BELLEVUE COASTAL COMMUNITY

Comprehensive Analysis of Stormwater Management and Shoreline Erosion Control

April 2011

Prepared by

BayLand Consultants & Designers, Inc.

"Integrating Engineering and Environment"

1321 Mercedes Drive, Suite A Phone: (410) 694-9401
Hanover, Maryland 21076 Fax: (410) 694-9405
http://www.baylandinc.com

TABLE OF CONTENTS

BACKGROUND

The Shoreline community of Bellevue in western Talbot County was selected by Talbot County Government as part of the pilot program under the Maryland's Chesapeake & Coastal Program Coastal Communities Initiative (CCI). The pilot program seeks to assess the existing conditions of stormwater management (SWM) and shoreline erosion control; and establish stormwater management and shoreline erosion control priorities for retrofits, improvements and enhancement.

Bellevue is a 57.9 acre community that has morphed from a village supported by a local canning operation to a single lot residential community. Bellevue is also home to the Oxford-Bellevue Ferry, which is believed to be the oldest privately operated ferry service, running continuously since 1836.

Figure 1: Bellevue Coastal Community Study Area

CURRENT STORMWATER MANAGEMENT AND CONVEYANCE

Field reconnaissance could not identify any onsite existing stormwater management best management practices (BMPs) for either the roads or other impervious surfaces of the coastal community of Bellevue. Recently constructed homes, as identified from aerial images, where not observed to have implemented any single lot stormwater management BMPs. Especially prominent was the lack of any BMPs for what appeared to be the recently redeveloped and well maintained community park and ferry launch parking, both of which discharge directly to tidal waters.

The current condition of the stormwater conveyance for all the interior roads of the coastal community of Bellevue were identified as either inadequate, nonexistent or nonfunctioning. Bellevue Road is well maintained and crowned so that stormwater runoff collects in the roadside drainage swales. But, the roadside drainage swales were observed with a significant amount of standing water and did not appeared to drain properly. The ferry parking and access were observed to drain properly to tidal waters, but the runoff, in a high use paved area, does not receive any type of stormwater management. As highlighted by concerns from Bellevue residents, and verified by field observations, at almost every intersection stormwater runoff backs up and ponds for extended periods of time. Particular areas of standing water were at either end of Dawson Street, midway down Gate Street and the entrance to Church Street. The state of the current stormwater conveyance has resulted in the roadways with standing water after storm events, potholes and accelerated deterioration of driving surfaces.

CURRENT SHORELINE EROSION

Field reconnaissance of the entire 6,160 LF of shoreline revealed that a significant majority of the coast has been protected by individual property owners. Appendix 1 details the stability of the shoreline for the entire coastline of the Bellevue coastal community, where approximately 1,875 feet or about 30% of the shoreline appeared to be in an unstable condition. The majority of the protection on the southeast side of the peninsula is either bulkhead or revetment armoring. Along the north and northwest the protection is stabilized with revetment or a combination of revetment and living shorelines stabilized with native vegetation. The area that was found to have significant erosion is the northwest of the peninsula where Tar Creek empties into the Chesapeake Bay. Several land owners in this vicinity have experienced failure of the existing structural stabilization, with the major failure being that of an existing bulkhead in a little cove with several abandoned wooden boats. Several landowners in this vicinity are currently experiencing high degree of shoreline erosion from lack of any type of stabilization. The closer to Tar Creek the more naturally stable the shoreline becomes. The individual property owner’s ability to prevent erosion of their waterfront property varies greatly. Generally, the larger lots with newer homes have protected their shoreline, while the smaller lots with older homes have not. Fortunately, from a shoreline erosion perspective, the majority of the homes along the shoreline are newer homes on larger lots that have protected their shoreline.

FUTURE FLOODING HAZARDS

Future flooding hazards, due to rising sea levels, impacts on the Bellevue coastal community were assessed with The Maryland Department of Natural Resources – Sea Level Rise Inundation Vulnerability dataset. The 2 Foot Sea Level Rise Inundation dataset is a derivative of high-resolution topographic data (LiDAR). The State of Maryland, through a National Oceanic and Atmospheric Administration, Coastal Zone Management Grant, created the 2 Foot Sea Level Rise Inundation dataset to assist the Maryland Commission on Climate Change develop a strategy for reducing Maryland's vulnerability to climate change-induced sea level rise.

The existing topographic information, when compared to the 2 foot sea level rise dataset, revealed that the coastal community of Bellevue would be adversely affected in the northwest tip of the peninsula where no bulkhead or stone revetment has been constructed. This area is where the shoreline is very stable from previous shoreline stabilization efforts with native vegetation. The Bellevue-Oxford ferry commercial operation may require mitigation or infrastructure upgrades to avoid any potential adverse impacts due to 2 foot sea level rise. No existing residential structures would be impacted from a 2 foot sea level rise.

The exiting aerial imagery was overlaid with the exiting FEMA 100-year floodplain (storm surge) dataset to determine the current flooding hazards. The analysis revealed that a significant majority of the existing residential structures and the Oxford-Bellevue Ferry are well within the existing floodplain and would be significantly impacted by a 100-year storm surge event at the current sea level and the risk of flooding be increased with any rise in sea level. Appendix 2 shows the extent of shoreline vulnerability to rising sea levels and current 100yr storm surges.

ESTIMATE OF CURRENT STORMWATER POLLUTION LOADING

An estimate of current pollutant loadings can be determined with the Simple Method, developed by Schueler (1987). The Simple Method provides a realistic level of accuracy for estimating pollutant loading for stormwater runoff in urban areas. It requires several input parameters such as drainage area, amount of impervious coverage, annual precipitation, and pollutant concentrations to estimate the pollutant loading. The input concentrations can either be specific to the type of land use within the drainage area, or utilize more generalized pollutant concentrations for urban runoff. General urban pollutant loadings for stormwater runoff were utilized for this estimate. Equation 1 list the Simple method of calculating annual pollutant loads (lbs/yr) and Table 1 lists the input parameters utilized in the simple method to develop the annual pre-project annual pollutant loads.

