Plumtree Branch Ecological Restoration Design (EP-21-003, WP-21-120)

Final Design Report

Howard County, Maryland

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1.0 INTRODUCTION

1.1 Project Description

Ecological restoration is planned for a 2,208 linear foot section of Plumtree Branch and an unnamed tributary to Plumtree Branch, on several Howard County Department of Recreation and Parks properties off Northfield Road in Ellicott City, Maryland. The project is in partnership with the Howard County Office of Community Sustainability (OCS) and will assist Howard County in accomplishing its 2018-2019 Programmatic Two-Year Milestones to restore the Chesapeake Bay and its local rivers, lakes, and streams. Design funding is provided by the Chesapeake Bay Trust Watershed Assistance Grant Program, a program that supports projects that lead to improved water quality in the Maryland portion of the Chesapeake Bay watershed. This reach of Plumtree Branch and the unnamed tributary were selected for restoration as they are currently in an incised and degraded state. The flows are confined within a single, highly erosive channel with limited aquatic habitat and function. Potential causes of degradation include manipulation of the system to a single thread channel lacking sinuosity and a drainage area composed primarily of urban and impervious areas.

1.2. Project Goals and Objectives

The goals of this project include:

- 1. Increase aquatic habitat quality and diversity within the project reach.
- 2. Improve water quality.
- 3. Increase floodplain connectivity throughout the reach.
- 4. Create a complex, heterogeneous floodplain habitat.
- 5. Increase sediment residence time within project reach.
- 6. Create a self-sustaining, resilient system.
- 7. Reduce total nutrient and sediment load

2.0 EXISTING CONDITIONS

2.1 Watershed Information

The proposed restoration project is located on several Howard County Department of Recreation and Parks properties between Northfield Road to the north and Columbia Road to the south. The full project encompasses approximately 1,250 linear feet (lf) of Plumtree Branch and approximately 958 linear feet of the unnamed tributary to Plumtree Branch. There are approximately 6.3 acres (ac) of existing wetlands adjacent to the proposed project. The streams run through existing forests and meadow.

Plumtree Branch is a confluent to Red Hill Branch, eventually flowing into the Little Patuxent River (Federal HUC 02060006). Plumtree Branch and the tributary are classified by the Maryland Department of the Environment (MDE) as Use IV-P: recreational trout waters and public water supply. The construction closure period for the streams runs from March 1 through May 31 inclusive of any year.

At the lower terminus of the project, the contributing watershed is approximately 2.93 square miles with 12.7% forest cover, 32.9% impervious cover, and is 75.3% urban according to 2010 Maryland land use data (U.S. Geological Survey Streamstats program, 2016). Dominant land uses within the drainage area consist primarily of low-density residential land with some areas of high and medium density residential land, commercial areas, and parks and open spaces. The project reach is in a depositional region within the watershed and was likely a forested stream-wetland complex prior to European settlement and subsequent deforestation and degradation of the watershed. Stream discharges at their lower terminuses within the project area are shown in Table 1.

Stream Reach	Bankfull Q (cfs)	2 Year Q (cfs)	10 Year Q (cfs)	100 Year Q (cfs)
Plumtree Branch	228	381	995	2600
Unnamed Tributary	84.4	130	300	714

Table 1: Stream discharges (Q) in cubic feet per second (cfs). Discharges are from the U.S. Geological Survey StreamStats program (2016).

The predominant soils within the study corridor, as mapped on the USDA Web Soil Survey, are Hatboro Codorus silt loams. Additional soils present in the project area include Gladstone-Urban land complexes, Mount Lucas silt loam, and Legore-Montalto-Urban land complex (Soil Survey Staff, accessed 2020). The silt loams contain sandy material. As erosion progresses, the silt entrains in the wash load and transported downstream while the sand aggregates within the channel as the energy of the channel wanes. This has resulted in channel bed material that is primarily sand.

Silt loams are found in alluvial valleys and are indicative of depositional systems. These soils are predominately moderately well drained with some that are poorly drained. This soil composition is likely from deposits of legacy sediment and does not represent the historical composition of the valley soils.

Legacy sediment is soil that has eroded from upland areas due to landscape disturbance, such as deforestation, impoundment of flow, and agricultural practices, following European settlement. Layers of legacy sediment built up over hundreds of years, often trapping thousands of tons of sediment in mill ponds (Walter and Merritts, 2008). Accumulation of legacy sediment buries natural floodplains and wetlands, causing easily erodible banks instead of natural, gently sloping ones. Without these natural features, streams have increased stream power that exacerbates erosion. The failing/breaching of historic mill dams release legacy sediment, commonly leading to channel incision, bank erosion, increased suspended sediment loads, and headcut migration upstream (Miller et al., 2019).

Historical mills most likely impacted the project area. Mills were known to be prevalent in the area. The area now known as Ellicott City was formerly known as Ellicott's Mills due to the abundance of mills in the area (Ellicott's Mills Historic District). Simon J. Martenet's map from

1860 (Figure 1) shows the upstream extent of Plumtree Branch in the project area. From historical records such as the Maryland Historical Trust (Ellicott's Mills Historic District), it is known that more mills existed than are indicated on Martenet's map. Some historic mills pre-date the map by more than 60 years. Mills resulted in the accumulation of highly erodible legacy sediment evident in the valley that buried historic floodplains and wetlands. With a historic abundance of mills within the area, is presumable that the project area of Plumtree Branch was impacted by these structures.



Figure 1: Historic map of Howard County, Maryland (Martenet, S. J., 1860). Arrow pointing to approximate upstream extent of Plumtree Branch in the proposed project area.

2.2 Current Stream Conditions

Using the Cluer & Thorne (2013) Stream Evolution Model (SEM), Plumtree Branch is a Stage Four stream transitioning into a Stage Five and the unnamed tributary is a Stage Four stream. According to Cluer and Thorne (2013), Stage Four channels are characterized as, "incising with unstable, retreating banks that collapse by slumping and/or rotational slips. Failed material is scoured away, and the enlarged channel becomes disconnected from its former floodplain." Streams in Stage Five of the SEM are both aggrading and widening. Cluer and Thorne (2013) characterize Stage Five streams as, "bed [is] rising, aggrading, widening channel with unstable banks in which excess load from upstream together with slumped bank material builds berms and silts bed. Banks [are] stabilizing and berming."

Plumtree Branch is degraded and incised for most of the project reach showing signs of vertical accretion in the form of the channel bottom being lacking riffle material but containing sediment bars formed along the channel. Plumtree Branch contains wide, shallow cross sections dominated by sand and silt. The banks are largely vertical and predominantly have minimal surface protection with a high erodibility risk. No clear riffle pool sequence is present. The unnamed tributary is in a state of degradation and widening. Large rock material was previously added to the tributary, which is incised with near vertical banks lacking surface protection. Both Plumtree Branch and the unnamed tributary lack sinuosity. Plumtree Branch carries large amounts of sediment through the homogeneous system as the stream is disconnected from the floodplain except during storm events. Both the unnamed tributary and Plumtree Branch begin in the project reach in a forested area. Plumtree Branch opens into a meadow surrounded by wetlands with dead and dying ash trees bordering the streambanks. A variety of utilities are present on-site including sewers running parallel to and crossing under Plumtree Branch, bridges, and electric lines. Photos of the existing conditions can be seen in Appendix A: Existing Conditions Photo Exhibit.



Figure 2: Cluer and Thorne's (2013) Stream Evolution model. Plumtree Branch and the unnamed tributary are currently in a Stage Four, with Plumtree Branch progressing transitioning into a Stage Five.

The Maryland Biological Stream Survey (MBSS) had surveyed at the upstream end of the project reach of Plumtree Branch four times. In 2000 (Site ID 956-2-2000), the sample size of benthic macroinvertibrates collected was too small to accurately determine an index of biological integrity. In 2006 (Site ID 0956-07-2006), 2009 (Site ID 0956-02-2009) and 2017 (Site ID 0956-01-2017), the benthic index of biotic integrity rating is poor. In 2017, the score was 1.86/5 (Maryland Stream Health, 2016). On a location on Plumtree Branch upstream of the project area, just south of Frederick Road, the site was surveyed by MBSS in 1997 and 2017. An index of biotic integrity for fish was determined to be fair on both occasions, with the 2017 score as 3.3/5. The fish found include blacknose dace, creek chub, green sunfish, tessellated darter, rosyside dace, white sucker, bluegill, and yellow bullhead (Maryland Stream Health, 2016).

2.3 Existing Riparian Conditions

Nine non-tidal wetlands were found within or adjacent to the project area. Three wetlands were forested, one wetland is emergent, and the remaining 6 wetlands were a combination of emergent and forested conditions. More information about the wetlands on-site, including data sheets, can be found in the attached Wetland Delineation Report (Appendix C).

Four forest stands were identified within or adjacent to the project area. Forest stand 1 is located in the northeast portion of the project area. It is an early- mid-successional, mixed hardwood forest containing floodplains, wetlands, and wetland buffers. Canopy coverage is approximately 75% and the area is dominated by red maple (*Acer rubrum*) and box elder (*Acer negundo*). The shrub layer and understory are sparse, with approximately 5% cover, and include boxelder. Invasive species are relatively high at 35% of the herbaceous plants. Stand condition is generally good.

Forest stand 2 is located in the southeast portion of the site. It is an early-mid-successional, mixed hardwood forest containing floodplains, wetlands, and wetland buffers. Canopy coverage is approximately 80% and the area is dominated by pin oak (*Quercus palustris*) and box elder (*Acer negundo*). The shrub layer and understory are sparse, with approximately 5% cover, and include boxelder. Invasive species are relatively high at 35% of the herbaceous plants. Stand 2 eventually gives way to a more open floodplain with scattered clusters of dying ash (Fraxinus pensylvanica), and black willow (*Salix nigra*). Stand condition is generally good. Areas with high concentrations of ash are in poor condition.

Forest stand 3 is located in the northwest portion of the project area and is an early-midsuccessional, mixed hardwood forest. Canopy coverage is approximately 85% and the area is dominated by box elder (Acer negundo), red maple (*Acer rubrum*), and black cherry (*Prunus serotina*). The shrub layer and understory are sparse, with approximately 5% cover, and include boxelder and red maple with some multiflora rose (*Rosa multifora*) along stand edges and in canopy gaps. Invasive species are relatively high at 30% of the herbaceous plants.

Forest stand 4 is a mid-successional, mixed hardwood forest located on the upland slopes near the southwest portion of the project area. Canopy coverage is approximately 85% and the area is dominated by white oak (*Quercus alba*), tulip poplar (*Liriodendron tulipifera*), red maple (*Acer rubrum*), and white ash (*Fraxinus americana*). The shrub layer and understory are sparse, with

approximately 5% cover, and include ironwood (*Carpinus caroliniana*) and red maple. Invasive species are moderate at 20% of the herbaceous plants.

All trees greater than 12" were surveyed and identified. In total, 973 trees were located, with 34 trees being identified as specimen trees. The list of all trees greater than 12" to be removed, can be found in Appendix D.

3.0 GEOMORPHIC ASSESSMENT

3.1 Assessment Introduction and Methods

A geomorphic assessment was conducted on the study reach of Plumtree Branch and the unnamed tributary. Longitudinal profile and cross sections were surveyed using a laser level and stadia rod to determine the current channel condition. The assessment included evaluating bankfull characteristics including effective discharge, width, depth, cross sectional area, velocity, slope, roughness, channel and bed material size, flood prone width, and channel pool/riffle profile. Bankfull indicators were surveyed as part of the geomorphic assessment to assist with the design discharge determination. Bank Erosion Hazard Index (BEHI) forms were completed along Plumtree Branch and the unnamed tributary.

Plumtree Branch and the unnamed tributary were also visually assessed and categorized using the Cluer & Thorne (2013) Stream Evolution Model (SEM). In addition, topography data was collected by CLSI.

3.2 Assessment Results

Plumtree Branch is degraded and incised for most of the project reach showing signs of vertical accretion in the form of the channel bottom being lacking riffle material but containing sediment bars formed along the channel. The unnamed tributary is in a state of degradation and widening. Large riffle material that was added for erosion protection is present in the tributary.

The assessment reveals Plumtree Branch and the unnamed tributary are incised and have minimal floodplain connectivity. The incision prevents stream flow from getting out of bank as frequently as would a natural, resilient stream. The amount of force contained within the channel is likely the cause of the bank erosion and degradation and prevents the stream from transitioning to a more functional condition. Other factors causing channel degradation are large amounts of impervious and urban land in the drainage area that contribute to extremely flashy flows and higher sediment loads. These flows and sediment loads would be better managed by a stream with more floodplain connectivity that can disperse energy and deposit sediment loads. Additionally, the streams lack dense, deep-rooted vegetation along the channel to stabilize the banks. The total nitrogen load using Protocol 1, 2 and 3 is expected to be reduced by 345.4 lb/yr. Additionally, using Protocol 1, 2, and 3, the approximate sediment reduction is expected to be reduced by 252 ton/yr. The streams are currently functioning as transport reaches, with wide, flat floodplains largely disconnected from

the hydrology of the streams. Channel bed material consists of sand, with some cobble material previously added to the tributary.

BEHI results can be found in Appendix B: Bank Erosion Hazard Index Assessment.

While conducting the stream assessment, it was noted that a large amount of sediment approximately 2 feet in depth has accumulated in the floodplain valley. The age of debris lodged in the sediment, such as that pictured in Figure 3, reveals that the sediment deposit is recent.



Figure 3: Debris lodged in the streambanks indicate a recent deposition of approximately 2 feet of sediment.

Further research was conducted to determine the cause of the accumulated sediment. Aerial imagery was obtained from Howard County Maryland's Interactive Map (2015). A historic aerial from 1943 (Figure 4) reveals Plumtree Branch to be a completely straight stream with no buffer on either side. Agricultural fields come nearly to the top of the streambanks and there are minimal impervious surfaces observed. Columbia Road is not yet built. As aerials progress chronologically, land disturbance, construction, and impervious surfaces increase. By the 1980's, the land surrounding Plumtree Branch and the unnamed tributary has been heavily developed. The photos depict the low sinuous stream present today (Figure 4), and a buffer is present around the stream. From these aerials, it is evident that the sediment has already been deposited in the floodplain. The meanders are caused by the stream moving the fine, aggregated sediment. The buffer was likely established as the accumulated silt was soft and saturated, preventing mowing and access to the

floodplain and allowing riparian vegetation to develop. While land disturbance and increased impervious area cause erosion and sheet runoff, it was likely that floods and storm events amplified the problems.

When Hurricane Agnes reached Maryland in June of 1972, it "dropped an estimated 10-14 inches of rain on already saturated areas of Maryland..." according to a *Baltimore Sun* article (Rector, 2012). The hurricane caused great flooding in Ellicott City and served as a benchmark for future local disasters (Rector, 2012). The flat floodplain of Plumtree Branch was already waterlogged and flooding from Hurricane Agnes presumably brought a large load of silty sediment that settled in the project area.

Consequentially, it is determined that prior to approximately 1980, construction and land disturbance in the drainage area caused sediment to accumulate in the floodplain, with Hurricane Agnes being an exacerbating event. The combination of these factors led to deposition of approximately 2 feet of sediment accumulating in the valley around 1972, causing an artificial floodplain that the Plumtree Branch and the unnamed tributary are disconnected from.



Figures 4: Side by side comparison of a historic aerial from 1943, prior to extensive development increasing impervious surfaces, and 2017 existing conditions. The project area existing stream centerline is shown in blue (Howard County, Maryland Interactive Map, 2015).

4.0 RESTORATION DESIGN

4.1 Design Approach

The stream evolution model (SEM) describes the cyclical nature of stream geomorphology changes as a stream responds to stimuli that alter the form and function of that system (Cluer & Thorne, 2013). The distinction between this and other channel evolution models is the addition of

a pre-disturbance condition referred to as "Stage Zero". This concept is based on recent research conclusions stating that current gravel-based single thread channels are the result of anthropogenic influence and therefore, are not the best target for stream condition when considering restoration in alluvial valleys (Walter & Merritts, 2008). The SEM model focuses on habitat and ecosystem benefits to assess the condition of a stream system. As a function-based model, it supports the habitat and water quality goals of this project. The assessment targeted the most likely predisturbance condition of Plumtree Branch and the unnamed tributary with the intent of maximizing habitat and water quality benefits.

The restoration will help Plumtree Branch and the unnamed tributary become a Stage Eight system. Cluer and Thorne (2013) describe a Stage Eight system as a "meta-stable" channel network. Postdisturbance channel featuring a low flow pilot channel which may ultimately become an anastomosed planform system. This channel is connected to a frequently inundated floodplain that supports wet woodland or grassland that is bounded by set-back terraces on one or both margins. Stage Eight systems function similarly to Stage Zero systems but are not able to access 100% of the floodplain due to various reasons, including infrastructure such as that prevalent at in the project area. The habitat and ecosystem benefits of Stage Eight systems are comparable to those of Stage Zero.

A low-flow, pilot channel carrying approximately one fifth of the current discharge will be created for the mainstem. The pilot channels mimic the radius of curvature and sinuosity of existing, stable reaches of the streams. The restored tributary and Plumtree Branch will have gently sloped banks and will easily and quickly get out of bank during storm events, reconnecting the streams with the floodplain. Existing segments of Plumtree Branch adjacent to the proposed channel will remain. These segments will have fill added and banks graded to create wetland pockets.

The UT Plumtree Branch will be restored using a natural channel design approach. This method was preferred because of site constraints and bed material identified within this area. Additionally, potential access to the floodplain was limited due to the adjacent valley constraints. It was decided that a Rosgen B type channel was appropriate approach due to the level of entrenchment level associated with the channel type and the existing valley constraints.

Energy reducing techniques are proposed throughout the project. A plunge pool proposed at the outfall near the upper terminus of the UT Plumtree Branch will dissipate energy and provide protection against bank and channel erosion. A scour pool is also proposed for the confluence of the UT with the main stem Plumtree Branch. Floodplain roughness is proposed throughout the floodplain. This will increase the roughness or Mannings n which has several benefits including reducing stream power, slowing the water and increasing water surface contact within the restored area, creates habitat, improves hydrology for wetland development and uplift, and can reduce the flood frequency immediately downstream of the site. Wood structures are proposed to reduce energy. These structures will include three inverted trunks with root wads intact that are placed within the center and banks of the low flow channel. Logs will be installed along the floodplain perpendicular to the stream to act as sills to prevent channel bypassing of the root wad structures. Analysis of wood analog structures can be found in Appendix F: Wood Stability Analysis.

The purpose of the low flow pilot channels are to disperse the water across the floodplain and encourage flow to spread out over a wide area. During storm events, the pilot channel will quickly overtop and flood the available width of the floodplain to spread out energy and encourage sediment deposition throughout the floodplain. The stream will be discouraged from incising by installing the wood analog grade control structures and will instead laterally migrate and/or form additional flow paths within the floodplain. Grading is minimized to protect utilities present and avoid impacting natural resources to the furthest extent possible. The grading is net zero, with balanced cut and fill to prevent the need for importing or exporting sediment from the project area. Proposed grading allows for maximum tree retention. Additionally, the trees harvested will be repurposed as mulch for access paths that could be used for community walking paths.

A total of 46 trees are proposed to be removed as a result of the project. Trees range in condition from very poor to good. Three trees larger than 20" diameter at breast height are estimated to be removed. This includes one red maple, one black walnut and one American elm, all of which are in poor condition. All trees except one are being removed as a result of channel grading necessary to establish a stable geometric cross section. One 20" red maple is proposed to be removed for access. Most of the smaller trees proposed to be removed are being removed as a result of channel grading. Channel grading was minimized to the greatest extent to avoid tree and wetland impacts. Trees will be saved to the greatest extent possible during construction. Fewer trees may be taken if it is determined in the field that removal is not necessary. This estimate was an approximate quantity for trees based upon the design plans. All existing trees and trees to be removed can be found in Appendix D: Trees to be Removed.

The restoration will serve to alter the form and SEM stage of the stream system. Current conditions prevent proper sediment transport and storage, flow regimes, floodplain storage and vegetative functions. Restoration will return functions to the system, allow it to function at a higher level, and become more resilient to stimuli as it progresses towards becoming a Stage Eight system. After restoration, the streams will have a higher capacity to respond to changes in the watershed and adjust accordingly to mitigate future loss of function. This project will emphasize and restore the dynamic nature of the channel while protecting existing infrastructure and roadways. The stream realignment, floodplain reconnection, and plantings will create increased functionality for the system and allow the stream to adjust within the valley as an adaptable alluvial system. The woody analog grade control structures will be added to prevent future incision, create habitat, and encourage water dispersion across the floodplain. Community access to the area will be improved by re-purposing mulch from access paths into walking pathways on site.

With the frequent inundation of the floodplain, side channels and wetlands are expected to naturally form, creating a stream-wetland complex. and progression towards a Stage Zero system. Additional flow paths will further reduce the erosion potential of the stream by reducing the overall channel power, promote additional wetland vegetation, and increase the retention time of water and sediment through the system. In turn, this will reduce sediment loads and aid in flood attenuation for downstream reaches. Multiple flow paths would also boost the habitat value of the system by creating the foundations for different complex habitats to develop. This will be beneficial for not only the existing trout use, but in promoting the food trophic levels needed to support fish communities.

4.2 Justification of Design

Wetland functions expected to be enhanced or provided include groundwater recharge and discharge; flood attenuation; fish habitat, food sources, and shade; sediment storage; nutrient removal; organic production export; stabilization of associated streams; and wildlife habitat.

Using Stream Functions Pyramid Framework (Harman et al., 2012), major components that will be enhanced are hydraulics, and geomorphology functions. While improvements to physicochemical and biological functions are anticipated, it is not conclusive.

Hydraulics will be enhanced by restoring the existing straightened Plumtree Branch to resemble that of a floodplain connected stream-wetland complex. A small, low flow pilot channel with a shallow bankfull depth will be created for Plumtree Branch and the tributary. The channels of Plumtree Branch and the unnamed tributary will have a significantly reduced bank height ratios, increased entrenchment ratios, and will promote more frequent out of bank events. This will allow for a frequent hydraulic connection with the existing adjacent wetlands and those expected to naturally form after floodplain reconnection. This hydraulic connection will further promote hydrology from both storm events and ground water connections. Improved flow dynamics will lower stream velocity, shear stress, and stream bank erosion to improve and enhance hyporheic zone for groundwater/surface water exchange.

A shear stress analysis was performed for the existing and proposed conditions using the Streamstats 1.25-yr, 2-yr, 10-yr, and 100-yr flow rates from Table 1 and the proposed floodplain design parameters. The results of the Hec-Ras analyses for shear stress, velocity, and water surface elevation can be seen in the Hec-Ras report (Appendix E). All shear stresses are well below 2.0 psf and should provide a stable foundation for the development of a greatly enhanced wetland complex throughout the floodplain.

Geomorphological functions will be enhanced by creation of bedform diversity, and improved sediment storage, and increased diversity of riparian vegetation. Wood analog grade control structures will be installed to improve bedform diversity and improve habitat as well as other benefits explained throughout the report. A dense riparian buffer of native species will be planted adjacent to the streams and within the constructed wetlands.

Physiochemical enhancement may include improved surface water quality parameters such as temperature, dissolved oxygen, conductivity, pH, and turbidity; improved biological nutrient uptake and storage; and enhanced organic carbon availability and processing. Native vegetation will shade and cool Plumtree Branch and the unnamed tributary while providing a mosaic of habitats valuable to a variety of flora and fauna. Organic matter will be added to the system gradually as leaf fall and natural plant succession. As the stream/wetland complex forms, nitrogen, phosphorus, and sediment will be filtered or stored before impacting downstream reaches.

Post construction the system is anticipated to have increased biodiversity of microbial, macrophytic plant, and aquatic macroinvertebrate communities which will in turn support upper trophic levels including fish. The design will include diverse habitats needed for all stages of fish life cycles.

Research on stream function supports an argument that this type of restoration approach will result in an increase in habitat and ecosystem benefits with an increase in physical complexity (Newson and Newson, 2000). Stream-wetland complexes provide maximal structural complexity throughout the floodplain by creating multiple channels with varying flow regimes and pockets of wetland habitat. This provides excellent habitat for fish, aquatic insects, and microscopic organisms. Stream-wetland complexes also support dense vegetation growth, which provide shade, habitat, cover from predators, and food for primary consumers.

Extremely channelized streams, such as those on-site, show reduced hyporheic connection. Ecotone's proposed restoration approach aims to restore and enhance hyporheic zones throughout the stream valley by morphological features and riparian plantings. Filling the existing channel can raise the water table of the stream valley and supports continuous hyporheic exchange, allowing cool groundwater to enter the stream system and reduce overall water temperature. In addition, the proposed restoration approach facilitates interconnectivity between the streams and their floodplain; dense floodplain and wetland vegetation will provide shade to the stream-wetland complexes and will reduce the input of heat from the sun. Enhanced hyporheic exchange in combination with the resulting high-water table, ensures that groundwater will supply the stream during dry periods and sustain aquatic habitat.

4.3 Planting

A variety of native species of trees and shrubs will be planted in the floodplain as part of the restoration project (Tables 2-4). The riparian buffer adjacent to the stream will consist primarily of species with facultative and facultative wetland indicator status while upland plantings will mostly consist of facultative upland species with upland, facultative, and facultative wetland species mixed in. A riparian buffer species will be planted adjacent to the small baseflow channels so that they establish a stream system controlled by vegetation (Castro & Thorne 2019). The trees and shrubs planted will prefer wetter conditions and will hold the stream together, provide shade to the streams, and encourage complexity both in flows and habitat features. Over time vegetation is expected to take over the stream wetted area and provide the long-term resilience to prevent future degradation. The floodplain planting will improve wildlife habitat, improve soil stabilization and erosion control, and act as a filtration of sediments and runoff pollutants. Additionally, live stakes will be installed in the floodplain.

Existing trees currently growing within the floodplain will be selectively cleared as required during grading operations and used as part of the restoration. This will provide a source for the root wads and log sills used in the wood analog structures and floodplain roughness. There are also small "islands" of trees that are slightly elevated above the proposed floodplain elevation. These will remain, as much as practical, to provide additional habitat and diversity within the proposed floodplain. The design will result in the harvesting of two (2) significant trees, smaller riparian trees, and numerous dead ash trees. The associated grading and limits of disturbance was reduced to the highest extent feasible to provide meaningful restoration while preserving as many existing trees as practicable.

Tables 2-9: Planting tables.

		RIPA	RIAN PLANTINGS TA	BLE (3.42 AC	CRES)		
	Quantity	Scientific Name	Common Name	Size	Condition	Spacing	Indicator
TREES	136	Acer rubrum	Red Maple	1" cal./6' ht	container/bare root	15x15'	FAC
	137	Platanus	American	1" cal./6'	container/bare	15x15'	FACW
	137	Quercus palustris	Pin Oak	1" cal./6' ht.	container/bare root	15x15'	FACW
	136	Salix nigra	Black Willow	1" cal./6' ht.	container/bare root	15x15'	OBL
	137	Betula nigra	River Birch	1" cal./6' ht.	container/bare root	15x15'	FACW
Total	683						
Note: Th	ne plant sche	edule above reflects a	a planting rate of 200) stems/acre			

		U	PLAND PLANTINGS	TABLE (0.07	ACRES)		
	Quantity	Scientific Name	Common Name Size Condition			Spacing	Indicator
TREES	3	Prunus serotina	Black Cherry	1" cal/6' ht.	container/bare root	15x15'	FACU
	2	Juglans nigra	Black walnut	1" cal/6' ht.	container/bare root	15x15'	UPL
	3	Quercus alba	White Oak	1" cal/6' ht.	container/bare root	15x15'	FACU
	3	Quercus palustris	Pin Oak	1" cal/6' ht.	container/bare root	15x15'	FACW
	2	Quercus rubra	Northern Red Oak	1" cal/6' ht.	container/bare root	15x15'	FACU
Total	13						
Note: T	he plant sch	edule above reflec	ts a planting rate of	200 stems/a	cre.		

		RIPARIAN	EXTENDED PLANTIN	IG SCHEDULI	E (6.2 ACRES)		
	Quantity	Scientific Name	Common Name	Size	Condition	Spacing	Indicator
TREES	277	Betula nigra	River Birch	1" cal./6' ht.	container/bare root	15x15'	FACW
	276	Celtis occidentalis	Hackberry	1" cal./6' ht.	container/bare root	15x15'	FACU
	277	Platanus occidentalis	American Sycamore	1" cal./6' ht.	container/bare root	15x15'	FACW
	276	Quercus bicolor	Swamp White Oak	1" cal./6' ht.	container/bare root	15x15'	FACW
	277	Nyssa sylvatica	Black Gum	1" cal./6' container/bare ht. root		15x15'	FAC
Total	1383						
Note: T	he plant sch	nedule above reflects	a planting rate of 2	00 stems/acı	re.		

	LIVE STAKE PLANTING TABLE (4,123 LF)											
	Quantity	Scientific Name Common Name Size Condition Spacing I										
	2910	Salix nigra	Black Willow	-	Live stake	3' triangular	OBL					
	2910	Salix interior	Sandbar Willow	-	Live stake	3' triangular	OBL					
Total	5820											
Note:	The plant sch	edule above reflects a	planting rate of 7,260	livesta	kes/acre based	l on spacing.						

		2" RII	PARIAN PLANTINGS	TABLE (0.41	ACRES)		
	Quantity	Scientific Name	fic Name Common Name Size Condition		Condition	Spacing	Indicator
TREES	8	Acer rubrum	Red Maple	2" cal./6' ht.	container/bare root	22'x22'	FAC
	8	Platanus occidentalis	American Sycamore	2" cal./6' ht.	container/bare root	22'x22'	FACW
	7	Quercus palustris	Pin Oak	2" cal./6' ht.	container/bare root	22'x22'	FACW
	7	Salix nigra	Black Willow	2" cal./6' ht.	container/bare root	22'x22'	OBL
	7	Betula nigra	River Birch	2" cal./6' ht.	container/bare root	22'x22'	FACW
Total	37						
Note: T	he plant sch	edule above reflects	a planting rate of 11	.0 stems/acre	e.		

		2"	UPLAND PLANTING	S TABLE (0.15	ACRES)		
	Quantity	Scientific Name	Common Name	Size	Condition	Spacing	Indicator
TREES	3	Prunus serotina	Black Cherry	2" cal./6' ht.	container/bare root	22'x22'	FACU
	3	Juglans nigra	Black walnut	2" cal./6' ht.	container/bare root	22'x22'	UPL
	3	Quercus alba	White Oak	2" cal./6' ht.	container/bare root	22'x22'	FACU
	3	Quercus palustris	Pin Oak	2" cal./6' ht.	container/bare root	22'x22'	FACW
	2	Quercus rubra	Northern Red Oak	2" cal./6' ht.	container/bare root	22'x22'	FACU
Total	14						
Note: T	he plant sch	edule above reflect	s a planting rate of 1	.10 stems/acre	2.		

		2" RIPARIAN	I EXTENDED PLANTIN	G SCHEDULE	(0.47 ACRES)		
	Quantity	Scientific Name	Common Name	Size	Condition	Spacing	Indicator
TREES	9	Betula nigra	River Birch	2" cal./6' ht.	container/bare root	22'x22'	FACW
	9	Celtis occidentalis	Hackberry	2" cal./6' ht.	container/bare root	22'x22'	FACU
	9	Platanus occidentalis	American Sycamore	2" cal./6' ht.	container/bare root	22'x22'	FACW
	8	Quercus bicolor	Swamp White Oak	2" cal./6' ht.	container/bare root	22'x22'	FACW
	8	Nyssa sylvatica	Black Gum	2" cal./6' ht.	container/bare root	22'x22'	FAC
Total	43						
Note: T	he plant sch	nedule above reflects a	a planting rate of 110	stems/acre.			

4.4 Alternatives Analysis

Alternatives were evaluated to determine which design approach for the project would achieve the goals and objectives of the proposed ecological restoration. The selection of the final design was based on criteria including ability to accomplish goals of the project, ability to protect existing natural resources while still attaining benefits from the project, locations of utilities in the project area, existing stream uses, and landowner and funder considerations and needs. Below are the alternatives that were considered, their benefits, and why they were rejected as the most appropriate approach for this project.

Alternative Design Approach: No Action

The first alternative was a no action approach, i.e., leave the stream in its current condition. This approach would result in failure to meet the project goals and objectives of reducing channel incision, increasing floodplain connectivity and improving aquatic habitat both instream and in the adjacent riparian areas.

Alternative Design Approach: Vegetative Stabilization Approach

The second alternative involved a vegetation stabilization approach, i.e. leave the sinuosity and planform geometry of Plumtree Branch as-is and install a vegetative buffer. However, this approach would fail to meet the project goals and objectives of achieving reduction of sediment and nutrient loading in the watershed while also increasing aquatic habitat.

Alternative Design Approach: Natural Channel Design

The third alternative involved the complete realignment of Plumtree Branch and the unnamed tributary to create a channel in accordance with natural channel design practices. This would create a sinuous, stable, single thread channel that would frequently flood onto its lowered floodplain, reduce bank erosion, and create aquatic habitat in the form of constructed riffles, toewood bank protection, and pools. While the channels would be stable, they would also be static and less resilient than the chosen approach. Most of the energy would still be contained within the channel. This approach would require massive amounts of grading and would remove most of the existing trees in order to construct a new channel and floodplain. Additionally, this design approach would be difficult to effectively implement while working around existing utilities on site such as the sewer line running parallel and crossing under Plumtree Branch. Materials such as rock would need to be imported to construct in-stream features. Materials would be used to construct riffle pool features which do not existing within stable sections of adjacent reaches. This would change the sediment transport dynamics. Project cost would be substantial, and the goals of the project would not be met quickly. The potential temporary impacts to existing wetland habitat and available tree cover are undesirable. The restoration would not align with the historic conditions of the stream and would not ensure a self-sustaining, resilient system. Habitat and sediment and nutrient reductions would not be maximized. While the goals of the project could be partially met with this alternative, it would be more costly and fall short of maximizing the opportunity to fulfill the goals of the project.

Preferred Alternative Design Approach: Restoration to a Stage Eight System

The fourth and selected alternative entails restoration to allow a Stage Eight condition to establish and the creation of a pilot channel for Plumtree Branch. Stage Eight stream systems mirror the functions of Stage Zero stream systems, but do not have access to the entire floodplain. The entirety of the floodplain around Plumtree Branch cannot be accessed due to manholes and existing infrastructure, such as a bridge.

The stream will be restored in order to maximize habitat and water quality benefits, primarily in the form of floodplain reconnection and reducing channel tractive forces. Low flow pilot channels carrying approximately one-fifth of the 1.25 year storm will be designed for Plumtree Branch based on dimensions from assessment data from the stream. The channels will require less grading and disturbance to natural resources than a threshold channel restoration approach. The undersized, low-flow channel with reduced streambank heights coupled with floodplain grading will allow water to frequently get out of bank with storm events and will reduce in-channel stresses.

During high flow events, the floodplain will store sediment that drops out of suspension as velocities are dissipated along the width of the floodplain. Reconnection with floodplain coupled with floodplain grading will recharge existing wetlands and encourage the formation of new

wetlands. By lowering the stream bank heights, we will increase the hydrologic interaction between the stream system and floodplain wetlands in addition to reducing impacts of tractive forces on the stream bed and bank.

Additional side channels are expected to form naturally as sediment accumulates and alters flow paths, creating a braided channel design and eventually, a stream-wetland complex. The stream will be resilient to large-scale degradation and instead will be dynamic and depositional which will form a multithreaded system over time. The stream-wetland complex expected to form will provide floodplain protection by slowing the flow of water, allow groundwater to recharge, and encourage the retention of nutrients and sediments.

Due to the aforementioned valley constraints, the UT Plumtree branch would be constructed using threshold channel design techniques. This would include the installation of a riffle pool complex that discharged into a confluence pool with the main branch.

Existing utilities and infrastructure on site will be avoided to the furthest extent possible. This restoration approach will meet the goals of the project to provide water quality benefits, habitat complexity, and reduced erosion in the watershed.

5.0 CONCLUSION

This restoration project is ideal to accomplish the project goals and increase the resiliency of Plumtree Branch and the unnamed tributary while limiting impacts to existing natural resources and on-site utilities while reducing costs. Approximately 2,208 linear feet of stream will be restored while restoring the floodplain connectivity of Plumtree Branch and the unnamed tributary. As sediment accumulates and alters flow paths a braided channel design will be created that is resilient to large-scale degradation and instead will be dynamic and depositional which will form a stream-wetland complex over time. Returning the stream to more functional stages of the SEM will reduce sediment and nutrient loads, flood velocities and tractive forces, and provide ecological uplift to the watershed. Total sediment and nutrient loads are estimated to be reduced by 252 ton/yr. This approach will result in Plumtree Branch and the unnamed tributary becoming self-sustaining systems. Allowing the system to progress to a Stage Eight stream-wetland complex with a pilot channel is an efficient way to restore this stream system while also limiting risk. The streams will exhibit increased resiliency to changes in land use and climate. Based on historical observations and current conditions, this is the ideal option for restoration, that maximizes stream function while minimizing short term impact and cost.

In 20 years, Plumtree Branch and the unnamed tributary will continue to be a resilient streamwetland complex. This stream-wetland complex will hold onto sediment and nutrients in the project reach for extended periods of time, slowly releasing them to limit downstream impacts. Dense vegetation will shade streams, keeping water cool for fish populations. Groundwater recharge will further cool streams and limit thermal fluctuation. A diverse mosaic of habitat will exist in the wetland complex providing food and refugia for a variety of species.

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Appendix: A

Appendix A: Existing Conditions Photo Exhibit



Photo 1: Existing bridge over the unnamed tributary to Plumtree Branch.



Photo 2: Looking downstream on the unnamed tributary. The stream is incised, and the left bank is almost completely devoid of vegetation. A walking path runs on the top of the left bank.

Plumtree Branch 1



Photo 3: The left bank of the unnamed tributary is near vertical and lacking vegetation with a rooting depth that would assist in bank stabilization. The bank is approximately 4 feet tall.



Photo 4: Manhole and utility pole on the right bank of the unnamed tributary. Many utilities are present in the project area.



Photo 5: Electric lines running over the unnamed tributary.



Photo 6: A walking path runs parallel to the unnamed tributary on the left bank.



Photo 7: Sediment bars are forming in the channel of Plumtree Branch.



Photo 8: Plumtree Branch lacks sinuosity.



Photo 9: Bridge spanning Plumtree Branch.



Photo 10: Plumtree Branch is incised with near vertical banks. The banks lack deep rooted vegetation to help stabilize the channel.



Photo 11: Vertical bank erosion on the outside of the meander.



Photo 12: Sewer line near Plumtree Branch. The sewer runs parallel to Plumtree Branch and crosses under the stream at several locations.



Photo 13: Walking path and sewer manhole adjacent to Plumtree Branch. Many utilities are present in the project area.



Photo 14: Dead and dying ash trees border the downstream reach of Plumtree Branch in the project area.



Photo 15: Culvert under Columbia Road.

Appendix: B

PROTOCOL Plumtree Run	<u>1</u> (Dunloggin Mic	ddle School)															
STEP 1: EST	IMATION OF E	ROSION RAT	TES						Γ		Erosion Rate (ft/yr)]		Sedim	ent Load (ton/	yr)
Description	Bank Side (Facing DS)	Station Star	t Station End	Bank Height (ft)	Radius of Curvature (ft)	Bankfull Width (ft)	BEHI Score	NBS Score*	Bulk Density of Soil (lb/cf)	Colorado, 1989	USFWS Draft DC ⁺	NRCS, NC ⁺	Length (ft)	Area (sf)	Colorado, 1989	USFWS Draf DC	t NRCS, NC
Trib	LEFT	0+00	1+25	10			HIGH	4	88.75	0.575	1.023	0.205	1+25	1250	31.9	56.8	11.4
Trib	RIGHT	0+00	1+25	3.5			moderate	4	88.75	0.420	0.812	0.106	1+25	437.5	8.2	15.8	2.1
Trib	LEFT	1+25	1+90	8			very high	4	88.75	0.575	1.023	0.913	0+65	520	13.3	23.6	21.1
Trib	RIGHT	1+25	1+90	4			moderate	4	88.75	0.420	0.812	0.106	0+65	260	4.8	9.4	1.2
Trib	LEFT	1+90	2+50	11			low	2	88.75	0.036	0.019		0+60	660	1.0	0.5	
Trib	RIGHT	1+90	2+50	4.5			very high	5	88.75	0.872	1.641	1.139	0+60	270	10.4	19.7	13.6
Trib	LEFT	2+50	3+45	9			very high	5	88.75	0.872	1.641	1.139	0+95	855	33.1	62.3	43.2
Trib	RIGHT	2+50	3+45	4			moderate	2	88.75	0.153	0.113	0.016	0+95	380	2.6	1.9	0.3
Trib	LEFT	3+45	4+60	8			moderate	3	88.75	0.253	0.303	0.041	1+15	920	10.3	12.4	1.7
Trib	RIGHT	3+45	4+60	3.5			moderate	3	88.75	0.253	0.303	0.041	1+15	402.5	4.5	5.4	0.7
Trib	LEFT	4+60	5+90	3			low	3	88.75	0.074	0.077		1+30	390	1.3	1.3	
Trib	RIGHT	4+60	5+90	4.5			HIGH	4	88.75	0.575	1.023	0.205	1+30	585	14.9	26.6	5.3
Trib	LEFT	5+90	7+25	5			HIGH	3	88.75	0.380	0.638	0.148	1+35	675	11.4	19.1	4.4
Trib	RIGHT	5+90	7+25	4			moderate	3	88.75	0.253	0.303	0.041	1+35	540	6.1	7.3	1.0
Trib	LEFT	7+25	8+30	3.5			moderate	3	88.75	0.253	0.303	0.041	1+05	367.5	4.1	4.9	0.7
Trib	RIGHT	7+25	8+30	2			low	2	88.75	0.036	0.019		1+05	210	0.3	0.2	
Trib	LEFT	8+30	9+20	5			HIGH	5	88.75	0.872	1.641	0.282	0+90	450	17.4	32.8	5.6
Trib	RIGHT	8+30	9+20	3.5			moderate	3	88.75	0.253	0.303	0.041	0+90	315	3.5	4.2	0.6
Mainstem	LEFT	9+20	10+65	3			low	2	75.55	0.036	0.019		1+45	435	0.6	0.3	
Mainstem	RIGHT	9+20	10+65	5			HIGH	4	75.55	0.575	1.023	0.205	1+45	725	15.8	28.0	5.6
Mainstem	LEFT	10+65	12+00	4			moderate	3	75.55	0.253	0.303	0.041	1+35	540	5.2	6.2	0.8
Mainstem	RIGHT	10+65	12+00	2			low	2	75.55	0.036	0.019		1+35	270	0.4	0.2	
Mainstem	LEFT	12+00	13+60	3			moderate	3	75.55	0.253	0.303	0.041	1+60	480	4.6	5.5	0.7
Mainstem	RIGHT	12+00	13+60	3			low	2	75.55	0.036	0.019		1+60	480	0.6	0.3	
Mainstem	LEFT	13+60	14+15	4			HIGH	4	75.55	0.575	1.023	0.205	0+55	220	4.8	8.5	1.7
Mainstem	RIGHT	13+60	14+15	2			low	2	75.55	0.036	0.019		0+55	110	0.1	0.1	
Mainstem	LEFT	14+15	15+40	1			low	2	75.55	0.036	0.019		1+25	125	0.2	0.1	
Mainstem	RIGHT	14+15	15+40	3			low	2	75.55	0.036	0.019		1+25	375	0.5	0.3	
Mainstem	LEFT	15+40	17+30	4			HIGH	3	75.55	0.380	0.638	0.148	1+90	760	10.9	18.3	4.3
Mainstem	RIGHT	15+40	17+30	3			moderate	3	75.55	0.253	0.303	0.041	1+90	570	5.5	6.5	0.9
Mainstem	LEFT	17+30	18+00	2			low	2	75.55	0.036	0.019		0+70	140	0.2	0.1	
Mainstem	RIGHT	17+30	18+00	4.5			HIGH	5	75.55	0.872	1.641	0.282	0+70	315	10.4	19.5	3.4
Mainstem	LEFT	18+00	18+66	4			moderate	3	75.55	0.253	0.303	0.041	0+66	264	2.5	3.0	0.4
Mainstem	RIGHT	18+00	18+66	3			low	3	75.55	0.074	0.077		0+66	198	0.6	0.6	
Mainstem	LEFT	18+66	19+15	1			low	2	75.55	0.036	0.019		0+49	49	0.1	0.0	
Mainstem	RIGHT	18+66	19+15	3.5			moderate	3	75.55	0.253	0.303	0.041	0+49	171.5	1.6	2.0	0.3
Mainstem	LEFT	19+15	21+00	5			HIGH	4	75.55	0.575	1.023	0.205	1+85	925	20.1	35.8	7.2
Mainstem	RIGHT	19+15	21+00	4			moderate	3	75.55	0.253	0.303	0.041	1+85	740	7.1	8.5	1.1
Mainstem	LEFT	21+00	21+40	3			moderate	3	75.55	0.253	0.303	0.041	0+40	120	1.1	1.4	0.2
Mainstem	RIGHT	21+00	21+40	3			low	2	75.55	0.036	0.019		0+40	120	0.2	0.1	
*Conservative	e estimate base	d on radius of	curvature and	bankfull esti	mate. Enter NB	S directly wh	en availabl	e.			*Low and Moderate set ed	ual to High above NBS 4.		Total	272	449	139

STEP 2: NUTRIENT LOADING

Nutrient	Site Specific (lb/ton)	CBP 2014 (lb/ton)
Phosphorus	1.48	
Nitrogen	3.08	

Estimated

Reduction	
50%	

STEP 3: NUTRIENT REMOVAL

Bank	Nitrogen	Phosphorus	Sediment
Erosion	(lb/yr)	(lb/yr)	Load (lb/yr)
Colorado	419	201	272253
DC	692	332	449264
NC	215	103	139336
Average	442	212	286951

Appendix: C



Plumtree Branch at Dunloggin Middle School Stream Restoration – Wetland Delineation Report

Introduction:

Ecotone, Inc. has completed a wetland delineation for the proposed Plumtree Branch at Dunloggin Middle School Stream Restoration Project. The Project aims to provide water quality improvements within the watershed through the reduction and removal of sediment, nitrogen, phosphorus, and other pollutants; increase the habitat availability and variety; and improve channel stability along this reach. This report provides location and presence information of non-tidal wetlands and waterways located within and adjacent to the project area.

Site Description:

The Plumtree Branch at Dunloggin Middle School Stream Restoration Project Site is located near the Dunloggin Middle School at 9129 Northfield Road in the Ellicott City area of Howard County, Maryland. (39.254685, -76.834042). The project affects an approximately 13 ac portion of the 25-acre parcel. The site is located in the Little Patuxent Watershed (02060006), part of the larger Patuxent River sub-basin. The project area is surrounded by institutional uses (school, parkland) and residences. The impacted parcel is zoned low density residential. Historically, uses for the site included forest, and residential uses.

Site Investigation Methodology:

Criteria used to conduct the wetland delineation are consistent with those procedures established by the 1987 U.S. Army Corps of Engineers Wetlands Delineation Manual and the 2010 Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Eastern Mountain and Piedmont Region (Version 2.0). The 1987 Manual describes wetlands as those areas that have permanent or periodic inundation or saturation by surface or ground water to create anaerobic conditions in the soil to support a prevalence of vegetation typically adapted for life in saturated soil conditions. Therefore, environmental criteria for wetlands includes the following:

- Vegetation: the prevalent vegetation is hydrophytic (>50%).
- Hydrology: the area is either permanently or periodically inundated, or the soil is saturated to the surface during the growing season.
- Soils: the soils observed have been classified as hydric, and/or anaerobic conditions have developed in the soils.

As described in the above documents, the Routine Onsite Inspection Determination Method was used for this wetland delineation. This method is a combination of an off-site data review and an on-site inspection to identify wetland boundaries. Off-site sources such as the National Wetland Inventory Map and the USDA Soil Map were consulted during this wetland delineation; final wetland determinations were based field observations. The following describes the approach used to complete the on-site wetland identification and delineation effort:

1. Plant community types were observed and their dominant species identified. Wetland indicator status was obtained, if available, for each species and recorded on the field data sheet. If greater than 50 percent of the dominant species in the plant community were observed to have an

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Plumtree Branch at Dunloggin Middle School Stream Restoration Wetland Delineation Report

indicator status of facultative (FAC) or wetter (FACW, OBL), then a hydrophytic vegetative community was determined to be present.

2. Prospective wetland areas were examined for the presence of hydrology. If wetland hydrologic indicators (surface water, high water table, saturation, etc.) were observed, then sufficient hydrology for the existence of wetlands was determined to be present.

3. Auger borings of the soil substrate in the prospective wetland areas were examined in multiple locations. The characteristics of the soil were compared to hydric soil indicators as prescribed by the 2012 Regional Supplement. If the soils were observed to have positive hydric soil indicators (depleted matrix, histosol, aquatic moisture regime, low chroma colors, etc.), then hydric soil was determined to be present.

4. If all the above characteristics (hydrophytic vegetation, hydrology, and hydric soils) were found to be present in a prospective wetland area, the area was defined and delineated as a wetland. If the any of the above characteristics were not found in a prospective wetland area, then the area is not considered a wetland. Given the farmed nature of some wetlands and their lack of hydrophytic vegetation, best professional judgement was used in determining wetland presence/absence.

Findings:

Desktop Findings: National Wetlands Inventory map indicated the presence of one linear waterway within the project t area. FEMA-mapped floodplains occur on site (Map Panel Number: 24025C0110E). Soil Survey information was obtained from the USDA National Resource Conservation Service online soil survey mapping website. The following soil types were identified for the project area and are shown on the Wetland Investigation Site Plan:

- GfB: Gladstone Urban Land complex, 0-8% slopes
- GfC: Gladstone Urban Land complex, 8-15% slopes
- Ha:Hatboro-Codorus silt loams, 0-3% slopes
- LoC: Legore-Montalto-Urban Land Complex, 8-15% slopes
- MoB: Mount Lucas silt loam, 3-8% slopes, stony

On-Site Findings: Wetland delineation field activities were conducted on April 27, 2020, Haley Kelly (Professional Wetland Scientist), an Ecotone environmental scientist trained in wetland delineation. During the site visit, it was determined that nontidal wetlands and waters of the U.S. exist on the site. Within the proposed project area, wetland boundaries and stream top-of-bank were identified in the field and located with a Leica GPS unit.

