4 | |
| 7.3 | 6.77 | 93.23 | |
| 7.6 | 6.9 | 93.1 | |
| 8 | 6.95 | 93.05 | |
| 8.5 | 6.9 | 93.1 | |
| 9 | 6.75 | 93.25 | |
| 9.5 | 6.58 | 93.42 | |
| 10 | 6.14 | 93.86 | |
| 11 | 5.92 | 94.08 | |
| 13 | 5.68 | 94.32 | BKF |
| 15 | 5.62 | 94.38 | |
| 45 | 5.62 | 94.38 | |

.....

Cross Sectional Geometry

| Chann | el Left | Rigl | nt |
|-------------------------|-----------|--------|---------|
| Floodprone Elevation (| ft) 95.59 | 9 95.5 | 9 95.59 |
| Bankfull Elevation (ft) | 94.32 | 94.32 | 94.32 |
| Floodprone Width (ft) | 45 | | |
| Bankfull Width (ft) | 10.54 | 5.33 | 5.21 |
| Entrenchment Ratio | 4.27 | | |
| Mean Depth (ft) | 0.53 | 0.5 | 0.55 |
| Maximum Depth (ft) | 1.27 | 1.24 | 1.27 |
| Width/Depth Ratio | 19.89 | 10.66 | 9.47 |
| Bankfull Area (sq ft) | 5.54 | 2.66 | 2.88 |
| Wetted Perimeter (ft) | 11.17 | 6.95 | 6.71 |

| Hydraulic Radius (ft) | 0.5 | 0.38 | 0.43 |
|-----------------------|------|------|------|
| Begin BKF Station | 2.46 | 2.46 | 7.79 |
| End BKF Station | 13 | 7.79 | 13 |
| | | | |
| | | | |

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

ChannelLeft SideRight SideSlope000Shear Stress (lb/sq ft)00Movable Particle (mm)00

River Name:Calvert CliffsReach Name:Johns SR-4Cross Section Name:Riffle at 220Survey Date:10/15/2009

Cross Section Data Entry

BM Elevation:98 ftBacksight Rod Reading:2 ft

| TAPE | FS | ELEV | NOTE | |
|----------|-------------|---------|------|----|
| 0 | 6.9 | 93.1 | LEP | |
| 2 | 6.81 | 93.19 | | |
| 3 | 6.91 | 93.09 | | |
| 3.5 | 7.16 | 92.84 | | |
| 4 | 8.93 | 91.07 | BKF | |
| 5 | 9.15 | 90.85 | | |
| 5.5 | 9.85 | 90.15 | | |
| 6 | 9.9 | 90.1 | | |
| 7 | 9.85 | 90.15 | LEW | |
| 8 | 9.82 | 90.18 | | |
| 9 | 9.83 | 90.17 | | |
| 10 | 9.67 | 90.33 | | |
| 11 | 7.75 | 92.25 | | |
| 12 | 6.94 | 93.06 | | |
| 13 | 6.6 | 93.4 | | |
| 15 | 6.54 | 93.46 | | |
| 17 | 6.72 | 93.28 | | |
| | | | | |
| | | | | |
| Cross Se | ectional Ge | eometry | | ·· |

| Chann | el | Left | Rig | ght | |
|-------------------------|-------|------|------|------|-------|
| Floodprone Elevation (| ft) 9 | 2.04 | 92. | 04 | 92.04 |
| Bankfull Elevation (ft) | 91 | .07 | 91.0 | 7 | 91.07 |
| Floodprone Width (ft) | 7. | 16 | | - | |
| Bankfull Width (ft) | 6.3 | 9 | 3.19 | 3. | 2 |
| Entrenchment Ratio | 1. | 12 | | | |
| Mean Depth (ft) | 0.72 | 2 | 0.62 | 0.8 | 31 |
| Maximum Depth (ft) | 0 | .97 | 0.97 | r | 0.91 |
| Width/Depth Ratio | 8.8 | 38 | 5.15 | 3 | .95 |
| Bankfull Area (sq ft) | 4.5 | 8 | 1.99 | 2. | .59 |
| Wetted Perimeter (ft) | 7.2 | 24 | 4.49 | 4 | .57 |
| Hydraulic Radius (ft) | 0.6 | 3 | 0.44 | 0 | .57 |
| Begin BKF Station | 4 | | 4 | 7.19 | 9 |
| | | | | | |

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

ChannelLeft SideRight SideSlope000Shear Stress (lb/sq ft)00Movable Particle (mm)00

·

| River Na Reach N Cross Se Survey I | ame: C ame: J ection Name Date: 10 | alvert Clif ohns SR-4 2: Pool at 2 0/15/2009 | fs : :38 | | |
|---|---|---|------------------|-------------|--|
| Cross Se | ction Data | Entrv | | | |
| | | 5 | | | |
| BM Elev Backsigh | vation: nt Rod Read | 98 ft ling: 2 | ft | | |
| TAPE | FS | ELEV | N | OTE | |
| 0 | 7.04 | 92.96 | lep | | |
| 1 | 7.17 | 92.83 | 1 | | |
| 2 | 7.42 | 92.58 | | | |
| 3 . | 7.57 | 92.43 | | | |
| 5 | 8.46 | 91.54 | BKF | | |
| 5.8 | 10 | 90 | LEW | | |
| 7 | 10.39 | 89.61 | | | |
| 8 | 10.55 | 89.45 | | | |
| 9 | 10 | 90 | REW | | |
| 10 | 9.86 | 90.14 | | | |
| 11 | 7.35 | 92.65 | | | |
| 11.5 | 7.32 | 92.68 | | | |
| 12 | 7.16 | 92.84 | | | |
| 13 | 7.04 | 92.96 | | | |
| 17 | 6.82 | 93.18 | | | |
| Cross Se | ctional Geo | metry | | | |
| | | 1 1 0 | , n. | • . | |
| F1 1 | Cha | nnel Lef | t Rig | ht op co | |
| Floodpro | ne Elevation | $n(\pi) 93.6$ | 3 .93.0 01.54 | 03 93.63 | |
| Bankrull | Elevation () | II) 91.54 | 91.54 | 91.54 | |
| Floodpro | 1000000000000000000000000000000000000 | () 1/ | 2 70 | 2.79 | |
| Bankrull | width (ff) | 5.50 | 2.78 | . 2.78 | |
| Entrench | ment Ratio | 3.00 | 1.50 | 1 40 | |
| Mean De | $\frac{\text{ptn}(\Pi)}{\text{D}(\Pi)}$ | 1.51 | 1.53 | 1.49 | |
| Maximur | n Depth (Π) | 2.09 | 2.05 | 2.09 | |
| Width/De | epin Katio | 5.68 | 1.82 | 1.8/ | |
| | Area (sq ft) | 8.58 | 4.20 | 4.15 | |
| wetted P | erimeter (ft |) /.0/ | 5.84 | 5.94 0.7 | |
| nyaraulia | : Kadius (It |) 1.09 | 0.75 | U./ | |
| Begin BK | Station |) 1057 | ט יי די | 1.18 | |
| THA DVL | Station | 10.00 | 1.10 | 10.30 | |

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

ChannelLeft SideRight SideSlope000Shear Stress (lb/sq ft)00Movable Particle (mm)00

River Name:Calvert CliffsReach Name:Johns SR-4Cross Section Name:Riffle Valley 100Survey Date:12/18/2009

Cross Section Data Entry

BM Elevation:0 ftBacksight Rod Reading:0 ft

| TAPE | FS | ELEV | NOTE | |
|--------------|-----|-------|------|--|
| 0 | 0 | 96.53 | | |
| 4 | 0 . | 95.06 | | |
| 7 | 0 | 94.93 | | |
| 15 | 0 | 94.96 | | |
| 20 | 0 | 95.11 | | |
| 22 | 0 | 95.21 | | |
| 24 | 0 | 95.07 | | |
| 27 | 0 | 94.89 | | |
| 33 | 0 | 94.87 | · . | |
| 36 | 0 | 95.06 | | |
| 39 | 0 | 94.95 | | |
| 44 | 0 | 94.75 | | |
| 47 | 0 | 94.76 | | |
| 50 | 0 | 94.94 | | |
| 51 | 0 | 94.85 | | |
| 52 | 0 | 94.3 | | |
| 54 | 0 | 94.21 | | |
| 56.4 | 0 | 94.2 | BKF | |
| 57.4 | 0 | 93.99 | | |
| 58.4 | 0 | 93.42 | | |
| 58.8 | 0 | 93.2 | | |
| 59.4 | 0 | 93.12 | | |
| 60.4 | 0 | 93.11 | | |
| 60.9 | 0 | 93.23 | | |
| 61.4 | 0 | 93.26 | | |
| 62.4 | 0 | 93.39 | | |
| 62.9 | 0 | 93.92 | | |
| 63.4 | 0 | 94.12 | | |
| 64.4 | . 0 | 94.18 | | |
| 66.4 | 0 | 94.03 | | |
| 68.4 70.4 | 0 | 93.82 | | |
| /0.4 72.4 | U . | 94.01 | | |
| 12.4 | U . | 94.32 | | |
| / 3.4 | U | 94.29 | | |
| 108.4 | U | 94.29 | | |

Cross Sectional Geometry

| Chann | el Left | Righ | ıt |
|-------------------------|-----------|-------|---------|
| Floodprone Elevation (| ft) 95.29 | 95.2 | 9 95.29 |
| Bankfull Elevation (ft) | 94.2 | 94.2 | 94.2 |
| Floodprone Width (ft) | 105.03 | 3 | |
| Bankfull Width (ft) | 15.23 | 7.61 | 7.62 |
| Entrenchment Ratio | 6.9 | | |
| Mean Depth (ft) | 0.42 | 0.65 | 0.19 |
| Maximum Depth (ft) | 1.09 | 1.09 | 0.38 |
| Width/Depth Ratio | 36.26 | 11.71 | 40.11 |
| Bankfull Area (sq ft) | 6.37 | 4.93 | 1.44 |
| Wetted Perimeter (ft) | 15.79 | 8.18 | 7.7 |
| Hydraulic Radius (ft) | 0.4 | 0.6 | 0.19 |
| Begin BKF Station | 56.4 | 56.4 | 64.01 |
| End BKF Station | 71.63 | 64.01 | 71.63 |

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

Slope

Channel Left Side Right Side 0 0 0 Shear Stress (lb/sq ft) Movable Particle (mm)

| River N Reach I Cross S Survey | Jame: Name: Section Nar Date: | Calvert Clif Johns SR ne: Valley R 10/15/2009 | ffs 4 Run at 49 |
|---|--|--|-----------------------|
| Cross S | Section Dat | a Entry | |
| BM Ele | evation: | 98 ft | |
| Backsig | ght Rod Re | ading: 2 | : ft |
| TAPE | FS | ELEV | NOTE |
| 0 | 3 75 | 06 25 | |
| 1 | 5.75 | 90.25 | |
| 7 | 5 3 5 | 94.78 04.65 | |
| 15 | 5 3 2 | 94.05 | |
| 20 | 5.17 | 94.83 | |
| 20 | 5.07 | 94.93 | |
| 24 | 5.21 | 94 79 | |
| 27 | 5 39 | 94 61 | |
| 33 | 5.41 | 94.59 | |
| 36 | 5.22 | 94.78 | |
| 39 | 5.33 | 94.67 | |
| 44 | .5.53 | 94.47 | |
| 47 | 5.52 | 94.48 | |
| 50 | 5.34 | 94.66 | |
| 51 | 5.43 | 94.57 | |
| 52 | 5.98 | 94.02 | |
| 54 | 6.07 | 93.93 | LEP |
| 55 | 6.09 | 93.91 | |
| 55.8 | 6.39 | 93.61 | LEW |
| 56 | 6.6 | 93.4 | |
| 57 | 6.72 | 93.28 · | |
| 58 | 6.84 | 93.16 | |
| 58.8 | 6.78 | 93.22 | |
| 59.5 | 6.75 | 93.25 | |
| 61 | 5.89 | 94.11 | |
| 62 | 5.89 | 94.11 | |
| 65 | 5.64 | 94.36 | |
| 73 | 5.4 | 94.6 | BKF |

Cross Sectional Geometry

94.58

94.77

5.42

5.23

82

90

 $file:///lovetonfp/...0Mitigation/Design\%20Data/all\%20rivermorph\%20reports/SR-4\%20Imp\%20Johns/sr-4\%20run\%20valley\%20report.txt [10/5/2010 10:43:14 AM] \\ file://lovetonfp/...0Mitigation/Design\%20Data/all\%20rivermorph\%20reports/SR-4\%20Imp\%20Johns/sr-4\%20run\%20valley\%20report.txt [10/5/2010 10:43:14 AM] \\ file://lovetonfp/...0Mitigation/Design\%20Data/all\%20rivermorph\%20reports/SR-4\%20Imp\%20Johns/sr-4\%20run\%20valley\%20report.txt [10/5/2010 10:43:14 AM] \\ file://lovetonfp/...0Mitigation/Design\%20Data/all\%20rivermorph\%20reports/SR-4\%20Imp\%20Johns/sr-4\%20run\%20valley\%20report.txt [10/5/2010 10:43:14 AM] \\ file://lovetonfp/...0Mitigation/Design\%20report.txt [10/5/2010 10:43:14 AM] \\ file:/lovetonfp/...0Mitigation/Design\%20report.txt [10/5/2010 10:43:14 AM] \\ file:/lovetonfp/...0Mitigation/Design\%20report.t$

| Channe | el Left | Righ | nt A OCOA |
|-------------------------|----------|--------|--------------|
| Floodprone Elevation (1 | n) 96.04 | F 96.0 | 4 96.04 |
| Bankfull Elevation (ft) | 94.6 | 94.6 | -94.6 |
| Floodprone Width (ft) | 89.43 | | |
| Bankfull Width (ft) | 32.18 | 7.16 | 25.01 |
| Entrenchment Ratio | 2.78 | | |
| Mean Depth (ft) | 0.37 | 0.77 | 0.25 |
| Maximum Depth (ft) | 1.44 | 1.42 | 1.44 |
| Width/Depth Ratio | 86.97 | 9.3 | 100.04 |
| Bankfull Area (sq ft) | 11.88 | 5.53 | 6.35 |
| Wetted Perimeter (ft) | 32.73 | 8.89 | 26.68 |
| Hydraulic Radius (ft) | 0.36 | 0.62 | 0.24 |
| Begin BKF Station | 50.67 | 50.67 | 57.83 |
| End BKF Station | 82.84 | 57.83 | 82.84 |
| | | | |

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

ChannelLeft SideRight SideSlope000Shear Stress (lb/sq ft)00Movable Particle (mm)00

SE-R 5 Imp

.

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

| Stream: | Calvert Cliffs, Reach - Johns SR-5 | | .2 |
|------------|---|--------------|-----------------|
| Basin: | Drainage Area: 0 acres | 0 | mi- |
| Location: | | | · |
| Twp.&Rge: | Sec.&Qtr.: ; | | |
| Cross-Sect | tion Monuments (Lat./Long.): 0 Lat / 0 Long | Date: | 10/15/ |
| Observers | | Valley Type: | IX |
| | Bankfull WIDTH (W _{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section. | , 6.1 |]ft |
| | Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section (d _{bkf} = A / W _{bkf}). | 0.4 | ft |
| | Bankfull X-Section AREA (A _{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section. | 2.45 | ft ² |
| | Width/Depth Ratio (W _{bkf} / d _{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section. | 15.25 |]ft/ft |
| | Maximum DEPTH (d _{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section. | 0.49 | ft |
| | WIDTH of Flood-Prone Area (W _{fpa}) Twice maximum DEPTH, or $(2 \times d_{mbkf})$ = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section. | 7.45 |] ft |
| | Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W _{tpa} / W _{bkf}) (riffle section). | 1.22 | ft/ft |
| | Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations. | 0.2 | mm |
| | Water Surface SLOPE (S) | |] |
| | Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage. | 0.00626 | ft/ft |
| | Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S). | 1.08 | |
| | Stream Type F 5 (See Figure 2- | 14) |] |

,

•

RIVERMORPH PROFILE SUMMARY

River Name: Calvert Cliffs Reach Name: Johns SR-5 Profile Name: Reach Survey Date: 10/15/2009

Survey Data

| DIST | CH | I W | 'S B | KF | P 1 | P2 | P3 | P4 |
|----------------------|------------|-----------|-------|-------|------------|----|----|----|
| 0 | 7.31 | 7.06 | 5.43 | | | | | |
| 1 | 7.55 | 7.08 | | | | | | |
| 4 | 7.79 | 7.08 | 5.92 | | | | | |
| 7 | 7.8 | 7.09 | | | | | | |
| 11 . | 8.08 | 7.09 | 5.83 | | | | | |
| 14 | 7.98 | 7.1 | 5.83 | | | | | |
| 17 | 7.41 | | 5.68 | | | | | |
| 19 | 7.28 | 7.1 | | | | | | |
| 22 | 7.26 | | 5.58 | | | | | |
| 27 | 7.45 | 7.1 | 6.13 | | | | | |
| - 30 | 8.18 | 7.1 | 5.93 | | | | | |
| 32 | 7.97 | 7.1 | | | | | | |
| 36 | 7.76 | 7.1 | | | | | | |
| 38 | 7.65 | | 6.01 | | | | | |
| 41 | 7.71 | 7.1 | | | | | | |
| 46 | 7.66 | | | | | | | |
| 48 | 7.34 | 7.1 | | | | | | |
| 50 | 7.19 | 7.1 | 6.63 | | | | | |
| 52 | 7.36 | 7.26 | | | | | | |
| 53 | 7.88 | 7.88 | | | | | | |
| 54 | 8.16 | 8.16 | | | | | | |
| 54.1 | 9.92 | | | | | | | |
| 55 | 10.67 | 8.34 | | | | | | |
| 63 | 8.72 | - | 5.66 | 1.15 | | | | |
| 68 | 0 50 | 8.22 | | | | | | |
| /1 | 8.38 | 8.22 | | | | | | |
| /4 70 | 8.09 | 8.22 | | | | | | |
| /8 70 | 8.48 | 8.22 | | | | | | |
| 19 | 9.45 | 8.33 | 676 ' | 7 2 7 | | | | |
| 00 | .9.40 | | 0.20 | 1.52 | | | | |
| 90 | 0.07 87 | 8 57 | | | | | | |
| 9 4 06 | 0.7 | 8.52 | | | | | | |
| 100 | 8.05 | 0.55 | • | | | | | |
| 102 | 9.06 | 8 56 | | | | | | |
| 102 | 9.00 | 8 56 | 6 87 | 817 | 67 | 3 | | |
| 111 | 8.71 | 8.56 | 0.07 | 0.17 | 0.7 | 5 | | |



| 115 | 8.81 | 8.57 | | |
|-------|------|------|------|------|
| 120 | 8.77 | 8.57 | 6.77 | |
| 123 | 9.29 | | | |
| 134 | 8.99 | 8.58 | 6.35 | |
| 138 | 8.75 | 8.58 | | |
| 142 | 8.7 | 8.58 | | |
| 146 | 8.7 | 8.59 | | |
| 150 | 8.7 | 8.6 | | |
| 153 | 9.45 | 8.61 | | |
| 165 | 8.81 | 8.61 | | |
| 168 | 8.8 | 8.62 | 6.5 | 6.13 |
| 170 · | 8.87 | 8.62 | | |
| | | | | |

Cross Section / Bank Profile Locations

| Name | Туре | Profile Station |
|---------------|-----------|-----------------|
| Pool at 29 | Pool XS | 29 |
| Riffle at 144 | Riffle XS | 144 |

Measurements from Graph

Bankfull Slope: 0.00626

| Variable | Min | Avg | Max | |
|-------------|----------|---------|---------|--------|
| S riffle | 0.00383 | 0.00753 | 0.01424 | |
| S pool | 0 | 0.00083 | 0.00153 | |
| S run | 0.27228 | 0.28546 | 0.29863 | |
| S glide | 0.00134 | 0.00293 | 0.00586 | |
| P - P | 19.58 | 23.97 | 29.73 | |
| Pool lengt | th 12.28 | 14.67 | 18.69 | |
| Riffle leng | gth 6.59 | 9.61 | 12.46 | |
| Dmax riff | le 1.39 | 2.06 | 2.44 | |
| Dmax poo | ol 2.25 | 2.94 | 4.54 | |
| Dmax run | 1.58 | 2 | 2.33 | |
| Dmax glio | ie 1.31 | 2.06 | 2.55 | |
| Low bank | ht 0.96 | 1.6 | 2.12 | |
| | | | C . 1 | . 0.10 |

Length and depth measurements in feet, slopes in ft/ft.

RIVERMORPH PROFILE SUMMARY

Notes

River Name: Calvert Cliffs Reach Name: Johns SR-5 Profile Name: Reach Survey Date: 10/15/2009

DIST Note

file:///lovetonfp/...II%20Mitigation/Design%20Data/all%20rivermorph%20reports/SE-R-5%20Imp%20Johns/ser-5%20profile%20report.txt[10/5/2010 10:49

| 30 | pool | section |
|----|------|---------|
| 50 | POOL | 000000 |

large log glide 32

48

63 bar

146

riffle section

| Cross S | ection Data | a Entry | |
|--|--|--|--|
| BM Ele Backsig | vation: ht Rod Rea | 98 ft ading: 2 | 2 ft |
| TAPE | FS | ELEV | NOTE |
| 0 | 6.43 | 93.57 | LEP |
| 2 | 6.38 | 93.62 | |
| 3 | 6.56 | 93.44 | |
| 4 | 6.93 | 93.07 | |
| 6 | 7.95 | 92.05 | |
| 6.3 | 0 | 91.81 | BKF - office estimate |
| 7 | 8.55 | 91.45 | LEW |
| 8 | 8.68 | 91.32 | • |
| 9 | 8.65 | 91.35 | |
| 10 | 8.65 | 91.35 | |
| 11 | 8.67 | 91.33 | |
| 12 | 8.55 | 91.45 | |
| 13 | 7.66 | 92.34 | |
| 14 | 7.39 | 92.61 | |
| 15 | 6.99 | 93.01 | |
| 16 | 6.7 | 93.3 | |
| 22 | 6.26 | 93.74 | |
| | | | |
| Cross Se | ectional Ge | ometry | |
| | | | |
| | Cł | nannel Let | ft Right |
| Floodpro | one Elevati | on (ft) 92.3 | 3 92.3 92.3 |
| Bankfull | l Elevation | (ft) 91.81 | 91.81 91.81 |
| Floodpro | one Width | (ft) 7.45 | |
| Bankfull | Width (ft) | 6.1 | 3.11 2.99 |
| Entrench | ment Ratio | o 1.22 | |
| | epth (ft) | 0.4 | 0.39 0.41 |
| Mean D | • • • | | 0.40 0.40 |
| Mean Do Maximu | m Depth (1 | ft) 0.49 | 0.49 0.48 |
| Mean Do Maximu Width/D | m Depth (1 epth Ratio | (t) 0.49 15.25 | 7.97 7.29 |
| Mean Do Maximu Width/D Bankfull | m Depth (1 epth Ratio Area (sq f | ft) 0.49 15.25 ft) 2.45 | 7.97 7.29 1.21 1.23 |
| Mean De Maximu Width/D Bankfull Wetted I | m Depth (f epth Ratio Area (sq f Perimeter (| ft) 0.49 15.25 ft) 2.45 ft) 6.34 | $\begin{array}{cccccccccccccccccccccccccccccccccccc$ |
| Mean De Maximu Width/D Bankfull Wetted I Hydrauli | m Depth (f epth Ratio Area (sq f Perimeter (ic Radius (| $\begin{array}{ccc} (t) & 0.49 \\ & 15.25 \\ (t) & 2.45 \\ (t) & 6.34 \\ (t) & 0.39 \end{array}$ | 0.49 0.48 7.97 7.29 1.21 1.23 3.67 3.6 0.33 0.34 |

file:///lovetonfp/...0II%20Mitigation/Design%20Data/all%20rivermorph%20reports/SE-R-5%20Imp%20Johns/ser-5%20riffle%20report.txt[10/5/2010 10:50

End BKF Station 12.4 9.41 12.4

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

ChannelLeft SideRight SideSlope000Shear Stress (lb/sq ft)Movable Particle (mm)

River Name:Calvert CliffsReach Name:Johns SR-5Cross Section Name:Pool at 29Survey Date:10/15/2009

Cross Section Data Entry

| BM Elevation: | 98 ft | |
|------------------------|-------|--|
| Backsight Rod Reading: | 2 ft | |

| TAPE | FS | ELEV | NOTE | |
|------|------|-------|------|--|
| 0 | 5.48 | 94.52 | lep | |
| 2 | 5.65 | 94.35 | • | |
| 3 | 5.84 | 94.16 | | |
| 4 | 6.28 | 93.72 | BKF | |
| 4.5 | 7.21 | 92.79 | LEW | |
| 5 | 7.36 | 92.64 | | |
| 6 | 7.75 | 92.25 | | |
| 7 | 7.68 | 92.32 | | |
| 8 | 8.01 | 91.99 | | |
| 9 | 7.75 | 92.25 | | |
| 9.5 | 6.25 | 93.75 | | |
| 10 | 5.78 | 94.22 | | |
| 12 | 5.35 | 94.65 | | |
| 13 | 5.26 | 94.74 | | |
| | | | | |

Cross Sectional Geometry

| Chann | el Left | Rig | ht |
|-------------------------|-----------|--------|---------|
| Floodprone Elevation (| ft) 95.45 | 5 95.4 | 5 95.45 |
| Bankfull Elevation (ft) | 93.72 | 93.72 | 93.72 |
| Floodprone Width (ft) | 13 | | |
| Bankfull Width (ft) | 5.49 | 2.75 | 2.74 |
| Entrenchment Ratio | 2.37 | | |
| Mean Depth (ft) | 1.27 | 1.12 | 1.42 |
| Maximum Depth (ft) | 1.73 | 1.47 | 1.73 |
| Width/Depth Ratio | 4.32 | 2.46 | 1.93 |
| Bankfull Area (sq ft) | 6.97 | 3.09 | 3.88 |
| Wetted Perimeter (ft) | 7.29 | 4.82 | 5.3 |
| Hydraulic Radius (ft) | 0.96 | 0.64 | 0.73 |
| Begin BKF Station | 4 | 4 | 6.75 |
| End BKF Station | 9.49 | 6.75 | 9.49 |
| | | | |

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

ChannelLeft SideRight SideSlope000Shear Stress (lb/sq ft)00Movable Particle (mm)00

Appendix E

Calculations for Weir Design

.


| Project | Calvert C | liffs Unit 3 | Phase II I | Mitigation P | lan | Project No. | 14 | 6210 | 3 |
|---------|------------|--------------|-------------|--------------|-----------------|-------------|------|------|------|
| Subject | Riffle Gra | ade Contro | I Sizing Ca | alculation - | Woodland Branch | Sheet No. | 1 | of | 2 |
| - | Based or | n Anne Aru | ndel Cour | ty Specifica | ations | Drawing No. | | | |
| Compute | d by | JJM | Date | 10/1/10 | Checked by | GAT | Date | 10/ | 1/10 |

OBJECTIVE:

Determine the dimensions and materials for the riffle grade control structures utilized for the Woodland Branch regenerative stormwater conveyance and riffle grade control practices.

ASSUMPTIONS:

For Woodland Branch, the watershed and upland areas are protected as reforestation areas, or part of the Chesapeake Bay Critical Area. Therefore, there is no additional planned impervious area to be introduced into the watershed. The design assumes that the existing discharges are conservative estimates reflecting future land use. Only the existing discharges are utilized for the weir design.

PROCEDURE:

From TR-55, determine the pre- and post- development discharges for the 1, 10 and 100 year storm and associated time of concentration. For Woodland Branch, Pre and Post development discharges are equal:

| Drainage Area | Tc (hours) | 100yr (CFS) | lyr (CFS) | 10yr (CFS) |
|------------------|---------------|-------------|-----------|---------------|
| 1 | 0.275 | 122.03 | 2.18 | 47.50 |
| 2 | 0.517 | 98.31 | 1.44 | 38.54 |
| 3 | 0.356 | 363.7 | 5.1 | 130.7 |
| 5 | 0.451 | 321.46 | 4.26 | 118.47 |
| 6 | 0.475 | 78.96 | 1.12 | 31.15 |
| 7 | 0.228 | 50.25 | 0.63 | 20.62 |
| . 8 | 0.377 | 73.58 | 0.96 | 29.27 |

Utilizing the site map, determine the length of conveyance areas and elevation drop through them. Calculate the desired number of weirs for the site based on the elevation drop through the weirs. For Woodland Branch, MDE comment in August 2010 requested a stone grade control structure for every foot of elevation drop, with woody grade controls in between. Woodland Branch utilizes pools with zero slope on steep gradients and thalweg grading areas with negligible slope in low gradient valleys (approximately 1% slope).

Elevation drop through the weir is chosen to work with site conditions and existing reference reach data and is an iterative process. Excessive loss of elevation through the weirs will result in a backwatering situation behind them or an entrenched channel situation. For steep slopes, a maximum of

Flores, Hala, (2009). Step Pool Storm Conveyance Design Calculator. Anne Arundel County Department of Public Works, Annapolis, Maryland.

Flores, Markusic, McMonigle, and Underwood (2009). *Step Pool Storm Conveyance*. Anne Arundel County Department of Public Works, Annapolis, Maryland.



| Project | Calvert | Cliffs Unit 3 | Phase II N | Mitigation F | Plan | Project No. | 14 | 6210 |)3 |
|---------|----------|---------------|-------------|--------------|-------------------|-------------|------|------|------|
| Subject | Riffle G | rade Contro | I Sizing Ca | alculation | - Woodland Branch | Sheet No. | 2 | of | 2 |
| | Based | on Anne Aru | indel Coun | ity Specific | ations | Drawing No. | | | |
| Compute | d by | JJM | Date | 10/1/10 | Checked by | GAT | Date | 10/ | 1/10 |

1' per weir is utilized. In situations where valley gradient is approximately 1% or less, 6" or less drop through the weir is utilized.

The Step Pool Design Conveyance Calculator from Anne Arundel County Department of Public Works is utilized in this calculation. This calculator is modified to achieve the desired number elevation drop through the weirs coupled with the desired design discharges. Spreadsheets are attached to this calculation.

The water quality component (pool and media bed design) of the Step Pool Design Conveyance Calculator was not utilized for Woodland Branch designs, as no proposed development is occurring in this watershed. The design focuses on riffle stability in lifting the channel bed elevation to reconnect it with the floodplain, with water quality and quantity effects being a secondary to the goals of changing shallow groundwater elevation.

RESULTS:

Weir designs are summarized below: Cobble Drainage Size Depth Area (Inches) Width (Feet) (Feet) Slope 3.00% DA-1 6 50 1.2 DA-2 6 21 1.5 4.00% DA-2 6 45 1 4.20% DA-3 6 120 1.5 1.80% DA-5 6 14 3 2.20% 6 27 2 DA-5 1.80% 6 DA-5 45 2.2 2.20% 6 22 DA-6 1.5 2.50% **DA-7** 6 25 1.5 3.60% DA-8 6 12 1.6 6.80% **DA-8** 6 20 1.5 6.80% 6 27 DA-8 1 6.80%

P:\Utilities\Unistar\1462103_CC3NP Phase II Mitigation\Design Data\RSC\RSC calc sheet-woodland.doc



<u>Contact</u>

2002 Riva Road Amappolis. MD 21401 Phone 410 222 4241

Developed by: Date: Hala Flores, P.E. 21-Dec-09

.