Equation 1: $L = [(P) (Pj) (Rv) / 12] (C) (A) (2.72)$, where $Rv = [0.05 + (0.9 Ia)]$

Table 1 – Simple Method Annual Pollutant Loading Model Input Parameters		
Parameter	**Symbol**	**Input Value**
Annul Precipitation (in/yr)	P	43.2
Fraction of Runoff Producing Events	Pj	0.9
Runoff Coefficient	Rv	0.149
Area (Acres)	A	60
Impervious Area (%)	Ia	11.0
Mean Concentration of Total Phosphorous (mg/L)	C – TP	0.26
Mean Concentration of Total Nitrogen (mg/L)	C – TN	2.00
Mean Concentration of Total Suspended Solids (mg/L)	C – TSS	54.50

Using the Simple Method Equation and the above input parameters, current annual stormwater pollutant loading was estimated. The results are listed in Table 2.

Table 2 – Current Annual Stormwater Pollutant Loading						
Project ID	**Description**	**DA**	**Imp. Area**	**Annual Pre-project Pollutant Loads**		
				TP	**TN**	**TSS**
		Acres	**%**	**lbs/yr**	**lbs/yr**	**lbs/yr**
BV	Bellevue Coastal Community	60	11	21.7	166.7	4,541.9

ESTIMATE OF CURRENT POLLUTANT LOADS FROM SHORELINE EROSION

An analysis of the historic shoreline erosion rates shows an estimated historical shoreline loss of 6 inches to 1 foot per year for unprotected areas. Shoreline without structural or non-structural shoreline erosion controls in Maryland can be attributed a sediment loading rate of 2.917 kg/day/ft, based on Maryland Department of Natural Resources data. This loading rate closely matched our estimates of shoreline erosion based on an analysis of the topography and historical shoreline. The amount of phosphorus and nitrogen attached to sediment was calculated using information collected by USDA Agriculture Research Service. The estimate starts with an overall phosphorus concentration of 0.0005 lbs per lb of soil and a nitrogen concentration of 0.001 lbs per lb of soil. Soil texture is determined and a correction factor is used to better estimate nutrient holding capacity of the soil, because sandy soil has a lower nutrient-holding capacity than a clay soil. Silt is the dominant soil texture for the study area, so a correction factor was not necessary. Table 3 list the estimated annual pollutant loads attributed to shoreline erosion while appendix 3 shows the historical shoreline for Bellevue coastal community.

Table 3 – Estimate of Current Pollutant Loads from Shoreline Erosion				
Shoreline Classification	Shoreline Length	Annual Pollutant Loading Rate		
		TSS	TP	TN
	LF	lbs/yr	lbs/yr	lbs/yr
Unstable	1,875	4,391,908	2,195	4,391

POTENTIAL STORMWATER AND SHORELINE EROSION CONTROL BMPs

A strategic assessment of potential stormwater and shoreline erosion control BMPs was conducted in order to identify opportunities for potential retrofit BMPs to control stormwater runoff, shoreline erosion and reduce pollutant loading of the Chesapeake Bay. The BMP assessment utilized information gathered from a comprehensive field assessment and a review of Talbot County GIS data. From the assessment, comprehensive stormwater management and shoreline erosion control plan was developed that identifies and prioritizes BMP concept opportunities that would most effectively benefit the coastal community of Bellevue.

The BMP concepts are group by methodology, with each concept implementation being briefly described. The potential impervious area to be treated or shoreline to be protected is also quantified and a reasonable cost analysis is presented for each concept based on our experiences with previous projects of a similar nature. Cost shown are for comparison purposes and do not include contingencies, engineering, permitting, etc…Appendix 4 shows a location map of each of the identified stormwater management or shoreline erosion control concepts.

BMP – Maintenance of Interior Roads (Concept 1)

Description

The interior roads of the Bellevue Coastal Community are either deteriorated asphalt or gravel surfaces. They do not have stormwater management controls, nor were they built to minimize erosion impacts during severe rainfall events. The road edge often becomes the collection point for concentrated stormwater flows resulting in gully erosion and high sediment loads. The concept is to maintain and fix the driving surface so that water drains properly and prevents sediment loading from accelerated deterioration of the driving surface.

Concept

Concept 1 – Resurface the existing 2.9 acres of the Bellevue coastal community interior roads with a minimum of 1 ½ inch bituminous surface course that to form a properly crowned residential road that will facilitate the drainage of water from the roadway surface to the pervious adjacent surfaces and prevent the accelerated deterioration of the driving surface. Additionally it would be advantageous to also encourage individual property owners to maintain their driveways in a manner that reduces the amount of water ponding at the edge of the driveway and road surface. This will reduce the pollutant loading associated with stormwater runoff from the deterioration of the driving surface. The cost of implementing the maintenance of the interior roads by applying a 1 ½ inch surface course of bituminous concrete would be approximately $20 per square yard or approximately $94,000 for this concept.

BMP – Bio-swales (Concepts 2 through 4)

Description

A bio-swale is a series of vegetated open channel management practices designed specifically to treat and attenuate stormwater runoff for a specified water quality volume. It is treated through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. All roadway bio-swales (concepts 2 through 4) are recommended to be implemented with concept 1 to provide positive drainage to the BMP from the roadway surface. Bio-swales are appropriate for the site because they will capture and treat runoff from adjacent impervious surfaces while being a linear BMP that does not require a vast amount of area to implement.