All resources have been located on the attached Existing Conditions Plan. Data were recorded on Wetland Determination Data Forms. A color photographic log depicting the wetland habitats observed during the field effort are included with this report. Presented below are the findings of the on-site wetland identification:

Nine non-tidal wetlands were identified within or adjacent to the project area:

Wetland 1 (approximately 2,904 square feet) is in the northern portion of the project area along the unnamed tributary to Plumtree Branch. It is a forested wetland dominated by box elder (*Acer negundo*), lesser celandine (*Ranunculus ficaria*), reed canary grass (*Phalaris arundinacea*), wild geranium (*Geranium maculatum*), and lurid sedge (*Carex lurida*). Hydrology is associated with

Plumtree Branch at Dunloggin Middle School Stream Restoration Wetland Delineation Report

surface water, high water table, and saturation. Soils in Wetland 1 meet hydric soil indicator F6 (Redox Dark Surface) and F7 (Depleted Dark Surface).

Wetland 2 (approximately 9,182 square feet) is in the northern portion of the project area along the unnamed tributary to Plumtree Branch. It is a forested wetland dominated by box elder, multiflora rose (*Rosa multiflora*), lesser celandine, reed canary grass, wild geranium, and lurid sedge. Hydrology is associated with surface water, high water table, and saturation. Soils in Wetland 1 meet hydric soil indicator F6 (Redox Dark Surface) and F7 (Depleted Dark Surface).

Wetland 3 (approximately 571square feet) is located in the central portion of the site along the west bank of Plumtree Branch. This floodplain depression wetland is dominated by red maple (*Acer rubrum*), multiflora rose, lesser celandine, and Japanese stilt grass (*Microstegium vimineum*). Wetland hydrology is indicated by saturation, water-stained leaves, and low geomorphic position. Soils meet the F7 hydric soil indicator.

Wetland 3B (approximately 240 square feet) is located in the central portion of the site along the west bank of Plumtree Branch. This floodplain depression wetland is dominated by red maple (*Acer rubrum*), multiflora rose, lesser celandine, and ground ivy (*Glechoma hederacea*). Wetland hydrology is indicated by saturation, water-stained leaves, and low geomorphic position. Soils meet the F7 hydric soil indicator.

Wetland 4 (approximately 37,862 square feet) is in the south-central portion of the site along the western bank of Plumtree Branch. This floodplain wetland is split evenly between forested and emergent wetland. The vegetative community can be summarized by red maple, lesser celandine, tussock sedge (*Carex stricta*), lurid sedge, and reed canary grass. Wetland hydrology was indicated by saturation, high water table, surface water, and water-stained leaves. Soils meet the F7 hydric soil indicator.

Wetland 5 (approximately 4,945 square feet) is in the southern portion of the site along the western bank of Plumtree Branch. This floodplain wetland is predominantly emergent (PEM) wetland with scattered trees throughout. The vegetative community can be summarized by scattered red maple and pin oak (*Quercus palustris*), multiflora rose, reed canary grass, lesser celandine, lurid sedge and skunk cabbage (*Symplocarpus foetidus*). Wetland hydrology was indicated by saturation, high water table, and surface water. Soils meet the F7 hydric soil indicator.

Wetland 6 (approximately 25,427 square feet) is in the southern portion of the site along the western bank of Plumtree Branch. This wetland has forested (PFO) and emergent portions (PEM). The vegetative community can be summarized by box elder, black willow (*Salix nigra*), and reed canary grass. Wetland hydrology was indicated by saturation, high water table, low geomorphic position, and drainage patterns. Soils meet the F7 hydric soil indicator.

Wetland 7 (approximately 71,843 square feet) is located in the southern portion of the site on the eastern bank of Plumtree Branch. This toe-of-slope, floodplain wetland is a predominantly emergent wetland (PEM). The wetland is dominated by reed canary grass and lesser celandine. Wetland hydrology is indicated by surface water, saturation, hydrogen sulfide odor, drainage patterns, and low geomorphic position. Soils consist of mineral layers with redox concentrations typical of an F3 hydric soil indicator and A4 indicator (Hydrogen sulfide).

Wetland 8 (approximately 120,629 square feet) is a toe-of-slope, floodplain wetland in the central portion of the site along the eastern bank of Plumtree Branch. The wetland is dominated by emergent

Plumtree Branch at Dunloggin Middle School Stream Restoration Wetland Delineation Report

vegetation in the south and forested in the north. Vegetation is dominated by red maple, box elder, multiflora rose, tussock sedge, lurid sedge, and reed canary grass. Wetland hydrology is indicated by high water table, surface water, saturation, hydrogen sulfide, drainage patterns, and low geomorphic position. Soils consist of mineral layers with redox concentrations typical of an F3 hydric soil indicator and A4 indicator (Hydrogen sulfide).

Waters of the U.S. include the following:

Plumtree Branch is an approximately 2,447-linear foot, perennial waterway located in the central portion of the site. The stream enters the project area from the north and flows south until it exits the project area via two 108" culverts under Columbia Road. The stream appears to have been historically straightened is currently experiencing significant bank erosion.

Plumtree Branch Tributary is an approximately 1,016 linear foot, perennial waterway located in the northern portion of the site. It daylights from a storm drain just north of the project boundary and flows down a concrete spillway before transitioning to a natural channel. It continues to flow southwest towards its confluence with Plumtree Branch. This tributary is also experiencing significant bank erosion.

Unnamed Tributary 1 is an approximately 62-linear foot, perennial waterway located in the central portion of the site along the western bank of Plumtree Branch. It enters the project area from the west and flows through a ravine to its confluence with Plumtree Branch.

Unnamed Tributary 2 is an approximately 142-linear foot, perennial waterway in the central portion of the site along the easter bank of Plumtree Branch. It originates just off-the property flows west to its confluence with UT First Mine Branch. This tributary was part of a previous restoration as evidenced by the presence of imbricated rock.

Uplands adjacent to these wetlands are characterized by depleted soils with some redoxomorphic features. The vegetative communities in these areas are similar to the vegetative communities in the neighboring wetlands and include typical floodplain species including box elder, red maple, black willow and reed canary grass. Hydrological indicators in these areas are lacking.

Conclusions:

On-site, there are nine non-tidal wetlands and three unnamed tributaries in addition to Plumtree Branch. Collectively there are approximately 6.28 acres of non-tidal wetland and 3,667 linear feet of stream. Final determination of the limits of Federal/State jurisdiction is the shared responsibility of the U.S. Army Corps of Engineers and Maryland Department of the Environment. If the proposed activities on the property require work within these jurisdictional areas and their applicable buffers, application for approvals from these agencies will be submitted.
Project/Site:	Plumtree E	3ranch/Dunloggin	1 Middle Schoo	I City	City/County: Ellicott City, Howard Co.				ampling Date:	4/2	27/20
Applicant/Owner:		Howard County	Dept. of Parks	and Recreation		Stat	te: MD) Sa	ampling Point:	[)P-1
Investigator(s):		HK		Sec	tion,Townsh	ip, Range:					
Landform (hillslope, t	errace, etc.)	F	loodplain	Loca	al relief (con	cave, convex	, none):	Concav	ve S	lope (%):	0%
Subregion (LRR or N	ILRA):	LRR S	\$	Lat: 39	9.2557	Long:		-76.8344	Datum:	WGS	84
Soil Map Unit Name:		Mob (Mount L	ucas Silt Loam	, 3-8% slopes, very	/ rocky)		NWI cla	assification:	Ν	I/A	
Are climatic / hydrolo	gic conditions o	n the site typical	for this time of	year? Yes	 	No	(If no, e	explain in Remai	rks.)		
Are Vegetation N	, Soil N	, or Hydrology	N Sign	ificantly disturbed?		Are "Norm	nal Circum	stances" presen	it? Yes [✓ N	о 🗌
Are Vegetation N	, Soil N	, or Hydrology	N Natu	rally problematic?		(If needed	, explain a	iny answers in F	 Remarks.)		
SUMMARY OF FI	NDINGS - A	- Attach site n	nap showi	ng sampling	point loc	ations, tr	ansect	s, importar	nt features	s, etc.	
Hydrophytic Vegetati	on Present?	Yes 🗸	No								
Hydric Soil Present?		Yes	No E	✓ Is th	ne Sampled	Area					
Wetland Hydrology F	'resent?	Yes 🗸	No [with	nin a Wetlan	nd?	Yes		b \checkmark		
Remarks: Approximately 2" of rain	fell on the site th	ne night before th	ne delineation.	Saturation was not	used as a s	sole indicator	of hydrolog	gy.			
HYDROLOGY											
Primary Indicators (r Primary Indicators (r Surface Water High Water Tal Saturation (A3) Water marks (f Sediment Depo Drift Deposits (Iron Deposits (Inundation Visi	y Indicato <u>ninimum of one</u> (A1) ble (A2) (A1) 31) poits (B2) B3) ust (B4) B5) ble on Aerial Im : : : : : : : : : : : : :	rs: <u>is required: chec</u> agery (B7) No [k all that apply Water-Stair Aquatic Far True Aquat Hydrogen S Oxidized R Presence o Recent Iror Thin Muck Other (Expl) ned Leaves (B9) una (B13) ic Plants (B14) Sulfide Odor (C1) hizospheres on Liv of Reduced Iron (C4 n Reduction in Tille Surface (C7) lain in Remarks)	ing Roots (C I) d Soils (C6))))))))))))))))))))	Second Surface Sparse Drainag Moss T Dry-Sea Crayfis Saturat Stunted Geomo Shallow Microto FAC-Ne	ary indicators of e Soil Cracks (Bi ly Vegetated Co ge Patterns (B10 rim Lines (B16) ason Water Tab h Burrows (C8) ion Visible on A d or Stressed Pla rphic Position (I v Aquitard (D3) pographic Relie eutral Test (D5)	<u>minimum or w</u> 6) incave Surfac)) le (C2) erial Imagery ants (D1) D2) f (D4)	(C9)	<u></u>
Water Table Present Saturation Present?	? Yes Yes	✓ № ✓ № ✓ № ✓ №	Depth (inch	nes): 3 nes): surface	— — —	atland Hydrol	loav Prese	ant? Ye	ae 🗸	No 🗌]
Describe Recorded Data	(stream gage, i	nonitoring well, a	ierial photos, pi	revious inspections), if available	e:					

Tree Stratum (Distrize) 20 ft radius)	Absolute	Dominant		Domiance Test worksheet
Tree Stratum (Piot size: <u>30 it radius</u>).	% Cover	Species?	Indicator Status	
1. Acer negundo	5	Yes	FAC	Number of Dominant Species
2.				That are OBL, FACW, or FAC: 3 (A)
3.				Tatal Number of Deminerat
4.				l otal Number of Dominant
5.				Species across all Strata: 4 (B)
0. 7				Porcont of Dominant Spoicos
7. 50% total cover: 2.5% 20% total cover: 1.0%	5%	– Total Cover		that are OBL EACW or EAC: 75.0% (A/B)
	0.10			
Sapling Stratum (Plot size: <u>15 ft radius</u>).	Absolute	Dominant Species2	Indiantar Status	Prevalence Index worksneet
1	% Cover	Species?	Indicator Status	OPL species 0 V 1 0
2				ODE species = 0 EACW species = 30 + 2 = -60
3				FAC species $35 \times 3 = 105$
4				FACU species $10 \times 4 = 40$
5.				UPL species $20 \times 5 = 100$
6.				Column Totals 95 (A) 305 (B)
7.				、/、/
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		Prevalence Index = B/A = 3.21%
	Absolute	- Dominant		Hydrophytic Vegetation Indicators:
Shrub Stratum (Plot size: <u>15 ft radius</u>).	% Cover	Species?	Indicator Status	1. Rapid Test of Hydrophytic Vegetation
1.				2. Dominance Test is >50%
2.				3. Prevalence Index is ≤3.0 ¹
3.				4. Morphological Adaptations ¹ (Provide supporting
4.				data in Remarks or on a separte sheet)
5.				Problematic Hydrophytic Vegetation ¹ (Explain)
6.				
7.				¹ Indicators of hydric soil and wetland hydrology must
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		be present, unless disturbed or problematic.
Harb Stratum (Diat size) Efficiency)	Absolute	Dominant		Definitions of Vegetation Strata:
Heid Stiatuili (Plot size. <u>5 it faulus</u>).	% Cover	Species?	Indicator Status	Tree Weedy plants, evoluting weedy vines, approximately
1. Ranunculus ficaria	30	Yes	FAC	20 ft (6 m) or more in beight and 3 in (7.6 cm) or larger in
2. Phalaris arundinaceae	30	Yes	FACW	diameter at breast height (DBH).
3. Stellaria media	20	Yes	UPL	
4. Galium aparine	10	No	FACU	Sapling - Woody plants, excluding woody vines,
5.				approximately 20 ft (6 m) or more in height and less then
0. 7				3 in. (7.6 cm) DBH.
7. 9				Chruh Weady plants such ding weady vince
8. 9				Shrub - woody plants, excluding woody vines,
10				
11.				
12				Herb - All nerbaceous (non-woody) plants, including
50% total cover: 45.0% 20% total cover: 18.0%	90%	= Total Cover		event woody vines, less than approximately 3 ft (1 m) in
	Absoluto	Dominant		height
Woody Vine Stratum (Plot size: <u>30 ft radius</u>).	% Cover	Species?	Indicator Status	Woody Vine - All woody vines, regardless of height
1	70 COVCI	Species:		
2				
3.	1		+	Hydropytic
4.	1		+ 1	Vegetation
7.				Present? Yes 🗹 No 🗌
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover	·	
Remarks: (If observed, list morphological adaptations bolow)		-		1
normano, in observed, normorphological adaptations below).				

Sampling Point:

Soils								Sampling Point:	DP-1
Profile Descri	ption: (Describe to the de	epth needed t	o document the i	ndicator or o	confirm the a	absence of in	dicators.)		
Depth	Matrix			Redox Fea	itures				
(inches)	Color (moist)	%	Color (moist)	%	Type ¹	Loc ²	Texture	Rema	rks
0.15		100			51		alau la am		
0-15	10YR 4/2	100					clay loam		
					<u> </u>				
					·				
					·				
					·				
1Type: C-Conc	entration D-Depletion R	M-Reduced M	atrix MS-Masked	Sand Grains	2		ore Lining M-Matrix	-	
					». Ц		ore Eming, m-matrix		
Hydric Soil Ind	dicators:						Indicators	of Problematic Hyd	Iric Soils ³ :
Histosol (A	1)		Dark Surfac	e (S7)			2 cm Muck	(A10) (MLRA 147)	
Histic Epipe	edon (A2)		Polyvalue B	elow Surace	(S8) (MLRA	147,148)	Coast Prairi	e Redox (A16) (MLF	RA 147, 148)
Black Histic	: (A3)		Thin Dark S	urface (S9) ((MLRA 147, 1	148)	Piedmont Fl	loodplain Soils (F19)) (MLRA 136,
Hydrogen S	Sulfide (A4)		Loamy Gley	ed Matrix (F	2)		147)		
Stratified La	ayers (A5)		Depleted M	atrix (F3)	、		Very Shallo	w Dark Surface (TF1	12)
			Redox Dark	Surface (F6)		Uther (Expla	ain in Remarks):	
	elow Dark Surface (ATT)			ark Surrace (F/)				
Sandy Muc	Sullace (ATZ) kv Mineral (S1)(I RR N MI	RA 147 148)		essions (Fo) nese Masses	(F12) (I RR	N MI RA 136)		
	od Matrix (SA)			ace (F13) (N	II RA 136 12	(2))		
Sandy Oicy	nx (S5)		Piedmont F	loodplain Soi	ils (F19) (MI	RA 148)			
Stripped Ma	atrix (S6)		Red Parent	Material (F2	1) (MLRA 12	7, 147)			
				· · · · · · · · · · · · · · · · · · ·			³ Indicators (of hydrophytic veget:	ation and
							wetland hvd	Iroloav must be pres	ent. unless
							disturbed or	problematic.	,
Restrictive Lay	er (if observed):								
Туре:	· · · ·								
Depth (inches	s):					F	lydric Soil Present?	Yes 🗌 No	, ✓
	·						5		
Remarks:	, roolu ,								
Solis were very	/ ГОСКУ.								

Project/Site:	Plumtree I	Branch/Dunloggin	Middle School	City/County:	Ellicott City, H	loward Co	i. Sa	ampling Date:	4/2	27/20
Applicant/Owner:		Howard County D	ept. of Parks and F	Recreation	State	e: MD	Sa	ampling Point:)P-2
Investigator(s):		HK		Section, Tow	nship, Range:					
Landform (hillslope,	terrace, etc.)	Flo	odplain	Local relief (concave, convex,	none):	Conca	ve S	lope (%):	0%
Subregion (LRR or M	/ILRA):	LRR S	L	at: 39.2557	Long:		-76.8344	Datum:	WGS	84
Soil Map Unit Name	:	Mob (Mount Lu	cas Silt Loam, 3-89	% slopes, very rocky)		NWI cla	ssification:	Ν	J/A	
Are climatic / hydrolo	ogic conditions o	on the site typical f	or this time of year	? Yes 🗸	No	(If no, e	xplain in Remar	ˈks.)		
Are Vegetation N	, Soil N	, or Hydrology	N Significan	itly disturbed?	Are "Norma	al Circums	stances" presen	it? Yes [✓ N	0
Are Vegetation N	, Soil N	, or Hydrology	N Naturally	problematic?	(If needed,	explain a	ny answers in F	≀emarks.)		
SUMMARY OF F	INDINGS - A	Attach site m	ap showing s	sampling point	ocations, tra	ansects	s, importan	t features	s, etc.	
Hydrophytic Vegetat	ion Present?	Yes 🗸	No							
Hydric Soil Present?)	Yes 🗸	No 🗌	Is the Samp	led Area					
Wetland Hydrology I	Present?	Yes 🗸	No 🗌	within a We	tland?	Yes	⊡ No	b 🗌		
Pomarks:						-				
In Wetland 1. Approxima	ately 2" of rain fe	ell on the site the n	ight before the deli	neation. Saturation wa	is not used as a s	ole indica	tor of hydrology	<u>.</u>		
Wetland Hydrol	ogy Indicato	ors:				Second	ary Indicators (r	minimum of tv	vo require	:d)
Primary Indicators (minimum of one	is required: check	all that apply)			Surface	Soil Cracks (Be	6)		
✓ Surface Water	· (A1)		Water-Stained L	eaves (B9)		Sparsel	y Vegetated Co	ncave Surfac	e (B8)	
High Water Ta	ible (A2)		Aquatic Fauna (B13)		Drainag	e Patterns (B10))		
Saturation (A3			True Aquatic Pla	ants (B14)		Moss II	im Lines (B16)	. (00)		
Vvater marks (BI)		Hydrogen Sulfid	e Odor (CT)	- (02)	Dry-Sea	ISON Water Tab	le (C2)		
Sediment Dep	OSITS (BZ)		Oxidized Rhizos	spheres on Living Root	s (C3)	Crayiisr	Buffows (C8)	orial Imagon	(CO)	
	(D3) rust (D4)		Presence of Rec	Juceu II 011 (C4) Juction in Tillod Soils ((Salurali		enai inagery	(09)	
	(B5)		Thin Muck Surfa	acco (C7)	.0)	Geomo	rnhic Position (דע) צוווג) רב		
	ible on Δerial Im	agery (B7)	Other (Explain in	n Remarks)		Shallow	$\Delta auitard (D3)$)2)		
				T Kemarksj		Microto	nogranhic Relie	f (D4)		
							outral Tast (DE)	1 (04)		
Field Observations						FAC-INE				
	o. ont2 V		Donth (mahaz)	2						
Surface water Prese	ent? Yes			2						
Water Table Present	t? Yes		Depth (inches):	3						
(includes capillary fr	inge)		Depth (Inches):	sunace	Wetland Hydrold	ogy Prese	ent? Y€	es 🗸	No 🗌]
Describe Recorded Data	a (stream gage,	monitoring well, ae	erial photos, previo	us inspections), if avai	able:					
Remarks:										
On previous site visit, th	is area was obs	erved to be satura	ted even without re	ecent rain.						

	Absolute	Dominant		Domiance Test worksheet
Tree Stratum (Plot size: <u>30 ft radius</u>).	% Cover	Species?	Indicator Status	
1. Acer negundo	15	Yes	FAC	Number of Dominant Species
2.				That are OBL, FACW, or FAC: 4 (A)
3.				
4.				Total Number of Dominant
5.				Species Across All Strata: <u>5</u> (B)
6. 7				Dereent of Deminent Choices
7. $\frac{1}{2} = \frac{1}{2} = \frac$	1E0/	Total Cover		that are ORL EACW or EAC: 90.0% (A/D)
	10%			
Sapling Stratum (Plot size: 15 ft radius).	Absolute	Dominant		Prevalence Index worksheet
	% Cover	Species?	Indicator Status	l otal % Cover of: Multiply by:
l. 2				$\begin{array}{llllllllllllllllllllllllllllllllllll$
2.				FACW species $10 \times 2 = 20$
5. A				FAC species $52 \times 5 = 150$
τ. Γ			<u> </u>	$IIPL species \qquad 0 \qquad X5 = 0$
6			<u> </u>	Column Totals 94 (A) 259 (B)
7				
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		Prevalence Index = B/A = 2.76%
	Absolute	– Dominant		Hydrophytic Vegetation Indicators:
Shrub Stratum (Plot size: <u>15 ft radius</u>).	% Cover	Species?	Indicator Status	1 Rapid Test of Hydrophytic Vegetation
1.	70 00101			2 Dominance Test is >50%
2.				3 . Prevalence Index is $\leq 3.0^1$
3.				4. Morphological Adaptations ¹ (Provide supporting
4.				data in Remarks or on a separte sheet)
5.				Problematic Hydrophytic Vegetation ¹ (Explain)
6.				
7.				¹ Indicators of hydric soil and wetland hydrology must
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		be present, unless disturbed or problematic.
	Absolute	Dominant		Definitions of Vegetation Strata:
Herd Stratum (Plot size: <u>5 ft radius</u>).	% Cover	Species?	Indicator Status	
1. Ranunculus ficaria	30	Yes	FAC	Tree - woody plants, excluding woody vines, approximately 20 ft (6 m) or more in height and 2 in (7.6 cm) or larger in
2. Phalaris arundinaceae	10	Yes	FACW	diameter at breast beight (DBH)
3. Geranium maculatum	10	Yes	FACU	
4. Carex lurida	10	Yes	OBL	Sapling - Woody plants, excluding woody vines
5. Lonicera japonica	5	No	FAC	approximately 20 ft (6 m) or more in height and less then
6. Juncus effusus	5	No	OBL	3 in. (7.6 cm) DBH.
1. Allium canadense	5	No	FACU	
8. VIOIA SOIOITA	2	NO	FAC	Shrub - Woody plants, excluding woody vines,
	Z	INU	FACU	approximately 3 to 20 ft (1 to 6 ff) in height.
10.				
12				Herb - All herbaceous (non-woody) plants, including
50% total cover: 39.5% 20% total cover: 15.8%	79%	= Total Cover	<u> </u>	nerbaceous vines, regardless of size, and and woody plants, overant woody vines, less than approximately 2 # /1 m in
	Absoluto	- Deminent		beight
Woody Vine Stratum (Plot size: <u>30 ft radius</u>).	Absolute % Cover	Dominant Species?	Indicator Status	Woody Vine - All woody vines, regardless of height.
1	70 00001	Species:		
2				
3.		1	+	Hydropytic
4.		1	+	Vegetation
7.			1 1	Present? Yes 🗹 No 🗌
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover	·	
Remarks: (If observed, list morphological adaptations bolow)		_		1
nemana, in observed, list morphological adaptations below).				

Sampling Point:

Soils								Sampling Point:	DP-2
Profile Descri	otion: (Describe to the d	lepth needed	to document the i	indicator or (confirm the	absence of ir	ndicators.)		
Depth	Matrix			Redox Fea	atures				
(inches)	Color (moist)	%	Color (moist)	%	Type ¹	Loc ²	Texture	Remai	rks
0-3	10YR 3/2	100					clay		
3-12	10YR 3/2	70	2.5Y 4/1	20	D	М	clay		
			10YR 4/4	10	С	М			
								<u>.</u> .	
								<u> </u>	
'Type: C=Conc	entration, D=Depletion, R	KIVI=Reduced IV	atrix, MS=Masked	I Sand Grains	S. ² L	.ocation: PL=P	ore Lining, M=Matrix		
Hydric Soil Ind	dicators:						Indicators	of Problematic Hyd	ric Soils ³ :
Histosol (A1)		Dark Surfac	ce (S7)			2 cm Muck	(A10) (MLRA 147)	
Histic Epipe	edon (A2)		Polyvalue E	Below Surace	e (S8) (MLR A	A 147,148)	🗌 Coast Prairi	e Redox (A16) (MLR	A 147, 148)
Black Histic	(A3)		Thin Dark S	Surface (S9) ((MLRA 147,	148)	Piedmont Fl	oodplain Soils (F19)	(MLRA 136,
Hydrogen S	ulfide (A4)		Loamy Gle	yed Matrix (F	2)		147)		
Stratified La	ayers (A5)		Depleted N	1atrix (F3)			Very Shallo	w Dark Surface (TF1	2)
2 cm Muck	(A10) (LRR N)		✓ Redox Darl	k Surface (F6)		Other (Expla	ain in Remarks):	
Depleted Be	elow Dark Surface (A11)		Depleted D	ark Surface ((F7)				
Thick Dark	Surface (A12)		Redox Dep	ressions (F8)) (F10) (I DF				
	KY Mineral (ST)(LRR N,M	LRA 147,148)		anese Masses	S (F I Z) (LRH	(N, MLRA 136 22)	b)		
Sandy Gley	ed Matrix (S4)			Tace (FT3) (IV Tacedolaio So	(ILKA 130, 1 ile (E10) (MI	ZZ) DA 140\			
Sandy Red	0X (S5)			• 1000piairi 50 t Matorial (E2	1) (MI DA 1'	.KA 148) 07 147)			
	atrix (S6)			i ivialeriai (FZ		27, 147)	3		
							"Indicators (of hydrophytic vegeta	ition and
							disturbed or	nroblematic	ent, uniess
								problematic.	
Restrictive Lav	er (if observed).								
Type:									
Depth (inches	5):					ŀ	Hvdric Soil Present?	Yes 🗹 No	
	,						,		
Remarks:									

Project/Site:	Plumtree E	Branch/Dunloggin	Middle School	City/County:	ty, Howard Co. Sampling Date:				//20	
Applicant/Owner:		Howard County E	ept. of Parks and Recre	eation	State	e: MD	Sam	pling Point:	DP	·-3
Investigator(s):		HK		Section, Towns	ship, Range:					
Landform (hillslope,	terrace, etc.)	Flo	odplain	Local relief (co	oncave, convex,	none):	Concave	Slope	e (%):	0%
Subregion (LRR or M	/ILRA):	LRR S	Lat:	39.2557	Long:	-	76.8344	Datum:	WGS84	4
Soil Map Unit Name:		Ha (Hatbo	o-Codorus Silt Loam, 0	-3% slopes)		NWI class	sification:	N/A		
Are climatic / hydrolc	ogic conditions o	n the site typical f	or this time of year?	Yes 🗸	No	(If no, exp	olain in Remarks	.)		
Are Vegetation N	, Soil N	, or Hydrology	N Significantly di	sturbed?	Are "Norma	al Circumsta	ances" present?	Yes 🗸	No	
Are Vegetation N	, Soil N	, or Hydrology	N Naturally prob	ematic?	(If needed,	explain any	, answers in Rer	narks.)		
SUMMARY OF F	INDINGS - A	Attach site m	ap showing sam	pling point lo	ocations, tra	ansects,	important	features, e	etc.	
Hydrophytic Vegetat	ion Present?	Yes 🗸	No							
Hydric Soil Present?		Yes 🗸	No	Is the Sample	ed Area					
Wetland Hydrology F	Present?	Yes 🗸	No 🗌	within a Wetla	and?	Yes	✓ No			
HYDROLOGY							i of fijalologj.			
Primary Indicators (r ✓ Surface Water ✓ High Water Ta ✓ Saturation (A3) ✓ Water marks (f ✓ Sediment Depo ✓ Drift Deposits (✓ Algal Mat or Cl ✓ Iron Deposits (✓ Inundation Visi	minimum of one (A1) ble (A2)) B1) osits (B2) (B3) rust (B4) (B5) ible on Aerial Im	is required: check	all that apply) Water-Stained Leave Aquatic Fauna (B13) True Aquatic Plants (Hydrogen Sulfide Od Oxidized Rhizospher Presence of Reduce Recent Iron Reductio Thin Muck Surface (Other (Explain in Ref	es (B9) (B14) or (C1) es on Living Roots d Iron (C4) on in Tilled Soils (C6 C7) marks)	(C3)	Surface S Sparsely Drainage Moss Trir Dry-Seas Crayfish I Saturation Stunted c Geomorp Shallow A Microtopo FAC-Neu	Soil Cracks (B6) Vegetated Conc Patterns (B10) n Lines (B16) on Water Table Burrows (C8) n Visible on Aeri r Stressed Plant hic Position (D2) Aquitard (D3) ographic Relief (I tral Test (D5)	ave Surface (E (C2) al Imagery (C9 s (D1)) D4)	;8))	
Field Observations	:									
Surface Water Prese Water Table Present Saturation Present? (includes capillary fri	ent? Yes ?? Yes Yes nge)	✓ No ✓ No ✓ No	Depth (inches): Depth (inches): Depth (inches):	2 3 surface	Vetland Hydrold	ogy Presen	t? Yes	No) <u> </u>	
Describe Recorded Data	a (stream gage, i	monitoring well, a	erial photos, previous in	spections), if availal	ble:					
Remarks:										

VEGETATION - Use scientific names of pla	ants.			Sampling Point: DP-3
Tree Stratum (Plot size: <u>30 ft radius</u>).	Absolute % Cover	Dominant Species?	Indicator Status	Domiance Test worksheet
1. Acer negundo	15	Yes	FAC	Number of Dominant Species
2.				That are OBL, FACW, or FAC: 4 (A)
3.				
4.				Total Number of Dominant
5.				Species Across All Strata: 6 (B)
6.				
7.				Percent of Dominant Speices
50% total cover: 7.5% 20% total cover: 3.0%	15%	= Total Cover		that are OBL, FACW, or FAC: 66.7% (A/B)
	Absolute	 Dominant		Prevalence Index worksheet
Sapling Stratum (Plot size: <u>15 ft radius</u>).	% Cover	Species?	Indicator Status	Total % Cover of: Multiply by:
1.				OBL species 20 $\overline{X1} = 20$
2.				FACW species 25 X 2 = 50
3.				FAC species 47 X 3 = 141
4.				FACU species $24 \times 4 = 96$
5.				UPL species 0 X 5 = 0
6.				Column Totals 116 (A) 307 (B)
7.				Devisione ladar D/A
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover	•	Prevalence index = $B/A = 2.65\%$
	Absolute	 Dominant		Hydrophytic Vegetation Indicators:
Shrub Stratum (Plot size: <u>15 ft radius</u>).	% Cover	Species?	Indicator Status	1 Rapid Test of Hydrophytic Vegetation
1 Rosa multiflora	10	Yes	FACU	\checkmark 2 Dominance Test is >50%
2	10	100	17100	\checkmark 3. Prevalence Index is $\leq 3.0^{1}$
3				4. Morphological Adaptations ¹ (Provide supporting
4		-		data in Remarks or on a senarte sheet)
5				Problematic Hydrophytic Vegetation ¹ (Explain)
6				· · · · · · · · · · · · · · · ·
7				¹ Indicators of hydric soil and wetland hydrology must
50% total cover: 5.0% 20% total cover: 2.0%	10%	= Total Cover		be present, unless disturbed or problematic.
	Abcoluto	- Dominant		Definitions of Vegetation Strate:
Herb Stratum (Plot size: <u>5 ft radius</u>).		Dominant Species2	Indicator Status	Deminitions of vegetation Strata:
1 Depunculus ficeria	% COVEI	Species		Tree - Woody plants, excluding woody vines, approximately
1. Rahuhulus huana 2. Dhalaris arundinacoao	10	Vos	FAC	20 ft (6 m) or more in height and 3 in. (7.6 cm) or larger in
2. Filalalis al ullullateae 3. Coranium maculatum	10	Vos	FACU	diameter at breast height (DBH).
5. Geranium macuatum A Carox lurida	10	Vos		
4. Carex lunda 5. Lysimachia nummularia	10	No	EACW/	Sapling - Woody plants, excluding woody vines,
5. Lysinacha hummuana 6. Arisaoma trinbullum	5	No	FACW	approximately 20 ft (6 m) or more in height and less then
7 Carox stricta	5	No		3 in. (7.6 cm) DBH.
8 Lonicera ianonica	5	No	EAC	Shrub Woody plants, evoluting woody vines
9 luncus effusus	5	No		approximately 3 to 20 ft (1 to 6 m) in bound
10 Allium canadense	2	No		$a_{\rm PP}$ oximately 5 to 20 ft (1 to 0 ff) in height.
11 Viola sororia	2	No	FAC	
1) Glechoma hederacea	2	No	FACIL	Herb - All herbaceous (non-woody) plants, including
50% total cover: 45.5% 20% total cover: 18.2%	<u> </u>	- Total Cover	TACU	nerbaceous vines, regardless of size, and and woody plants,
	7170			except woody vines, less than approximately 3 ft (1 m) in
Woody Vine Stratum (Plot size: 30 ft radius)	Absolute	Dominant		
	% Cover	Species?	Indicator Status	Woody Vine - All woody vines, regardless of height.
1.				
2.				
3.		1		Hydropytic
4.				Vegetation
7.				Present? Yes <u>V</u> No
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		
Remarks: (If observed, list morphological adaptations below)				•
Remarks, in observed, list morphological adaptations below)	•			

Soils								Sampling Point:	DP-3
Profile Descrip	otion: (Describe to the d	epth needed	to document the i	indicator or o	confirm the	absence of ir	ndicators.)	-	
Depth	Matrix			Redox Fea	atures				
(inches)	Color (moist)	%	Color (moist)	%	Type ¹	Loc ²	Texture	Rema	rks
0-3	10YR 3/2	100					clay		
3-12	10YR 3/2	70	2.5Y 4/1	20	D	М	clay		
			10YR 4/4	10	С	М			
								_	
'Type: C=Conc	entration, D=Depletion, R	IM=Reduced N	latrix, MS=Masked	Sand Grains	S. ² L	.ocation: PL=P	ore Lining, M=Matrix		
Hydric Soil Inc	dicators:						Indicators	of Problematic Hyd	ric Soils ³ :
Histosol (A1)		Dark Surfac	ce (S7)			2 cm Muck	(A10) (MLRA 147)	
Histic Epipe	edon (A2)		Polyvalue E	Below Surace	e (S8) (MLR A	A 147,148)	🗌 Coast Prairi	ie Redox (A16) (MLR	A 147, 148)
Black Histic	(A3)		Thin Dark S	Surface (S9) ((MLRA 147,	148)	Piedmont F	loodplain Soils (F19)	(MLRA 136,
Hydrogen S	Sulfide (A4)		Loamy Gle	yed Matrix (F	2)		147)		
Stratified La	iyers (A5)		Depleted N	latrix (F3)			Very Shallo	w Dark Surface (TF1	2)
	(A10) (LRR N)		Redox Darl	k Surface (F6)) 		Other (Expla	ain in Remarks):	
	elow Dark Surface (A11)		Depleted D	ark Surface (F/)				
Sandy Mucl	Sufface (AT2) ky Mineral (S1)(LPP N M I	I PA 1/7 1/8)	Redox Dep	ressions (F8)) s (F12) (I PE		5)		
	od Matrix (SA)			face (F13) (N	M RA 136 1	22)	<i>)</i>		
Sandy Gley	cu (S5)		Piedmont F	loodplain So	ils (F19) (ML	RA 148)			
Stripped Ma	atrix (S6)		Red Parent	t Material (F2	1) (MLRA 12	27, 147)			
				,	/ 、	. ,	³ Indicators (of hydrophytic vegeta	ation and
							wetland hyd	Irology must be pres	ent, unless
							disturbed or	problematic.	
Restrictive Laye	er (if observed):								
Туре:								_	_
Depth (inches	5):					ł	Hydric Soil Present?	Yes 🔽 No	,
Remarks [.]									
rtomarto.									

Project/Site: Plumtr	ee Branch/Dunloggin Mi	ddle School	City/County: Ellicott City, Howard Co. Sampling					/27/20
Applicant/Owner:	Howard County Dep	pt. of Parks and Recreat	ion	State	: MD	Sampling Pc	oint: I	DP-4
Investigator(s):	НК		Section, Towns	ship, Range:				
Landform (hillslope, terrace, etc.)	Floor	dplain	Local relief (co	ncave, convex, r	none):	Concave	Slope (%):	0%
Subregion (LRR or MLRA):	LRR S	Lat:	39.2557	Long:	-76.834	44 Datum	n: WGS	\$84
Soil Map Unit Name:	Ha (Hatboro-	-Codorus Silt Ioam, 0-3%	6 slopes)		NWI classification	on:	N/A	
Are climatic / hydrologic condition	ns on the site typical for	this time of year?	Yes 🗸	No	(If no, explain in	1 Remarks.)		
Are Vegetation N , Soil N	J . or Hydrology	N Significantly dist	irhed?	Are "Norma	- I Circumstances"	' present? Ye	s 🗸 🛛 N	lo 🗌
Are Vegetation N , Soil N	<pre>v v v v v v v v v v v v v v v v v v v</pre>	N Naturally problem	natic?	(If needed,	explain any answ	vers in Remarks.)	<u> </u>	<u> </u>
SUMMARY OF FINDINGS	- Attach site ma	p showing samp	ling point lo	ocations, tra	insects, imp	ortant featu	res, etc.	
Hydrophytic Vegetation Present?	Yes 🗸	No						
Hydric Soil Present?	Yes	No	Is the Sample	d Area				
Wetland Hydrology Present?	Yes	No 🗸	within a Wetla	and?	Yes	No	/	
Approximately 2" of rain fell on the si	ite the night before the d	elineation. Saturation w	<u>/as not used as a</u>	sole indicator of	hydrology.			
								T
Primary Indicators (minimum of minimum of mini	ators: <u>one is required: check al</u>	<u>II that apply)</u> Water-Stained Leaves (Aquatic Fauna (B13) True Aquatic Plants (B1 Hydrogen Sulfide Odor Oxidized Rhizospheres Presence of Reduced Ir Recent Iron Reduction i Thin Muck Surface (C7) Other (Explain in Rema	(B9) (C1) on Living Roots (ron (C4) in Tilled Soils (C6)) rks)	(C3)	Secondary mut Surface Soil Cra Sparsely Vegeta Drainage Patter Moss Trim Line: Dry-Season Wa Crayfish Burrow Saturation Visib Stunted or Stres Geomorphic Po Shallow Aquitar Microtopograph FAC-Neutral Te	<u>aters (mmmun o</u> acks (B6) ated Concave Sur ns (B10) s (B16) iter Table (C2) <i>r</i> s (C8) ole on Aerial Image ssed Plants (D1) isition (D2) rd (D3) ic Relief (D4) est (D5)	face (B8) ery (C9)	<u>(0)</u>
Surface Water Present? Y Water Table Present? Y Saturation Present? Y (includes capillary fringe)	'es □ No ✓ 'es □ No ✓ 'es □ No ✓	Depth (inches): Depth (inches): Depth (inches):		Vetland Hydrolo	gy Present?	Yes 📃	No]
Describe Recorded Data (stream gag	ge, monitoring well, aeria	al photos, previous inspe	ections), if availat	ole:				

VEGETATION - Use scientific names of pla	nts.			Sampling Point: DP-4
Tree Stratum (Plot size - 30 ft radius)	Absolute	Dominant		Domiance Test worksheet
	% Cover	Species?	Indicator Status	
l.		-		Number of Dominant Species
3				
4				Total Number of Dominant
5.				Species Across All Strata: 5 (B)
6.				(-,
7.				Percent of Dominant Speices
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		that are OBL, FACW, or FAC: 80.0% (A/B)
	Absolute	Dominant		Prevalence Index worksheet
Sapling Stratum (Plot size: <u>15 ft radius</u>).	% Cover	Species?	Indicator Status	Total % Cover of: Multiply by:
1. Acer rubrum	5	Yes	FAC	OBL species 10 X 1 = 10
2. Fraxinus pensylvanica	5	Yes	FACW	FACW species 5 X 2 = 10
3. Acer negundo	5	Yes	FAC	FAC species $60 \times 3 = 180$
4.				FACU species $35 \times 4 = 140$
0.				UPL species $0 \times 5 = 0$
5. 7				Column Totals = 110 (A) = 340 (B)
7. 50% total covor: 7.5% 20% total covor: 3.0%	15%	- Total Covor		Prevalence Index = $B/A = \frac{300\%}{100\%}$
	1370			
Shrub Stratum (Plot size: 15 ft radius).	Absolute	Dominant	la d'a stan Ctatur	Hydrophytic Vegetation Indicators:
, <u> </u>	% Cover	Species?	Indicator Status	I. Rapid Test of Hydrophytic Vegetation
l. 2				2. Dominance Lest is >50%
2.				4 Morphological Adaptations ¹ (Provide supporting
4				data in Remarks or on a senarte sheet)
5				Problematic Hydrophytic Vegetation ¹ (Explain)
6.				
7.				¹ Indicators of hydric soil and wetland hydrology must
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		be present, unless disturbed or problematic.
	Absolute	– Dominant		Definitions of Vegetation Strata
Herb Stratum (Plot size: <u>5 ft radius</u>).	% Cover	Species?	Indicator Status	
1. Ranunculus ficaria	50	Yes	FAC	Tree - Woody plants, excluding woody vines, approximately
2. Glechoma hederacea	25	Yes	FACU	20 ft (6 m) or more in height and 3 in. (7.6 cm) or larger in
3. Festuca rubra	10	No	FACU	diameter at breast neight (DBH).
4. Carex stricta	10	No	OBL	Carling Weedy dente evoluting weedy vince
5.				Saping - woody plants, excluding woody vines,
5.				3 in. (7.6 cm) DBH.
7.				
				Shrub - Woody plants, excluding woody vines,
۶. ۱۵		-		approximately 3 to 20 ft (1 to 6 m) in height.
IU. 11				
12		-		Herb - All herbaceous (non-woody) plants, including
50% total cover: 47.5% 20% total cover: 19.0%	95%	= Total Cover		nerbaceous vines, regardless of size, and and woody plants,
	Absolute	- Deminent		beight
Woody Vine Stratum (Plot size: <u>30 ft radius</u>).	Absolute % Cover	Dominant Species2	Indicator Status	Moody Vine - All woody vines regardless of height
1	% Cover	Species	Indicator Status	
)				
3				Hydropytic
4.				Vegetation
7.			1	Present? Yes 🗹 No 🗌
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		
Remarks: (If observed, list morphological adaptations below)				
in observed, list merphological adaptations below).				

Soils								Sampling Point:	DP-4
Profile Descrip	otion: (Describe to the d	lepth needed	to document the	indicator or	confirm the	absence of ir	ndicators.)	-	
Depth	Matrix			Redox Fea	atures				
(inches)	Color (moist)	%	Color (moist)	%	Type¹	Loc ²	Texture	Remai	rks
0-4	10YR 3/2	100					clay		
4-10	10YR 4/4	95	10YR 4/6	5	С	М	clay		
¹ Type: C=Conc	entration, D=Depletion, R	M=Reduced M	atrix, MS=Masked	Sand Grains	δ. 2	.ocation: PL=P	Pore Lining, M=Matrix		
Hudric Soil Inc	licatore						Indicators	of Problematic Hyd	ric Soils ^{3.}
			Dark Surfa	ce (S7)			2 cm Muck	(A10) (MLRA 147)	
Histic Epipe	don (A2)		Polyvalue I	Below Surace	e (S8) (MLRA	A 147,148)	🛄 Coast Prairi	e Redox (A16) (MLR	A 147, 148)
Black Histic	(A3)		Thin Dark S	Surface (S9)	(MLRA 147,	148)	Piedmont Fl	loodplain Soils (F19)	(MLRA 136,
Hydrogen S	ulfide (A4)		Loamy Gle	yed Matrix (F	2)		147)		
Stratified La	(A10) (LDD N)		Depleted N	Aatrix (F3)			Very Shallow	w Dark Surface (TF1	2)
	(ATU) (LKK N) Now Dark Surfaco (A11)		Redox Dar Depleted D	K SUITACE (F0)ark Surfacou) (F7)			ain in Remarks):	
Thick Dark ?	Surface (A12)			pressions (F8)				
Sandy Muck	ky Mineral (S1)(LRR N,M	LRA 147,148)	Iron-Manga	anese Masse	, s (F12) (LRR	N, MLRA 136	6)		
Sandy Gley	ed Matrix (S4)		Umbric Su	rface (F13) (N	/ILRA 136, 1	22)			
Sandy Redo	ох (S5)		Piedmont F	loodplain Sc	oils (F19) (ML	.RA 148)			
Stripped Ma	atrix (S6)		Red Paren	t Material (F2	(MLRA 12	27, 147)	3, ,, ,		
							vetland byd	of nydropnytic vegeta Irology must be prese	ation and ent_unless
							disturbed or	problematic.	
Restrictive Laye	er (if observed):								
Туре:								—	
Depth (inches	s):					l	Hydric Soil Present?	Yes 🛄 No	
Remarks:									

Project/Site:	Plumtree I	Branch/Dunloggin N	/liddle School	City/County: Ellicott City, Howard Co. Sampling Date:						4/2	27/20
Applicant/Owner:		Howard County De	ept. of Parks and Recreat	tion		State:	MD	Samp	pling Point:	D	P-5
Investigator(s):		НК		Section, Towns	ship, Range	:					
Landform (hillslope,	terrace, etc.)	Flor	odplain	Local relief (co	oncave, con	vex, non	ie):	Concave	Slo	ope (%):	0%
Subregion (LRR or N	/ILRA):	LRR S	Lat:	39.2557	Lor	ng:	-76.8	8344	Datum:	WGS8	34
Soil Map Unit Name:		Ha (Hatbor	o-Codorus Silt Loam, 0-3	% slope)		N	WI classific	ation:	N/	/A	
Are climatic / hydrolo	ogic conditions o	on the site typical fo	r this time of year?	Yes 🗸	No	(I1	i no, explair	ı in Remarks.	.)		
Are Vegetation N	, Soil N	, or Hydrology	N Significantly dist	urbed?	Are "N	lormal C	ircumstance	es" present?	Yes 🗹	∕ No) 🗌
Are Vegetation N	, Soil N	, or Hydrology	N Naturally probler	matic?	(If nee	ded, exp	olain any an	swers in Ren	narks.)		
SUMMARY OF F		– Attach site ma	ap showing samp	ling point lo	ocations	, trans	sects, in	nportant f	features	, etc.	
Hydrophytic Vegetat	ion Present?	Yes 🗸	No								
Hydric Soil Present?		Yes 🗹	No 🗌	Is the Sample	ed Area						
Wetland Hydrology F	Present?	Yes 🗌	No	within a Wetl	and?	Y	es 🗌	No	\checkmark		
Remarks:											
Approximately 2" of rain	fell on the site t	he night before the	delineation. Saturation v	vas not used as a	a sole indica	ator of we	etland hydro	ology.			
HYDROLOGY											
							<u> </u>			<u> </u>	0
Wetland Hydrol	ogy Indicato	I rs:	all that apply)			\Box	econdary In	<u>idicators (min</u>	imum of two	o required	<u>1)</u>
Primary Indicators (MINIMUM OF ONE		<u>All that apply)</u> Water Steined Leoves	(DO)			ULLACE SOIL	UTACKS (B6)	ava Surfaca	(D0)	
	(AT)		Mater-Stained Leaves	(BA)			parsely veg	Jetated Conca	ave Surface	(B8)	
	N (AZ)		Aqualic Faulia (DIS)	1 /)			lanaye Pal	noc (P14)			
)		True Aqualic Planis (B	14)				nes (BTO)	(00)		
	BI)		Hydrogen Suilide Odor		(00)		ry-season v		(CZ)		
	osits (B2)		Oxidized Rhizospheres	S on Living Roots	(C3)		rayrish Burr	OWS (C8)	/		
Drift Deposits	(B3)		Presence of Reduced I	ron (C4)			aturation Vis	sible on Aeria	al Imagery (C9)	
Algal Mat or C	rust (B4)		Recent Iron Reduction	in Tilled Soils (Co	6)		iunted or St	ressed Plants	s (D1)		
Iron Deposits ((B5)		Thin Muck Surface (C7)		✓ G	eomorphic	Position (D2)			
Inundation Vis	ible on Aerial Im	iagery (B7)	Other (Explain in Rema	arks)		S	hallow Aqui	tard (D3)			
						M	icrotopogra	phic Relief (E)4)		
						E F	AC-Neutral	Test (D5)			
Field Observations	:										
Surface Water Prese	ent? Yes	No 🗸	Depth (inches):								
Water Table Present	t? Yes		Depth (inches):								
Saturation Present?	Yes		Depth (inches):								
(includes capillary fri	nge)		` `	v	Vetland Hyd	drology	Present?	Yes		No 🗸	
Describe Recorded Data	a (stream gage,	monitoring well, ae	rial photos, previous insp	ections), if availa	ıble:						
		ů.									
Remarks [,]											
Remarks.											