Anne Arundel County Government Department of Public Works Bureau of Engineering Watershed ad Ecosystem Services and Restoration Watershed Assessment and Planning



Check parameters in bold

| Checkin | a the Channel Conve | vance for the design flood | | | | | |
|--|--|--|---|--------------------|---------------------|--|---------------------|
| Design Return Period (Yr) | e konstaat faar is s | 100 100 100 100 100 100 100 100 100 100 | New March 1 al and the second | NH410:4c4 | | | |
| Time of Concentration in minutes (Before Development) | y here a second | | 0.28 | The state of the | | | |
| Pre davelopment discharge (cfs) | Que Carlos | 122.0 | | 完.47.5款 | lsbash d | urve for Stone De | ensity = 165 lb/ft3 |
| | 6 74 7 8 7 2 3 7 | 1722 C | | | Cobble d50 | Allowable | Allowable Velocity |
| | | | de la contra de la | | size | Velocity | (Subcritical) |
| | | | | | | (Supercritical) | |
| Post development design discharge (cfs) | C the Qpe beau | 122.0 g and the second | 2.4 4 2.2 | 47.5 | | | |
| | (特别的) | Same and the provident of | Cascade Design (maximum | 5 ft drop | [inches] | ft/sec | {ft/sec} |
| Total available length (ft) | | 909 | per segment) | | | | |
| Elevation drop over length (ft) | deta E | 14.0 | Design Width (fl) | 2012年1月 | 4 | 5.1 | 7,1 |
| Total Cascade Length for Project (ft) | Lcascade | 0.00 | Design Depth (R) | 用和法律法 | 5 | 5.7 | 8.0 |
| Maximum Cascade Slope (ft/ft) | Slope _{cascade} | 0.50 | Roughness | 0.05 | 6 | 6.3 | 8.7 |
| Water Quality slope (ft/ft) | Slope | 0.02 | A | 0.00 | 7 | 6.8 | 9,4 |
| Average Length of Riffle Segments (f), Minimum 10 ft | | 33 No. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | 8 | #DIV/0! | 8 | 7.1 | 10.1 |
| Number of Riffle Segments for Project | Nnille | 14 | P | #DIV/0! | 9 | 7.7 | 10.7 |
| Number of Cascade Segments for Project | Ncascade | 0 | R _h | #DIV/0! | 10 | 8,1 | 11.3 |
| Required Length of Pool Segments (ft) | -pool | 33 | Design Velocity (ft/sec) | #DIV/0! | | 8,5 | 11.8 |
| | | | | | 12 | 8,8 | 12.3 |
| Cobble d50 size (f) - choose - 6 inches | 2 ST 250 W 200 St 250 | 0.50 5 10 5 10 5 | Conveyed Q (cfs) | #017/01 | | | 12.0 |
| | | | | | 15 | 9.9 | 13.8 |
| Top warn of SPSC nille channel (ft) | THE WAY WE WANT | 50.0 (1) Sec. 2 | NO Lascade is Need | uea | | | |
| | | | Minimum Pool Depth "Use 3 | [| 1 18 | 10.8 | 15.1 |
| Depth of SPSC office change (#) | in the second second | | cascade segment (ft) | #DIV/0 | | | |
| of the SPSC (ft) | | The state of the second s | nk | - DIVIO! | | | |
| | STREET, STREET | 1.7 | subcritical/ok | | | | of dealers ato |
| Enter Desired Pool Depth (II) | | 204720 | subcritical/ok | I | Adequat | e conveyance | or design storm |
| | | | | | | | |
| Check Riffle Side Slope, Must be > 2H:1V | | 20.8 | | N N | Salactad | obble Size is | Adequaté for 100 |
| Check the Frourie Number to ensure Subcritical Flow Co | ortitions | 0.6 | 1 | | Selected | vear stor | m |
| | 1 | | 4 | · · · · · | L | 100 0101 | |
| | | | | • | | | |
| Computed Roughness | n | 0.05 | ļ | | \ | | |
| Rifle Cross Section Area (ft2) for parabola | A | 40.00 | | | Subc | ritical Flow is F | redominant |
| | | | - | | | | |
| Theta - Intermediate step for solving | θ | 0.10 | 1 | | | | |
| | | | 1 | | | | |
| | | | • | | | | |
| Rifte Hurtra fic Perimeter (f) for parabola | | 50.08 | | | | | |
| | · · · · · | | 1 | | | | |
| | | | | | | | |
| Riffle Hydraulic Radius (ft), using Chow 1959 | R | 0.80 | | | | | |
| | | | 1 | | | | |
| Calculated Flow for design parameters (cfs) | Q | 137.21 | | | | | |
| | | | 1 | | 1 | | |
| Check Riffle Velocity (ft/sec) | v | 3.43 | Required Number | of Pools | 14 | | |
| | | | Required total pool da | noth (ft) = | 28 | | |
| | ····· | ······································ | | spin (it) - | 1 40 | | |
| Checking Qua | ntity Management | | hydrautic power for return pe | riod 100 year st | form is satisfied | | |
| | T | | | | | | |
| USDA 2006, n expressed in terms of d _{out} and d ₅₀ = 8 inches | n | 0.03 | Required Volume of Storage (| Rational Hydroc | araph) | | |
| ** | | FO 00 | 1 | | | | |
| The width at the entrance riffle | W _n | 50.00 | | 100 | Yr 1 Yr | TU Yr | |
| | i i | |] | | | | |
| | | | 1 | | [| | |
| The velocity at the entrance mile is calculated using Manning formula calculator and O for the 1 year storm | V | 7 67 | Required Volume of Storage (#3 | | | | |
| tormale valuation and spectron the inyear storm | · · · · | 1.31 | 1 | , 0 | | | |
| | | | | | | | |
| | i i | | | | | | |
| The depth at the entrance riffle is calculated using Manning | | | | | | | |
| formula calculator and Q _{post} for the 1 year storm | Dn | 1.20 | Volume provided in pools (ft3) | | 1794 | | |
| Enter Trial Value : The total pool depth needed to render | | | | | | | |
| the power equivalent to rou-year precevelopment/desired levels. This should be compared against the total | D | 15.25 | Volume provided in voids (ft3) | 1 | 10908 | . 1 | |
| | - 001 | | The second second | 1805.40 | | and get to the state of the | |
| This is the typical top width of the dead storage pool parabolic | | | No. and Anna | | | | |
| areas, 10:1 side slope | Wax | 9 | | 新教室 中学家 | | | |
| | | 8- | Provided Volume of Storage (| excludes | 1999 - Sale | | |
| r ne area is for a semi parabola | A ₀₀₁ | 92 | institution) (ft3) | AUTOSTAN S.S.S. | 13702 | 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1 | |
| protection volume. | | U 1.42 | STATISTIC REPORTED ON VOILING (R3) | interiment interim | A | d Constanting | • |
| metal - metimediate step for solving | | 1.42 | Peak managem | ment of 1 upp- | storm is satisfie | | |
| CARDINATION PROTOPING TO LICE SHITL DATADOLA | | | | | CALLER OF CALLERING | | |
| Hydraudic Pedras, using Chow 1950 | ^r wi p | 33 | reak manayer | nierit of r years | nterm is | | |
| Hydraulic Radius, using Chow 1959 | R_ | 2.81 | Peak Managen | nent of 10 years | storm is satisfied | · | |

| Checking Qua | lity Management | |
|--|--------------------------------|-------------|
| Site Drainage Area (Acres) | A A A | A |
| Contributory Impervious Area (Acres) | 建设的管理规则。 | 35 BH & HAR |
| Volumetric Runoff Coefficient | Rv | 0.53 |
| Water Quality Volume, ft3 | WQv | 113692 |
| Average Sand filter bed depth (fi) minimum 18 inches | di (Average of Pool and Rifle) | 5.0 |
| Width of sand filter (f) | Wand | 8 |
| Length of sand filter, where slope < = 5% (fl) | Lsand | 909 |
| Area of sand filter provided (ft2) | Ar Provided | 7272 |
| coefficient of permeability of filter media (ft/day) | k | 3.50 |
| height of water above filter bed- pool depth (ft) | h, | 2.00 |
| design filter bed drain time (days), MDE recommended value | ti - | 1.67 |
| Required filter bed area (ft2) | Ar Required | 4168 |

.

×

Water quality requirement is satisfied in SPSC

•

.

· · · · ·

•



Contact

Total Cascade Length for Project (#) Maximum Cascade Stope (#/#)

Number of Cascade Segments for Project

2662 Riva Road Annapolis, MD 21401 Phone 410 222 4241

Developed by: Date:

Hala Flores, P.E. 21-Dec-09

 Checking the Channel Conveyance for the design flood

 Design Return Period (Yr)
 100-married conveyance
 <td

 Water Quality slope
 0.02
 A

 Average Length of Ruffle Segments (ft), Minimum 10 ft, Lutric Segments (ft), Minimum 10 ft, Lutric Segments for Project
 Number of Ruffle Segments for

Leasede

Slopecascade

Nesscade

Anne Arundel County Government Department of Public Works Bureau of Engineering Watershed and Ecosystem Services and Restoration Watershed Assessment and Planning

Checking the Channel Conveyance for the design flood



70.52

Roughness

0.00

0.50

0

式で10.84 新たうな 6-01Sh Sec. 14 38,5 42 Isbash curve for Stone Density = 165 lb/ft3 Cobble d50 Allowable Allowable Velocity Velocity (Subcritical) size Supercritical - 16-5 - 38.5 35.55 14 {inches] [ff/sec] [ft/sec] Cascade Design (maximum 5 ft drop per segment) Design Width (1) 7.1 5.1 8.0 8.7 Design Depth (ft) 的复数 5 5.7 0.05 6 6.3 0.00 6.8 9.4 #DIV/O 8 7.2 10.1 #D)V/d! 9 7.7 10.7 #DIV/0! 10 8.1 11.3 01 11 8.5 11.8 12 5,8 12.3 01 9.9 13.8 15 0! 18 10.8 15.1 -Adequate conveyance of design storm Selected Cobble Size is Adequate for 100 year storm Subcritical Flow is Predominant

| Required Length of Pool Segments (h) | -pool | •••••••••••••••• | Design velocity (rusec) | #WIV/ |
|---|------------------|------------------|--|-----------|
| Cobble (59 size (1) choose - 6 increa | d50 * 5 | 0.50 | Conveyed Q (cfs) | #D1V/ |
| Top width of SPSC/MTM discuss (0) | | 210 | No Cascade is Ne | eded |
| Parth of SPSc rifler control (ff) | | | Minimum Pool Depth, Use 3 pools, following each cascade segment (ft) | #DJV/ |
| of the SPSC (ft) | h | 2.0 | ok | |
| Enter Desired Pool Depth (ft) | ak 場合h 高速電量 | 1 | subcritical/o | k . |
| Check Riffle Side Slope, Must be > 2H:1V | | 7,0 | | |
| Check the France Number to ensure Subcritical Flow Cond | itions . | Ó.7 |] | |
| Computed Roughness | a | D.04 | | |
| Riffle Cross Section Area (ff2), for parabola | A | 21:00 | 1 | |
| Theta - Intermediate step for solving | | D.28 | · · · | |
| | | | | |
| Rifle Hydraulic Perimeter (ft), for parabola | Ρ. | 21.28 | | |
| Riffle Hydraulic Radius (ft), using Chow 1959 | | 0.99 | - * | |
| Calculated Row for design parameters (cfs) | ۵ | 99.64 | | |
| Check Riffle Velocity (ft/sec) | v | 4.74 | Reguired Numbe | r of Po |
| | | | Provided total pool | depth (f |
| Checking Quanti | ty Management | | hydraulic power for return | period 10 |
| USDA 2006, n expressed in terms of d_{out} and $d_{50} = 8$ inches | R, | 0.03 | Required Volume of Storage | Rationa |
| The width at the entrance riffle | | 21.0D | | |
| The velocity at the entrance riffle is calculated using Manning formula calculator and Q _{pert} for the 1 year storm | V. | 7.57 | Required Volume of Storage (| ft3) |
| The depin at the entrance riffle is calculated using Manning formula calculator and Q _{ost} for the 1 year storm | D _{iñ} | 1,50 | Volume provided in pools (ft3) | |
| Enter Trial Value : The total pool depth needed to render the power equivalent to 100-year predevelopment/desired levels. This should be compared against the total | D _{out} | 11.64 | Volume provided in voids (ft3) | |
| Fhis is the typical top width of the dead storage pool parabolic areas, 10:1 side slope | Wbut | 12 | petropic soles | |
| The area is for a semi parabola | A | 63 | Provided Volume of Storage | e (exclud |

21 hile 63 t) =

0 year storm is satisfied al Hydrograph)

Water guality requirement is satisfied in SPSC

| The width at the entrance riffle | Ŵ'n | 21.00 | | 100 Yr | 1 Yr | 10 Yr |
|---|-------------------------------------|-------|--|-----------|-----------------|----------------|
| | | | | | | |
| The velocity at the entrance riffle is calculated using Manning . formula calculator and Q _{post} for the 1 year storm. | V., | 7.57 | Required Volume of Storage (ft3) | 0 | 0 | o |
| The depth at the entrance rifile is calculated using Manning | | | | | | |
| formula calculator and Qpost for the 1 year storm | D,, | 1,50 | Volume provided in pools (ft3) | | 9075 | |
| Enter Trial Value : The total pool depth needed to render the power equivalent to 100-year predevelopment/desired | _ | | | | | |
| levels. This should be compared against the total | D _{out} | 11.64 | Volume provided in voids (ft3) | L | 3000 | |
| This is the typical top width of the dead storage pool parabolic areas, 10:1 side slope | Wbut | 12 | | 10.50 | | |
| The area is for a serm parabola. | Aut | 93 | Provided Volume of Storage (excludes inditration) (ft3) | | 1307 | |
| protection volume. | rin i kada | | State Stationion Volume (R3) Service | No. | 1000 | State of Third |
| Theta - Intermediate step for solving | θ | 1.32 | Peak Management of 10 | 0 year st | orm is satisfie | d |
| Hydrautic Perimeter (ft), for semi parabola | Pour | | Peak Management of 1 | year sto | rm is satisfied | |
| Hydraulic Radius, using Chow 1959 | R | 3.42 | Peak Management of 10 | year sto | rm is satisfied | . I |
| Darcy Weisbach Inction factor expressed in terms of Lade Vpur | ····· | 0.20 | | | | |
| Solved using Solver equation: Bernoulli equation rewritten | in terms of d _{out} as the | 0.00 |] | | | |

Checking Quality Management

| Required filter had area (#2) | A | 402 |
|--|-------------------------------|--|
| design fitter bed drain time (days), MDE recommended value | ···· | 1.67 |
| height of water above filler bed- pool depth (ft) | hr | 3.do |
| coefficient of permeability of filler media (ft/day) | k | 3.50 |
| Area of sand filter provided (ft2) | Ar Provided | 5000 |
| Length of sand filter, where slope < = 5% (ft) | -séad | 500 |
| Width of sand filter (R) | 「「ない」を見ていた。 | 10, Hill Sole |
| Average Sand filter bed depth (ft) minimum 18 inches 2023 | di prininge of Pool and Rites | · 22、10年4月20日日本市大市 |
| Water Quality Volume, ftS | WQv | .7841. |
| | | |
| Volumetric Runoff Coefficient | Řv | 0.05 |
| **** | | |
| Contributory Impervious Area (Acres) | 由学家在中国主任网络运行法公司 | State of the Distance of the state of the st |
| STOLUTED DO ARE ACTOS INTERACTOR AND A STATE AND A STA | STORE AND A POLICE AND | 123 ALC NO TO ARACE AND AND A |



Riva Road Iolis, MD 21401 1410 222 4241

Developed by: Date:

Hata Flores, P.E. 21-Dec-09

Anne Arundel County Government Department of Public Works Bureau of Engineering Watershed and Ecosystem Services and Restoration Watershed Assessment and Planning



input values of board in Gray, Required Check parameters in bold

Checking the Channel Conveyance for the design flood Design Return Period (Yr) and the Transaction States and Anna 100 Actions Time of Concentration in minutes (Before Development) 314 96.3 velopment discharge (cfs) 作品:Q2:图明器 合 e development design discharge (rfs) Q₂ 00 3 2.99.5 Total available imgin (n) 500 Cascade Design (maximum 5 ft drop per segment) Design Width (ft) Elevation drop over length (ft) otal Cascade Length for Project (fl) Lean ada 0.0 新潟市市 Maximum Cascade Slope (ft/tt). Slopecascade 0.50 0.05 Water Quality stope (ft/ft) Stope 0.00 0.02 A Average Length of Riffle Segments (ft), Minimum 10 ft #D)V/0 Number of Riffle Segments for Project #D)V/0 Nate -21 Number of Cascade Segments for Project . 0. . #DIV/0 Ncascada equired Length of Pool Segments (ft) 12 Design Velocity (ft/sec) #D1V/01 Cobble (150 size (ff) - choose - 6 inches d50 0.50 onveyed O (cfs) #DIV/01 Top width of SPSC riffle channel (ft) W ST 深深的 No Cascade is Needed Minimum Pool Depth "Use 3 bools" following each Depth of SPSC riffle caused (ff) 10 S 10 cascade segment (ft) #Div/o of the SPSC (ft) h, 1.5 ok subcritical/ok Enter Desired Pool Depth (ft) 30-Check Riffle Side Slope, Must be > 2H:1V 22:5 Check the Froude Number to ensure Subcritical Flow Conditions 0.6 Computed Roughness 0.05 Riffie Cross Section Area (ft2), for parabola 30.00 A Theta - intermediate step for solving 0.09 Riffle Hydraulic Penmeter (ft), for parabola 45.06 Riffle Hydraulic Radius (ft). using Chow 1959 R. 0.67 Calculated Flow for design parameters (cfs) ۵ 98.82 Check Riffle Velocity (ft/sec) 3.29 **Regulred Number of Pools** Provided total pool depth (ft) = **Checking Quantity Management** USDA 2006, n expressed in terms of dour and door = B inches 0.03 The width at the entrance riffle. w. 45 00 The velocity at the entrance offle is calculated using Manning formula calculator and Q_{pos}, for the 1 year storm.

Isbash curve for Stone Density = 165 lb/ft3 Cobble d50 Alfowable Allowable Velocity size Velocity (Subcritical) (Supercritical linches [ft/sec] [ft/sec] 5.1 7.1 4 8.0 6 6.3 87 6.8 9,4 7. 10.1 10.7 0 10 8.1 11.3 U 11.8 8.5 12 8.8 12.3 15 9.9 13.8 18 10.8 15.1 Adequate conveyance of design storm Selected Cobble Size is Adequate for 100 year storm

Subcritical Flow is Predominant

21 63 hydraulic power for return period 100 year storm is satisfie equired Volume of Storage (Rational Hydrograph) 100 Yr 1 Yr 10 Yr Required Volume of Storage (ft3) 7.57 0 Ô 0 The depth at the entrance riffle is calculated using Manning Volume provided in pools (ft3) D. 1.00 9075 ol depth peeded to rende desired 11.06

Volume provided in voids (f13) 3000 Provided Volume of Storage (excluder infiltration) (ft3) 13075 Intersion Votime (R3) Peak Management of 100 year storm is satisfied Peak Management of 1 year storm is satisfied Peak Management of 10 year storm is satisfied

Water quality requirement is satisfied in SPSC

Darcy Weisbach Inction factor expressed in terms of L_{edd}, v_{pix} . Solved using Solver equation: Bernoulli equation rewritten in terms of d_{au}

formula, calculator and Q_{post} for the 1 year storm. Enter Trial Value : The total pool depth needed to r the power equivalent to 100-year predevelopment/

levels. This should be compared against the total

areas, 10:1 side slope

protection volume.

The area is for a semi parabola.

heta - Intermediate step for solving

Hydraulic Perimeter (ft), for semi parabola

Hydraulic Radius, using Chow 1959

This is the typical top width of the dead storage pool parabolic

Checking Quality Management

as the

9

86

0

1.37

25

2.69

0.22

0.00

| j | | _ | | | | | | | | | ٤ |) | • | u1 | i, | | | | | | | | | | | | | | | | | | | | |
|---|----|---|---|-----|---|---|---|---|---|---|----|---|---|-----|----|---|----|---|----|---|---|---|---|-----|---|----|---|---|-----|-----|---|---|---|-----|---|
| · | | | · | . 1 | | • | | • | | • | | ÷ | | ÷ | | | | 7 | | 7 | ÷ | | Ŧ | . 1 | • | Ŀ | | ÷ | 7 | | ٠ | | ÷ | | 1 |
| | ŀ | | ٠ | ٠, | 1 | , | | | | | | | 1 | | 1 | | ۰. | C | ۰. | 1 | ٠ | | • | ۰. | • | Ŀ | | | ۰, | • | | 1 | | ۰, | |
| | ١. | • | | ۰. | • | | • | | 1 | | • | | • | | ۰. | | ۰. | 1 | ۰. | • | | • | | ۰. | | ۱. | • | | ۰. | . 1 | | 1 | | ۰. | |
| l | ١. | • | | ۰. | • | | ٠ | | • | | 1 | | ċ | | • | ċ | ۰. | 1 | | • | | • | | ۰. | | ł. | • | | ۰. | | | ٠ | ÷ | ۰. | |
| J | | • | | ۰. | • | | • | • | • | | Y | Y | ł | w | L, | | ۰. | ł | ۰. | • | | • | | ۰. | | ١. | • | | ۰. | . ' | | • | | ۰. | |
| 1 | | 1 | , | ۰, | 1 | | 1 | | Ĩ | 7 | - | | ~ | | 7 | | | 1 | 7 | | 7 | | , | | | | | | | | , | | 7 | | 1 |
| ł | ١. | ٠ | | ۰. | ٠ | | • | | ٠ | | ٠ | | ۲ | . 1 | ۰. | 1 | ۰. | 1 | | • | | ٠ | | ۰. | | ł. | ٠ | | ۰. | . 1 | | • | | ۰. | |
| 1 | | • | | • | • | | • | | • | | ۰. | | • | | | 1 | | 1 | | | | • | | ÷ | 1 | | • | | • ` | | | • | | • ` | |
| ł | ć | | 2 | ÷ | • | ì | • | : | • | : | ۶ | ١ | 0 | út | ć | | Ċ, | • | Ĵ | • | 1 | • | 1 | - 1 | 1 | Ľ | • | 1 | ÷ | | 1 | • | 1 | ÷ | |

ρ.,

R.

| Required fitter bed area (ft2) | A Required | 402 |
|--|---|----------------------------|
| design filter bed drain time (days); MDE recommended value . | | 1,67 |
| height of water above filler bed- pool depth (ft) | 6 | 9.d0, |
| coefficient of permeability of filler media (fl/day) | | 3.50 |
| Area of sand filter provided (ft2) | A Provided | 5000 |
| Length of sand filler, where slope < = 5% (ft) | Lead. | |
| Width of sand filter (f) 2 (12) (12) (12) | 法法で見て、 | 同時有些共產黨10是改善的意志 |
| Average Sand files bed depth (R) minimum 18 inches (2123) | 10 (Average of Pool and Polley) | 14-15-15-12.0 (APR 19-1) * |
| Water Quality Volume, ft9. | WQv | |
| | | |
| Volumetric Runoff Coefficient | Rv | 0.05 |
| Contributory impervious Area (Acres) | 北部沿地址12月1日 | |
| Sta Dranage Area (Acres) | ALL | 12-21 |

.

• • •

. .

220 500 350 3.0 1.67 402



.

Contact

Ð 2662 Riva Road Annapolis, MD 21461 Phone 410 222 4241

Developed by: Date:

Anne Arundei County Gavernment Department of Public Works Bureou of Engineering Watershed and Ecoxystem Services and Restoration Watershed Assessment and Planning Hala Flores, P.E. 21-Dec-09



Chick parameters in bold

| | | | | | , | | | |
|--|--|---|---|--------------------|---------------|-----------------|--------------------|---------------------|
| Checking | the Channel Conve | yance for the design flood | - MARTINE CONTRACTOR | and the entropy of | | | | |
| Design Return Period (11) | | A STATE OF A | 0.36 | 1-3-10-5 | | | | |
| Pre-development discharge (cfs) | C. SHOW OF | 100 100 100 100 100 100 100 100 100 100 | 0.00 | 64130.7 | | Isbash c | upre for Stope De | ansity = 165 lb/#3 |
| | Electron and the second second second | | Construction of the second s | 25623446.622 | | Cabble d50 | Allow able | Allowable Valuation |
| | | | | | | Conne uso | Milwabe | Cubavitiants |
| | | | | 15.5 | | size | (Supercritical) | (subcritical) |
| Deat development design der berein (rfs) | 14.42.754 | 1 | | 120.7 | | | (Supercritical) | |
| Loss ceseichtustu gezicht diernal de (cra) | Blockstation Pipel | 200.7 pr 20.2 cm | n and an and a state of the second | 22130.1.20 | | thurst and | 151 | 1661 |
| | | 2 2 2 2 2 1 1 1 2 1 2 1 2 1 2 1 2 1 2 1 | Cascade Design (maximum | n 5 ft drop | | [inches] | [ff/sec] | [II/sec] |
| Total available length (fl) | Carter and the second | 1849 | per segment) | | | | | |
| Elevation drop over length (ft) | deta E | 16.0 | Design Width (ft) | 新行的资源 | | 4 | 5.1 | 7.1 |
| Total Cascade Length for Project (ft) | Lcascade | 0.00 | Design Depth (R) | 的基本社 | | 5 | 5.7 | 8.0 |
| Maximum Cascade Slope (ft/ft) | Slope _{cascade} | 0.50 | Roughness | 0.05 | | · 6 | 6.3 | 8.7 |
| Water Quality slope (ft/ft) | Slope | 0.01 | Α | 0.00 | | 7 | 6.8 | 9,4 |
| Average Length of Riffle Segments (ft), Minimum 10 ft. | 「学校の学生」の言語を行う | · 注意,这个人们也是不是这些问题。 | θ | #DIV/0! | | 8 | 7.2 | 10.1 |
| Number of Riffle Segments for Project | Nriffe | 66 | P | #DIV/0! | | 9 | 7.7 | 10.7 |
| Number of Cascade Segments for Project | Ncascade | 0 | R _h | #DIV/0! | | 10 | 8,1 | 11.3 |
| Required Length of Pool Segments (ft) | Lpool | 14 | Design Velocity (ft/sec) | #DIV/0! | | 11 | 8.5 | 11.8 |
| | 注注的建筑的现在分 点 | 高速10月2月1日,19月1日(19月1日)(19月1日) 19月1日 - 19月1日(19月1日)(19月1日) 19月1日 - 19月1日(19月1日) | 1 | | | 12 | 8,8 | 12.3 |
| Cobble d50 size (ft) - choose - 6 inches | d50 | 0.50 | Conveyed Q (cfs) | #DIV/0! | | | | |
| CORRECTOR CONTRACTOR OF CARLS | Martin Grand Martin and | CONTRACTOR AND | 2 | | | 15 | 9.9 | 13.8 |
| Too write of SPSC rifle channel (R) | 1 Story with the | 120.0 | No Cascade is Ner | bebe | | | | |
| | and the second | San Barrer (Briefferferferferferferferferferferferferfe | "Musiceum Real Death 1 les 2 | | | 19 | 10.9 | 15.1 |
| | | | inools* following each | | | 1 '" | 10.11 | F.,, I |
| Depth of SPSC riffle channel (ft) | D | ×16 * | cascade segment (ft) | #DIV/0! | | | | |
| of the SPSC (ft) | h | 15 | ok | | | | L | |
| | No adda for a second second | Consistent and consistent and any instrumentation | aubaritiaal/a | | | . | | |
| Enter Desired Pool Depth (II) | 《 》的新闻的"新闻"的"新闻"的"新闻"的"新闻"的"新闻"的"新闻"的"新闻"的" | 3.0 | subcritical/o | <u> </u> | | Adequate | e conveyance | of design storm |
| | | | | | | | | |
| Check Riffle Side Slope, Must be > 2H:1V | | 40.0 | | · \ | | | | |
| | | | 1 | | \ | Selected | ODDIe Size is | Adequate for 100 |
| Check the Froude Number to ensure Subcritical Flow Con | ditions | 0.5 | 4 | | \ | L | year stor | m |
| | | | | | | | | |
| Commented Reserves | | 0.04 | | | | | | |
| Computed Roughness | <u> </u> | 0,04 | - | | `. | 2 | | |
| Riffle Cross Section Area (ft2), for parabola | A | 120.00 | | | | Subcr | itical Flow is I | Predominant |
| | | | | | | | | |
| Theta - Intermediate step for solving | θ | 0.05 | 1 | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| Diffe Hudende Desimates (#) for encodes | | 120.05 | | | | | | |
| The Tydrauk Penineter (17, 10) paratora | | 120.05 | - | | | | | |
| | | | | | | | | |
| Biffe Hudroutic Badius (6) union Chaw 1959 | | 1.00 | | | | | | |
| Kine Hydraulic Kaulus (k), using Glow 1838 | · | 1.00 | 4 · | | | | | |
| | - | | | | | | | |
| Calculated Flow for design parameters (cfs) | <u> </u> | 377.75 | | | | | | |
| Charle Differ Malarity (filesa) | | 2.45 | Boguizad Number | r of Dooin | | 6 66 | | |
| Check Rime velocity (fusec) | · · ·· ·· ·· ·· ·· ·· ·· ·· ·· ·· ·· · | 3.15 | Required Number | 10170015 | | | | |
| | | | Provided total pool of | depth (ft) = | | 198 | | |
| | | | 1 | | | | | |
| Checking Quar | ntity Management | | Rur | n Solver | | | | |
| | | | | | | | | |
| USDA 2006, n expressed in terms of dout and doe = 8 inches | n | 0.03 | Required Volume of Storage | (Rational H | drogra | ph) | | |
| · · · · · · · · · · · · · · · · · · · | | | | | | | | |
| The width at the entrance riffle | w _n | 120.00 | . | | 100 Yr | 1 Yr | 10 Yr | |
| | | | | | | 1 | | |
| | | | | | | | | |
| The velocity at the entrance riffle is calculated using Manning | | | | . 1 | | | | |
| formula calculator and Q _{post} for the 1 year storm | V, | 7.57 | Required Volume of Storage (ff | t3) | 0 | 0 | 0 | |
| | | | | | | | | |
| 1 | | | | | | | i | |
| | | | | | | | | |
| The depth at the entrance riffle is calculated using Manning | | | Mature environments and a second | | | | | |
| formula calculator and Qpost for the 1 year storm | | 1.50 | volume provided in pools (ft3) | | | 28521 | | |
| Enter mail value : the total pool depth heeded to render | | | | | | | | |
| levels. This should be compared against the total | Davi | 17.01 | Volume provided in voids (ft3) | | | 22188 | | |
| | - 001 | | 行為の必要なななななななな | STORE STORE | e Karika | 0776 17 X C4 (A | R. M. D. M. S. Lo. | |
| This is the typical top width of the dead storage pool parabolic | | | | N. A. | | 6.712.83 | 24 C | |
| areas, 10:1 side slope | Wowl | 9 | 1. 化学校学校 计学 | | 3× 9 | EN LES | | |
| | | | Provided Volume of Storage | (excludes | (45)) (45) | | | |
| The area is for a semi parabola | A _{oul} | 102 | infiltration) (ft3) | | of preside | 51709 | | |
| protection volume. | Ladd | 0 | infitration Volume (ft | 3) (12) (2) | 北海市 | Sec. 1000 | states and the | |
| Theta - Intermediate step for solving | θ | 1.44 | | Run Sc | lver | | | |
| Hydraulic Perimeter (ft), for semi parabola | Pout | 36 | | Run So | iver | | | |
| Hydraulic Radius, using Chow 1959 | Rh | 2.84 | | Run Sc | iver | | | |
| Darcy Weisbach friction factor expressed in terms of Ladd, Voul- | f | 0.21 | | | | | | |
| | the second se | | - | | | | | |

| Checking Qua | lity Management | |
|--|--|---|
| Ste Dranage Area (Acres) | des restations | 66 CONTRACTOR OF THE CONTRACT CONTRACT OF THE CONTRACT. CONTRACT OF THE CONTRACT. CONTRACT OF THE CONTRACT OF THE CONTRACT OF THE CONTRACT OF THE CONTRACT. CONTRACT OF THE CONTRACT OF THE CONTRACT OF THE CONTRACT. CONTRACT OF THE CONTRACT. CONTRACT OF THE CONTRACT OF THE CONTRACT. CONTRACT |
| Contributory Impervious Area (Acres) | No. of the other states of the | 35 J. S. |
| Volumetric Runoff Coefficient | Rv | 0.53 |
| Water Quality Volume, ft3 | WQv | 113692 |
| Average Sand filter bed depth (R) minimum 18 inches | A Avenue of Paci and Rate - | 199 - Company - |
| Width of sand filter (R) | のない。それの言語を | 1 |
| Length of sand filter, where slope < = 5% (ft) | Laand | 1849 |
| Area of sand filter provided (ft2) | A Provided | 14792 |
| coefficient of permeability of fitter media (fl/day) | k | 3.50 |
| height of water above filter bed- pool depth (ft) | n, | 3.00 |
| design filter bed drain time (days), MDE recommended value | 4 | 1.67 |
| Required filter bed area (ft2) | A Required | 3647 |

Water quality requirement is satisfied in SPSC

r

.