Concepts

<u>Concept 2</u> – Install 300 feet of 2'-4' wide bio-swales along either and/or both sides of Orchard Terrace. The design of the bio-swales should include the use of an underdrain. This concept could provide water quality treatment for approximately 0.16 acres of impervious roadway and up to 0.8 acres of the 1/8 acre residential lots located on Orchard Terrace. The cost to construct the bio-swales would be approximately $120 per foot or $36,000 for this concept.

<u>Concept 3</u> – Install up to 800 feet of 2'-4' wide bio-swale along the East side on Poplar Street. This concept could provide water quality treatment for approximately 0.52 acres of impervious roadway. The installation of several driveway culverts and an outfall easement across an adjacent landowner would be required for this concept. There is the possibility for an additional 500 foot bio-swale to be extended where the ideal outfall is located- an old road bed from a previous water access. The additional bio-swale would capture a limited amount of impervious area and is not recommended unless the roadway swale cannot be sized large enough to effectively treat the entire roadway stormwater runoff. The cost to construct the bio-swale would be approximately $90 per foot or $72,000 for this concept.

<u>Concept 4</u> – Install 200 feet of 4'-8' wide bio-swale on the between Bellevue Park and the Bellevue-Oxford Ferry parking lot. The bio-swale would drain into a yard inlet that would discharge underneath Bellevue Road directly to tidal waters. This concept could also utilize a trenchdrain installed across the parking lot to capture and treat more of the stormwater runoff. The concept could capture and treat runoff from approximately 0.25 acres of the impervious parking area. The cost to construct the bio-swale would be

approximately $180 per foot $36,000 for this concept, inclusive of the installation of the outfall and trenchdrain.

BMP – Hydrodynamic Structures (Concept 5)

Description

Hydrodynamic structures are devices designed to improve quality of stormwater using features such as swirl concentrators, grit chambers, oil barriers, baffles, micropools, and absorbent pads that are designed to remove sediments, nutrients, metals, organic chemicals, or oil and grease from urban runoff. They also may be effective in removing contaminants that are not removed by less highly-engineered systems. However, they may also require greater maintenance than other BMPs and may not be economical for large runoff volumes.

Concept

Concept 5 – Install one or multiple basins (trenchdrains or inlets) and an online hydrodynamic separator to capture and treat stormwater runoff from the Bellevue-Oxford Ferry parking lot and boat ramp that currently sheet flows to tidal waters with no treatment. This device would also be ideal to capture other pollutants such as oil or gas that accumulate on the pavement from the high access of vehicular traffic and from the used oil/grease disposal site located in the parking lot.

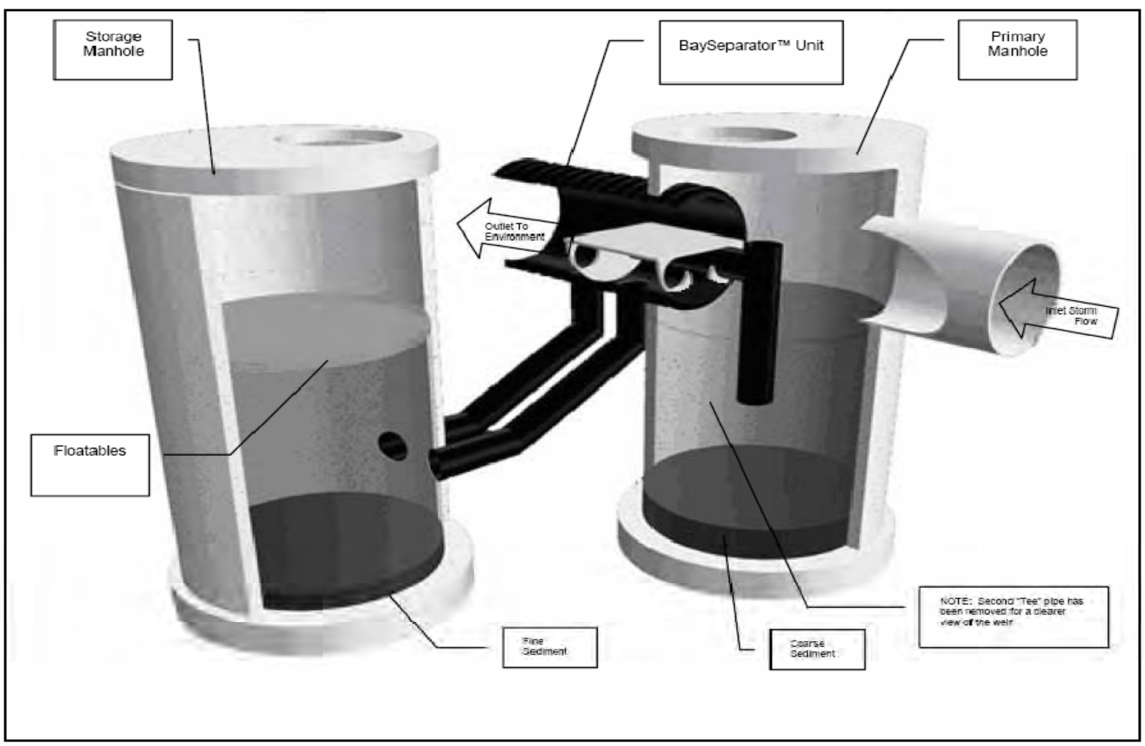


Figure 2: Example of a hydrodynamic separator.

The concept could capture and treat runoff from up to 0.35 acres of the impervious parking area and ferry access. Figure 2 shows an example of a hydrodynamic separator.

The cost to install the hydrodynamic separator can vary depending on the configuration/type of the capture and conveyance and the proprietary system selected. A standard hydrodynamic separator configuration for this concept would cost approximately $50,000.