Tree Stratum (Dist size: 20 ft radius)	Absolute	Dominant		Domiance Test worksheet
The Stratum (Plot Size: 30 it radius).	% Cover	Species?	Indicator Status	
1. Quercus palustris	5	Yes	FACW	Number of Dominant Species
2.				That are OBL, FACW, or FAC: 4 (A)
3.				Total Number of Dominant
4. F				Species Across All Strata:
6				Species Across Air Strata. 4 (D)
7				Percent of Dominant Speices
50% total cover: 2.5% 20% total cover: 1.0%	5%	= Total Cover	1	that are OBL, FACW, or FAC: 100.0% (A/B)
	Absoluto	- Dominant		Broyalanco Index workshoot
Sapling Stratum (Plot size: <u>15 ft radius</u>).	% Cover	Species?	Indicator Status	Total % Cover of: Multiply by:
1. Acer negundo	5	Yes	FAC	$\frac{1}{\text{OBL species}} \qquad 15 \qquad \text{X1} = 15$
2.				FACW species $20 \times 2 = 40$
3.				FAC species 55 X 3 = 165
4.				FACU species 15 X 4 = 60
5.				UPL species $0 \times 5 = 0$
6.				Column Totals 105 (A) 280 (B)
7.				Provalence Index - B/A -
50% total cover: 2.5% 20% total cover: 1.0%	5%	= Total Cover		2.67%
Shruh Stratum (Dlat siza) 15 ft radius)	Absolute	Dominant		Hydrophytic Vegetation Indicators:
Stildulli (Piol size. <u>15 it idulus</u>).	% Cover	Species?	Indicator Status	1. Rapid Test of Hydrophytic Vegetation
1.				✓ 2. Dominance Test is >50%
2.				3 . Prevalence Index is $\leq 3.0^{1}$
3.				4. Morphological Adaptations' (Provide supporting
4. F				data in Remarks or on a separte sheet)
5.		-		
0.				Indicators of hydric soil and wotland hydrology must
7. 50% total cover: 0.0% 20% total cover: 0.0%	0%	– Total Cover		he present unless disturbed or problematic
	070			
Herb Stratum (Plot size: 5 ft radius).	Absolute	Dominant Species2	Indiantar Ctatua	Definitions of Vegetation Strata:
1 Danunculus ficaria	% COVEI	Species?		Tree - Woody plants, excluding woody vines, approximately
1. Rahuhulus ilaha 2. Glachama badaracaa	15	No	FAC	20 ft (6 m) or more in height and 3 in. (7.6 cm) or larger in
3 Symplocarnus foetidus	15	No	OBL	diameter at breast height (DBH).
4. Phalaris arundinacea	10	No	FACW	
5.				Sapling - Woody plants, excluding woody vines,
6.				approximately 20 ft (6 m) or more in height and less then
7.				3 in. (7.6 cm) DBH.
8.				Shrub - Woody plants, excluding woody vines,
9.				approximately 3 to 20 ft (1 to 6 m) in height.
10.				
11.				Herb - All herbaceous (non-woody) plants, including
12.				herbaceous vines, regardless of size, and and woody plants,
50% total cover: 45.0% 20% total cover: 18.0%	90%	= I otal Cover		except woody vines, less than approximately 3 ft (1 m) in
Woody Vino Stratum (Plot size: 30 ft radius)	Absolute	Dominant		height
	% Cover	Species?	Indicator Status	Woody Vine - All woody vines, regardless of height.
1. Vitis riparia	5	Yes	FACW	
2.				
3.			↓]	Hydropytic Manadatian
4.		-		Vegetation
7. 50% total covor: 2.5% 20% total covor: 1.0%	F 9/	- Total Covor		
	U 70			
Remarks: (If observed, list morphological adaptations below).				

Sampling Point:

Soils								Sampling Point:	DP-5		
Profile Descrip	ption: (Describe to the d	epth needed	to document the ir	ndicator or	confirm the	absence of i	indicators.)				
Depth	Matrix			Redox Fea	atures						
(inches)	Color (moist)	%	Color (moist)	%	Type ¹	Loc ²	Texture	Remark	٢S		
0-5	10YR 2/2	90	10YR 4/6	- 5	С	М	sandy loam				
			2.5Y 5/4	5	С	М					
5-12	10YR 2/2	90	10YR 4/6	10	С	M	sandy loam				
12-14	5Y 4/1	90	7.5YR 4/6	10	С	M, PL	sandy loam				
¹ Type: C=Conc	centration, D=Depletion, R	M=Reduced N	Aatrix, MS=Masked	Sand Grains	S. 2	.ocation: PL=I	Pore Lining, M=Matrix				
Hydric Soil Ind	dicators:						Indicators of	Problematic Hydr	ic Soils ³ :		
Histosol (A1	1)		Dark Surfac	.e (S7)			2 cm Muck (A	.10) (MLRA 147)			
Histic Epipe	edon (A2)		Polyvalue B	elow Surace	e (S8) (MLRA	147,148)	Coast Prairie	Redox (A16) (MLRA	A 147, 148)		
Black Histic	; (A3)			urface (59)	(MLRA 147,	148)	Piedmont Floo	odplain Solls (F 19) (MLRA 136,		
Hydrogen 3 Stratified 14	vulfide (A4)			'ed Matrix (F atrix (E3)	2)		147)	Dark Surface (TE1)))		
	(A10) (LRR N)		Redox Dark	Surface (Fé	6)		Other (Explain	n in Remarks):	-)		
Depleted B	elow Dark Surface (A11)		Depleted Da	ark Surface	(F7)			Thirtonianc,			
Thick Dark	Surface (A12)		Redox Depr	essions (F8	() ()						
Sandy Mucky Mineral (S1)(LRR N,MLRA 147,148) Iron-Manganese Masses (F12) (LRR N, MLRA 136)											
Sandy Gleyed Matrix (S4) Umbric Surface (F13) (MLRA 136, 122)											
Sandy Red	OX(S5)		Pleamont Fi Red Parent	Matarial (E2) S (F 19) (IVIL)1) (MI RA 1:	.RA 148) 07 147)					
	31(1X (SO)			Ναιτιαί (ι 2	(IVILNA 12	(1,147)	³ Indicators of	hudronhutic voqotai	Hon and		
							wetland hydro	nyarophylic vegetat	ion anu int: unless		
							disturbed or p	problematic.			
Restrictive Lay	er (if observed):										
Туре:											
Depth (inches	s):						Hydric Soil Present?	Yes <u> </u>			
Remarks:											

Project/Site:	Plumtree Branch	/Dunloggin N	1iddle School	City/County:	Ellicott City, H	loward Co.	Sampl	ing Date:	4/2	27/20
Applicant/Owner:	Howa	rd County De	ept. of Parks and Recre	eation	State	e: MD	Sampli	ing Point:	D	P-6
Investigator(s):		HK		Section, Towns	ship, Range:					
Landform (hillslope, terrace	e, etc.)	Floo	odplain	Local relief (co	oncave, convex,	none):	Concave	Slop	oe (%):	0%
Subregion (LRR or MLRA)	:	LRR S	Lat:	39.2557	Long:	-76.8	3344	Datum:	WGS8	34
Soil Map Unit Name:		Ha (Hatbor	o-Codorus Silt Loam, ()-3% slope)		NWI classific	ation:	N/A	۱ <u> </u>	
Are climatic / hydrologic co	onditions on the s	site typical fo	r this time of year?	Yes 🔽	No	(If no, explain	in Remarks.)			
Are Vegetation N ,	Soil N, or H	lydrology	N Significantly di	isturbed?	Are "Norma	al Circumstance	es" present?	Yes 🗸	No)
Are Vegetation N,	Soil N, or H	Hydrology	N Naturally prob	lematic?	(If needed,	explain any an	swers in Rema	arks.)	-	
SUMMARY OF FINDI	NGS - Attac	h site ma	ap showing sam	npling point lo	ocations, tra	ansects, in	nportant fe	eatures,	etc.	
Hydrophytic Vegetation Pr	esent? Yes	√	No							
Hydric Soil Present?	Yes	\checkmark	No	Is the Sample	ed Area					
Wetland Hydrology Preser	nt? Yes		No	within a Wetla	and?	Yes] No	\checkmark		
In Wetland 3. Approximately 2 HYDROLOGY	" of rain fell on th	ne site the niç	ght before the delineati	ion. Saturation was	not used as a s	ole indicator of	wetland hydro	logy.		
Watland Llydrology	ndiaatara					Cocondon In	diaatara (minir	mum of two	roguiros	4)
Primary Indicators (minim Surface Water (A1) High Water Table (A Saturation (A3) Water marks (B1) Sediment Deposits (B3) Algal Mat or Crust (E Iron Deposits (B5) Inundation Visible or	um of one is requ 2) B2) 34) 1 Aerial Imagery	uired: check :	all that apply) Water-Stained Leave Aquatic Fauna (B13) True Aquatic Plants (Hydrogen Sulfide Od Oxidized Rhizospher Presence of Reduce Recent Iron Reductio Thin Muck Surface (Other (Explain in Ret	es (B9) (B14) for (C1) res on Living Roots d Iron (C4) on in Tilled Soils (C6 C7) marks)	(C3)	Surface Soil (Sparsely Veg Drainage Pat Moss Trim Li Dry-Season V Crayfish Burr Saturation Vi: Stunted or St Geomorphic Shallow Aqui Microtopogra FAC-Neutral	Cracks (B6) etated Concav terns (B10) nes (B16) Nater Table (C ows (C8) sible on Aerial ressed Plants Position (D2) tard (D3) phic Relief (D4 Test (D5)	/e Surface (2) Imagery (C (D1) 4)	9)	<u>u</u>
FIELD ODSELVALIOUS.		No 🔽	Denth (inches):							
Water Table Present?			Dopth (inchos):							
Saturation Present?			Depth (inches):	Surfaco						
(includes capillary fringe)	res 🗸			Sunace W	Vetland Hydrold	ogy Present?	Yes	<u> </u>	lo 🗌	_
Describe Recorded Data (strea	am gage, monito	ring well, aer	ial photos, previous in	spections), if availa	ble:					
Remarks [.]										
Kondika.										

Tree Stratum (Dist size, 20 ft radius)	Absolute	Dominant		Domiance Test worksheet
Tree Stratum (Piot Size: <u>30 it Taulus</u>).	% Cover	Species?	Indicator Status	
1. Acer rubrum	5	Yes	FAC	Number of Dominant Species
2.				That are OBL, FACW, or FAC:4 (A)
3.				Tatal Number of Deminerat
4. F				Total Number of Dominant
5.				Species Across All Strata: 5 (B)
0.				Porcent of Dominant Spoices
7. 50% total covor: 2.5% 20% total covor: 1.0%	5%	– Total Covor		that are OBL_EACW or EAC: 80.0% (A/B)
	570			
Sapling Stratum (Plot size: 15 ft radius).	Absolute	Dominant	Indiantar Ctatua	Prevalence Index worksheet
1	% Cover	Species?	Indicator Status	OPL species 10 X 1 10
1.				$\begin{array}{llllllllllllllllllllllllllllllllllll$
2.				FACW species $20 \times 2 = 40$ EAC species 75 X 3 - 225
а. А				FACIl species $5 \times 4 = 20$
5				$IIPL species \qquad 0 \qquad X = 0$
6				Column Totals 110 (A) 295 (B)
7.				
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		Prevalence Index = B/A = 2.68%
	Absolute	– Dominant		Hydrophytic Vegetation Indicators:
Shrub Stratum (Plot size: <u>15 ft radius</u>).	% Cover	Species?	Indicator Status	1 Rapid Test of Hydrophytic Vegetation
1 Rosa multiflora	5	Yes	FACI	2 Dominance Test is >50%
2.		103	11100	3 . Prevalence Index is $\leq 3.0^1$
3.				4. Morphological Adaptations ¹ (Provide supporting
4.				data in Remarks or on a separte sheet)
5.				Problematic Hydrophytic Vegetation ¹ (Explain)
6.				
7.				¹ Indicators of hydric soil and wetland hydrology must
50% total cover: 2.5% 20% total cover: 1.0%	5%	= Total Cover	<u> </u>	be present, unless disturbed or problematic.
	Absolute	_ Dominant		Definitions of Vegetation Strata:
Herb Stratum (Plot size: <u>5 ft radius</u>).	% Cover	Species?	Indicator Status	
1. Ranunculus ficaria	40	Yes	FAC	Tree - Woody plants, excluding woody vines, approximately
2. Microstegium vimineum	30	Yes	FAC	20 ft (6 m) or more in height and 3 in. (7.6 cm) or larger in
3. Symplocarpus foetidus	10	No	OBL	
4. Arisaema triphyllum	5	No	FACW	Sapling Woody plants, excluding woody vines
5. Phalaris arundinacea	5	No	FACW	approximately 20 ft (6 m) or more in height and less then
6.				3 in (7.6 cm) DBH
7.				
8.				Shrub - Woody plants, excluding woody vines,
9.				approximately 3 to 20 ft (1 to 6 m) in height.
10.				
12				Herb - All herbaceous (non-woody) plants, including
12.	000/	Total Covor		herbaceous vines, regardless of size, and and woody plants,
	90%			except woody vines, less than approximately 3 ft (1 m) in
Woody Vine Stratum (Plot size 30 ft radius)	Absolute	Dominant		height
	% Cover	Species?	Indicator Status	Woody Vine - All woody vines, regardless of height.
1. Vitis riparia	10	Yes	FACW	
2.			ļ]	Ukuda sa dia
3. A			┨────┤	Hydropylic
7				Vegetation Present? Vec V
7. E0% total covor: E0% 20% total covor: 2.0%	100/	Total Covor		
	IU%			
Remarks: (If observed, list morphological adaptations below).				

Sampling Point:

Soils								Sampling Point:	DP-6
Profile Descri	ption: (Describe to the d	epth needed	to document the ir	ndicator or	confirm the	absence of i	indicators.)		
Depth	Matrix			Redox Fea	atures				
(inches)	Color (moist)	%	Color (moist)	%	Type ¹	LOC ²	Texture	Remark	<s< td=""></s<>
0-5	10YR 2/2	90	10YR 4/6	5	С	М	sandy loam		
			2.5Y 5/4	5	С	М			
5-12	10YR 2/2	90	10YR 4/6	10	С	Μ	sandy loam		
12-14	5Y 4/1	90	7.5YR 4/6	10	С	M, PL	sandy loam		
¹ Type: C=Conc	entration, D=Depletion, R	M=Reduced M	Aatrix, MS=Masked	Sand Grains	S. 2	ocation: PL=I	Pore Lining, M=Matrix		
Hydric Soil Ind	dicators:						Indicators of	Problematic Hydr	ic Soils ³ :
Histosol (A	I)		Dark Surfac	e (S7)			2 cm Muck (A	10) (MLRA 147)	
Histic Epipe	edon (A2)		Polyvalue B	elow Surace	e (S8) (MLRA	(147,148)	Coast Prairie	Redox (A16) (MLR/	A 147, 148)
Black Histic	(A3) Sulfido (A4)			urface (S9)	(MLRA 147,	148)		odpiain Soiis (F 19)	MLRA 136,
Stratified La	vunue (A4) avers (A5)			eu Matrix (F atrix (F3)	2)		Very Shallow	Dark Surface (TE1)	2)
2 cm Muck	(A10) (LRR N)		Redox Dark	Surface (F6	5)		Other (Explain	n in Remarks):	-)
Depleted B	elow Dark Surface (A11)		Depleted Date	ark Surface	, (F7)				
Thick Dark	Surface (A12)		Redox Depr	essions (F8)				
Sandy Muc	ky Mineral (S1)(LRR N,MI	LRA 147,148)	Iron-Mangar	nese Masse	s (F12) (LRR	N, MLRA 13	36)		
Sandy Gley	ed Matrix (S4)			ace (F13) (N Ioodolain So	/ILKA 136, 1. ils (F19) (MI	22) RA 148)			
Stripped Ma	atrix (S6)		Red Parent	Material (F2	1) (MLRA 12	27, 147)			
				, i i i i	/ (, ,	³ Indicators of	hydrophytic vegetal	ion and
							wetland hydro	logy must be prese	nt, unless
							disturbed or p	roblematic.	
							I		
Restrictive Lay	er (If observed):								
Depth (inches	s):						Hydric Soil Present?	Yes 🗸 No	
								<u> </u>	
Remarks:									

Project/Site: Pl	umtree Branch/Dunloggin N	vliddle School	City/County:	Ellicott City, H	oward <u>Co.</u>	Sampling Dat	te: 4/	27/20
Applicant/Owner:	Howard County De	ept. of Parks and Recreat	ion	State	: MD	Sampling Poi	int: D)P-7
Investigator(s):	НК		Section, Towns	ship, Range:				
Landform (hillslope, terrace,	etc.) Flor	odplain	Local relief (co	ncave, convex, r	none):	Concave	Slope (%):	0%
Subregion (LRR or MLRA):	LRR S	Lat:	39.2557	Long:	-76.834	44 Datum	: WGS	84
Soil Map Unit Name:	Ha (Hatbor	o-Codorus Silt Loam, 0-39	% slope)		NWI classification	on:	N/A	
Are climatic / hydrologic con	ditions on the site typical fo	or this time of year?	Yes 🗸	No	(If no, explain in	ı Remarks.)		
Are Vegetation N , S	oil N , or Hydrology	N Significantly distu	urbed?	Are "Norma	- Il Circumstances"	' present? Yes	s 🔽 🛛 N'	0
Are Vegetation N , S	oil N , or Hydrology	N Naturally problem	natic?	(If needed,	explain any answ	vers in Remarks.)	<u> </u>	- <u> </u>
SUMMARY OF FINDIN	IGS - Attach site ma	ap showing samp	ling point lo	ocations, tra	insects, imp	ortant featur	es, etc.	
Hydrophytic Vegetation Pres	sent? Yes 🔽	No						
Hydric Soil Present?	Yes 🗸	No 🗌	Is the Sample	d Area				
Wetland Hydrology Present	? Yes 🔽	No 🗌	within a Wetla	and?	Yes 🗸	No	1	
Remarks: Approximately 2" of rain fell on t	the site the night before the	delineation. Saturation w	vas not used as a	sole indicator of	f wetland hydrolog	gy. In Wetland 3B		
HYDROLOGY								
Wetland Hydrology in Primary Indicators (minimur Surface Water (A1) High Water Table (A2) Saturation (A3) Water marks (B1) Sediment Deposits (B3) Algal Mat or Crust (B4) Iron Deposits (B5) Inundation Visible on P	dicators: <u>n of one is required: check</u>) 2) Aerial Imagery (B7)	all that apply) Water-Stained Leaves (Aquatic Fauna (B13) True Aquatic Plants (B1 Hydrogen Sulfide Odor Oxidized Rhizospheres Presence of Reduced Ir Recent Iron Reduction i Thin Muck Surface (C7) Other (Explain in Rema	(B9) (C1) on Living Roots (ron (C4) in Tilled Soils (C6) rks)	(C3)	Secondary India Surface Soil Cra Sparsely Vegeta Drainage Patter Moss Trim Line: Dry-Season Wa Crayfish Burrow Saturation Visib Stunted or Stres Geomorphic Po Shallow Aquitar Microtopograph FAC-Neutral Te	<u>actors (minimum of</u> acks (B6) ated Concave Surf ns (B10) s (B16) iter Table (C2) <i>is</i> (C8) ole on Aerial Image ssed Plants (D1) isition (D2) rd (D3) ic Relief (D4) est (D5)	ry (C9)	
Surface Water Present? Water Table Present? Saturation Present? (includes capillary fringe)	Yes No Yes No Yes No	Depth (inches): Depth (inches): Depth (inches): Si	urface N	/etland Hydrolo	gy Present?	Yes 🔽	No]
Describe Recorded Data (strear	n gage, monitoring well, ae	rial photos, previous inspe	ections), if availat	ole:				
Remarks:								

Troo Stratum (Diat size: 20 ft radius)	Absolute	Dominant		Domiance Test worksheet
	% Cover	Species?	Indicator Status	
1. Acer rubrum	5	Yes	FAC	Number of Dominant Species
2.	_			That are OBL, FACW, or FAC: 3 (A)
3.				Total Number of Dominant
4. 5				Species Across All Strata: 5 (B)
6	-			Species Acioss All Stildia. 5 (B)
7				Percent of Dominant Speices
50% total cover: 2.5% 20% total cover: 1.0%	5%	= Total Cover		that are OBL, FACW, or FAC: 60.0% (A/B)
	Absoluto	- Dominant		Brovalance Index worksheet
Sapling Stratum (Plot size: <u>15 ft radius</u>).	% Cover	Species?	Indicator Status	Total % Cover of: Multiply by:
1.	70 00101			$\frac{1}{\text{OBL species}} \qquad 0 \qquad \overline{\text{X 1}} = 0$
2.				FACW species $15 \times 2 = 30$
3.				FAC species 45 X 3 = 135
4.				FACU species 70 X 4 = 280
5.				UPL species $0 \times 5 = 0$
6.				Column Totals <u>130</u> (A) <u>445</u> (B)
7.				Prevalence Index = R/A =
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		3.42%
Shruh Stratum (Dlat size) 15 ft radius)	Absolute	Dominant		Hydrophytic Vegetation Indicators:
Shiud Shaluni (Piol Size: <u>15 il Tadius</u>).	% Cover	Species?	Indicator Status	1. Rapid Test of Hydrophytic Vegetation
1. Rosa multiflora	30	Yes	FACU	✓ 2. Dominance Test is >50%
2.				3. Prevalence Index is $\leq 3.0^1$
3.				4. Morphological Adaptations ¹ (Provide supporting
4.				data in Remarks or on a separte sheet)
5.	_			
0. 7				Indicators of hydric soil and wotland hydrology must
7. 50% total covor: 15.0% 20% total covor: 6.0%	30%	– Total Covor		halcalors of Hydric soil and weitand Hydrology must
Herb Stratum (Plot size: <u>5 ft radius</u>).	Absolute % Cover	Dominant Species?	Indicator Status	Definitions of Vegetation Strata:
1 Ranunculus ficaria	70 COVER	Ves		Tree - Woody plants, excluding woody vines, approximately
2 Glechoma hederacea	40	Yes	FACU	20 ft (6 m) or more in height and 3 in. (7.6 cm) or larger in
3. Phalaris arundinacea	5	No	FACW	diameter at breast height (DBH).
4.		-	-	
5.				Sapling - Woody plants, excluding woody vines,
6.				approximately 20 ft (6 m) or more in height and less then
7.				3 III. (7.0 СIII) DBП.
8.				Shrub - Woody plants, excluding woody vines,
9.				approximately 3 to 20 ft (1 to 6 m) in height.
10.				
11.			↓	Herb - All herbaceous (non-woody) plants, including
12. 50% total covor: 12.5% 20% total covor: 17.0%	050/	- Total Cavar		herbaceous vines, regardless of size, and and woody plants,
	%60			except woody vines, less than approximately 3 ft (1 m) in
Woody Vine Stratum (Plot size: 30 ft radius).	Absolute	Dominant		neight
	% Cover	Species?	Indicator Status	woody vine - All woody vines, regardless of height.
1. VIIIS riparia	10	Yes	FACW	
2.			┨────┤	Hydropytic
Δ			<u> </u>	Vegetation
7. 7	-	<u> </u>		Present? Yes V No
50% total cover: 5.0% 20% total cover: 2.0%	10%	= Total Cover	1	
Remarks: (If observed, list morphological adaptations below).				

Sampling Point:

Soils								Sampling Point:	DP-7
Profile Descri	ption: (Describe to the d	epth needed	to document the ir	ndicator or	confirm the	absence of i	indicators.)	' <u>-</u>	
Depth	Matrix			Redox Fea	atures				
(inches)	Color (moist)	%	Color (moist)	%	Type¹	Loc ²	Texture	Remar	٨S
0-5	10YR 2/2	90	10YR 4/6	- 5	С	М	sandy loam		
			2.5Y 5/4	5	С	М			
5-12	10YR 2/2	90	10YR 4/6	10	С	М	sandy loam		
12-14	5Y 4/1	90	7.5YR 4/6	10	С	M, PL	sandy loam		
	<u> </u>						·		
¹ Type: C=Conc	entration, D=Depletion, R	M=Reduced N	Aatrix, MS=Masked	Sand Grains	5. 2 L	ocation: PL=	Pore Lining, M=Matrix		
Hydric Soil Ind	dicators:						Indicators of	Problematic Hydr	ic Soils ³ :
Histosol (A1	1)		Dark Surfac	e (S7)			2 cm Muck (A	10) (MLRA 147)	
Histic Epipe	edon (A2)		Polyvalue B	elow Surace	e (S8) (MLRA	147,148)	Coast Prairie	Redox (A16) (MLR	A 147, 148)
Black Histic	; (A3)		Thin Dark S	urface (S9)	(MLRA 147,	148)	Piedmont Floo	odplain Soils (F19)	(MLRA 136,
Hydrogen S	Sulfide (A4)		Loamy Gley	ed Matrix (F	2)		147)		
Stratified La	iyers (A5) (A10) (I PP N)			atrix (F3) Surface (E4	.)		Very Shallow	Dark Surface (TFT2	<u>?</u>)
	elow Dark Surface ($\Delta 11$)			sunace (Fo ark Surface ()) (F7)			THI REMARKS):	
Thick Dark	Surface (A12)		Redox Depr	essions (F8)				
Sandy Muc	ky Mineral (S1)(LRR N,MI	LRA 147,148)	Iron-Mangar	nese Masse	, s (F12) (LRR	N, MLRA 13	36)		
Sandy Gley	ed Matrix (S4)		Umbric Surf	ace (F13) (N	/ILRA 136, 12	22)			
Sandy Rede	эх (S5)		Piedmont Fl	loodplain So	ils (F19) (ML	RA 148)			
Stripped Ma	atrix (S6)		Red Parent	Material (F2	1) (MLRA 12	27, 147)	3		
							³ Indicators of I	hydrophytic vegeta	tion and
							disturbed or p	roblematic.	ni, uniess
Restrictive Lay	er (if observed):								
Туре:									_
Depth (inches	s):						Hydric Soil Present?	Yes <u>V</u> No	
Remarks:									

Project/Site: Plumt	tree Branch/Dunloggin N	liddle School	City/County:	Ellicott City, H	oward Co.	Sampling	g Date:	4/27/20
Applicant/Owner:	Howard County De	pt. of Parks and Recrea	ation	State	: MD	Sampling	g Point:	DP-8
Investigator(s):	НК		Section, Towns	ship, Range:				
Landform (hillslope, terrace, etc) Floc	odplain	Local relief (co	ncave, convex, r	none):	Concave	Slope	e (%): 0%
Subregion (LRR or MLRA):	LRR S	Lat:	39.2557	Long:	-76.83	344 Da	atum:	WGS84
Soil Map Unit Name:	Ha (Hatbord	o-Codorus Silt Loam, 0-	-3% slope)		NWI classificat	ion:	N/A	
Are climatic / hydrologic condition	ons on the site typical for	this time of year?	Yes 🗸	No	(If no, explain i	n Remarks.)		
Are Vegetation N , Soil	N , or Hydrology	N Significantly dis	sturbed?	Are "Norma	I Circumstances	" present?	Yes 🗸	No 🗌
Are Vegetation N, Soil	N, or Hydrology	N Naturally proble	ematic?	(If needed,	explain any ans	wers in Remark	(S.)	
SUMMARY OF FINDING	S - Attach site ma	ap showing sam	pling point lo	ocations, tra	insects, im	portant fea	itures, e	tc.
Hydrophytic Vegetation Present	t? Yes 🔽	No						
Hydric Soil Present?	Yes 🗸	No 🗌	Is the Sample	d Area				
Wetland Hydrology Present?	Yes 🗸	No	within a Wetla	and?	Yes 🗸	No		
Remarks: Approximately 2" of rain fell on the :	site the night before the	delineation. Saturation	was not used as a	sole indicator of	f wetland hydrold	ogy. In wetland	4	
HYDROLOGY								
Wetland Hydrology Indic Primary Indicators (minimum of ✓ Surface Water (A1) ✓ High Water Table (A2) ✓ Saturation (A3) ✓ Water marks (B1) Sediment Deposits (B2) Drift Deposits (B3) △ Algal Mat or Crust (B4) □ Iron Deposits (B5) □ Inundation Visible on Aeri Field Observations: Surface Water Present? Water Table Present? Saturation Present? Saturation Present? (includes capillary fringe)	ial Imagery (B7)	all that apply) Water-Stained Leaves Aquatic Fauna (B13) True Aquatic Plants (E Hydrogen Sulfide Odo Oxidized Rhizosphere Presence of Reduced Recent Iron Reductior Thin Muck Surface (C Other (Explain in Rem Depth (inches): Depth (inches):	s (B9) 314) or (C1) is on Living Roots (Iron (C4) n in Tilled Soils (C6 .7) narks) <u>1"</u> Surface Surface W	(C3)	Secondary Ind Surface Soil Ci Sparsely Vege Drainage Patte Moss Trim Line Dry-Season W Crayfish Burro Saturation Visi Stunted or Stre Geomorphic Pr Shallow Aquita Microtopograpi FAC-Neutral T	icators (minimu racks (B6) tated Concave erns (B10) es (B16) ater Table (C2) ws (C8) ble on Aerial In essed Plants (D osition (D2) rd (D3) hic Relief (D4) est (D5) Yes	m of two re Surface (B nagery (C9) 1) 1) ✓ No	<u>equired)</u> 8)
Describe Recorded Data (stream ga	age, monitoring well, aer	ial photos, previous insp	pections), if availab	ole:				
Remarks:								

Tree Stratum (Distaine)	Absolute	Dominant		Domiance Test worksheet
Tree Stratum (Piot size: <u>30 it radius</u>).	% Cover	Species?	Indicator Status	
1. Acer rubrum	15	Yes	FAC	Number of Dominant Species
2.				That are OBL, FACW, or FAC: 5 (A)
3.				Total Number of Dominant
4. F				Species Across All Strata: 5 (P)
6	-		+	Species Across All Stillia. 5 (B)
7				Percent of Dominant Speices
50% total cover: 7.5% 20% total cover: 3.0%	15%	= Total Cover		that are OBL, FACW, or FAC: 100.0% (A/B)
	Absolute	- Dominant		Prevalence Index worksheet
Sapling Stratum (Plot size: 15 ft radius).	% Cover	Species?	Indicator Status	Total % Cover of: Multiply by:
1. Acer rubrum	5	Yes	FAC	$\begin{array}{c} \text{OBL species} \\ \text{OBL species} \\ 30 \\ \hline \text{X 1} \\ = \\ 30 \\ \hline \end{array}$
2.				FACW species 5 X 2 = 10
3.				FAC species 65 X 3 = 195
4.				FACU species 0 X 4 = 0
5.				UPL species $0 \times X5 = 0$
6.				Column Totals 100 (A) 235 (B)
7.	50/			Prevalence Index = B/A =
50% total cover: 2.5% 20% total cover: 1.0%	5%	= I otal Cover		2.35%
Shruh Stratum (Plot size) 15 ft radius)	Absolute	Dominant		Hydrophytic Vegetation Indicators:
	% Cover	Species?	Indicator Status	1. Rapid Test of Hydrophytic Vegetation
1.				✓ 2. Dominance Test is >50%
2.				\checkmark 3. Prevalence Index is \leq 3.0'
3.				4. Morphological Adaptations' (Provide supporting
4. E				data in Remarks or on a separte sneet)
6				
7			+	¹ Indicators of hydric soil and wetland hydrology must
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		be present, unless disturbed or problematic.
	Absoluto	- Dominant		Definitions of Vagetation Strate
Herb Stratum (Plot size: <u>5 ft radius</u>).	ADSUIULE % Cover	Dummani Species?	Indicator Status	Deminitions of vegetation strata.
1 Ranunculus ficaria	40	Yes	FAC	Tree - Woody plants, excluding woody vines, approximately
2. Carex stricta	20	Yes	OBL	20 ft (6 m) or more in height and 3 in. (7.6 cm) or larger in
3. Carex lurida	10	No	OBL	diameter at breast height (DBH).
4. Phalaris arundinacea	5	No	FACW	
5.				Sapling - Woody plants, excluding woody vines,
6.				approximately 20 it (6 m) of more in height and less them 3 in (7.6 cm) DBH
7.				
8.				Shrub - Woody plants, excluding woody vines,
9.				approximately 3 to 20 ft (1 to 6 m) in height.
10.				
12				Herb - All herbaceous (non-woody) plants, including
12. 50% total cover: 37.5% 20% total cover: 15.0%	75%	– Total Cover		herbaceous vines, regardless of size, and and woody plants,
	7370			except woody vines, less than approximately 3 it (1 m) in bought
Woody Vine Stratum (Plot size: <u>30 ft radius</u>).	Absolute	Dominant	Indicator Status	Moody Vine - All woody vines, regardless of height
1 Tovicodondron radicanc	% Cover	Species		Woody Vine - All woody vines, regardless of height.
1. TOXICOUEIIUIUITIAUICAIIS	5	res	FAC	
3	+		╂────┨	Hydropytic
4.	+	1	+	Vegetation
7.	1		1 1	Present? Yes 🗹 No 🗌
50% total cover: 2.5% 20% total cover: 1.0%	5%	= Total Cover		
Remarks: (If observed, list morphological adaptations below)				1
nomano, in observed, iist morphological adaptations below).				

Sampling Point:

Soils								Sampling Point:	DP-8
Profile Descrip	otion: (Describe to the d	lepth needed	to document the	indicator or	confirm the	absence of i	ndicators.)	-	
Depth	Matrix			Redox Fea	atures				
(inches)	Color (moist)	%	Color (moist)	%	Type ¹	Loc ²	Texture	Remai	rks
0-4	10YR 3/2	90	10YR 4/6	10	С	М	Clay loam		
4-12	2.5Y 5/3	85	10YR 4/6	15	С	М	Clay loam		
					· ·				
¹ Type: C-Conc	entration D-Depletion R	M-Roducod M	latriv MS-Maskor	Sand Grain	s 2	ocation: PI -	Pore Lining M-Matrix		
					з. L				2
Hydric Soil Inc	dicators:							of Problematic Hyd	ric Soils ³ :
Histosol (A1	l)		Dark Surfa	ce (S7) Deleve Surree		147 140)	2 cm Muck ((A10) (MLRA 147)	0. 1.47 1.40
	edon (A2)			Below Surace Surface (S0)	e (58) (MLRA /MLDA 147	147,148) 179)		e Redox (A16) (MLR loodplain Soils (E10)	(MI DA 136
	(A3) Sulfido (A4)			Sunace (39) wod Matrix (F	(IVILKA 147,	140)	147)	1000µ1a111 30113 (1°17)	(IVILKA 130,
Stratified La	avers (A5)			Aatrix (E3)	2)		Very Shallov	w Dark Surface (TF1	2)
2 cm Muck	(A10) (LRR N)		Redox Dar	k Surface (Fé	6)		Other (Expla	ain in Remarks):	-)
Depleted Be	elow Dark Surface (A11)		Depleted D	ark Surface	, (F7)			,	
Thick Dark	Surface (A12)		Redox Dep	pressions (F8	3)				
Sandy Muck	ky Mineral (S1)(LRR N,M	LRA 147,148)	Iron-Manga	anese Masse	es (F12) (LRR	N, MLRA 13	6)		
Sandy Gley	ed Matrix (S4)			rface (F13) (N	MLRA 136, 12	22)			
Sandy Redo	ox (S5)			- 1000piain Sc t Material (E2)IIS (F 19) (ML)1) (ML DA 13	RA 148) 7 147)			
	atrix (S6)			t Material (F2		7,147)	³ Indiantara a		tion and
							wetland hyd	or nyaropnytic vegeta Irology must be prese	ation and ent unless
							disturbed or	problematic.	
Restrictive Laye	er (if observed):								
Туре:									_
Depth (inches	s):						Hydric Soil Present?	Yes 🗹 No	
Remarks:									

Project/Site:	Plumtr	Plumtree Branch/Dunloggin Middle School				Ellicott City, Ho	o. Sar	Sampling Date:		27/20			
Applicant/Owner:		Howard County [)ept. of F	Parks and Recrea	tion	State	D Sar	npling Point	t: [)P-9			
Investigator(s):	НК			Section, Township, Range:									
Landform (hillslope, terrace, etc.) Floodplain				Local relief (concave, convex, none): Concave			9	Slope (%)					
Subregion (LRR or MLRA): LRR S Lat:		Lat:	39.2557	Long:		-76.8344	Datum:	WGS	84				
Soil Map Unit Name	he: Ha (Hatboro-Codorus Silt Loam, 0			rus Silt Loam, 0-3	3% slope)	ope) NWI classification:					N/A		
Are climatic / hydrol	logic conditio	ns on the site typical f	or this tir	ne of year?	Yes 🗸	No	(If no, e	explain in Remark	s.)				
Are Vegetation	N , Soil <mark>I</mark>	, or Hydrology	Ν	Significantly dist	urbed?	Are "Norma	I Circum	nstances" present?	? Yes	✓ N	0		
Are Vegetation	N, Soil M	, or Hydrology	Ν	Naturally problem	matic?	(If needed, explain any answers in Remarks.)							
		Attack alto m							f	4-			

SUMMARY OF FINDINGS - Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes	\checkmark	No	\checkmark						
Hydric Soil Present?	Yes	\checkmark	No		Is the Sampled Area					
Wetland Hydrology Present?	Yes	\checkmark	No		within a Wetland?	Yes	\checkmark	No		
Remarks:										
Approximately 2" of rain fell on the site the night before the delineation. Saturation was not used as a sole indicator of wetland hydrology. In Wetland 5, but also representative of emergent portion of Wetland 4										

HYDROLOGY

Wetland Hydrology Indicators:	Secondary Indicators (minimum of two required)			
Primary Indicators (minimum of one is required: check all that apply)	Surface Soil Cracks (B6)			
Surface Water (A1) Water-Stained Leaves (B9)	Sparsely Vegetated Concave Surface (B8)			
High Water Table (A2) Aquatic Fauna (B13)	Drainage Patterns (B10)			
Saturation (A3) True Aquatic Plants (B14)	Moss Trim Lines (B16)			
Water marks (B1) Hydrogen Sulfide Odor (C1)	Dry-Season Water Table (C2)			
Sediment Deposits (B2) Oxidized Rhizospheres on Living Roots (C3)	Crayfish Burrows (C8)			
Drift Deposits (B3)	Saturation Visible on Aerial Imagery (C9)			
Algal Mat or Crust (B4) Recent Iron Reduction in Tilled Soils (C6)	Stunted or Stressed Plants (D1)			
Iron Deposits (B5) Thin Muck Surface (C7)	Geomorphic Position (D2)			
Inundation Visible on Aerial Imagery (B7) Other (Explain in Remarks)	Shallow Aquitard (D3)			
	Microtopographic Relief (D4)			
	FAC-Neutral Test (D5)			
Field Observations: Surface Water Present? Yes Image: Constraint of the present of the present? Yes Image: Constraint of the present of the present of the present? No Depth (inches): 1mage: Constraint of the present of the present of the present? Yes Image: Constraint of the present of	drology Present? Yes 🔽 No 🗌			
Remarks:				

VEGETATION - Use scientific names of plan	ts.			Sampling Point: DP-9
Tree Stratum (Plot size: <u>30 ft radius</u>).	Absolute % Cover	Dominant Species?	Indicator Status	Domiance Test worksheet
1. Acer rubrum	2	Yes	FAC	Number of Dominant Species
2. Quercus palustris	2	Yes	FACW	That are OBL, FACW, or FAC: 3 (A)
3.				
4.				Total Number of Dominant
5.				Species Across All Strata: 4 (B)
6.				
7.	40/	Tatal Causer		Percent of Dominant Speices
	4%	= 10tal Cover		that are OBL, FACW, of FAC: <u>75.0%</u> (A/B)
Sapling Stratum (Plot size: 15 ft radius).	Absolute	Dominant		Prevalence Index worksheet
	% Cover	Species?	Indicator Status	Total % Cover of: Multiply by:
. -		1		$\begin{array}{cccc} \text{OBL species} & 10 & \text{X} & \text{I} & = & 10 \\ \text{EACM} & \text{species} & \text{AD} & \text{X} & \text{D} & \text{AD} \\ \end{array}$
2.				FACW species $42 \times 2 = 84$
S. Л				FAC species $12 \times 3 = 30$
ት. 5			+	$11PL \text{ species} \qquad 0 \qquad X 5 = 0$
6				Column Totals 69 (A) 150 (B)
7.				
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		Prevalence Index = B/A = 2.17%
	Absolute	 Dominant		Hydrophytic Vegetation Indicators:
Shrub Stratum (Plot size: <u>15 ft radius</u>).	% Cover	Species?	Indicator Status	1 Rapid Test of Hydrophytic Vegetation
1 Rosa multiflora	5	Yes	FACU	\sim 2 Dominance Test is >50%
2.		100	11100	3 . Prevalence Index is $\leq 3.0^1$
3.				4. Morphological Adaptations ¹ (Provide supporting
4.				data in Remarks or on a separte sheet)
5.				Problematic Hydrophytic Vegetation ¹ (Explain)
6.				
7.				¹ Indicators of hydric soil and wetland hydrology must
50% total cover: 2.5% 20% total cover: 1.0%	5%	= Total Cover		be present, unless disturbed or problematic.
Herb Stratum (Plot size: <u>5 ft radius</u>).	Absolute % Cover	Dominant	Indicator Status	Definitions of Vegetation Strata:
1 Phalaris arundinacea	40	Species: Ves		Tree - Woody plants, excluding woody vines, approximately
2 Ranunculus ficaria	10	No	FAC	20 ft (6 m) or more in height and 3 in. (7.6 cm) or larger in
3. Carex lurida	5	No	OBL	diameter at breast height (DBH).
4. Symplocarpus foetidus	5	No	OBL	
5.				Sapling - Woody plants, excluding woody vines,
6.				approximately 20 ft (6 m) or more in height and less then
7.				5 III. (7.0 СП) DBП.
8.				Shrub - Woody plants, excluding woody vines,
9.				approximately 3 to 20 ft (1 to 6 m) in height.
10.				
11.				Herb - All herbaceous (non-woody) plants, including
12.	(00)	Tatal Causa		herbaceous vines, regardless of size, and and woody plants,
50% total cover: <u>30.0%</u> 20% total cover: <u>12.0%</u>	60%	= 10tal Cover		except woody vines, less than approximately 3 ft (1 m) in
Woody Vine Stratum (Plot size: <u>30 ft radius</u>).	Absolute % Cover	Dominant Species?	Indicator Status	height Woody Vine - All woody vines, regardless of height.
1.				
2.				
3.		1	1	Hydropytic
4.				Vegetation
7.				Present? Yes Ves No
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		
Remarks: (If observed, list morphological adaptations below).				

I

Soils			-					Sampling Point:	DP-9
Profile Descrip	otion: (Describe to the d	lepth needed	to document the in	ndicator or	confirm the	absence of i	ndicators.)	оср. 3	
Depth	Matrix	•		Redox Fea	atures				
(inches)	Color (moist)	%	Color (moist)	%	Type ¹	LOC ²	Texture	Remar	ks
0-3	10YR 3/2	100		-			Clay loam		
3-6	10YR 4/2	90	10YR 4/6	10	С	М	Clay loam		
6-9	10YR 5/4	85	7.5YR 4/6	15	С	М	Clay loam		
9-15	10YR 5/4	95	7.5YR 4/6	5	С	М	Clay		
				_					
	·								
1 Type: C=Conc	entration D=Depletion R	M=Reduced M	Matrix MS=Masked	Sand Grains	2	ocation: PI =	Pore Lining M=Matrix		
					. L		Indicators of	Problematic Hydr	ric Soils ³ :
Hydric Soli Ind			Dark Surface	·o (S7)				10) (MI RA 147)	10 30115 .
	don (A2)			e (S7) Below Surace	• (S8) (MI RA	147 148)		Redox (A16) (MI R	A 147 148)
Black Histic	(Δ3)		Thin Dark S	Surface (S9)	(MI RA 147.)	148)	Piedmont Flor	odplain Soils (F19)	(MI RA 136.
Hydrogen S	ulfide (A4)			/ed Matrix (F	(,	147)		
Stratified La	ivers (A5)		Depleted M	atrix (F3)	2)		Very Shallow	Dark Surface (TF1)	2)
2 cm Muck ((A10) (LRR N)		Redox Dark	Surface (F6	b)		Other (Explain	n in Remarks):	_/
Depleted Be	elow Dark Surface (A11)		Depleted Da	ark Surface (, (F7)				
Thick Dark	Surface (A12)		Redox Depr	ressions (F8))				
Sandy Muck	ky Mineral (S1)(LRR N,M	LRA 147,148)	Iron-Manga	nese Masse	s (F12) (LRR	N, MLRA 13	6)		
Sandy Gley	ed Matrix (S4)		Umbric Surf	face (F13) (N	/ILRA 136, 12	22)			
Sandy Redo	ox (S5)		Piedmont F	loodplain So	ils (F19) (ML	RA 148)			
Stripped Ma	ıtrix (S6)		Red Parent	Material (F2	1) (MLRA 12	27, 147)			
							³ Indicators of	hydrophytic vegeta	tion and
							wetland hydro	ology must be prese	ent, unless
							disturbed of p		
Restrictive Lave	er (if observed):								
Туре:									
Depth (inches	s):						Hydric Soil Present?	Yes 🔽 No	
Romarks [,]	·						5		
INCHIAINS.									

Project/Site:	Plumtree E	3ranch/Dunloggin N	vliddle School	City/County: Ellicott City, Howard Co. Sampling Date:					4/27/20
Applicant/Owner:		Howard County De	ept. of Parks and Recr	reation	Stat	e: MD	Samplinç	J Point:	DP-10
Investigator(s):		НК		Section, Town	ship, Range:				
Landform (hillslope, t	errace, etc.)	Flo	odplain	Local relief (cr	oncave, convex,	none):	Concave	Slope	e (%): 0%
Subregion (LRR or M	ILRA):	LRR S	Lat:	39.2557	Long:	-76.83	344 Da	itum: N	WGS84
Soil Map Unit Name:		Ha (Hatbor	o-Codorus Silt Loam,	0-3% slope)		NWI classificat	ion:	N/A	
Are climatic / hydrolo	gic conditions o	n the site typical fo	or this time of year?	Yes 🗸	No 🗌	(If no, explain i	n Remarks.)		
Are Vegetation N	, Soil N	, or Hydrology	N Significantly of	disturbed?	Are "Norm	al Circumstances	" present?	Yes 🗸	No 🗌
Are Vegetation N	, Soil N	, or Hydrology	N Naturally prot	blematic?	(If needed,	, explain any ans	vers in Remark	s.)	
SUMMARY OF FI	NDINGS - /	- Attach site ma	ap showing sar	npling point le	ocations, tra	ansects, imp	portant fea	tures, e	tc.
Hydrophytic Vegetati	on Present?	Yes 🗸	No						
Hydric Soil Present?		Yes 🗸	No 🗌	Is the Sample	ed Area				
Wetland Hydrology P	'resent?	Yes 🗸	No	within a Wetl	and?	Yes 🗸	No		
Remarks: Approximately 2" of rain	fell on the site t	he night before the	delineation. Saturatic	on was not used as a	a sole indicator c	of wetland hydrold	ogy. In wetland	6	
HYDROLOGY									
Wetland Hydroid Primary Indicators (r Surface Water High Water Tal Saturation (A3) Water marks (E Sediment Depo Drift Deposits (Iron Deposits () Inundation Visi	Dgy Indicato ninimum of one (A1) ble (A2)) 31) psits (B2) [B3) rust (B4) B5) ble on Aerial Im : ::	rs: <u>is required: check</u>	all that apply) Water-Stained Leav Aquatic Fauna (B13 True Aquatic Plants Hydrogen Sulfide Or Oxidized Rhizosphe Presence of Reduce Recent Iron Reducti Thin Muck Surface (Other (Explain in Re	res (B9) (B14) dor (C1) eres on Living Roots ed Iron (C4) ion in Tilled Soils (C (C7) emarks)	(C3)	Secondary Inu Surface Soil Cl Sparsely Vege Drainage Patte Moss Trim Line Dry-Season W Crayfish Burrov Saturation Visi Stunted or Stre Geomorphic Pe Shallow Aquita Microtopograph FAC-Neutral T	<u>cators (minimu</u> acks (B6) lated Concave rns (B10) as (B16) ater Table (C2) ws (C8) ble on Aerial Im assed Plants (D position (D2) rd (D3) hic Relief (D4) est (D5)	<u>m of two re</u> Surface (B8 Iagery (C9) 1)	<u>quirea)</u> 3)
Water Table Present Saturation Present? (includes capillary fri	? Yes Yes nge)	✓ No ✓ No ✓ No	Depth (inches): Depth (inches):	6" Surface	Netland Hydrol	ogy Present?	Yes ַ	/No	
Describe Recorded Data	ı (stream gage, ı	monitoring well, ae	rial photos, previous ir	nspections), if availa	ıble:				
Remarks:									

	Absolute	Dominant		Domiance Test worksheet
Tree Stratum (Plot size: <u>30 ft radius</u>).	% Cover	Species?	Indicator Status	
1. Acer negundo	5	Yes	FAC	Number of Dominant Species
2. Salix nigra	5	Yes	OBL	That are OBL, FACW, or FAC: 4 (A)
3.	ł	İ	1 1	
4.	<u> </u>			Total Number of Dominant
5.				Species Across All Strata: 4 (B)
6.				
7				Percent of Dominant Speices
50% total cover: 5.0% 20% total cover: 2.0%	10%	= Total Cover	<u> </u>	that are OBL, FACW, or FAC: 100.0% (A/B)
	Absolute	 Dominant		Prevalence Index worksheet
Sapling Stratum (Plot size: <u>15 ft radius</u>).	% Cover	Species?	Indicator Status	Total % Cover of: Multiply by:
1. Acer negundo	5	Yes	FAC	OBL species $20 \times 1 = 20$
2.			1 1	FACW species 50 X 2 = 100
3.			1 1	FAC species $35 \times 3 = 105$
4.			1 1	FACU species 0 X 4 = 0
5.			1 1	UPL species $0 \times 5 = 0$
6.	1		1	Column Totals 105 (A) 225 (B)
7.			1 1	
50% total cover: 2.5% 20% total cover: 1.0%	5%	= Total Cover		Prevalence Index = B/A = 2.14%
	∆hsolute	_ Dominant		Hydrophytic Vagatation Indicators:
Shrub Stratum (Plot size: <u>15 ft radius</u>).	% Cover	Snecies?	Indicator Status	1 Rapid Test of Hydronbytic Vegetation
1				1.1 Napid Test of Hydrophydro regetation
7. 2				3 Prevalence Index is <3.0 ¹
3				4. Morphological Adaptations ¹ (Provide supporting
4				data in Remarks or on a separte sheet)
5				Problematic Hydrophytic Vegetation ¹ (Explain)
6	1			
7		1		¹ Indicators of hydric soil and wetland hydrology must
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover	11	be present, unless disturbed or problematic.
	Abaaluta	- Dominant		Definitions of Verstetion Chotes
Herb Stratum (Plot size: <u>5 ft radius</u>).	Absolute	Dominant	Indiantar Status	Definitions of vegetation Strata:
1 Phalaria ar undinazza	% Cover	Species?		Tree - Woody plants, excluding woody vines, approximately
Phalaiis arunumacea Derejeerie perfectee	50	res	FACVV	20 ft (6 m) or more in height and 3 in. (7.6 cm) or larger in
2. Pelsicalla pellullata 2. Sumplecembre feotidue	10	No.		diameter at breast height (DBH).
3. Sympolarpus locinuus A Danunculus ficaria	10	No		
4. Kahuhulus Ilaha 5. Carav lurida	5	No	OBL	Sapling - Woody plants, excluding woody vines,
	J	INU	UDL	approximately 20 ft (6 m) or more in height and less then
0. 7				3 in. (7.6 cm) DBH.
Ω	}			Shruh Moody plants, avaluding woody vines
0.	}			Shiub - Woody pidilis, exclouing woody vines,
7. 10	}			
11	1		+	
12	1	1		Herb - All herbaceous (non-woody) plants, including
50% total cover: 45.0% 20% total cover: 18.0%	90%	- Total Cover	<u> </u>	herbaceous vines, regardless of size, and and woody plants,
				except woody villes, less than approximately site (i m) in balabt
Woody Vine Stratum (Plot size: <u>30 ft radius</u>).	Absolute % Cover	Dominant Species?	Indicator Status	Woody Vine - All woody vines, regardless of height.
1.				
2.				
3.				Hydropytic
4.				Vegetation
7.				Present? Yes 🗹 No 🗌
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		
Remarks: (If observed, list morphological adaptations below).				