<u>Contact</u>

2662 Riva Road Annapolis, MD 21401 Phone 410 222 4241

.

Developed by: Date: Hone 410 222 4241 Hala Flores, P.E. 21-Dec-09

Anne Arundel County Government Department of Public Works Bureau of Engineering Watershed and Ecosystem Services and Restoration Watershed Assessment and Planning



Inpld values shaded in Grey Required Calculated values are noted with dotted pattern Check parameters in bold . ·

| Checking | the Channel Conve | vance for the design flood | | | 1 | | | |
|---|--|---|--|----------------|--------------|-------------|---|--------------------|
| Design Return Period (Yr) | Contractor Total Advances Contractor advances | 100 · · · · · · · · · · · · · · · · · · | Next Selle 27 1 Sect Tend 26 | 1×==10++- | | | | |
| me of Concentration in minutes (Before Development) | A CONTRACTOR OF THE OWNER | 204 E | | POPPAGE A | 1 | lebach o | upen for Stope D | oprity # 165 (6/97 |
| te ueveuparient uscherge (cis) | And Andrew Provident Andrews | and the second s Second second s Second second sec second second sec | Construction of the second | 121110.0 | | Cable de | | Allowed by States |
| | C. S. Starting | | 1 | 10.00 | 1 | Connie asu | Anowable | Anowable veloci |
| | | | | 1943 | | size | velocity | (Subermear) |
| | | | A CALL STATE | 1993年1985 | [· | | (Supercritical) | |
| ost development design discharge (cfs) | Server Com About Back | 321.5 | 4.3 | 118.53 | | | | |
| CONTRACTOR AND A STOCK AND A STOCK | 建态是这些正常的 | ·全、公式客户方:"在一方方面。"在 | Canada Dasiga (maximu | m E A dron | | [inches] | [ft/sec] | [ft/sec] |
| and combined provide (#) | | 1855 | Cascade Design (maximu | in 5 it drop | 1 | | | |
| | Webs Mardalla Frederica | 1 state to a state of the state | Contract and the state of the | PENNING STOR | | | 5.1 | 7.1 |
| evaluation or op over length (it) is easily as a second second second second second second second second second | PROCESS COURSE CONTRACTOR | CALCULATION CONTRACTOR OF CONTRA | Design within (ii) | 10000 | | - | | |
| tal Cascade Length for Project (it) | -cascade | 0.00 | Desgn Depuryntys Ster 2 desa | AV200-2-Fox of | | | 3.7 | 5.0 |
| aximum Cascade Slope (ft/ft) | Siope _{cascade} | 0.50 | Roughness | 0.05 | 4 | 6 | 6.3 | 8.7 |
| ater Quality slope (ft/ft) | Slope | 0.01 | A | 0.00 | 1 | 7 | 6.8 | 9.4 |
| erage Length of Riffle Segments (ft), Minimum 10 ft | 国家的第三国家的 的第三 | (in sec. 2) (in 18 | Êθ | #DIV/01 | | 8 | 7.2 | 10,1 |
| umber of Riffle Segments for Project | Npille | 46 | P | #DIV/01 | 1 | 9 | 7.7 | 10.7 |
| umber of Cascade Segments for Project | Neuronte | 0 | R. | #DIV/0! | 1 | 10 | 8.1 | 11.3 |
| equired Length of Pool Segments (ft) | - Land | 18 | Design Velocity (ft/sec) | #DIV/0) | 1 | 11 | 8.5 | 13.8 |
| A second s | -poor | | Draight Clocky (10000) | | 4 | 12 | 0.0 | 12.2 |
| | 11月1日日 11月1日 | | | | | 12 | 0.0 | 14.3 |
| bble d50 size (it) - choose - 6 inches | 1. C. 1. C. | 9.50 State 19.50 | Conveyed Q (cfs) | #DIV/0! | 1 | L | | |
| | Electron Spinite | | | | | 15 | 9.9 | 13.8 |
| o width of SPSC riffle channel (ft) | CONTRACTOR OF STREET | 45.0 | No Cascade is Ne | eded | 1 | | | |
| We we have a set of the | AND THE PROPERTY OF THE PROPERTY OF | | Minimum Rool Depth "Line 3 | 1 | 1. | 18 | 10.8 | 15.1 |
| | | | nools" following each | | | 1 | | |
| anth of SPSC office channel (ff) | 3. Sern Sales | 22 10 22 | cascade segment (ft) | #DiV/0 | | 1 | | |
| the CDCC (0) | angaran sang sakangangangan | We want the constant of the second statement of the | ak ak | ****** | 1 1 | | | |
| me SPSC (it) | P4 | 2.0 | OK | | 1 | | | |
| ter Desred Pool Depth (ft) | A GERTH THE ALL | 3.0 | subcritical/o | K _ | | Adequate | e conveyance | of design storm |
| | | | | | - | | | |
| | | | | | | | | |
| heck Riffle Side Slope, Must be > 2H:1V | | 10.2 | 1 | | | Selected (| Cobble Size is | Adequate for 10 |
| neck the Ecourde Number to ensure Subcritical Flow Con | ditione | 0.6 | 1 | | \mathbf{i} | | vear sto | m |
| | T | 0.0 | - | | | | 700. 010 | |
| | | | | | | | | |
| me ded Baucheens | | 0.04 | | | · \ | | | |
| simplified Roughness | | 0.04 | - | | | <u> </u> | | |
| fle Cross Section Area (ft2), for parabola | A | 66.00 | | | | Subci | ritical Flow is | Predominant |
| | 1 | | 1 | | | | | |
| neta - Intermediate step for solving | 0 | 0.19 | | | | | | |
| | | | 1 | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| iffle Hydrautic Perimeter (ft), for parabola | P | 45.29 | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| He Hudraulic Padius (ft) using Chow 1959 | R | 1.46 | 1 | | | | | |
| ine Hydradiic Realds (k), dsing Chew 1955 | | 1.40 | - | | | | | |
| | | | 1 | | | | | |
| alculated Flow for design parameters (cfs) | <u> </u> | 322.51 | | | | , | | |
| | | | | | | | | |
| heck Riffle Velocity (ft/sec) | V | 4.89 | Required Numbe | er of Pools | | 46 | | |
| | | | | | | | [| |
| 1 | | | Provided total pool | depth (ft) = | | 1 138 | | |
| Chashing Over | | | | m Cahma | | | | |
| Checking Quan | nuty management | | N. | IN SOIVER | | | | |
| · · · · · · · · · · · · · · · · · · · | _ | | | | | | | |
| SUA 2006, n expressed in terms of d _{out} and d ₅₀ = 8 inches | n | 0.03 | Inequired volume of Storage | e (Kational H | yarogra | ipn) | 1 | г |
| | | 45.00 | | | 100.1 | | 10.1 | 1 |
| e waan at the entrance rime | ٧٧'n | 45.00 | | | 100 11 | 197 | 10 17 | 4 |
| | | | | | | 1 | | [|
| | | | | | | | | 1 |
| e velocity at the entrance riffle is calculated using Manning | 1 | | | | | 1 | | 1 |
| rmula calculator and Q _{post} for the 1 year storm | V. | 7.57 | Required Volume of Storage | (ft3) | 0 | 0 | 0 | 1 |
| | | A | | | 1 | | | 1 |
| | | | i i | | 1 | | | |
| | 1 | | | | 1 | | | 1 |
| and on the animan of the is as in dated using Manada | | | | | I | | | 1 |
| re vepor at the entrance rate is calculated using manning rmsta calculator and O for the 1 year storm | í n | 2 20 | Volume provided in pools (#3) | | 1 | 1987 | B | 1 |
| nter Trial Value : The total nool denth nearled to render | | 6.40 | 1 | <u> </u> | <u> </u> | 1501 | | 1 |
| e power equivalent to 100-year predevelopment/desired | | | l l | | i | | | |
| vals. This should be compared against the total | p., | 21.23 | Volume provided in voids (fr3) | | 1 | 1986 | D | 1 |
| reie, mill andraid de compared against the total | Pout | | Note #Existings Altranties | | 5 6-124-0 | 1000 | - \$17.46 (2019) 10:00:00:00 | 1 |
| is is the typical top width of the dead storage pool parabolic | 1 | | IN THE REAL PROPERTY OF | 19.54 | 法派 | A A W | | |
| eas, 10:1 side slope | W~ | 12 | FIRE STATE | | 19 | | | 1 |
| | | - | Drowling Volume of C | | | | | |
| a area is for a semi parabola | <u>م</u> | 170 | Provided Volume or Storag | W (BACHLICOS | 1. S | 4070 | | |
| ie area is for a semi parabola | Mout | 170 | Tantanon) (II3) | K. Watcher | 1 Caller | 0.95 | الم | - |
| ptection volume. | Ladd | 0 | Prestration Volume (| ことのないない | 然 前沿 | CARGE (1000 | 17.240.5 ALEXA | 1 |
| eta - Intermediate step for solving | θ | 1.43 | L | Run \$ | olver | | | 1 |
| draulic Perimeter (ft), for semi parabola | Poul | 45 | | Run S | olver | | | J |
| draulic Radius, using Chow 1959 | R, | 3.76 | | Run S | olver | | | 1 |
| arcy Weisbach friction factor expressed in terms of 1 v | 1 | 0.19 | | | | | | • |
| shed using Solver equation: Berpoulli equation sewritten | in terms of d ar the | | f . | | | | | |

| Checking Qua | lity Management | |
|--|-----------------------------|-------------------|
| Site Drainage Area (Acres) | District Antipation | 56 State 68 State |
| Contributory Impervious Area (Acres) | | 35 31 |
| Volumetric Runoff Coefficient | Rv | 0.53 |
| Water Quality Volume, ft3 | WQv | 113692 |
| Average Sand filter bed depth (fi) minimum 18 inches | (Average of Paul and Rille) | 5 4 PACE 50 |
| Width of sand filter (ft) | W. W. STAN | 1. 1. 1. 1. 1. B |
| Length of sand filter, where slope < = 5% (ft) | Land | 1655 |
| Area of sand filter provided (ft2) | A Provided | 13240 |
| coefficient of permeability of filter media (ft/day) | k | 3.50 |
| height of water above filter bed- pool depth (ft) | h, . | 3.00 |
| design filter bed drain time (days), MDE recommended value | L. | - 1.67 |
| Required filter bed area (ft2) | A Required | 3647 |

Water quality requirement is satisfied in SPSC

~



Contact

2652 Riva Road Anuspolis. MD 21461 Phone 410 222 4241

Developed by: Date: Hala Flores, P.E. 21-Dec-09

٠

Anne Arundel County Government Department of Public Works Bureau of Engineering Watershed and Ecoxystem Services and Restoration Watershed Assessment and Planning



Input values shaded in Grey Thequired Calculated values are noted with dotted pattern Check parameters in bold

| Checking | the Channel Conve | yance for the design flood | | | · · | | | |
|--|--|---|---|---------------------------------------|----------|------------------|-------------------|--------------------|
| Design Return Period (Yr) : Se | A SPACE OF TAKE SALE | 100 | CARLES DEPTERSION | 10点题 | | | | |
| Time of Concentration in minutes (Before Development) | | | U.45 ALCO SERVICE TO B | | | (| | ACC 11-16-2 |
| Pte development discharge (cts) | More States | 321.52 | Contraction of the second states of the | 18.5 A | | Isbash ci | Urve for Stone De | isity = 165 16/113 |
| | · 法规律法 法规律法律 | | 125.22 | 4. A. | | Cobhie d50 | Allowable | Allowable velocity |
| | 1887 C 1995 A 2 | | 1000 | | | size | Velocity | (Subcrutical) |
| | | | | | | | (Supercritical) | |
| Post development design discharge (cfs) | A STATE OF THE STATE | 321.5 States | STATES A. STREET, STREE | Sec.118.5 12 | | | | |
| | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | | Cascade Design (maximur | n 5 ft drop | | [inches] | [ft/sec] | (ft/sec) |
| Total available length (ft) | 128月19日1月1月1日 | 1655 · · · · · | per segment) | | | | | |
| Elevation drop over length (ft) | 👬 🗧 delta E | 18.0 | Design Width (ft) | 12月4日月2月 | | 4 | 5.1 | 7,1 |
| Total Cascade Length for Project (ft) | Lcascade | 0.00 | Design Depth (it) | 的法规和提 | | 5 | 5.7 | 8.0 |
| Maximum Cascade Slope (ft/ft) | Slopecascade | 0.50 | Roughness | 0.05 | | 6 | 6.3 | 8.7 |
| Water Quality slope (ft/ft) | Slope | 0.01 | A | 0.00 | | 7 | 6.8 | 9,4 |
| Average Length of Riffle Segments (ft), Minimum 10 ft. | AREAS AND AND A DESCRIPTION OF | 18 | θ | #DIV/0! | | 8 | 7.2 | 10.1 |
| Number of Riffle Segments for Project | N.s. | 46 | Р | #DIV/0! | | 9 | 7.7 | 10.7 |
| Number of Cascade Segments for Project | Newcara | 0 | R. | #DIV/0! | | 10 | 8.1 | 11.3 |
| Bequired Length of Pool Segments (ft) | L. | 18 | Design Velocity (ft/sec) | #DIV/0! | | 11 | 8.5 | 11.8 |
| | I ORDANIA AND AND | | | | | 12 | 5.8 | 12.3 |
| | 化学学学学会 | 0.60 | Commund O (rfs) | #00//01 | | 12 | 0,6 | 12 |
| COBINE COUNTER (II) - CRACKE - C INCIDE | Contraction of the second second | Constant of the Action of the | Conveyed G (clay | WDIVIO: | | 15 | u 0 | 12.0 |
| A second state of the second stat | press Constraints | AND A DEALER OF SHIELD | | | | 1.5 | 9.9 | 12.0 |
| Top width of SPSC rifle channel (it) | A REAL PROPERTY AND A REAL | 100.0 | No Cascade is Ne | eaea | | | | |
| | | | Minimum Pool Depth *Use 3 | | | 18 | 10.8 | 15.1 |
| And the second second second second second second | The second states | | pools" following each | | | | | |
| Depth of SPSC rifle channel (ft) | · 这次,他们D 和P 的是这 | 15 State 15 | cascade segment (ft) | #DIV/0! | | | | |
| of the SPSC (ft) | h _r | 1.5 | ok | | | | | |
| Enter Desired Pool Depth (ft) | 122 A 11 12 12 12 | 3.0 | subcritical/o | k | | Adequate | conveyance | of design storm |
| | | | 1 | | | | | |
| | | | ľ | · · · · · · · · · · · · · · · · · · · | | | | |
| Check Riffie Side Slope, Must be > 2H:1V | | 33.3 | | · · · · | | Selected C | obble Size is | Adequate for 100 |
| Check the Froude Number to ensure Subcritical Flow Cor | nditions | 0.5 | | | <u>۱</u> | 1 | year stor | m |
| | 1 | | 1 | | | R | | |
| | | | | | · \ | | | |
| Computed Roughness | n | 0.04 | | | ``` | \ | | |
| Diffe Course Castian Area (62) for parabola | | 100.00 | 1 | | | Subcr | itical Flow is | Predominant |
| Kinie Cross Section Area (12), for parabola | ^ | 100.00 | 4 | | | 0000 | | rouonnant |
| Theta - Intermediate step for solving | 8 | 0.06 | | | | | | |
| Them - mermediate drop fail conting | Ť, | 0.00 | 1 | | | | | |
| | | | 1 | | | | | |
| | | | | | | | | |
| Riffle Hydraulic Perimeter (ft), for parabola | P | 100.06 |] | | | | | |
| | | |] | | | | | |
| | | | | | | | | |
| Riffle Hydraulic Radius (ft), using Chow 1959 | R, | 1.00 | | | | | | |
| | | | 1 | | | | | |
| Calculated Flow for design parameters (cfs) | · • | 352.87 | | | | | | |
| | | | | | | | | |
| Check Riffle Velocity (ft/sec) | v | 3.53 | Required Numbe | r of Pools | | 46 | | |
| h | • | | | | | | | |
| | | | Provided total pool | depth (ft) = | | 138 | | |
| | | | | | | | | |
| Checking Quar | ntity Management | | hydraulic power for return p | seriod 100 ye | ar stor | m is satisfied | | |
| | 1 | 0.00 | | /D | | | | |
| USDA 2005, n expressed in terms of dout and do = 6 inches | <u> </u> | 0.03 | Required volume of Storage | (Rational n | rurogra | | | 1 |
| The width at the entrance riffle | w | 100.00 | | | 100 Yr | 1 17 | 10 Yr | |
| | | | | | 100 11 | | 10 11 | |
| | 1 | | | | | | | |
| | <u></u> | | | | | | | |
| The velocity at the entrance riffle is calculated using Manning | | 7.77 | Required Volume of Store " | | ~ | | | |
| rormula calculator and Uppel for the 1 year storm | Vn. | 1.51 | Insidence Anorus of Stolage (I | | U | <u> </u> | <u> </u> | |
| 1 |] | | | · · ·] | | | | |
| | | | | | | | | |
| The death of the extension of the inclusion details at the | | | | | | | | |
| I ne depth at the entrance riffle is calculated using Manning | | 1 50 | Volume provided in pools (63) | | | 10070 | | |
| Enter Trial Value : The total pool don'th peaded to render | | 1.50 | round provided in pools (ita) | | | 13070 | | |
| the power equivalent to 100-year predevelopment/desired | | | | | | | | |
| levels. This should be compared against the total | 0~ | 19.52 | Volume provided in voids (ft3) | | | 19860 | | |
| | <u></u> | | EN A ASTRACTOR | 100 BC 100 | 1 | 心的情况的 | HAR AND A | |
| This is the typical top width of the dead storage pool parabolic | | _ | | SSA STATE | | | | |
| areas, 10:1 side slope | Wout | 9 | 和国际,和中国的 | 18. S. C. | | Est the | | |
| | | | Provided Volume of Storage | (excludes | | | | |
| The area is for a semi parabola | Aout | 117 | infiltration) (ft3) | | - 6 da | 40738 | 家都認知道 | |
| protection volume. | Ladd | 0 | Infitration Volume (ft | 3) HE AR | ks Re | 1000 × 1000 | 机合合体的行动的利 | |
| Theta - Intermediate step for solving | θ | 1.46 | Peak Manage | ment of 100 | year st | orm is satisfied | d | |
| Hydraulic Perimeter (ft), for semi parabola | Poul | 41 | Peak Manag | ement of 1 y | ear sto | rm is satisfied | | |
| Hydraulic Radius, using Chow 1959 | R _h | 2.87 | Peak Manage | ement of 10 | year sto | orm is satisfied | | |
| Darcy Weisbach friction factor expressed in terms of Law, Volt | f | 0.21 | | | | | | I |
| Salved using Solver equation: Barboulli equation rewritten | in terms of d _{aut} as the | 0.00 | | | | | | |

| Checking Qua | lity Management | |
|--|-------------------------------|--|
| Site Drainage Area (Acres) | CARGE A BANK | 4 |
| Contributory Impervious Area (Acres) | Stational Strength | 5 (2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 |
| Volumetric Runoff Coefficient | Rv | 0.53 |
| Water Quality Volume, ft3 | WQv | 113692 |
| Average Sand filter bed depth (it) minimum 18 inches | Gi Lawerage of Pool and Rille | 5.0 |
| Width of sand filter (ft) | W. W. Starte | 8 N 10 10 10 10 10 10 10 10 10 10 10 10 10 |
| Length of sand filter, where slope < = 5% (ft) | Lsend | 1655 |
| Area of sand filter provided (ft2) | Ar Provided | 13240 |
| coefficient of permeability of filter media (ft/day) | <u>k</u> | 3.50 |
| height of water above filter bed- pool depth (ft) | hr | 3.00 |
| design filter bed drain time (days), MDE recommended value | t, | 1.67 |
| Required filter bed area (ft2) | A _{l Required} | 3647 |

.

•

Water quality requirement is satisfied in SPSC

•



<u>Contact</u>

Ŧ 2652 Riva Road Annapolis, MD 21401 Phone 410 222 4241

Developed by: Date:

Anne Arundei County Government Department of Public Works Bureau of Engineering Watershed and Ecoxystem Services and Restoration Watershed Assessment and Planning Hala Flores, P.E. 21-Dec-09



Calculated values are noted with dotted pattern Check parameters in bold

| Checking | g the Channel Conve | yance for the design flood | | | | | | |
|--|---|----------------------------|--|---|-----------------------|--------------------|--|-------------------------------------|
| Design Reham Period (Yr) | A STATE TO SERVE | 100 | Later and a state of the second state of the | N 10 | | | | |
| Pre development discharge (CIs) | 0 | 158.8 | 22-1 | 62.8 | | isbash c | urve for Stone De | insity = 165 lb/ft3 |
| Port sectore design of burgs (51) | | | 22 | 62 A | | Cobble d50 size | Allowable Velocity (Supercritical) | Allowable Velocity (Subcritical) |
| T da orrespendor do gran de la composición de la composi Composición de la composición de la comp | | | Cascade Design (maximum | n 5 ft drop | | [inches] | [ft/sec] | [ft/sec] |
| Total available length (ft) | Le de la company | 1655 | per segment) | and the second | | | 41 | 7. |
| Levation drop over length (ru | Carlos della Esta della | 0.00 | Design With (f) | San | | | 5.7 | 8.0 |
| Maximum Cascade Slope (ft/ft) | Slope _{cascada} | 0.50 | Roughness | 0.05 | | 6 | 6.3 | 8.7 |
| Water Quality stope (ft/ft) | Slope | 0.01 | A | 0.00 | | 7 | 6.8 | 9,4 |
| Average Length of Riffle Segments (ft), Minimum 10 ft 1 | 1. S. C. S. | 16 No. 15 No. 15 | θ | #DIV/0! | | 8 | 7.2 | 101 |
| Number of Riffle Segments for Project | N _{nille} | 55 | ρ | #DIV/0! | | 9 | 7.7 | 10.7 |
| Number of Cascade Segments for Project | Ncascade | 0 | R _n | #DIV/0! | | 10 | 8,1 | 11.3 |
| Required Length of Pool Segments (it) | | 15 | Design velocity (rosec) | #DIVIO! | | 13 | 8.2 v v | 11.8 |
| Cobble d50 size (it) - choose - 8 inches | d50 | 0.50 | Conveyed Q (cfs) | #DIV/0! | | 12 | 0.0 | 12 |
| Top width of SPSC rifle onamel (ft) | | 14.0 - | No Cascade is Nee | eded | | 1.3 | 9.9 | 13,8 |
| Depth of SPSG Tiffle channel (ft) | 0 | | Minimum Pool Depth "Use 3 pools" following each cascade segment (ft) | #DIV/0! | | 18 | 10.8 | 15.1 |
| of the SPSC (ft) | h | 3.0 | ok | | | Į | | |
| Entra Desired Pool Depth (ft): | h. | 30 | subcritical/ok | <u> </u> | | Adequate | conveyance | of design storm |
| Check Riffle Side Slope, Must be > 2H:1V | | 2.3 | | | | Selected C | obble Size is | Adequate for 100 |
| Check the Froude Number to ensure Subcritical Flow Con | nditions | 0.6 |] | | $\mathbf{\mathbf{N}}$ | | year stor | m |
| | | | | | | | | |
| Computed Roughness | n | 0.04 | 4 | | | | ······································ | |
| Riffle Cross Section Area (ft2), for parabola | A | 28.00 | - | | | SUDC | nical Flow IS F | recominant |
| Theta - Intermediate step for solving | | 0.71 | | | | | | |
| Riffle Hydraulic Perimeter (ft), for parabola | Ρ | 15.56 | • | | | | | |
| Riffle Hydraulic Radius (ft), using Chow 1959 | R | 1.80 | | | | | | |
| Calculated Flow for design parameters (cfs) | Q | 165.11 | | | | | I | |
| Check Riffle Velocity (ft/sec) | v | 5.90 | Required Number | of Pools | | 55 | | |
| | | , | Provided total pool d | lepth (ft) = | | 165 | | |
| Checking Quar | ntity Management | · · · | hydraulic power for return pe | eriod 100 ye | ar stori | n is satisfied | | |
| USDA 2006, n expressed in terms of d_{aut} and $d_{50} = 8$ inches | n | 0.03 | Required Volume of Storage | (Rational Hy | drogra | ph) | | |
| The width at the entrance riffle | | 14.00 | | | 100 Yr | 1 Yr | 10 Yr | |
| The velocity at the entrance riffle is calculated using Manning formula calculator and Q_{post} for the 1 year storm | Vn | 7.57 | Required Volume of Storage (ft: | 3) | D | 0 | 0 | |
| The depth at the entrance riffle is calculated using Manning | | 2.00 | Volume erevited is peak (#2) | | | 00767 | | |
| Enter Trial Value : The total pool depth needed to render | Uin | 3.00 | volume provided in pools (113) | ł | | 23/6/ | | |
| the power equivalent to 100-year predevelopment/desired levels. This should be compared against the total | Dout | 21.22 | Volume provided in voids (ft3) | | | 19860 | | |
| This is the typical top width of the dead storage pool parabolic areas, 10:1 side slope | Woul | 18 | | | 35€. 1 | | | |
| The area is for a semi parabola | A _{out} | 255 | Provided Volume of Storage infiltration) (ft3) | (excludes | | 44627 | | |
| protection volume. | Lado | 0 | 22. An Influetion Volume (R3 | n a car | 111 | n / 1000 | 10 M.T. (2017 | |
| Theta - Intermediate step for solving | e P | 1.36 | Peak Managen | ment of 100 | ear sto | orm is satisfied | · | |
| Hydraulic Radius, using Chow 1959 | R. | 5.34 | Peak Manage | ment of 10 v | ear sto | rm is satisfied | | |
| Darcy Weisbach friction factor expressed in terms of Lastr. Voite | f | 0.17 | . son inbridger | | -3, 510 | | | |
| Solved using Solver equation: Bernoulli equation rewritten | in terms of d _{out} as the | 0.00 | | | | | | |

| Checking Qua | lity Management | |
|--|--------------------------------|--|
| Site Drainage Area (Acres) | A CARLEND | 682370000 |
| Contributory Impervious Area (Acres) | 影響的際語是最佳的作品 | 35 - 1.5 - 1.5 - 1.5 - 1.5 - 1.5 - 1.5 - 1.5 - 1.5 - 1.5 - 1.5 - 1.5 - 1.5 - 1.5 - 1.5 - 1.5 - 1.5 - 1.5 - 1.5 |
| Volumetric Runoff Coefficient | Rv | 0.53 |
| Water Quality Volume, ft3 | wav | 113692 |
| Average Sand filter bed depth (ft) minimum 18 mches | di (Average of Puol and Rille) | 5.0 |
| Wistin of sand filter (it) | Wand to Care | 8 |
| Length of sand filter, where slope < = 5% (ft) | Lsand | 1655 |
| Area of sand filter provided (ft2) | A Provided | 13240 |
| coefficient of permeability of filter media (ft/day) | k | 3.50 |
| height of water above filter bed- pool depth (ft) | ħŗ | 3.00 |
| design filter bed drain time (days), MDE recommended value | ՝ Կ | 1.67 |
| Required filter bed area (ft2) | A _{l Required} | 3647 |

Water quality requirement is satisfied in SPSC

.