BMP – Constructed Wetland (Concepts 6 and 7)

Description

Constructed wetlands are systems that perform a series of pollutant removal mechanisms including sedimentation, filtration, absorption, microbial decomposition and vegetative uptake to remove sediment, nutrients, oil and grease, bacteria and metals. Wetland systems reduce runoff velocity thereby promoting settling of solids. Plant uptake accounts for removal of dissolved constituents. In addition, plant material can serve as an effective filter medium, and effectively remove nitrogen.

Concept

Concept 6 – Convert an old 1.8 acre overgrown phragmites marsh that may have been previously used as a dredge material placement site into a shallow wetland with multiple permanent pools and landscaped with native vegetation. This concept could capture runoff from approximately 11.5 acres, of which 7.3 would be 1/8 acre residential lots. This option would also provide for habitat enhancement in addition to the pollutant removal benefits. Figure 3 shows an example of a site that was converted from a phragmites marsh into a constructed wetland.

Figure 3: Example of a constructed wetland before and after.

The concept would require a permanent easement or purchase of the land from a private land owner. If this concept was implemented, then concept 2 and part of concept 3 would not be necessary. The cost to construct a constructed wetland would be approximately $180,000.

Concept 7 – Construct a small shallow wetland at the culvert underneath Bellevue Road. The constructed wetland would need an easement or property purchase from a private landowner, who is not part of the Bellevue coastal community. The facility would capture runoff from the remainder of the land, which the current use is cultivation. The cost of the wetland would be dependent on the size of the parcel of land acquired and is directly linked to the potential pollutant removal benefits.

BMP – Rain Gardens (Concept 8)

Description

Rain Gardens are bio-retention basins primarily utilized for treating single lot runoff. They are planting areas installed in shallow basins in which the stormwater runoff is treated by filtering through the bed components, biological and biochemical reactions within the soil matrix and around the root zones of the plants and infiltration into the underlying soil strata. The majority of soils in the Bellevue coastal community are classified with a hydraulic conductivity of B and C, therefore each individual lot would require a separate infiltration test to determine whether or not an underdrain would be required.

Concept

Concept 8 - The concept is to promote individual property owners on the larger lots situated to the north/northeast of Bellevue community to install rain gardens or infiltration practices to provide water quality for their rooftop and adjacent impervious surfaces. This BMP would not be ideal for individual property owners on smaller lots located in the more urbanized part of the community. The design of the rain gardens will be lot dependant with each rain garden sized to 2% of the contributing drainage area, with an average contributing drainage area of 5,000 square feet. The cost for each individual project would be approximately $180 per square yard for a rain garden, or about $3,000 per project. The pollutant removal benefit is based on an uptake of 50%, or 10 individual private lot owners who own the larger lots installing rain gardens.

BMP - Living Shorelines (Concepts 9 through 12)

Description

Living shorelines are a combination of structures, practices and vegetative measures, including beach nourishment, wetlands and dune plantings that are positioned along a shore to deflect and dissipate the force of waves in order to protect the shoreline. Living shorelines are typically recommended for coastal environments experiencing low to medium energy. Living shorelines can help shorelines withstand wave impact, retain the protected earth on the bank, trap sand, and, in general, may very effectively prevent erosion at the site of protection. Figure 4 and 5 show some examples of a living shoreline.

Figure 4: Example of a completed living shoreline project.

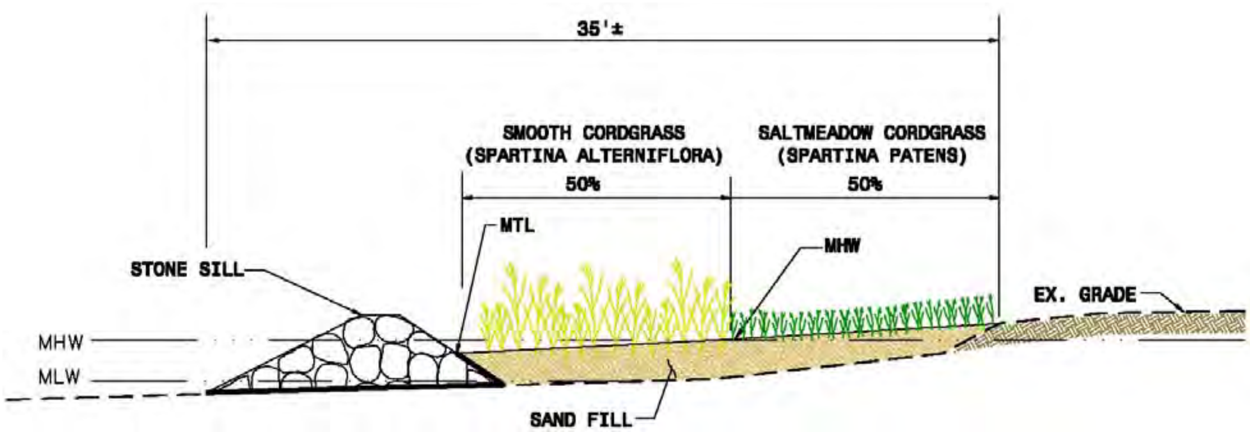


Figure 5: Cross-section of a typical living shoreline project.

<u>Concept 9</u> – Construct a 350 foot long living shoreline project on an individual lot owner's parcel for a currently unstable shoreline. The project is located on the southeast side of the peninsula below the Oxford-Bellevue Ferry. The project will protect the shoreline from further erosion and provide aquatic habitat for native wetland vegetation and sea life. A portion of the project is not within the coastal community of Bellevue, but the degree of shoreline erosion suggests that this would be a worthwhile project. The cost to construct a living shoreline would be approximately $250 per foot or $87,500.

Concept 10 – Construct a 300 foot long living shoreline project on an individual lot owner's parcel for a currently unstable shoreline. The project is located on the southeast side of the peninsula, north of the inlet where the Oxford-Bellevue Ferry is located. The project will protect the shoreline from further erosion and provide aquatic habitat for native wetland vegetation and sea life. The cost to construct a living shoreline would be approximately $250 per foot or $75,000.