Sampling Point: DP-10

Soils								Sampling Point:	DP-10
Profile Descri	otion: (Describe to the d	lepth needed	to document the i	ndicator or	confirm the	absence of i	ndicators.)		
Depth	Matrix	•		Redox Fea	atures				
(inches)	Color (moist)	%	Color (moist)	%	Type ¹	Loc ²	Texture	Remar	ks
0-10	10YR 3/2	90	10YR 4/6	10	С	М	Clay loam		
10-14	10YR 4/1	98	10YR 4/6	2	С	М	Clay loam	concentrations are	faint
14-16	10YR 4/3	80	10YR 4/6	20	С	М	Clay loam	-	
16-18	10YR 4/1	85	10YR 4/6	15	С	М	Clay		
					· ·				
					·				
¹ Type: C=Conc	entration, D=Depletion, R	RM=Reduced M	Matrix, MS=Masked	Sand Grains	5. 2	ocation: PL=F	Pore Lining, M=Matrix		
Hydric Soil Im Histosol (A' Black Histic Hydrogen S Stratified La 2 cm Muck Depleted B Thick Dark Sandy Muc Sandy Gley Sandy Red Stripped Ma	dicators: 1) 2don (A2) 3ulfide (A4) ayers (A5) (A10) (LRR N) elow Dark Surface (A11) Surface (A12) ky Mineral (S1)(LRR N,M red Matrix (S4) bx (S5) atrix (S6)	LRA 147,148)	 □ Dark Surface □ Polyvalue E □ Thin Dark S □ Loamy Gley □ Depleted M □ Redox Dark ✓ Depleted D □ Redox Dep □ Iron-Manga □ Umbric Sur □ Piedmont F □ Red Parent 	ce (S7) Below Surace Surface (S9) yed Matrix (F latrix (F3) < Surface (F4 ark Surface (ressions (F8 nese Masse face (F13) (N loodplain So Material (F2	e (S8) (MLRA (MLRA 147, 7 2) 5) (F7)) s (F12) (LRR ALRA 136, 12 ills (F19) (ML 1) (MLRA 12	. 147,148) 148) N, MLRA 13 22) RA 148) 7, 147)	Indicators of 2 cm Muck of Coast Prairi Piedmont FI 147) Very Shallor Other (Explain 6) ³ Indicators of wetland hyddisturbed or	of Problematic Hydr (A10) (MLRA 147) e Redox (A16) (MLR loodplain Soils (F19) w Dark Surface (TF1: ain in Remarks): of hydrophytic vegeta rology must be prese problematic.	ric Soils ³ : A 147, 148) (MLRA 136, 2) tion and ent, unless
Restrictive Lay Type: Depth (inche:	er (if observed):						Hydric Soil Present?	Yes 🔽 No	
Remarks:									

Project/Site: PI	umtree Branch/Dunloggin	Viddle School	City/County:	Ellicott City, H	Date:	4/27/20		
Applicant/Owner:	Howard County D	ept. of Parks and Recrea	tion	State	: MD	Sampling I	Point:	DP-11
Investigator(s):	НК		Section, Towns	ship, Range:				
Landform (hillslope, terrace,	etc.) Flo	odplain	Local relief (co	ncave, convex, i	none):	Concave	Slope (%	6): 0%
Subregion (LRR or MLRA):	LRR S	Lat:	39.2557	Long:	-76.834	14 Datu	ım: WC	GS84
Soil Map Unit Name:	Ha (Hatbo	ro-Codorus Silt Loam, 0-3	3% slope)		NWI classification	on:	N/A	
Are climatic / hydrologic con	ditions on the site typical for	or this time of year?	Yes 🗸	No	(If no, explain in	Remarks.)		
Are Vegetation N , S	oil N , or Hydrology	N Significantly dist	turbed?	Are "Norma	I Circumstances"	present? Y	'es 🗸	No 🗌
Are Vegetation N , S	oil N, or Hydrology	N Naturally proble	matic?	(If needed,	explain any answ	ers in Remarks.)	
SUMMARY OF FINDIN	GS - Attach site m	ap showing sam	oling point lo	ocations, tra	insects, imp	ortant feat	ures, etc.	
Hydrophytic Vegetation Pres	sent? Yes 🔽	No						
Hydric Soil Present?	Yes 🗸	No	Is the Sample	d Area				
Wetland Hydrology Present	? Yes 🗸	No 🗌	within a Wetla	and?	Yes 🗸	No		
Remarks: Approximately 2" of rain fell on t	he site the night before the	delineation. Saturation	was not used as a	sole indicator of	wetland hydrolog	gy. In wetland 7		
HYDROLOGY								
Primary Indicators (minimur Surface Water (A1) High Water Table (A2) Saturation (A3) Water marks (B1) Sediment Deposits (B3) Algal Mat or Crust (B4) Iron Deposits (B5) Inundation Visible on A	n of one is required: check n	all that apply) Water-Stained Leaves Aquatic Fauna (B13) True Aquatic Plants (B Hydrogen Sulfide Odo Oxidized Rhizosphere: Presence of Reduced Recent Iron Reduction Thin Muck Surface (C Other (Explain in Rem	(B9) r (C1) s on Living Roots Iron (C4) in Tilled Soils (C6 7) arks)	(C3)	Secondary India Surface Soil Cra Sparsely Vegeta Drainage Patter Moss Trim Lines Dry-Season Wa Crayfish Burrow Saturation Visib Stunted or Stres Geomorphic Por Shallow Aquitar Microtopographi FAC-Neutral Te	actors (IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	gery (C9)	<u></u>
Surface Water Present?	Yes 🗸 No 🗌	Depth (inches):	1"					
Water Table Present?	Yes No 🗸	Depth (inches):						
Saturation Present? (includes capillary fringe)	Yes 🔽 No 🗌	Depth (inches):S	Surface N	/etland Hydrolo	gy Present?	Yes 🗸	No _[
Describe Recorded Data (strear	n gage, monitoring well, ae	rial photos, previous insp	pections), if availal	ole:				
Remarks:								

	Absolute	Dominant		Domiance Test worksheet
Tree Stratum (Plot size: <u>30 ft radius</u>).	% Cover	Species?	Indicator Status	
1.				Number of Dominant Species
2				That are OBL EACW or EAC: 2 (A)
3.				(,
4.				Total Number of Dominant
5.				Species Across All Strata: 2 (B)
6				
7.				Percent of Dominant Speices
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		that are OBL_EACW_or_EAC: 100.0% (A/B)
		- Deminent		
Sapling Stratum (Plot size: 15 ft radius).	Absolute	Dominant	Indiantar Ctatua	Prevalence index worksneet
1	% Cover	Species?	Indicator Status	ODL sussists
l.				$\begin{array}{cccc} \text{OBL Species} & 5 & \text{X} & \text{I} & = & 5 \\ \text{EACIV} & & & \text{I} & \text{I} & \text{I} & \text{I} & \text{I} \\ \end{array}$
2.				FACW species $35 \times 2 = 70$
3.				FAC species $30 \times 3 = 90$
4.				FACU species $0 \times 4 = 0$
b.				UPL species $U = X S = 0$
b.				$\begin{array}{c} \text{Column Lotals} & 70 & (A) & 165 & (B) \end{array}$
				Prevalence Index = B/A =
50% total cover: 0.0% 20% total cover: 0.0%	0%	= I otal Cover		2.36%
Chrub Stratum (Diataiza) 15 ft radius)	Absolute	Dominant		Hydrophytic Vegetation Indicators:
Shrud Stratum (Piot size: <u>15 it radius</u>).	% Cover	Species?	Indicator Status	1. Rapid Test of Hydrophytic Vegetation
1.				✓ 2. Dominance Test is >50%
2.				\checkmark 3. Prevalence Index is ≤3.0 ¹
3.				4. Morphological Adaptations ¹ (Provide supporting
4.				data in Remarks or on a separte sheet)
5.				Problematic Hydrophytic Vegetation ¹ (Explain)
6.				
7.				¹ Indicators of hydric soil and wetland hydrology must
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		be present, unless disturbed or problematic.
	Absolute	 Dominant		Definitions of Vegetation Strata:
Herb Stratum (Plot size: <u>5 ft radius</u>).	% Cover	Species?	Indicator Status	
1. Phalaris arundinacea	30	Yes	FACW	Tree - Woody plants, excluding woody vines, approximately
2. Ranunculus ficaria	30	Yes	FAC	20 ft (6 m) or more in height and 3 in. (7.6 cm) or larger in
3. Impatiens capensis	5	No	FACW	diameter at breast height (DBH).
4. Carex Jurida	5	No	OBI	
5.				Sapling - Woody plants, excluding woody vines,
6.				approximately 20 ft (6 m) or more in height and less then
7.				3 in. (7.6 cm) DBH.
8.				Shrub - Woody plants, excluding woody vines
9				approximately 3 to 20 ft (1 to 6 m) in height
10				
11				Hards - All backson of Associated National States
12				Herb - All nerbaceous (non-woody) plants, including
50% total cover: 35.0% 20% total cover: 14.0%	70%	= Total Cover		nerbaceous vines, regaluless of size, and and woody plants,
		- 10tal 00101		boight
Woody Vine Stratum (Plot size: 30 ft radius).	Absolute	Dominant		Maadu Mina - Alluuseku jaas sesenduse ef beiekt
, <u> </u>	% Cover	Species?	Indicator Status	woody vine - All woody vines, regardless of height.
1.				
۷.	ļ			
<u>3.</u>				Hydropytic
4.				
				Present? Yes V
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		
Remarks: (If observed, list morphological adaptations below).				·
, , , , , , , , , , , , , , , , , , ,				

Sampling Point:

Soils Sa	ampling Point: DP-11
Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)	
Depth Matrix Redox Features	
(inches) Color (moist) % Color (moist) % Type ¹ Loc ² Texture	Remarks
0-4 10YR 3/2 90 10YR 4/6 10 C M Clay loam	
4-12 2.5Y 5/3 85 10YR 4/6 15 C M Clay loam	
Type: C-Concentration D-Depletion PM-Reduced Matrix MS-Masked Sand Grains 2 location: PL=Pore Lining M=Matrix	
Hydric Soil Indicators:	roblematic Hydric Soils ³ :
Histosol (A1)) (MLRA 147) (A17) (AU DA 147, 149)
Histic Epipedon (A2) Polyvalue Below Sulace (So) (IVILKA 147,146) Coast Plane Re	200X (A10) (MILKA 147, 140) Inlain Sails (F10) (MI RA 136
	טפר בארשואר ואראל אוואראין אוואראין אוואר, אוואראין אוואר, אוואראין אוואראיז איז אוואר, אוואראיז אוואראיז אווא
Stratified Lavers (A5)	ark Surface (TF12)
2 cm Muck (A10) (LRR N) Redox Dark Surface (F6) Other (Explain in	n Remarks):
Depleted Below Dark Surface (A11)	
Thick Dark Surface (A12)	
Sandy Mucky Mineral (S1)(LRR N,MLRA 147,148) Iron-Manganese Masses (F12) (LRR N, MLRA 136)	
Sandy Gleyed Matrix (S4)	
Sandy Redox (S5) Piedmont Floodplain Soils (F19) (MLRA 148) Ded Decent Material (521) (MLRA 147)	
Stripped Matrix (S6)	L. Judie constation and
indicators of ny wetland hydrolog	drophytic vegetation and
disturbed or prol	blematic.
Restrictive Layer (if observed):	
Туре:	
Depth (inches): Hydric Soil Present? Ye	es 🗹 No 🛄
Remarks:	

Project/Site:	Plumtree	Branch/Dunloggin M	vliddle School	City/County: Ellicott City, Howard			ward Co. Sampling Date:			27/20
Applicant/Owner:		Howard County D	ept. of Parks and Recrea	ition	S	itate: MI	D Sai	mpling Point:	DI	P-12
Investigator(s):		НК		Section, Towns	ship, Range:					
Landform (hillslope,	terrace, etc.)	Flo	odplain	Local relief (co	oncave, conve	ex, none):	Concav	e Sl	ope (%):	0%
Subregion (LRR or N	/ILRA):	LRR S	Lat:	39.2557	Lonç	g:	-76.8344	Datum:	WGS8	34
Soil Map Unit Name		Ha (Hatbor	ro-Codorus Silt Loam, 0-3	3% slope)		NWI cl	assification:	N	/A	
Are climatic / hydrolo	ogic conditions of	on the site typical fo	or this time of year?	Yes 🗸	No	(If no, e	explain in Remark	(S.)		
Are Vegetation N	, Soil N	, or Hydrology	N Significantly dist	turbed?	Are "No	rmal Circum	stances" present	? Yes 🗔	∕ No	з 🗌
Are Vegetation N	, Soil N	, or Hydrology	N Naturally proble	matic?	(If need	ed, explain a	any answers in Re	emarks.)		
- SUMMARY OF F		– Attach site m	ap showing samp	oling point lo	ocations,	transect	s, importan	t features	, etc.	
Hydrophytic Vegetat	ion Present?	Yes 🗸	No							
Hydric Soil Present?	,	Yes 🗸	No	Is the Sample	ed Area					
Wetland Hydrology F	Present?	Yes	No	within a Wetl	and?	Yes	No	\checkmark		
Remarks:						-			<u> </u>	
Approximately 2" of rain	fell on the site t	he night before the	delineation. Saturation	was not used as a	a sole indicate	or of wetland	l hydrology.			
							<u> </u>			
HIDROLOGI										
Primary Indicators (Surface Water High Water Ta Saturation (A3 Water marks (Sediment Dep Drift Deposits Algal Mat or C Iron Deposits (Inundation Vis	minimum of one (A1) ble (A2)) B1) osits (B2) (B3) rust (B4) (B5) ible on Aerial Im	is required: check	all that apply) Water-Stained Leaves Aquatic Fauna (B13) True Aquatic Plants (B Hydrogen Sulfide Odor Oxidized Rhizospheres Presence of Reduced Recent Iron Reduction Thin Muck Surface (CT Other (Explain in Rema	(B9) 14) r (C1) s on Living Roots Iron (C4) in Tilled Soils (Ca 7) arks)	(C3) [6) [[[[Surface Sparse Draina Moss 1 Dry-Se Crayfis Satura Stunted Geomo Shallou Microto	e Soil Cracks (B6 ely Vegetated Cor ge Patterns (B10) Frim Lines (B16) eason Water Table th Burrows (C8) tion Visible on Ae d or Stressed Pla orphic Position (D w Aquitard (D3) opographic Relief eutral Test (D5)) ncave Surface e (C2) rial Imagery (nts (D1) 2) (D4)	: (B8) <u>(</u> C9)	
Surface Water Prose	• ont? Vos		Dopth (inchos):							
Water Table Dresen	ли: 103 Ю Voo		 	<u> </u>						
Saturation Present	.r res Voc		Depth (inches):							
(includes capillary fri	inge)			v	Vetland Hydr	ology Pres	ent? Yes	s 🗌	No 🔽	
Describe Recorded Data	e (stream dade	monitoring well as	rial photos provious insr	octions) if availa	hle [,]					
	r (sirearn gage,	momoning weil, de	nai protos, previous insp							
Remarks:										

	Absolute	Dominant		Domiance Test worksheet			
Tree Stratum (Plot size: <u>30 ft radius</u>).	% Cover Species? Indicator Sta		Indicator Status	s			
1.				Number of Dominant Species			
2.				That are OBL, FACW, or FAC: 2 (A)			
3.				、			
4.				Total Number of Dominant			
5.				Species Across All Strata: 2 (B)			
6.				(,			
7.				Percent of Dominant Speices			
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		that are OBL, FACW, or FAC: 100.0% (A/B)			
	Absoluto	_ Dominant		Drovalance Index worksheet			
Sapling Stratum (Plot size: <u>15 ft radius</u>).	% Cover Specie		Indicator Status	Total % Cover of: Multiply by:			
1	70 COVCI	Species:		1000000000000000000000000000000000000			
)				EACW species $65 \times 2 = 130$			
3				FAC species $20 \times 2 = 130$			
5. 1				$FACU species \qquad 0 \qquad XA = 0$			
t. 5				$1 \text{ ACO species} \qquad 0 \qquad X = 0$			
6				Column Totals $00 (A) = 0$			
7							
7. F0% total covor: 0.0% 20% total covor: 0.0%	0%	- Total Covor		Prevalence Index = $B/A = 2.17\%$			
	078			2.1770			
Shrub Stratum (Plot size: 15 ft radius).	Absolute	Dominant		Hydrophytic Vegetation Indicators:			
<u>10 (11 di </u>	% Cover	Species?	Indicator Status	1. Rapid Test of Hydrophytic Vegetation			
1.				2. Dominance Test is >50%			
2.				3 . Prevalence Index is $\leq 3.0^{1}$			
3.				4. Morphological Adaptations' (Provide supporting			
4.				data in Remarks or on a separte sheet)			
5.				Problematic Hydrophytic Vegetation' (Explain)			
5.							
7.				¹ Indicators of hydric soil and wetland hydrology must			
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		be present, unless disturbed or problematic.			
Jorh Strotum (Diot cizo, Efficiency)	Absolute	Dominant		Definitions of Vegetation Strata:			
neid Stratum (Piol Size. <u>5 it radius</u>).	% Cover	Species?	Indicator Status				
1. Phalaris arundinacea	60	Yes	FACW	20 ft (6 m) or more in height and 2 in (7.6 cm) or larger in			
2. Ranunculus ficaria	20	Yes	FAC	diameter at breast beight (DRH)			
3. Impatiens capensis	5	No	FACW	diameter at breast height (DDH).			
4. Carex lurida	5	No	OBL	Sepling Weedy plants, evaluating weedy vines			
5.				approvimately 20 ft (6 m) or more in height and loss then			
5.				3 in (7.6 cm) DBH			
7.							
3.				Shrub - Woody plants, excluding woody vines,			
9.				approximately 3 to 20 ft (1 to 6 m) in height.			
10.							
11.				Herb - All herbaceous (non-woody) plants, including			
12.				herbaceous vines, regardless of size, and and woody plants,			
50% total cover: 45.0% 20% total cover: 18.0%	90%	= Total Cover		except woody vines, less than approximately 3 ft (1 m) in			
	Absolute	Dominant		height			
Woody Vine Stratum (Plot size: <u>30 ft radius</u>).	% Cover	Species?	Indicator Status	Woody Vine - All woody vines, regardless of height.			
1.							
2.							
3.				Hydropytic			
4.			1	Vegetation			
7.				Present? Yes 🗹 No 🗌			
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover					
Domarke: (If obconvod, liet morphological adaptations help://		-		1			
remains. (ii observeu, iist morphological adaptations below).							

Sampling Point:

Soils								Sampling Point:	DP-12		
Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)											
Depth	Matrix			Redox Fe	atures						
(inches)	Color (moist)	%	Color (moist)	%	Type ¹	Loc ²	Texture	Remar	Remarks		
0-4	10YR 3/2	90	10YR 4/6		С	М	Clay loam				
4-12	2.5Y 5/3	85	10YR 4/6	15	С	М	Clay loam				
1Typo: C_Conc	optration D-Doplation P		Antrix MS_Mackod	Sand Crain	c 2	ocation: DL_E	Poro Lipipa M-Matrix				
' I ype: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. ² Location: PL=Pore Lining, M=Matrix											
Hydric Soil Inc	dicators:						Indicators of	f Problematic Hydi	ic Soils ³ :		
Histosol (A1	l)		Dark Surfa	ce (S7)		447 440	2 cm Muck (A	A10) (MLRA 147)	A 4 47 4 40		
Histic Epipe	edon (A2)		Polyvalue I	Below Surace	e (S8) (MLRA /MLDA 147	(147,148) 149)	Coast Prairie Redox (A16) (MLRA 147, 148) Diedmont Electrolain Sails (E10) (MLDA 124)				
	(A3) Julfido (A4)			Suilace (S9)	(IVILKA 147,	148)	147)				
Stratified La	ounue (A4) avers (Δ5)			yeu ivialitix (r Aatrix (E3)	- 2)		Very Shallow Dark Surface (TF12)				
2 cm Muck	(A10) (LRR N)		Redox Dar	k Surface (Fi	6)						
Depleted Be	elow Dark Surface (A11)		Depleted D	ark Surface	(F7)						
Thick Dark	Surface (A12)		Redox Dep	pressions (F8	3)						
Sandy Muck	ky Mineral (S1)(LRR N ,M	LRA 147,148)	Iron-Manga	anese Masse	es (F12) (LRR	N, MLRA 13	6)				
Sandy Gley	ed Matrix (S4)			rface (F13) (I	MLRA 136, 1	22)					
Sandy Redo	DX (S5)			- 1000piain So t Matorial (E1	DIIS (F 19) (IVIL D1) (MI DA 11	.RA 148) 07 147)					
	allix (So)					.7, 147)	³ Indicators of	budrophytic vogota	tion and		
							wetland hydro	ology must be prese	and ent. unless		
							disturbed or p	problematic.			
Restrictive Laye	er (if observed):										
Туре:											
Depth (inches	s):						Hydric Soil Present?	Yes 🔽 No			
Remarks:											
WETLAND DETERMINATION DATA FORM- Eastern Mountains and Piedmont

Project/Site:	: Plumtree Branch/Dunloggin Middle School			City/County:	Ellicott City, H	loward Co.	Sampli	ng Date:	4/2	7/20
Applicant/Owner:		Howard County [Dept. of Parks and Recr	eation	State	e: MD	Sampli	ng Point:	DF	۶-13
Investigator(s):		НК		Section, Towns	ship, Range:					
Landform (hillslope,	terrace, etc.)	FI	oodplain	Local relief (co	oncave, convex,	none):	Concave	Slope	e (%):	0%
Subregion (LRR or	MLRA):	LRR S	Lat:	39.2557	Long:	-76.8	3344 I	Datum:	WGS8	4
Soil Map Unit Name):	Ha (Hatbo	pro-Codorus Silt Loam, (0-3% slope)		NWI classifica	ation:	N/A		
Are climatic / hydrol	logic conditions of	on the site typical f	or this time of year?	Yes 🗸	No	(If no, explain	in Remarks.)			
Are Vegetation	N , Soil N	, or Hydrology	N Significantly d	listurbed?	Are "Norma	al Circumstance	es" present?	Yes 🗸	No	
Are Vegetation	N, Soil N	, or Hydrology	N Naturally prob	lematic?	(If needed,	explain any an	swers in Rema	arks.)	-	
- SUMMARY OF F	INDINGS -	– Attach site m	ap showing san	npling point lo	ocations, tra	ansects, im	portant fe	atures, e	etc.	
Hydrophytic Vegeta	tion Present?	Yes 🗸	No							
Hydric Soil Present	?	Yes 🗸	No	Is the Sample	ed Area					
Wetland Hydrology	Present?	Yes 🗸	No	within a Wetla	and?	Yes 🗸] No			
Approximately 2" of rair	n fell on the site t	he night before th	e delineation. Saturatio	n was not used as a	sole indicator c	of wetland hydro	logy. In Wetla	ind 8		
HIDROLOGI										
Primary Indicators Primary Indicators Surface Wate High Water Ta Saturation (A: Water marks Sediment Dep Drift Deposits Algal Mat or C Iron Deposits Inundation Vis	(minimum of one r (A1) able (A2) 3) (B1) bosits (B2) (B3) Crust (B4) (B5) sible on Aerial Im	≥ is required: checl	 <u>all that apply</u>) Water-Stained Leave Aquatic Fauna (B13) True Aquatic Plants Hydrogen Sulfide Oc Oxidized Rhizospher Presence of Reduce Recent Iron Reduction Thin Muck Surface (Other (Explain in Reservance) 	es (B9)) (B14) dor (C1) res on Living Roots ed Iron (C4) on in Tilled Soils (Ce C7) marks)	(C3)	Secondary III Surface Soil (Sparsely Veg Drainage Pati Moss Trim Lin Dry-Season V Crayfish Burr Saturation Vis Stunted or Sti Geomorphic I Shallow Aquil Microtopogra FAC-Neutral	dicators (minin Cracks (B6) etated Concav terns (B10) nes (B16) Vater Table (C ows (C8) sible on Aerial ressed Plants Position (D2) tard (D3) phic Relief (D4 Test (D5)	re Surface (E 2) Imagery (C9 (D1)	98) 98)	2
Field Observations	S:			4.1						
Surface water Pres	ent? Yes			1						
Water Table Preser	nt? Yes		Depth (inches):	4"						
Saturation Present? (includes capillary fi	ringe)	No	Depth (inches):	surface V	Vetland Hydrolo	ogy Present?	Yes	✓ No	» <u> </u>	_
Describe Recorded Dat	a (stream gage,	monitoring well, a	erial photos, previous in	ispections), if availa	ble:					

VEGETATION - Use scientific names of plants.

	Absolute	Dominant		Domiance Test worksheet
Tree Stratum (Plot size: <u>30 ft radius</u>).	% Cover	Species?	Indicator Status	
1. Acer negundo	5	Yes	FAC	Number of Dominant Species
2.				That are OBL, FACW, or FAC: 3 (A)
3.				
4.				Total Number of Dominant
5.				Species Across All Strata: 3 (B)
6.				
7.				Percent of Dominant Speices
50% total cover: 2.5% 20% total cover: 1.0%	5%	= Total Cover		that are OBL, FACW, or FAC: 100.0% (A/B)
	Absolute	 Dominant		Prevalence Index worksheet
Sapling Stratum (Plot size: <u>15 ft radius</u>).	% Cover	Species?	Indicator Status	Total % Cover of: Multiply by:
1. Acer neaundo	5	Yes	FAC	$\frac{1}{\text{OBL species}} \qquad 30 \qquad \overline{\text{X 1}} = 30$
2	-			FACW species $45 \times 2 = 90$
3.				FAC species $20 \times 3 = 60$
4.				FACU species $0 \times 4 = 0$
5.				UPL species $0 \times 5 = 0$
6.				Column Totals 95 (A) 180 (B)
7.				
50% total cover: 2.5% 20% total cover: 1.0%	5%	= Total Cover	1	Prevalence Index = B/A = 1.89%
		- Dereiser		
Shrub Stratum (Plot size: 15 ft radius).	Absolute	Dominant		Hydrophytic Vegetation Indicators:
,,	% Cover	Species?	Indicator Status	I. Rapid Test of Hydrophytic Vegetation
1.				✓ 2. Dominance Lest is >50%
2.				✓ 3. Prevalence index is ≤3.0'
3.				4. Morphological Adaptations' (Provide supporting
4.				data in Remarks or on a separte sheet)
5.				Problematic Hydrophytic Vegetation' (Explain)
6.				
7.				'Indicators of hydric soil and wetland hydrology must
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		be present, unless disturbed or problematic.
	Absolute	Dominant		Definitions of Vegetation Strata:
Herb Stratum (Plot size: <u>5 ft radius</u>).	% Cover	Species?	Indicator Status	
1. Phalaris arundinacea	40	Yes	FACW	Tree - Woody plants, excluding woody vines, approximately
2. Carex lurida	15	Yes	OBL	20 ft (6 m) or more in height and 3 in. (7.6 cm) or larger in
3. Ranunculus ficaria	10	No	FAC	diameter at breast height (DBH).
4. Symplocarpus foetidus	10	No	OBL	
5. Lysimachia nummularia	5	No	FACW	Sapling - Woody plants, excluding woody vines,
6. Persicaria hydropiper	5	No	OBL	approximately 20 ft (6 m) or more in height and less then
7.	-	-	-	3 in. (7.6 cm) DBH.
8.				Shrub - Woody plants, excluding woody vines.
9.				approximately 3 to 20 ft (1 to 6 m) in height.
10.				
11.				Harb All borbaccous (non-weady) plants installing
12.			1	herbaceous vines, regardloss of size, and and weady plants
50% total cover: 42.5% 20% total cover: 17.0%	85%	= Total Cover		nervaceous vines, regariness of size, and and woody plants, except woody vines, loss than approximately 2 ft (1 m) in
	Aba-1	- Developed		height
Woody Vine Stratum (Plot size: 30 ft radius).	Absolute	Dominant		Meadu Vina Alluvadu vinaa ragardlaaa of baight
·····, ·····	% Cover	Species?	Indicator Status	woody vine - All woody vines, regardless of height.
1.				
2.				
3.				Hydropytic
4.				
1.				Present? Yes Ves No
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		
Remarks: (If observed, list morphological adaptations below).				•
,				

Sampling Point: DP-13

Soils								Sampling Point:	DP-13
Profile Descrip	ption: (Describe to the d	lepth needed	to document the i	ndicator or	confirm the	absence of i	ndicators.)		
Depth	Matrix			Redox Fea	atures				
(inches)	Color (moist)	%	Color (moist)	%	Type ¹	Loc ²	Texture	Remar	ks
0-1	10YR 3/2	100		_			Clay loam		
1-5	10 YR 4/1	95	10YR 4/6	15	С	PL	Clay loam		
5-15	10 YR 5/4	96	10YR 4/6	2	С	М	Clay	faint	
			10YR 4/6	2	С	PL		bold concentration	S
¹ Type: C=Conc	entration, D=Depletion, R	M=Reduced M	Matrix, MS=Masked	Sand Grain	s. 2	ocation: PL=	Pore Lining, M=Matrix		
	dicatora							of Problematic Hydi	ric Soils ^{3.}
Hydric Soil Ind	dicators:		Dark Surfa	no (S7)				(A10) (MI RA 147)	10 30115 .
	n) Adon (A2)		Polyvalue E	Selow Surace	e (S8) (MLRA	147.148)		e Redox (A16) (MLR	A 147, 148)
Black Histic	; (A3)		Thin Dark S	Surface (S9)	(MLRA 147,	148)	Piedmont F	loodplain Soils (F19)	(MLRA 136,
Hydrogen S	Sulfide (A4)		Loamy Gle	yed Matrix (F	-2)	·	147)		
Stratified La	ayers (A5)		Depleted M	latrix (F3)			Very Shallo	w Dark Surface (TF1	2)
2 cm Muck	(A10) (LRR N)		Redox Dark	k Surface (Fe	6)		Other (Expl	ain in Remarks):	
Depleted Be	elow Dark Surface (A11)		Depleted D	ark Surface	(F7)				
Thick Dark	Surface (A12)		Redox Dep	ressions (F8) ([10] (I DD				
	ky Milleral (ST)(LKK N,M vod Matrix (S4)	LKA 147,148)		face (F13) (N	S (F I 2) (LKK Μ ΡΔ 136 1'	N, WILKA 13	60)		
Sandy Red	$\frac{1}{2}$		Piedmont F	Toodplain Sc	oils (F19) (MI	RA 148)			
Stripped Ma	atrix (S6)		Red Parent	Material (F2	21) (MLRA 12	27, 147)			
				,	, (. ,	³ Indicators of	of hydrophytic yeaeta	ition and
							wetland hyd	Irology must be prese	ent, unless
							disturbed or	problematic.	
Restrictive Lay	er (if observed):								
Type.	-). 						Hudric Soil Drocont?		
Deptit (inches	5).						Hyunc Soli Present?		
Remarks:									

WETLAND DETERMINATION DATA FORM- Eastern Mountains and Piedmont

Project/Site:	Plumtree	Plumtree Branch/Dunloggin Middle School			City/County: Ellicott City, Howard Co. Sampling Date:					4/2	27/20
Applicant/Owner:		Howard County D	Howard County Dept. of Parks and Recreat			State	: MD	Samp	ling Point:	DI	² -14
Investigator(s):		НК		Section,T	Section, Township, Range:						
Landform (hillslope,	terrace, etc.)	Flo	odplain	Local relie	ef (concave, o	convex, i	none):	Concave	Slo	pe (%):	0%
Subregion (LRR or M	ILRA):	LRR S	Lat	39.255	1	Long:	-76.	8344	Datum:	WGS8	34
Soil Map Unit Name:		Ha (Hatbo	ro-Codorus Silt Loan	n, 0-3% slope)			NWI classific	ation:	N/A	١	
Are climatic / hydrolo	ogic conditions of	on the site typical fe	or this time of year?	Yes 🗸] No		(If no, explain	n in Remarks.))		
Are Vegetation N	, Soil N	, or Hydroloay	N Significantly	v disturbed?	Are	e "Norma	I Circumstance	es" present?	Yes 🗸	Nc	
Are Vegetation N	, Soil N	, or Hydrology	N Naturally pr	oblematic?	(lf ı	needed,	explain any an	swers in Rem	arks.)		
SUMMARY OF F		Attach site m	ap showing sa	ampling poir	nt locatio	ns, tra	insects, in	nportant f	eatures,	etc.	
Hydrophytic Vegetat	on Present?	Yes 🗸	No								
Hydric Soil Present?		Yes 🗹	No 🗌	Is the Sa	mpled Area						
Wetland Hydrology F	Present?	Yes 🗸	No 🗌	- within a	Netland?		Yes	No	\checkmark		
Remarks:	<u>, , , , , , , , , , , , , , , , , , , </u>										
Approximately 2" of rain	tell on the site t	the night before the	delineation. Satura	tion was not used	as a sole inc	dicator of	wetland hydro	ology. In Wetl	and 8		
HYDROLOGY											
Primary Indicators (i Primary Indicators (i) Surface Water High Water Ta Saturation (A3) Water marks (i) Sediment Depo Drift Deposits (i) Iron Deposits (i) Inundation Visit	ninimum of one (A1) ble (A2) (A1) (A1) (A1) (A2) (A2) (A2) (A2) (A2) (A2) (A2) (A2	≥ <u>is required: check</u>	all that apply) Water-Stained Lea Aquatic Fauna (B' True Aquatic Plan Hydrogen Sulfide Oxidized Rhizospl Presence of Redu Recent Iron Redu Thin Muck Surface Other (Explain in F	aves (B9) 13) Odor (C1) heres on Living R ced Iron (C4) ction in Tilled Soil e (C7) Remarks)	oots (C3) s (C6)		Secondary II Surface Soil Sparsely Veg Drainage Pal Moss Trim Li Dry-Season 1 Crayfish Burn Saturation Vi Stunted or Si Geomorphic Shallow Aqui Microtopogra FAC-Neutral	Cracks (B6) getated Conca terns (B10) nes (B16) Water Table (rows (C8) sible on Aeria tressed Plants Position (D2) tard (D3) phic Relief (D Test (D5)	ive Surface C2) I Imagery (C G(D1) 4)	.B8) 9)	<u>n</u>
Field Observations	nt? Vee		Donth (inchoo)								
Sunace water Prese	inter res										
Water Table Present	? Yes		Depth (inches):								
Saturation Present? (includes capillary fri	rge)	<u> </u>	Depth (inches):	surface	Wetland	Hydrolo	gy Present?	Yes	<u> </u>	lo 🗌	_
Describe Recorded Data	ı (stream gage,	monitoring well, ae	rial photos, previous	inspections), if a	vailable:						
Remarks:											

VEGETATION - Use scientific names of plants.

VEGETATION - Use scientific names of plant	.s.			Sampling Point: DP-14
Tree Stratum (Plot size: <u>30 ft radius</u>).	Absolute % Cover	Dominant Species?	Indicator Status	Domiance Test worksheet
1. Acer rubrum	10	Yes	FAC	Number of Dominant Species
2.				That are OBL, FACW, or FAC: 3 (A)
3.				
4.		───	┫	Lotal Number of Dominant
5.		 		Species Across All Strata: 4 (D)
7.		┼────	+{	Percent of Dominant Speices
50% total cover: 5.0% 20% total cover: 2.0%	10%	= Total Cover		that are OBL, FACW, or FAC: 75.0% (A/B)
	Absolute	- Dominant		Prevalence Index worksheet
Sapling Stratum (Plot size: <u>15 ft radius</u>).	% Cover	Species?	Indicator Status	Total % Cover of: Multiply by:
1. Acer rubrum	5	Yes	FAC	OBL species 30 X 1 = 30
2.	·			FACW species 20 X 2 = 40
3.				FAC species $15 \times 3 = 45$
4.		Ļ		FACU species 5 X 4 = 20
5.			<u> </u>	UPL species $0 \times 5 = 0$
6. ¬		───	┫	$\frac{135}{10}$
7. 50% total cover: 2.5% 20% total cover: 1.0%	5%	– Total Cover	I	Prevalence Index = $B/A = 1.93\%$
				<u> </u>
Shrub Stratum (Plot size: <u>15 ft radius</u>).	Absolute	Dominant Spacios 2	Indicator Statuc	Hydrophytic Vegetation Indicators:
1 Doco multifloro	% Cover			I. Rapid Test of Hydrophylic Vegetation
ו. Kusa munimura ז	C	162	FACU	2. DUITINGTICE LEST IS >00% 2×2 Prevalence Index is <3.0 ¹
2.		╂────		4. Morphological Adaptations ¹ (Provide supporting
4		╂────		data in Remarks or on a separte sheet)
I5.		┼────	1	Problematic Hydrophytic Vegetation ¹ (Explain)
6.		1	11	
7.				¹ Indicators of hydric soil and wetland hydrology must
50% total cover: 2.5% 20% total cover: 1.0%	5%	= Total Cover	<u>.</u>	be present, unless disturbed or problematic.
Herb Stratum (Plot size: <u>5 ft radius</u>).	Absolute % Cover	Dominant Species?	Indicator Status	Definitions of Vegetation Strata:
1. Carex stricta	30	Yes	OBL	Tree - Woody plants, excluding woody vines, approximately
2. Phalaris arundinacea	10	Yes	FACW	diameter at breast height (DRH)
3. Bidens frondosa	5	No	FACW	
4. Arisaema triphyllum	5	No	FACW	Sapling - Woody plants, excluding woody vines,
5.				approximately 20 ft (6 m) or more in height and less then
6. ¬		───	┫	3 in. (7.6 cm) DBH.
Ω		───		Shruh Woody plants, oveluding woody vines
Q			+{	annroximately 3 to 20 ft (1 to 6 m) in height.
10.		┼────	1 1	
11.		 	11	Herb - All berbaceous (non-woody) plants, including
12.			1	herbaceous vines, regardless of size, and and woody plants,
50% total cover: 25.0% 20% total cover: 10.0%	50%	= Total Cover	•	except woody vines, less than approximately 3 ft (1 m) in
Woody Vine Stratum (Plot size: <u>30 ft radius</u>).	Absolute % Cover	Dominant Species?	Indicator Status	height Woody Vine - All woody vines, regardless of height.
1.		<u> </u>		
2.			1 1	
3.			<u> </u>	Hydropytic
4.				Vegetation
7.				Present? Yes 🖄 No 🛄
50% total cover: 0.0% 20% total cover: 0.0%	0%	= Total Cover		
Remarks: (If observed, list morphological adaptations below).				

Soils								Sampling Point:	DP-14
Profile Descrip	otion: (Describe to the d	epth needed	to document the i	ndicator or	confirm the	absence of in	ndicators.)	' -	
Depth	Matrix			Redox Fea	atures				
(inches)	Color (moist)	%	Color (moist)	%	Type¹	LOC ²	Texture	Remar	ks
0-4	10YR 4/1	95	10YR 4/6	-			Clay loam		
4-6	10YR 4/2	95	10YR 4/6	5	С	М	Clay loam		
6-13	10YR 4/4	80	10YR 4/1	10	D	М	Clay		
			10YR 4/6	10	С	М			
					· ·				
					<u> </u>				
¹ Type: C=Conc	entration, D=Depletion, R	M=Reduced N	Aatrix, MS=Masked	Sand Grains	<u>,</u> 2	ocation: PL=P	ore Lining, M=Matrix		
Hydric Soil Inc	licators:						Indicators of	Problematic Hydr	ric Soils ³ :
Histosol (A1)		Dark Surfac	ce (S7)			2 cm Muck (A1	10) (MLRA 147)	
Histic Epipe	don (A2)		Polyvalue E	Jelow Surace	: (S8) (MLRA	. 147,148)	Coast Prairie F	Redox (A16) (MLR	A 147, 148)
Black Histic	(A3)			Surface (S9)	(MLRA 147, 1	148)	Piedmont Floo	dplain Soils (F19)	(MLRA 136,
✓ Hydrogen S	UIFICIE (A4)			Jed Matrix (F	2)		I47)	Dark Surface (TE1	2)
	(A10) (LRR N)		Redox Darl	auix (F3) k Surface (F7)		Other (Explain	uin Remarks).	2)
Depleted Be	elow Dark Surface (A11)		Depleted D	ark Surface	, (F7)			in Remarks).	
Thick Dark	Surface (A12)		Redox Dep	ressions (F8)				
Sandy Mucl	<y (s1)(lrr="" mineral="" n,mi<="" td=""><td>LRA 147,148)</td><td>Iron-Manga</td><td>inese Masse</td><td>s (F12) (LRR</td><td>N, MLRA 136</td><td>)</td><td></td><td></td></y>	LRA 147,148)	Iron-Manga	inese Masse	s (F12) (LRR	N, MLRA 136)		
Sandy Gley	ed Matrix (S4)		Umbric Sur	face (F13) (N	ILRA 136, 12	22)			
Sandy Redo	эх (S5)		Piedmont F	loodplain So	ils (F19) (ML	RA 148)			
Stripped Ma	itrix (S6)			IVIATERIAI (F2	I) (IVILRA IZ	.7, 147)	3		
							Indicators of h	hydrophytic vegeta	ition and
							disturbed or pr	roblematic.	fill, ulliess
							·		
Restrictive Lay	er (if observed):								
Туре:									
Depth (inches	;):					F	-lydric Soil Present?	Yes <u>V</u> No	
Remarks:									

Plumtree Branch Ecological Restoration Design Report

Appendix: D

Plumtree Branch

Ecological Restoration Design

Trees to be Removed

Tree Number	Common Name	Scientific Name	DBH	Condition
T1	Red Maple	Acer Rubrum	18.8	Poor
T2	Sweet Gum	Liquidambar styraciflua	16.1	Poor
Т3	American Elm	Ulmus Americana	18.4	Poor
T4	Black Walnut	Juglans Nigra	20.2	Poor
T5	Red Maple	Acer Rubrum	19.9	Poor
Т6	Unknown	-	17.6	Dead
T7	American Elm	Ulmus Americana	11.5	Fair
Т8	Black Walnut	Juglans Nigra	13.0	Fair
Т9	Pin Oak	Quercus Palustris	11.9	Fair
T10	American Sycamore	Platanus occidentalis	18.0	Fair
T11	Unknown	-	13.4	Dead
T12	Pin Oak	Quercus Palustris	13.5	Good
T13	Black Walnut	Juglans Nigra	17.9	Fair
T14	Black Walnut	Juglans Nigra	15.6	Fair
T15	American Elm	Ulmus Americana	10.5	Poor
T16	Black Walnut	Juglans Nigra	14.3	Fair
T17	Red Maple	Acer Rubrum	19.1	Poor
T18	American Elm	Ulmus Americana	21.1	Poor
T19	Black Walnut	Juglans Nigra	11.5	Fair
T20	American Elm	Ulmus Americana	17.5	Poor
T21	American Elm	Ulmus Americana	14.5	Poor
T22	American Elm	Ulmus Americana	12.1	Fair
T23	Red Maple	Acer Rubrum	10.1	Fair
T24	Pin Oak	Quercus Palustris	13.5	Fair
T25	Red Maple	Acer Rubrum	22.7	Poor
T26	Red Maple	Acer Rubrum	15.6	Fair
T27	American Sycamore	Platanus occidentalis	16.0	Fair
T28	Green Ash	Fraxinus Pennsylvanica	13.0	Poor
T29	Green Ash	Fraxinus Pennsylvanica	15.0	Poor
T30	American Elm	Ulmus Americana	14.3	Good
T31	Black Cherry	Prunus Serotina	13.5	Poor
T32	Black Cherry	Prunus Serotina	18.1	Fair
T33	Red Maple	Acer Rubrum	13.4	Poor
T34	Black Cherry	Prunus Serotina	12.7	Fair
T35	Black Cherry	Prunus Serotina	13.8	Poor
T36	Black Walnut	Juglans Nigra	9.6	Fair
T37	Black Cherry	Prunus Serotina	12.7	Dead
T38	Black Walnut	Juglans Nigra	10.1	Poor
T39	Black Walnut	Juglans Nigra	13.7	Poor
T40	Green Ash	Fraxinus Pennsylvanica	10.8	Poor
T41	Red Maple	Acer Rubrum	10.2	Good
T42	Red Maple	Acer Rubrum	14.4	Fair
T43	Red Maple	Acer Rubrum	10.1	Poor
T44	Red Maple	Acer Rubrum	12.1	Poor
T45	Green Ash	Fraxinus Pennsylvanica	12.0	Fair
T46	Silver Maple	Acer Saccharinum	11.5	Fair

Plumtree Branch Ecological Restoration Design Report

Appendix: E

PLUMTREE BRANCH STREAM RESTORATION PROJECTS HYDROLOGIC AND HYDRAULIC REPORT HOWARD COUNTY, MARYLAND

Prepared for:



Ecotone, Inc. 129 Industry Lane Forest Hill, MD 21050

Prepared by: ECOSYSTEM PLANNING & RESTORATION Ecosystem Planning and Restoration, LLC 8808 Centre Park Drive Columbia, MD 21045

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LI5	sure I.	Fleamont	Ulball	rixeu neg	IOII REGIE	SSIOIT EYU	ations (i	nomas 201	LOJ	<u> </u>

APPENDICES

Appendix A. Hydraulic Figures Appendix B. Hydraulic Modeling Results



1. Introduction

Ecosystem Planning and Restoration (EPR) was contracted by Ecotone, Inc. (Ecotone) to provide H&H modeling for Plumtree Branch and the Unnamed Tributary flowing into it. The proposed Plumtree Branch Restoration project is located in Ellicot City, Howard County, Maryland. The Plumtree Branch project reach is approximately 3,450 linear feet in length and has a drainage area of approximately 3.10 mi² at the lower terminus of the project. Services provided in this report include hydrologic analysis of existing regression equations to provide accurate flow regimes, and hydraulic modeling to compare existing and proposed velocities, shear stress, and water surface elevations for the 1.25-, 2-, 10-, and 100-year storm flows. This report documents the methodology and findings of the H&H modeling conducted for the project areas.

2. Hydrology

2.1. Methodology

EPR prepared a hydrologic analysis of Plumtree Branch and Unnamed Tributary using the Effective FEMA hydraulic models for the two stream systems, Stream Stats, and regression equations provided in the Applications of Hydrologic Methods in Maryland (Thomas 2010) document.

Using the FEMA Effective models for Plumtree Branch and the Unnamed Tributary, flow change locations were identified and confirmed based on the flow files used in the hydraulic analysis. Using these cross-section points along the streams, Drainage Areas (DA) were obtained using USGS Stream Stats. The reports generated from Stream Stats provided drainage areas and Percent Impervious Areas (IA) necessary for the Piedmont (Urban) Fixed Region Regression Equations shown below in Figure 1.