Contact

Ð 2652 Riva Road Annupolis, MD 21401 Phone 410 222 4241

Developed by: Date:

Anne Arundel County Government Department of Public Works Bureau of Engineering Watershed And Ecosystem Services and Restoration Watershed Assessment and Planning Hala Flores, P.E. 21-Dec-09



Calculated values are noted with dotted pattern Check parameters in bold

| Checking | the Channel Conve | vance for the design flood | | | 1 | | | |
|--|--|--|---------------------------------|--------------|--------------|------------------|--------------------------------|---------------------|
| Design Return Period (Yr) | - Paracent Testatent | hard and the design hood | | ¥2310×55 | | • | | |
| Time of Concentration in minutes (Before Development) | 1 改变大致同1 和中国政 | | 0.45 | C.F.F.F.F. | | | | |
| Pre development discharge (cfs) | Q. Start | 158.8 | - 74 | 62.8 | | lsbash c | urve for Stone De | insity = 165 lb/ft3 |
| | 1. S. A. C. S. A. A. C. A. | | 10 D. D. S. S. S. | | | Connie d50 | Allowable | Allowable velocity |
| | | | | (75,377) | | Size | (Supercritical) | ((10)(11)(21) |
| Post development design discharge (cfs) | Q _{rea} () | 158.8 | 22 1.1 | £ 62.8 | | | | |
| | Mar and a constant | | Cascade Design (maximum | 5 ft drop |] | [inches] | [ft/sec] | [ft/sec] |
| Total available length (fl) | and the second second | 1855 | per segment) | | | | | |
| Elevation drop over length (ft) | deta E | 18 0 2 | Design Width (ff) | 建设合物 | | 4 | 5.1 | 7,1 |
| Total Cascade Length for Project (ft) | L _{cascade} | 0.00 | Design Depth (ft) | 14.5 255 | | <u>.</u> | 5.7 | 8.0 |
| Water Orality slope (101) | Sione | 0.55 | | 0.05 | | 7 | 6.5 | 5.7 94 |
| Average Length of Riffle Segments (ft), Minimum 10 ft | | 18 | 6 | #DIV/0! | ł | 8 | 7.2 | 10.1 |
| Number of Riffle Segments for Project | N _{relle} | 46 | Ρ | #DIV/0! | 1 | 9 | 7.7 | 10.7 |
| Number of Cascade Segments for Project | Nesscade | 0 | Rh | #DIV/0! | | 10 | 8,1 | 11.3 |
| Required Length of Pool Segments (ft) | Lpool | 18 | Design Velocity (ft/sec) | #DIV/0! | | 11 | 8.5 | 11.8 |
| | and the second second | | | #D0//01 | | 12 | <u>8,8</u> | 12.3 |
| CONDE USU SIZE (II) - CINCER - CINCING | Construction of the second | | Conveyed Q (cis) | #DIV/U! | | 15 | 49 | 13.8 |
| Too with of SPSC offe charge (ft) | • w | 27.0 | No Cascade is Nee | ded | | | | 12.0 |
| | ALC: DOM: NOT | and the second | Minimum Pool Depth "Use 3 | | | 18 | 10.8 | 15.1 |
| and the second | | | pools" following each | | | | | |
| Depth of SPSC riffle channel (ft) | D States | 2.0 | cascade segment (ft) | #DIV/0! | | | | |
| of the SPSC (ft) | hy Destroyed and the second states | 2.0 | OK | | | | | |
| Enter Desired Pool Depth (ft) | · 网络加州东西加州东西和市东西 | | Subcritical/or | <u>`</u> | | Adequate | e conveyance | of design storm |
| | | | | | | | | |
| Check Riffle Side Slope, Must be > 2H:1V | | 6.8 | | | | Selected C | obble Size is | Adequate for 100 |
| Check the Froude Number to ensure Subcritical Flow Con | ditions | 0.6 | | | | | year stor | m j |
| | | | | | | | | |
| Computed Roughness | n | 0.04 | | | | ` | | |
| Piffe Cross Section Area (#2) for parabola | <u>م</u> | 36.00 | 1 · | | | N Subci | itical Flow is F | Predominant |
| | <u> </u> | 56.00 | 4 | | i | 0050 | | |
| Theta - Intermediate step for solving | θ | 0.29 | 1 | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| Riffle Hydraulic Perimeter (ft), for parabola | Р | 27.39 | ł | | | | | |
| | | | i i | | | | | |
| Riffle Hydraulic Radius (ft), using Chow 1959 | R, | 1.31 | | | | | | |
| | | | | | | | | |
| Calculated Flow for design parameters (cfs) | <u> </u> | 161.48 | | | | | | |
| | | | De aufau d Number | - (D - | | 40 · | | |
| Check Riffle Velocity (fusec) | v | 4.49 | Required Number | of Pools | | 40 | | |
| | | | Provided total pool d | lepth (ft) = | | 138 | | |
| Checking Quan | tity Management | | hydrautic power for return p | ariod 100 v | ar stor | n is satisfied | | |
| Checking adam | inty management | | Injuruune power for return p | 11100 100 y | | n is sucising | | |
| USDA 2006, n expressed in terms of dout and doo = 8 inches | n | 0.03 | Required Volume of Storage | (Rational H | drogra | <u>ph)</u> | | |
| The width at the entrance ciffle | w | 27.00 | | | 100 . | · v. | 10 % | |
| | ····· | £1,00 | | | 100 18 | 111 | | |
| | | | | | | | | |
| The velocity at the entrance riffle is calculated using Manning | | | | | | | | |
| formula calculator and Q _{post} for the 1 year storm | Vn | 7.57 | Required Volume of Storage (ft: | 3) | 0 | 0 | 0 | |
| | | | | | | | | |
| | | • | | | | | | |
| The depth at the entrance riffle is calculated using Manning | | | | | | | | |
| formula calculator and Q _{post} for the 1 year storm | D _n | 2.00 | Volume provided in pools (ft3) | | | 19878 | | |
| the power equivalent to 100-year predevelopment/desired | | | | | | | | |
| levels. This should be compared against the total | D _{out} | 20.13 | Volume provided in voids (ft3) | 461.045.001 | Mary and the | 19860 | 2.47.27 A 200 200 - 402 - 1000 | |
| This is the typical top width of the dead storage pool parabolic | | | | | | | | |
| areas, 10:1 side slope | · W _{out} | 12 | 计通知 分子法 | | | Sec. An | | |
| The area is for a comi parabola | | 164 | Provided Volume of Storage | (excludes | | | | |
| protection volume. | Mout | 0 | news (13) | NO PLAN | and a start | 40738 | | |
| Theta - Intermediate step for solving | θ | 1.42 | Peak Manager | nent of 100 | year sto | orm is satisfied | d | |
| Hydraulic Perimeter (ft), for semi parabola | P _{oul} | 43 | Peak Manage | ment of 1 y | ear sto | m is satisfied | | |
| Hydraulic Radius, using Chow 1959 | R _n | 3.74 | Peak Manager | ment of 10 | year sto | rm is satisfied | | |
| Darcy Weisbach friction factor expressed in terms of Ledd, voul. | t to the set of the se | 0.19 | | | | | | |
| Solved using Solver equation: Berhoulli equation rewritten | interms of d _{eut} as the | 0.00 | I | | | | | |

| Checking Qua | lity Management | |
|--|---------------------------------|------------|
| Site Dranage Area (Acres) | 1327-1-13 A 12-25-18 | 66 -65 -25 |
| Contributory Impervious Area (Acres) | 「「ないた他」」の言語の影 | 2.5.4.9 |
| Volumetric Runoff Coefficient | Rv | 0.53 |
| Water Quality Volume, ft3 | WQv | 113692 |
| Average Sand filter bed depth (ft) minimum 18 inches | Cr (Average of Paul and Rillie) | 5.0 |
| Width of sand filter (ft) | Section Wand Street and | 8 |
| Length of sand filter, where slope < = 5% (ft) | Lund | 1655 |
| Area of sand filter provided (ft2) | A Provided | 13240 |
| coefficient of permeability of filter media (ft/day) | k | 3.50 |
| height of water above filter bed- pool depth (ft) | h, | 3.00 |
| design filter bed drain time (days), MDE recommended value | Li Li | 1.67 |
| Required filter bed area (ft2) | A _{f Required} | 3647 |

: -

Water quality requirement is satisfied in SPSC



P 2652 Riva Road Amispolis MD (1401 Phone 410 222 4241

Developed by: Date:

Hala Flores, P.E. 21-Dec-09

Anne Arundel County Government Department of Public Works Bureau of Engineering Watershed and Ecosystem Services and Restoration Watershed Assessment and Planning



| Checking | the Channel Conve | yance for the design flood | | | | | | |
|--|--|--|--|-------------------------------------|--------------|-----------|---------------------------------------|--------------------|
| Design Return Period (Yr) Charles Contraction States | Linger and the property | | AND ROOM TO THE MENDER OF | 750-10 | | | | |
| Time of Concentration in minutes (Before Development) | | | 0.48 | 1. H. C. S. B. | | | | |
| Pre development discharge (Cf5) | | /904 · 4 | 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1 | 31.2 | | Isbash c | urve for Stone De | nsity = 165 ib/it3 |
| | | | · · · · · · · · · · · · · · · · · · · | | Cot | ohle d50 | Allowable | Allowable Velocity |
| | | il i de la company | | | | SIZe | velocity | (Subcritical) |
| | | | | | | | (Supercruican | |
| Loca opverbiller gesehl bischaße (ris) | CALL STREET | /9.0 | | 高级和学会参 | | | 16 () | 101 |
| | | | Cascade Design (maximum | 5 ft drop | 1 10 | acnesj | pu/sec) | [it/sec] |
| Total available length (ft) | A CALE STATE | 170 | per segment) | | | | | · |
| Elevation drop over length (ft) | dela E | 2.0 | Design Width (fi) | | | 4 | 5.1 | 7.1 |
| Total Cascade Length for Project (ft) | Classe | 0.00 | Design Depth (ft) | | | 5 | 5.7 | 8.0 |
| Maximum Cascade Siope (n/n) | Siopecascade | 0.50 | Rouganess | 0.05 | | 6 | 6.5 | 8.7 |
| vvater Quality slope (π/π) | Siope | U.U1 | A | 0.00 | | - / e | - 0.8 | 9,4 |
| Average conget of state Segments (in Administration in Segments) | | 4 | 0 | #DIV/0 | | 0 | 7 | 10.1 |
| Number of Casando Segments for Project | N | 4 | <u> </u> | #01//01 | | <u> v</u> | ····· /·/ | 10.7 |
| Required Longth of Pool Segments for Project | cascade | | Design Velocity (ft/sec) | #01//01 | | 10 | | 11.2 |
| Required Length of Poor Segments (in) | - POOR | | Design Velocity (Ibsec) | *01010: | | 12 | | 11.8 |
| | de la companya de la | | Communed O (offe) | #D11/401 | | 12 | <u>^.</u> ^ | 12.5 |
| CODING COVIELE (1) - CROCKE - C INCINE - C ARE-COLLEGE | How Area in the state of the second | Service of the servic | Conveyeo G (cis) | #DIVIO! | - I | 15 | 6.6 | 12.8 |
| | | the second second second second | No Coscodo is Noo | 444 | | 12 | 7.7 | 12.0 |
| 10p would of SPSC nine channel (I) | International Activity of States International Activity of States | 22.0 K | no cascade is nee | ueu | | 10 | 16 | |
| | | | Minimum Pool Depth "Use 3 | | | 18 | 10.8 | 10.1 |
| Depth of SPSC rifle channel (ft) | D D | | cascade segment (ft) | #DIV/0 | | | | |
| of the SPSC (ft) | h | 10 | ok | | | | · · · · · · · · · · · · · · · · · · · | |
| | BURNERSON AND MARKED | | subcriticat/ok | | | | | f decign storm |
| Cines Lasteo Pox Depot (n) | | an and a state of the order of the state of | subcritical/ok | | | uequate | r conveyance c | or design storm |
| | | | | | | | | |
| Check Riffle Side Slope, Must be > 2H:1V | | 7.3 | | | Sel | ected C | obble Size is / | Adequate for 100 |
| Check the Froude Number to ensure Subcritical Flow Con | ditions | 0.5 | | | | | vear storr | m |
| | | 0.0 | • | | | | <i>juu o</i> ton | |
| | | | 1 | | \mathbf{X} | | | |
| Computed Roughness | n | 0.04 |] | | | | | |
| Biffle Cross Section Area (ft2), for parabola | A . | 22.00 | | | A | Subcr | itical Flow is P | redominant |
| | | | 1 | | | | | |
| Theta - Intermediate step for solving | θ | 0.27 | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| Biffle Hydraulic Perimeter (ft) for parabola | Р | 22.27 | | | | | | |
| | | | 1 | | | | | |
| | | | | | | | | |
| Riffle Hydraulic Radius (ft), using Chow 1959 | R, | 0.99 | | | | | | |
| | | | i · | | | | | |
| Calculated Flow for design parameters (cfs) | ٩ | 80.12 | | | | | | |
| | | | | | | | | |
| Check Riffle Velocity (ft/sec) | v | 3.64 | Required Number | of Pools | | 4 | | |
| | | | Received total as all d | | | 42 | | |
| · · · · · · | ····· | | Provided total pool of | eptn (n) = | | 12 | 1 | |
| Checking Quar | itity Management | | hydraulic power for return pe | riod 100 year | r storm is s | atisfied | | |
| | | | | | | | | |
| USDA 2006, n expressed in terms of dout and ds0 = 8 inches | n | 0.04 | Required Volume of Storage (| Rational Hyd | rograph) | | | |
| | | | | ŀ | | | | |
| I ne width at the entrance riffle | Win | 22.00 | ··· | 10 | UU Yr | 1 Yr | 10 Yr | |
| | 1 | | | | 1 | | | |
| | | | | | | | | |
| The velocity at the entrance riffle is calculated using Manning formula calculator and Q is for the 1 year form | v | 7 67 | Required Volume of Storace /#5 | 3) | | | , I | |
| normal concedent and const for the rigear storin | ** | 1.01 | Contraction of the state of the | | ان≚ | <u> </u> | ř | |
| | | | | | | | ļ | |
| | | | | | | | | |
| The depth at the entrance riffle is calculated using Manning | | | | | | | | |
| formula calculator and Q _{post} for the 1 year storm | D, | 1.50 | Volume provided in pools (ft3) | | | 1729 | | |
| Enter Trial Value : The total pool depth needed to render | | | | | | | | |
| levels. This should be compared against the total | р., | 3.35 | Volume provided in voids (ft3) | | | 2040 | | |
| | Poul | 0.00 | Sector Provide Transfer (14) | 19999 199 199 199 199 199 | 12.44.40 | | | |
| This is the typical top width of the dead storage pool parabolic | | _ | | Sector in | | 动动 | | |
| areas, 10:1 side slope | Wout | 6 | | | | | STATE AND | |
| | | | Provided Volume of Storage (| excludes | | | | |
| The area is for a semi parabola | A _{out} | 13 | infiltration) (ft3) | 194月至1956年(1977 1947年至1956年(1977 | | 4769 | | |
| protection volume. | Lado | 0 | ntituation Volume (fl3 | North Carlson | | 0001 | and the second second | |
| Inera - intermediate step for solving | А | 1.15 | Peak Managen | ment of 100 ye | ar storm is | saustie | ·{ | |
| Hydrautic Perlineter (II), for semi parabola | ' oui | 9 | Peak Manage | ment of 1 yea | 5 Storm 15 | saustied | | |
| riyurauno Naulus, using unuw 1959 | | 1.42 | Peak Manager | ment of 10 ye | ar storm is | saustied | | |
| Solved up in Solver equation: Persoulli equation | in terms of d or the | 0.34 | | | | | | |
| Gover using conver equation: Demoun equation rewritten | as the | 0.00 | | | | | | |

| Checking Qua | lity Management | | - |
|--|---------------------------------------|---|---|
| Site Drainage Area (Acres) | A A A A A A A A A A A A A A A A A A A | | |
| Contributory Impervious Area (Acres) 2003 | 4043037631975364755 | 8664 (STR) - 2 35 (MIRC) - 2007 | |
| Votumetric Runoff Coefficient | Rv | 0.53 | |
| Water Quality Volume, ft3 | wav | 113692 | |
| Average Sand filler bed depth (ft) minimum 18 inches | dr (Average of Pool and Rille) | 5.0 | |
| Width of sand filter (R) | State Wand Hall | 8 | |
| Length of sand filter, where slope < = 5% (ft) | Liand | 170 | |
| Area of sand filter provided (ft2) | Ar Provided | 1360 | |
| coefficient of permeability of filter media (ft/day) | k | 3.50 | |
| height of water above filter bed- pool depth (ft) | h, | 3.00 | |
| design filter bed drain time (days), MDE recommended value | L L | 1,67 | |
| Required filter bed area (ft2) | A _{I Required} | 3647 | |

•

More Water Quality Treat

.

.



<u>Contact</u>

2652 Riva Road Annapolis, MD 21461 Phone 410 222 4241

Developed by: Date: hone 410 222 4241 Hala Flores, P.E. 21-Dec-09

Anne Arundei County Government Department of Public Works -Bureau of Engineering Watershed and Ecosystem Services and Restoration Watershed Assessment and Planning



Input values shaded in Grey Trequired Calculated values are noted with dotted pattern Check parameters in bold

Checking the Channel Conveyance for the design flood Design Return Period (Yr) Carses (Before Development) (Carses) (Ca 0.23 Aug. 2 An and a second second second second second Isbash curve for Stone Density = 165 lb/ft3 50,3 3 0.6 . . 20.6 Pre overeprimi discrarge (ch) Cobhle d50 Allowable Allowable Velocity 0.8 size Velocity (Subcritical) Supercritical 0 50 3 20.6 otal available kirgin (II) 500 [inches] [ft/sec] [ft/sec] Cascade Design (maximum 5 ft drop per segment) 4223年3 中学研究 Elevation drop over length (fl) 0.00 Design Width (ft) della E 7.1 4 Design Depth (R) 5. 8,0 fotal Cascade Length for Project (ft) Lascade Slopecested Maximum Cascade Slope (ft/ft) 0.50 Roughness 0.05 6 6.3 8.7 Water Quality slope (ft/ft) Slope 0.02 0.00 6.8 9.4 Average Length of Riffle Segments (fl), Minimum 10 fl - 14 #DIV/0! 8 10.1 Number of Riffle Segments for Project 18 #DIV/0 NoBe 7.7 10.7 Number of Cascade Segments for Project n #DIV/0! 10 8.1 11.3 Nesseed Required Length of Pool Segments (ft) Design Velocity (ft/sec) #DIV/0! -11 8.5 11.8 Cobble d50 size (ft) - choose - 6 inches d50 0.50 12 8,8 12.3 #DIV/0 Conveyed O (cfs) op width of SPSC:riffle channel (ft) 14 10 17 9.9 13.8 15 25.0 No Cascade is Needed W 25.0 Depth of SPSC mfle churce (n) 18 10.5 15.1 Minimum Pool Depth "Use 3 S. 之间到 pools" following each D 10.00 cascade segment (ft) #DIV/01 of the SPSC (ft) 1.5 ok h, subcritical/ok Enter Desired Pool Depth (ft) - 30 Adequate conveyance of design storm Check Riffle Side Slope, Must be > 2H:1V 12.5 Selected Cobble Size is Adequate for 100 Check the Froude Number to ensure Subcritical Flow Conditions 0.5 year storm Computed Roughness 0.05 D Subcritical Flow is Predominant Riffle Cross Section Area (ft2), for parabola 16.67 A Theta - Intermediate step for solving A 0.16 Riffle Hydraulic Perimeter (ft), for parabola 25.11 Riffle Hydraulic Radius (ft), using Chow 1959 R, 0.66 Calculated Flow for design parameters (cfs) Q 51.98 **Required Number of Pools** 18 Check Riffle Velocity (fl/sec) 3.12 Provided total pool depth (ft) = 54 **Checking Quantity Management** hydraulic power for return period 100 year storm is satisfied USDA 2006, n expressed in terms of d_{evil} and d₅₀ = 8 inches 0.03 Required Volume of Storage (Rational Hydrograph) The width at the entrance riffle w,, 25.00 100 Y 10 Yr 1 Yr The velocity at the entrance riffle is calculated using Manning formula calculator and Qpost for the 1 year storm V. 7.57 Required Volume of Storage (ft3) 0 ۵ 0 The depth at the entrance riffle is calculated using Manning The bepting the end and a part is a calculated using membra formula calculator and Q_{point} for the 1 year storm Enter Trial Value : The total pool depth needed to rem the power equivalent to 100-year predevelopment/des D., 1.00 Volume provided in pools (ft3) 7778 nt/desired 00... levels. This should be compared against the total D, 10.06 Volume provided in voids (ft3) Volume provided in voors (113) Provided Volume of Storage (excludes infiltration) (113) This is the typical top width of the dead storage pool parabolic reas, 10:1 side slope waw 9 The area is for a semi parabola 60 ٨., 0 Peak Management of 100 year storm is satisfied protection volume e Hand Theta - Intermediate step for solving Hydraulic Perimeter (ft), for semi parabola P ... 23 Peak Management of 1 year storm is satisfied R, Hydraulic Radius, using Chow 1959 2 64 Peak Management of 10 year storm is satisfied Darcy Weisbach friction factor expressed in terms of L_{astr}, v_{out}, f Solved using Solver equation: Bernoulli equation rewritten in terms of d_{est} as the 0.23 0.00







| Checking Qua | lity Management | |
|---|------------------------------|-----------------------------|
| Site Drainage Area (Acres) #42.11 (Martal Content of Area) | A | Store and an AB Solo of the |
| Gontributory Impervious Area (Acres) 23 | | |
| Volumetric Runoff Coefficient | Rv | 0.05 |
| Water Quality Volume, ft3 | WQv | 7841 |
| Average Sand filler bed depth (ft) minimum 18 mines | di presage of Pool and Rille | 20, |
| Width of send filter (ft) cs (2 s - 1) c | Server Water | 10 St. 40 St. 40 St. 4 |
| Length of sand filter, where slope < = 5% (ft) | Lsand | 500 |
| Area of sand filter provided (ft2) | A _{t Provided} | 5000 |
| coefficient of permeability of filter media (ft/day) | k | 3.50 |
| height of water above filter bed- pool depth (ft) | hr | 3.00 |
| design filter bed drain time (days), MDE recommended value | 4 | 1.67 |
| Required filter bed area (ft2) | Ar Required | 402 |

. .



<u>acı</u>

Developed by: Date: 2662 Riva Read Annapolis, MD 21401 Phone 410 222 4241 Hala Flores, P.E. 21-Dec-09 Anne Arundei County Government Department of Public Works Bureau of Engineering Watershed and Ecosystem Services and Restoration Watershed Assessment and Planning



Check parameters in bold

.

| Checking | the Channel Conve | vance for the design flood | • | |] | | | |
|--|---|----------------------------|---|-----------------------|------------|-----------------------------|---------------------------|---------------------|
| Design Return Period (Yr) | Ta sate | 46 (100) | 0.98 | v≪ 10 | | | | |
| Pre development discharge (cfs) | | 73.6 | Less Lines 1.0 Parties | 29.31 | | Isbash c | urve for Stone De | ensity = 165 lb/ft3 |
| | Contraction of the second | | | NO. | 1 | Cubhle d50 | Allowable | Allowable Velocity |
| | | And the second second | 「「「「「「「」」」 | | | size | Velocity | (Subcritical) |
| | 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - | | | | | | (Supercritical) | |
| Post development design discharge (cfs) | The second se | 73.6 | 1.0 million 1.0 | 29.3 | 1 | the should | 164.0 | 140/0001 |
| | 1990 - 199 1 - 1997 | | Cascade Design (maximu | m 5 ft drop | 1 | Incresi | prosect | [10/Sec] |
| Total available length (ff) | | 452 | er segment) | and the second second | | <u> </u> | 5.1 | 21 |
| Total Cascade Length for Project (ft) | 1206420-0648 C 2240-634 | 0.00 | Design (Vicin (fi) | Contraction of the | | | 57 | 80 |
| Maximum Cascade Slope (ft/ft) | Sioperate | 0.50 | Roughness | 0.05 | | (j | 6.3 | 8.7 |
| Water Quality slope (ft/ft) | Skope | 0.03 | A | 0.00 | 1 | 7 | 6.8 | 9,4 |
| Average Length of Riffle Segments (ft) Minimum 10 ft 3 | 世際に見ていたとなった。 | 20 | θ | #DIV/0! | | х | 7.2 | 10.1 |
| Number of Riffle Segments for Project | NnBa | 11 | P | #DIV/0! | | ý | 7.7 | 10.7 |
| Number of Cascade Segments for Project | Nesscade | 0 | Rh | #DIV/0! | · · | 10 | 8,1 | 11.3 |
| Required Length of Pool Segments (ft) | | 20 | Design Velocity (ft/sec) | #DIV/0! | | 11 | 8.5 | 11.8 |
| | | | | | | 12 | 8,8 | 12.3 |
| CODDIE 050 EIZE (IT) = CIRCOSE - 6 Inclues | 14.794 COU 4.795 | 0.00 | Conveyed G (CIS) | #017/0! | | 15 | 44 | 13.8 |
| Too with a SBSC affectment (ff) | 5 S | 120 | No Cascade is Ne | eded | | 1.1 | · | 1.0.05 |
| The second s | THE REPORT AND A DESCRIPTION | | Minimum Pool Death "Lice 3 | 1 | | 18 | 10.8 | 151 |
| | | Louis Constant | pools" following each | 1 | | | | |
| Depth of SPSC riffle channel (ft) | *****D.**** | 16 | cascade segment (ft) | #DIV/0! | | | | |
| of the SPSC (ft) | hi | 2.0 | ok | | | | | |
| Enter Desired Pool Depth (ft) | 為這些一 的 。這個的 | 3.0 | subcritical/c | k | | Adequate | conveyance | of design storm |
| | | | | | | | | |
| - Check Riffle Side Slope, Must be > 2H:1V | | 3.8 | | | | 0-1 | | |
| Check the Evente Number to ensure Substitiont Flow Con | ditions | 2.9 | 1 | | | Selected C | ODDIE SIZE IS | Adequate for 100 |
| Check the Produe Humber to ensure Subcratcal Flow Con | | 0.9 | 4 | | | | year stor | |
| | | | | | | | | |
| Computed Roughness | n | 0.04 | | | | | | |
| Riffle Cross Section Area (ft2), for parabola | A . | 12.80 | | | | Subcr | itical Flow is I | Predominant |
| | 1 | | 1 | | | | | |
| Theta - Intermediate step for solving | θ | 0.49 | - | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| Riffle Hydraulic Perimeter (ft), for parabola | P | 12.55 | - | | | | | |
| | | | | | | | | |
| Rifle Hydraulic Radius (ft) using Chow 1959 | R. | 1.02 | | | | | | |
| | ····· | 1.02 | 4 | | | | | |
| Calculated Flow for design parameters (cfs) | Q | 81.10 | | | | | | |
| | | | | | | | | |
| Check Riffle Velocity (ft/sec) | V | 6,34 | . Required Number | er of Pools | | 11 | | |
| | | | Provided total pool | depth (ft) = | | 33 | | |
| | | | 1 | | | | | |
| Checking Quar | tity Management | | hydraulic power for return | period 100 y | ear stor | n is satisfi o d | | |
| USDA 2005 neversed in terms of deand der Bischer | | 0.03 | Required Volume of Storage | e (Rational H | vdroors | ob) | | |
| outre 2000, respressed in terms of uput and uso = 0 fillines | | 0.00 | interior to the or | | , 5, 541 8 | | | |
| The width at the entrance riffle | w, | 12.00 | | | 100 Yr | 1 Yr | 10 Yr | |
| | | | | | | | | |
| | | | | | | | | |
| The velocity at the entrance riffle is calculated using Manning formula calculater and Q for the 1 year starm. | , I | 7 57 | Required Volume of Storage | (#3) | | n | | |
| normala caliculator and caposi for the 1 year storm | <u>'n</u> | 1.01 | in a dament a contraction of contracted | | | ····· | <u>_</u> | |
| | | | | | | | | |
| | | | | | | | | |
| The depth at the entrance riffle is calculated using Manning | | 4.00 | Volume provident in analy (10) | | | | | |
| formula catculator and Qpost for the 1 year storm Enter Trial Value : The total pool depth needed to render | U _n | 1.00 | volume provided in pools (ft3) | | | 4/53 | | |
| the power equivalent to 100-year predevelopment/desired | | | | | | | | |
| levels. This should be compared against the total | D _{ov1} | 16.83 | Volume provided in voids (ft3) | AND SHALL M. | er and s | 2712 | | |
| This is the typical top width of the dead storage pool parabolic | | | | | 98 | | | |
| areas, 10:1 side slope | Wax | 12 | | 1712 | | | | |
| | | | Provided Volume of Storag | e (excludes | | | | |
| The area is for a semi parabola | | 135 | infiltration) (ft3) | Bela Staniard Gr | States a | 8465 | State State State | |
| protection volume. Theta - Intermediate step for solvion | - bod A | 1.39 | Paak Manan | ement of 100 | vear st | orm is satisfied | en 1942 et 13 (2013) 1 | |
| Hydrautic Perimeter (ft), for semi parabola | P _{eul} | 37 | Peak Mana | gement of 1 | ear sto | m is satisfied | | |
| Hydraulic Radius, using Chow 1959 | R | 3.66 | Peak Manac | ement of 10 | year sto | rm is satisfied | | |
| Darcy Weisbach friction factor expressed in terms of Large, Volume | 1 | 0.19 | | | | | | |
| Solved using Solver equation: Bernoulli equation rewritten | in terms of d _{out} as the | 0.00 | 1 | | | | | |

.

| Checking Quality Management | | | | | | | | | |
|--|------------------------------|--|--|--|--|--|--|--|--|
| Site Dramage Area (Acres) | SERVICE A SPRING | A CONTRACTOR OF A DESCRIPTION OF A DESCRIPANTE A DESCRIPANTE A DESCRIPANTE A DESCRIPTION OF A DESCRIPTION OF | | | | | | | |
| Contributory Impervious Area (Acres) | Automa Para Ala | States and the states of the s | | | | | | | |
| Volumetric Runoff Coefficient | Rv | 0.05 | | | | | | | |
| Water Quality Volume, ft3 | wqv | 7841 | | | | | | | |
| Average Send filter bed depth (ft) minimum 18 mches | U Destage of Pupi and Rifle) | 205 10 52 | | | | | | | |
| Width of sand lifter (ft) | A REAL WARRANT | 24 Lat An T 101 Call Ser Valida | | | | | | | |
| Length of sand filter, where slope < = 5% (ft) | Lsand | 452 | | | | | | | |
| Area of sand filter provided (ft2) | Ar Provided | 4520 | | | | | | | |
| coefficient of permeability of filter media (ft/day) | <u>k</u> | 3.50 | | | | | | | |
| height of water above filter bed- pool depth (ft) | h, | 3.00 | | | | | | | |
| design fitter bed drain time (days), MDE recommended value | 4 | 1.67 | | | | | | | |
| Required filter bed area (ft2) | Ar Required | 402 | | | | | | | |

.