Concept 11 – Repair and improve 50 foot of existing living shoreline on an individual lot owner's parcel. The project is located on the northwest side of the peninsula. The project will protect the shoreline from further erosion and improve the aquatic habitat for native wetland vegetation and sea life. The cost to construct a living shoreline would be approximately $200 per foot or $10,000.

Concept 12 – Construct a 250 foot long living shoreline project on an individual lot owner's parcel for a currently unstable shoreline. The project is located on the southwest side of the peninsula, north the point where Tar Creek empties into the Chesapeake Bay. The project will protect the shoreline from further erosion and provide aquatic habitat for native wetland vegetation and sea life. The cost to construct a living shoreline would be approximately $250 per foot or $62,500.

BMP – Shoreline Structural Stabilization (Concept 13)

Description

This type of shoreline protection is structural stabilization that are rigid, barrier-type structures that result in a "hardening" of the shoreline to protect against the action of waves, currents, tides, wind driven water, runoff from storms, and/or groundwater seepage that erodes shorelines. Such structural measures include, but are not limited to: riprap, revetments, bulkheads, groins (built perpendicular to the shoreline to trap sand, also known as a jetty), and seawalls.

Concept

Concept 13 – This project would consist of replacing 550 feet of a previously failed bulkhead on a commercially utilized shoreline access spanning several property owners. The new bulkhead would reduce to near zero the current levels of shoreline erosion. The installation cost of the bulkhead would be approximately $500 per foot, or $275,000 for the project.

ESTIMATE OF REDUCTION IN ANNUAL POLLUTANT LOADS

Current stormwater best management practices pollutant removal efficiencies as detailed in Section 6 of the Chesapeake Bay Watershed Model Phase 5.3 were utilized to evaluate the potential pollutant load reductions that could be achieved with each of the proposed projects. Hydrodynamic separator pollutant removal efficiency effectiveness estimates is from field gathered testing data from Efficiency Assessment of BaySeparator and BayFilter Systems, Mid-Atlantic Stormwater Research Center September 2008. Concept 11, repairing the existing living shoreline is proposed to provide half the pollutant removal efficiency of installing a new living shoreline was quantified so that the existing living shoreline is providing some form of pollutant removal. Table 5 lists the Efficiency Effectiveness Estimate used for each of the existing and proposed BMPs.

Table 5 – Chesapeake Bay Watershed Model Phase 5.3: Pollutant Removal Efficiency Effectiveness Estimate

Urban Best Management Practice	Target Pollutant Removal Efficiencies		
	TP	TN	TSS
	%	%	%
Constructed Wetland	30	50	80
Infiltration Practices	80	85	90
Hydrodynamic Separator	30	30	50
Gravel Road Stormwater Management Control	25	40	40
Bioretention Filtering Practices	40	60	80
Living Shoreline	90	90	90
Living Shoreline - Repair	45	45	45
Structural Stabilization	75	75	75

Each stormwater and erosion control BMP retrofits was analyzed for the potential amount of pollutant removal based on the amount of impervious area treated or length of shoreline protected. For stormwater BMPs that are sized based on the drainage area, they are assumed to provide BMPs were assumed to provide 100% of the of the water quality volume. Table 6 lists the target pollutant removal for each of the proposed stormwater and shoreline erosion control BMP projects.

Table 6 – Target Pollutant Removal for Stormwater and Shoreline Erosion Control BMPs

Concept	Concept Description	Area Treated	Target Pollutant Removal		
			TP	TN	TSS
		Acres / foot	lbs/yr	lbs/yr	lbs/yr
1	Paving of Interior Road	2.9 acres	1.7	20.5	559.9
2	Bio-Swale Orchard Terrace	0.16 acres	0.1	1.7	61.8
3	Bio-Swale Poplar Street	0.52 acres	0.5	5.5	200.8
4	Bio-Swale Bellevue Park	0.25 acres	0.2	2.7	96.5
5	Hydrodynamic Structure	0.35 acres	0.2	1.9	84.5
6	Constructed Wetland – Bellevue	2.4 acres	2.0	25.6	1117.1
7	Constructed Wetland – Offsite	-	-	-	-

Table 6 – Target Pollutant Removal for Stormwater and Shoreline Erosion Control BMPs					
Concept	Concept Description	Area Treated	Target Pollutant Removal		
			TP	TN	TSS
		Acres / foot	lbs/yr	lbs/yr	lbs/yr
8	Rain Gardens – 10 lots	1.15 acres	2.1	17.3	499.5
9	Living Shoreline – Offsite	350 FT	368.2	736.3	736,344
10	Living Shoreline – SE	300 FT	315.6	631.2	631,152
11	Living Shoreline Repair – NW	50 FT	26.3	52.6	52,596
12	Living Shoreline – SW	250 FT	263.0	526.0	525,960
13	Structural Stabilization	550 FT	482.1	964.3	964,260

Each stormwater and erosion control BMP was then analyzed based on a cost per pound of pollutant removal. Total Phosphorus (TP) was used as the base pollutant to conduct the cost analysis. Table 7 ranks the proposed concepts based on capital return.