Piedmont (Urban) Fixed Region Regression Equation	Standard error (percent)	Equivalent years of record		
$Q_{1.25} = 17.85 \text{ DA}^{0.652} (\text{IA}+1)^{0.635}$	41.7	3.3		
$Q_{1.50} = 24.66 \text{ DA}^{0.648} (\text{IA}+1)^{0.631}$	36.9	3.8		
$Q_2 = 37.01 \text{ DA}^{0.635} (\text{IA}+1)^{0.588}$	35.1	4.5		
$Q_5 = 94.76 \text{ DA}^{0.624} (\text{IA}+1)^{0.499}$	28.5	13		
$Q_{10} = 169.2 \text{ DA}^{0.622} (\text{IA}+1)^{0.435}$	26.2	24		
$Q_{25} = 341.0 \text{ DA}^{0.619} (\text{IA}+1)^{0.349}$	26.0	38		
$Q_{50} = 562.4 \text{ DA}^{0.619} (\text{IA}+1)^{0.284}$	27.7	44		
$Q_{100} = 898.3 \text{ DA}^{0.619} (\text{IA}+1)^{0.222}$	30.7	45		
$Q_{200} = 1413 \text{ DA}^{0.621} (\text{IA}+1)^{0.160}$	34.8	44		
$Q_{500} = 2529 \text{ DA}^{0.623} (\text{IA}+1)^{0.079}$	41.2	40		

Figure 1. Piedmont (Urban) Fixed Region Regression Equations (Thomas 2010)

To properly model the hydraulics of the project, discharge values were calculated using the regression equations above for 1.25-, 2-, 10-, and 100-year storms. Drainage Areas (DA) and Percent Impervious Cover (IA) values are provided in Table 1.

Table 1. Summary of Regressio	on Equation Parameters
-------------------------------	------------------------

	Plumtree l	Branch		Unnamed Tributary				
Cross-	Baseline	DA	IA (%)	Cross-	Baseline	DA	IA (%)	
Section	STA	(mi^2)		Section	STA	(mi^2)		
0.3951	33+61	3.05	32.9	76.46746	8+99	0.33	29.3	
0.6214	21+92	2.76	32.4					
0.6757	19+00	2.76	32.5					
0.8698	N/A	2.35	33.0					

2.2. Results

The results of the hydrologic regression analysis are summarized in Table 2.



Plumtree Branch								
Cross-Section	Baseline STA	Q1.25 (cfs)	Q2 (cfs)	Q10 (cfs)	Q100 (cfs)			
0.3951	33+61	346	596	1568	3917			
0.6214	21+92	321	555	1464	3670			
0.6757	19+00	322	556	1466	3672			
0.8698	N/A	292	506	1335	3335			
Unnamed Tributary								
76.46746	8+99	76	136	374	964			

Table 2. Hydrologic Analysis Results

To comply with HEC RAS modeling best practices, flows at XS 21+92 were rounded to match XS 19+00 as differences in flows are minor, due to minor differences in Impervious Area in the watershed.

3. Hydraulic

3.1. Methodology

EPR prepared hydraulic models for Plumtree Creek and Unnamed Tributary using the HEC-RAS, version 6.1, hydraulic modeling program. One-Dimensional (1-D) Steady State models were developed to support the hydrologic model routing (see Section 2.1) and to evaluate existing and proposed conditions. Effective FEMA HEC-RAS hydraulic models were used to develop the project models. Details of the hydraulic modeling are described in the following sections.

3.2. Existing Conditions

Two existing conditions 1D-model were developed to evaluate the 1.25-, 2-, 10-, and 100-year flow frequency events for Plumtree Branch and the Unnamed Tributary flowing into the main branch. The Plumtree Branch model extends from the Columbia Street Road to the convergence of the Unnamed Tributary approximately 500 ft downstream of the Chatham Road Bridge. The Unnamed Tributary model extends from that same convergence to the pedestrian crossing approximately 500 LF downstream of Pebble Branch Road. Stations 21+92 to 0.8698 on Plumtree Branch and Stations 8+99 to 0+30 on the Unnamed Tributary are within the proposed project area. The existing condition cross-section layout is shown on Figures 1 and 2 in Appendix A.

The Effective FEMA geometry was truncated to only include the project area. Station and elevation data were modified using a composite terrain created using 2018 LiDAR and existing

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condition survey data within the project site provided by the Client. Existing pedestrian crossings were preserved from the FEMA model and capture the backwater areas upstream of the crossings. Additionally, cross-sections were placed to allow for comparison of results with the proposed design within the project site and capture the flood inundation area within the project area.

Bank stations were selected to correspond with bankfull elevations identified in the field and at grade breaks between the channel and the floodplain. Manning's n-values were selected based on the channel material and overbank vegetation ranging from 0.04 in the channel, and 0.06 in the overbanks.

One existing pedestrian crossing was modeled to represent the rectangular opening with sloped abutments that spans the Unnamed Tributary. The pedestrian bridge opening is a 15-ft wide by 10-ft high rectangular opening with a natural bottom. In the Plumtree Branch model, one existing pedestrian bridge is modeled as well. The pedestrian bridge opening is an arched opening that is 120-ft wide and 4.5-ft high that spans the length of the existing floodplain with a natural bottom. Ineffective flow areas were coded, and contraction and expansion coefficients were set at 0.3 and 0.5, respectively, at cross-section 0+30 through 0+56 for the Unnamed Tributary, and cross-section 15+92 through 16+24 for Plumtree Branch to model the crossing structures.

Flow data were input based on the hydrologic methods provided in Section 2.2. The downstream boundary condition was set to normal depth for both models.

3.3. Proposed Conditions

Two proposed conditions 1D-models were developed to evaluate the 1.25-, 2, 10- and 100-year flow frequency events. The existing conditions models were used as the base model for the proposed conditions. Figures 1 and 2, located in Appendix A, shows the proposed cross-section layout.

Cross-section positions were maintained from the existing conditions model through to the proposed model. River Stations were preserved from the existing condition model for comparison purposes. Cross-sections alignments were drawn to be perpendicular with the proposed channel and the overbank flood flow paths. Reach lengths were updated to reflect the proposed channel alignment. Station and elevation data were derived from a composite terrain created using LiDAR, existing survey data and the proposed design grading plan within the project site provided by the Client.



Bank stations were selected to correspond with design bankfull elevation at each cross-section. Manning's n-values were preserved from the existing conditions model ranging from .035 in the channel due to the smaller pilot channel design, and 0.06 in the overbanks to model the wetland complex.

Flow data were input based on the hydrologic methods described in Sections 3.1 and 3.2. The downstream boundary condition was set to normal depth for both models.

3.4. Hydraulic Modeling Results

Tables 3 through 10 present and compare the results of the 1.25-, 2-, 10- and 100-year frequency events for the existing and proposed conditions. Figures 1 and 2 in Appendix A show the 100-year existing and proposed conditions floodplain extents. The results indicate that shear stresses under the proposed design condition are under 2 ft-lbs/ft² for all modeled frequencies except at isolated locations for higher frequency events. Additional structural support is included in the design at these higher stress locations. The results indicate a rise of 0.01 feet at cross-section 10+76, though the change in the 100-year water surface elevation is so minor it does not show in the mapped figures. The remaining cross sections indicate no-rise in the 100-year water surface elevations.



	Existing Condition				Prope	osed Condit	ion	Change Ex-Prop			
River Sta	Baseline Sta	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (Ib/sq ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (Ib/sq ft)	
0.8698	N/A	331.54	2.48	0.19	331.93	1.59	0.06	0.39	-36%	-68%	
0.8287	10+76	331.27	2.70	0.23	331.77	3.08	0.24	0.5	14%	4%	
0.7530	14+86	330.71	2.82	0.25	331.1	3.14	0.25	0.39	11%	0%	
0.7337	15+92	330.58	2.76	0.24	330.94	2.98	0.23	0.36	8%	-4%	
0.7278	16+24	330.54	2.43	0.20	330.73	3.8	0.42	0.19	56%	110%	
0.6757	19+00	329.80	4.20	0.58	329.88	3.07	0.27	0.08	-27%	-53%	
0.6214	21+92	329.12	3.16	0.33	329.15	3.26	0.3	0.03	3%	-9%	

Table 3. 1.25-year, 1-D Hydraulic Model Results Plumtree Branch

Table 4. 2-year, 1-D Hydraulic Model Results Plumtree Branch

	Existing Condition			Prop	osed Condit	ion	Change			
River Sta	Baseline Sta	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (Ib/sq ft)
0.8698	N/A	332.20	2.93	0.25	332.55	2.11	0.1	0.35	-28%	-60%
0.8287	10+76	331.89	3.24	0.32	332.34	3.84	0.35	0.45	19%	9%
0.7530	14+86	331.28	3.28	0.32	331.59	3.65	0.32	0.31	11%	0%
0.7337	15+92	331.14	3.31	0.33	331.41	3.66	0.32	0.27	11%	-3%
0.7278	16+24	331.08	2.93	0.27	331.18	4.27	0.5	0.1	46%	85%
0.6757	19+00	330.35	4.57	0.65	330.39	3.56	0.34	0.04	-22%	-48%
0.6214	21+92	329.88	2.94	0.26	329.88	3.08	0.24	0	5%	-8%

Table 5. 10-year, 1-D Hydraulic Model Results Plumtree Branch

		Exi	Existing Condition			osed Condit	ion	Change			
D i 01	Baseline	W.S.	Vel Chnl	Shear Chan	W.S. Elev	Vel Chnl	Shear Chan (Ib/sq	W.S.	Vel Chnl	Shear Chan (lb/sq	
River Sta	Sta	Elev (ft)	(ft/s)	(lb/sq ft)	(ft)	(ft/s)	ft)	Elev (ft)	(ft/s)	ft)	
0.8698	N/A	333.99	3.63	0.34	334.13	3.22	0.21	0.14	-11%	-38%	
0.8287	10+76	333.69	4.08	0.44	333.89	4.73	0.47	0.2	16%	7%	
0.7530	14+86	333.31	3.30	0.28	333.38	3.85	0.31	0.07	17%	11%	
0.7337	1 <mark>5+92</mark>	333.23	3.32	0.28	333.28	3.85	0.3	0.05	16%	7%	
0.7278	16+24	333.18	2.95	0.23	333.18	3.62	0.29	0	23%	26%	
0.6757	19+00	332.98	3.10	0.25	332.97	2.97	0.18	-0.01	-4%	-28%	
0.6214	2 <mark>1+92</mark>	332.87	2.14	0.11	332.87	2.39	0.11	0	12%	0%	



		Exist	Existing Condition			sed Condi	tion		Change		
River Sta	Baseline Sta	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)	
0.8698	N/A	339.59	2.74	0.15	339.59	2.81	0.12	0	3%	-20%	
0.8287	10+76	339.54	2.73	0.15	339.55	3.21	0.17	0.01	18%	13%	
0.7530	14+86	339.48	2.18	0.10	339.48	2.52	0.1	0	16%	0%	
0.7337	<mark>15+92</mark>	339.47	2.13	0.09	339.47	2.43	0.09	0	14%	0%	
0.7278	16+24	339.46	1.94	0.08	339.46	2.2	0.08	0	13%	0%	
0.6757	19+00	339.43	2.01	0.08	339.43	2.13	0.07	0	6%	-13%	
0.6214	21+92	339.41	1.65	0.05	339.41	1.9	0.05	0	15%	0%	

Table 6. 100-year, 1-D Hydraulic Model Results Plumtree Branch

Table 7. 1.25-year, 1-D Hydraulic Model Results Unnamed Tributary

	Existing Condition		Proposed Condition			Change				
River Sta	Baseline Sta	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)
950.6651	0+30	336.23	1.62	0.08	337.44	2.1	0.16	1.21	30%	100%
924.3994	0+56	334.07	3.18	0.30	334.14	2.16	0.18	0.07	-32%	-40%
687.7156	2+84	332.59	4.84	0.76	333.17	3.76	0.65	0.58	-22%	-14%
453.6399	5+20	331.38	3.46	0.36	331.66	2.78	0.33	0.28	-20%	-8%
76.46746	8+99	329.88	3.73	0.41	330.11	2.48	0.27	0.23	-34%	-34%

Table 8. 2-year, 1-D Hydraulic Model Results Unnamed Tributary

Existing Condition				Prop	osed Cond	ition	Change			
River Sta	Baseline Sta	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)
950.6651	0+30	336.95	2.03	0.11	338.04	2.57	0.22	1.09	27%	100%
924.3994	0+56	334.81	3.77	0.41	334.51	3.15	0.37	-0.3	-16%	-10%
687.7156	2+84	333.29	5.36	0.84	333.55	3.47	0.5	0.26	-35%	-40%
453.6399	5+20	332.12	4.12	0.47	332.08	3.54	0.5	-0.04	-14%	6%
76.46746	<mark>8+99</mark>	330.71	3.05	0.30	330.36	2.78	0.32	-0.35	-9%	7%



		Existing Condition			Proposed Condition			Change		
River Sta	Baseline Sta	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)
950.6651	0+30	338.90	2.96	0.19	340.3	1.31	0.05	1.4	-56%	-74%
924.3994	0+56	335.85	6.21	0.99	335.58	5.21	0.96	-0.27	-16%	-3%
687.7156	2+84	334.43	5.43	0.81	334.26	4.39	0.69	-0.17	-19%	-15%
453.6399	5+20	332.90	5.98	0.90	332.68	4.96	0.88	-0.22	-17%	-2%
76.46746	8+99	331.35	3.62	0.39	330.84	3.28	0.41	-0.51	-9%	5%

Table 9. 10-year, 1-D Hydraulic Model Results Unnamed Tributary

Table 10. 100-year, 1-D Hydraulic Model Results Unnamed Tributary

	Existing Condition			Prop	osed Cond	ition	Change			
River Sta	Baseline Sta	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)
950.6651	0+30	341.53	2.58	0.12	341.16	2.71	0.19	-0.37	5%	58%
924.3994	0+56	337.12	10.31	2.40	336.74	8.62	2.3	-0.38	-16%	-4%
687.7156	2+84	335.62	7.42	1.32	335.22	6.13	1.19	-0.4	-17%	-10%
453.6399	5+20	333.81	8.38	1.61	333.43	6.61	1.41	-0.38	-21%	-12%
76.46746	8+99	332.09	4.62	0.56	331.52	4.04	0.56	-0.57	-13%	0%

4. References

1. Thomas, Jr., W.O. and G.E. Moglen. 2010. *An Update of Regression Equations for Maryland, Appendix 3 in Application of Hydrologic Methods in Maryland, Third Edition, September 2010.* Maryland State Highway Administration and Maryland Department of the Environment. 38 pp.



Appendix A Hydraulic Figures



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Appendix B

Hydraulic Modeling Results

		Baseline		Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	
Reach	River Sta	Sta	Profile	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	Froude # Chl
1	0.8698	N/A	Q1.25	292	328	331.93	330	331.96	0.000299	1.59	310.43	160.69	0.16
1	0.8287	10+76	Q1.25	292	328.81	331.77		331.83	0.001602	3.08	205.99	148.04	0.34
1	0.753	14+86	Q1.25	292	328.39	331.1		331.16	0.001673	3.14	221.3	197.41	0.35
1	0.7337	15+92	Q1.25	292	328.04	330.94	330.16	330.99	0.001434	2.98	227.55	185.52	0.33
1	0.73	16+08		Bridge									
1	0.7278	16+24	Q1.25	292	328.03	330.73		330.88	0.004194	3.8	139.05	170.69	0.52
1	0.6757	19+00	Q1.25	322	327.03	329.88		329.98	0.002525	3.07	182.45	180.13	0.41
1	0.6214	21+92	Q1.25	322	327	329.15		329.21	0.002659	3.26	221.85	218.44	0.42

 Table 1. Proposed 1.25-year, 1-D Standard Table 1 Plumtree Branch

Table 2. Proposed 2-year, 1-D Standard Table 1 Plumtree Branch

		Baseline		Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	
Reach	River Sta	Sta	Profile	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	Froude # Chl
1	0.8698	N/A	Q2	506	328	332.55	330.59	332.59	0.000418	2.11	417.95	187.05	0.19
1	0.8287	10+76	Q2	506	328.81	332.34		332.42	0.001893	3.84	303.54	189.53	0.38
1	0.753	14+86	Q2	506	328.39	331.59		331.67	0.001776	3.65	323.84	218.31	0.37
1	0.7337	15+92	Q2	506	328.04	331.41	330.48	331.48	0.001736	3.66	319.45	207.71	0.37
1	0.73	16+08		Bridge									
1	0.7278	16+24	Q2	506	328.03	331.18		331.35	0.003831	4.27	225.04	209.38	0.52
1	0.6757	19+00	Q2	556	327.03	330.39		330.5	0.002414	3.56	279.43	201.99	0.42
1	0.6214	21+92	Q2	556	327	329.88		329.93	0.001531	3.08	391.93	247.84	0.34

Table 3. Proposed 10-year, 1-D Standard Table 1 Plumtree Branch

		Baseline		Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	
Reach	River Sta	Sta	Profile	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	Froude # Chl
1	0.8698	N/A	Q10	1335	328	334.13	331.58	334.21	0.000621	3.22	751.35	232.76	0.24
1	0.8287	10+76	Q10	1335	328.81	333.89		334	0.00167	4.73	618.19	222.64	0.39
1	0.753	14+86	Q10	1335	328.39	333.38		333.45	0.001052	3.85	769.82	273.99	0.31
1	0.7337	15+92	Q10	1335	328.04	333.28	331.23	333.34	0.001021	3.85	786.22	281.65	0.31
1	0.73	16+08		Bridge									
1	0.7278	16+24	Q10	1335	328.03	333.18		333.27	0.001134	3.62	727.93	288.24	0.32
1	0.6757	19+00	Q10	1466	327.03	332.97		333.03	0.000609	2.97	953.65	307.92	0.24
1	0.6214	21+92	Q10	1466	327	332.87		332.89	0.000331	2.39	1297.6	348.15	0.18

Table 4. Proposed 100-year, 1-D Standard Table 1 Plumtree Branch

		Baseline		Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	
Reach	River Sta	Sta	Profile	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	Froude # Chl
1	0.8698	N/A	Q100	3335	328	339.59	333.06	339.65	0.000188	2.81	2290.01	337.62	0.15
1	0.8287	10+76	Q100	3335	328.81	339.55		339.6	0.000266	3.21	2205.8	333.47	0.18
1	0.753	1 <mark>4+86</mark>	Q100	3335	328.39	339.48		339.51	0.00015	2.52	2720.96	358.36	0.13
1	0.7337	15+92	Q100	3335	328.04	339.47	332.35	339.5	0.000138	2.43	2841.11	372.14	0.13
1	0.73	16+08		Bridge									
1	0.7278	16+24	Q100	3335	328.03	339.46		339.49	0.000122	2.2	2905.2	388.99	0.12
1	0.6757	19+00	Q100	3672	327.03	339.43		339.46	0.000101	2.13	3295.47	409.02	0.11
1	0.6214	21+92	Q100	3672	327	339.41		339.43	0.000074	1.9	3956.44	455.14	0.1

		Baseline		Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	
Reach	River Sta	Sta	Profile	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	Froude # Chl
1	0.8698	N/A	Q1.25	292	328	331.54	330.03	331.6	0.000977	2.48	211.85	151.84	0.24
1	0.8287	10+76	Q1.25	292	327	331.27		331.35	0.001341	2.7	170.09	131.01	0.28
1	0.753	14+86	Q1.25	292	327	330.71		330.8	0.001428	2.82	178.29	174.27	0.29
1	0.7337	15+92	Q1.25	292	327	330.58	329.62	330.66	0.001296	2.76	194.76	165.07	0.27
1	0.73	16+08		Bridge									
1	0.7278	16+24	Q1.25	292	326.89	330.54		330.6	0.001337	2.43	201.89	172.69	0.27
1	0.6757	19+00	Q1.25	322	326	329.8		329.99	0.003481	4.2	145.39	162.62	0.43
1	0.6214	21+92	Q1.25	322	325.75	329.12		329.2	0.002041	3.16	215.48	224.05	0.33

Table 5. Existing 1.25-year, 1-D Standard Table 1 Plumtree Branch

Table 6. Existing 2-year, 1-D Standard Table 1 Plumtree Branch

		Baseline		Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	
Reach	River Sta	Sta	Profile	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	Froude # Chl
1	0.8698	N/A	Q2	506	328	332.2	330.92	332.28	0.001066	2.93	318.35	178.07	0.26
1	0.8287	10+76	Q2	506	327	331.89		332	0.00151	3.24	253.02	137.08	0.3
1	0.753	14+86	Q2	506	327	331.28		331.39	0.001516	3.28	288.82	204.16	0.31
1	0.7337	<mark>15+9</mark> 2	Q2	506	327	331.14	330.14	331.24	0.001494	3.31	295.57	194.66	0.3
1	0.73	16+08		Bridge									
1	0.7278	16+24	Q2	506	326.89	331.08		331.16	0.001504	2.93	303.11	203.7	0.29
1	0.6757	19+00	Q2	556	326	330.35		330.53	0.003279	4.57	254.38	210.86	0.43
1	0.6214	21+92	Q2	556	325.75	329.88		329.93	0.00129	2.94	398.63	257.86	0.27

Table 7. Existing 10-year, 1-D Standard Table 1 Plumtree Branch

		Baseline		Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	
Reach	River Sta	Sta	Profile	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	Froude # Chl
1	0.8698	N/A	Q10	1335	328	333.99	331.93	334.09	0.000994	3.63	684.78	229.93	0.27
1	0.8287	10+76	Q10	1335	327	333.69		333.83	0.001388	4.08	584.56	207.6	0.31
1	0.753	14+86	Q10	1335	327	333.31		333.39	0.000841	3.3	778.76	271.67	0.25
1	0.7337	15+92	Q10	1335	327	333.23	331.12	333.3	0.000831	3.32	802.32	279.58	0.24
1	0.73	16+08		Bridge									
1	0.7278	16+24	Q10	1335	326.89	333.18		333.24	0.000767	2.95	826.93	287.63	0.23
1	0.6757	19+00	Q10	1466	326	332.98		333.04	0.000719	3.1	947.56	308.26	0.22
1	0.6214	21+92	Q10	1466	325.75	332.87		332.9	0.000305	2.14	1316.65	347.88	0.15

Table 8. Existing 100-year, 1-D Standard Table 1 Plumtree Branch

		Baseline		Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	
Reach	River Sta	Sta	Profile	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	Froude # Chl
1	0.8698	N/A	Q100	3335	328	339.59	333.23	339.64	0.000228	2.74	2250.07	330.55	0.14
1	0.8287	10+76	Q100	3335	327	339.54	,	339.59	0.000234	2.73	2197.64	328.28	0.14
1	0.753	14+86	Q100	3335	327	339.48	J.	339.51	0.000136	2.18	2740.92	356.85	0.11
1	0.7337	15+92	Q100	3335	327	339.47	332.36	339.5	0.00013	2.13	2855.41	371.66	0.11
1	0.73	16+08		Bridge									
1	0.7278	16+24	Q100	3335	326.89	339.46	J	339.49	0.000116	1.94	2980.77	387.29	0.1
1	0.6757	19+00	Q100	3672	326	339.43	J	339.46	0.000115	2.01	3285.23	408.57	0.1
1	0.6214	21+92	Q100	3672	325.75	339.41		339.43	0.000072	1.65	3999.09	459.48	0.08

		Baseline		Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	
Reach	River Sta	Sta	Profile	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	Froude # Chl
PT_T2	950.6651	0+30	Q1.25	76	335.1	337.44	336.46	337.5	0.001372	2.1	48.58	96.45	0.27
PT_T2	937.5322	0+43		Bridge									
PT_T2	924.3994	0+56	Q1.25	76	331.47	334.14	332.89	334.21	0.001715	2.16	35.15	20.15	0.29
PT_T2	687.7156	2+84	Q1.25	76	331.94	333.17	333.17	333.37	0.011277	3.76	29.38	93.13	0.68
PT_T2	453.6399	5+20	Q1.25	76	329.81	331.66		331.78	0.004331	2.78	27.34	22.04	0.44
PT_T2	76.46746	8+99	Q1.25	76	328.64	330.11	329.58	330.2	0.004006	2.48	43.15	170.67	0.42

Table 9. Proposed 1.25-year, 1-D Standard Table 1 Unnamed Tributary

Table 10. Proposed 2-year, 1-D Standard Table 1 Unnamed Tributary

		Baseline		Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	
Reach	River Sta	Sta	Profile	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	Froude # Chl
PT_T2	950.6651	0+30	Q2	136	335.1	338.04	336.81	338.12	0.001421	2.57	74	111.85	0.29
PT_T2	937.5322	0+43		Bridge									
PT_T2	924.3994	0+56	Q2	136	331.47	334.51	333.37	334.67	0.003176	3.15	43.13	22.24	0.4
PT_T2	687.7156	2+84	Q2	136	331.94	333.55		333.67	0.006157	3.47	65.66	101.45	0.53
PT_T2	453.6399	<mark>5+2</mark> 0	Q2	136	329.81	332.08	331.44	332.27	0.005661	3.54	46.72	119.51	0.52
PT_T2	76.46746	8+99	Q2	136	328.64	330.36	329.92	330.45	0.004004	2.78	92.82	254.12	0.43

Table 11. Proposed 10-year, 1-D Standard Table 1 Unnamed Tributary

		Baseline		Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	
Reach	River Sta	Sta	Profile	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	Froude # Chl
PT_T2	950.6651	0+30	Q10	374	335.1	340.3	337.85	340.31	0.000158	1.31	479.24	164.57	0.11
PT_T2	937.5322	0+43		Bridge									
PT_T2	924.3994	0+56	Q10	374	331.47	335.58	334.66	336	0.00737	5.21	71.8	44.71	0.62
PT_T2	687.7156	2+84	Q10	374	331.94	334.26		334.43	0.005542	4.39	142.87	113.87	0.54
PT_T2	453.6399	5+20	Q10	374	329.81	332.68	332.55	332.95	0.007045	4.96	132.6	169.17	0.61
PT_T2	76.46746	8+99	Q10	374	328.64	330.84	330.59	330.93	0.003996	3.28	221.63	275.82	0.45

Table 12. Proposed 100-year, 1-D Standard Table 1 Unnamed Tributary

		Baseline		Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	
Reach	River Sta	Sta	Profile	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	Froude # Chl
PT_T2	950.6651	0+30	Q100	964	335.1	341.16	339.2	341.21	0.000538	2.71	606.69	187.41	0.2
PT_T2	937.5322	0+43		Bridge									
PT_T2	924.3994	0+56	Q100	964	331.47	336.74	336.43	337.89	0.011712	8.62	113.75	109.27	0.84
PT_T2	687.7156	2+84	Q100	964	331.94	335.22		335.53	0.006447	6.13	257.5	123.83	0.62
PT_T2	453.6399	5+20	Q100	964	329.81	333.43	333.23	333.81	0.00825	6.61	284.89	232.68	0.7
PT_T2	76.46746	8+99	Q100	964	328.64	331.52	330.9	331.62	0.004001	4.04	498.28	476.69	0.47

		Baseline		Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	
Reach	River Sta	Sta	Profile	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	Froude # Chl
PT_T2	950.6651	0+30	Q1.25	76	333.34	336.23	335.06	336.27	0.000746	1.62	46.87	80.63	0.22
PT_T2	937.5322	0+43		Bridge									
PT_T2	924.3994	0+56	Q1.25	76	331.34	334.07	333.13	334.23	0.00314	3.18	25.34	16.4	0.43
PT_T2	687.7156	2+84	Q1.25	76	330.97	332.59	332.31	332.96	0.009803	4.84	15.7	11.5	0.73
PT_T2	453.6399	5+20	Q1.25	76	328.97	331.38		331.57	0.003756	3.46	21.96	12.8	0.47
PT_T2	76.46746	8+99	Q1.25	76	327.01	329.88	328.98	330.1	0.004006	3.73	20.36	10.52	0.47

Table 13. Existing 1.25-year, 1-D Standard Table 1 Unnamed Tributary

Table 14. Existing 2-year, 1-D Standard Table 1 Unnamed Tributary

		Baseline		Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	
Reach	River Sta	Sta	Profile	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	Froude # Chl
PT_T2	950.6651	0+30	Q2	136	333.34	336.95	335.43	337.02	0.000723	2.03	67.67	85.24	0.23
PT_T2	937.5322	0+43		Bridge									
PT_T2	924.3994	0+56	Q2	136	331.34	334.81	333.73	335.02	0.00371	3.77	39.38	22.48	0.48
PT_T2	687.7156	2+84	Q2	136	330.97	333.29	333.1	333.71	0.008112	5.36	37.66	68.99	0.68
PT_T2	453.6399	5+20	Q2	136	328.97	332.12	331.15	332.37	0.003969	4.12	46.02	123.69	0.49
PT_T2	76.46746	8+99	Q2	136	327.01	330.71	329.64	330.82	0.004002	3.05	96.28	195.26	0.47

Table 15. Existing 10-year, 1-D Standard Table 1 Unnamed Tributary

		Baseline		Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	
Reach	River Sta	Sta	Profile	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	Froude # Chl
PT_T2	950.6651	0+30	Q10	374	333.34	338.9	336.33	339.03	0.0007	2.96	146.48	125.95	0.25
PT_T2	937.5322	0+43		Bridge									
PT_T2	924.3994	0+56	Q10	374	331.34	335.85	335.31	336.41	0.006436	6.21	75.06	73.28	0.67
PT_T2	687.7156	2+84	Q10	374	330.97	334.43		334.72	0.006653	5.43	150.22	115.91	0.64
PT_T2	453.6399	5+20	Q10	374	328.97	332.9	332.76	333.3	0.005532	5.98	169.07	189.73	0.62
PT_T2	76.46746	8+99	Q10	374	327.01	331.35	330.94	331.46	0.004003	3.62	309.43	457	0.49

Table 16. Existing 100-year, 1-D Standard Table 1 Unnamed Tributary

		Baseline		Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	
Reach	River Sta	Sta	Profile	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	Froude # Chl
PT_T2	950.6651	0+30	Q100	964	333.34	341.53	337.98	341.6	0.000297	2.58	712.71	251.19	0.18
PT_T2	937.5322	0+43		Bridge									
PT_T2	924.3994	0+56	Q100	964	331.34	337.12	337.05	338.61	0.010558	10.31	127.69	124.8	0.91
PT_T2	687.7156	2+84	Q100	964	330.97	335.62		336.09	0.006984	7.42	296.04	129.06	0.71
PT_T2	453.6399	5+20	Q100	964	328.97	333.81	333.66	334.37	0.007583	8.38	374.09	262.22	0.75
PT_T2	76.46746	8+99	Q100	964	327.01	332.09	331.56	332.22	0.004	4.62	683.24	591.48	0.52

		Baseline		E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
Reach	River Sta	Sta	Profile	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
1	0.8698	N/A	Q1.25	331.96	331.93	0.03	0.13	0	114.59	176.25	1.15	160.69
1	0.8287	10+76	Q1.25	331.83	331.77	0.06	0.67	0	193.56	78.06	20.38	148.04
1	0.753	1 <mark>4+86</mark>	Q1.25	331.16	331.1	0.06	0.16	0	131.42	93.6	66.99	197.41
1	0.7337	15+92	Q1.25	330.99	330.94	0.05	0.01	0.01	190.72	77.99	23.29	185.52
1	0.73	16+08		Bridge								
1	0.7278	16+24	Q1.25	330.88	330.73	0.15	0.87	0.03	105.13	180.61	6.26	170.69
1	0.6757	19+00	Q1.25	329.98	329.88	0.09	0.76	0.01	133.69	180.16	8.15	180.13
1	0.6214	21+92	Q1.25	329.21	329.15	0.05	0.54	0	190.99	64.33	66.69	218.44

Table 17. Proposed 1.25-year, 1-D Standard Table 2 Plumtree Branch

Table 18. Proposed 2-year, 1-D Standard Table 2 Plumtree Branch

		Baseline		E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
Reach	River Sta	Sta	Profile	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
1	0.8698	N/A	Q2	332.59	332.55	0.04	0.17	0	223.93	278	4.07	187.05
1	0.8287	10+76	Q2	332.42	332.34	0.08	0.75	0	345.99	118.85	41.16	189.53
1	0.753	14+86	Q2	331.67	331.59	0.07	0.19	0	254.91	130.41	120.68	218.31
1	0.7337	15+92	Q2	331.48	331.41	0.07	0.01	0.02	335.67	112.77	57.56	207.71
1	0.73	16+08		Bridge								
1	0.7278	16+24	Q2	331.35	331.18	0.16	0.82	0.03	226.09	259.01	20.9	209.38
1	0.6757	19+00	Q2	330.5	330.39	0.11	0.55	0.02	258.61	269.17	28.22	201.99
1	0.6214	21+92	Q2	329.93	329.88	0.04	0.34	0	319.04	84.55	152.42	247.84

Table 19. Proposed 10-year, 1-D Standard Table 2 Plumtree Branch

		Baseline		E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
Reach	River Sta	Sta	Profile	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
1	0.8698	N/A	Q10	334.21	334.13	0.09	0.21	0	687.83	599.29	47.88	232.76
1	0.8287	10+76	Q10	334	333.89	0.11	0.54	0.01	1004.2	220.02	110.75	222.64
1	0.753	14+86	Q10	333.45	333.38	0.07	0.11	0	762.77	220.16	352.06	273.99
1	0.7337	15+92	Q10	333.34	333.28	0.07	0.02	0	878.67	190.52	265.8	281.65
1	0.73	1 <mark>6+0</mark> 8		Bridge								
1	0.7278	<mark>16+24</mark>	Q10	333.27	333.18	0.09	0.22	0.01	718.79	427.73	188.48	288.24
1	0.6757	19+00	Q10	333.03	332.97	0.06	0.13	0.01	806.75	482.73	176.52	307.92
1	0.6214	21+92	Q10	332.89	332.87	0.02	0.1	0	827.97	141.04	496.99	348.15

Table 20. Proposed 100-year, 1-D Standard Table 2 Plumtree Branch

		Baseline		E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
Reach	River Sta	Sta	Profile	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
1	0.8698	N/A	Q100	339.65	339.59	0.05	0.05	0	1842	1047.8	445.24	337.62
1	0.8287	10+76	Q100	339.6	339.55	0.05	0.08	0	2660.2	330.55	344.28	333.47
1	0.753	14+86	Q100	339.51	339.48	0.03	0.02	0	2047	328.35	959.63	358.36
1	0.7337	<mark>15+92</mark>	Q100	339.5	339.47	0.03	0	0	2122.3	271.1	941.63	372.14
1	0.73	16+08		Bridge								
1	0.7278	16+24	Q100	339.49	339.46	0.03	0.03	0	1873.9	659.21	801.87	388.99
1	0.6757	19+00	Q100	339.46	339.43	0.03	0.03	0	2203.1	808.14	660.78	409.02
1	0.6214	<mark>21+92</mark>	Q100	339.43	339.41	0.02	0.03	0	2164.3	243.88	1263.8	455.14

		Baseline		E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
Reach	River Sta	Sta	Profile	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
1	0.8698	N/A	Q1.25	331.6	331.54	0.06	0.25	0	111.89	179.01	1.1	151.84
1	0.8287	10+76	Q1.25	331.35	331.27	0.09	0.55	0	72.28	219.67	0.05	131.01
1	0.753	14+86	Q1.25	330.8	330.71	0.1	0.14	0.01	57.65	219.08	15.27	174.27
1	0.7337	15+92	Q1.25	330.66	330.58	0.08	0.01	0	101.72	180.85	9.43	165.07
1	0.73	16+08		Bridge								
1	0.7278	16+24	Q1.25	330.6	330.54	0.06	0.57	0.04	107.19	180.1	4.71	172.69
1	0.6757	19+00	Q1.25	329.99	329.8	0.19	0.76	0.03	94.5	216.93	10.57	162.62
1	0.6214	21+92	Q1.25	329.2	329.12	0.08	0.52	0	152.79	144.14	25.08	224.05

Table 21. Existing 1.25-year, 1-D Standard Table 2 Plumtree Branch

Table 22. Existing 2-year, 1-D Standard Table 2 Plumtree Branch

		Baseline		E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
Reach	River Sta	Sta	Profile	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
1	0.8698	N/A	Q2	332.28	332.2	0.08	0.27	0	249.45	253.57	2.98	178.07
1	0.8287	10+76	Q2	332	331.89	0.11	0.6	0	186.71	319.03	0.27	137.08
1	0.753	14+86	Q2	331.39	331.28	0.11	0.15	0	157.52	303.54	44.94	204.16
1	0.7337	15+92	Q2	331.24	331.14	0.1	0.01	0.02	217.38	254.59	34.03	194.66
1	0.73	16+08		Bridge								
1	0.7278	16+24	Q2	331.16	331.08	0.08	0.6	0.03	222.21	262.52	21.27	203.7
1	0.6757	19+00	Q2	330.53	330.35	0.18	0.56	0.04	231.02	280.25	44.72	210.86
1	0.6214	21+92	Q2	329.93	329.88	0.06	0.34	0	284.88	170	101.12	257.86

Table 23. Existing 10-year, 1-D Standard Table 2 Plumtree Branch

		Baseline		E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
Reach	River Sta	Sta	Profile	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
1	0.8698	N/A	Q10	334.09	333.99	0.1	0.25	0	821.51	457.96	55.53	229.93
1	0.8287	10+76	Q10	333.83	333.69	0.14	0.43	0.02	725.61	601.62	7.78	207.6
1	0.753	14+86	Q10	333.39	333.31	0.08	0.08	0	626.84	478.84	229.32	271.67
1	0.7337	15+92	Q10	333.3	333.23	0.07	0.01	0.01	705.35	398.19	231.47	279.58
1	0.73	16+08		Bridge								
1	0.7278	16+24	Q10	333.24	333.18	0.06	0.2	0	715.86	443.36	175.78	287.63
1	0.6757	19+00	Q10	333.04	332.98	0.06	0.13	0.01	875.11	331.87	259.02	308.26
1	0.6214	21+92	Q10	332.9	332.87	0.02	0.1	0	799.36	226.58	440.06	347.88

Table 24. Existing 100-year, 1-D Standard Table 2 Plumtree Branch

		Baseline		E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
Reach	River Sta	Sta	Profile	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
1	0.8698	N/A	Q100	339.64	339.59	0.05	0.05	0	2141.64	682.91	510.45	330.55
1	0.8287	10+76	Q100	339.59	339.54	0.05	0.07	0.01	2272.66	837.47	224.87	328.28
1	0.753	14+86	Q100	339.51	339.48	0.03	0.01	0	1877.22	666.59	791.19	356.85
1	0.7337	15+92	Q100	339.5	339.47	0.03	0	0	1914.57	529.35	891.09	371.66
1	0.73	16+08		Bridge								
1	0.7278	16+24	Q100	339.49	339.46	0.02	0.03	0	1921.78	643.1	770.12	387.29
1	0.6757	19+00	Q100	339.46	339.43	0.02	0.03	0	2381.01	439.42	851.57	408.57
1	0.6214	21+92	Q100	339.43	339.41	0.01	0.03	0	2116.19	347.33	1208.48	459.48

		Baseline		E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
Reach	River Sta	Sta	Profile	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
PT_T2	950.6651	0+30	Q1.25	337.5	337.44	0.05	0.04	0.11	7.14	55.05	13.81	96.45
PT_T2	937.5322	0+43		Bridge								
PT_T2	924.3994	0+56	Q1.25	334.21	334.14	0.07	0.81	0.04		76		20.15
PT_T2	687.7156	2+84	Q1.25	333.37	333.17	0.2	1.56	0.02	0	67.31	8.68	93.13
PT_T2	453.6399	5+20	Q1.25	331.78	331.66	0.12	1.57	0.01		76		22.04
PT_T2	76.46746	8+99	Q1.25	330.2	330.11	0.09				71.13	4.87	170.67

Table 25. Proposed 1.25-year, 1-D Standard Table 2 Unnamed Tributary

Table 26. Proposed 2-year, 1-D Standard Table 2 Unnamed Tributary

		Baseline		E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
Reach	River Sta	Sta	Profile	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
PT_T2	950.6651	0+30	Q2	338.12	338.04	0.08	0.04	0.15	22.61	88.42	24.97	111.85
PT_T2	937.5322	0+43		Bridge								
PT_T2	924.3994	0+56	Q2	334.67	334.51	0.15	0.98	0.01		136		22.24
PT_T2	687.7156	2+84	Q2	333.67	333.55	0.13	1.39	0.01	0.11	86.66	49.23	101.45
PT_T2	453.6399	5+20	Q2	332.27	332.08	0.19	1.79	0.03	0	132.24	3.76	119.51
PT_T2	76.46746	<mark>8+9</mark> 9	Q2	330.45	330.36	0.09				98.91	37.09	254.12

Table 27. Proposed 10-year, 1-D Standard Table 2 Unnamed Tributary

		Baseline		E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
Reach	River Sta	Sta	Profile	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
PT_T2	950.6651	0+30	Q10	340.31	340.3	0.01	0.01	0.09	65.57	85.6	222.83	164.57
PT_T2	937.5322	0+43		Bridge								
PT_T2	924.3994	0+56	Q10	336	335.58	0.42	1.45	0.13		373.99	0.01	44.71
PT_T2	687.7156	2+84	Q10	334.43	334.26	0.17	1.47	0.01	1.13	168.93	203.94	113.87
PT_T2	453.6399	5+20	Q10	332.95	332.68	0.28	1.97	0.06	2.34	260.58	111.08	169.17
PT_T2	76.46746	8+99	Q10	330.93	330.84	0.09				161.08	212.92	275.82

Table 28. Proposed 100-year, 1-D Standard Table 2 Unnamed Tributary

		Baseline		E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
Reach	River Sta	Sta	Profile	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
PT_T2	950.6651	0+30	Q100	341.21	341.16	0.05	0.02	0.16	189.09	208.88	566.02	187.41
PT_T2	937.5322	0+43		Bridge								
PT_T2	924.3994	0+56	Q100	337.89	336.74	1.15	1.94	0.42	2.52	958.24	3.24	109.27
PT_T2	687.7156	2+84	Q100	335.53	335.22	0.31	1.71	0.01	5.33	348.54	610.12	123.83
PT_T2	453.6399	5+20	Q100	333.81	333.43	0.38	2.1	0.08	21.92	475.38	466.7	232.68
PT_T2	76.46746	8+99	Q100	331.62	331.52	0.1			42.19	281.88	639.93	476.69

		Baseline		E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
Reach	River Sta	Sta	Profile	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
PT_T2	950.6651	0+30	Q1.25	336.27	336.23	0.04	0.02	0.14	0.01	75.99		80.63
PT_T2	937.5322	0+43		Bridge								
PT_T2	924.3994	0+56	Q1.25	334.23	334.07	0.16	1.21	0.06	0.84	75.16		16.4
PT_T2	687.7156	2+84	Q1.25	332.96	332.59	0.36	1.34	0.05		76		11.5
PT_T2	453.6399	5+20	Q1.25	331.57	331.38	0.19	1.46	0		76		12.8
PT_T2	76.46746	<mark>8+99</mark>	Q1.25	330.1	329.88	0.22				76		10.52

Table 29. Existing 1.25-year, 1-D Standard Table 2 Unnamed Tributary

Table 30. Existing 2-year, 1-D Standard Table 2 Unnamed Tributary

		Baseline		E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
Reach	River Sta	Sta	Profile	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
PT_T2	950.6651	0+30	Q2	337.02	336.95	0.06	0.02	0.19	0.17	135.83		85.24
PT_T2	937.5322	0+43		Bridge								
PT_T2	924.3994	0+56	Q2	335.02	334.81	0.22	1.25	0.06	3.15	132.85		22.48
PT_T2	687.7156	2+84	Q2	333.71	333.29	0.42	1.29	0.05		128.96	7.04	68.99
PT_T2	453.6399	5+20	Q2	332.37	332.12	0.26	1.5	0.04	0	132.72	3.28	123.69
PT_T2	76.46746	8+99	Q2	330.82	330.71	0.11				105.27	30.73	195.26

Table 31. Existing 10-year, 1-D Standard Table 2 Unnamed Tributary

		Baseline		E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
Reach	River Sta	Sta	Profile	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
PT_T2	950.6651	0+30	Q10	339.03	338.9	0.13	0.02	0.32	15.43	358.57		125.95
PT_T2	937.5322	0+43		Bridge								
PT_T2	924.3994	0+56	Q10	336.41	335.85	0.57	1.55	0.13	11.98	352.39	9.63	73.28
PT_T2	687.7156	2+84	Q10	334.72	334.43	0.3	1.42	0.01	0.02	234.75	139.23	115.91
PT_T2	453.6399	5+20	Q10	333.3	332.9	0.39	1.76	0.09	2.52	262.66	108.82	189.73
PT_T2	76.46746	8+99	Q10	331.46	331.35	0.11			12.3	197.39	164.31	457

Table 32. Existing 100-year, 1-D Standard Table 2 Unnamed Tributary

		Baseline		E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
Reach	River Sta	Sta	Profile	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
PT_T2	950.6651	0 <mark>+30</mark>	Q100	341.6	341.53	0.07	0.01	0.07	87.55	642.45	233.99	251.19
PT_T2	937.5322	0+43		Bridge								
PT_T2	924.3994	0+56	Q100	338.61	337.12	1.49	2.02	0.51	40.83	864.59	58.57	124.8
PT_T2	687.7156	2+84	Q100	336.09	335.62	0.47	1.71	0.01	1.29	494.83	467.88	129.06
PT_T2	453.6399	5+20	Q100	334.37	333.81	0.56	2.01	0.13	20.38	480.78	462.84	262.22
PT_T2	76.46746	8+99	Q100	332.22	332.09	0.13			94.02	364.42	505.56	591.48

Plumtree Branch Ecological Restoration Design Report

Appendix: F

Directions for LW Stability Analysis Tool

This design tool may be used by practitioners if they cite the developer on each sheet.

Disclaimer:

This Microsoft Excel 2010 spreadsheet tool is provided free of charge. Use this tool at your own risk. In offering this tool, the author, the U.S. Forest Service, and Colorado State University do not accept any responsibility or liability for the tool's use by third parties. This tool has specific uses and limits of applicability. Design practitioners shall take full responsibility for the final large wood structure design and performance. Designers are expected to verify the calculated values and validity of the design method. Designers should be qualified to work in river environments, and depending on the State, they may be required to be licensed as a professional engineer to design large wood structures. You cannot be sure the tool is authentic and unmolested unless downloaded from the following website:

https://www.fs.fed.us/biology/nsaec/products-tools.html#tools-stabilitylargewoodstructures

DATA INPUT

Order of Input

Update the worksheets from "left to right" Update the spreadsheet cells from "left to right" and "top to bottom"

IMPORTANT - User should only edit the following cells:



User should verify, but not edit the following cells because these cells contain formulas or headings:

Cell Format Heading	Directions Table Heading (Scroll over sample heading for description of comments)
Automatic Value	Verify value in cell which is automatically calculated by formulas
Key Value	Verify value of force calculation
Solution	Verify value of force balance or factor of safety calculation
Background Value	Optional - Verify value of background calculation (outside of print area)

The "Single Log" and "Multi-Log" spreadsheets have several built-in error messages (in column 'K'):

Error Message

"CHECK" Prompts user to check a specific input

"ERROR" Prompts user to change a specific input

User Input Note 1 - Several worksheets have a built in "clear inputs" button linked to a macro (these are the only macros built into the tool). Be aware that you can't undo the "clear input" command.

User Input Note 2 - User may enter a custom "bank soil type", "wood species", or "anchor type" by scrolling over to the right to find the lookup table and editing the "custom" cells.

User Input Note 3 - The spreadsheet is not locked, and therefore every cell can be manually edited. However, the

user is encouraged to exercise caution to avoid unintended consequences of changing reference formulas.

User Input Note 4 - User should also be very careful when removing or adding cells (at least scroll over and down to see what other cells may be impacted). Hiding unused rows or columns is recommended instead of deleting them. If the user needs to add cells on the "Single Log Design" spreadsheet, they should add a row of cells for all columns between 'A' and 'J'. Important: Adding cells will break the code in the "Clear Inputs" macro, and cause it to clear the wrong cells.

User Input Note 5 - To avoid compounding potential errors, the user should use the original download version of the spreadsheet (without personal edits) at the beginning of each design.

User Input Note 6 - Input values should be in English units, with one exception: D₅₀ for the bed substrate gradation (mm).

ANALYSIS OF MULTIPLE LOG STRUCTURES

The LW Stability Analysis Tool can also be used to design multiple log structures. The user must manually translate the resulting vertical and horizontal forces from one log design sheet into another (or write their own formulas). This data should be entered in the "Interaction Forces with Adjacent Logs" section of the "Single Log Design" worksheet. In theory, there is no limit to the number of logs that can be considered, although the force balance accounting may become cumbersome beyond a few logs. The general procedure is as follows:

- **Step 1** Begin by creating a preliminary structure layout (in AutoCAD or similar) to define the quantity of logs, locate intersect points, and identify key members. Key members are typically the largest logs (or the logs that are going to be have anchors attached).
- **Step 2** Fill out Sheets 1 through 5 of this tool. Next, input the channel geometry in a blank "Single Log Design" worksheet (Sheet 6), and then make copies for analysis of each log.
- Step 3 Complete a preliminary force balance analysis for each stacked member log, ignoring the "Interaction Forces with Adjacent Logs" and "Anchor Forces" sections. The user should manually record the resisting forces required to stabilize each stacked member in a table. The required vertical force can be found in cell 'K61' of the "Single Log Design" worksheet, and the required horizontal force can be found in cell 'K72'. If the log is already vertically or horizontally stable, record the excess force that may be applied to resist driving forces of the adjacent log(s). This information can be found in cell 'K62' and 'K73'. An example table is shown to the right of these directions →
- Step 4 Complete a force balance analysis for the key members. In the "Interaction Forces with Adjacent Logs" section on the force balance sheet, enter the relative position of each adjacent stacked log in contact with the key member, the connection type (gravity or pinned), the intersection point, and the required vertical and horizontal forces to achieve stability for each stacked member. If the load from the adjacent logs is spread over multiple key members, divide the required forces by the number of key members sharing the load (note--these loads do not need to be evenly distributed between key members). If an adjacent log is either horizontally or vertically stable, then enter any excess force (see Step 3 above) value as a negative number in the key member design spreadsheet. The tool will automatically determine which loads are transferable to the next layer of logs. For instance, a non-pinned log situated above the key member will not transfer buoyancy force to the key member.
- **Step 5** Add "Anchor Forces" as necessary to stabilize the key members.
- Step 6 Return to the stacked member log worksheets and in the "Interaction Forces with Adjacent Logs" section, input the forces that were resisted by the stability analysis of the key members. Add additional "Anchor Forces" as necessary to stabilize the forces that were not resisted by the design of the key members. It is advisable to create a copy of the "preliminary" design worksheets for the stacked member logs to create a separate "final" design worksheet. This will make it easier for the user to review the interaction forces between logs or make necessary edits.