Water quality requirement is satisfied in SPSC

•

•

•



Contact

Developed by: Date: 2662 Riva Road Arunipolis. MD 21401 Phone 410 222 4241 Hala Flores, P.E. 21-Dec-09 Anne Arundel County Government Department of Public Works Bureau of Engineering Watershed and Ecceystem Services and Restoration Watershed Assessment and Planning



Input values alloced in Gray (Hog and) Calculated values are noted with dotted pattern Check parameters in bold

| Checking | g the Channel Conve | yance for the design flood | | | | | | | | |
|--|-------------------------------|---|--------------------------------|----------------|------------------------------|------------------|---------------------------------------|--------------------|-----------------|--|
| Design Return Period (Yr) | e destrictes history/ | 100 | 1 98 F 7 F 62 F 7 F 1 | A SAMONE A | | | | | | |
| Pre development discherge (cfs) | Q | 73.6 | 10.00 | 29.3 | | Isbash c | urve for Stone De | ensity = 165 lb/#3 | | |
| THE PARTY OF THE REPORT | STATE STATE | Contraction of the second | CONTRACTOR OF STREET | Tratistical de | | Cobble d50 | Allowable | Allowable Velocity | | |
| | | | | | | size | Velocity | (Subcritical) | | |
| | 1.1.1.1.1.1.1.1 | a second second second | | | and the second second second | | | | (Supercritical) | |
| Post development design discharge (cfs) | Qpost. | 73.6 km | 1.0 | 29.3 | | • | | | | |
| | | and the second second | Cascade Design (maximu | m 5 ft drop | | [inches] | [ft/sec] | [ft/sec] | | |
| Total available length (ft) | | 452 | per segment) | ······ | | | | | | |
| Elevation drop over length (ft) | deta E | 15.0 | Design Width (ft) | 建設設備 | | 4 | 5.1 | 7.1 | | |
| Total Cascade Length for Project (ft) | Lascade | 0.00 | Design Depth (R) | 新新的 的 | | 5 | 5.7 | 8,0 | | |
| Maximum Cascade Slope (ft/ft) | Slopecascade | 0.50 | Roughness | 0.05 | | 6 | 6.3 | 8.7 | | |
| Water Quality slope (ft/ft) | Slope | 0.03 | | 0.00 | | <u> </u> | 6.8 | 9,4 | | |
| Average Length of Harre Segments (II): Minimum TV II versa. | | Active Contractor Contractor State | 10 | #DIV/01 | | 8 | /.2 | 10.1 | | |
| Number of Cascade Segments for Project | N | | R. | #010/01 | | 10 | 1.1 | 11.3 | | |
| Required Length of Pool Segments (ft) | Loon | 20 | Design Velocity (ft/sec) | #DIV/0 | | 10 | × 5 | 11.5 | | |
| | Service of the service of the | IN STRUCT OF MAR POINTS AND ADDRESS | 3 | | | 12 | 5.8 | 12.3 | | |
| Cobble d50 size (ft) - choose - 6 inches | d50 | 0.50 | Conveyed Q (cfs) | #DIV/0! | | | | | | |
| | | BURNER CONTRACTOR | | | | 15 | 9.9 | 13.8 | | |
| Top width of SPSC offic channel (it) | | 20.0 01 14 | No Cascade is Ne | eded | | 1 1 | | | | |
| | The second second | TATES CONTRACTOR | Minimum Pool Depth *Use 3 | | | 18 | 10.8 | 15.1 | | |
| Comparison of the second s | | | pools" following each | | | | | | | |
| Depth of SPSC riffle channel (ft) | D Startes | 221-1-1-2-2-2-1-5-7-6-1-1-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5 | cascade segment (ft) | #DIV/0! | | | | | | |
| of the SPSC (ft) | h | 2,0 | ok | | | ł | | | | |
| Enter Desired Pool Depth (R) | Lager News | 3.0 | subcritical/o | ĸ | | Adequate | conveyance | of design storm | | |
| | | | | | | | | | | |
| Check Riffle Side Stope, Must be > 2H:1V | | 6.7 | | | | | | | | |
| Check the Eroude Number to ensure Substituted Flow Co. | aditions | | 1 |) | \ | Selected C | obble Size is | Adequate for 100 | | |
| Check the Froude Number to ensure Subcritical Flow Col | | 0.9 | 4 | | Υ. | L | year stor | m | | |
| | | | | | | | | | | |
| Computed Roughness | n | 0.04 | | | 1 | | | | | |
| Riffle Cross Section Area (#2) for parabola | Α. | 20.00 | | | | Subcr | itical Flow is I | Predominant | | |
| | ······ | | 4 | | | | | | | |
| Theta - Intermediate step for solving | θ | 0.29 | 1 | | | | | | | |
| | | | | | | | | | | |
| | | 1 | | | | | | | | |
| Riffle Hydrautic Perimeter (ft), for parabola | P | 20.30 | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| Riffle Hydraulic Radius (ft), using Chow 1959 | R _h | 0.99 | | | | | | | | |
| | | | | | | | | | | |
| Calculated Flow for design parameters (cfs) | Q | 122.12 | | | | | | | | |
| Check Riffe Velocity (ft/sec) | v | 6 11 | Required Numbe | r of Pools | | 11 | | | | |
| | • | • | | | | <u> </u> | | | | |
| | | | Provided total pool | depth (ft) = | | 33 | | | | |
| Checking Quar | tity Management | | budraulic nower for return r | veried 100 ve | ar etar | m is entirfied | | | | |
| Checking Quai | Inty management | | rightadire power for retaining | Seriod Too ye | a) 510/ | in is satisfied | | | | |
| USDA 2006, n expressed in terms of d _{out} and d ₅₀ = 8 inches | n | 0.03 | Required Volume of Storage | (Rational Hy | drogra | iph) | | | | |
| | | | 1 | | | | | | | |
| The width at the entrance riffle | W _n | 20.00 | | | 100 Yr | 1 Yr | 10 Yr | | | |
| | | | | | | | Į | | | |
| | | | | | | 1 | ĺ | | | |
| The velocity at the entrance offle is calculated using Manning | | 7 67 | Required Volume of Storeme // | 13) | n | ا _م ا | | | | |
| Tormaa calculator and upost for the Tyear atorn | , in | 7.51 | ricquice Found of Storage (| | 0 | , v | | | | |
| | | | | 1 | | | | | | |
| | | · · · · · | | | | | 1 | | | |
| The depth at the entrance riffle is calculated using Manning | _ | | | | | | | | | |
| formula calculator and Qposi for the 1 year storm | υ <u>,</u> | 1.50 | volume provided in pools (ft3) | | | 4753 | | | | |
| the power equivalent to 100-year predevelopment/desired | | | | 1 | | | | | | |
| levels. This should be compared against the total | D _{out} | 16.59 | Volume provided in voids (ft3) | | | 2712 | | | | |
| This is the typical top with of the dead storage cool parabolic | | | | | 15.6 | | · · · · · · · · · · · · · · · · · · · | | | |
| areas, 10:1 side slope | w | 12 | | | 22.20 | | Res al | | | |
| · · · · · · · · · · · · · · · · · · · | | | Provided Volume of Storage | (excludes | 6.7 C | | | | | |
| The area is for a semi parabola | Aout | 133 | (infiltration) (it3) | | 3. S. F. | 8465 | | | | |
| protection volume. | Ladd | 0 | 12.2. Winfiltration Volume (ft | 3) (19 19 1 | 238 | AL 1000 | E Secondary | | | |
| Theta - Intermediate step for solving | 0 | 1.39 | Peak Manage | ment of 100 y | ear st | orm is satisfied | | | | |
| Hydraulic Perimeter (ft), for semi parabola | Poul | 36 | Peak Manag | ement of 1 ye | ar sto | rm is satisfied | | | | |
| Involation Radius, Using Chow 1959 | к _ь | 3.65 | Peak Manage | ement of 10 y | ear sto | orm is satisfied | | | | |
| Darcy weisbach inclion racio/ expressed in terms of Ladi, Vout- | 1 | 0.19 | | | | | | | | |

| Checking Qua | lity Management | |
|--|--------------------------------|---|
| Site Dramage Area (Acres) | LANDER BARRIER | State and 48 States Making |
| Contributory Impervious Area (Acres) | 2. There is the the second | Contraction of the State State of the |
| Volumetric Runoff Coefficient | Rv | 0.05 |
| Water Quality Volume, ft3 | WQv | 7841 |
| Average Sand filter bed depth (ft) minimum 18 inches | (Interlage of Post and Rille) | 2.0 |
| Width of sand filter (ft) | Wand the fam | -3 de -10 de -5 |
| Length of sand fifter, where slope < = 5% (ft) | Lsand | 452 |
| Area of sand filter provided (ft2) | Ar Provided | 4520 |
| coefficient of permeability of filter media (fl/day) | k | 3.50 |
| height of water above filter bed- pool depth (ft) | h, | 3.00 |
| design filter bed drain time (days), MDE recommended value | 4 | 1.67 |
| Required filter bed area (ft2) | A _{l Required} | 402 |

Water quality requirement is satisfied in SPSC

. .

.

. .

.

.



Contact

2652 Riva Road Arenadis MD 21401 Phone 410 222 4241

Anne Arundei County Government Department of Public Works Bureau of Engineering Watershed and Ecosystem Services and Restoration Watershed Assessment and Planning

Checking the Channel Conveyance for the design flood



Input values shaded in Grey "Required" alculated values are noted with dotted pattern Check parameters in bold

Developed by: Date:

Hala Flores, P.E. 21-Dec-09

Design Return Period (Yr): The of Concentration in minutes (Before Development) 0.38 Pre development discharge (cfs) - * - Q____ 1.0 29.3 Isbash curve for Stone Density = 165 lb/ft3 47 S. 2 . 49 Cobble d50 Allowable Allowable Velocity Velocity (Subcritical) size Q_{poe} Supercritical) 1.0 Post development design discharge (cfs) 73.6 29.3 at al and [ft/sec] [ft/sec] 452, [inches] Cascade Design (maximum 5 ft drop Total evaluable length (N) per segment) Deskyn Wikith (fil) ita E Elevation drop over length (ft) 31 7.1 15.0 1 Total Cascade Length for Project (ft) L_{cascade} Skope_{cascade} 0.00 Design Depth (ft) 1. 大学学家 5.7 8.0 5 Maximum Cascade Slope (ft/ft) 0.50 0.05 8.7 Roughness 6.3 6 Water Quality slope (ft/ft) Slope 0.03 0.00 6.5 94 Average Length of Riffle Segments (ft), Minimum 10 ft 200 aller i 20 and an and a state of the state o #DIV/0! 8 7.2 10.1 Number of Riffle Segments for Project #DIV/0! Nnthe 11 9 10.7 umber of Cascade Segments for Project Ncascade 0 #DIV/01 10 8,1 11.3 Required Length of Pool Segments (ft) Looo 20 Design Velocity (ft/sec) #DIV/0! 8.5 11.8 S 8 12.3 Cobble d50 size (R) - choose - 6 inches 150 d50 ved Q (cfs) #DIV/01 Top width of SPSC riffle chennel (it) 13.8 9.9 27.0 15 No Cascade is Needed N. 18 10.8 15.1 Minimum Pool Depth "Use 3 Geographic 1. 1. 1. pools" following each cascade segment (ft) Depth of SPSC riffle channel (ft) D D #DIV/0 of the SPSC (ft) 15 ok Enter Desired Pool Depth (ft) subcritical/ok 30-Adequate conveyance of design storm Check Riffle Side Slope, Must be > 2H:1V 13.5 Selected Cobble Size is Adequate for 100 Check the Froude Number to ensure Subcritical Flow Conditions 0.7 vear storm Computed Roughness 0.05 Subcritical Flow is Predominant Riffle Cross Section Area (ft2), for parabola А 18.00 Theta - Intermediate step for solving θ 0.15 Riffle Hydraulic Perimeter (ft), for parabola Р 27.10 Riffle Hydraulic Radius (ft), using Chow 1959 R, 0.66 Calculated Flow for design parameters (cfs) 0 76.26 **Required Number of Pools** Check Riffle Velocity (ft/sec) v 4.24 11 Provided total pool depth (ft) = 33 hydraulic power for return period 100 year storm is satisfied **Checking Quantity Management** Required Volume of Storage (Rational Hydrograph) USDA 2006, n expressed in terms of dout and dsn = 8 inches 0.03 n The width at the entrance riffle W"n 27.00 100 Yr 1 Yr 10 Yr . The velocity at the entrance riffle is calculated using Manning formula calculator and Qpost for the 1 year storm ۷. 7.57 Required Volume of Storage (ft3) 0 O 0 The depth at the entrance riffle is calculated using Manning formula calculator and Ω_{post} for the 1 year storm 1.00 4753 D., olume provided in pools (ft3) Enter Trial Value : The total pool depth needed to render he power equivalent to 100-year predevelopment/desired Volume provided in voids (ft3) levels. This should be compared against the total 16.11 2712 D.,, This is the typical top width of the dead storage pool paraboli areas, 10:1 side slope Wout 9 Provided Volume of Storage (excludes The area is for a semi parabola 97 Infiltration (ft3) 8465 Infiltration Volume (ft3) Peak Management of 100 year storm is satisfied Α., rotection volume. Land 0 0 Theta - Intermediate step for solving Hydraulic Perimeter (ft), for semi parabola Poul 34 Peak Management of 1 year storm is satisfied Hydraulic Radius, using Chow 1959 R. 2.83 Peak Management of 10 year storm is satisfied Darcy Weisbach friction factor expressed in terms of L_{app}, v_{out} f Solved using Solver equation: Bernoulli equation rewritten in terms of d_{put} as the 0.21



0.00

| Checking Quality Management | | | | | | | | | |
|--|---|-------------|--|--|--|--|--|--|--|
| Site Drainage Area (Acres) | A | 48 | | | | | | | |
| Contributory Impervious Area (Acres) | <u> 4 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -</u> | 0 | | | | | | | |
| Volumetric Runoff Coefficient | Rv | 0.05 | | | | | | | |
| Water Quality Volume, ft3 | WQv | 7841 | | | | | | | |
| Average Sand filter bad depth (ii) minimum 16 inches | Gr (Averlige of Pool and Riller) | 2.0 | | | | | | | |
| Width of sand filter (ft) | Wand | 1° 🕂 🔍 👘 10 | | | | | | | |
| Length of sand filter, where slope < = 5% (ft) | Liand - | 452 | | | | | | | |
| Area of sand filter provided (ft2) | Al Provided | 4520 | | | | | | | |
| coefficient of permeability of filter media (ft/day) | ĸ | 3.50 | | | | | | | |
| height of water above filter bed- pool depth (ft) | <u>h,</u> | 3.00 | | | | | | | |
| Required filter bed area (ft2) | Ar Required | 402 | | | | | | | |

Water quality requirement is satisfied in SPSC

1



| Project Calvert Cliffs Unit 3 Phase II Mitigation Plan | | | | | Project No. | 14 | 16210 |)3 | |
|--|---------|------------|------------|---------------|---------------|-------------|-------|-----|------|
| Subject Riffle Grade Control Sizing Calculation - SE-4 | | | | | | Sheet No. | 1 | of | 2 |
| | Based o | n Anne Aru | indel Cour | nty Specifica | ations | Drawing No. | | | |
| Compute | d by | JJM | Date | 10/1/10 | _Checked by _ | GAT | Date | 10/ | 1/10 |

OBJECTIVE:

Determine the dimensions and materials for the riffle grade control structures utilized for the SE-4 Reach (Unnamed Tributary to the Chesapeake Bay) regenerative stormwater conveyance practices.

ASSUMPTIONS:

The SE-4 reach is proposed to receive stormwater from the planned Unit 3 site development. Proposed condition design discharges for this reach were obtained from the Bechtel Corporation in October of 2009.

The design assumes that no additional stormwater will be routed through this reach and that the proposed conditions are a conservative estimate of the ultimate watershed condition.

PROCEDURE:

From TR-55, determine the pre- and post- development discharges for the 1, 10 and 100 year storm and associated time of concentration. For SE-4, Pre and Post development discharges are not equal since a large amount of stormwater from the site development is routed through the reach:

| Drainage Area | Tc (hours) | 100yr (CFS) | lyr (CFS) | 10yr (CFS) |
|------------------|---------------|-------------|-----------|---------------|
| SE-4 Reach | | | | |
| Pre- | | | | |
| Development | 0.321 | 169.0 | 10.0 | 101.1 |
| SE-4 Reach | | | | |
| Post- | | | | |
| Development | 0.321 | 395.2 | 23.0 | 236.7 |

As the valley width varies between the upper and lower portions of the site, two appropriate weir designs were utilized for the design.

Utilizing the site map, determine the length of conveyance areas and elevation drop through them. Calculate the desired number of weirs for the site based on the elevation drop through the weirs. For SE-4, the reach is designed according to Anne Arundel County Specifications with 1' of drop per riffle and no slope on pools, with the reach having a regular riffle-pool distribution. Therefore all elevation change occurs within riffles.

Two separate riffle widths were selected to meet site conditions, one each for the upper and lower portions of the reach.

Flores, Hala, (2009). *Step Pool Storm Conveyance Design Calculator*. Anne Arundel County Department of Public Works, Annapolis, Maryland.

Flores, Markusic, McMonigle, and Underwood (2009). Step Pool Storm Conveyance. Anne Arundel County Department of Public Works, Annapolis, Maryland.



| Project | oject Calvert Cliffs Unit 3 Phase II Mitigation Plan | | | | | | 1462103 | | | |
|---------|--|--------|-------------|---------|-------------|-----|---------|-----|------|--|
| Subject | Subject Riffle Grade Control Sizing Calculation - SE-4 | | | | | | 2 | of | 2 | |
| | Based | ations | Drawing No. | | | | | | | |
| Compute | d by | JJM | Date _ | 10/1/10 | _Checked by | GAT | Date | 10/ | 1/10 | |

The Step Pool Design Conveyance Calculator from Anne Arundel County Department of Public Works is utilized in this calculation. This calculator is modified to achieve the desired number elevation drop through the weirs coupled with the desired design discharges. Spreadsheets are attached to this calculation.

The water quality component was utilized for SE-4 designs. Water quality and quantity criteria are met in the storage in the sand filter and regenerative pools.

RESULTS:

Weir designs are summarized below:

| Drainage Area | Cobble Size (Inches) | Width (Feet) | Depth (Feet) | Slope |
|---------------|-------------------------|-----------------|-----------------|-------|
| SE-4 Upper | 6 | 45 | 2.0 | 5.0% |
| SE-4 Lower | . 6 | 30 | 3.0 | 3.3% |

P:\Utilities\Unistar\1462103_CC3NP Phase II Mitigation\Design Data\RSC calc sheet-se-4.doc



.



Ð 2662 Rivo Rono Avinapolis, MD 21401 Phone 410 222 4241

Hala Flores, P.E. 21-Dec-09

Developed by: Date:

Anno Arundel County Government Department of Public Works Bureau of Engineering Watershed Assessment and Planning



Input values shaded in Grey Required Calculated values are noted with dotted pattern Check parameters in bold

| Checking | the Channel Conve | yance for the design flood | | | | | |
|--|---|---|---|--------------------|---------------------|------------------|---------------------|
| Design Return Period (Yr) | Harde and Transmission | 100 | A CONTRACT OF A CONTRACT | 10 57 | | | |
| Time of Concentration is restored (percent development) | ante de la compañía de alterna de la compañía de la | A STATE OF | LIG.OU PERFORMANCE TO CALL | 210101012 | tchach a | | |
| | Territory and the second second | The second s | | Constant of the | Cable 180 | tillum ukla | A Donuble Victorite |
| | 1. 1. 2 × 1. 5 × 1. | | | 200 S.M. | Copple date | Allowable | Antiwanie v cocity |
| | | | | | Size | venicity | (Supermean) |
| Band development division development (refs) (b) | | | 200 | ALC: Y | | (Supercrucca) | |
| LOSI COMPONIAL CONTRACTOR (COR) CONTRACTOR (COR) | A CONTRACT OF A | | 1 200 20 20 20 20 20 20 20 20 20 20 20 20 | A | | 101 | |
| | LAND THE SECOND | | Cascade Design (maximum | n 5 ft drop | functions | [ff/sec] | Insect |
| Total available length (fl) | 1.200 201 2020 PM | 200 - 40 - 200 | per segment) | | | | |
| Elevation drop over length (II) | delta E | 6.0 | Design Width (R) | 的主要的 | 4 | 5,1 | 7.1 |
| Total Cascade Length for Project (ft) | Lascade | 0.00 | Design Depth (II) Line (1995) | 法政治法院 | 5 | 5.7 | 8,0 |
| Maximum Cascade Stope (ft/ft) | Slopecascade | 0,50 | Roughness | 0.05 | 6 | 6.3 | 8.7 |
| Water Quality stope (ft/ft) | Siope | 0.03 | Α | 0.00 | 7 | 6.8 | 9,4 |
| Average Length of Riffle Segments (fl), Minimum 10 ft | | 20 20 20 20 | (0 | #DIV/01 | к | 7.2 | 10.1 |
| Number of Riffle Segments for Project | N _{eme} | 5 | P | #DIV/0! | | 7.7 | 10.7 |
| Number of Cascade Segments for Project | Neascada | 0 | R _n | #D1V/0! | 10 | 8.1 | 11.3 |
| Required Length of Pool Segments (ft) | L _{peo} | 20 | Design Velocily (fl/sec) | #DIV/0! | 11 | ¥.5 | 11.8 |
| the state of the second se | · 公司》:"你们的问题?" | AT THE REAL PROPERTY OF | i | | 12 | 8.8 | 12.3 |
| Cobble ti50 elze (ft) - choose - 6 inches 5, 199 | 47 d50 | 0.50 | Conveyed Q (cfs) | #DIV/0! | | | |
| | 新市市市市市市市市市 | 参加 国际的运行的 计图 计算机 | 4 | | 15 | 9.9 | 13.8 |
| Top width of SPSC riffle chartyer (ft) | W W | 45.0 | No Cascade is Nee | aded | | | |
| | 14.7% (14.5%) 建立 的 | STATES AND | Minimum Pool Depth "Use 3 | | 18 | 10.8 | . 15.1 |
| the state of the state of the state of the | all in the second | | pools" following each | i 1 | | | |
| Depth of SPSC riffle channel (ft) | D to child | 20. A 2.5. Set | cascade segment (II) | #DIV/0! | | | |
| pools of the SPSC (ft) | h, | 3.0 | ok | | | | |
| Enter Desired Pool Depth (ft) | Brought Sh State 15 | 33. A.M. 2010 3.0 THE REAL | subcritical/o | k 1 | Adequate | conveyance | of design storm |
| | Construction of the second proceeds of | | | <u> </u> | | ,, | g. |
| | | | | | | | |
| Check Riffle Side Slope, Must be > 2H:1V | | 11.3 | | | Selected C | obble Size is | Adequate for 100 |
| Check the Froude Number to ensure Subcritical Flow Co. | oditions | 0.9 | 1 | \ | | vear stor | m |
| | | | 1 | · · · · · | | | |
| | | | | • | <u>۱</u> | | |
| Computed Roughness | ' n | 0.04 | | | \ | | |
| Biffle Cross Section Area (#2) for parabole | Δ. | 60.00 | 1 | | Subcr | itical Flow is I | Predominant |
| Forme Cross Section Alea (12), for parabola | <u>^</u> | 00.00 | 4 | | 50507 | | recommand |
| Theta - Intermediate step for solving | 0 | 0.18 | | | | | |
| | | | 1 | | | | |
| | | | | | | | |
| | | | 1 | | | | |
| Riffle Hydraulic Perimeter (ft), for parabola | P | 45.24 | 4 | | | | |
| | | | | | | | |
| | | | | | | | |
| Riffle Hydraulic Radius (II), using Chow 1959 | R _h | 1.33 | 4 | | | | |
| | | | | | | | |
| Calculated Flow for design parameters (cfs) | <u> </u> | 449,72 | | | | | |
| Chart Diffe Malesky (Mars) | | 7.69 | Required Number | r of Poole | | | |
| Check Rime velocity (rosec) | · | 7.50 | Required Autriber | OF FOOR | | • | |
| | | | Provided total pool of | Jepth (ft) = | 15 | | |
| | | | | | | | |
| Checking Quar | ntity Management | | hydraulic power for return p | eriod 100 year st | torm is satisfied | | |
| | | | | | | | |
| USDA 2006, n expressed in terms of dout and ds0 = 8 inches | n | 0.04 | Required Volume of Storage | (Rational Hydro | graph) | | |
| The width at the entrance rifle | wi | 45.00 | } | | v | 10 % | |
| | **** | 40.00 | l | 100 | | 17 01 | |
| | | | 1 | | | | |
| | | | 1 | | 1 | | |
| The velocity at the entrance riffle is calculated using Manning formula calculator and Q for the 1 year storm | v . | 7 57 | Required Volume of Storage If | 13) 2610 | 15053 | 157132 | |
| remove carculator and Great for the Types south | ** | 7.57 | in addinate A channe of cronade th | 2019 | 10000 | 107 102 | |
| · · | | | ł | | | j | |
| 1 | | | ĺ | | | | |
| The depth at the entrance riffle is calculated using Manning | | | | | | | |
| formula calculator and Qpost for the 1 year storm | D. | 2.00 | Volume provided in pools (ft3) | | 2161 | • | |
| Enter Trial Value : The total pool depth needed to render | | | 1 | | | | |
| the power equivalent to 100-year | | • | | 1 | | | |
| predevelopment/desired levels. This should be | D _{ov1} | 6.57 | Volume provided in voids (II3) | Man Andrews | 5400 | | |
| This is the typical top width of the dead storage pool | | | | 和沙漠 开 | 经济运行 | | |
| parabolic areas, 10:1 side slope | ₩ _∞ | 18 | 这些我们在我们 | 把 注意了 | | | |
| | | | Provided Volume of Storage | (excludes | | | |
| The area is for a semi parabola | A _{out} . | 79 | Inflitration) (ft3) | 这种学生的 | 8561 | | |
| protection volume. | Land | 268 | ASS 2 Ministration Volume (N | DEPENDING | 201 Ha #61000 | 的时代中国的 | |
| Theta - Intermediate step for solving | 0 | 0.97 | Peak Managem | ent of 100 year s | torm is not satisfi | ed | |
| Hydraulic Perimeter (II), for semi parabola | Poul | 23 | Peak Managem | nent of 1 year sto | orm is not satisfie | d | |
| Hydraulic Radius, using Chow 1959 | R, | 3.41 | Peak Managem | ent of 10 year st | orm is not satisfic | b | |
| Vp.r. and dout | f | 0.22 | · · · · · · | | | | |
| Solved using Solver equation: Bernoutil equation rewritte | n in terms of d | 0.00 | 1 | | | | |
| | | 0.00 | 1 | | | | |
| | | | · | | | | |



| 1 | | |
|--|-------------|------|
| design filter bed drain time (days), MDE recommended value | ţ, | 1.67 |
| Required filter bed area (ft2) | Ar Resulted | 2898 |

Value 4 I.Gr Armanine 2898

x

· · · ·



261.2 Phys. Road Annapolis, MO 21401 Physic 410 222 4241

Hala Flores, P.E. 21-Dec-09

Devei Date: ed by:

Anne Anundel County Government Department of Public Works Bureau of Engineering Watershed HEcosystem Services and Restoration Watershed Assessment and Planning



| Checking | the Channel Conve | yance for the design flood | | | | | |
|---|---|---|---|--|---------------------------|--|---------------------|
| Design Return Period (Yr) | The served Frances and | | 主义运动 输出性 经回转信用 | ≓a , 10 = ≋: | | | |
| Time of Concentration in minutes (Before Development) | | | 19.30 | 548-25-34-5-4 | | | |
| Pre development discharge (cts) | | 169.0 | 10.0 7 - 19 | 76 101:0 %7 | Isbash c | urve for Stone Do | ensity = 165 lb/ft3 |
| | 「読みらいなく | | [1] [1] [2] [2] [2] [2] [2] [2] [2] [2] [2] [2 | | Cobble d50 | Allowable | Allowable Velocity |
| | 1. A. B. | Contractor and states | | | 1/10 | Supercritical | (subtrinear) |
| Post development design discharge (cts) | | 395.2 | 23.0 | 236.7 | | e.super er meary | |
| the line of a second second second second | No. PESTATA IN | CONTRACTOR OF STREET | | | linchest | fi/see! | lft/seel |
| Total manipher legist (f) | | 100 C | Cascade Design (maximum | 5 ft drop | 1 | 1 | 1 |
| Elevative date over length (ft) | Constant P | State Section 5 note Section 7 | Design Width (1) | 80:00-0555 | 4 | 51 | 7.1 |
| Total Cascade Length for Project (fi) | Lancade | 0.00 | Design Depth (ft) | - destination of the | 5 | 5.7 | 8.0 |
| Maximum Cascade Slope (fl/ft) | Slopecascade | 0.50 | Roughness | 0.05 | 6 | 6.3 | 8.7 |
| Water Quality slope (ft/ft) | Slope | 0.02 | A | 0.00 | 7 | 6,8 | 9,4 |
| Average Length of Riffle Segments (fi), Minimum 10 Bases | 北京である | 30 | 0 | #DIV/0! | к | 7.2 | 10.1 |
| Number of Riffle Segments for Project | N _{ritte} | 5 | P | #DIV/0! | | 7.7 | 10.7 |
| Number of Cascade Segments for Project | N _{cascade} | 0 | R, | #DIV/0! | 10 | 8.4 | 11.3 |
| Required Length of Pool Segments (fl) | Lponi | 30 | Design Velocity (ft/sec) | #DIV/01 | 11 | 8.5 | 11.8 |
| | 15.26 815 11 | | | | 12 | 8.8 | 12.3 |
| Cobble d50 size (ft) - choose - 6 inches | 1. d50 | 0.50 | Conveyed Q (cfs) | #DIV/0! | | | |
| the second of the second second | 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1 | | | | 15 | 9,9 | 13.8 |
| Top width of SPSC rible channel (1) | Enderstein Wittere Anter | 30.0 | No Cascade is Need | ted | | | |
| | 新福达 黄金素 | 14 - 18 - 18 - 18 - 18 - 18 - 18 - 18 - | Minimum Pool Depth "Use 3 | | 18 | 10.8 | 15.1 |
| Depth of SPSC riffle channel (fit) | D State | 30 20 10 | cascade segment (ft) | #DIV/0! | | 1 | |
| pools of the SPSC (ft) | h. | 4.0 | ok | | | • • • • • • • • • | |
| Enter Destrad Prod Dards (8) | S.Said & h.Z. Atom | TO MARK OF ALL REAL CONTRACT | subcritical/ok | | Adequate | conveyance | of design storm |
| | ACTIVE AND ALL AND A SACING AND | | | | Accident | conveyance | or design storm |
| | | | | | | | |
| Check Riffle Side Slope, Must be > 2H:1V | | 5.0 | | | Selected C | obble Size is | Adequate for 100 |
| Check the Froude Number to ensure Subcritical Flow Co | nditions | 0.8 | | | | year stor | m |
| | | | 1 | | | | |
| | | | | | \mathbf{i} | | |
| Computed Roughness | <u>n</u> | 0,04 | - | | 2 | | |
| Riffle Cross Section Area (ft2), for parabola | A | 60,00 | | | Subc | itical Flow is F | Predominant |
| | | 0.28 | | | | | |
| Theta - Intermediate step for solving | , v | 0.38 | 4 | | | | |
| | | | | | | | |
| | · _ | | | | | | |
| Riffle Hydraulic Perimeter (ft), for parabola | P | 30.78 | 4 | | | | |
| | | | 1 | | | | |
| Diffe Hydrautic Padius /II) using Chaw 1959 | R. | 1.05 | | | | | |
| Tanks Hydradile Hadids (H), dang bilow 1955 | | 1.55 | 1 | | | | |
| Calculated Flow for design parameters (cfs) | 0 | 462.00 | | | | | |
| | | | | | | | |
| Check Riffle Velocity (f#sec) | v | 7.70 | Required Number | of Pools | 5 | | |
| , | | | Desident set of a set of | | 20 | | |
| | | | Provided total pool de | ipin (n) | | | |
| Checking Quar | ntity Management | | hydraulic power for return per | riod 100 year st | orm is satisfied | | |
| | | | | | | | |
| USDA 2006, n expressed in terms of deut and dst = 8 inches | n | 0.04 | Required Volume of Storage (I | Rational Hydrog | graph) | | 1 |
| The width at the entrance riffle | w., | 30.00 | | 100 | 1 1 1 | 10 Yr | |
| | | | 1 | | 1 | | |
| | | | | | | | |
| The velocity at the entrance riffle is calculated using Manning | | | | | | | |
| formula calculator and Q _{peat} for the 1 year storm | V., | 7.57 | Required Volume of Storage (fl3 |) 2619 | 25 15053 | 157132 | |
| | | | | | | | |
| | | | | | | | |
| The dealh of the entrance office is coloridated using Manaina | | | 1 | | | | |
| formula calculator and Q _{sout} for the 1 year storm | D. | 3.00 | Volume provided in pools (fl3) | | 5120 | 1 | |
| Enter Trial Value : The total pool depth needed to render | | | | | | | |
| the power equivalent to 100-year | _ | 7 35 | Volume provided in uside (60) | 1 | a | 1 | |
| preuevelopinentruestrea terefis, inis snouto be | Your | 1.37 | volume provided in volds (((3) | States and | o 100 | an a | |
| This is the typical top width of the dead storage pool | | - | A STARLEY STARLEY | | | 2018 | |
| parabolic areas, 10:1 side slope | Wout | 24 | · · · · · · · · · · · · · · · · · · · | 政治律学 | 國民國的法 | 1 A | |
| The eres is for a semi-parabola | | 1-0 | Provided Volume of Storage (| excludes | | ELEMENT'S | |
| rine area is for a semi paraooia | ^~u | 118 | in a second s | and the second | 1. ** ** 19 ** 1.3221 | Carly South Ling Last | I |
| Theta - Intermediate step for solving | 0 | 402 0 R0 | Peak Managemen | nt of 100 year - | orn is not and | and the second | 1 |
| Hydraulic Perimeter (II), for semi narabola | Pne | 29 | Peak Manageme | ant of 1 year sto | erm is not satisfi | ed . | |
| Hydraulic Radius, using Chow 1959 | | 4.04 | Peak Managemer | nt of 10 year sto | orm is not satisf | ed | |
| v _{est} , and d _{est} | 1 | 0.20 | | | | | I |
| Solved using Solver equation: Bernoulli equation rewritte | n in terms of d _{eat} as | 0.00 | | | | | |
| | | | | | | | |

| Checking Qu | ality Management | | Water quality requirement is satisfied in SPS |
|--|------------------------------------|--|---|
| Site Drainege Area (Acres) | A REAL | 116 | 2 |
| Contributory Impervious Area (Acres) | 2 36464746668 \$**2896822 | 16.6 ··································· | |
| Volumetric Runoff Coefficient | Rv | 0.18 | |
| Water Quality Volume, ft3 | wav | 67758 | |
| Average Sand filler bed depih (N) minimum 18 inches | T. C. (Anarope of Pool and Rillin) | 3.0 40 500 40 500 40 50 | |
| Watth of sand filler (ft) | We and Water to | 30 Sec. 27 30 Sec. 2. 20 Sec. | |
| Length of sand filter, where slope < = 5% (ft) | Land | 300 | |
| Area of sand filter provided (ft2) | A _{1 Provided} | 9000 | |
| coefficient of permeability of filter media (ft/day) | · k | 3.50 | |
| heigh) of water above filler bed- pool depth (ft) | n | 4.00 | |

}

,

| guired filter bed area (f12) Aranguned 24 | design filter bed drain time (days), MDE recommended value | 4 | 1.6 |
|---|--|-------------------------|------|
| | Required filter bed area (ft2) | A _{f Required} | 2484 |
| · · · · · · · · · · · · · · · · · · · | | | |
| · · · · | | | |
| | | | |
| · | • | | |
| | | | |
| • | | | |
| | | | • |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

` .



| Project | Calvert Cliffs Unit 3 Phase II Mitigation Plan | | | | | Project No. | 14 | 1462103 | |
|---------|--|---------|---------|---------|---------------|-------------|------|---------|------|
| Subject | Riffle Grade Control Sizing Calculation - Upper JC | | | | Sheet No. | 1 | of | 2 | |
| | Based on Anne Arundel County Specifications | | | | | Drawing No. | | | |
| Compute | d by | CJS/JJM | _Date _ | 10/8/10 | _Checked by _ | GAT | Date | 10/ | 1/10 |

OBJECTIVE:

Determine the dimensions and materials for the riffle grade control structures utilized for regenerative stormwater conveyance practices at Johns Creek stations JC 4+60 and JC 12+00 through 25+00.