Table 7 – Cost per lb/yr of TP Removal for the Proposed Concepts					
Concept	Concept Description	Projected Project Cost	Total Phosphorus Removal	Cost per lb/yr of TP Removal	Project Rank
		dollars	lbs/yr	$/lb/yr	#
1	Paving of Interior Road	94,000	1.7	56,311	8
2	Bio-Swale Orchard Terrace	3,600	0.1	24,430	7
3	Bio-Swale Poplar Street	72,000	0.5	150,339	10
4	Bio-Swale Bellevue Park	36,000	0.2	156,352	11
5	Hydrodynamic Structure	50,000	0.2	206,815	12
6	Constructed Wetland – Bellevue	180,000	2.0	90,070	9
7	Constructed Wetland – Offsite	-	-	-	NR
8	Rain Gardens – 10 lots	20,000	2.1	9,442	6
9	Living Shoreline – Offsite	87,500	368.2	238	1
10	Living Shoreline – SE	75,000	315.6	238	1
11	Living Shoreline – NW	10,000	26.3	380	4
12	Living Shoreline – SW	62,500	263.0	238	1
13	Structural Stabilization	275,000	482.1	570	5

DISCUSSION

Based on the ranking of the stormwater management and shoreline erosion control concepts from the cost per pound of pollutant removal analysis, the most economical projects with the highest rate of return on capital investment are the protection of the shoreline. A hardened shoreline does protect property, and sometimes it is the best solution in high-energy areas, however it does not provide a viable or natural habitat for the Bay's living resources. In areas experiencing erosion of low level of erosion (2 feet per year of less), nonstructural or bioengineering shore erosion controls, that create protective vegetative buffers, should be considered as a more environmentally sensitive way to protect shorelines, reduce erosion and help provide good habitat. They also provide a more economical benefit to standard shoreline hard armoring erosion control techniques. In fact, The U.S. Army Corps of Engineers estimates that for every dollar spent to control shoreline erosion, as much as $1.75 is returned to the economy in the form of improvements to resources, including submerged aquatic vegetation, fish, benthic organisms, shellfish, and wetland habitat.

Other stormwater management concepts to provide economical return on capital investment and promotion of general improvement of the coastal community would be resurfacing of the Bellevue coastal community interior roads with some edge of road grading to promote positive drainage along with the installation of roadside bio-swales. Implementation of the rain gardens would provide a beneficial return where the cost of the projects could be mitigated with capital input from the property owners on a dollar for dollar basis. While the hydrodynamic separator and Bellevue-Oxford Parking bio-swale rank low on the cost per pound of removal ranking, not quantified is the proposed benefits of removal of other pollutants, such as oil or gas, that accumulate on the pavement from the high access of vehicular traffic to the ferry and from the used oil/grease disposal site located in the parking lot. These concepts will provide more actual benefits then those identified in this concept report and are recommended for further exploration.

REFERENCES

The Chesapeake Bay Program's Sediment Workgroup. Sediment in the Chesapeake Bay and Management Issues: Tidal Erosion Processes. May 2005.

The Chesapeake Bay Program's Best Management Practices for Sediment Control and Water Clarity Enhancement CBP/TRS-282-06. October 2006.

The Chesapeake Bay Program's Chesapeake Bay Program Nutrient Trading Fundamental Principles and Guidelines. March 2001.

U.S. EPA. Chesapeake Bay Phase 5 Community Watershed Model In preparation EPA XXX-X-XX-010 Chesapeake Bay Program Office, Annapolis, Maryland. December 2010.

Klimkos M and Scheetz B. Dirt and Gravel Road Erosion and Sediment Control Definition and Nutrient and Sediment Reduction Effectiveness Estimates. 2008.

The Maryland Department of the Environment, 2000 Stormwater Design Manual, Current version.

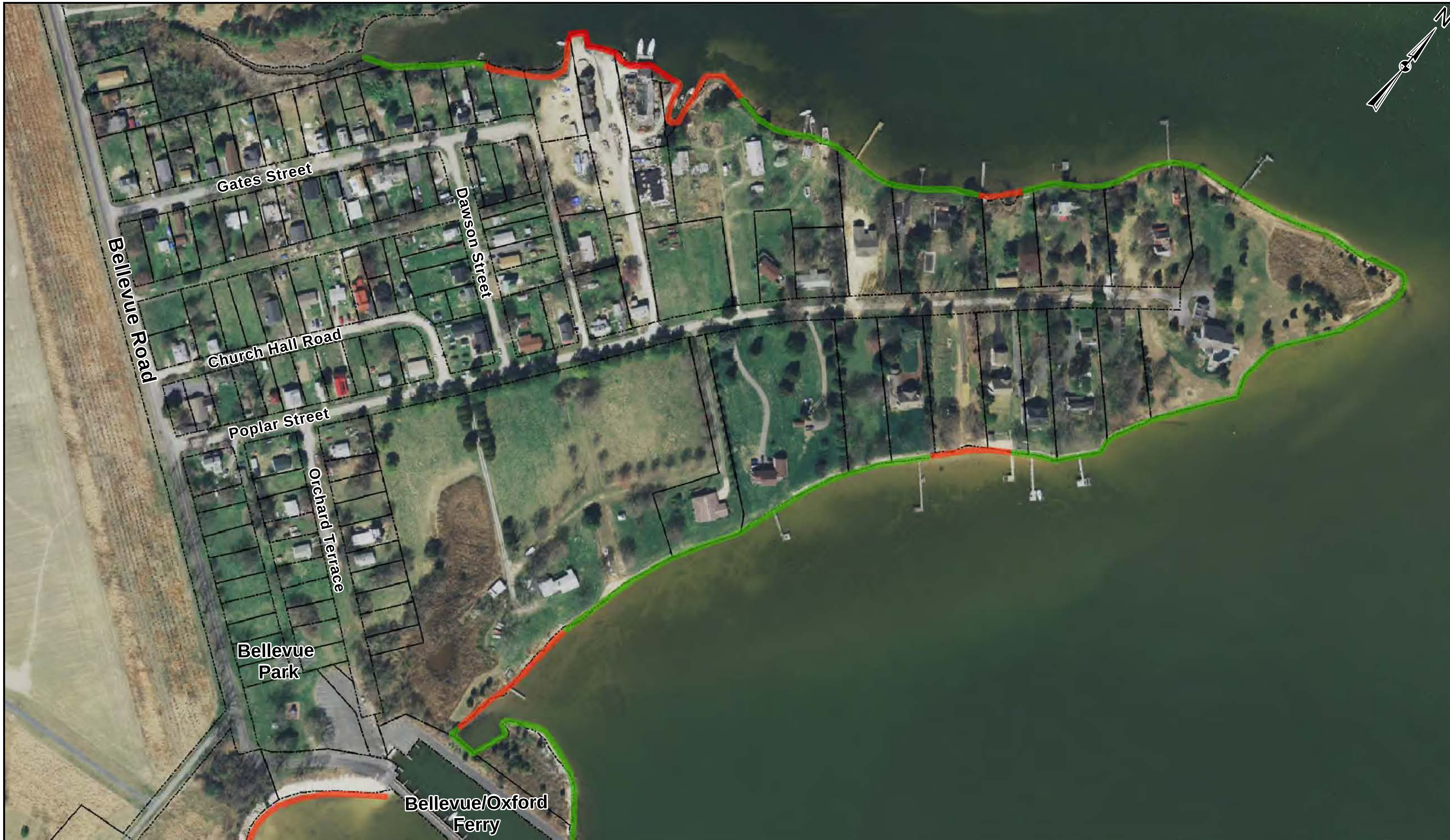
The State of Maryland's Shoreline Erosion Task Force Final Report. January 2000.