Tip 1: It is recommended that the user creates a spreadsheet to tally the transferred forces for each log.

Tip 2: The design of multiple log structures should initially focus on achieving vertical stability, before moving on to horizontal stability, and finally the moment analysis.

Note 1: Most design procedures for larger wood jams (ELJ's) typically ignore the lift and moment forces, and the drag coefficient may be assumed to be between 0.6 and 0.7 for the entire structure (plus corrections for constriction, or blockage, of the channel). Therefore, the analysis procedure described above is likely conservative for larger

structures.

Note 2: The designer should also perform scour computations and consider the structure's potential to trap mobile wood. The design and/or factor of safety may need modified accordingly.

TO PRINT WORKBOOK

Highlight tabs numbered 1 through 7, and click "Print". Pages are pre-formatted except the "Anchors" Lookup sheet, which is not intended to be printed.

User is encouraged to provide comments and feedback for: Suitability: Range of application or limitations Ease of use Results: Are they reasonable and verified? Any other comments for improvement E-mail comments to: mrafferty@interfluve.com

TOOL UPDATES

Version 1.0 July 2, 2013

Version 1.1 January 8, 2016

Sheet, Cell

- S1, A42 Added reference on cover sheet to new companion paper (USFS National Stream and Aquatic Ecology Ce
- S2, A6,7 Changed default factor of safety to 1.5 (from 2.0) for horizontal and moment force balances
- S6, B6 Updated log structure types in pull-down list on worksheet for single log design

S6, B9 Added terminology of "key", "stacked", and "wracked" logs to dropdown list for consistency with guidelines

S6, B25 Added error message restricting input values for orientation angle (can not equal exactly 0)

- S6, B26 Added error message restricting input values for tilt angle (can not equal exactly 0, 90, 180, 270, or 360)
- S6, D83 Changed soil type from stream bed to bank soils in formula for F_{A,V} applied by additional soil ballast
- Multiple General updates to cell formats

Multiple Fixed page layouts for printing

Version 1.2 January 21, 2020

Update of tools link on NSAEC webpage
Plumtree Branch - Salvaged Log/Root Wad

Large Wood Structure Stability Analysis



TABLE OF CONTENTS

	Sheet
Factors of Safety and Design Constants	2
Hydrologic and Hydraulic Inputs	3
Stream Bed Substrate Properties	4
Bank Soil Properties	5
Wood Properties	6
Single Log Stability Analysis	7 - 8
Notation and List of Symbols	9 - 10

Date of Last Revision: January 7, 2016

Designer:	Reviewed by:
insert Name	Insert Name

Large Wood Structure Stability Analysis Spreadsheet was developed by Michael Rafferty, P.E. Version 1.1

Reference for Companion Paper:

Rafferty, M. 2016. Computational Design Tool for Evaluating the Stability of Large Wood Structures. Technical Note TN-103.1. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, National Stream & Aquatic Ecology Center. 27 p.

Plumtree Branch - Salvaged Log/Root Wad Factors of Safety and Design Constants

Spreadsheet developed by Michael Rafferty, P.E.

Symbol	Description	Value
FS_V	Factor of Safety for Vertical Force Balance	1.00
FS _H	Factor of Safety for Horizontal Force Balance	1.00
FS _M	Factor of Safety for Moment Force Balance	1.00

Symbol	Description	Units	Value
C_{Lrock}	Coefficient of lift for submerged boulder (D'Aoust, 2000)	-	0.17
C _{Drock}	Coefficient of drag for submerged boulder (Schultz, 1954)	-	0.85
g	Gravitational acceleration constant	ft/s ²	32.174
DF_{RW}	Diameter factor for rootwad ($DF_{RW} = D_{RW}/D_{TS}$)	-	3.00
LF _{RW}	Length factor for rootwad ($LF_{RW} = L_{RW}/D_{TS}$)	-	1.50
SG _{rock}	Specific gravity of quartz particles	-	2.65
γrock	Dry unit weight of boulders	lb/ft ³	165.0
γ _w	Specific weight of water at 50°F	lb/ft ³	62.40
η	Rootwad porosity from NRCS Tech Note 15 (2001)	-	0.20
ν	Kinematic viscosity of water at 50°F	ft/s ²	1.41E-05

Plumtree Branch - Salvaged Log/Root Wad Hydrologic and Hydraulic Inputs

Spreadsheet developed by Michael Rafferty, P.E.

Average Return Interval (ARI) of Design Discharge:

100 yr

Site ID	Proposed Station	Design Discharge, Q _{des} (cfs)	Maximum Depth, d _w (ft)	Average Velocity, u _{avg} (ft/s)	Bankfull Width, W _{BF} (ft)	Wetted Area, A _w (ft ²)	Radius of Curvature, R _c (ft)
XS 0.6757 Channel		2,600	11.29	2.13	409.0	411	1,000

Plumtree Branch - Salvaged Log/Root WSpreadsheet developed byStream Bed Substrate PropertiesMichael Rafferty, P.E.

Site ID	Proposed Station	Stream bed D ₅₀ (mm)	Stream Bed Substrate Grain Size Class	Bed Soil Class	Dry Unit Weight ¹ , γ_{bed} (lb/ft ³)	Buoyant Unit Weight, γ' _{bed} (lb/ft ³)	Friction Angle, φ _{bed} (deg)
6 0.6757 Chanr	Channel	14.10	Medium gravel	5	121.4	75.6	36

Source: Compiled from Julien (2010) and Shen and Julien (1993); soil classes from NRCS Table TS14E–2 Soil classification

¹ γ_{bed} (kg/m³) = 1,600 + 300 log D₅₀ (mm) (from Julien 2010) 1 kg/m³ = 0.062 1 lb/ft³

Plumtree Branch - Salvaged Log/R Bank Soil Properties

Spreadsheet developed by Michael Rafferty, P.E.

Site ID	Proposed Station	Bank Soils (from field observations)	Bank Soil Class	Dry Unit Weight, γ _{bank} (Ib/ft ³)	Buoyant Unit Weight, γ' _{bank} (lb/ft ³)	Friction Angle, \$\\$\$_bank\$ (deg)
6 0.6757 Chanr	Channel	Clayey silt	6	84.0	52.3	27

Plumtree Branch - Salvaged Log/Root Wad Large Wood Properties

Mid-Atlantic

Project Location:

-		1		
	Timber Unit Weig	hts	Air-dried ¹	$\operatorname{Green}^2 \gamma_{\operatorname{Tgr}}$
Selected Species	Common Name	Scientific Name	γ _{Td} (lb/ft ³)	(lb/ft ³)
Tree Type #1:	Beech, American	Fagus grandifolia	44.7	54.0
Tree Type #2:	Cherry, Black	Prunus serotina	34.9	45.0
Tree Type #3:	Walnut, Black	Juglans nigra	38.4	57.0
Tree Type #4:	Oak, Pin	Quercus palustris	44.0	64.0
Tree Type #5:	Maple, Red	Acer rubrum	37.7	50.0
Tree Type #6:	Ash, White	Fraxinus americana	41.9	50.0
Tree Type #7:	Willow, Black	Salix nigra	27.3	51.0
Tree Type #8:	Box Elder	(user selection in input table)	27.3	51.0
Tree Type #9:				
Tree Type #10:				

¹ **Air-dried unit weight**, γ_{Td} = Average unit weight of wood after exposure to air on a 12% moisture content volume basis. Air-dried unit weight is used in the force balance calculations for the portion of wood that is above the proposed thalweg elevation (assuming unsaturated conditions).

² **Green unit weight**, γ_{Tgr} = Average unit weight of freshly sawn wood when the cell walls are completely saturated with water. Green unit weight is used in the force balance calculations as a conservative estimate of the unit weight for the portion of wood that is below the proposed thalweg elevation (assuming saturated conditions). For comparison, Thevenet, Citterio, & Piegay (1998) determined wood unit weight typically increases by more than 100% after less than 24 hours exposure to water.

Source for timber unit weights:

U.S. Department of Agriculture, U.S. Forest Service. (2009) Specific Gravity and Other Properties of Wood and Bark for 156 Tree Species Found in North America. Research Note NRS-38. Table 1A.

Spreadsheet developed by Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d _w (ft)	R_c/W_{BF}	u _{des} (ft/s)
0.6757 Chan	Rootwad	Right bank	Straight	+	11.29	2.44	2.13

Multi-Log	Layer	Log ID		
Structures	Key Log	1		

Channel Geometry Coordinates					
Proposed	x (ft)	y (ft)			
Fidpin LB	0.00	1.00			
Top LB	10.50	1.00			
Toe LB	13.50	0.00			
Thalweg	15.50	0.00			
Toe RB	17.50	0.00			
Top RB	20.50	1.00			
FldpIn RB	31.00	1.00			



Wood Species	Rootwad	L _T (ft)	D _{TS} (ft)	L _{RW} (ft)	D _{RW} (ft)	γ _{Td} (lb/ft ³)	γ_{Tgr} (lb/ft ³)
Willow, Black	Yes	10.5	1.67	2.50	5.00	27.3	51.0

Structure	θ (deg)	β (deg)	Define Fixed Point	x _T (ft)	y⊤ (ft)	y _{T,min} (ft)	y _{T,max} (ft)	A _{Tp} (ft ²)
Geometry	270.1	-30.0	Root collar: Bottom	17.50	0.00	-4.00	4.14	6.76

Soils	Material	γ _s (lb/ft³)	γ' _s (lb/ft³)	φ (deg)	Soil Class	L _{T,em} (ft)	d _{b,max} (ft)	d _{b,avg} (ft)
Stream Bed	Medium gravel	121.4	75.6	36.0	5	0.00	0.00	0.00
Bank	Clayey silt	84.0	52.3	27.0	6	6.52	3.56	1.91



0.6757	Chan R	ootwad
--------	--------	--------

Net Buoyancy Force							
Wood	V_{TS} (ft ³)	V_{RW} (ft ³)	V_{T} (ft ³)	W _T (lbf)	F _B (lbf)		
↑WSE	0.0	0.0	0.0	0	0		
↓WS ↑Thw	3.1	18.8	21.9	597	1,367		
↓Thalweg	14.3	0.1	14.4	737	902		
Total	17.5	18.9	36.4	1,334	2,269		

9

Soil	V _{dry} (ft ³)	V _{sat} (ft ³)	V _{soil} (ft ³)	F _{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	0.0	20.7	20.7	1,082
Total	0.0	20.7	20.7	1,082

.5	18.9	36.4	1,334	2,269
Soil	Ballast Fo	orce		
(ft ³)	V_{sat} (ft ³)	V _{soil} (ft ³)	F _{soil} (lbf)	
.0	0.0	0.0	0	
.0	20.7	20.7	1,082	
0	20.7	20.7	1.082	

Lift Force					
C _{LT}	0.06				
F _L (lbf)	2				
Vertical F	Force Bala	ince			
F _B (lbf)	2,269	1			
F _L (lbf)	2	1			
W _T (lbf)	1,334	$\mathbf{\Psi}$			
F _{soil} (lbf)	1,082	\mathbf{V}			
F _{w,v} (lbf)	0				
F _{A,V} (lbf)	0				
ΣF_{V} (lbf)	145	$\mathbf{\Psi}$			
FSv	1.06				

Horizontal Force Analysis							
Drag Force							
A_{Tp} / A_W	Fr _L	C _{Di}	C _w	C _D *	F _D (lbf)		
0.02	0.29	1.10	0.00	1.13	34		

Passive Soil Pressure			Friction Force			
Soil	K _P	F _P (lbf)	L _{Tf} (ft)	μ	F _F (lbf)	
Bed	3.85	0	2.00	0.73	20	
Bank	2.66	1,440	8.37	0.51	60	
Total	-	1,440	10.37	-	80	

Additional Soil Ballast

 V_{Adry} (ft³) V_{Awet} (ft³) c_{Asoil} (ft) $F_{A,Vsoil}$ (lbf) $F_{A,HP}$ (lbf)

0

Horizontal Force Balance							
F _D (lbf)	34	→					
F _P (lbf)	1,440	÷					
F _F (lbf)	80	←					
F _{W,H} (lbf)	0						
F _{A,H} (lbf)	0						
ΣF _H (lbf)	1,487	÷					
FS _H	45.04						

Moment Force Balance									
Driving Moment Centroids			Resisting Moment Centroids				Moment Force Balance		
c _{T,B} (ft)	c _∟ (ft)	c _D (ft)	c _{T,W} (ft)	c _{soil} (ft)	c _{F&N} (ft)	c _P (ft)	M _d (lbf)	12,429	>
6.2	9.0	8.5	6.2	3.3	4.2	4.3	M _r (lbf)	16,431	5
*Distances ar	e from the s	stem tip	Point of F	Rotation:	Stem Tip		FS _M	1.32	

	Anc	hor	Forces
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Mechanical Anchors

Туре	c _{Am} (ft)	Soils	F _{Am} (lbf)
			0
			0

Boulder Ballast

0

Position	D _r (ft)	c _{Ar} (ft)	V _{r,dry} (ft ³)	$V_{r,wet}$ (ft ³)	W _r (lbf)	F _{L,r} (lbf)	F _{D,r} (lbf)	F _{A,Vr} (lbf)	F _{A,Hr} (lbf)
								0	0
								0	0
								0	0

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Spreadsheet developed by Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d _w (ft)	R _c /W _{BF}	u _{des} (ft/s)
0.6757 Chan	Rootwad	Right bank	Straight	+	11.29	2.44	2.13

Multi-Log	Layer	Log ID
Structures	Key Log	1

Channel Geometry Coordinates							
Proposed	x (ft)	y (ft)					
Fidpin LB	0.00	1.00					
Top LB	10.50	1.00					
Toe LB	13.50	0.00					
Thalweg	15.50	0.00					
Toe RB	17.50	0.00					
Top RB	20.50	1.00					
FldpIn RB	31.00	1.00					



Wood Species	Rootwad	L _T (ft)	D _{TS} (ft)	L _{RW} (ft)	D _{RW} (ft)	γ _{Td} (lb/ft ³)	γ_{Tgr} (lb/ft ³)
Cherry, Black	Yes	10.5	1.67	2.50	5.00	34.9	45.0

Structure	θ (deg)	β (deg)	Define Fixed Point	x _T (ft)	y⊤ (ft)	y _{T,min} (ft)	y _{T,max} (ft)	A_{Tp} (ft ²)
Geometry	270.1	-30.0	Root collar: Bottom	17.50	0.00	-4.00	4.14	6.76

Soils	Material	γ _s (lb/ft³)	γ' _s (lb/ft³)	φ (deg)	Soil Class	L _{T,em} (ft)	d _{b,max} (ft)	d _{b,avg} (ft)
Stream Bed	Medium gravel	121.4	75.6	36.0	5	0.00	0.00	0.00
Bank	Clayey silt	84.0	52.3	27.0	6	6.52	3.56	1.91



0.6757	Chan R	ootwad
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Net Buoyancy Force									
Wood	V_{TS} (ft ³)	V_{RW} (ft ³)	V_{T} (ft ³)	W _T (lbf)	F _B (lbf)				
↑WSE	0.0	0.0	0.0	0	0				
↓WS ↑Thw	3.1	18.8	21.9	766	1,367				
↓Thalweg	14.3	0.1	14.4	650	902				
Total	17.5	18.9	36.4	1,416	2,269				

Soil Ballast Force

Soil	V _{dry} (ft ³)	V _{sat} (ft ³)	V _{soil} (ft ³)	F _{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	0.0	20.7	20.7	1,082
Total	0.0	20.7	20.7	1,082

Lift Force						
C _{LT}	0.06					
F _L (lbf)	2					
Vertical F	Force Bala	ance				
F _B (lbf)	2,269	Λ				
F _L (lbf)	2	Λ				
W _T (lbf)	1,416	$\mathbf{\Psi}$				
F _{soil} (lbf)	1,082	$\mathbf{\bullet}$				
F _{W,V} (lbf)	0					
F _{A,V} (lbf)	0					
ΣF_{V} (lbf)	227	$\mathbf{+}$				
FSv	1.10	\checkmark				

			Horiz	ontal Fo	orce Ana	lysis				
Drag Force										
A_{Tp} / A_W	Fr _L	C _{Di}	C _w	C _D *	F _D (lbf)					
0.02	0.29	1.10	0.00	1.13	34					

Passive Soil Pressure			Friction Force				
Soil	К _Р	F _P (lbf)	L _{Tf} (ft)	μ	F _F (lbf)		
Bed	3.85	0	2.00	0.73	32		
Bank	2.66	1,440	8.37	0.51	93		
Total	-	1,440	10.37	-	125		

Additional Soil Ballast

 V_{Adry} (ft³) V_{Awet} (ft³) c_{Asoil} (ft) $F_{A,Vsoil}$ (lbf) $F_{A,HP}$ (lbf)

0

Horizonta	Horizontal Force Balance								
F _D (lbf)	34	→							
F _P (lbf)	1,440	←							
F _F (lbf)	125	÷							
F _{W,H} (lbf)	0								
F _{A,H} (lbf)	0								
ΣF_{H} (lbf)	1,532	÷							
FS _H	46.38	\checkmark							

Moment Force Balance										
Driving Moment Centroids Resisting Moment Centroids					Moment	Force Bal	ance			
c _{T,B} (ft)	c _∟ (ft)	c _D (ft)	c _{T,W} (ft)	c _{soil} (ft)	c _{F&N} (ft)	c _P (ft)	M _d (lbf)	13,302	>	
6.6	9.0	8.5	6.6	3.3	4.2	4.3	M _r (lbf)	17,872	5	
*Distances ar	e from the s	stem tip	Point of F	Rotation:	Stem Tip		FS _M	1.34		

Mechanical Anchors

Туре	c _{Am} (ft)	Soils	F _{Am} (lbf)
			0
			0

Boulder Ballast

0

Position	D _r (ft)	c _{Ar} (ft)	V _{r,dry} (ft ³)	V _{r,wet} (ft ³)	W _r (lbf)	F _{L,r} (lbf)	F _{D,r} (lbf)	F _{A,Vr} (lbf)	F _{A,Hr} (lbf)
								0	0
								0	0
								0	0

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Spreadsheet developed by Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d _w (ft)	R_c/W_{BF}	u _{des} (ft/s)
0.6757 Chan	Rootwad	Right bank	Straight	+	11.29	2.44	2.13

Multi-Log	Layer	Log ID
Structures	Key Log	1

Channel Geometry Coordinates							
Proposed	x (ft)	y (ft)					
Fidpin LB	0.00	1.00					
Top LB	10.50	1.00					
Toe LB	13.50	0.00					
Thalweg	15.50	0.00					
Toe RB	17.50	0.00					
Top RB	20.50	1.00					
FldpIn RB	31.00	1.00					



Wood Species	Rootwad	L _T (ft)	D _{TS} (ft)	L _{RW} (ft)	D _{RW} (ft)	γ _{Td} (lb/ft ³)	γ_{Tgr} (lb/ft ³)
Maple, Red	Yes	10.5	1.67	2.50	5.00	37.7	50.0

Structure	θ (deg)	β (deg)	Define Fixed Point	x _T (ft)	y⊤ (ft)	y _{T,min} (ft)	y _{T,max} (ft)	A _{Tp} (ft ²)
Geometry	270.1	-30.0	Root collar: Bottom	17.50	0.00	-4.00	4.14	6.76

Soils	Material	γ _s (lb/ft³)	γ' _s (lb/ft³)	φ (deg)	Soil Class	L _{T,em} (ft)	d _{b,max} (ft)	d _{b,avg} (ft)
Stream Bed	Medium gravel	121.4	75.6	36.0	5	0.00	0.00	0.00
Bank	Clayey silt	84.0	52.3	27.0	6	6.52	3.56	1.91



0.6757	Chan R	ootwad
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Net Buoyancy Force									
Wood	V_{TS} (ft ³)	V_{RW} (ft ³)	V_{T} (ft ³)	W _T (lbf)	F _B (lbf)				
↑WSE	0.0	0.0	0.0	0	0				
↓WS ↑Thw	3.1	18.8	21.9	827	1,367				
↓Thalweg	14.3	0.1	14.4	722	902				
Total	17.5	18.9	36.4	1,549	2,269				

Soil Ballast Force

Soil	V _{dry} (ft ³)	V _{sat} (ft ³)	V _{soil} (ft ³)	F _{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	0.0	20.7	20.7	1,082
Total	0.0	20.7	20.7	1,082

Lift F	Lift Force							
CLT	C _{LT} 0.06							
F _L (lbf)	2							
Vertical F	Vertical Force Balance							
F _B (lbf)	2,269	1						
F _L (lbf)	2	1						
W _T (lbf)	1,549	$\mathbf{\Psi}$						
F _{soil} (lbf)	1,082	$\mathbf{\Psi}$						
F _{w,v} (lbf)	0							
F _{A,V} (lbf)	0							
ΣF_{V} (lbf)	360	$\mathbf{\Psi}$						
FSv	1.16							

			Horizontal Force Analysis						
Drag Force									
A_{Tp} / A_W	Fr _L	C _{Di}	C _w	C _D *	F _D (lbf)				
0.02	0.29	1.10	0.00	1.13	34				

Passive	soil Pre	ssure	Friction Force			
Soil	K _P	F _P (lbf)	L _{Tf} (ft)	μ	F _F (lbf)	
Bed	3.85	0	2.00	0.73	50	
Bank	2.66	1,440	8.37	0.51	148	
Total	-	1,440	10.37	-	199	

Additional Soil Ballast

 V_{Adry} (ft³) V_{Awet} (ft³) c_{Asoil} (ft) $F_{A,Vsoil}$ (lbf) $F_{A,HP}$ (lbf)

0

Horizontal Force Balance							
F _D (lbf)	34	→					
F _P (lbf)	1,440	÷					
F _F (lbf)	199	÷					
F _{W,H} (lbf)	0						
F _{A,H} (lbf)	0						
ΣF_{H} (lbf)	1,605	÷					
FS _H	48.56						

Moment Force Balance									
Driving Moment Centroids Resisting Moment Centroids				Moment	Force Ba	ance			
c _{T,B} (ft)	c _∟ (ft)	c _D (ft)	c _{T,W} (ft)	c _{soil} (ft)	c _{F&N} (ft)	c _P (ft)	M _d (lbf)	13,236	>
6.6	9.0	8.5	6.6	3.3	4.2	4.3	M _r (lbf)	19,343	5
*Distances are from the stem tip		Point of F	Rotation:	Stem Tip		FS _M	1.46		

Anchor F	Forces
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Mechanical Anchors

Туре	c _{Am} (ft)	Soils	F _{Am} (lbf)
			0
			0

Boulder Ballast

0

Position	D _r (ft)	c _{Ar} (ft)	V _{r,dry} (ft ³)	$V_{r,wet}$ (ft ³)	W _r (lbf)	F _{L,r} (lbf)	F _{D,r} (lbf)	F _{A,Vr} (lbf)	F _{A,Hr} (lbf)
								0	0
								0	0
								0	0

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Spreadsheet developed by Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d _w (ft)	R_c/W_{BF}	u _{des} (ft/s)
0.6757 Chan	Rootwad	Right bank	Straight	+	11.29	2.44	2.13

Multi-Log	Layer	Log ID	
Structures	Key Log	1	

Channel Geometry Coordinates							
Proposed	x (ft)	y (ft)					
Fidpin LB	0.00	1.00					
Top LB	10.50	1.00					
Toe LB	13.50	0.00					
Thalweg	15.50	0.00					
Toe RB	17.50	0.00					
Top RB	20.50	1.00					
FldpIn RB	31.00	1.00					



Wood Species	Rootwad	L _T (ft)	D _{TS} (ft)	L _{RW} (ft)	D _{RW} (ft)	γ _{Td} (lb/ft ³)	γ_{Tgr} (lb/ft ³)
Walnut, Black	Yes	10.5	1.67	2.50	5.00	38.4	57.0

Structure	θ (deg)	β (deg)	Define Fixed Point	x _T (ft)	y⊤ (ft)	y _{T,min} (ft)	y _{T,max} (ft)	A_{Tp} (ft ²)
Geometry	270.1	-30.0	Root collar: Bottom	17.50	0.00	-4.00	4.14	6.76

Soils	Material	γ _s (lb/ft³)	γ' _s (lb/ft³)	φ (deg)	Soil Class	L _{T,em} (ft)	d _{b,max} (ft)	d _{b,avg} (ft)
Stream Bed	Medium gravel	121.4	75.6	36.0	5	0.00	0.00	0.00
Bank	Clayey silt	84.0	52.3	27.0	6	6.52	3.56	1.91



0.6757	Chan R	ootwad
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Net Buoyancy Force									
Wood	V_{TS} (ft ³)	V_{RW} (ft ³)	V_{T} (ft ³)	W _T (lbf)	F _B (lbf)				
↑WSE	0.0	0.0	0.0	0	0				
↓WS ↑Thw	3.1	18.8	21.9	842	1,367				
↓Thalweg	14.3	0.1	14.4	824	902				
Total	17.5	18.9	36.4	1,666	2,269				

Soil Ballast Force

Soil	V _{dry} (ft ³)	V _{sat} (ft ³)	V _{soil} (ft ³)	F _{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	0.0	20.7	20.7	1,082
Total	0.0	20.7	20.7	1,082

Lift Force								
CLT	0.06							
F _L (lbf)	2							
Vertical F	Force Bala	ance						
F _B (lbf)	2,269	1						
F _L (lbf)	2	1						
W _T (lbf)	1,666	$\mathbf{\Psi}$						
F _{soil} (lbf)	1,082	↓						
F _{w,v} (lbf)	0							
F _{A,V} (lbf)	0							
ΣF_{V} (lbf)	477	¥						
FSv	1.21	\checkmark						
	Lift F C_{LT} F_L (lbf) Vertical F F_B (lbf) F_L (lbf) W_T (lbf) $F_{w,V}$ (lbf) $F_{A,V}$ (lbf) ΣF_V (lbf) FS_V	Lift Force C _{LT} 0.06 F _L (lbf) 2 Vertical Force Bala F _B (lbf) 2,269 F _L (lbf) 2 W _T (lbf) 1,666 F _{soil} (lbf) 1,082 F _{w,v} (lbf) 0 F _{A,v} (lbf) 0 Σ F _V (lbf) 477 FS _V 1.21						

	Horizontal Force Analysis							
Drag Force								
A_{Tp} / A_W	Fr _L	C _{Di}	C _w	C _D *	F _D (lbf)			
0.02	0.29	1.10	0.00	1.13	34			

Passive Soil Pressure			Friction Force			
Soil	К _Р	F _P (lbf)	L _{Tf} (ft)	μ	F _F (lbf)	
Bed	3.85	0	2.00	0.73	67	
Bank	2.66	1,440	8.37	0.51	196	
Total	-	1,440	10.37	-	263	

Horizonta	Horizontal Force Balance					
F _D (lbf)	34	→				
F _P (lbf)	1,440	÷				
F _F (lbf)	263	←				
F _{w,H} (lbf)	0					
F _{A,H} (lbf)	0					
ΣF_{H} (lbf)	1,670	←				
FS _H	50.46					

Moment Force Balance									
Driving Moment Centroids Resisting Moment Centroids Moment Force Balance							ance		
c _{T,B} (ft)	c _∟ (ft)	c _D (ft)	c _{T,W} (ft)	c _{soil} (ft)	c _{F&N} (ft)	c _P (ft)	M _d (lbf)	12,972	>
6.5	9.0	8.5	6.5	3.3	4.2	4.3	M _r (lbf)	20,468	5
*Distances ar	e from the s	stem tip	Point of F	Rotation:	Stem Tip		FS _M	1.58	

Anchor Forces

Additional Soil Ballast						
V_{Adry} (ft ³)	V _{Adry} (ft ³) V _{Awet} (ft ³) c _{Asoil} (ft) F _{A,Vsoil} (lbf) F _{A,HP} (lbf)					
0 0						

Mechanical Anchors

Туре	c _{Am} (ft)	Soils	F _{Am} (lbf)
			0
			0

Boulder Ballast

Position	D _r (ft)	c _{Ar} (ft)	V _{r,dry} (ft ³)	V _{r,wet} (ft ³)	W _r (lbf)	F _{L,r} (lbf)	F _{D,r} (lbf)	F _{A,Vr} (lbf)	F _{A,Hr} (lbf)
								0	0
								0	0
								0	0

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Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d _w (ft)	R _c /W _{BF}	u _{des} (ft/s)
0.6757 Chan	Rootwad	Right bank	Straight	+	11.29	2.44	2.13

Multi-Log	Layer	Log ID
Structures	Key Log	1

Channel Geometry Coordinates				
Proposed	x (ft)	y (ft)		
Fidpin LB	0.00	1.00		
Top LB	10.50	1.00		
Toe LB	13.50	0.00		
Thalweg	15.50	0.00		
Toe RB	17.50	0.00		
Top RB	20.50	1.00		
FldpIn RB	31.00	1.00		



Wood Species	Rootwad	L _T (ft)	D _{TS} (ft)	L _{RW} (ft)	D _{RW} (ft)	γ _{Td} (lb/ft ³)	γ_{Tgr} (lb/ft ³)
Ash, White	Yes	10.5	1.67	2.50	5.00	41.9	50.0

Structure	θ (deg)	β (deg)	Define Fixed Point	x _T (ft)	y⊤ (ft)	y _{T,min} (ft)	y _{T,max} (ft)	A _{Tp} (ft ²)
Geometry	270.1	-30.0	Root collar: Bottom	17.50	0.00	-4.00	4.14	6.76

Soils	Material	γ _s (lb/ft³)	γ' _s (lb/ft³)	φ (deg)	Soil Class	L _{T,em} (ft)	d _{b,max} (ft)	d _{b,avg} (ft)
Stream Bed	Medium gravel	121.4	75.6	36.0	5	0.00	0.00	0.00
Bank	Clayey silt	84.0	52.3	27.0	6	6.52	3.56	1.91



0.6757	Chan R	ootwad
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Net Buoyancy Force						
Wood	V_{TS} (ft ³)	V_{RW} (ft ³)	V_{T} (ft ³)	W _T (lbf)	F _B (lbf)	
↑WSE	0.0	0.0	0.0	0	0	
↓WS ↑Thw	3.1	18.8	21.9	919	1,367	
↓Thalweg	14.3	0.1	14.4	722	902	
Total	17.5	18.9	36.4	1,641	2,269	

Soil Ballast Force

Soil	V _{dry} (ft ³)	V _{sat} (ft ³)	V _{soil} (ft ³)	F _{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	0.0	20.7	20.7	1,082
Total	0.0	20.7	20.7	1,082

Lift Force				
C _{LT}	0.06			
F _L (lbf)	2			
Vertical F	Force Bala	ince		
F _B (lbf)	2,269	1		
F _L (lbf)	2	1		
W _T (lbf)	1,641	$\mathbf{\bullet}$		
F _{soil} (lbf)	1,082	$\mathbf{+}$		
F _{w,v} (lbf)	0			
F _{A,V} (lbf)	0			
ΣF_{V} (lbf)	452	$\mathbf{+}$		
FSv	1.20			

Horizontal Force Analysis							
Drag Force							
A_{Tp} / A_W	Fr _L	C _{Di}	C _w	C _D *	F _D (lbf)		
0.02	0.29	1.10	0.00	1.13	34		

Passive Soil Pressure			Friction Force			
Soil	К _Р	F _P (lbf)	L _{Tf} (ft)	μ	F _F (lbf)	
Bed	3.85	0	2.00	0.73	63	
Bank	2.66	1,440	8.37	0.51	186	
Total	-	1,440	10.37	-	249	

Additional Soil Ballast

 V_{Adry} (ft³) V_{Awet} (ft³) c_{Asoil} (ft) $F_{A,Vsoil}$ (lbf) $F_{A,HP}$ (lbf)

0

Horizonta	Horizontal Force Balance					
F _D (lbf)	34	→				
F _P (lbf)	1,440	÷				
F _F (lbf)	249	÷				
F _{W,H} (lbf)	0					
F _{A,H} (lbf)	0					
ΣF_{H} (lbf)	1,656	÷				
FS _H	50.06					

Moment Force Balance									
Driving Moment Centroids			Resisting Moment Centroids				Moment	Force Bal	ance
c _{T,B} (ft)	c _∟ (ft)	c _D (ft)	c _{T,W} (ft)	c _{soil} (ft)	c _{F&N} (ft)	c _P (ft)	M _d (lbf)	13,480	>
6.7	9.0	8.5	6.7	3.3	4.2	4.3	M _r (lbf)	20,560	5
*Distances a	e from the	stem tip	Point of F	Rotation:	Stem Tip		FS _M	1.53	

Anchor	Forces
--------	--------

Mechanical Anchors

Туре	c _{Am} (ft)	Soils	F _{Am} (lbf)
			0
			0

Boulder Ballast

0

Position	D _r (ft)	c _{Ar} (ft)	V _{r,dry} (ft ³)	V _{r,wet} (ft ³)	W _r (lbf)	F _{L,r} (lbf)	F _{D,r} (lbf)	F _{A,Vr} (lbf)	F _{A,Hr} (lbf)
								0	0
								0	0
								0	0

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Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d _w (ft)	R_c/W_{BF}	u _{des} (ft/s)
0.6757 Chan	Rootwad	Right bank	Straight	+	11.29	2.44	2.13

Multi-Log	Layer	Log ID
Structures	Key Log	1

Channel Geometry Coordinates							
Proposed	Proposed x (ft) y (ft)						
Fidpin LB	0.00	1.00					
Top LB	10.50	1.00					
Toe LB	13.50	0.00					
Thalweg	15.50	0.00					
Toe RB	17.50	0.00					
Top RB	20.50	1.00					
FldpIn RB	31.00	1.00					



Wood Species	Rootwad	L _T (ft)	D _{TS} (ft)	L _{RW} (ft)	D _{RW} (ft)	γ _{Td} (lb/ft ³)	γ_{Tgr} (lb/ft ³)
Oak, Pin	Yes	10.5	1.67	2.50	5.00	44.0	64.0

Structure	θ (deg)	β (deg)	Define Fixed Point	x _T (ft)	y⊤ (ft)	y _{T,min} (ft)	y _{T,max} (ft)	A_{Tp} (ft ²)
Geometry	270.1	-30.0	Root collar: Bottom	17.50	0.00	-4.00	4.14	6.76

Soils	Material	γ _s (lb/ft³)	γ' _s (lb/ft³)	φ (deg)	Soil Class	L _{T,em} (ft)	d _{b,max} (ft)	d _{b,avg} (ft)
Stream Bed	Medium gravel	121.4	75.6	36.0	5	0.00	0.00	0.00
Bank	Clayey silt	84.0	52.3	27.0	6	6.52	3.56	1.91



0.6757	Chan R	ootwad
--------	--------	--------

Net Buoyancy Force										
Wood	V_{TS} (ft ³)	V_{RW} (ft ³)	V_{T} (ft ³)	W _T (lbf)	F _B (lbf)					
↑WSE	0.0	0.0	0.0	0	0					
↓WS ↑Thw	3.1	18.8	21.9	965	1,367					
↓Thalweg	14.3	0.1	14.4	925	902					
Total	17.5	18.9	36.4	1,890	2,269					

Soil Ballast Force

Soil	V _{dry} (ft ³)	V _{sat} (ft ³)	V _{soil} (ft ³)	F _{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	0.0	20.7	20.7	1,082
Total	0.0	20.7	20.7	1,082

Lift Force									
C _{LT}	0.06								
F _L (lbf)	2								
Vertical F	orce Bala	ince							
F _B (lbf)	2,269	1							
F _L (lbf)	2	1							
W _T (lbf)	1,890	$\mathbf{\Psi}$							
F _{soil} (lbf)	1,082	$\mathbf{\Psi}$							
F _{w,v} (lbf)	0								
F _{A,V} (lbf)	0								
ΣF_{V} (lbf)	701	$\mathbf{\Psi}$							
FSv	1.31								

Horizontal Force Analysis										
Drag Force										
A_{Tp} / A_W	Fr _L	C _{Di}	C _w	C _D *	F _D (lbf)					
0.02	0.29	1.10	0.00	1.13	34					

Passive Soil Pressure			Friction Force				
Soil	К _Р	F _P (lbf)	L _{Tf} (ft)	μ	F _F (lbf)		
Bed	3.85	0	2.00	0.73	98		
Bank	2.66	1,440	8.37	0.51	288		
Total	-	1,440	10.37	-	386		

Horizontal Force Balance								
F _D (lbf)	34	→						
F _P (lbf)	1,440	←						
F _F (lbf)	386	←						
F _{W,H} (lbf)	0							
F _{A,H} (lbf)	0							
ΣF _H (lbf)	1,793	÷						
FS _H	54.11							

Moment Force Balance										
Driving Moment Centroids Resisting Moment Centro						Moment	Force Bal	ance		
с _{т,w} (c _D (ft)	c _{T,W} (ft)	c _{soil} (ft)	c _{F&N} (ft)	c _P (ft)	M _d (lbf)	13,019	>		
6.5	8.5	6.5	3.3	4.2	4.3	M _r (lbf)	23,014	5		
Point of Rotation: Stem Tip		Point of F		FS _M	1.77					

Anchor Forces

Additional Soil Ballast								
V _{Adry} (ft ³)	V _{Adry} (ft ³) V _{Awet} (ft ³) c _{Asoil} (ft) F _{A,Vsoil} (lbf) F _{A,HP} (lbf)							
0 0								

Mechanical Anchors

Туре	c _{Am} (ft)	Soils	F _{Am} (lbf)
			0
			0

Boulder Ballast

Position	D _r (ft)	c _{Ar} (ft)	V _{r,dry} (ft ³)	V _{r,wet} (ft ³)	W _r (lbf)	F _{L,r} (lbf)	F _{D,r} (lbf)	F _{A,Vr} (lbf)	F _{A,Hr} (lbf)
								0	0
								0	0
								0	0

Page 2

Spreadsheet developed by Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d _w (ft)	R_c/W_{BF}	u _{des} (ft/s)
0.6757 Chan	Rootwad	Right bank	Straight	+	11.29	2.44	2.13

Multi-Log	Layer	Log ID
Structures	Key Log	1

Channel Geometry Coordinates						
Proposed	x (ft)	y (ft)				
Fidpin LB	0.00	1.00				
Top LB	10.50	1.00				
Toe LB	13.50	0.00				
Thalweg	15.50	0.00				
Toe RB	17.50	0.00				
Top RB	20.50	1.00				
FldpIn RB	31.00	1.00				



Wood Species	Rootwad	L _T (ft)	D _{TS} (ft)	L _{RW} (ft)	D _{RW} (ft)	γ _{Td} (lb/ft ³)	γ_{Tgr} (lb/ft ³)
Beech, American	Yes	10.5	1.67	2.50	5.00	44.7	54.0

Structure	θ (deg)	β (deg)	Define Fixed Point	x _T (ft)	y⊤ (ft)	y _{T,min} (ft)	y _{T,max} (ft)	A_{Tp} (ft ²)
Geometry	270.1	-30.0	Root collar: Bottom	17.50	0.00	-4.00	4.14	6.76

Soils	Material	γ _s (lb/ft³)	γ' _s (lb/ft³)	φ (deg)	Soil Class	L _{T,em} (ft)	d _{b,max} (ft)	d _{b,avg} (ft)
Stream Bed	Medium gravel	121.4	75.6	36.0	5	0.00	0.00	0.00
Bank	Clayey silt	84.0	52.3	27.0	6	6.52	3.56	1.91



0.6757	Chan R	ootwad
--------	--------	--------

Net Buoyancy Force									
Wood	V_{TS} (ft ³)	V_{RW} (ft ³)	V_{T} (ft ³)	W _T (lbf)	F _B (lbf)				
↑WSE	0.0	0.0	0.0	0	0				
↓WS ↑Thw	3.1	18.8	21.9	980	1,367				
↓Thalweg	14.3	0.1	14.4	780	902				
Total	17.5	18.9	36.4	1,760	2,269				

Soil Ballast Force

Soil	V _{dry} (ft ³)	V _{sat} (ft ³)	V _{soil} (ft ³)	F _{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	0.0	20.7	20.7	1,082
Total	0.0	20.7	20.7	1,082

CLT	0.06	
F _L (lbf)	2	
Vertical F	orce Bala	ance
F _B (lbf)	2,269	1
F _L (lbf)	2	1
W _T (lbf)	1,760	\mathbf{V}
F _{soil} (lbf)	1,082	$\mathbf{\Psi}$
F _{w,v} (lbf)	0	
F _{A,V} (lbf)	0	
ΣF_{V} (lbf)	571	\mathbf{V}
FSv	1.25	

Lift Force

Horizontal Force Analysis						lysis	
Drag Force							
A_{Tp} / A_W	Fr _L	C _{Di}	C _w	C _D *	F _D (lbf)		
0.02	0.29	1.10	0.00	1.13	34		

Passive Soil Pressure			Friction Force			
Soil	К _Р	F _P (lbf)	L _{Tf} (ft)	μ	F _F (lbf)	
Bed	3.85	0	2.00	0.73	80	
Bank	2.66	1,440	8.37	0.51	235	
Total	-	1,440	10.37	-	315	

Horizontal Force Balance					
F _D (lbf)	34	→			
F _P (lbf)	1,440	÷			
F _F (lbf)	315	÷			
F _{W,H} (lbf)	0				
F _{A,H} (lbf)	0				
ΣF_{H} (lbf)	1,722	÷			
FS _H	52.00				

Moment Force Balance									
Driving Moment Centroids Resisting Moment Centroids Moment Force Balar						ance			
CL	c _∟ (ft)	c _D (ft)	c _{T,W} (ft)	c _{soil} (ft)	c _{F&N} (ft)	c _P (ft)	M _d (lbf)	13,452	>
ç	9.0	8.5	6.7	3.3	4.2	4.3	M _r (lbf)	21,899	5
*Distances are from the stem tip		Point of F	Rotation:	Stem Tip		FS _M	1.63		

Anchor Forces

Additional Soil Ballast					
V _{Adry} (ft ³) V _{Awet} (ft ³) C _{Asoil} (ft) F _{A,Vsoil} (lbf) F _{A,HP} (lbf)					
			0	0	

Mechanical Anchors

Туре	c _{Am} (ft)	Soils	F _{Am} (lbf)
			0
			0

Boulder Ballast

Position	D _r (ft)	c _{Ar} (ft)	V _{r,dry} (ft ³)	$V_{r,wet}$ (ft ³)	W _r (lbf)	F _{L,r} (lbf)	F _{D,r} (lbf)	F _{A,Vr} (lbf)	F _{A,Hr} (lbf)
								0	0
								0	0
								0	0

Page 2

Plumtree Branch - Salvaged Log/Root Wad Notation, Units, and List of Symbols

Notation

Symbol	Description	Unit
Aw	Wetted area of channel at design discharge	ft ²
ATD	Projected area of wood in plane perpendicular to flow	ft ²
CD	Centroid of the drag force along log axis	ft
C _{Am}	Centroid of a mechanical anchor along log axis	ft
CAr	Centroid of a ballast boulder along log axis	ft
C _{Asoil}	Centroid of the added ballast soil along log axis	ft
C _{F&N}	Centroid of friction and normal forces along log axis	ft
CL	Centroid of the lift force along log axis	ft
CP	Centroid of the passive soil force along log axis	ft
C _{soil}	Centroid of the vertical soil forces along log axis	ft
с _{т,в}	Centroid of the buoyancy force along log axis	ft
с _{т,W}	Centroid of the log volume along log axis	ft
с _{WI}	Centroid of a wood interaction force along log axis	ft
CLrock	Coefficient of lift for submerged boulder	-
C _{LT}	Effective coefficient of lift for submerged tree	-
C _{Di}	Base coefficient of drag for tree, before adjustments	-
C _D ^	Effective coefficient of drag for submerged tree	-
C _{Di}	Mayo drag coefficient of submorged tree	-
C.W.	Average buried don'th of log	- -
a _{b,avg}	Average buried depth of log	ц П
۵ _{b,max}	Maximum buried depth of log	π 4
a _w	Maximum now depin at design discharge in reach	IL mm
D ₅₀	Equivalent diameter of boulder	ft
D,	Assumed diameter of rootwad	ft
D _{RW}	Nominal diameter of tree stem (DBH)	ft
	Diameter factor for rootwad ($DF_{DW} = D_{DW}/D_{TC}$)	-
	Void ratio of soils	_
F	Total horizontal load capacity of anchor techniques	lhf
• A,H F	Passive soil pressure applied to log from soil ballast	lbf
I A,HP	Horizontal resisting force on log from boulder	lbf
'A,Hr E	Load capacity of mechanical anchor	lbf
• Am F	Total vertical load capacity of anchor techniques	lbf
F	Vertical resisting force on log from boulder	lbf
• A,Vr F	Vertical soil loading on log from added ballast soil	lbf
• A,Vsoil F	Buovant force applied to log	lbf
• в F-	Drag forces applied to log	lbf
F-	Drag forces applied to boulder	lbf
D,r	Friction force applied to log	lbf
F.,	Resultant horizontal force applied to log	lbf
. н F.	Lift force applied to log	lbf
Γ	Lift force applied to boulder	lbf
F.	Passive soil pressure force applied to log	lbf
Fsoil	Vertical soil loading on log	lbf
F _{W.H}	Horizontal forces from interactions with other logs	lbf
F _{w,v}	Vertical forces from interactions with other logs	lbf

Notation (continued) Symbol Description Unit Resultant vertical force applied to log lbf F_V $\mathbf{Fr}_{\mathbf{L}}$ Log Froude number _ FSv Factor of Safety for Vertical Force Balance _ Factor of Safety for Horizontal Force Balance FS_H _ FS_M Factor of Safety for Moment Force Balance ft/s² Gravitational acceleration constant g K_P Coefficient of Passive Earth Pressure $\mathbf{L}_{\mathrm{T,em}}$ Total embedded length of log ft L_{RW} Assumed length of rootwad ft LT Total length of tree (including rootwad) ft \mathbf{L}_{Tf} Length of log in contact with bed or banks ft Length of tree stem (not including rootwad) ft LTS Exposed length of tree stem ft L_{TS.ex} Length factor for rootwad ($LF_{RW} = L_{RW}/D_{TS}$) LF_{RW} _ Driving moment about embedded tip lbf Md lbf M, Driving moment about embedded tip Ν Blow count of standard penetration test -Porosity of soil volume p_o **Q**des Design discharge cfs Radius R ft Radius of curvature at channel centerline ft R_{c} SG, Specific gravity of quartz particles _ SG⊤ Specific gravity of tree _ u_{avg} Average velocity of cross section in reach ft/s u_{des} Design velocity ft/s u_m Adjusted velocity at outer meander bend ft/s ft³ Vdry Volume of soils above stage level of design flow ft³ V_{sat} Volume of soils below stage level of design flow ft³ $\mathbf{V}_{\mathrm{soil}}$ Total volume of soils over log ft³ V_{RW} Volume of rootwad ft³ Vs Volume of solids in soil (void ratio calculation) ft³ VT Total volume of log ft³ V_{TS} Total volume of tree ft³ Vv Volume of voids in soil ft³ $\mathbf{V}_{\mathbf{Adry}}$ Volume of ballast above stage of design flow ft³ Volume of ballast below stage of design flow VAwet ft³ V_{r,dry} Volume of boulder above stage of design flow ft³ Volume of boulder below stage of design flow V_{r,wet} W_{BF} Bankfull width at structure site ft W, Effective weight of boulder lbf Wτ Total log weight lbf ft Horizontal coordinate (distance) х ft У Vertical coordinate (elevation) ft **Y**T.max Minimum elevation of log Maximum elevation of log ft **Y**T,min

Greek Sy	ymbols	
Symbol	Description	Unit
β	Tilt angle from stem tip to vertical	deg
γ_{bank}	Dry specific weight of bank soils	lb/ft ³
γµbank,sat	Saturated unit weight of bank soils	lb/ft ³
γ _{bank}	Effective buoyant unit weight of bank soils	lb/ft ³
γ_{bed}	Dry specific weight of stream bed substrate	lb/ft ³
γ'_{bed}	Effective buoyant unit weight of stream bed substrate	lb/ft ³
Yrock	Dry unit weight of boulders	lb/ft ³
γs	Dry specific weight of soil	lb/ft ³
γs	Effective buoyant unit weight of soil	lb/ft ³
γ _{td}	Air-dried unit weight of tree (12% MC basis)	lb/ft ³
γ _{Tgr}	Green unit weight of tree	lb/ft ³
γw	Specific weight of water at 50°F	lb/ft ³
η	Rootwad porosity	-
θ	Rootwad (or large end of log) orientation to flow	deg
μ	Coefficient of friction	-
ν	Kinematic viscosity of water at 50°F	ft/s ²
Σ	Sum of forces	-
∮ bank	Internal friction angle of bank soils	deg
o bed	Internal friction angle of stream bed substrate	deg

Units

cfs	Cubic fe	et per s	econd

- ft Feet
- lb Pound
- lbf Pounds force
- kg m Kilograms Meters
- mm Millimeters
- s Seconds
- Year yr

Abbreviations

Notation	Description
ARI	Average return interval
Avg	Average
DBH	Diameter at breast height
deg	Degrees
Dia	Diameter
Dist	Distance
D/S	Downstream
ELJ	Engineered log jam
Ex	Example
Fldpin	Floodplain
Н&Н	Hydrologic and hydraulic
ID	Identification
i.e.	That is
LB	Left bank
LW	Large wood
Max	Maximum
MC	Moisture content
Min	Minimum
ML	Multi-log
SL	Single log
N/A	Not applicable
no	Number
Pt	Point
rad	Radians
RB	Right bank
RW	Rootwad
SL	Single log
Thw	Thalweg (lowest elevation in channel bed)
Тур	Typical
0.8.	United States
WS	vvater surface
WSE	Water surface elevation
Υ	Above

Below $\mathbf{1}$

Reference Sheet - Anchoring Techniques Anchor Technique Lookup Table (average holding capacities)

Anchor Technique	Lookup Table (average holding capacities)			Manta Ray			Stingray			Duc	:kbill			Platipus	Stealth				Platipus Bat			Cu	stom (User Selectio	n)
Roll Class	Roll Description	Blow Count	MR-1	MR-2	MR-SR	SR-1	SR-2	SR-3	DB-40	DB-68	DB-88	DB-138	P-802	P-804	P-S06	P-S08	P-804T	P-806T	P-BteT	P-810T	P-812T	Custom#1	Custom#2	Custom#3
OCH CHARA	oon beacipion	(N)	Capacity (lb)	Capacity (lb)	Capacity (Ib)	Capacity (Ib)	Capacity (lb)	Capacity (Ib)	Capacity (Ib)	Capacity (lb)	Capacity (lb)	Capacity (Ib)	Capacity (Ib)	Capacity (lb)	Capacity (lb)									
4	Dense gravels; gravel/cobble; very hard sits and clays	40-100+	24,000	15,000	32,000	39,000	62,000	85,000	user input	user input	user input	user input	300	1,000	3,500	4,500	6,000	11,000	16,500	22,000	33,000	(user input)	(user input)	(user input)
5	Dense coarse sand; gravel/sand; loose gravels; stiff slits and clays	14-40	15,000	9,000	18,000	24,000	31,000	48,000	300	1,100	3,000	5,000	150	600	2,000	2,500	3,500	6,500	9,000	14,000	20,000	(user input)	(user input)	(user input)
6	Loose coarse sand; dense fine sand; firm silts and clays	7-14	10,000	7,000	14,000	16,000	27,000	37,000	user input	user input	user input	user input	50	300	800	1,500	2,500	4,000	6,500	11,000	16,000	(user input)	(user input)	(user input)
7	Loose fine sand; alluvium; soft silts and clays; silty sanc	4-8	8,000	5,000	9,000	13,000	19,000	24,000	user input	user input	user input	user input	N/A	200	400	1,000	2,000	3,500	5,500	9,000	13,000	(user input)	(user input)	(user input)
Notes	1. All types—Jush this durat for admittation only. Values above mellect the lower inspeciation for heaving pairs of pairs. The two sequelying mult be a subscription of the two sequelying multiple and the subscription of the subscription of the subscription of the subscription of the subscription of the subscription of the subscription of the subscription S. Wilde values of the subscription of the subscription of the subscription of subscription of the subscription of the subscription of the Another bolding capacity will vary in a filterant unker, toronautic appointers as Another bolding capacity will vary in a filterant back, toronautic appointers of a cubsclin actions are used as a cubscling capacities to Another bolding capacity will vary in a filterant back toronautic appointers of the low value was assigned to these 7 subs. Hotting capacities for class 5 willing values of the subscription.	manufacturer's e tested by pro tructed field te loading is the in be expectes es (numerical acities. The h and 6 soits w	a minimum exp sof-loading. Mir st recommende only way to insi d in harder soil- ly lower blow co ligh manufactu ere interpolated	ected holding ca nimum 2:1 Safet ad. ure the exact ca classes (numeri punt). er/s rating was. d as a guide only	pacity of each is pacity of each is cally higher blox applied to class r. User is respon	n condition. nmended. stallation. r count 4 soils, while sible for																		



Directions for LW Stability Analysis Tool

This design tool may be used by practitioners if they cite the developer on each sheet.