ASSUMPTIONS:

The Johns Creek Valley at stations JC 4+60 and JC 12+00 through 25+00 is proposed to receive stormwater from the planned Unit 3 site development. Proposed condition design discharges for this reach were calculated by EA in October 2010.

SE/SR-5 reach is undeveloped and it is assumed that the pre=development conditions will persist into the future.

The design assumes that no additional stormwater will be routed through these reaches and that the proposed conditions for JC 4+60 and JC 12+00 through 25+00 are a conservative estimate of the ultimate watershed condition. The design further assumes that the pre-development condition is a suitable estimate of the watershed condition for SE/SR-5 since there is no proposed development to the drainage area of this reach.

Flores, Hala, (2009). Step Pool Storm Conveyance Design Calculator. Anne Arundel County Department of Public Works, Annapolis, Maryland.

Flores, Markusic, McMonigle, and Underwood (2009). Step Pool Storm Conveyance. Anne Arundel County Department of Public Works, Annapolis, Maryland.

P:\Utilities\Unistar\1462103_CC3NP Phase II Mitigation\Design Data\RSC\RSC calc sheet-SR-4 and sw outfalls.doc



| Project | Calvert Cliffs Unit 3 Phase II Mitigation Plan | | | | Project No. | 1462103 | | | |
|---------|--|---------|------|---------|-------------|-------------|------|-----------------|--|
| Subject | Riffle Grade Control Sizing Calculation - Upper JC | | | | Sheet No. | 2 | of | 2 | |
| | Based on Anne Arundel County Specifications | | | | | Drawing No. | | - | |
| Compute | d by | CJS/JJM | Date | 10/8/10 | _Checked by | GAT | Date | e <u>10/1/1</u> | |

PROCEDURE:

From TR-55, determine the design discharges for the 1, 10 and 100 year storm and associated time of concentration. EA developed design discharges from the site development utilizing information from Bechtel from 2009-2010, and developed the SE/SR-5 discharges through a TR-55 model:

| Drainage Area | Tc (hours) | 100yr (CFS) | 1yr (CFS) | 10yr (CFS) |
|------------------|---------------|-------------|---------------------------------------|---------------|
| SE/SR-5 | | | · · · · · · · · · · · · · · · · · · · | |
| Reach DA-9 | 0.28 | 324.2 | 5.3 | 126.1 |
| SE/SR-5 | | | | |
| Reach DA- | | | | |
| 10 | 0.69 | 126.1 | 0.7 | 24.2 |
| B2 Outfall | | | | |
| Post- | | | | |
| Development | 0.11 | 265.9 | 3.9 | 29.0 |
| JNC 11B | | | | |
| Outfall Post- | | | | |
| Development | 0.14 | 595.2 | 12.2 | 182.8 |
| JNC 11CD | | | | |
| Reach | | | | |
| Outfall Post- | | | | |
| Development | 0.11 | 388.2 | 7.9 | 149.8 |
| T-4 Outfall | | | | |
| Post- | | | | |
| Development | 0.26 | 147.7 | 2.4 | 21.9 |

Utilizing the site map, determine the length of conveyance areas and elevation drop through each reach individually. Calculate the desired number of weirs for the site based on the elevation drop through the weirs.

For B2, the reach is designed according to Anne Arundel County Specifications with 1' of drop per riffle and no slope on pools, with the reach having a regular riffle-pool distribution. Therefore all elevation change occurs within riffles. For the main stem of Johns Creek, MDE comment in August 2010 requested a stone grade control structure for every foot of elevation drop, with woody grade controls in between.

P:\Utilities\Unistar\1462103_CC3NP Phase II Mitigation\Design Data\RSC\RSC calc sheet-SR-4 and sw outfalls.doc


| Project | Calver | Project No. | 14 | 6210 |)3 | | | | |
|---------|--|-------------|------|---------|---------------|-----------|------|-----|------|
| Subject | Riffle Grade Control Sizing Calculation - Upper JC | | | | | Sheet No. | 3 | of | 2 |
| | Based | Drawing No. | | | | | | | |
| Compute | d by | CJS/JJM | Date | 10/8/10 | _Checked by _ | GAT | Date | 10/ | 1/10 |

The riffle weirs are therefore designed to have 3-4" of drop per riffle.

Reaches with proposed work included only those needed for discharges for the B2 reach, SE/SR-5, and the main stem of Johns Creek using JNC11CD.

The Step Pool Design Conveyance Calculator from Anne Arundel County Department of Public Works is utilized in this calculation. This calculator is modified to achieve the desired number elevation drop through the weirs coupled with the desired design discharges. Spreadsheets are attached to this calculation.

RESULTS:

As the valley width varies within the reaches, multiple weir designs were utilized for each reach assessed.

Weir designs are summarized below:

| Drainage Area | Cobble Size (Inches) | Width (Feet) | Depth (Feet) | Slope |
|---------------|-------------------------|-----------------|-----------------|-------|
| • B2 | 6 | 63 | 1.5 | 3.5% |
| JNC11CD | 6 | 100 | 2.2 | 1.2% |
| JNC11CD | 6 | 80 | 2.5 | 1.2% |
| JNC11B | 6 | 100 | 2.1 | 1.2% |
| JNC11B | . 6 | 130 | 2.0 | 1.2% |
| DA-9 | 6 | 100 | 1.5 | 2.1% |
| DA-9 | 6 | 57 | 2.0 | 2.1% |
| DA-10 | 6 | 62 | 2.0 | 1.7% |

P:\Utilities\Unistar\1462103_CC3NP Phase II Mitigation\Design Data\RSC\RSC calc sheet-SR-4 and sw outfalls.doc

<u>Contact</u>

2652 Riva Rea

2652 Riva Roari Annapolis MO 23461 Phone 410 222 4241 Hala Flores P F

Developed by: Date: Hala Flores, P.E. 21-Dec-09 Anne Arundei County Government Department of Public Works Bureau of Engineering Watershet and Ecosystem Services and Restoration Watershed Assessment and Planning



Calculated values are noted with dotted pattern Calculated values are noted with dotted pattern Check parameters in bold

| Checking | the Channel Conve | vance for the design flood | | |] | | | |
|---|---|--|---|--|----------------------------------|---|-------------------|-------------------|
| Design Return Period (Yr) | The second states and the second s | A DE LA TINO DE LA DELLA D | Contraction of the second s | 2 5410 and | | | | |
| Pre development discharge (rfs) | 10420 | 265.0 | Carlon Asher Charles | 20 0 3 | | lebseb c | urve for Stope De | neity = 165 (b/#3 |
| | A CONTRACTOR OF | | 24 24 24 24 24 24 24 24 24 24 24 24 24 2 | 2253.05.840 | 4 | Cobbla d50 | Allowable | Allowable Valacit |
| | 12 17 2 2 3 17 - 2 | la ser a ser a ser a ser | | 1.1 | | size | Velocity | (Subcritical) |
| | | | | 101111 | | | (Supercritical) | (nuber and al) |
| Post development design discherge (cfs) | a start | 265.9 | 101 - 101 - 101 - 101 - 101 - 101 - 101 - 101 - 101 - 101 - 101 - 101 - 101 - 101 - 101 - 101 - 101 - 101 - 101 | 29.0 | | 1 | (| |
| | CONTRACTOR OF THE | | | a longer of the second second | 1 | linchest | lft/sec1 | lfr/secl |
| | | | Cascade Design (maximur | n 5 ft drop | | , inclusion, | [] | [hister] |
| (dal evaluable length (ft) | 6 - 17 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - | 190 | per segment) | AGENGROOM | - | | <i>.</i> | - 1 |
| Levation drop over length (1) | CARGE Deta Langer | 0.00 | Design with mit | 1000 A. 100 | | | 3.1 | 7.1 |
| Navimum Cascade Length for Project (n) | -cascade Siono | 0.00 | Design Depin (n) Stages | 0.05 | 4 | | · 3.7 | 8.0 |
| Maxinum Cascade Slope (IDR) | Sibpecascade | 0.50 | Roughness | 0.05 | 4 | 6 | 0.5 | 8.7 |
| Water Quality Slope (IVII) | Slope | 0.02 | A | 0.00 | 4 | | 6.8 | 9,4 |
| Average Length of Hime Segments (n), Minimum 1V n #42264 | Case State | | 5.0 | #DIV/0! | 4 | × | 1.2 | 10.1 |
| Number of Riffle Segments for Project | N _{nBe} | / | P | #DIV/0! | 4 | 9 | 7.7 | 10.7 |
| Number of Cascade Segments for Project | Ncascade | 0 | R _n | #DIV/0! | ł | 10 | 8.1 | 11.3 |
| Required Length of Pool Segments (II) | -poot | 14 | Design Velocity (ft/sec) | #DIV/0! | 4 | 11 | 8.5 | 11.8 |
| | 的中的方法。 | | | 1 | | 12 | 8,8 | 12.3 |
| Cobble d50 size (ft) - choose - 6 inches | d50 | 0.50 | Conveyed Q (cfs) | #DIV/0! | 1 | | | |
| | | | <u> </u> | | | 15 | 9.9 | 13.8 |
| Top width at SPSC riffle channel (0) | TO STATE | 63.0 ···· | No Cascade is Ne | eded | l | 1 | | |
| | 新教育中学校的 行政 | We share the state of the | Minimum Pool Depth "Use 3 | | 1 | 18 | 10.8 | 15.1 |
| | | | pools" following each | 1 | [| | | |
| Depth of SPSC rifle channel (ft) | General A Difference | | cascade segment (ft) | #DIV/01 | 1 | | | |
| of the SPSC (ft) | ht | 2.0 | ok | | ł | | | |
| Enter, Desired Pool Depth (R) | \$1.445 minates | 3.0 3.0 3.0 | subcritical/o | k | 1 | Adequate | conveyance o | of design storm |
| | 1 - CALLER AND AND A PROPERTY AND A | | | 1 | 8 | | | , v |
| | | | 1 | | | | | |
| Check Riffle Side Slope, Must be > 2H:1V | | 21.0 | | | | Selected C | obble Size is A | dequate for 100 |
| Check the Froude Number to ensure Subcritical Flow Con | ditions | 0.6 | | | Υ. | | vear storn | n |
| | | | | | | L | | |
| | | | | | | | | |
| Computed Roughness | n | 0.04 | | | | \mathbf{i} | | |
| Biffle Cross Section Area (#2) for parabola | A | 63.00 | 7 | | | Suber | itical Flow is P | redominant |
| | | 03.00 | 4 · | | | | ideal flow is f | redominant |
| Theta - Intermediate step for solving | θ | 0.09 | | | | | | |
| | | | 1 | | | | | |
| | | | | | | | | |
| | | | - | | | | | |
| Riffle Hydraulic Perimeter (ft), for parabola | Р | 63.10 | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| Riffle Hydraulic Radius (ft), using Chow 1959 | Rh | 1.00 | | | | | | |
| | | | | | | | | |
| Calculated Flow for design parameters (cfs) | ٩ | 267.69 | | | | | | |
| | | | | | | | | |
| Check Riffle Velocity (ft/sec) | V | 4.25 | Required Numbe | r of Pools | | 7 | | |
| | | | Description of the second | | | | | |
| | | | Provided total pool of | σερεπ (π) = | | 21 | | |
| Checking Quan | tity Management | | hydraulic power for return p | eriod 100 v | ear stor | rm is satisfied | | |
| | 1 | the second s | | , | | | | |
| JSDA 2006, n expressed in terms of dout and dso = 8 inches | n | 0.04 | Required Volume of Storage | (Rational H | ydrogra | aph) | | |
| | | | | | | 1 | | |
| The width at the entrance riffle | w, | 63.00 | | | 100 Yr | 1 Yr | 10 Yr | |
| | | | | | | 1 | | |
| | | | | | | 1 | | |
| The velocity at the entrance riffle is calculated using Manning | | | | | | 1 | | |
| formula calculator and Qpost for the 1 year storm | Vn | 7.57 | Required Volume of Storage (f | 13) | 0 | 0 | 0 | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | (| |
| he depth at the entrance riffle is calculated using Manning | | | | | | | | |
| ormula calculator and Q _{post} for the 1 year storm | De | 1.50 | Volume provided in pools (ft3) | | | 3025 | | |
| Inter I riar Value : The total pool depth needed to render | | | | | | | | |
| avels. This should be compared against the total | D | 4.19 | Volume provided in voids (43) | | | 1140 | | |
| in analia of compared igenative total | - out | | The second | C. Cale A.F. | N:20/04 | CLEFF RUSS - French | Storawie and date | |
| his is the typical top width of the dead storage pool parabolic | | | | | 2303 | 2 4 P | Rest of the | |
| ireas, 10:1 side slope | Wowl | 12 | ALL | | | | | |
| | | | Provided Volume of Storage | (excludes | 1 | | | |
| | Aout | 34 | 2 infiltration) (ft3) | 1. 1. Ser 1 | 2.35 1 | 5165 | 自由国际实际 | |
| he area is for a semi parabola | | 0 | Sector Colume (1) | 3) 168 高利 | 1 | 000 | 1.5.1. | |
| The area is for a semi parabola protection volume. | Lado | 0 | | | | and the second se | | |
| he area is for a semi parabola rotection volume. heta - intermediate step for solving | μ _{φά} | 0.95 | Peak Manage | ment of 100 | year st | torm is satisfied | 1 | |
| he area is for a semi parabola rotection volume. Tella - Intermediate step for solving tydraulic Perimeter (ft), for semi parabola | L _{add} θ P _{oul} | 0.95 | Peak Manage Peak Manag | ment of 100 ement of 1 y | year st /ear sto | torm is satisfied | 1 | |
| The area is for a semi parabola wotection volume. Theta - Intermediate step for solving lydrautic Perimeter (II), for semi parabola lydrautic Radius, using Chow 1959 | Pout Rh | 0.95 15 2.21 | Peak Manage Peak Manag Peak Manage | ment of 100 ement of 1 y ement of 10 | year sto year sto year sto | torm is satisfied form is satisfied form is satisfied | 1 | |
| The area is for a semi parabola wotection volume. Theta - Intermediate step for solving hydraulic Perimeter (ft), for semi parabola hydraulic Radius, using Chow 1959 harcy Weisbach friction factor expressed in terms of L _{eso} , v _{out} . | L _{add} θ P _{oul} <u>R_h</u> f | 0.95 15 2.21 0.28 | Peak Manage Peak Manag Peak Manage | ment of 100 ement of 1 ement of 10 | year st /ear sto year st | form is satisfied form is satisfied form is satisfied | | |

,

| Checking Quality Management | | | | | | | | |
|--|----------------------------------|---------------------------------|--|--|--|--|--|--|
| Site Drainage Area (Acres) | IS THE A PROVIDE | Salar Street 48 Documents Store | | | | | | |
| Contributory Impervious Area (Acres) | Contract, Classify of | 0 AD 0 - | | | | | | |
| Volumetric Runoff Coefficient | Rv | 0.05 | | | | | | |
| Water Quality Volume, ft3 | wàv | 7841 | | | | | | |
| Average Sand filter bed depth (ft) minimum 18 inches | · Or (Average of Puol and Pulle) | 2.0 | | | | | | |
| Width of sand filter (fl) | Street Ward Store | 10 Seturation | | | | | | |
| Length of sand filter, where slope < = 5% (ft) | Lsend | 190 | | | | | | |
| Area of sand filter provided (ft2) | A Provided | 1900 | | | | | | |
| coefficient of permeability of filter media (ft/day) | ĸ | 3.50 | | | | | | |
| height of water above filter bed- pool depth (ft) | hr | 3.00 | | | | | | |
| design filter bed drain time (days), MDE recommended value | ţ, | 1.67 | | | | | | |
| Required filter bed area (ft2) | A Required | 402 | | | | | | |

.

.

ent is satisfied in SPSC

•

Water quality requiren

•

κ.

<u>Contact</u>

2662 Riva Road Amapolis, MD 21401 Phone 410 222 4241

Developed by: Date: Hała Flores, P.E. 21-Dec-09 Anne Arundei County Government Department of Public Works Bureau of Engineering Watershed and Ecosystem Services and Restoration Watershed Assessment and Planning



.

| · · · · · · · · · · · · · · · · · · · | | | | | - | | | |
|---|-------------------------------------|--|--|-----------------|--------------|--------------------|--|-------------------------------------|
| Checking Deson Return Period (Y) | the Channel Conve | yance for the design flood | | Carten Datas | ĩ | | | |
| Time of Concentration in minutes (Before Development) | 1 | | 0.28 | 19 - P (165) - | - | | | |
| Pre development discharge (cfs) | Cont y Street | 59.7 STA | 0.7 | 24.2 | 1 | Isbash c | urve for Stone De | ensity = 165 lb/ft3 |
| | | | | 120.7 | | Cobble d50 size | Allowable Velocity (Supercritical) | Allowable Velocity (Subcritical) |
| I del ambés super d' | | | Cascade Design (maximum | n 5 ft drop | · | [inches] | ft/sec | [ft/sec] |
| Elevation drop over length (ft) | della E | 9.0 | Design Width (ft) | 推示 "你 | | 4 | 5.1 | 7.1 |
| Total Cascade Length for Project (ft) | Leascade | 0.00 | Design Depth (ft) | 制的可能的 | 1 | 5 | 5.7 | 8.0 |
| Maximum Cascade Slope (ft/ft) | Siopecascade | 0.50 | Roughness | 0.05 | 1 | 6 | 6.3 | 8.7 |
| Water Quality slope (ft/ft) | Skope | 0.01 | A | 0.00 | | 7 | 6.8 | 9.4 |
| Average Length of Hitle Segments (II), Minimum 10 Tables | N N | 4 9 4 10 10 10 10 10 10 10 10 10 10 10 10 10 | 8 | #DIV/0! | | 8 | 7.2 | 10.1 |
| Number of Cascade Segments for Project | N | | P R | #017/01 | | 10 | 1.1 | 10.7 |
| Required Length of Pool Segments (ft) | Larri | 16 | Design Velocity (ft/sec) | #DIV/0 | | 10 | | 11.5 |
| | | Subdenie and Automatic Provide Calendary | Design Velocity (insec) | WDIVIU: | ł | 12 | 0.0 V V | 11.5 |
| Cobble d50 size (ft) - choose • 6 inches | ri50 - | 0.50 | Conveyed Q (cfs) | #DIV/01 | | 12 | 0.0 6.6 | 13.5 |
| Top width of SPSC rifle charged (ft) in Annual SPSC rifle charged (ft) | A RWISH | 57.0 | No Cascade is Nee | eded | | | 7.7 | 12.05 |
| Death of SPSC rate channel (II) | | 20 | Minimum Pool Depth "Use 3 pools" following each cascade segment (ft) | #DIV/01 | | 18 | 10.8 | 15.1 |
| of the SPSC (ft) | h, | 2.0 | ok | | 1 | | | |
| Enter Desired Pool Depth (ft) | 学家:会议的 法学生法律 | 5 (b) | subcritical/ol | < | | Adequate | conveyance o | of design storm |
| Check Riffle Side Slope, Must be > 2H:1V | | 14.3 | | $\overline{\ }$ | | | | |
| Check the Froude Number to ensure Subcritical Flow Cor | ditions | 0.6 | 1 | | | Selected C | obble Size is / | Adequate for 100 |
| | | | 1 | | \mathbf{X} | | year atom | |
| Computed Roughness | | 0.04 | | | | | | |
| Biffle Cross Section Area (ft2) for parabola | A | 76.00 | 1 | | | Subcr | itical Flow is P | redominant |
| | | | 1 | | | | | |
| Theta - Intermediate step for solving | θ | 0.14 | | | | | | |
| Riffle Hydraulic Perimeter (ft), for parabola | Р | 57.19 | | | | | | |
| Riffle Hydraulic Radius (ft), using Chow 1959 | R _h | 1.33 | | | | | | |
| Calculated Flow for design parameters (cfs) | ٩ | 338.27 | | | | | | |
| Check Riffle Velocity (ft/sec) | v | 4.45 | Required Number | of Pools | | 27 | | |
| | | | Provided total pool d | lepth (ft) = | | 81 | | |
| Checking Quar | tity Management | - | Run | Solver | | | | |
| USDA 2006, n expressed in terms of d_{out} and $d_{so} = 8$ inches | n | 0.03 | Required Volume of Storage | (Rational H | ydrograj | oh) | | |
| The width at the entrance riffle | w | 57.00 | | | 100 % | 1 2- | 10.14 | |
| | | 57.00 | | | 100 Yr | . 1 Yr | 10 Yr | |
| The velocity at the entrance riffle is calculated using Manning formula calculator and Ω_{peak} for the 1 year storm | v, | 7.57 | Required Volume of Storage (ft | 3) | 4655 | 85 | 1786 | |
| The doub of the potence office is cale dated union Manufacture | | | | | | • | | |
| formula calculator and Q _{post} for the 1 year storm | D _e | 2.00 | Volume provided in pools (ft3) | | | 11668 | | |
| Enter Trial Value : The total pool depth needed to render the power equivalent to 100-year predevelopment/desired levels. This should be compared analist the total | D | 12.20 | Volume provided in weids (92) | | | 10336 | | • |
| This is the typical top width of the dead storage pool parabolic | | 10.40 | Verenie provided (1) Volds (113) | | | 10230 | | |
| areas, iu. I side side | VV _{ovt} | 12 | Provided Volume of Storage | (excludes | | | | |
| protection volume. | Ladd | 3932 | influeton Volume (R3 | | 10492 | | | |
| Theta - Intermediate step for solving | θ | 1.35 | | Run Sc | lver | a companya ang | | |
| Hydraulic Perimeter (ft), for semi parabola | P _{oul} | 30 | | Run Sc | lver | | | |
| Hydraulic Radius, using Chow 1959 | R _n | 3.51 | | Run Sc | lver | | | |
| Darcy Weisbach friction factor expressed in terms of Lad, voul- | 1 | 0.20 | | | | | | |
| solved using Solver equation: Bernoulli equation rewritten | in terms of d _{out} as the | -6.28 | | | | | | |



| Checking Qua | lity Management | |
|--|----------------------------------|------------------------------------|
| Site Drainage Area (Acres) | 1325 DEPARTMENT | 43744457396776845684569755997C |
| Contributory Impervious Area (Acres) | SRACESBERGE DATE SAN | No. 1997 - 2017 35 - 400 Same 1999 |
| Volumetric Runoff Coefficient | Rv | 0.53 |
| Water Quality Volume, ft3 | wav | 113692 |
| Average Sand filter bed depth (ft) minimum 18 inches | - Or (Average of Poot and Rolle) | 5.0 State |
| Width of sand filter (ft) | Wand R State | 8 |
| Length of sand filter, where slope < = 5% (ft) | Lsand | 853 |
| Area of sand filter provided (ft2) | A _{l Provided} | 6824 |
| coefficient of permeability of filter media (ft/day) | k | 3.50 |
| height of water above filter bed- pool depth (ft) | h, | 3.00 |
| tesign filter bed drain time (days), MDE recommended value | ե | 1.67 |
| Required filter bed area (ft2) | Alexind | 3647 |

.

.

.

·

istied in SPSC

Water o

•

<u>Contact</u>

2652 Riva Road Ammpolis, MD 21401 Phone 410 222 4241

Developed by: Date: Phone 410 222 4241 Hala Flores, P.E. 21-Dec-09

5

Anne Arundel County Government Department of Public Works Bureau of Ergineering Watershed And Ecosystem Services and Restoration Watershed Assessment and Planning



Calculated values are noted with dotted pattern Check parameters in bold

| Checking | g the Channel Conve | yance for the design flood | |] | | | |
|--|--|-------------------------------------|--|---------------------------------------|--------------|---|---------------------|
| Design Return Period (Yr) and the state of t | C Constant Transformer | Trivial Seat 100 Seattle Seattle | South Frankins 1 1. 49 Shok Ma | ****10 | | | |
| Time of Concentration in minutes (Before Development) | | 50 7 C | 0.20 - 312 - 21 - 21 - 22 - 2 | S | labor | haumin far Stana D | ancity = 165 (biff) |
| File Gevelopinera Giociargo (cos) | And the second second | Personal and a second second | A state of the sta | 155. 29. 4 9-3 7-30-44 2-45 | Cobbled | 50 Allonable | Allowable Vetecity |
| | | 25 7 7 24 41 4 2 4 | The second second | | c obilie u | Velocity | (Subcritical) |
| | | | | | | Supercritical | (concernical) |
| Post development design discharge (cfs) | Com A | 334.8 | 5-5-5-75.75 T 55 | 129.7 | | | |
| | 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1 | | Canada Danian (manimum | | linches | [ft/sec] | [ft/sec] |
| Total available length (fi) | | 653 | per segment) | η 5 π ατορ | | | . , |
| Elevation drop over length (ft) | dete E dete | 1 | Desion Width (ft) | 14.00 | 4 | 5.1 | 7.1 |
| Total Cascade Length for Project (fl) | Lessende | 0.00 | Design Depth (ft) : | 200 T | 5 | 5.7 | . 8.0 |
| Maximum Cascade Slope (ft/ft) | Slope _{cascade} | 0.50 | Roughness | 0.05 | 6 | 6.3 | 8.7 |
| Water Quality slope (ft/ft) | Siope | D.01 | A | 0.00 | 7 | 6.8 | 9,4 |
| Average Length of Riffle Segments (ft), Minimum 10 ft | | 安曇寺"。這個是18月至18月2日的 | 0 | #DIV/0! | 8 | 7.2 | 1u. I |
| Number of Riffle Segments for Project | NnBa | 27 | P | #DIV/0! | 9 | 7.7 | 10.7 |
| Number of Cascade Segments for Project | Ncascada | 0 | R | #DIV/01 | 10 | 8,1 | 11.3 |
| Required Length of Pool Segments (ft) | | 16 | Design Velocity (fl/sec) | #DIV/0! | <u> </u> | 8.5 | 11.8 |
| | 1月1月1日日1月1日 | | | | 12 | 8,8 | 12.3 |
| CODIE COU EIZE (IT) • CIODEE • 6 LICINE • 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 | | 0.50 7 54 7 56 9 56 | Conveyed Q (cts) | #DIV/0 | 15 | 6.0 | 13.0 |
| | | | No Concodo io Nov | | 12 | 9.9 | 13.8 |
| 100 widel of SPSC Intel charges (in) the second sec | | 100.05 (100.05 (1.00) (1.00) (1.00) | NO Cascade is Net | sueu | 10 | 10.0 | 12.1 |
| | 12.54 | | Innimum Pool Depth "Use 3 | | 10 | 10.8 | 15.1 |
| Depth of SPSC rifle channel (ft) | D2 | 15.4 | cascade segment (ft) | #DIV/0! | | | |
| of the SPSC (ft) | h, | 1.5 | ok | | | • | |
| Enter Desired Pool Depth (fi) | THE ACT NO. 22 | 105-2.4-3.0 | subcritical/ol | k l | Adequ | ate convevance | of design storm |
| | | | | | | ······ | |
| | | | | | | | |
| Check Riffle Side Slope, Must be > 2H:1V | | 33.3 | 4 | | Selected | I Cobble Size is | Adequate for 100 |
| Check the Froude Number to ensure Subcritical Flow Cor | nditions | 0.5 | | | | year stor | m |
| | | | 1 | | | | |
| Computed Revelopers | | 0.04 | | | \mathbf{X} | | |
| Compared Roagimeas | | 0.04 | 4 | | À | | |
| Riffle Cross Section Area (ft2), for parabola | A | 100.00 | 4 | | Sut | critical Flow is | Predominant |
| Theta - Intermediate sten for solving | A | 0.06 | | | | | |
| | | ······ | | | | | |
| | | | | | | | |
| | | 100.00 | 1 | | | | |
| Riffie Hydraulic Perimeter (ft), for parabola | | 100.06 | - | | | | |
| | | | | | | | |
| Riffle Hydraulic Radius (ft) using Chow 1959 | R. | 1.00 | | | | | |
| ······································ | | | 4 | | | | |
| Calculated Flow for design parameters (cfs) | 0 | 347.55 | | | | | |
| | | | · · · · · · · · · · · · · · · · · · · | | T | ר | |
| Check Riffle Velocity (ft/sec) | v | 3.48 | Required Number | r of Pools | 27 | | |
| | | | Described total as all | 1 | | | |
| | | | | epui (ii) - | | - | |
| Checking Quar | ntity Management | | Rur | Solver | | | |
| | | | | | | | |
| USDA 2006, n expressed in terms of d _{out} and d ₅₀ = 8 inches | n | 0.03 | Required Volume of Storage | (Rational Hyd | ograph) | | |
| The width at the entrance riffle | | 100.00 | | | N V- 4 V. | 10.4- | |
| | | 100.00 | | ⁿ | ~ | | |
| | | | | | | | |
| The velocity at the entrance offle is calculated using Manning | | | | · | | | |
| formula calculator and Qpost for the 1 year storm | V., | 7.57 | Required Volume of Storage (ft | 3) 4 | 655 85 | 1786 | |
| | | | | | | • | |
| | | | | | | | |
| | | | | | | | |
| formula calculator and Q for the 1 year storm | <u>р.</u> | 1.50 | Volume provided in pools (ft3) | 1 | 116 | 69 | |
| Enter Trial Value : The total pool depth needed to render | | | | | | | |
| the power equivalent to 100-year predevelopment/desired | | | | | | | |
| levels. This should be compared against the total | D _{pul} | 13.20 | Volume provided in voids (ft3) | 1 of Ma . 19 . 4 | 102 | 36 | |
| This is the typical top width of the dead storage pool parabolic | | | | | | | |
| areas, 10:1 side slope | Wow | 9 | | | | · 《 · · · · · · · · · · · · · · · · · · | |
| | | | Provided Volume of Storage | (axcludes | 2230年9月20日 | | |
| The area is for a semi parabola | A _{ou1} | 79 | infiltration) (ft3) | 調査部門語 | 229 | 04 | |
| protection volume. | Ladd | 3932 | average in Interation Volume (II) | DATE: SA | 3 NA 10 | 01.5 | |
| I heta - Intermediate step for solving | | 1.40 | | Run Solv | 16 | | |
| Hydraulic Perimeter (ft), for semi parabola | r _{oul} | 29 | | Run Solv | or | | |
| riyuraulic Kadius, Using Chow 1959 | R _h | 2.76 | | Run Solve | er. | | |
| Darcy weisbach friction factor expressed in terms of Lade, voul- | in terms of d 4t - | 0.22 | | | | | |
| Convert using Solver equation, bernouin equation rewritten | interms of u _{evt} as the | -10.72 | | | | | • |
| | | | | | | | r F |

| | | | Î |
|----------|---------|------------|---|
| Checking | Quality | Management | |

Site Drainage Area (Acres) uis Aspendico 21-22 B Volumetric Runoff Coefficient Rv 0.53 Water Quality Volume, ft3 Average Sand filter bed depth (ft) minimum 16 inches 2000 Woth of sand filter (ft) Length of sand filter, where sope < = 5% (ft) Area of sand filter provided (ft2) coefficient of permeability of filter media (ft/day) WQv verige of Pool and Raffe Weend Land , d., At Provided k 3.50 height of water above filter bed- pool depth (ft) design filter bed drain time (days), MDE recommended value Required filter bed area (ft2) հյ Լ 3.00 1.67 3647 A Required