New York State Stormwater Management Design Manual Appendix A - The Simple Method to Calculate Urban Stormwater Loads. Current version.

Wiedeman, A. Nutrient Trading for the Chesapeake Bay, April, 2001

Schueler, T. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMP. 1987.

Appendix 1: Shoreline Assessment



NOTES:

1. Aerial Photography from Talbot County GIS.

Stable - Total Length 4,285 LF

Unstable - Total Length 1,875 LF

200 100 0 200 400 Feet

1" = 200'

BayLand Consultants & Designers, Inc.

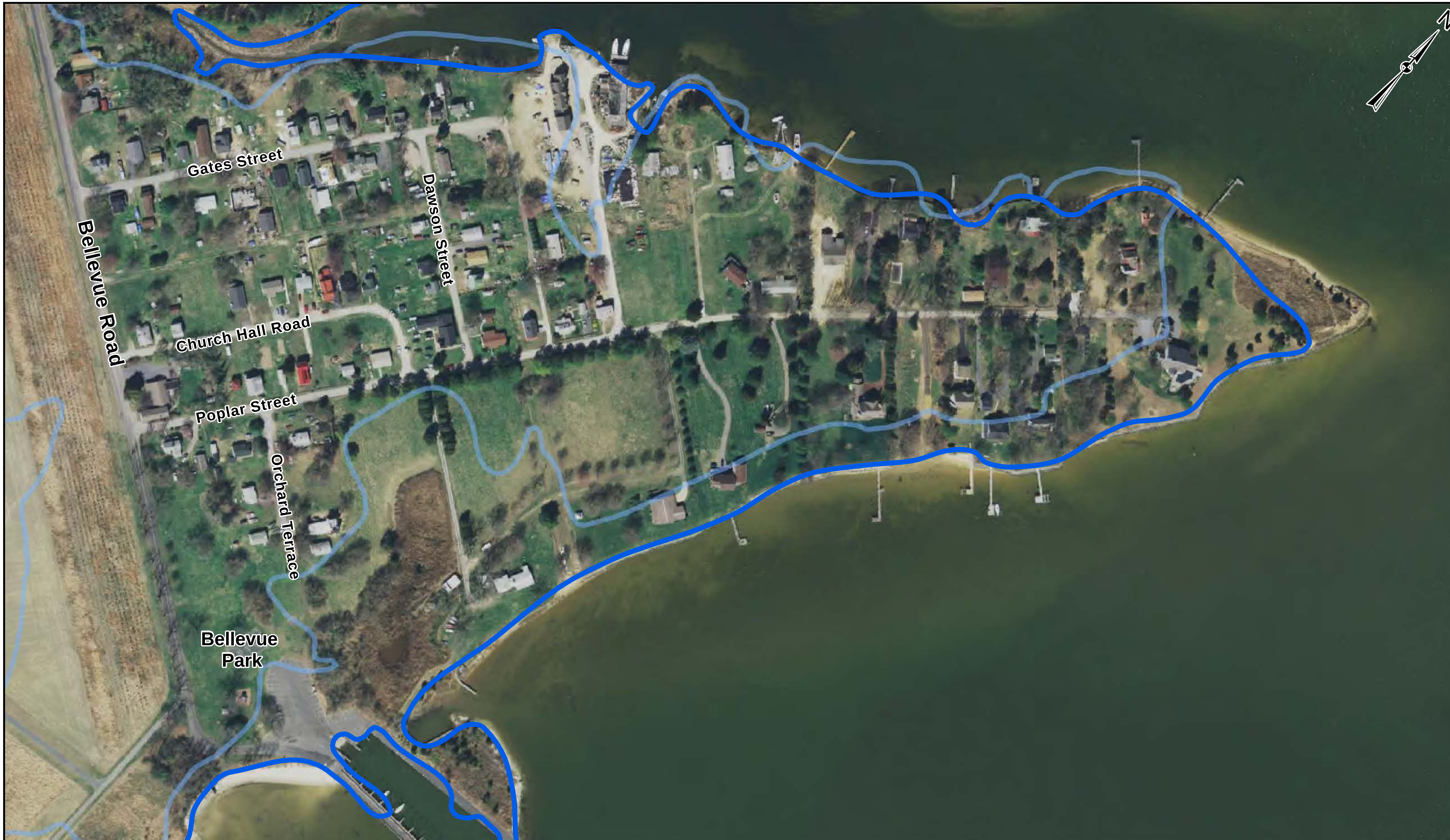
"Integrating Engineering and Environment"

1321 Mercedes Drive, Suite A
Hanover, Maryland 21076
Phone: (410) 694-9401
Fax: (410) 694-9405
bayland@baylandinc.com

Village of Bellevue Shoreline Assessment

P:\18_12501_Talbot Communities-Bellevue Coastal\GIS\ShorelineAssessment.mxd

Appendix 2: Shoreline Vulnerability



NOTES:

1. Aerial Photography from Talbot County GIS.
2. Floodplain from Maryland DNR Geospatial Data Download.
2. Shoreline Inundation from Maryland DNR Geospatial Data Download.