Disclaimer:

This Microsoft Excel 2010 spreadsheet tool is provided free of charge. Use this tool at your own risk. In offering this tool, the author, the U.S. Forest Service, and Colorado State University do not accept any responsibility or liability for the tool's use by third parties. This tool has specific uses and limits of applicability. Design practitioners shall take full responsibility for the final large wood structure design and performance. Designers are expected to verify the calculated values and validity of the design method. Designers should be qualified to work in river environments, and depending on the State, they may be required to be licensed as a professional engineer to design large wood structures. You cannot be sure the tool is authentic and unmolested unless downloaded from the following website:

https://www.fs.fed.us/biology/nsaec/products-tools.html#tools-stabilitylargewoodstructures

DATA INPUT

Order of Input

Update the worksheets from "left to right" Update the spreadsheet cells from "left to right" and "top to bottom"

IMPORTANT - User should only edit the following cells:



User should verify, but not edit the following cells because these cells contain formulas or headings:

Cell Format Heading	Directions Table Heading (Scroll over sample heading for description of comments)
Automatic Value	Verify value in cell which is automatically calculated by formulas
Key Value	Verify value of force calculation
Solution	Verify value of force balance or factor of safety calculation
Background Value	Optional - Verify value of background calculation (outside of print area)

The "Single Log" and "Multi-Log" spreadsheets have several built-in error messages (in column 'K'):

Error Message

"CHECK" Prompts user to check a specific input

"ERROR" Prompts user to change a specific input

User Input Note 1 - Several worksheets have a built in "clear inputs" button linked to a macro (these are the only macros built into the tool). Be aware that you can't undo the "clear input" command.

User Input Note 2 - User may enter a custom "bank soil type", "wood species", or "anchor type" by scrolling over to the right to find the lookup table and editing the "custom" cells.

User Input Note 3 - The spreadsheet is not locked, and therefore every cell can be manually edited. However, the

user is encouraged to exercise caution to avoid unintended consequences of changing reference formulas.

User Input Note 4 - User should also be very careful when removing or adding cells (at least scroll over and down to see what other cells may be impacted). Hiding unused rows or columns is recommended instead of deleting them. If the user needs to add cells on the "Single Log Design" spreadsheet, they should add a row of cells for all columns between 'A' and 'J'. Important: Adding cells will break the code in the "Clear Inputs" macro, and cause it to clear the wrong cells.

User Input Note 5 - To avoid compounding potential errors, the user should use the original download version of the spreadsheet (without personal edits) at the beginning of each design.

User Input Note 6 - Input values should be in English units, with one exception: D₅₀ for the bed substrate gradation (mm).

ANALYSIS OF MULTIPLE LOG STRUCTURES

The LW Stability Analysis Tool can also be used to design multiple log structures. The user must manually translate the resulting vertical and horizontal forces from one log design sheet into another (or write their own formulas). This data should be entered in the "Interaction Forces with Adjacent Logs" section of the "Single Log Design" worksheet. In theory, there is no limit to the number of logs that can be considered, although the force balance accounting may become cumbersome beyond a few logs. The general procedure is as follows:

- **Step 1** Begin by creating a preliminary structure layout (in AutoCAD or similar) to define the quantity of logs, locate intersect points, and identify key members. Key members are typically the largest logs (or the logs that are going to be have anchors attached).
- **Step 2** Fill out Sheets 1 through 5 of this tool. Next, input the channel geometry in a blank "Single Log Design" worksheet (Sheet 6), and then make copies for analysis of each log.
- Step 3 Complete a preliminary force balance analysis for each stacked member log, ignoring the "Interaction Forces with Adjacent Logs" and "Anchor Forces" sections. The user should manually record the resisting forces required to stabilize each stacked member in a table. The required vertical force can be found in cell 'K61' of the "Single Log Design" worksheet, and the required horizontal force can be found in cell 'K72'. If the log is already vertically or horizontally stable, record the excess force that may be applied to resist driving forces of the adjacent log(s). This information can be found in cell 'K62' and 'K73'. An example table is shown to the right of these directions →
- Step 4 Complete a force balance analysis for the key members. In the "Interaction Forces with Adjacent Logs" section on the force balance sheet, enter the relative position of each adjacent stacked log in contact with the key member, the connection type (gravity or pinned), the intersection point, and the required vertical and horizontal forces to achieve stability for each stacked member. If the load from the adjacent logs is spread over multiple key members, divide the required forces by the number of key members sharing the load (note--these loads do not need to be evenly distributed between key members). If an adjacent log is either horizontally or vertically stable, then enter any excess force (see Step 3 above) value as a negative number in the key member design spreadsheet. The tool will automatically determine which loads are transferable to the next layer of logs. For instance, a non-pinned log situated above the key member will not transfer buoyancy force to the key member.
- **Step 5** Add "Anchor Forces" as necessary to stabilize the key members.
- Step 6 Return to the stacked member log worksheets and in the "Interaction Forces with Adjacent Logs" section, input the forces that were resisted by the stability analysis of the key members. Add additional "Anchor Forces" as necessary to stabilize the forces that were not resisted by the design of the key members. It is advisable to create a copy of the "preliminary" design worksheets for the stacked member logs to create a separate "final" design worksheet. This will make it easier for the user to review the interaction forces between logs or make necessary edits.

Tip 1: It is recommended that the user creates a spreadsheet to tally the transferred forces for each log.

Tip 2: The design of multiple log structures should initially focus on achieving vertical stability, before moving on to horizontal stability, and finally the moment analysis.

Note 1: Most design procedures for larger wood jams (ELJ's) typically ignore the lift and moment forces, and the drag coefficient may be assumed to be between 0.6 and 0.7 for the entire structure (plus corrections for constriction, or blockage, of the channel). Therefore, the analysis procedure described above is likely conservative for larger

structures.

Note 2: The designer should also perform scour computations and consider the structure's potential to trap mobile wood. The design and/or factor of safety may need modified accordingly.

TO PRINT WORKBOOK

Highlight tabs numbered 1 through 7, and click "Print". Pages are pre-formatted except the "Anchors" Lookup sheet, which is not intended to be printed.

User is encouraged to provide comments and feedback for: Suitability: Range of application or limitations Ease of use Results: Are they reasonable and verified? Any other comments for improvement E-mail comments to: mrafferty@interfluve.com

TOOL UPDATES

Version 1.0 July 2, 2013

Version 1.1 January 8, 2016

Sheet, Cell

- S1, A42 Added reference on cover sheet to new companion paper (USFS National Stream and Aquatic Ecology Ce
- S2, A6,7 Changed default factor of safety to 1.5 (from 2.0) for horizontal and moment force balances
- S6, B6 Updated log structure types in pull-down list on worksheet for single log design

S6, B9 Added terminology of "key", "stacked", and "wracked" logs to dropdown list for consistency with guidelines

S6, B25 Added error message restricting input values for orientation angle (can not equal exactly 0)

- S6, B26 Added error message restricting input values for tilt angle (can not equal exactly 0, 90, 180, 270, or 360)
- S6, D83 Changed soil type from stream bed to bank soils in formula for F_{A,V} applied by additional soil ballast
- Multiple General updates to cell formats

Multiple Fixed page layouts for printing

Version 1.2 January 21, 2020

Update of tools link on NSAEC webpage

Plumtree Branch - Floodplain Sill

Large Wood Structure Stability Analysis



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Factors of Safety and Design Constants	2
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Date of Last Revision: January 7, 2016

Designer:	
Insert Name	

Large Wood Structure Stability Analysis Spreadsheet was developed by Michael Rafferty, P.E. Version 1.1

Reviewed by:

Insert Name

Reference for Companion Paper:

Rafferty, M. 2016. Computational Design Tool for Evaluating the Stability of Large Wood Structures. Technical Note TN-103.1. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, National Stream & Aquatic Ecology Center. 27 p.

Plumtree Branch - Floodplain Sill Factors of Safety and Design Constants

Spreadsheet developed by Michael Rafferty, P.E.

Symbol	Description	Value
FS_V	Factor of Safety for Vertical Force Balance	1.00
FS _H	Factor of Safety for Horizontal Force Balance	1.00
FS _M	Factor of Safety for Moment Force Balance	1.00

Symbol	Description	Units	Value
C _{Lrock}	Coefficient of lift for submerged boulder (D'Aoust, 2000)	-	0.17
C _{Drock}	Coefficient of drag for submerged boulder (Schultz, 1954)	-	0.85
g	Gravitational acceleration constant	ft/s ²	32.174
DF_{RW}	Diameter factor for rootwad ($DF_{RW} = D_{RW}/D_{TS}$)	-	3.00
LF _{RW}	Length factor for rootwad ($LF_{RW} = L_{RW}/D_{TS}$)	-	1.50
SG _{rock}	Specific gravity of quartz particles	-	2.65
$\gamma_{ m rock}$	Dry unit weight of boulders	lb/ft ³	165.0
γw	Specific weight of water at 50°F	lb/ft ³	62.40
η	Rootwad porosity from NRCS Tech Note 15 (2001)	-	0.20
ν	Kinematic viscosity of water at 50°F	ft/s ²	1.41E-05

Plumtree Branch - Floodplain Sill Hydrologic and Hydraulic Inputs

Spreadsheet developed by Michael Rafferty, P.E.

Average Return Interval (ARI) of Design Discharge:

100 yr

Site ID	Proposed Station	Design Discharge, Q _{des} (cfs)	Maximum Depth, d _w (ft)	Average Velocity, u _{avg} (ft/s)	Bankfull Width, W _{BF} (ft)	Wetted Area, A _w (ft ²)	Radius of Curvature, R _c (ft)
XS 0.6757 Channel		2,600	11.29	2.13	409.0	411	1,000

Plumtree Branch - Floodplain Sill Stream Bed Substrate Properties

Spreadsheet developed by Michael Rafferty, P.E.

Site ID	Proposed Station	Stream bed D ₅₀ (mm)	Stream Bed Substrate Grain Size Class	Bed Soil Class	Dry Unit Weight ¹ , γ _{bed} (lb/ft ³)	Buoyant Unit Weight, γ' _{bed} (lb/ft ³)	Friction Angle, φ _{bed} (deg)
6 0.6757 Chanr	Channel	14.10	Medium gravel	5	121.4	75.6	36

Source: Compiled from Julien (2010) and Shen and Julien (1993); soil classes from NRCS Table TS14E–2 Soil classification

¹ γ_{bed} (kg/m³) = 1,600 + 300 log D₅₀ (mm) (from Julien 2010) 1 kg/m³ = 0.062 1 lb/ft³

Plumtree Branch - Floodplain Sill Bank Soil Properties

Spreadsheet developed by Michael Rafferty, P.E.

Site ID	Proposed Station	Bank Soils (from field observations)	Bank Soil Class	Dry Unit Weight, γ _{bank} (Ib/ft ³)	Buoyant Unit Weight, γ' _{bank} (Ib/ft ³)	Friction Angle,
6 0.6757 Chanr	Channel	Clayey silt	6	84.0	52.3	27

Plumtree Branch - Floodplain Sill Large Wood Properties

Mid-Atlantic

Project Location:

	Timber Unit Weigl	hts	Air-dried ¹	Green ² γ _{Tgr}
Selected Species	Common Name	Scientific Name	γ _{Td} (lb/ft ³)	(lb/ft ³)
Tree Type #1:	Beech, American	Fagus grandifolia	44.7	54.0
Tree Type #2:	Cherry, Black	Prunus serotina	34.9	45.0
Tree Type #3:	Walnut, Black	Juglans nigra	38.4	57.0
Tree Type #4:	Oak, Pin	Quercus palustris	44.0	64.0
Tree Type #5:	Maple, Red	Acer rubrum	37.7	50.0
Tree Type #6:	Ash, White	Fraxinus americana	41.9	50.0
Tree Type #7:	Willow, Black	Salix nigra	27.3	51.0
Tree Type #8:	Box Elder	(user selection in input table)	27.0	(input)
Tree Type #9:				
Tree Type #10:				

¹ **Air-dried unit weight**, γ_{Td} = Average unit weight of wood after exposure to air on a 12% moisture content volume basis. Air-dried unit weight is used in the force balance calculations for the portion of wood that is above the proposed thalweg elevation (assuming unsaturated conditions).

² **Green unit weight**, γ_{Tgr} = Average unit weight of freshly sawn wood when the cell walls are completely saturated with water. Green unit weight is used in the force balance calculations as a conservative estimate of the unit weight for the portion of wood that is below the proposed thalweg elevation (assuming saturated conditions). For comparison, Thevenet, Citterio, & Piegay (1998) determined wood unit weight typically increases by more than 100% after less than 24 hours exposure to water.

Source for timber unit weights:

U.S. Department of Agriculture, U.S. Forest Service. (2009) Specific Gravity and Other Properties of Wood and Bark for 156 Tree Species Found in North America. Research Note NRS-38. Table 1A.

Plumtree Branch - Floodplain Sill

Spreadsheet developed by Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d _w (ft)	R_c/W_{BF}	u _{des} (ft/s)
0.6757 Chan	Full-Span	Full span	Straight	+	11.29	2.44	2.13

Multi-Log	Layer	Log ID	
Structures	Key Log	1	

Channel Geometry Coordinates					
Proposed	x (ft)	y (ft)			
FldpIn LB	0.00	1.00			
Top LB	10.50	1.00			
Toe LB	13.50	0.00			
Thalweg	15.50	0.00			
Toe RB	17.50	0.00			
Top RB	20.50	1.00			
FldpIn RB	40.00	1.00			

14 WSE 12 10 8 6 4 LB RB 2 0 20 30 -2 50 х -4

Wood Species	Rootwad	L _T (ft)	D _{TS} (ft)	L _{RW} (ft)	D _{RW} (ft)	γ _{Td} (lb/ft ³)	γ_{Tgr} (lb/ft ³)
Willow, Black	No	20.0	3.00	-	-	27.3	51.0

Structure	θ (deg)	β (deg)	Define Fixed Point	x _T (ft)	y _T (ft)	y _{T,min} (ft)	y _{T,max} (ft)	A_{Tp} (ft ²)
Geometry	270.1	0.0	Root collar: Crown	15.50	0.00	-3.00	0.00	0.00

Soils	Material	γ _s (lb/ft³)	γ'_{s} (lb/ft ³)	φ (deg)	Soil Class	L _{T,em} (ft)	d _{b,max} (ft)	d _{b,avg} (ft)
Stream Bed	Medium gravel	121.4	75.6	36.0	5	2.00	0.00	0.00
Bank	Clayey silt	84.0	52.3	27.0	6	18.00	1.00	0.92



0.6757 Cha	n Full-Span
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Net Buoyancy Force							
Wood	V_{TS} (ft ³)	V_{RW} (ft ³)	V_{T} (ft ³)	W _T (lbf)	F _B (lbf)		
↑WSE	0.0	0.0	0.0	0	0		
↓WS ↑Thw	0.0	0.0	0.0	0	0		
↓Thalweg	141.4	0.0	141.4	7,210	8,821		
Total	141.4	0.0	141.4	7,210	8,822		

Soil Ballast Force

Soil	V _{dry} (ft ³)	V _{sat} (ft ³)	V _{soil} (ft ³)	F _{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	0.0	49.4	49.4	2,584
Total	0.0	49.4	49.4	2,584

Lift Force					
C _{LT}	0.00				
F _L (lbf)	0				
Vertical F	Force Bala	ance			
F _B (lbf)	8,822	1			
F _L (lbf)	0				
W _T (lbf)	7,210	$\mathbf{\Psi}$			
F _{soil} (lbf)	2,584	$\mathbf{+}$			
F _{w,v} (lbf)	0				
F _{A,V} (lbf)	0				
ΣF_{V} (lbf)	972	$\mathbf{\bullet}$			
FSv	1.11				

Page 2

		Horizontal Force Analysis					
Drag Force							
A_{Tp} / A_W	Fr _L	C _{Di}	C _w	C _D *	F _D (lbf)		
0.00	0.22	0.90	0.00	0.90	0		

Passive Soil Pressure			Friction Force			
Soil	K _P	F _P (lbf)	L _{Tf} (ft)	μ	F _F (lbf)	
Bed	3.85	0	4.05	0.73	130	
Bank	2.66	3,440	17.95	0.51	404	
Total	-	3,440	22.00	-	534	

Horizontal Force Balance						
F _D (lbf)	0					
F _P (lbf)	3,440	÷				
F _F (lbf)	534	÷				
F _{W,H} (lbf)	0					
F _{A,H} (lbf)	0					
ΣF_{H} (lbf)	3,974	←				
FS _H	7,949.33					

Moment Force Balance									
Driving N	loment Co	entroids	Resisting Moment Centroids			Moment Force Balance			
с _{т,в} (ft)	c _L (ft)	c _D (ft)	c _{T,W} (ft)	c _{soil} (ft)	c _{F&N} (ft)	c _P (ft)	M _d (lbf)	88,216	>
10.0	0.0	0.0	10.0	9.0	10.0	11.9	M _r (lbf)	151,328	5
*Distances are from the stem tip			Point of F	Rotation:	Stem Tip		FS _M	1.72	

Anchor Fo	rces
------------------	------

Additional Soil Ballast						Mech	anical An	chors	
V _{Adry} (ft ³)	V_{Awet} (ft ³)	c _{Asoil} (ft)	F _{A,Vsoil} (lbf)	F _{A,HP} (lbf)		Туре	c _{Am} (ft)	Soils	F _{Am} (lbf)
			0	0					0
					-				0
				Boulder	Ballast				
Position	D _r (ft)	c _{Ar} (ft)	V _{r,dry} (ft ³)	$V_{r,wet}$ (ft ³)	W _r (lbf)	F _{L,r} (lbf)	F _{D,r} (lbf)	F _{A,Vr} (lbf)	F _{A,Hr} (lbf)
								0	0
								0	0
								0	0

Plumtree Branch - Floodplain Sill Notation, Units, and List of Symbols

Notation

Symbol	Description	Unit
Aw	Wetted area of channel at design discharge	ft ²
Ann	Projected area of wood in plane perpendicular to flow	ft ²
CD	Centroid of the drag force along log axis	ft
CAm	Centroid of a mechanical anchor along log axis	ft
C _{Ar}	Centroid of a ballast boulder along log axis	ft
C _{Asoil}	Centroid of the added ballast soil along log axis	ft
C _{F&N}	Centroid of friction and normal forces along log axis	ft
сL	Centroid of the lift force along log axis	ft
CP	Centroid of the passive soil force along log axis	ft
C _{soil}	Centroid of the vertical soil forces along log axis	ft
$\mathbf{c}_{T,B}$	Centroid of the buoyancy force along log axis	ft
с _{т,W}	Centroid of the log volume along log axis	ft
c _{wi}	Centroid of a wood interaction force along log axis	ft
CLrock	Coefficient of lift for submerged boulder	-
CLT	Effective coefficient of lift for submerged tree	-
C _{Di}	Base coefficient of drag for tree, before adjustments	-
C _D *	Effective coefficient of drag for submerged tree	-
C _{Di}	Base coefficient of drag for tree, before adjustments	-
C _w	wave drag coefficient of submerged tree	-
d _{b,avg}	Average buried depth of log	ft
d _{b,max}	Maximum buried depth of log	ft
d _w	Maximum flow depth at design discharge in reach	ft
D ₅₀	Median grain size in millimeters (Si units)	mm #
	Equivalent diameter of boulder	π #
	Nominal diameter of tree stem (DBH)	n fi
	Diameter factor for rootwad (DE $-D$ /D)	п
	Vaid ratio of acilo	-
e	Tatal harizantal load conseits of another techniques	- 16f
	Passive seil pressure applied to les frem seil bellest	IDI Ihf
F _{A,HP}	Passive soil pressure applied to log from soil ballast	IDI
F _{A,Hr}	Horizontal resisting force on log from boulder	IDI
F _{Am}	Load capacity of mechanical anchor	IDI
	l otal vertical load capacity of anchor techniques	IDT
F _{A,Vr}	Vertical resisting force on log from boulder	IDI
F _{A,Vsoil}	Vertical soil loading on log from added ballast soil	IDI
FB	Buoyant force applied to log	TCI
F _D	Drag forces applied to log	TCI
F _{D,r}	Drag forces applied to boulder	lbt
F _F	Friction force applied to log	IDI Ihf
FH F	Resultant horizontal force applied to log	IDI Ihf
г. Е	Lin force applied to log	IDI Ihf
FL,r	Lin lorde applied to boulder Dassive soil pressure force applied to log	IDI Ibf
г _Р F	rassive soil pressure lorce applied to log	IDI Ibf
soil	Horizontal forces from interactions with other logs	lhf
• W,H F	Vertical forces from interactions with other logs	lhf
• w,v	vertion forces norm interactions with other logs	

Notation (continued)

Symbol	Description	Unit
Fv	Resultant vertical force applied to log	lbf
Fr	Log Froude number	-
FSv	Factor of Safety for Vertical Force Balance	-
FS _H	Factor of Safety for Horizontal Force Balance	-
FS _M	Factor of Safety for Moment Force Balance	-
g	Gravitational acceleration constant	ft/s²
K _P	Coefficient of Passive Earth Pressure	-
$L_{T,em}$	Total embedded length of log	ft
L _{RW}	Assumed length of rootwad	ft
LT	Total length of tree (including rootwad)	ft
L _{Tf}	Length of log in contact with bed or banks	ft
LTS	Length of tree stem (not including rootwad)	ft
L _{TS,ex}	Exposed length of tree stem	ft
LF _{RW}	Length factor for rootwad ($LF_{RW} = L_{RW}/D_{TS}$)	-
M _d	Driving moment about embedded tip	lbf
M _r	Driving moment about embedded tip	lbt
N	Blow count of standard penetration test	-
P₀ O	Porosity of soll volume	- ofo
	Design discharge	us #
ĸ	Radius	и и
κ _c	Radius of curvature at channel centerline	π
SGr	Specific gravity of quartz particles	-
30 _T	Average velocity of cross section in reach	- ft/c
u _{avg}	Design velocity	ft/s
udes U	Adjusted velocity at outer meander bend	ft/s
V	Volume of soils above stage level of design flow	ft ³
V.	Volume of soils below stage level of design flow	ft ³
visat V	Total volume of soils over log	ft ³
V	Volume of rootwad	ft ³
V.	Volume of solids in soil (void ratio calculation)	ft ³
V.	Total volume of log	ft ³
V _{To}	Total volume of tree	ft ³
•15 V.,	Volume of voids in soil	ft ³
V	Volume of ballast above stage of design flow	ft ³
V	Volume of ballast below stage of design flow	ft ³
Value	Volume of boulder above stage of design flow	ft ³
V.	Volume of boulder below stage of design flow	ft ³
Wpr	Bankfull width at structure site	ft
W,	Effective weight of boulder	lbf
w,	Total log weight	lbf
x	Horizontal coordinate (distance)	ft
У	Vertical coordinate (elevation)	ft
y _{T,max}	Minimum elevation of log	ft
y T,min	Maximum elevation of log	ft

Greek S	ymbols	
Symbol	Description	Unit
β	Tilt angle from stem tip to vertical	deg
Ybank	Dry specific weight of bank soils	lb/ft ³
γ _{bank,sat}	Saturated unit weight of bank soils	lb/ft ³
γ_{bank}	Effective buoyant unit weight of bank soils	lb/ft ³
γ _{bed}	Dry specific weight of stream bed substrate	lb/ft ³
γ' _{bed}	Effective buoyant unit weight of stream bed substrate	lb/ft ³
Yrock	Dry unit weight of boulders	lb/ft ³
γs	Dry specific weight of soil	lb/ft ³
γ's	Effective buoyant unit weight of soil	lb/ft ³
γ _{Td}	Air-dried unit weight of tree (12% MC basis)	lb/ft ³
γ _{Tgr}	Green unit weight of tree	lb/ft ³
γw	Specific weight of water at 50°F	lb/ft ³
η	Rootwad porosity	-
θ	Rootwad (or large end of log) orientation to flow	deg
μ	Coefficient of friction	-
v	Kinematic viscosity of water at 50°F	ft/s²
Σ	Sum of forces	-
Ф _{bank}	Internal friction angle of bank soils	aeg
Φ _{bed}	Internal friction angle of stream bed substrate	deg

Units

Notation Description

ofo	Cubic fact per second
CIS	Cubic leet per second

- ft Feet
- lb Pound
- Pounds force Kilograms Meters lbf
- kg
- m Millimeters mm
- Seconds s
- Year yr

Abbreviations Notation Description

Notation	Description
ARI	Average return interval
Avg	Average
DBH	Diameter at breast height
deg	Degrees
Dia	Diameter
Dist	Distance
D/S	Downstream
ELJ	Engineered log jam
Ex	Example
Fldpin	Floodplain
H&H	Hydrologic and hydraulic
ID	Identification
i.e.	That is
LB	Left bank
LW	Large wood
Мах	Maximum
MC	Moisture content
Min	Minimum
ML	Multi-log
SL	Single log
N/A	Not applicable
no	Number
Pt	Point
rad	Radians
RB	Right bank
RW	Rootwad
SL	Single log
Thw	Thalweg (lowest elevation in channel bed)
Тур	lypical
U.S.	United States
WS	vvater surface
WSE	Water surface elevation
\uparrow	Above

Ŷ Below
Reference Sheet - Anchoring Techniques

Anchor Technique Lookup Table (average holding capacities)

Soil Class	Soil Description	Blow Count (N)
4	Dense gravels; gravel/cobble; very hard silts and clays	40-100+
5	Dense coarse sand; gravel/sand; loose gravels; stiff slits and clays	14-40
6	Loose coarse sand; dense fine sand; firm silts and clays	7-14
7	Loose fine sand; alluvium; soft silts and clays; silty sand	4-8
Notes:	 All types Use this chart for estimation only. Values shown reflect the n User is responsible for verifying load capacities. The true capacity must be 2. Installation may be difficult. Pilot hole may be required. Holding capacity limited by working load of anchors. Holding capacity limited by soil failure. 	nanufacturer's tested by pro

5. Wide variation in soil properties reduces prediction accuracy. Pre-constructed field tes 6. Duckbill anchors are rated in an average (class 5) soil condition. Proof-loading is the c Anchor holding capacity will vary in different soils. Increased capacities can be expected classifications) and lower capacity can be expected in the softer soil classes (numerically 7. Platipus Stealth and Bat anchors are given a wide range for holding capacities. The hi the low value was assigned to class 7 soils. Holding capacities for class 5 and 6 soils we verifying all rating capacities.

Anchor/Ballast Technique Lookup Table

Technique	Description
Added Soil Ballast	Add coarse material soil lifts on top of structure to increase burial depth
Rouldor Ballact	Place boulder on top of structure. Alternatively, secure structure to
Douider Dallast	boulder located beside or beneath structure.
Wood Pile	Drive or bury vertical wood piles into the bed or banks to brace structure.
(In development)	Alternatively, brace structure against existing large tree.
Machanical Anchor	Secure structure to soil anchor which uses overlying soil to resist pullout.
	Alternatively, secure the structure to bedrock using a rock anchor.

Four common alternatives exist for securing or stabilizing placements of large wood in water. In order of preference for habitat formation, they are:

1. No added stability -- where wood is supplied to the stream and allowed to be stable without manipulation or, as conditions develop, moved by the flow.

2. Passive stability -- where the weight and shape of the structure is the anchor, and movement at some flow level is acceptable (includes ballast).

3. Flexible stability -- such as tethering the structure so some degree of movement is allowed with varying flows.

4. Rigid stability -- holding the logs permanently in place with no movement allowed. (Source: 2012 WA Stream Habitat Restoration Guidelines)

	Manta Ray					
MR-1	MR-2	MR-SR	SR-1	SR-2	SR-3	DB-40
Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)
24,000	15,000	32,000	39,000	62,000	85,000	user input
15,000	9,000	18,000	24,000	31,000	48,000	300
10,000	7,000	14,000	16,000	27,000	37,000	user input
8,000	5,000	9,000	13,000	19,000	24,000	user input

minimum expected holding capacity for a given condition. of-loading. Minimum 2:1 Safety Factor is recommended.

t recommended.

only way to insure the exact capacity of each installation. in harder soil classes (numerically higher blow count *i* lower blow count).

gh manufacturer's rating was applied to class 4 soils, while re interpolated as a guide only. User is responsible for

Duckbill			Platipus Stealth			
DB-68 DB-88 DB-138		P-S02	P-S04	P-S06	P-S08	
Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)
user input	user input	user input	300	1,000	3,500	4,500
1,100	3,000	5,000	150	600	2,000	2,500
user input	user input	user input	50	300	800	1,500
user input	user input	user input	N/A	200	400	1,000

	Cu				
P-B04T	P-B06T	P-B08T	P-B10T	P-B12T	Custom#1
Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)
6,000	11,000	16,500	22,000	33,000	(user input)
3,500	6,500	9,000	14,000	20,000	(user input)
2,500	4,000	6,500	11,000	16,000	(user input)
2,000	3,500	5,500	9,000	13,000	(user input)

stom (User Selection)					
Custom#2	Custom#3				
Capacity (lb)	Capacity (lb)				
(user input)	(user input)				
(user input)	(user input)				
(user input)	(user input)				
(user input)	(user input)				

Directions for LW Stability Analysis Tool

This design tool may be used by practitioners if they cite the developer on each sheet.

Disclaimer:

This Microsoft Excel 2010 spreadsheet tool is provided free of charge. Use this tool at your own risk. In offering this tool, the author, the U.S. Forest Service, and Colorado State University do not accept any responsibility or liability for the tool's use by third parties. This tool has specific uses and limits of applicability. Design practitioners shall take full responsibility for the final large wood structure design and performance. Designers are expected to verify the calculated values and validity of the design method. Designers should be qualified to work in river environments, and depending on the State, they may be required to be licensed as a professional engineer to design large wood structures. You cannot be sure the tool is authentic and unmolested unless downloaded from the following website:

https://www.fs.fed.us/biology/nsaec/products-tools.html#tools-stabilitylargewoodstructures

DATA INPUT

Order of Input

Update the worksheets from "left to right" Update the spreadsheet cells from "left to right" and "top to bottom"

IMPORTANT - User should only edit the following cells:



User should verify, but not edit the following cells because these cells contain formulas or headings:

Cell Format Heading	Directions Table Heading (Scroll over sample heading for description of comments)
Automatic Value	Verify value in cell which is automatically calculated by formulas
Key Value	Verify value of force calculation
Solution	Verify value of force balance or factor of safety calculation
Background Value	Optional - Verify value of background calculation (outside of print area)

The "Single Log" and "Multi-Log" spreadsheets have several built-in error messages (in column 'K'):

Error Message

"CHECK" Prompts user to check a specific input

"ERROR" Prompts user to change a specific input

User Input Note 1 - Several worksheets have a built in "clear inputs" button linked to a macro (these are the only macros built into the tool). Be aware that you can't undo the "clear input" command.

User Input Note 2 - User may enter a custom "bank soil type", "wood species", or "anchor type" by scrolling over to the right to find the lookup table and editing the "custom" cells.

User Input Note 3 - The spreadsheet is not locked, and therefore every cell can be manually edited. However, the

user is encouraged to exercise caution to avoid unintended consequences of changing reference formulas.

User Input Note 4 - User should also be very careful when removing or adding cells (at least scroll over and down to see what other cells may be impacted). Hiding unused rows or columns is recommended instead of deleting them. If the user needs to add cells on the "Single Log Design" spreadsheet, they should add a row of cells for all columns between 'A' and 'J'. Important: Adding cells will break the code in the "Clear Inputs" macro, and cause it to clear the wrong cells.

User Input Note 5 - To avoid compounding potential errors, the user should use the original download version of the spreadsheet (without personal edits) at the beginning of each design.

User Input Note 6 - Input values should be in English units, with one exception: D₅₀ for the bed substrate gradation (mm).

ANALYSIS OF MULTIPLE LOG STRUCTURES

The LW Stability Analysis Tool can also be used to design multiple log structures. The user must manually translate the resulting vertical and horizontal forces from one log design sheet into another (or write their own formulas). This data should be entered in the "Interaction Forces with Adjacent Logs" section of the "Single Log Design" worksheet. In theory, there is no limit to the number of logs that can be considered, although the force balance accounting may become cumbersome beyond a few logs. The general procedure is as follows:

- **Step 1** Begin by creating a preliminary structure layout (in AutoCAD or similar) to define the quantity of logs, locate intersect points, and identify key members. Key members are typically the largest logs (or the logs that are going to be have anchors attached).
- **Step 2** Fill out Sheets 1 through 5 of this tool. Next, input the channel geometry in a blank "Single Log Design" worksheet (Sheet 6), and then make copies for analysis of each log.
- Step 3 Complete a preliminary force balance analysis for each stacked member log, ignoring the "Interaction Forces with Adjacent Logs" and "Anchor Forces" sections. The user should manually record the resisting forces required to stabilize each stacked member in a table. The required vertical force can be found in cell 'K61' of the "Single Log Design" worksheet, and the required horizontal force can be found in cell 'K72'. If the log is already vertically or horizontally stable, record the excess force that may be applied to resist driving forces of the adjacent log(s). This information can be found in cell 'K62' and 'K73'. An example table is shown to the right of these directions →
- Step 4 Complete a force balance analysis for the key members. In the "Interaction Forces with Adjacent Logs" section on the force balance sheet, enter the relative position of each adjacent stacked log in contact with the key member, the connection type (gravity or pinned), the intersection point, and the required vertical and horizontal forces to achieve stability for each stacked member. If the load from the adjacent logs is spread over multiple key members, divide the required forces by the number of key members sharing the load (note--these loads do not need to be evenly distributed between key members). If an adjacent log is either horizontally or vertically stable, then enter any excess force (see Step 3 above) value as a negative number in the key member design spreadsheet. The tool will automatically determine which loads are transferable to the next layer of logs. For instance, a non-pinned log situated above the key member will not transfer buoyancy force to the key member.
- **Step 5** Add "Anchor Forces" as necessary to stabilize the key members.
- Step 6 Return to the stacked member log worksheets and in the "Interaction Forces with Adjacent Logs" section, input the forces that were resisted by the stability analysis of the key members. Add additional "Anchor Forces" as necessary to stabilize the forces that were not resisted by the design of the key members. It is advisable to create a copy of the "preliminary" design worksheets for the stacked member logs to create a separate "final" design worksheet. This will make it easier for the user to review the interaction forces between logs or make necessary edits.

Tip 1: It is recommended that the user creates a spreadsheet to tally the transferred forces for each log.

Tip 2: The design of multiple log structures should initially focus on achieving vertical stability, before moving on to horizontal stability, and finally the moment analysis.

Note 1: Most design procedures for larger wood jams (ELJ's) typically ignore the lift and moment forces, and the drag coefficient may be assumed to be between 0.6 and 0.7 for the entire structure (plus corrections for constriction, or blockage, of the channel). Therefore, the analysis procedure described above is likely conservative for larger

structures.

Note 2: The designer should also perform scour computations and consider the structure's potential to trap mobile wood. The design and/or factor of safety may need modified accordingly.

TO PRINT WORKBOOK

Highlight tabs numbered 1 through 7, and click "Print". Pages are pre-formatted except the "Anchors" Lookup sheet, which is not intended to be printed.

User is encouraged to provide comments and feedback for: Suitability: Range of application or limitations Ease of use Results: Are they reasonable and verified? Any other comments for improvement E-mail comments to: mrafferty@interfluve.com

TOOL UPDATES

Version 1.0 July 2, 2013

Version 1.1 January 8, 2016

Sheet, Cell

- S1, A42 Added reference on cover sheet to new companion paper (USFS National Stream and Aquatic Ecology Ce
- S2, A6,7 Changed default factor of safety to 1.5 (from 2.0) for horizontal and moment force balances
- S6, B6 Updated log structure types in pull-down list on worksheet for single log design

S6, B9 Added terminology of "key", "stacked", and "wracked" logs to dropdown list for consistency with guidelines

S6, B25 Added error message restricting input values for orientation angle (can not equal exactly 0)

- S6, B26 Added error message restricting input values for tilt angle (can not equal exactly 0, 90, 180, 270, or 360)
- S6, D83 Changed soil type from stream bed to bank soils in formula for F_{A,V} applied by additional soil ballast
- Multiple General updates to cell formats

Multiple Fixed page layouts for printing

Version 1.2 January 21, 2020

Update of tools link on NSAEC webpage

Plumtree Branch - Wood Analog Structure

Large Wood Structure Stability Analysis



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	Sheet
Factors of Safety and Design Constants	2
Hydrologic and Hydraulic Inputs	3
Stream Bed Substrate Properties	4
Bank Soil Properties	5
Wood Properties	6
Single Log Stability Analysis	7 - 8
Notation and List of Symbols	9 - 10

Date of Last Revision: January 7, 2016

<u>Designer:</u>	
nsert Name	

Reviewed by: Insert Name

Large Wood Structure Stability Analysis Spreadsheet was developed by Michael Rafferty, P.E. Version 1.1

Reference for Companion Paper:

Rafferty, M. 2016. Computational Design Tool for Evaluating the Stability of Large Wood Structures. Technical Note TN-103.1. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, National Stream & Aquatic Ecology Center. 27 p.

Plumtree Branch - Wood Analog Structure Factors of Safety and Design Constants

Spreadsheet developed by Michael Rafferty, P.E.

Symbol	Description	Value
FS_V	Factor of Safety for Vertical Force Balance	1.00
FS _H	Factor of Safety for Horizontal Force Balance	1.00
FS _M	Factor of Safety for Moment Force Balance	1.00

Symbol	Description	Units	Value
C _{Lrock}	Coefficient of lift for submerged boulder (D'Aoust, 2000)	-	0.17
C _{Drock}	Coefficient of drag for submerged boulder (Schultz, 1954)	-	0.85
g	Gravitational acceleration constant	ft/s ²	32.174
DF _{RW}	Diameter factor for rootwad ($DF_{RW} = D_{RW}/D_{TS}$)	-	3.00
LF _{RW}	Length factor for rootwad ($LF_{RW} = L_{RW}/D_{TS}$)	-	1.50
SG _{rock}	Specific gravity of quartz particles	-	2.65
$\gamma_{ m rock}$	Dry unit weight of boulders	lb/ft ³	165.0
γw	Specific weight of water at 50°F	lb/ft ³	62.40
η	Rootwad porosity from NRCS Tech Note 15 (2001)	-	0.20
ν	Kinematic viscosity of water at 50°F	ft/s ²	1.41E-05

Plumtree Branch - Wood Analog Structure Hydrologic and Hydraulic Inputs

Spreadsheet developed by Michael Rafferty, P.E.

Average Return Interval (ARI) of Design Discharge:

100 yr

Site ID	Proposed Station	Design Discharge, Q _{des} (cfs)	Maximum Depth, d _w (ft)	Average Velocity, u _{avg} (ft/s)	Bankfull Width, W _{BF} (ft)	Wetted Area, A _w (ft ²)	Radius of Curvature, R _c (ft)
XS 0.6757 Channel		2,600	11.29	2.13	409.0	411	0

Plumtree Branch - Wood Analog StructulSpreadsheet developed byStream Bed Substrate PropertiesMichael Rafferty, P.E.

Site ID	Proposed Station	Stream bed D ₅₀ (mm)	Stream Bed Substrate Grain Size Class	Bed Soil Class	Dry Unit Weight ¹ , γ_{bed} (lb/ft ³)	Buoyant Unit Weight, γ' _{bed} (Ib/ft ³)	Friction Angle, φ _{bed} (deg)
6 0.6757 Chanr	Channel	14.10	Medium gravel	5	121.4	75.6	36

Source: Compiled from Julien (2010) and Shen and Julien (1993); soil classes from NRCS Table TS14E–2 Soil classification

¹ γ_{bed} (kg/m³) = 1,600 + 300 log D₅₀ (mm) (from Julien 2010) 1 kg/m³ = 0.062 1 lb/ft³

Plumtree Branch - Wood Analog S Bank Soil Properties

Spreadsheet developed by Michael Rafferty, P.E.

Site ID	Proposed Station	Bank Soils (from field observations)	Bank Soil Class	Dry Unit Weight, γ _{bank} (lb/ft ³)	Buoyant Unit Weight, γ' _{bank} (lb/ft ³)	Friction Angle, \$\\$p_bank\$ (deg)
6 0.6757 Chanr	Channel	Clayey silt	6	84.0	52.3	27
				ļ		

Plumtree Branch - Wood Analog Structure Large Wood Properties

Mid-Atlantic

Project Location:

•		1				
	Timber Unit Weights					
Selected Species	Common Name	Scientific Name	γ_{Td} (lb/ft ³)	(lb/ft ³)		
Tree Type #1:	Beech, American	Fagus grandifolia	44.7	54.0		
Tree Type #2:	Cherry, Black	Prunus serotina	34.9	45.0		
Tree Type #3:	Walnut, Black	Juglans nigra	38.4	57.0		
Tree Type #4:	Oak, Pin	Quercus palustris	44.0	64.0		
Tree Type #5:	Maple, Red	Acer rubrum	37.7	50.0		
Tree Type #6:	Ash, White	Fraxinus americana	41.9	50.0		
Tree Type #7:	Willow, Black	Salix nigra	27.3	51.0		
Tree Type #8:						
Tree Type #9:						
Tree Type #10:						

¹ **Air-dried unit weight**, γ_{Td} = Average unit weight of wood after exposure to air on a 12% moisture content volume basis. Air-dried unit weight is used in the force balance calculations for the portion of wood that is above the proposed thalweg elevation (assuming unsaturated conditions).

² Green unit weight, γ_{Tgr} = Average unit weight of freshly sawn wood when the cell walls are completely saturated with water. Green unit weight is used in the force balance calculations as a conservative estimate of the unit weight for the portion of wood that is below the proposed thalweg elevation (assuming saturated conditions). For comparison, Thevenet, Citterio, & Piegay (1998) determined wood unit weight typically increases by more than 100% after less than 24 hours exposure to water.

Source for timber unit weights:

U.S. Department of Agriculture, U.S. Forest Service. (2009) Specific Gravity and Other Properties of Wood and Bark for 156 Tree Species Found in North America. Research Note NRS-38. Table 1A.