Water quality requirement is satisfied in SPSC

<u>Contact</u>

2652 Riva Road Annapolis, MD 21401 Phone 410 222 4241

Developed by: Date: Phone 410 222 4241 Hala Flores, P.E. 21-Dec-09 Anne Arundel County Government Department of Public Works Bureau of Engineering Watershed and Ecosystem: Services and Restoration Watershed Assessment and Planning



Input values shaded in Grey Received Calculated values are noted with dotted pattern Check parameters in bold

,

| Checkin | g the Channel Conve | yance for the design flood | ····· | |] | | | |
|--|--|---|---|--|--------------|----------------|-------------------|--------------------|
| Design Return Period (Yr) | E Mission Paramana Resident Paramana | Strike and the second se | 0.80 | 10 10 | | | | |
| Pre development discharge (cis) | - C | 324 2 March 19 10 10 10 10 10 10 10 10 10 10 10 10 10 | 5.9 | 124126.14 | | lsbash c | urve for Stone De | nsity = 165 lb/ft3 |
| and the second | | E P. S. Levis Const. Have a provide | WE PERCENTED THE | arries al | | Cobhle d50 | Allowable | Allowable Velocity |
| | | | in the second | Other | | size | Velocity | (Subcritical) |
| | | | · 一般的 · · · · · · · · · · · · · · · · · · · | 2. 年代 | | | (Supercritical) | |
| Post development design discharge (cfs); | Contraction of the second | 324.2 | 5.3 | 126.1 | | | | |
| the second second second second second | | | Cascade Design (maximur | m 5 ft drop | | [inches] | [ft/sec] | [ft/sec] |
| Total aveitable length (fl) | | 725 | per segment) | 1. | | | | |
| Elevation grop over length for Project (ft) | S ANNO COLORE LA COLOR | 6.0 | Design Width (ff) | ·通行学校的第一 | - | | 2.1 | /,] ¥0 |
| Maximum Cascade Slope (ft/ft) | Slope | 0.50 | Roughness | 0.05 | | 6 | 63 | 8.7 |
| Water Quality stope (ft/ft) | Skope | 0.01 | A | 0.00 | 1 | 7 | 6.8 | 9,4 |
| Average Length of Rafle Segments (f), Minimum 10 (1.5%) | | | θ | #DIV/01 | 1 | 8 | 7.2 | 10.1 |
| Number of Riffle Segments for Project | N _{nBe} | 18 | Р | #DIV/0! | | 9 | 7.7 | 10.7 |
| Number of Cascade Segments for Project | Ncascade | 0 | Rh | #DIV/0! | | 10 | 8,1 | 11.3 |
| Required Length of Pool Segments (ft) | | 20 | Design Velocity (ft/sec) | #DIV/0! | | 11 | 8.5 | 11.8 |
| | 10 1 A 1 | | | | | 12 | · 8,8 | 12.3 |
| Cobble dou size (1) - choose - 8 miches - 1 | 6 (1997) (1990) - S. | 0.50 | Conveyed Q (cfs) | #DIV/0 | | 15 | | 12.0 |
| Too with a SDSC offic change (fr) | | | No Cascada is Ne | haha | | 15 | 9.9 | 4.61 |
| | | | Minimum Pool Depth *Lter 2 | | | 14 | 16.8 | 15.1 |
| | | | pools" following each | l | | | 10,11 | 1254 |
| Depth of SPSC riffle channel (f) | | 3. de 64 2 04 4. de | cascade segment (ft) | #DIV/0! | | | | |
| of the SPSC (ft) | h, | 2.0 | ok | | | | | |
| Enter Desired Pool Depth (ft) | Line b | 3.0 | subcritical/o | k | | Adequate | conveyance o | of design storm |
| | | | | | | | | |
| Check Riffle Side Slope, Must be > 2H:1V | | 15.5 | | | | C | | |
| Check the Eroude Number to ensure Subcritical Flow Cou | nditions | 0.5 | 1 | • | | Selected C | ODDIe Size is / | Adequate for 100 |
| Check the Protoe Runder to ensure Subcritical Prov Co | | 0.5 | 4 | | \mathbf{X} | L | year storr | 1 |
| | | | • | | · / | | | |
| Computed Roughness | n | 0.04 | | | | | | |
| Riffle Cross Section Area (ft2), for parabola | A | 82.67 | | | | Subcr | itical Flow is P | redominant |
| | | 1 | | | | | | |
| Theta - Intermediate step for solving | θ | 0.13 | Į | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| Riffle Hydraulic Perimeter (ft), for parabola | Р | 62.17 | | | | | | |
| | | | | | | | | |
| Rifle Hudrovic Radius (8) using Chau 1959 | | 1 22 | | | | | | |
| Rune Hydrauk, Radius (it), using chow 1959 | 1 | 1.33 | | | | | | |
| Calculated Flow for design parameters (cfs) | l a | 325.97 | | | | | | |
| | | | | | | | | |
| Check Riffle Velocity (ft/sec) | v | 3.94 | Required Number | r of Pools | | 18 | | |
| | | | Provided total pool r | denth (ft) e | | 54 | | |
| | | | r toridad total poor c | Jepur (u) - | | | | |
| Checking Quar | ntity Management | · · · · · · · · · · · · · · · · · · · | hydraulic power for return p | eriod 100 ye | ar stor | n is satisfied | | |
| | - | | | | | | | |
| USUA 2000, il expressed in terms of d _{out} and d ₅₀ = 8 thches | | 0,04 | required volume of Storage | (Kational Hy | orogra | on) | 1 | |
| The width at the entrance riffle | W _{in} | 62.00 | | | 100 Yr | 1 Yr | 10 Yr | |
| | | | | | | | | |
| | F | | | | | | · | |
| The velocity at the entrance riffle is calculated using Manning | v | 7.77 | Required Velume of Starsa 4 | | | | | |
| rormula calculator and Qpost for the 1 year storm | V _n | 1.57 | required volume or storage (it | (J) | 0 | U | 0 | |
| | | | | 1 | | | | |
| | | | | | | | ł | |
| The depth at the entrance riffle is calculated using Manning | _ | | | | | | i i | |
| formuta calculator and Qpost for the 1 year storm Enter Trial Value : The total pool depth needed to reprise | Un | 2.00 | volume provided in pools (ft3) | | | 7778 | | |
| the power equivalent to 100-year predevelopment/desired | | | | | | | | |
| levels. This should be compared against the total | Dout | 7.93 | Volume provided in voids (ft3) | | | 4350 | | |
| This is the typical top width of the dead storage pool parabolic | | | | 國際副 | | | | |
| areas, 10:1 side slope | Wout | 12 | | | 1110 | | | |
| | | | Provided Volume of Storage | (excludes | C STORES. | | | |
| The area is for a semi parabola | Aout | 63 | infiltration) (ft3) | Start (C) | | 13128 | an sa sange | |
| protection volume. | Ledo | 0 | An Antipation Volume (12 | 明朝日期 | | sin - 1000 | | |
| Hydraulic Perimeter (ft), for semi parebola | P~ | 21 | Peak Manager Dank Manager | ment of 100 | year sto | m is satisfied | | |
| Hydraulic Radius, using Chow 1959 | R | 3.05 | Peak Manage | ment of 10 | ear sto | m is satisfied | | |
| Darcy Weisbach friction factor expressed in terms of Land. Void | f | 0.22 | | | | | | |
| Solved using Solver equation: Bernoulli equation rewritten | in terms of d _{eal} as the | 0.00 | | | | | | |

| Cheaking Oue | lib. Management | |
|--|---------------------------------|--|
| Checking Qua | iity Management | |
| Site Drainage Area (Acres) 1, 2012 2013 | Charles Con Although Show | 时间的过去式和自己的第三人称单数 |
| Contributory Impervious Area (Acres) | 与中国的中国和中国的中国的 | 1962 (A 1993 A 1997 O 1997 A 1997 |
| Volumetric Runoff Coefficient | Rv | 0.05 |
| Nater Quality Volume, ft3 | wav | 31527 |
| verage Sand filter bed depth (it) minimum (8 inches | (In Uniting of Pool and Rillio) | 2.0 |
| Vidth of sand filter (ft) | Wand State | 10 - 1 - 10 - 10 - 10 - 10 - 10 - 10 - |
| ength of sand filter, where slope < = 5% (ft) | Lsand | 725 |
| Area of sand filter provided (ft2) | A _{t Provided} | 7250 |
| coefficient of permeability of filter media (ft/day) | k | 3.50 |
| eight of water above filter bed- pool depth (ft) | hr | 3.00 |
| lesign filter bed drain time (days), MDE recommended value | t, | 1.67 |
| Required filter bed area (ft2) | A Required | 1618 |

. . .

Water quality requirement is satisfied in SPSC

· · ·

Contact

Developed by: Date:

.

E 2652 Riva Road Annapolis, MD 21401 Phone 416 222 4241

Hala Flores, P.E. 21-Dec-09

Anne Arundel County Government Department of Public Works Bureau of Engineering Watershed and Ecosystem Services and Restoration Watershed Assessment and Planning



| Checking | the Channel Conve | yance for the design flood | | |] | | | |
|---|---------------------------------------|--|---------------------------------------|--|--------------|---------------------------------------|------------------|--------------------|
| Design Return Period (Yr) | Providence Tarters and | 100 | 0.92 | 10 10 Miles | | | | |
| Pre development discharge (cfs) | Contraction of the second | State of the second | 197 | 5-182 B | | lshash c | upe for Stone De | neity = 165 lb/#3 |
| | The star of the start of the | Value Arth L. Barrison and | | | | Cobble d50 | Allowable | Allowable Velocity |
| ALC NO. THE REPORT OF A REAL PROPERTY OF | 1 | | and the second | | | size | Velocity | (Subcritical) |
| | | | | | | | (Supercritical) | (|
| Post development design discharge (cfs) | A A A A A A A A A A A A A A A A A A A | 596.3 - AN | 122 | 162.8 | | | | |
| | 1993年1993年1993年1 | The second second second | Cascade Design (maximum | 5 ft drop | 1 | [inches] | ft/sec | [ft/sec] |
| Total evaluate length (ft) | 之中的法律 | 900 | per segment) | i s it drop | | | | |
| Elevation drop over length (ft) | en deta Erre | 90 | Design Width (fl) | ution (S | | 4 | 5.1 | 7,1 |
| Total Cascade Length for Project (ft) | Lascade | 0.00 | Design Depth (ft) | 建合物 | | 5 | 5,7 | 8.0 |
| Maximum Cascade Slope (ft/ft) | Siopecascade | 0.50 | Roughness | 0.05 | | 6 | 6.3 | 8.7 |
| Water Quality slope (ft/ft) | Slope | 0.01 | Ä | 0.00 | | 7 | 6.8 | પત |
| Average Length of Rifle Segments (1), Minimum 10 15:53 | | The second second second second | θ | #DIV/0! | | 8 | 7.2 | 10.1 |
| Number of Rime Segments for Project | N _{riffe} | 30 | | #DIV/0) | | 9 | 7.7 | 10.7 |
| Required Length of Pool Segments (ff) | "cescade | 15 | Design Velocity (ft/sec) | #DIV/01 | | 10 | 8.1 | 11.8 |
| | CONSIGNATION OF THE | | Design Felocity (1936) | | | 17 | 6.2 V V | 12.3 |
| Cobbie (150 size (ft) - choose - 6 inches | 100 miles | 0.50 | Conveyed O (cfs) | #DIV/0I | | 12 | | 14 |
| SALA STRATE STRATE STRATE STRATE | A CONTRACTOR | | | | | 15 | 9.9 | 13.8 |
| Top width of SPSC riffle channel (ft) | W W | 100.0 | No Cascade is Nee | ded | | | | |
| dart gette in sector and sector and sector | A DEFENSION ALL SECURITY | 15 Martin Carlo Carlo Barrowski | Minimum Pool Depth Use 3 | | | 18 | 10.8 | 15.1 |
| AND A CONTRACT OF | 100000000 | | pools" following each | | | | | |
| Depth of SPSC riffle channel (II) | States Cost (182) | 2.00 | cascade segment (ft) | #DIV/0! | | | | |
| of the SPSC (ft) | h, | 2.0 | ok | | | | | |
| Erikar Desired Pool Depth (ft) | A LANGE AND A LANGE | 10 State + 10 State + 444 | subcritical/ok | | | Adequate | e conveyance o | of design storm |
| | | | | | | | | |
| Check Riffie Side Slope, Must be ≥ 2H:1V | | 23.8 | | · \ | | | | |
| | | 20.0 | 1 | ``` | \ | Selected C | obble Size is / | Adequate for 100 |
| Check the Froude Number to ensure Subcritical Flow Con | ditions | 0.5 | 4 | | \mathbf{N} | | year stor | m |
| | | | | | | | | |
| Computed Roughness | n | 0.04 | | | | | | |
| Refle Cross Section Area (#2) for parabola | A . | 140.00 | | | | Subcr | itical Flow in F | Prodominant |
| Fine cross Section Alea (hz), for parabola | <u>^</u> | 140.00 | - | | | 30001 | | recommant |
| Theta - Intermediate step for solving | Ð | 0.08 | | | | | | |
| | | | 1 | | | | | |
| | | | | | | | | |
| Riffle Hydraulic Perimeter (ft), for parabola | Р | 100.12 | | | | | | |
| | | | 1 | | | | | |
| | | | | | | | | |
| Riffle Hydraulic Radius (ft), using Chow 1959 | R, | 1.40 | | | | | | |
| | | | | | | | | |
| Calculated Flow for design parameters (cfs) | Q | 633.03 | | | | | | |
| Chank Biffin Velopity (#/rec) | | 4.52 | Boguirod Number | | | 20 | | |
| | | 4.52 | Required Number | ULL POOIS | | | | |
| | | | Provided total pool de | epth (ft) = | | 90 | | |
| Checking Quar | titu Managamant | | | | | | | |
| Checking waan | inty management | · · · · · · · · · · · · · · · · · · · | #1 | | | | | |
| USDA 2006, n expressed in terms of d _{out} and d _{so} = 8 inches | n | #NUM! | Required Volume of Storage (| Rational H | /drogra | oh) | | |
| | | | | | a | | | |
| The width at the entrance riffle | W,n | 100.00 | | | 100 Yr | 1 Yr | 10 Yr | |
| 1 | | | | | | | 7 | |
| | | | | | | | | |
| The velocity at the entrance rittle is calculated using Manning formula calculator and Q for the 1 year storm | v | 7 67 | Required Volume of Stornes (#3 | " | , | | | |
| formale calculator and capasi for the 1 year storm | | 1.57 | required volume or Storage (inc | <i>"</i> | | U | | |
| | | | | | | | | |
| | | | | | | | | |
| The depth at the entrance riffle is calculated using Manning | _ | | | | | | | |
| formula calculator and Q _{post} for the 1 year storm | D _n | 2.10 | Volume provided in pools (ft3) | | | 12964 | | |
| the power equivalent to 100-year predevelopment/desired | | | | | | | 1 | |
| levets. This should be compared against the total | Dout | -34.68 | Volume provided in voids (ft3) | | | 5400 | | |
| This is the build too width of the dead starses and namesia | | | ····································· | | 6 | | | |
| areas, 10:1 side slope | Wat | 12 | | 2012 - 12 10 - 12 - 12 - 12 - 12 - 12 - 12 - 12 - | | | | |
| | ·· da | .2 | Provided Volume of Storess / | | | and the second | | |
| The area is for a semi parabola | Aout | -277 | infiltration) (ft3) | | | 19364 | | |
| protection volume. | Lade | 0 | A | 1.1.2.764 | 2.1.5 A.S. | 000100 | 4. 18 12 . NY . | |
| Theta - Intermediate step for solving | θ | -1.48 | | #NU | A1 | A A A A A A A A A A A A A A A A A A A | | |
| Hydraulic Perimeter (ft), for semi parabola | Pout | 71 | | #NU | 11 | | | |
| Hydraulic Radius, using Chow 1959 | R _h | -3.89 | | #NUI | 41 | | | |
| Darcy Weisbach friction factor expressed in terms of Ladd, Voul- | 1 | #NUM! | | | | | | |
| Solved using Solver equation: Bernoulli equation rewritten | in terms of d _{eut} as the | #NUM! | | | | | | |

| Checking Qua | lity Management | |
|--|----------------------------------|---|
| Ste Dranage Area (Acres) | PERSONA VOIDANS | 48 |
| Contributory Impervious Area (Acres) | of the second second second | 0 - A 2 - A |
| Volumetric Runoff Coefficient | Rv | 0.05 |
| Water Quality Volume, ft3 | WQv | 7841 |
| Average Sand filter bed depth (fl) maximum 18 inches | * Of (Anarage of Pasi and Rifle) | 2.0 Jack 2.0 |
| Width of sand filter (R) | Wand Street | 10 Kest 1 |
| Length of sand filter, where slope < = 5% (ft) | Lsand | · 900 |
| Area of sand filter provided (ft2) | A Provided | 9000 |
| coefficient of permeability of filter media (ft/day) | k | 3.50 |
| height of water above filter bed- pool depth (ft) | h, | 3.00 |
| design filter bed drain time (days), MDE recommended value | t, | 1.67 |
| Required filter bed area (ft2) | A Required | 402 |

.

.

.

tisfied in SPS

Wat

.

<u>Contact</u>

.

Ŧ 2652 Riva Road Annapolis, MD 21401 Phone 470 222 4241

Developed by: Date:

Hala Flores, P.E. 21-Dec-09

.

Anne Arundel County Government Department of Public Works Bureau of Engineering Watershed and Ecosystem Services and Restoration Watershed Assessment and Planning



Calculated values are noted with dotted pattern Check parameters in bold

.

| Checking | g the Channel Conve | yance for the design flood | | |] | | | |
|--|---|--|--|----------------------|--------------|---------------|---------------------------|---------------------|
| Design Return Period (Yr) | i dattaren Turatean. | 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 | o reconstanting and a second | 14-240 Mile | 1 | | | |
| Time of Concentration in minutes (Before Development) | | | 0.23 | | | | | |
| Pre development discherge (cfs) | the second states | 595.2 | CH2 | 182.8 | | lsbash d | curve for Stone D | ensity = 165 lb/ft3 |
| | | | 205 | 1.63 | | Cobble d50 | Allowable | Allowable Velocity |
| 16 | A SANTAGER | | | 5 P 14 | | size | Velocity | (Subcritical) |
| | Contraction of the second | | · 注意的 · · · · · · · · · · · · · · · · · · · | 清算之 | | | (Supercritical) | 1 |
| Post development design discharge (cfs) | Add and Quarter to | 595.3 Jan 24 | 12.2 | 182.8 m | | | ļ | |
| | | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | Cascade Design (maximum | 5 # drop | | [inches] | ff/sec] | [ft/sec] |
| Total available length (fi) | | 900 | per segment) | | | | | |
| Elevation drop over length (ft) | della E | 90 | Design Width (ft) | | | 4 | 5.1 | 7,1 |
| Total Cascade Length for Project (ft) | Lancade | 0.00 | Design Depth (ft) | the states | | 5 | 5.7 | 8.0 |
| Maximum Cascade Slope (ft/ft) | Stoperascade | 0.50 | Roughness | 0.05 | 1 | 6 | 6.3 | 8.7 |
| Water Quality slope (ft/ft) | Slope | 0.01 | A | 0.00 | 1 | 7 | 6.8 | 94 |
| Average Length of Riffle Segments (f) Minimum 10 ft | CARLES PERSONAL ST | 15 (10 - 15 (10 - 15 (10 - 10 - 10 - 10 - 10 - 10 - 10 - 10 | e e e e e e e e e e e e e e e e e e e | #DIV/0 | 1 | 8 | 7 7 | 10.1 |
| Number of Riffle Segments for Project | N-n- | 30 | P | #01//01 | 1 | 0 | 7.7 | 10.7 |
| Number of Cascade Segments for Project | N | | , p | #DIV/0 | 1 | 3 | 1.1 | 10.7 |
| Required Length of Bool Segments (#) | · Cascade | 15 | Design Valocity (filmes) | #017/0 | 1 | <u> </u> | | 11.5 |
| required Length of Pool Segments (it) | - pool | 13 | Design velocity (lusec) | #DIV/U | 1 | 11 | 8.3 | 11.8 |
| | 1. 12 F - 12 - 12 - 12 - 12 - 12 - 12 - 12 | and the state of the state of the state | | | | 12 | 8,8 | 12.3 |
| Cobble d50 size (R) - choose - 6 Inches | 100 00 050 050 C | 0.50 | Conveyed Q (cfs) | #DIV/0! | 1 | L | | |
| | Contraction of the | and the second second second | | | | 15 | 9.9 | 13.8 |
| Top width of SPSC riffle channel (ft) | W W States | 130.04 | No Cascade is Nee | eded | | 1 | 1 | |
| General States States | 心死在起西方方法 | | Minimum Pool Depth "Use 3 | | I | 18 | 10.8 | 15.1 |
| | | 1 | pools" following each | | | 1 | | 1 |
| Depth of SPSC effle channel (ft) | D. D. D. | 182 H. L. BERLEY, 1997 | cascade segment (ft) | #DIV/0! | l | | | |
| of the SPSC (ft) | h, | 2.0 | ok | | 1 | | | |
| E N D I D D D D D D D D D D D D D D D D D | S SERVICE AND A S | and the second | superifical/ol | | | Adamina | | of decise starm |
| CING LOOSEUT IN MOUTH INT | 284-583-5-595-55 | Support the Contesting of Contesting to Contesting | 3uber titean of | <u>`</u> | | Auequali | e conveyance | or design storm |
| | | | | | | | | |
| Check Riffle Side Slope, Must be > 2H:1V | | 36.1 | | · · · · | | Colored of | abble Cies is | |
| | | | 1 | | | Selected | JODDIE SIZE IS | Adequate for 100 |
| Check the Froude Number to ensure Subcritical Flow Cor | ditions | 0.5 | 1 | | \mathbf{N} | L | year stor | m |
| | | | | | | | | |
| | | | | | | | | |
| Computed Roughness | n | 0.04 | 4 | | | <u> </u> | | |
| Riffle Cross Section Area (ft2), for parabola | A . | 156.00 | | | | Subci | ritical Flow is i | Predominant |
| | | | 1 | | | | | |
| Theta - Intermediate step for solving | θ | 0.06 |] | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| Riffle Hydraulic Perimeter (ft), for parabola | PP | 130.07 | 4 | | | | | |
| | | | | | | | | |
| · · · | | | | | | | | |
| Riffle Hydraulic Radius (ft), using Chow 1959 | Rh | 1.20 | | | | | | |
| | | | | | | | | |
| Calculated Flow for design parameters (cfs) | Q | 618.94 | | | | | | |
| | | | | | | | | |
| Check Riffle Velocity (ft/sec) | v | 3.97 | Required Number | of Pools | | 30 | | |
| | | | | | | | | |
| | | | Provided total pool d | epth (ft) = | | 90 | | |
| | | | | | | | | |
| Checking Quar | ntity Management | | # | NUMI | | | | |
| | | | | | | | | |
| USDA 2006, n expressed in terms of d _{out} and d ₅₀ = 8 inches | <u>n</u> | #NUM! | Required Volume of Storage | (Rational H | ydrogra | ph) | | |
| The width at the entrance riffle | l I | 130.00 | | | 100 1 | 1 | 10.2- | |
| | "" | 130.00 | · · · · · · · · · · · · · · · · · · · | | | 197 | | |
| | | | | | | | | • |
| | | | | | | | | |
| The velocity at the entrance riffle is calculated using Manning | | | | | | | | |
| formula calculator and Q _{post} for the 1 year storm | V., | 7.57 | Required Volume of Storage (ft | 3) | 1 | 0 | 0 | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| The depth at the entrance riffle is calculated using Manning | | | | | | | | |
| formuta calculator and Qpost for the 1 year storm | D _n | 1.80 | volume provided in pools (ft3) | | | 12964 | | |
| Enter Trial Value : The total pool depth needed to render | • | | | | | | | |
| the power equivalent to 100-year predevelopment/desired | | 20.54 | Mahampi menjaka kara sara sara | | | **** | | |
| levels. This should be compared against the total | Dout | -29.94 | volume provided in voids (ft3) | 11 2012 24 57 | 2.154.00.00 | 5400 | PERCENT OF PERCENT | |
| This is the typical top width of the dead storage pool parabolic | | | YTER AND AND AND | a strate of | | | | |
| areas, 10:1 side slope | w | 12 | | | | | 、空后之外 | |
| ······ | | | Prostand Walterna of State | Constante- | 治治 学者 | ESCALE | ·异圣秘的公 | |
| The area is for a semi parabola | Α. Ι | -240 | infiltration (#3) | STATES OF | 5.55 | 10744 | 222 238 | |
| protection volume | luor · | -240 | Statistics of the second states of the second state | 1.440 1 1 (Pr 18 15) | 1 | AND COMPANY | A CONTRACTOR OF THE OWNER | |
| Theta - Intermediate sten for solving | – ⊶dd A | -1.47 | AND AND AND AND A COUNT OF A DECISION OF A DECISIONO OF A DECISIONO OF | | 5451765 | 12.100.101 | | |
| Ludrautia Desimator (ff) for east analysis | p | -1.47 | | #NU | *** | | | |
| Hydrouic Feltineter (n), für seint parabola | owl | 02 | | #NU | an I | | | |
| nyuraulic itaulus, using chow 1959 | R _h | -3.86 | | #NU | 11 | | | |
| Darcy Weisbach friction factor expressed in terms of Lado, voul, | 1 | #NUM! | | | | | | |
| Solved using Solver equation: Bernoulli equation rewritten | in terms of d _{out} as the | #NUM! | | | | | | |

| Checking Quality Management | | | | | | | | |
|--|--|--|--|--|--|--|--|--|
| Ste Oranage Area (Acres) | ASTONIC ASSESSO | 48 19 K A 19 C A 18 C A 19 C | | | | | | |
| Contributory Impervious Area (Acres) | NAMES OF STREET, STREE | 305 - 407 - 0 - 401 - 407 - 407 - 407 - 407 - 407 - 407 - 407 - 407 - 407 - 407 - 407 - 407 - 407 - 407 - 407 - | | | | | | |
| Volumetric Runoff Coefficient | Rv | 0.05 | | | | | | |
| Water Quality Volume, ft3 | WQv | 7841 | | | | | | |
| Average Sand filter bed depth (ft) minimum 18 inches | d (Average of Ploy and Pulle) | 20 - | | | | | | |
| Width of sand filter (ft) | Went Parts | 10 | | | | | | |
| Length of sand fater, where slope < = 5% (ft) | Lsand | 900 | | | | | | |
| Area of sand filter provided (ft2) | A Provided | 9000 | | | | | | |
| coefficient of permeability of fitter media (ft/day) | k | 3.50 | | | | | | |
| height of water above filter bed- pool depth (ft) | h, | 3.00 | | | | | | |
| design filter bed drain time (days), MDE recommended value | 4 | 1.67 | | | | | | |
| Required filter bed area (ft2) | Annual | 402 | | | | | | |

,

Water g

entirfied in SPSC

<u>Contact</u>

.

١.

۲. 2002 Riva Read Aonapolis, MD 21401 Phone 410 222 4241

Developed by: Date:

Hala Flores, P.E. 21-Dec-09

Anne Arunde! County Government Department of Public Works Bureau of Engineering Watershed and Ecosystem Services and Restoration Watershed Assessment and Planning



Calculated values are noted with dotted pattern Calculated values are noted with dotted pattern Check parameters in bold

| Checkin | g the Channel Conve | yance for the design flood | | | | | | |
|--|--|--|--|---|--------------|------------------|--------------------|--------------------|
| Design Return Period (Yr) | s. Conserve Tacycology | a | | a ans 10 ma | 99 | | | |
| Tate of Concentration in minutes (Before Development) | | Neur La desta de la desta de la seconda d | 20.23 | | 2 | | | |
| Pre ovecoment discharge (crs) | | 308.2 V | | 749.8 | 4 | Isbash o | curve for Stone De | nsity = 165 lb/ft3 |
| | A CONTRACTOR OF A | Carl Carl Carl Carl | | 1 | | Connie dau | Allowable | Allowable Velocity |
| | | | of a particular second | | | size | velocity | (Superincar) |
| Post development design (achaine (rfs) | n - 1 | 288.2 | 1 | 140 8 | ÷. | | (Supercroican | |
| | | A CONTRACTOR OF A CONT | n satta an | Trastao.u/ | 79 79 | Lingh and | 161/con1 | littlenal |
| | | | Cascade Design (maximu | m 5 ft drop | | nucrest | Insect | Invsec |
| Total evaluable length (tt) | | 1015 | per segment) | 1 AND 1 CALLS - 120 | | | | |
| Elevation drop over length (II) | P AND ROOMA EVERY | 5 5 0 | Design Width (fi) | 40.00 | 10 10 | 4 | 5.1 | 7.1 |
| Maximum Cossade Slope (##) | Sione | 0.60 | Design Deput ((1)) 292 202 23 | 22010.002 | 8 | | 2.7 | 8,0 |
| Water Curcher share (1/#) | Sinne | 0.30 | Rouginiess | 0.05 | - | | 0.5 | 0.7 |
| Average Langest of Differences and Maria and An Average | Siope | 0.01 | | 266.67 | - | | 0.8 | 9,4 |
| Number of Piffle Segments for Project | N . | 10 | 50 D | 45.01 | 4 | | 1.2 | 10.1 |
| Number of Cascade Segments for Project | N | 18 | P ID | 43.91 | - | | 7.7 | 10,7 |
| Required Length of Pool Segments (ft) | Cascada | 28 | Design Volocity (ft/sec) | 69.00 | - | <u> </u> | <u>0.1</u> | 11.3 |
| required Length of Pool Segments (ii) | -pool | 20 | Design velocity (insec) | 66.09 | 4 | | 8.3 | 11.8 |
| | 1 - 2 | And the second second | | | | 12 | N,X | 14.5 |
| CODDING COD BIZE (D) - CROOSE(C) & FICTION | 000 | 1.00 | Lonveyed Q (crs) | 18156.55 | 4 | | | 12.0 |
| | | | No Considerito No | | | 10 | 9.9 | 15.8 |
| Top width of SPSC rifle channel (ft) | N HAR STREET | 100.0 States 24.0 States | No Cascade is Ne | eded | 1 | | | |
| | | | Minimum Pool Depth "Use 3 | | 1 | 18 | 10.8 | 15.1 |
| Country of COCC (1996) company (19) | | 1 | pools" tollowing each | 0.000 | | | | |
| - (Abs CDCC (A) | A NUMBER OF STREET, ST | | Cascade segment (it) | [02.00 | 4 | | | |
| | ny | 2.0 | | | 4 | | | |
| Enter Desired Pool Depth (ft) | rje se ten setter | 0.0 State 20 State 10.1 | subcritical/o | K | J | Adequate | e conveyance (| of design storm |
| | | | | | | | | |
| Check Riffle Side Slope, Must be > 2H:1V | | 22.7 | | | | | | |
| | | | - | | \mathbf{N} | Selected C | Cobble Size is / | Adequate for 100 |
| Check the Froude Number to ensure Subcritical Flow Co | nditions | 0.3 | | | \mathbf{i} | L | year stori | n |
| | | | | | | | | |
| Computed Roughness | | 0.05 | | | | ` | | |
| | | | -1 | | | À | | |
| Riffle Cross Section Area (ft2), for parabola | <u> </u> | 146.67 | | | | Subci | ritical Flow is P | redominant |
| Thete - Intermediate step for schules | | 0.00 | | | | | | |
| Theta - Interfilediate step for solving | | 0.09 | 1 . | | | | | |
| | | | | | | | | |
| · | | | | | | | | |
| Riffle Hydrautic Perimeter (ft), for parabola | Р | 100.13 | | | | | | |
| | 1 | | | | | | | |
| | | | | | | | | |
| Riffle Hydraulic Radius (ft), using Chow 1959 | Rh | 1.46 | | | | | | |
| | | | | | | | | |
| Calculated Flow for design parameters (cfs) | Q | 406.58 | | | | | | |
| | 1 | | _ | | | | | |
| Check Riffle Velocity (ft/sec) | VV | 2.77 | Required Numbe | r of Pools | ; | 18 | | |
| | | | Provided total pool | denth (ft) s | | 54 | | |
| | | | | uapar (n) - | | <u> </u> | | |
| Checking Quar | ntity Management | | hydraulic power for return p | period 100 y | ear ston | m is satisfied | | |
| | | | 1 | | | | r | |
| USDA 2006, n expressed in terms of dout and dso = 8 inches | . n | 0.04 | Required Volume of Storage | (Rational H | lydrogra | ph) | | |
| - | | | | | i | | | |
| The width at the entrance rime | W _n | 100.00 | | | 100 Yr | 1 Yr | 10 Yr | |
| 1 | | | | | [. | | ļ | |
| | | | | | | | ļ | 1 |
| The velocity at the entrance riffle is calculated using Manning | | 7.57 | Beaufund Mahar 10 | k 2) | | | _ | |
| formula calculator and Qpost for the 1 year storm | Vn Vn | 7.57 | Required volume of Storage (| (3) | 0 | 0 | | |
| | | | | | | | | |
| | | | | | [| | | |
| The depth at the entrance riffle is calculated using Magning | | | | | | • | [| |
| formula calculator and Q _{mul} for the 1 year storm | D _n | 2.20 | Volume provided in pools (ft3) | | | 7778 | | |
| Enter Trial Value : The total pool depth needed to render | | | | | | | | |
| the power equivalent to 100-year predevelopment/desired | | | | | | | | |
| levels. This should be compared against the total | Dput | 7.99 | Volume provided in voids (ft3) | | | 6090 | | |
| This is the braical top width of the dead storage pool parabolic | | | 教理论会会的主要发 | Martin Mertin | 200 | "你们"的"你们" | FIELD C | |
| areas. 10:1 side slope | Wat | 12 | M. C. | all solo | \$ C.2 | | 国際建築学校計 | |
| | ··· Duk | | Provided Volume of Str | 12.2.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1. | 發展 | 公式合計書 | | |
| The area is for a semi parabola | A., | 64 | infiltration) /ha) | CALLUND . | | 14868 | | |
| protection volume. | L | 0 | Page Suffrains Volume 10 | 31.500 | Bratene. | 1 | | |
| Theta - Intermediate step for solving | θ | 1.21 | Peak Manage | ment of 100 | vear sto | orm is satisfied | 1 | |
| Hydraulic Perimeter (ft), for semi parabola | Pout | 21 | Peak Manao | ement of 1 | vear stor | m is satisfied | | |
| Hydraulic Radius, using Chow 1959 | R, | 3.06 | Peak Manage | ment of 10 | vear sto | rm is satisfied | | |
| Darcy Weisbach friction factor expressed in terms of 1 | <u> </u> | 0.32 | - co. munoge | | , | | | |
| Solved using Solver equation: Bernoulli equation rewritter | in terms of data as the | 0.00 | | , | | | | |
| | | | | | | | | |



| Checking Qua | lity Management | |
|---|------------------------------|---|
| ile Drainage Arisa (Acres) | MATTING & AMARIA AND | ABL DOWN ABL SET DOWN |
| Contributory Impervious Area (Acres) | Station has a kind | A STATE OF A |
| /olumetric Runoff Coefficient | Rv | 0.05 |
| Vater Quality Volume, ft3 | wav | 7841 |
| verage Sand filter bed depth (ft) minimum 18 inches | d (Average of Pool and Rate) | 2.0 2.0 |
| Vidith of sand filter (fi) | Wand Steve | 10 50 40 |
| ength of sand filter, where slope < = 5% (ft) | Lsand | 1015 |
| Area of sand filter provided (ft2) | A Provided | 10150 |
| coefficient of permeability of filter media (ft/day) | k | 3.50 |
| eight of water above filter bed- pool depth (ft) | ħ, | 3.00 |
| esign filter bed drain time (days), MDE recommended value | 4 4 | 1.67 |
| Required filter bed area (ft2) | A Parming | 402 |

...

t is satisfied in SPSC

Water g

. . .