Plumtree Branch - Wood Analog Structure

Spreadsheet developed by Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d _w (ft)	R_c/W_{BF}	u _{des} (ft/s)
0.6757 Chan	Rootwad	Mid-channel	Straight	+	11.29	0.00	2.13

Multi-Log	Layer	Log ID	
Structures	Key Log	1	

Channel Geometry Coordinates					
Proposed	x (ft)	y (ft)			
Fidpin LB	0.00	1.00			
Top LB	10.50	1.00			
Toe LB	13.50	0.00			
Thalweg	15.50	0.00			
Toe RB	17.50	0.00			
Top RB 20.50 1.00					
FldpIn RB	31.00	1.00			

Proposed Cross-Section and Structure Geometry (Looking D/S)



Wood Species	Rootwad	L _T (ft)	D _{TS} (ft)	L _{RW} (ft)	D _{RW} (ft)	γ_{Td} (lb/ft ³)	γ _{Tgr} (lb/ft ³)
Willow, Black	Yes	6.8	2.67	4.00	8.00	27.3	51.0

Structure	θ (deg)	β (deg)	Define Fixed Point	x _T (ft)	y⊤ (ft)	y _{T,min} (ft)	y _{T,max} (ft)	A _{Tp} (ft ²)
Geometry	0.0	-89.9	Stem tip: Crown	15.50	-6.00	-6.00	0.75	50.27

Soils	Material	γ _s (lb/ft³)	γ' _s (lb/ft³)	φ (deg)	Soil Class	L _{T,em} (ft)	d _{b,max} (ft)	d _{b,avg} (ft)
Stream Bed	Medium gravel	121.4	75.6	36.0	5	6.00	6.00	3.01
Bank	Clayey silt	84.0	52.3	27.0	6	0.00	0.00	0.00



0.6757	Chan R	ootwad
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Key Log Log ID 1 Vertical Force Analysis

Net Buoyancy Force									
Wood	V_{TS} (ft ³)	V_{RW} (ft ³)	V_{T} (ft ³)	W _T (lbf)	F _B (lbf)				
↑WSE	0.0	0.0	0.0	0	0				
↓WS ↑Thw	0.0	77.4	77.4	2,111	4,833				
↓Thalweg	15.4	0.0	15.4	783	958				
Total	15.4	77.4	92.8	2,894	5,791				

Soil Ballast Force

Soil	V _{dry} (ft ³)	V _{sat} (ft ³)	V _{soil} (ft ³)	F _{soil} (lbf)
Bed	0.0	48.0	48.0	3,629
Bank	0.0	0.0	0.0	0
Total	0.0	48.0	48.0	3,629

Lift Force						
C _{LT}	0.32					
F _L (lbf)	72					
Vertical F	Force Bala	ince				
F _B (lbf)	5,791	Λ				
F _L (lbf)	72	1				
W _T (lbf)	2,894	$\mathbf{\Psi}$				
F _{soil} (lbf)	3,629	$\mathbf{\Psi}$				
F _{w,v} (lbf)	0					
F _{A,V} (lbf)	0					
ΣF_{V} (lbf)	660	$\mathbf{\Psi}$				
FSv	1.11					

Horizontal Force Analysis								
Drag Force								
A_{Tp} / A_W	Fr _L	C _{Di}	C _w	C _D *	F _D (lbf)			
0.12	0.23	1.20	0.00	1.57	346			

Passive	soil Pre	ssure	Friction Force			
Soil K _P F _P (lbf)		L _{Tf} (ft) μ		F _F (lbf)		
Bed	3.85	6,988	7.99	0.73	480	
Bank	2.66	0	0.00	0.51	0	
Total	-	6,988	7.99	-	480	

Additional Soil Ballast

 V_{Adry} (ft³) V_{Awet} (ft³) c_{Asoil} (ft) $F_{A,Vsoil}$ (lbf) $F_{A,HP}$ (lbf)

0

Horizontal Force Balance							
F _D (lbf)	346	→					
F _P (lbf)	6,988	÷					
F _F (lbf)	480	÷					
F _{w,H} (lbf)	0						
F _{A,H} (lbf)	0						
ΣF_{H} (lbf)	7,122	÷					
FS _H	21.57						

Moment Force Balance									
Driving Moment Centroids Resisting Moment Centroids					roids	Moment	Force Bal	ance	
c _{T,B} (ft)	c _∟ (ft)	c _D (ft)	c _{T,W} (ft)	c _{soil} (ft)	c _{F&N} (ft)	c _P (ft)	M _d (lbf)	48	>
4.3	6.4	6.4	4.3	3.0	3.0	4.0	M _r (lbf)	95	5
*Distances ar	e from the s	stem tip	Point of F	Rotation:	Stem Tip		FS _M	1.98	

Anchor F	Forces
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Mechanical Anchors

Туре	c _{Am} (ft)	Soils	F _{Am} (lbf)
			0
			0

Boulder Ballast

0

Position	D _r (ft)	c _{Ar} (ft)	V _{r,dry} (ft ³)	$V_{r,wet}$ (ft ³)	W _r (lbf)	F _{L,r} (lbf)	F _{D,r} (lbf)	F _{A,Vr} (lbf)	F _{A,Hr} (lbf)
								0	0
								0	0
								0	0

Page 2

Plumtree Branch - Wood Analog Structure

Spreadsheet developed by Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d _w (ft)	R_c/W_{BF}	u _{des} (ft/s)
0.6757 Chan	Rootwad	Mid-channel	Straight	+	11.29	0.00	2.13

Multi-Log	Layer	Log ID		
Structures	Key Log	1		

Channel Geometry Coordinates						
Proposed	x (ft)	y (ft)				
Fldpln LB	0.00	1.00				
Top LB	10.50	1.00				
Toe LB	13.50	0.00				
Thalweg	15.50	0.00				
Toe RB	17.50	0.00				
Top RB	20.50	1.00				
FldpIn RB	31.00	1.00				

Proposed Cross-Section and Structure Geometry (Looking D/S)



Wood Species	Rootwad	L _T (ft)	D _{TS} (ft)	L _{RW} (ft)	D _{RW} (ft)	γ _{Td} (lb/ft ³)	γ_{Tgr} (lb/ft ³)
Cherry, Black	Yes	6.8	2.67	4.00	8.00	34.9	45.0

Structure	θ (deg)	β (deg)	Define Fixed Point	x _T (ft)	y⊤ (ft)	y _{T,min} (ft)	y _{T,max} (ft)	A _{Tp} (ft ²)
Geometry	0.0	-89.9	Stem tip: Crown	15.50	-6.00	-6.00	0.75	50.27

Soils	Material	γ _s (lb/ft³)	γ' _s (lb/ft³)	φ (deg)	Soil Class	L _{T,em} (ft)	d _{b,max} (ft)	d _{b,avg} (ft)
Stream Bed	Medium gravel	121.4	75.6	36.0	5	6.00	6.00	3.01
Bank	Clayey silt	84.0	52.3	27.0	6	0.00	0.00	0.00



0.6757	Chan R	ootwad
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Key Log Log ID 1 Vertical Force Analysis

Net Buoyancy Force							
Wood	V_{TS} (ft ³)	V_{RW} (ft ³)	V_{T} (ft ³)	W _T (lbf)	F _B (lbf)		
↑WSE	0.0	0.0	0.0	0	0		
↓WS ↑Thw	0.0	77.4	77.4	2,706	4,833		
↓Thalweg	15.4	0.0	15.4	691	958		
Total	15.4	77.4	92.8	3,397	5,791		

Soil Ballast Force

Soil	V _{dry} (ft ³)	V _{sat} (ft ³)	V _{soil} (ft ³)	F _{soil} (lbf)
Bed	0.0	48.0	48.0	3,629
Bank	0.0	0.0	0.0	0
Total	0.0	48.0	48.0	3,629

Lift Force						
C _{LT}	0.32					
F _L (lbf)	72					
Vertical F	Force Bala	ance				
F _B (lbf)	5,791	1				
F _L (lbf)	72	1				
W _T (lbf)	3,397	$\mathbf{\Psi}$				
F _{soil} (lbf)	3,629	$\mathbf{+}$				
F _{w,v} (lbf)	0					
F _{A,V} (lbf)	0					
ΣF_{V} (lbf)	1,163	$\mathbf{\Psi}$				
FSv	1.20					

		Horizontal Force Analysis						
Drag Force								
A_{Tp} / A_W	Fr _L	C _{Di}	C _w	C _D *	F _D (lbf)			
0.12	0.23	1.20	0.00	1.57	346			

Passive	e Soil Pre	ssure	Friction Force			
Soil	Κ _P	F _P (lbf)	L _{Tf} (ft)	μ	F _F (lbf)	
Bed	3.85	6,988	7.99	0.73	845	
Bank	2.66	0	0.00	0.51	0	
Total	-	6,988	7.99	-	845	

Additional Soil Ballast

 V_{Adry} (ft³) V_{Awet} (ft³) c_{Asoil} (ft) $F_{A,Vsoil}$ (lbf) $F_{A,HP}$ (lbf)

0

Horizonta	al Force E	alance
F _D (lbf)	346	→
F _P (lbf)	6,988	÷
F _F (lbf)	845	÷
F _{W,H} (lbf)	0	
F _{A,H} (lbf)	0	
ΣF _H (lbf)	7,487	÷
FS _H	22.62	

Moment Force Balance									
Driving Moment Centroids Resisting Moment Centroids Moment Force Balance						ance			
c _{T,B} (ft)	c _∟ (ft)	c _D (ft)	c _{T,W} (ft)	c _{soil} (ft)	c _{F&N} (ft)	c _P (ft)	M _d (lbf)	51	>
4.6	6.4	6.4	4.6	3.0	3.0	4.0	M _r (lbf)	105	5
*Distances are from the stem tip Point of Rotation:		Stem Tip		FS _M	2.07	\bigcirc			

Anchor F	Forces
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Mechanical Anchors

Туре	c _{Am} (ft)	Soils	F _{Am} (lbf)
			0
			0

Boulder Ballast

0

Position	D _r (ft)	c _{Ar} (ft)	V _{r,dry} (ft ³)	$V_{r,wet}$ (ft ³)	W _r (lbf)	F _{L,r} (lbf)	F _{D,r} (lbf)	F _{A,Vr} (lbf)	F _{A,Hr} (lbf)
								0	0
								0	0
								0	0

Page 2

Plumtree Branch - Wood Analog Structure

Spreadsheet developed by Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d _w (ft)	R_c/W_{BF}	u _{des} (ft/s)
0.6757 Chan	Rootwad	Mid-channel	Straight	+	11.29	0.00	2.13

Multi-Log	Layer	Log ID
Structures	Key Log	1

Channel Geometry Coordinates						
Proposed	x (ft)	y (ft)				
Fidpin LB	0.00	1.00				
Top LB	10.50	1.00				
Toe LB	13.50	0.00				
Thalweg	15.50	0.00				
Toe RB	17.50	0.00				
Top RB	20.50	1.00				
FldpIn RB	31.00	1.00				

Proposed Cross-Section and Structure Geometry (Looking D/S)



Wood Species	Rootwad	L _T (ft)	D _{TS} (ft)	L _{RW} (ft)	D _{RW} (ft)	γ _{Td} (lb/ft ³)	γ _{Tgr} (lb/ft ³)
Maple, Red	Yes	6.8	3.00	4.50	9.00	37.7	50.0

Structure	θ (deg)	β (deg)	Define Fixed Point	x _T (ft)	y⊤ (ft)	y _{T,min} (ft)	y _{T,max} (ft)	A _{Tp} (ft ²)
Geometry	0.0	-89.9	Stem tip: Crown	15.50	-6.00	-6.01	0.76	63.62

Soils	Material	γ _s (lb/ft³)	γ' _s (lb/ft³)	φ (deg)	Soil Class	L _{T,em} (ft)	d _{b,max} (ft)	d _{b,avg} (ft)
Stream Bed	Medium gravel	121.4	75.6	36.0	5	6.00	6.00	3.01
Bank	Clayey silt	84.0	52.3	27.0	6	0.00	0.00	0.00



0.6757	Chan R	ootwad
--------	--------	--------

Key Log Log ID 1 Vertical Force Analysis

	Net Buoyancy Force										
Wood	V_{TS} (ft ³)	V_{RW} (ft ³)	V_{T} (ft ³)	W _T (lbf)	F _B (lbf)						
↑WSE	0.0	0.0	0.0	0	0						
↓WS ↑Thw	0.0	110.3	110.3	4,161	6,881						
↓Thalweg	15.9	0.0	15.9	795	993						
Total	15.9	110.3	126.2	4,957	7,873						

Soil Ballast Force

Soil	V _{dry} (ft ³)	V _{sat} (ft ³)	V _{soil} (ft ³)	F _{soil} (lbf)
Bed	0.0	54.0	54.0	4,082
Bank	0.0	0.0	0.0	0
Total	0.0	54.0	54.0	4,082

Lift F	Lift Force						
C _{LT}	0.34						
F _L (lbf)	95						
Vertical F	Force Bala	ance					
F _B (lbf)	7,873	↑					
F _L (lbf)	95	Λ					
W _T (lbf)	4,957	$\mathbf{\Psi}$					
F _{soil} (lbf)	4,082	$\mathbf{+}$					
F _{w,v} (lbf)	0						
F _{A,V} (lbf)	0						
ΣF_{V} (lbf)	1,071	$\mathbf{+}$					
FSv	1.13	\checkmark					

			Horiz	ontal Fo	orce Ana	lysis		
Drag Force								
A_{Tp} / A_W	Fr _L	C _{Di}	C _w	C _D *	F _D (lbf)			
0.15	0.22	1.20	0.00	1.69	474			

Passive Soil Pressure			Friction Force			
Soil	Κ _P	F _P (lbf)	L _{Tf} (ft)	μ	F _F (lbf)	
Bed	3.85	7,862	7.99	0.73	778	
Bank	2.66	0	0.00	0.51	0	
Total	-	7,862	7.99	-	778	

 Additional Soil Ballast

 V_{Adry} (ft³)
 V_{Awet} (ft³)
 c_{Asoil} (ft)
 F_{A,Vsoil} (lbf)
 F_{A,HP} (lbf)

0

Horizontal Force Balance						
F _D (lbf)	474	→				
F _P (lbf)	7,862	÷				
F _F (lbf)	778	÷				
F _{W,H} (lbf)	0					
F _{A,H} (lbf)	0					
ΣF_{H} (lbf)	8,166	÷				
FS _H	18.24					

Moment Force Balance									
Driving M	oment Ce	entroids	Resisting Moment Centroids				Moment Force Balance		
c _{T,B} (ft)	c _∟ (ft)	c _D (ft)	c _{T,W} (ft)	c _{soil} (ft)	c _{F&N} (ft)	c _P (ft)	M _d (lbf)	69	>
4.5	6.4	6.4	4.5	3.0	3.0	4.0	M _r (lbf)	125	5
*Distances are from the stem tip		Point of F	Rotation:	Stem Tip		FS _M	1.82		

	Anc	hor	Force	S
--	-----	-----	-------	---

Туре	c _{Am} (ft)	Soils	F _{Am} (lbf)
			0
			0

Boulder Ballast

0

Position	D _r (ft)	c _{Ar} (ft)	V _{r,dry} (ft ³)	$V_{r,wet}$ (ft ³)	W _r (lbf)	F _{L,r} (lbf)	F _{D,r} (lbf)	F _{A,Vr} (lbf)	F _{A,Hr} (lbf)
								0	0
								0	0
								0	0

Page 2

Plumtree Branch - Wood Analog Structure Notation, Units, and List of Symbols

Notation

Symbol	Description	Unit
Aw	Wetted area of channel at design discharge	ft ²
ATD	Projected area of wood in plane perpendicular to flow	ft ²
C _D	Centroid of the drag force along log axis	ft
C _{Am}	Centroid of a mechanical anchor along log axis	ft
CAr	Centroid of a ballast boulder along log axis	ft
C _{Asoil}	Centroid of the added ballast soil along log axis	ft
C _{F&N}	Centroid of friction and normal forces along log axis	ft
CL	Centroid of the lift force along log axis	ft
CP	Centroid of the passive soil force along log axis	ft
C _{soil}	Centroid of the vertical soil forces along log axis	ft
с _{т,в}	Centroid of the buoyancy force along log axis	ft
с _{т,W}	Centroid of the log volume along log axis	ft
с _{WI}	Centroid of a wood interaction force along log axis	π
CLrock	Coefficient of lift for submerged boulder	-
С _{LT}	Effective coefficient of lift for submerged tree	-
C _{Di}	Base coefficient of drag for tree, before adjustments	-
C _D ^	Effective coefficient of drag for submerged tree	-
C _{Di}	Wave drag coefficient of submorged tree	-
-Cw	Average buried don'th of log	-
a _{b,avg}	Average buried depth of log	n H
۵ _{b,max}	Maximum buried depth of log	π #
u _w	Maximum now deput at design discharge in reach	mm
D 50	Equivalent diameter of boulder	ft
D _r	Assumed diameter of rootwad	ft
D _{F0}	Nominal diameter of tree stem (DBH)	ft
	Diameter factor for rootwad ($DF_{DW} = D_{DW}/D_{TC}$)	-
kw	Void ratio of soils	_
F	Total horizontal load capacity of anchor techniques	lbf
F	Passive soil pressure applied to log from soil ballast	lbf
ГА, НР F	Horizontal resisting force on log from boulder	lbf
· A,Hr F.	Load capacity of mechanical anchor	lbf
• Am F	Total vertical load capacity of anchor techniques	lbf
• A,V E	Vertical resisting force on log from boulder	lbf
F. y	Vertical soil loading on log from added ballast soil	lbf
• A,VSOII F_	Buovant force applied to log	lbf
. в F-	Drag forces applied to log	lbf
F.	Drag forces applied to boulder	lbf
• D,r F-	Eriction force applied to log	lbf
Fu	Resultant horizontal force applied to log	lbf
F.	Lift force applied to log	lbf
F,	Lift force applied to boulder	lbf
F _P	Passive soil pressure force applied to log	lbf
F _{soil}	Vertical soil loading on log	lbf
F _{w,H}	Horizontal forces from interactions with other logs	lbf
F _{w,v}	Vertical forces from interactions with other logs	lbf

Notation (continued) Symbol Description Unit Resultant vertical force applied to log lbf Fv $\mathbf{Fr}_{\mathbf{L}}$ Log Froude number _ FSv Factor of Safety for Vertical Force Balance _ Factor of Safety for Horizontal Force Balance FS_H _ FS_M Factor of Safety for Moment Force Balance ft/s² Gravitational acceleration constant g K_P Coefficient of Passive Earth Pressure $\mathbf{L}_{\mathsf{T},\mathsf{em}}$ Total embedded length of log ft Assumed length of rootwad ft L_{RW} LT Total length of tree (including rootwad) ft \mathbf{L}_{Tf} Length of log in contact with bed or banks ft Length of tree stem (not including rootwad) ft LTS Exposed length of tree stem ft L_{TS.ex} Length factor for rootwad ($LF_{RW} = L_{RW}/D_{TS}$) LF_{RW} _ Driving moment about embedded tip lbf Md lbf M, Driving moment about embedded tip Ν Blow count of standard penetration test -Porosity of soil volume p_o **Q**des Design discharge cfs Radius R ft Radius of curvature at channel centerline ft R_{c} SG, Specific gravity of quartz particles _ SG⊤ Specific gravity of tree _ u_{avg} Average velocity of cross section in reach ft/s u_{des} Design velocity ft/s u_m Adjusted velocity at outer meander bend ft/s ft³ Vdry Volume of soils above stage level of design flow ft³ V_{sat} Volume of soils below stage level of design flow ft³ $V_{\rm soil}$ Total volume of soils over log ft³ V_{RW} Volume of rootwad ft³ Vs Volume of solids in soil (void ratio calculation) ft³ VT Total volume of log ft³ V_{TS} Total volume of tree ft³ Vv Volume of voids in soil ft³ $\mathbf{V}_{\mathbf{Adry}}$ Volume of ballast above stage of design flow ft³ Volume of ballast below stage of design flow V_{Awet} ft³ V_{r,dry} Volume of boulder above stage of design flow ft³ Volume of boulder below stage of design flow V_{r,wet} W_{BF} Bankfull width at structure site ft W, Effective weight of boulder lbf Wτ Total log weight lbf ft Horizontal coordinate (distance) х ft У Vertical coordinate (elevation) ft **Y**T.max Minimum elevation of log Maximum elevation of log ft **Y**T,min

Greek Sy	ymbols	
Symbol	Description	Unit
β	Tilt angle from stem tip to vertical	deg
γ_{bank}	Dry specific weight of bank soils	lb/ft ³
γµbank,sat	Saturated unit weight of bank soils	lb/ft ³
γ _{bank}	Effective buoyant unit weight of bank soils	lb/ft ³
γ_{bed}	Dry specific weight of stream bed substrate	lb/ft ³
γ'_{bed}	Effective buoyant unit weight of stream bed substrate	lb/ft ³
Yrock	Dry unit weight of boulders	lb/ft ³
γs	Dry specific weight of soil	lb/ft ³
γs	Effective buoyant unit weight of soil	lb/ft ³
γ _{td}	Air-dried unit weight of tree (12% MC basis)	lb/ft ³
γ _{Tgr}	Green unit weight of tree	lb/ft ³
γw	Specific weight of water at 50°F	lb/ft ³
η	Rootwad porosity	-
θ	Rootwad (or large end of log) orientation to flow	deg
μ	Coefficient of friction	-
ν	Kinematic viscosity of water at 50°F	ft/s ²
Σ	Sum of forces	-
∮ bank	Internal friction angle of bank soils	deg
o bed	Internal friction angle of stream bed substrate	deg

Units

cfs	Cubic fe	et per s	econd

- ft Feet
- lb Pound
- lbf Pounds force
- kg m Kilograms Meters
- mm Millimeters
- s Seconds
- Year yr

Abbreviations

Notation	Description
ARI	Average return interval
Avg	Average
DBH	Diameter at breast height
deg	Degrees
Dia	Diameter
Dist	Distance
D/S	Downstream
ELJ	Engineered log jam
Ex	Example
Fldpin	Floodplain
Н&Н	Hydrologic and hydraulic
ID	Identification
i.e.	That is
LB	Left bank
LW	Large wood
Max	Maximum
MC	Moisture content
Min	Minimum
ML	Multi-log
SL	Single log
N/A	Not applicable
no	Number
Pt	Point
rad	Radians
RB	Right bank
RW	Rootwad
SL	Single log
Thw	Thalweg (lowest elevation in channel bed)
Тур	Typical
0.8.	United States
WS	vvater surface
WSE	Water surface elevation
Υ	Above

Below $\mathbf{1}$

Reference Sheet - Anchoring Techniques Anchor Technique Lookup Table (average holding capacities)

Anchor Technique	Lookup Table (average holding capacities)			Manta Ray			Stingray			Duc	:kbill			Platipus	Stealth				Platipus Bat			Cu	stom (User Selectio	n)
Roll Class	Roll Description	Blow Count	MR-1	MR-2	MR-SR	SR-1	SR-2	SR-3	DB-40	DB-68	DB-88	DB-138	P-802	P-804	P-S06	P-S08	P-804T	P-806T	P-BteT	P-810T	P-812T	Custom#1	Custom#2	Custom#3
OCH CHARA	oon beacipion	(N)	Capacity (lb)	Capacity (lb)	Capacity (Ib)	Capacity (Ib)	Capacity (lb)	Capacity (Ib)	Capacity (Ib)	Capacity (lb)	Capacity (lb)	Capacity (Ib)	Capacity (Ib)	Capacity (lb)	Capacity (lb)									
4	Dense gravels; gravel/cobble; very hard sits and clays	40-100+	24,000	15,000	32,000	39,000	62,000	85,000	user input	user input	user input	user input	300	1,000	3,500	4,500	6,000	11,000	16,500	22,000	33,000	(user input)	(user input)	(user input)
5	Dense coarse sand; gravel/sand; loose gravels; stiff slits and clays	14-40	15,000	9,000	18,000	24,000	31,000	48,000	300	1,100	3,000	5,000	150	600	2,000	2,500	3,500	6,500	9,000	14,000	20,000	(user input)	(user input)	(user input)
6	Loose coarse sand; dense fine sand; firm silts and clays	7-14	10,000	7,000	14,000	16,000	27,000	37,000	user input	user input	user input	user input	50	300	800	1,500	2,500	4,000	6,500	11,000	16,000	(user input)	(user input)	(user input)
7	Loose fine sand; alluvium; soft silts and clays; silty sanc	4-8	8,000	5,000	9,000	13,000	19,000	24,000	user input	user input	user input	user input	N/A	200	400	1,000	2,000	3,500	5,500	9,000	13,000	(user input)	(user input)	(user input)
Notes	1. All types—Jush this durat for admittation only. Values above mellect the lower inspeciation for heaving pairs of pairs. The two sequelying mult be a subscription of the two sequelying multiple and the subscription of the subscription of the subscription of the subscription of the subscription of the subscription of the subscription of the subscription S. Wilde values of the subscription of the subscription of the subscription of subscription of the subscription of the subscription of the Another bolding capacity will vary in a filterant unker, toronautic appointers as Another bolding capacity will vary in a filterant back, toronautic appointers of a cubsclin actions are used as a cubscription of the subscription of the Another bolding capacity will vary in a filterant back toronautic appointers as the filter and the activity and subscription of the subscription of the subscription of the subscription of the subscription of the subscription of the the subscription of	manufacturer's e tested by pro tructed field te loading is the in be expectes es (numerical acities. The h and 6 soits w	a minimum exp sof-loading. Mir st recommende only way to insi d in harder soil- ly lower blow co ligh manufactu ere interpolated	ected holding ca nimum 2:1 Safet ad. ure the exact ca classes (numeri punt). er/s rating was. d as a guide only	pacity of each is pacity of each is cally higher blox applied to class r. User is respon	n condition. nmended. stallation. r count 4 soils, while sible for																		



Directions for LW Stability Analysis Tool

This design tool may be used by practitioners if they cite the developer on each sheet.

Disclaimer:

This Microsoft Excel 2010 spreadsheet tool is provided free of charge. Use this tool at your own risk. In offering this tool, the author, the U.S. Forest Service, and Colorado State University do not accept any responsibility or liability for the tool's use by third parties. This tool has specific uses and limits of applicability. Design practitioners shall take full responsibility for the final large wood structure design and performance. Designers are expected to verify the calculated values and validity of the design method. Designers should be qualified to work in river environments, and depending on the State, they may be required to be licensed as a professional engineer to design large wood structures. You cannot be sure the tool is authentic and unmolested unless downloaded from the following website:

https://www.fs.fed.us/biology/nsaec/products-tools.html#tools-stabilitylargewoodstructures

DATA INPUT

Order of Input

Update the worksheets from "left to right" Update the spreadsheet cells from "left to right" and "top to bottom"

IMPORTANT - User should only edit the following cells:



User should verify, but not edit the following cells because these cells contain formulas or headings:

Cell Format Heading	Directions Table Heading (Scroll over sample heading for description of comments)
Automatic Value	Verify value in cell which is automatically calculated by formulas
Key Value	Verify value of force calculation
Solution	Verify value of force balance or factor of safety calculation
Background Value	Optional - Verify value of background calculation (outside of print area)

The "Single Log" and "Multi-Log" spreadsheets have several built-in error messages (in column 'K'):

Error Message

"CHECK" Prompts user to check a specific input

"ERROR" Prompts user to change a specific input

User Input Note 1 - Several worksheets have a built in "clear inputs" button linked to a macro (these are the only macros built into the tool). Be aware that you can't undo the "clear input" command.

User Input Note 2 - User may enter a custom "bank soil type", "wood species", or "anchor type" by scrolling over to the right to find the lookup table and editing the "custom" cells.

User Input Note 3 - The spreadsheet is not locked, and therefore every cell can be manually edited. However, the

user is encouraged to exercise caution to avoid unintended consequences of changing reference formulas.

User Input Note 4 - User should also be very careful when removing or adding cells (at least scroll over and down to see what other cells may be impacted). Hiding unused rows or columns is recommended instead of deleting them. If the user needs to add cells on the "Single Log Design" spreadsheet, they should add a row of cells for all columns between 'A' and 'J'. Important: Adding cells will break the code in the "Clear Inputs" macro, and cause it to clear the wrong cells.

User Input Note 5 - To avoid compounding potential errors, the user should use the original download version of the spreadsheet (without personal edits) at the beginning of each design.

User Input Note 6 - Input values should be in English units, with one exception: D₅₀ for the bed substrate gradation (mm).

ANALYSIS OF MULTIPLE LOG STRUCTURES

The LW Stability Analysis Tool can also be used to design multiple log structures. The user must manually translate the resulting vertical and horizontal forces from one log design sheet into another (or write their own formulas). This data should be entered in the "Interaction Forces with Adjacent Logs" section of the "Single Log Design" worksheet. In theory, there is no limit to the number of logs that can be considered, although the force balance accounting may become cumbersome beyond a few logs. The general procedure is as follows:

- **Step 1** Begin by creating a preliminary structure layout (in AutoCAD or similar) to define the quantity of logs, locate intersect points, and identify key members. Key members are typically the largest logs (or the logs that are going to be have anchors attached).
- **Step 2** Fill out Sheets 1 through 5 of this tool. Next, input the channel geometry in a blank "Single Log Design" worksheet (Sheet 6), and then make copies for analysis of each log.
- Step 3 Complete a preliminary force balance analysis for each stacked member log, ignoring the "Interaction Forces with Adjacent Logs" and "Anchor Forces" sections. The user should manually record the resisting forces required to stabilize each stacked member in a table. The required vertical force can be found in cell 'K61' of the "Single Log Design" worksheet, and the required horizontal force can be found in cell 'K72'. If the log is already vertically or horizontally stable, record the excess force that may be applied to resist driving forces of the adjacent log(s). This information can be found in cell 'K62' and 'K73'. An example table is shown to the right of these directions →
- Step 4 Complete a force balance analysis for the key members. In the "Interaction Forces with Adjacent Logs" section on the force balance sheet, enter the relative position of each adjacent stacked log in contact with the key member, the connection type (gravity or pinned), the intersection point, and the required vertical and horizontal forces to achieve stability for each stacked member. If the load from the adjacent logs is spread over multiple key members, divide the required forces by the number of key members sharing the load (note--these loads do not need to be evenly distributed between key members). If an adjacent log is either horizontally or vertically stable, then enter any excess force (see Step 3 above) value as a negative number in the key member design spreadsheet. The tool will automatically determine which loads are transferable to the next layer of logs. For instance, a non-pinned log situated above the key member will not transfer buoyancy force to the key member.
- **Step 5** Add "Anchor Forces" as necessary to stabilize the key members.
- Step 6 Return to the stacked member log worksheets and in the "Interaction Forces with Adjacent Logs" section, input the forces that were resisted by the stability analysis of the key members. Add additional "Anchor Forces" as necessary to stabilize the forces that were not resisted by the design of the key members. It is advisable to create a copy of the "preliminary" design worksheets for the stacked member logs to create a separate "final" design worksheet. This will make it easier for the user to review the interaction forces between logs or make necessary edits.

Tip 1: It is recommended that the user creates a spreadsheet to tally the transferred forces for each log.

Tip 2: The design of multiple log structures should initially focus on achieving vertical stability, before moving on to horizontal stability, and finally the moment analysis.

Note 1: Most design procedures for larger wood jams (ELJ's) typically ignore the lift and moment forces, and the drag coefficient may be assumed to be between 0.6 and 0.7 for the entire structure (plus corrections for constriction, or blockage, of the channel). Therefore, the analysis procedure described above is likely conservative for larger

structures.

Note 2: The designer should also perform scour computations and consider the structure's potential to trap mobile wood. The design and/or factor of safety may need modified accordingly.

TO PRINT WORKBOOK

Highlight tabs numbered 1 through 7, and click "Print". Pages are pre-formatted except the "Anchors" Lookup sheet, which is not intended to be printed.

User is encouraged to provide comments and feedback for: Suitability: Range of application or limitations Ease of use Results: Are they reasonable and verified? Any other comments for improvement E-mail comments to: mrafferty@interfluve.com

TOOL UPDATES

Version 1.0 July 2, 2013

Version 1.1 January 8, 2016

Sheet, Cell

- S1, A42 Added reference on cover sheet to new companion paper (USFS National Stream and Aquatic Ecology Ce
- S2, A6,7 Changed default factor of safety to 1.5 (from 2.0) for horizontal and moment force balances
- S6, B6 Updated log structure types in pull-down list on worksheet for single log design

S6, B9 Added terminology of "key", "stacked", and "wracked" logs to dropdown list for consistency with guidelines

S6, B25 Added error message restricting input values for orientation angle (can not equal exactly 0)

- S6, B26 Added error message restricting input values for tilt angle (can not equal exactly 0, 90, 180, 270, or 360)
- S6, D83 Changed soil type from stream bed to bank soils in formula for F_{A,V} applied by additional soil ballast
- Multiple General updates to cell formats

Multiple Fixed page layouts for printing

Version 1.2 January 21, 2020

Update of tools link on NSAEC webpage

Plumtree Branch - Wooden Posts

Large Wood Structure Stability Analysis



TABLE OF CONTENTS

	Sheet
Factors of Safety and Design Constants	2
Hydrologic and Hydraulic Inputs	3
Stream Bed Substrate Properties	4
Bank Soil Properties	5
Wood Properties	6
Single Log Stability Analysis	7 - 8
Notation and List of Symbols	9 - 10

Date of Last Revision: January 7, 2016

Designer:	
Insert Name	

Reviewed by: Insert Name

Large Wood Structure Stability Analysis Spreadsheet was developed by Michael Rafferty, P.E. Version 1.1

Reference for Companion Paper:

Rafferty, M. 2016. Computational Design Tool for Evaluating the Stability of Large Wood Structures. Technical Note TN-103.1. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, National Stream & Aquatic Ecology Center. 27 p.

Plumtree Branch - Wooden Posts Factors of Safety and Design Constants

Spreadsheet developed by Michael Rafferty, P.E.

Symbol	Description	Value
FS_V	Factor of Safety for Vertical Force Balance	1.00
FS _H	Factor of Safety for Horizontal Force Balance	1.00
FS _M	Factor of Safety for Moment Force Balance	1.00

Symbol	Description	Units	Value
C _{Lrock}	Coefficient of lift for submerged boulder (D'Aoust, 2000)	-	0.17
C _{Drock}	Coefficient of drag for submerged boulder (Schultz, 1954)	-	0.85
g	Gravitational acceleration constant	ft/s ²	32.174
DF_{RW}	Diameter factor for rootwad ($DF_{RW} = D_{RW}/D_{TS}$)	-	3.00
LF _{RW}	Length factor for rootwad ($LF_{RW} = L_{RW}/D_{TS}$)	-	1.50
SG _{rock}	Specific gravity of quartz particles	-	2.65
Yrock	Dry unit weight of boulders	lb/ft ³	165.0
γw	Specific weight of water at 50°F	lb/ft ³	62.40
η	Rootwad porosity from NRCS Tech Note 15 (2001)	-	0.20
ν	Kinematic viscosity of water at 50°F	ft/s ²	1.41E-05

Plumtree Branch - Wooden Posts Hydrologic and Hydraulic Inputs

Spreadsheet developed by Michael Rafferty, P.E.

Average Return Interval (ARI) of Design Discharge:

100 yr

Site ID	Proposed Station	Design Discharge, Q _{des} (cfs)	Maximum Depth, d _w (ft)	Average Velocity, u _{avg} (ft/s)	Bankfull Width, W _{BF} (ft)	Wetted Area, A _w (ft ²)	Radius of Curvature, R _c (ft)
XS 0.6757 Channel		2,600	11.29	2.13	409.0	411	1,000

Plumtree Branch - Wooden Posts Stream Bed Substrate Properties

Spreadsheet developed by Michael Rafferty, P.E.

Site ID	Proposed Station	Stream bed D ₅₀ (mm)	Stream Bed Substrate Grain Size Class	Bed Soil Class	Dry Unit Weight ¹ , γ_{bed} (lb/ft ³)	Buoyant Unit Weight, γ' _{bed} (lb/ft ³)	Friction Angle, φ _{bed} (deg)
6 0.6757 Chanr	Channel	14.10	Medium gravel	5	121.4	75.6	36

Source: Compiled from Julien (2010) and Shen and Julien (1993); soil classes from NRCS Table TS14E–2 Soil classification

¹ γ_{bed} (kg/m³) = 1,600 + 300 log D₅₀ (mm) (from Julien 2010) 1 kg/m³ = 0.062 1 lb/ft³

Plumtree Branch - Wooden Posts Bank Soil Properties

Spreadsheet developed by Michael Rafferty, P.E.

Site ID	Proposed Station	Bank Soils (from field observations)	Bank Soil Class	Dry Unit Weight, γ _{bank} (Ib/ft ³)	Buoyant Unit Weight, γ' _{bank} (lb/ft ³)	Friction Angle,
6 0.6757 Chanr	Channel	Clayey silt	6	84.0	52.3	27

Plumtree Branch - Wooden Posts Large Wood Properties

Mid-Atlantic

Project Location:

	Air-dried ¹	Green ² γ _{Tgr}		
Selected Species	Common Name	Scientific Name	γ _{Td} (lb/ft ³)	(lb/ft ³)
Tree Type #1:	Beech, American	Fagus grandifolia	44.7	54.0
Tree Type #2:	Cherry, Black	Prunus serotina	34.9	45.0
Tree Type #3:	Walnut, Black	Juglans nigra	38.4	57.0
Tree Type #4:	Oak, Pin	Quercus palustris	44.0	64.0
Tree Type #5:	Maple, Red	Acer rubrum	37.7	50.0
Tree Type #6:	Ash, White	Fraxinus americana	41.9	50.0
Tree Type #7:	Willow, Black	Salix nigra	27.3	51.0
Tree Type #8:	Box Elder	(user selection in input table)	27.3	51.0
Tree Type #9:				
Tree Type #10:				

¹ **Air-dried unit weight**, γ_{Td} = Average unit weight of wood after exposure to air on a 12% moisture content volume basis. Air-dried unit weight is used in the force balance calculations for the portion of wood that is above the proposed thalweg elevation (assuming unsaturated conditions).

² **Green unit weight**, γ_{Tgr} = Average unit weight of freshly sawn wood when the cell walls are completely saturated with water. Green unit weight is used in the force balance calculations as a conservative estimate of the unit weight for the portion of wood that is below the proposed thalweg elevation (assuming saturated conditions). For comparison, Thevenet, Citterio, & Piegay (1998) determined wood unit weight typically increases by more than 100% after less than 24 hours exposure to water.

Source for timber unit weights:

U.S. Department of Agriculture, U.S. Forest Service. (2009) Specific Gravity and Other Properties of Wood and Bark for 156 Tree Species Found in North America. Research Note NRS-38. Table 1A.

Plumtree Branch - Wooden Posts

Spreadsheet developed by Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d _w (ft)	R_c/W_{BF}	u _{des} (ft/s)
0.6757 Chan	Floodplain	Left bank	Straight	+	11.29	2.44	2.13

Multi-Log	Layer	Log ID			
Structures	Key Log	1			

Proposed Cross-Section and Structure Geometry (Looking D/S)





Wood Species	Rootwad	L _T (ft)	D _{TS} (ft)	L _{RW} (ft)	D _{RW} (ft)	γ_{Td} (lb/ft ³)	γ_{Tgr} (lb/ft ³)
Willow, Black	No	6.0	3.00	-	-	27.3	51.0

Structure	θ (deg)	β (deg)	Define Fixed Point	x _T (ft)	y⊤ (ft)	y _{T,min} (ft)	y _{T,max} (ft)	A_{Tp} (ft ²)
Geometry	0.0	-89.9	Stem tip: Crown	8.00	-5.00	-5.01	1.00	0.00

Soils	Material	γ _s (lb/ft³)	γ'_{s} (lb/ft ³)	φ (deg)	Soil Class	L _{T,em} (ft)	d _{b,max} (ft)	d _{b,avg} (ft)
Stream Bed	Medium gravel	121.4	75.6	36.0	5	0.00	0.00	0.00
Bank	Clayey silt	84.0	52.3	27.0	6	0.00	6.00	3.00



0.6757 Chan Floodplain			Key Log	Log ID	1			
			Vert	ical For	ce Analy	ysis		
Net Buoyancy Force								
Wood	V _{TS} (ft ³)	V_{RW} (ft ³)	V_{T} (ft ³)	W _T (lbf)	F _B (lbf)			
↑WSE	0.0	0.0	0.0	0	0	F		
↓WS↑Thw	7.1	0.0	7.1	192	440	Ver		
↓Thalweg	35.4	0.0	35.4	1,803	2,207	F _E		
Total	42.4	0.0	42.4	1,996	2,646	F		
						W		
	0.1							

Soil Ballast Force

Soil	Soil V _{dry} (ft ³) V _{sat} (V _{soil} (ft ³)	F _{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	0.0	54.0	54.0	2,824
Total	0.0	54.0	54.0	2,824

Lift Force							
C _{LT}	0.00						
F _L (lbf)	0						
Vertical Force Balance							
F _B (lbf)	2,646	↑					
F _L (lbf)	0						
W _T (lbf)	1,996	$\mathbf{\Psi}$					
F _{soil} (lbf)	2,824	$\mathbf{+}$					
F _{w,v} (lbf)	0						
F _{A,V} (lbf)	0						
ΣF_{V} (lbf)	2,173	$\mathbf{+}$					
FSv	1.82	\checkmark					

Page 2

Horizontal Force Analysis								
Drag Force								
A _{Tp} / A _W	Fr _L	C _{Di}	C _w	C _D *	F _D (lbf)			
0.00	0.22	1.12	0.00	1.11	0			

Passive	e Soil Pre	ssure	Friction Force			
Soil	К _Р	F _P (lbf)	L _{Tf} (ft)	μ	F _F (lbf)	
Bed	3.85	0	2.00	0.73	395	
Bank	2.66	3,760	6.00	0.51	831	
Total	-	3,760	8.00	-	1,225	

He	Horizontal Force Balance								
F	_D (lbf)	0	→						
F	_P (lbf)	3,760	÷						
F	⁼ _F (lbf)	1,225	←						
F	_{w,H} (lbf)	0							
F	_{A,H} (lbf)	0							
Σ	F _H (lbf)	4,986	÷						
	FS _H	324,543.55							

Moment Force Balance									
Driving Moment Centroids Resisting Moment Centroids					roids	Moment	Force Bal	ance	
c _{T,B} (ft)	c _∟ (ft)	c _D (ft)	c _{T,W} (ft)	c _{soil} (ft)	c _{F&N} (ft)	c _P (ft)	M _d (lbf)	14	>
3.0	0.0	0.0	3.0	3.0	3.0	3.0	M _r (lbf)	63	5
*Distances are from the stem tip		Point of Rotation:		Root Collar		FS _M	4.53		

	Anc	hor	Forces	
--	-----	-----	--------	--

	Additional Soil Ballast					Mechanical Anchors			
V _{Adry} (ft ³)	V_{Awet} (ft ³)	c _{Asoil} (ft)	F _{A,Vsoil} (lbf)	F _{A,HP} (lbf)		Туре	c _{Am} (ft)	Soils	F _{Am} (lbf)
			0	0					0
									0
	Boulder Ballast								
Position	D _r (ft)	c _{Ar} (ft)	V _{r,dry} (ft ³)	$V_{r,wet}$ (ft ³)	W _r (lbf)	F _{L,r} (lbf)	F _{D,r} (lbf)	F _{A,Vr} (lbf)	F _{A,Hr} (lbf)
								0	0
								0	0
								0	0

Plumtree Branch - Wooden Posts Notation, Units, and List of Symbols

Notation

Symbol	Description	Unit
Aw	Wetted area of channel at design discharge	ft ²
Ann	Projected area of wood in plane perpendicular to flow	ft ²
C _D	Centroid of the drag force along log axis	ft
C _{Am}	Centroid of a mechanical anchor along log axis	ft
C _{Ar}	Centroid of a ballast boulder along log axis	ft
C _{Asoil}	Centroid of the added ballast soil along log axis	ft
C _{F&N}	Centroid of friction and normal forces along log axis	ft
cL	Centroid of the lift force along log axis	ft
CP	Centroid of the passive soil force along log axis	ft
C _{soil}	Centroid of the vertical soil forces along log axis	ft
$\mathbf{c}_{T,B}$	Centroid of the buoyancy force along log axis	ft
с _{т,W}	Centroid of the log volume along log axis	ft
с _{WI}	Centroid of a wood interaction force along log axis	ft
CLrock	Coefficient of lift for submerged boulder	-
CLT	Effective coefficient of lift for submerged tree	-
C _{Di}	Base coefficient of drag for tree, before adjustments	-
C _D *	Effective coefficient of drag for submerged tree	-
C _{Di}	Base coefficient of drag for tree, before adjustments	-
C _W	Average burged death of land	-
α _{b,avg}	Average buried depth of log	п
a _{b,max}	Maximum buried depth of log	π
a _w	Maximum flow depth at design discharge in reach	π
D ₅₀	Fauivalant diameter of boulder	mm #
D,	Assumed diameter of rootwad	ft
D _{RW}	Nominal diameter of tree stem (DBH)	ft
DF	Diameter factor for rootwad ($DE_{nu} = D_{nu}/D_{ro}$)	-
	Void ratio of soils	-
E	Total barizontal load capacity of anchor techniques	- Ihf
FA,H	Passive soil pressure applied to lea from soil ballast	IDI Ibf
	Harizantal registing fares on log from boulder	IDI Ibf
F _{A,Hr}	Load capacity of machanical anchor	IDI Ibf
r Am ⊑	Total vertical lead especitiv of apphar techniques	IDI Ibf
	Vertical registing force on log from boulder	IDI Ibf
F _{A,Vr}	Vertical resisting force of log from odded bellest soil	IDI Ibf
FA,Vsoil	Puovent force applied to leg	IDI Ibf
г _в г	Buoyant force applied to log	IDI Ibf
г _D	Drag forces applied to log	IDI Ihf
F _{D,r}	Eristian forces applied to boulder	IDT Ibf
r _F	Proclon force applied to log	IDI Ibf
F.	Lift force applied to log	lbf
• L F.	Lift force applied to boulder	lhf
• ∟,r F~	Passive soil pressure force applied to log	lhf
Гр Fa	Vertical soil loading on log	lbf
F _w , L	Horizontal forces from interactions with other loas	lbf
Fwv	Vertical forces from interactions with other loos	lbf
••,•	5	

Notation (continued) Symbol Description Unit Resultant vertical force applied to log lbf F_V $\mathbf{Fr}_{\mathbf{L}}$ Log Froude number _ FSv Factor of Safety for Vertical Force Balance _ Factor of Safety for Horizontal Force Balance FS_H _ FS_M Factor of Safety for Moment Force Balance ft/s² Gravitational acceleration constant g K_P Coefficient of Passive Earth Pressure $\mathbf{L}_{\mathrm{T,em}}$ Total embedded length of log ft L_{RW} Assumed length of rootwad ft LT Total length of tree (including rootwad) ft \mathbf{L}_{Tf} Length of log in contact with bed or banks ft Length of tree stem (not including rootwad) LTS ft L_{TS,ex} Exposed length of tree stem ft Length factor for rootwad ($LF_{RW} = L_{RW}/D_{TS}$) **LF**_{RW} _ Driving moment about embedded tip lbf Md lbf M, Driving moment about embedded tip Ν Blow count of standard penetration test -Porosity of soil volume p_o Q_{des} Design discharge cfs Radius R ft R_{c} Radius of curvature at channel centerline ft SG, Specific gravity of quartz particles _ SGτ Specific gravity of tree u_{avg} Average velocity of cross section in reach ft/s u_{des} Design velocity ft/s u_m Adjusted velocity at outer meander bend ft/s ft³ Vdry Volume of soils above stage level of design flow ft³ V_{sat} Volume of soils below stage level of design flow ft³ V_{soil} Total volume of soils over log ft³ V_{RW} Volume of rootwad ft³ Vs Volume of solids in soil (void ratio calculation) ft³ VT Total volume of log ft³ Total volume of tree VTS ft³ Vv Volume of voids in soil ft³ Volume of ballast above stage of design flow V_{Adry} ft³ Volume of ballast below stage of design flow VAwet ft³ V_{r,dry} Volume of boulder above stage of design flow $\mathbf{V}_{\mathrm{r,wet}}$ ft³ Volume of boulder below stage of design flow \mathbf{W}_{BF} Bankfull width at structure site ft W, Effective weight of boulder lbf Wτ Total log weight lbf Horizontal coordinate (distance) ft х Vertical coordinate (elevation) ft У ft **y**_{T,max} Minimum elevation of log Maximum elevation of log ft **Y**T,min

Greek Symbols			
Symbol	Description	Unit	
β	Tilt angle from stem tip to vertical	deg	
Ybank	Dry specific weight of bank soils	lb/ft ³	
γ _{bank,sat}	Saturated unit weight of bank soils	lb/ft ³	
γ_{bank}	Effective buoyant unit weight of bank soils	lb/ft ³	
γ _{bed}	Dry specific weight of stream bed substrate	lb/ft ³	
γ' _{bed}	Effective buoyant unit weight of stream bed substrate	lb/ft ³	
Yrock	Dry unit weight of boulders	lb/ft ³	
γs	Dry specific weight of soil	lb/ft ³	
γ's	Effective buoyant unit weight of soil	lb/ft ³	
γ _{Td}	Air-dried unit weight of tree (12% MC basis)	lb/ft ³	
γ _{Tgr}	Green unit weight of tree	lb/ft ³	
γw	Specific weight of water at 50°F	lb/ft ³	
η	Rootwad porosity	-	
θ	Rootwad (or large end of log) orientation to flow	deg	
μ	Coefficient of friction	-	
v	Kinematic viscosity of water at 50°F	ft/s²	
Σ	Sum of forces	- 	
Ф _{bank}	Internal friction angle of bank soils	aeg	
Φ _{bed}	Internal friction angle of stream bed substrate	deg	

Units

Notation Description

ofo	Cubic fact per second
CIS	Cubic leet per second

- ft Feet
- lb Pound
- Pounds force Kilograms Meters lbf
- kg
- m Millimeters mm
- Seconds s
- Year yr

Abbreviations Notation Description

Notation	Description
ARI	Average return interval
Avg	Average
DBH	Diameter at breast height
deg	Degrees
Dia	Diameter
Dist	Distance
D/S	Downstream
ELJ	Engineered log jam
Ex	Example
Fldpin	Floodplain
H&H	Hydrologic and hydraulic
ID	Identification
i.e.	That is
LB	Left bank
LW	Large wood
Мах	Maximum
MC	Moisture content
Min	Minimum
ML	Multi-log
SL	Single log
N/A	Not applicable
no	Number
Pt	Point
rad	Radians
RB	Right bank
RW	Rootwad
SL	Single log
Thw	Thalweg (lowest elevation in channel bed)
Тур	lypical
U.S.	United States
WS	vvater surface
WSE	Water surface elevation
\uparrow	Above

Ŷ Below
Reference Sheet - Anchoring Techniques

Anchor Technique Lookup Table (average holding capacities)

Soil Class	Soil Description	Blow Count (N)		
4	Dense gravels; gravel/cobble; very hard silts and clays	40-100+		
5	Dense coarse sand; gravel/sand; loose gravels; stiff slits and clays	14-40		
6	Loose coarse sand; dense fine sand; firm silts and clays	7-14		
7	Loose fine sand; alluvium; soft silts and clays; silty sand	4-8		
Notes:	 All types Use this chart for estimation only. Values shown reflect the manufacturer's User is responsible for verifying load capacities. The true capacity must be tested by pro Installation may be difficult. Pilot hole may be required. Holding capacity limited by working load of anchors. Holding capacity limited by soil failure. 			

5. Wide variation in soil properties reduces prediction accuracy. Pre-constructed field tes 6. Duckbill anchors are rated in an average (class 5) soil condition. Proof-loading is the c Anchor holding capacity will vary in different soils. Increased capacities can be expected classifications) and lower capacity can be expected in the softer soil classes (numerically 7. Platipus Stealth and Bat anchors are given a wide range for holding capacities. The hi the low value was assigned to class 7 soils. Holding capacities for class 5 and 6 soils we verifying all rating capacities.

Anchor/Ballast Technique Lookup Table

Technique	Description		
Added Soil Ballast	Add coarse material soil lifts on top of structure to increase burial depth		
Rouldor Ballact	Place boulder on top of structure. Alternatively, secure structure to		
Douider Dallast	boulder located beside or beneath structure.		
Wood Pile	Drive or bury vertical wood piles into the bed or banks to brace structure.		
(In development) Alternatively, brace structure against existing large tree.			
Machanical Anchor	Secure structure to soil anchor which uses overlying soil to resist pullout.		
	Alternatively, secure the structure to bedrock using a rock anchor.		

Four common alternatives exist for securing or stabilizing placements of large wood in water. In order of preference for habitat formation, they are:

1. No added stability -- where wood is supplied to the stream and allowed to be stable without manipulation or, as conditions develop, moved by the flow.

2. Passive stability -- where the weight and shape of the structure is the anchor, and movement at some flow level is acceptable (includes ballast).

3. Flexible stability -- such as tethering the structure so some degree of movement is allowed with varying flows.

4. Rigid stability -- holding the logs permanently in place with no movement allowed. (Source: 2012 WA Stream Habitat Restoration Guidelines)

Manta Ray						
MR-1	MR-2	MR-SR	SR-1	SR-2	SR-3	DB-40
Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)
24,000	15,000	32,000	39,000	62,000	85,000	user input
15,000	9,000	18,000	24,000	31,000	48,000	300
10,000	7,000	14,000	16,000	27,000	37,000	user input
8,000	5,000	9,000	13,000	19,000	24,000	user input

minimum expected holding capacity for a given condition. of-loading. Minimum 2:1 Safety Factor is recommended.

t recommended.

only way to insure the exact capacity of each installation. in harder soil classes (numerically higher blow count *i* lower blow count).

gh manufacturer's rating was applied to class 4 soils, while re interpolated as a guide only. User is responsible for

Duckbill			Platipus Stealth				
DB-68	DB-88	DB-138	P-S02	P-S04	P-S06	P-S08	
Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)	
user input	user input	user input	300	1,000	3,500	4,500	
1,100	3,000	5,000	150	600	2,000	2,500	
user input	user input	user input	50	300	800	1,500	
user input	user input	user input	N/A	200	400	1,000	

	Cu				
P-B04T	P-B06T	P-B08T	P-B10T	P-B12T	Custom#1
Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)	Capacity (lb)
6,000	11,000	16,500	22,000	33,000	(user input)
3,500	6,500	9,000	14,000	20,000	(user input)
2,500	4,000	6,500	11,000	16,000	(user input)
2,000	3,500	5,500	9,000	13,000	(user input)

stom (User Selection)				
Custom#2	Custom#3			
Capacity (lb)	Capacity (lb)			
(user input)	(user input)			
(user input)	(user input)			
(user input)	(user input)			
(user input)	(user input)			