· ·

. . <u>Contact</u>

2662 Riva Ro Annapolis, M Phone 410 22

Developed by: Date:



Anne Arundel Caunty Government Department of Public Works Bureau of Engineering Watershed and Ecoxystem Services and Restoration Watershed Assessment and Planning



Input values shaded in Grey, Required Calculated values are noted with dotted pattern Check parameters in bold

| Checking | the Channel Conve | yance for the design flood | | Stower Stelle | | | |
|--|---------------------------------------|--|--|-------------------|--------------------|--|-------------------------------------|
| Time of Concentration in minutes (Before Development) | | 运行全国公司 在10月2日。 | 0.23 0 | | | | |
| Pre development discharge (cfs) | の思想があるので、 | 388.2 | 图是过来2010年1月15日的 | 20149.8 | isbash o | urve for Stone D | ensity = 165 lb/ft3 |
| Post development design discharge (c/s) | | 2007 - 10000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1 | | 149,8 | Cobble d50 size | Allowable Velocity (Supercritical) | Allowable Velocity (Subcritical) |
| Total evaluable length (ff) | | 1015 | Cascade Design (maximum | n 5 ft drop | [inches] | ft/sec | [ft/sec] |
| Elevation drop over length (ft) | delta E 2013 | (This | Design Width (ft) | 40.00 | 4 | 5.1 | 7.1 |
| Total Cascade Length for Project (#) | Lcancede | 0.00 | Design Depth (ft) | 橋 10.00 湯 | 5 | 5.7 | 8,0 |
| Maximum Cascade Slope (ft/ft) | Skope _{cescade} | 0.50 | Roughness | 0.05 | 6 | 6.3 | 8.7 |
| Water Quality stope (ft/ft) | Stope | 0.01 | A | 266.67 | 7 | 6.8 | 9,4 |
| Average Langer of Rifle Segments for Project | N. | | 5 B | 0.79 | 8 | 7.2 | 10.1 |
| Number of Cascade Segments for Project | Nctactada | 0 | R. | 5.81 | 10 | 81 | 11.3 |
| Required Length of Pool Segments (ft) | Lpool | 28 | Design Velocity (fl/sec) | 68.09 | 11 | 8.5 | 11.8 |
| Cobble d50 size (f) - choose -12 inches | a50 | 1.00 | Conveyed Q (cfs) | 18156.55 | 12 | 8,8 | 12.3 |
| Top width of SPSC riffle channel (ft) | w the | 80.0 | No Cascade is Ne | eded | 15 | 9.9 | 13.8 |
| Depth of SPSC tiffle channel (A) | | | Ninimum Pool Dep(h.*Use 3 pools* following each cascade segment (ft) | 82:00 | 18 | 10.8 | 15.1 |
| of the SPSC (if) Enter Decree Pool Depth (fU) | n References | 2,0 30 | ok subcritical/o | k l | Adequate | e convéyance | of design storm |
| Check Riffie Side Siope, Must be > 2H:1V | | 16.0 | | $\overline{}$ | | | |
| Check the Froude Number to ensure Subcritical Flow Con | nditions | 0.3 | | | Selected | year stor | Adequate for 100 |
| | | | | ``` | \ | | |
| Computed Roughness | A | 0.05 | | | 1 | | |
| Riffle Cross Section Area (f(2), for parabola | A | 133,33 | | | Subci | ritical Flow is I | Predominant |
| | | | | | | | |
| 1.heta - Intermediate step for solving | | | ÷ | | | | |
| | | | | | | | |
| Biffie Hurtrauir: Perimeter /ft) for parabola | | an 24 | | - | | | |
| rune rivitatile reminer (ii), ioi paraooa | · · · · · · · · · · · · · · · · · · · | | | | | | |
| | | | | | | | |
| Riffle Hydraulic Radius (ft), using Chow 1959. | | 1.86 | | | | | |
| | | | | | | | |
| Calculated Flow for design parameters (cts) | <u>.</u> | 415:78 | | | | 1 | |
| Check Riffle Velocity (TUSEC) | 1V | 3.12 | Provided total pool | epth (ft) = | 18 54 | | |
| Checking Quan | ntity Management | | hydraulic power for return p | eriod 100 year st | orm is satisfied | | |
| USDA 2006; n.expressed in terms of d_{ss} and $d_{ss} \neq 8$ inches: . | a | .0.04 | Required Volume of Storage | (Rational Hydrod | raph) | | 1 |
| The width at the entrance riffle | tV _{in} . | 60.0D | 1 | 100 | Yr 1 Yr | 10 Yr | |
| | | | | | | | |
| The velocity at the entrance riffle is calculated using Manning | | | | | 1 1 | | |
| formula calculator and Q _{post} for the 1 year storm | V.,, | 7_57 | Required Volume of Storage (fi | 3) 0 | 0 | 0 | |
| | | | } | | | | |
| | | | | | | | |
| The depth at the entrance riffle is calculated using Manning | | | | | | | |
| formule calculator and Q _{post} for the 1 year storm | D _A | 2.50 | Volume provided in pools (ft3) | | 7778 | | |
| the power equivalent to 100-year predevelopment/desired levels. This should be compared against the total | Dowi | 8.32 | Volume provided in voids (ft3) | | 6090 | | |
| This is the typical top width of the dead storage pool parabolic areas, 10:1 side elope | Wout | 12 | | | 98. 19 S - 19 | | |
| The area is for a semi parabola. | Ane | 87 0 | Provided Volume of Storage Infiltration) (ft3) | (excludes | 14868 | | |
| Theta - Internediate step for solving | ⊫eciti .θ. | 1.22 | Peak Manage | ment of 100 year | storm is satisfie | d | |
| Hydrauhc Perimeter (ft), for semi parabola | Pou | | Peak Manag | ment of 1 year s | torm is satisfied | | |
| Hydrautic Radius, using Chow 1959 | | 3.10 | Peak Manage | ment of 10 years | storm is satisfied | 1 | |
| Darcy Weisbach Inclion factor expressed in terms of Ladd, Vpur | | 0.31 | | | | | |
| Solved using Solver equation: Bernoulli equation rewritten | im terms of d _{out} as the | 0.00 | 1 | | | | |
| Checking Qual | ity Management | | Water quality | requirement is s | atisfied in SPSC | | |
| · · · · · · · · · · · · · · · · · · · | | | | | | | |

| Required filter bed area (ft2) | Ar Required | 402 |
|--|---------------------------------------|---|
| design filter bed drain time (days); MDE recommended value | ····· | 4,67 |
| height of water above filler bed, pool depiti (ft) | ħr | 3 .Q9 |
| coefficient of permeability of filter media (ft/day) | | 3.50 |
| Area of sand filter provided (ft2) | A Provided | 10150 |
| Length of sand (ater, where slope < = 5% (ft) | tsead. | 1015 |
| Width of sand filter (fi) | | 2(14)2-2014 - 10 March 2017 |
| Average Sand filter bed depth (ft) minimum 18 inches | CL Average of Add and Hilles | 2.0 A A A A A A A A A A A A A A A A A A A |
| Water Quality Volume, f13 | WOV | 7841. |
| | · · · · · · · · · · · · · · · · · · · | |
| Volumetric Runoff Coefficient | ₽v | 0.D5 |
| Contributory Impervious Area (Acres) | San Shine and the state of the second | 至4年代的全国中国的中国中国的中国中国 |
| Ste Drainage Area (Acres) | 「学校」は、日本語を見てい | 各方的是中国中国共同中国48月4日中国国际和中国 |

.

•

•

,



Appendix F

List of Plan Details and Standard Specifications

PLAN DETAILS AND SPECIFICATION LIST DRAFT FINAL PHASE II NONTIDAL WETLAND AND STREAM MITIGATION PLAN CALVERT CLIFFS NUCLEAR POWER PLANT, UNIT 3

GENERAL REQUIREMENTS

SUMMARY OF WORK SUBMITTAL PROCEDURES CONTRACTOR HEALTH AND SAFETY PLAN ENVIRONMENTAL MANAGEMENT TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS EROSION AND SEDIMENT CONTROL CLOSEOUT PROCEDURES

EARTHWORK

EARTHWORK AND DEWATERING CLEARING AND GRUBBING

RESTORATION TECHNIQUE SPECIFICATIONS REGENERATIVE STORMWATER CONVEYANCE (AA CO. SPEC)

TEMPORARY INSTREAM CONSTRUCTION MEASURES MGWC 1.2: PUMP-AROUND PRACTICE

STREAM CROSSINGS

MGWC 4.1: FORD CROSSING

SLOPE PROTECTION AND STABILIZATION TECHNIQUES

MGWC 2.2: IMBRICATED RIPRAP MGWC 2.4: LIVE STAKES MGWC 2.5: LIVE FACINES MGWC 2.7: BRUSH LAYERING MGWC 2.10: ROOT WADS MGWC 2.11: TOE PROTECTION

CHANNEL STABILIZATION AND REHABILITATION TECHNIQUES

MGWC 3.1: BOULDER PLACEMENT MGWC 3.2: LOG VANES MGWC 3.3: ROCK VANES MGWC 3.4: J-HOOK VANES MGWC 3.8: CROSS VANES MGWC 3.9: STEP POOLS LOG CHANNEL CUT-OFF STRUCTURES ROOT WAD/LOG VANE STRUCTURES

SPECIAL EXCAVATION

WETLAND EXCAVATION STREAM CHANNEL EXCAVATION AND FILL TIDAL EXCAVATION

SPECIAL ENVIRONMENTAL CONTROLS CONTRACTOR POLLUTION CONTROL PLAN

CONSERVATION PLANTING AND SEEDING PLUG/CONTAINER PLANTING DETAIL TREE PLANTING 1" CAL. TREE DETAIL TREE/SHRUB PLANTING DETAIL SOD MATS CONSERVATION PLANTS AND SEEDING

WATER QUALITY MONITORING (DURING CONSTRUCTION)

Appendix G

RSC Specification

REGENERATIVE STORMWATER CONVEYANCE SPECIFICATION (Formerly "Coastal Plains Outfall")

GEOTEXTILE

02550.01 GENERAL

A. Description

Geotextile shall be placed over the prepared surface after The Engineer has approved the excavation as shown on the drawings or as directed by The Engineer.

B. Related Work Included Elsewhere

Not applicable.

C. Quality Assurance

The engineer will inspect all materials prior to and/or after installation to ensure compliance with the Contract Documents.

D. Submittals

None.

02550.02 MATERIALS

A. Materials Furnished by the County

The County will not furnish any materials for geotextile.

B. Contractor's Options

Not applicable.

C. Detailed Material Requirements

1. Fabric shall be furnished in accordance with Section 02295.02. Paragraph 4.

02550.03 EXECUTION

All materials and construction techniques shall be inspected and approved by The Engineer prior to installation.

After the Engineer has approved the excavation, the Contractor shall install the geotextile fabric over the prepared surface. Securing pins shall be used to anchor the fabric in place. Where fabric overlaps are necessary, the minimum overlap shall at least 12 inches.

Geotextile fabric under the cobble weirs will not be required; however, the Contractor shall place geotextile under the sandstone boulders and exercise care in the placement of boulders to prevent puncture of the geotextile. If geotextile is punctured, the boulders shall be fully removed for at least three feet outside the limits of the fabric puncture and a new geotextile patch with minimum overlap, shall be securely fastened over the puncture with securing pins. No payment will be made for work involved in the repair of Contractor damaged geotextile.

The Contractor shall be responsible for disposal of all trash and any materials incidental to the project and disposing of them off-site.

02550.04 METHOD OF MEASUREMENT

Measurement for geotextile will be made of the surface area measured in place and acceptably installed.

02550.04 BASIS OF PAYMENT

Geotextile shall be measured and paid for at the Contract unit price per square yard of fabric installed. Payment for geotextile will be full compensation for furnishing and installing all materials, labor, equipment, tools and incidentals necessary to complete the work as specified in these special provisions and as on the plans.

BANK RUN GRAVEL AND SAND

02551.01 GENERAL

A. Description

The contractor shall furnish all labor, material and equipment required to install bank run gravel and sand as fill material as described in these Special Provisions and shown on the plans. This work shall consist of transporting, installing and maintaining bank run gravel and sand materials within the channel and on the floodplain, as specified on the plans or as directed by The Engineer.

B. Related Work Included Elsewhere

Not applicable.

C. Quality Assurance

The engineer will inspect all materials prior to and/or after installation to ensure compliance with the Contract Documents.

D. Submittals

The Contractor will locate potential sources for the bank run gravel and sand. The Contractor and the Engineer will jointly visit the sites to determine whether the sand and bank run gravel meets the specified requirements. The Contractor will not be granted an extension of time or extra compensation due to delay caused by sampling, testing, approval or disapproval of stone protection material under the requirements of these specifications.

02551.02 MATERIALS

A. Materials Furnished by the County

The County will not furnish any materials for bank run gravel and sand.

B. Contractor's Options

Not applicable.

C. Detailed Material Requirements

- 1. Sand shall meet the requirements of AASHTO C-33 size, #57, Section 02621.02.
- 2. Bank-run gravel shall be BRG base in accordance with Section 02621.02.
- 3. Wood chips and mulch shall be in accordance with Section 02860.02.

The Contractor will locate potential sources for the bank run gravel and sand. The Contractor and the Engineer will jointly visit the sites to determine whether the sand and bank run gravel meets the specified requirements. The Contractor will not be granted an extension of time or extra compensation due to delay caused by sampling, testing, approval or disapproval of stone protection material under the requirements of these specifications.

02551.03 EXECUTION

The Contractor shall install the bank run gravel and sand in accordance with Construction Drawings and these Special Provisions.

All remaining fill areas along the edges, ends of the placed cobble, and the underlying sand bed shall be backfilled with a soil mix comprised of masonry or concrete sand, containing less than 10 percent silt and / or clay, mixed and evenly blended with 20% wood chips or stump grindings, by volume. This material shall be placed to blend in with contiguous slopes, swales, or existing ground or used to form pool bottom.

Bank run gravel and sand shall be placed by mechanical or other acceptable methods with a minimum of voids. The bank run gravel and sand shall be placed to form a neat and uniform surface area. No mortar is permitted.

02551.04 METHOD OF MEASUREMENT

Measurement for bank run gravel and sand will be made of the volume measured in place, in cubic yards, and acceptably installed.

02551.04 BASIS OF PAYMENT

Payment for bank run gravel and sand shall be paid on per cubic yard of sand and bank run gravel installed. Payment will be full compensation for all materials, excavation and installation of sand and bank run gravel and for all material, labor, equipment, tools, and incidentals necessary to complete the work as specified in these special provisions and on the plans.

COBBLE

02552.01 GENERAL

A. Description

The contractor shall furnish all labor, material and equipment required to install cobble structures as described in these Special Provisions and shown on the plans. This work shall consist of transporting, installing and maintaining cobble materials within the channel, as specified on the plans or as directed by The Engineer.

B. Related Work Included Elsewhere

Not applicable.

C. Quality Assurance

The engineer will inspect all materials prior to and/or after installation to ensure compliance with the Contract Documents.

D. Submittals

The contractor will locate potential sources for rock. The contractor shall obtain from the quarry and submit to the Engineer a certificate verifying the rock size, weight per cubic foot, specifications, and weight range of rock being supplied. A representative rock sample and sieve analysis will be submitted to the Engineer for approval <u>prior</u> to delivery to the site. The rock will be accepted upon visual inspection at the point of usage.

02552.02 MATERIALS

A. Materials Furnished by the County

The County will not furnish any materials for cobble.

B. Contractor's Options

Not applicable.

C. Detailed Material Requirements

The stone shall be silica cobbles and shall meet the following requirements as specified.

Grading by Class

Class I Cobble: contain individual pieces between 3 and 12 inches in diameter. The total weight of cobble shall contain not more than 10% of the pieces smaller than 1 inch in diameter.

Grading by D₅₀ Size

Cobble shall be composed of a well-graded mixture of stone size so that 50% of the pieces, by weight, shall be larger than the d_{50} size determined by using charts prepared by the US Department of Agriculture, Soil Conservation Service. A well graded mixture as used herein is defined as a mixture composed primarily of larger stone sizes but with a sufficient mixture of other sizes to fill the large voids between the stones. The diameter of the largest stone size in such a mixture shall be 1.5 times the d_{50} size (e.g., 8" * 1.5 = 12").

Sandstone Grizzly

This material is often referred to as "tailings" which are generated as a result of conventional sand mining operations in the coastal plain or piedmont regions. Sands and gravels that are mined in this region are typically screened prior to being washed to remove these large particles.

Sandstone grizzly shall contain individual pieces between 6 and 24 inches in length (10 - 50lbs). The total weight of boulders shall contain not more than 10% of the pieces smaller than 8 inches in diameter. This material can be used to expand the d_{50} in weirs where engineered sizes require stone larger than silica cobble (listed above).

The Contractor will locate potential sources for the rocks. The Contractor and the Engineer will jointly visit the sites to determine whether the stone meets the specified requirements. The Contractor will not be granted an extension of time or extra compensation due to delay caused by sampling, testing, approval or disapproval of stone protection material under the requirements of these specifications.

02552.03 EXECUTION

The Contractor shall install the cobble in accordance with Construction Drawings and these Special Provisions for cobble weirs. Cobble shall be placed by mechanical or other acceptable methods. The cobble shall be placed to form a neat and uniform surface area. No mortar is permitted.

Cobble shall be graded from the smallest to the largest pieces as specified above and will be controlled by visual inspection. The thickness of the cobble layer shall be 1.5×1.5 times the d50 (18" in depth). Sandstone grizzly may be utilized

in critical areas as determined by The Engineer during construction and shall contain individual pieces between 6 and 24 inches in length (20 - 50lbs).

02552.04 METHOD OF MEASUREMENT

Measurement for cobble will be made of the volume measured in place, in cubic yards, and acceptably installed.

02552.04 BASIS OF PAYMENT

Payment for cobble shall be paid on per cubic yard of cobble installed. Payment will be full compensation for all materials, excavation and installation of cobble, and resetting of cobbles, and for all material, labor, equipment, tools, and incidentals necessary to complete the work as specified in these special provisions and on the plans.

SANDSTONE BOULDERS

02553.01 GENERAL

A. Description

Sandstone (aka, bog iron, ferracrete) is the only large type of boulder found on the coastal plain in Anne Arundel County. It is irregular and generally tabular in shape and neutral or acidic in pH.

The contractor shall furnish all labor, material and equipment required to install sandstone boulders as described in these Special Provisions and shown on the plans. This work shall consist of transporting, installing and maintaining sandstone boulder materials within the channel, as specified on the plans or as directed by The Engineer.

B. Related Work Included Elsewhere

Not applicable.

C. Quality Assurance

The engineer will inspect all materials prior to and/or after installation to ensure compliance with the Contract Documents.

D. Submittals

The contractor will locate potential sources for rock. The contractor shall obtain from the quarry and submit to the Engineer a certificate verifying the rock size, weight per cubic foot, specifications, and weight range of rock being supplied. A representative rock sample and sieve analysis will be submitted to the Engineer for approval <u>prior</u> to delivery to the site. The rock will be accepted upon visual inspection at the point of usage.

02553.02 MATERIALS

A. Materials Furnished by the County

The County will not furnish any materials for sandstone boulders.

B. Contractor's Options

Not applicable.

C. Detailed Material Requirements

Grading by Weight/Size

Sandstone boulders shall contain individual pieces between 2 and 6 feet in length (500 - 6,000lbs). The total weight of boulders shall contain not more than 10% of the pieces smaller than 15 inches in diameter.

The Contractor will locate potential sources for the sandstone boulders. The Contractor and the Engineer will jointly visit the sites to determine whether the stone meets the specified requirements. The Contractor will not be granted an extension of time or extra compensation due to delay caused by sampling, testing, approval or disapproval of stone protection material under the requirements of these specifications.

02553.03 EXECUTION

The Contractor shall install the sandstone boulders in accordance with Construction Drawings and these Special Provisions for sandstone boulders. Geotextile shall be placed at grade under the sandstone boulders as per the construction detail on the plans or as directed by The Engineer. Sandstone boulders shall be placed by mechanical or other acceptable methods with a minimum of voids. The sandstone boulders shall be placed to form a neat and uniform surface area. If necessary, sandstone can be chiseled or broken to achieve improved contact between stones. No mortar is permitted.

02553.04 METHOD OF MEASUREMENT

Measurement for sandstone boulders will be made of the volume measured in place and acceptably installed.

02553.04 BASIS OF PAYMENT

Payment for sandstone boulders shall be paid on per cubic yard of sandstone boulder installed. Payment will be full compensation for all materials, excavation and installation of sandstone boulders, and resetting of sandstone boulders, and for all material, labor, equipment, tools, and incidentals necessary to complete the work as specified in these special provisions and on the plans.

COMPOST

02554.01 GENERAL

A. Description

The contractor shall furnish all labor, material and equipment required to install compost as described in these Special Provisions and shown on the plans. This work shall consist of transporting, installing and maintaining compost material within the project area, as specified on the plans or as directed by The Engineer.

B. Related Work Included Elsewhere

Not applicable.

C. Quality Assurance

The engineer will inspect all materials prior to and/or after installation to ensure compliance with the Contract Documents.

D. Submittals

None.

02554.02 MATERIALS

A. Materials Furnished by the County

The County will not furnish any materials for compost.

B. Contractor's Options

Not applicable.

C. Detailed Material Requirements

Compost shall have a pH between 5.0 and 7.0. It shall be stable and not reheat upon restacking. Compost shall have a moisture content between 30 and 55 percent, a particle size of .5" or less.

Compost shall be of the following type:

Source-Separated Compost (Type B). Source-separated compost will be approved by the Maryland Department of the Agriculture (MDA). Compost shall be produced by an MDA certified compost operator. Compost shall have a soluble salt concentration not to exceed 5 ds (mmhos/cm). Source-separated compost shall be one of the following types: Tree leaf compost.

Non-tree leaf compost. When compost is from lawn clippings, it shall be tested for contaminant in conformance with COMAR 15.18.04.05.

The Contractor will locate, arrange, and coordinate visits to potential sources for the compost. The Contractor and the Engineer will jointly visit the sites to determine whether the compost meets the specified requirements. Compost shall be screened, and subject to approval by the Engineer. The Contractor will not be granted an extension of time or extra compensation due to delay caused by sampling, testing, approval or disapproval of compost material under the requirements of these specifications.

02554.03 EXECUTION

The Contractor shall install compost materials by mechanically blowing the compost into place at depths as specified on the construction drawings.

02554.04 METHOD OF MEASUREMENT

Measurement for compost will be made of the volume, in cubic yards, delivered to the site and acceptably installed.

02554.04 BASIS OF PAYMENT

Payment for compost shall be paid on per cubic yard of compost installed. Payment will be full compensation for all materials, excavation and installation of compost and for all material, labor, equipment, tools, and incidentals necessary to complete the work as specified in these special provisions and on the plans.

INVERTED ROOTWAD

02555.01 GENERAL

A. Description

The contractor shall furnish all labor, material and equipment required to install each inverted rootwad as described in these Special Provisions and shown on the plans. This work shall consist of harvesting, transporting, installing and maintaining inverted rootwad material within the project area, as specified on the plans or as directed by The Engineer.

B. Related Work Included Elsewhere

Not applicable.

C. Quality Assurance

The engineer will inspect all materials prior to and/or after installation to ensure compliance with the Contract Documents.

D. Submittals

None.

02555.02 MATERIALS

A. Materials Furnished by the County

The County will not furnish any materials for inverted rootwads.

B. Contractor's Options

Not applicable.

C. Detailed Material Requirements

Inverted rootwads shall consist of the root fan and trunk of a hardwood or pine tree with a trunk diameter at breast height (DBH) of 6 inches to 24 inches. Root fans shall be oblong to circular in shape and have a minimum spread of 2 feet as measured at its narrowest axis and covering an area a minimum of 16 square feet. The attached trunk shall be a minimum of 6 feet in length.

Inverted rootwads to be used for this construction can be salvaged from the project site provided that they meet the above requirements, are within the limits

of grading, and are clearly flagged for clearing and grubbing. No live trees shall be harvested for the sole purpose of providing materials for this item. If sufficient materials meeting the above requirements are not available from the project site, the Contractor shall then obtain off site material meeting specified requirements.

02555.03 EXECUTION

Inverted rootwads shall be harvested by pushing over trees, leaving as much of the root fan and accompanying sod and soil clumps intact as possible. Care shall be taken in transporting rootwads to the construction site to minimize breakage of the root fan and loss of sod and soil.

Inverted rootwads are located in shallow aquatic pools at locations shown on the profile. Either push the trunk (stem side down) into soil or excavate the trench for the inverted rootwad and place in the trench so that the inverted rootwad sits with the root mass upward in the shallow aquatic pools, and backfill to secure. Placement of the inverted rootwads shall be verified by The Engineer to ensure that the inverted rootwads are secure.

02555.04 METHOD OF MEASUREMENT

Measurement for inverted rootwards will be made per rootwad placed and acceptably installed.

02555.04 BASIS OF PAYMENT

Payment for inverted rootwads shall be measured and paid at the Contract unit price per each inverted rootwad installed. Payment will be full compensation for the harvest and transport of all materials, excavation, installation and resetting of inverted rootwads all materials, excavation and installation of inverted rootwads and for all material, labor, equipment, tools, and incidentals necessary to complete the work as specified in these special provisions and on the plans.

PLANTS AND PLANTING

02556.01 GENERAL

A. Description

Contractor shall furnish all labor, material, equipment required to install plantings as specified on the plans or directed by the Engineer.

All requirements of Section 02860 <u>Furnish and Plant Trees, Shrubs, Vines,</u> <u>Groundcovers and Seedling Stock of the Standard Specifications</u> shall apply except as herein modified or as directed by the Engineer.

B. Related Work Included Elsewhere

Not applicable.

C. Quality Assurance

All requirements of Section 02860 <u>Furnish and Plant Trees, Shrubs, Vines,</u> <u>Groundcovers and Seedling Stock of the Standard Specifications</u> shall apply except as herein modified or as directed by the Engineer.

D. Submittals

None.

02556.02 MATERIALS

A. Materials Furnished by the County

The County will not furnish any materials for plants and planting.

B. Contractor's Options

Not applicable.

C. Detailed Material Requirements

Plants – All planting material shall be native to the Atlantic Coastal Plain region, and should be planted in appropriate wetness zones, as determined by designer, on the site.

The Contractor shall notify the Engineer of the plant deliver date(s), in writing, two (2) weeks prior to delivery.

02556.03 EXECUTION

All requirements of Section 02860 <u>Furnish and Plant Trees, Shrubs, Vines,</u> <u>Groundcovers and Seedling Stock of the Standard Specifications</u> shall apply except as herein modified or as directed by the Engineer.

After 3 years, the planted species must have an 85% survival, or the site must be 85% covered with native, non-invasive species. The pool bottoms must be 85% vegetated with native, non-invasive, wetland plants or aquatic vegetation.

02556.04 METHOD OF MEASUREMENT

All requirements of Section 02860 <u>Furnish and Plant Trees, Shrubs, Vines,</u> <u>Groundcovers and Seedling Stock of the Standard Specifications</u> shall apply except as herein modified or as directed by the Engineer.

02556.04 BASIS OF PAYMENT

All requirements of Section 02860 <u>Furnish and Plant Trees, Shrubs, Vines,</u> <u>Groundcovers and Seedling Stock of the Standard Specifications</u> shall apply except as herein modified or as directed by the Engineer.