100 Year Floodplain
2 ft Shoreline Inundation

200 100 0 200 400 Feet

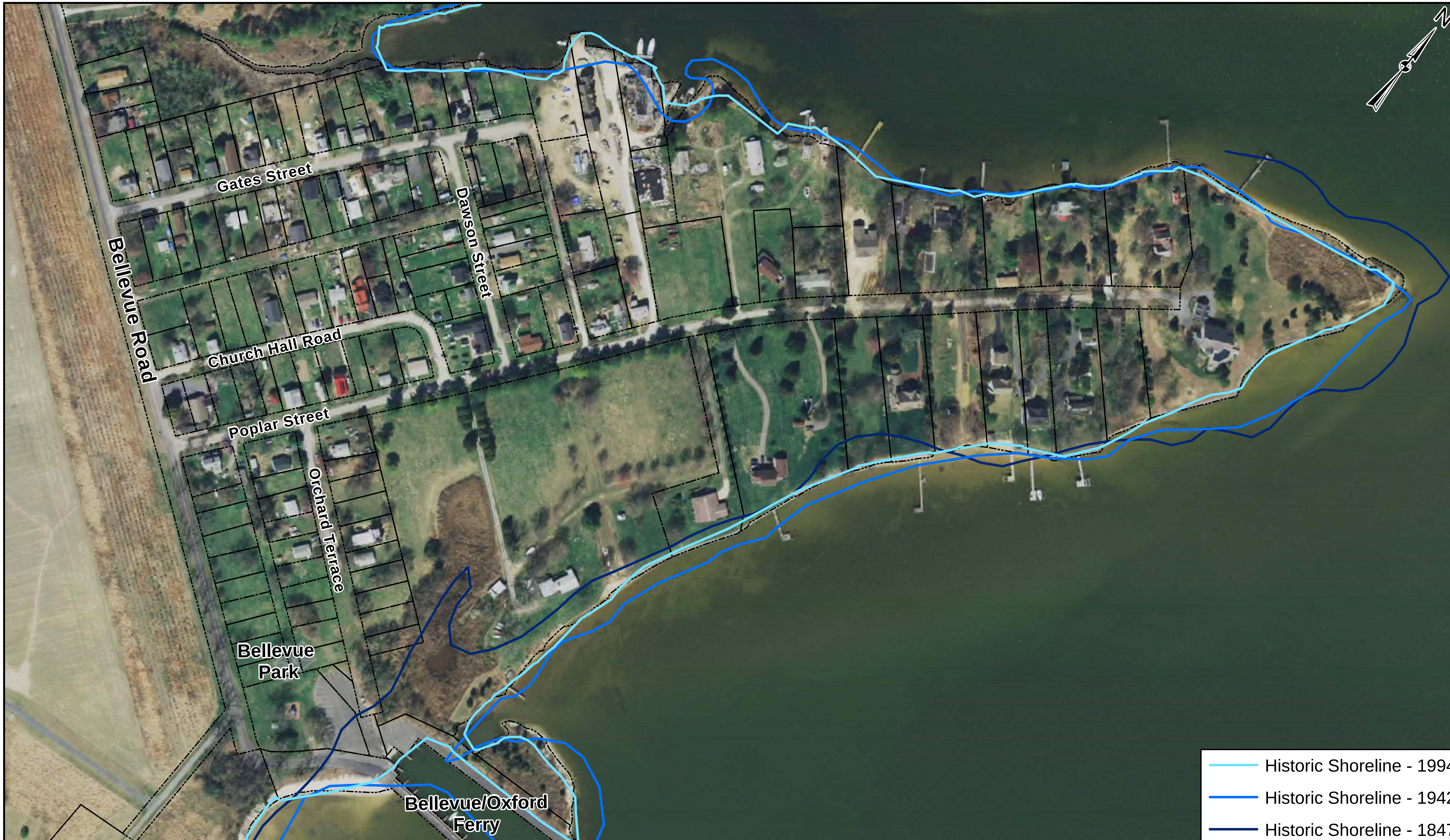
1" = 200'

BayLand Consultants & Designers, Inc.
"Integrating Engineering and Environment"
1321 Mercedes Drive, Suite A Phone: (410) 694-9401
Hanover, Maryland 21076 Fax: (410) 694-9405
bayland@baylandinc.com

Village of Bellevue Shoreline Vulnerability

P:\18_12501_Talbot Communities-Bellevue Coastal\GIS\ShorelineInundation2ft.mxd

Appendix 3: Shoreline Change



NOTES:

1. Aerial Photography from Talbot County GIS.
2. Historic Shoreline data from MD DNR Geospatial Data Download.

200 100 0 200 400 Feet

1" = 200'

BayLand Consultants & Designers, Inc.
"Integrating Engineering and Environment"
1321 Mercedes Drive, Suite A
Hanover, Maryland 21076
Phone: (410) 694-9401
Fax: (410) 694-9405
bayland@baylandinc.com

Village of Bellevue Historic Shoreline

P:\18_12501_Talbot Communities-Bellevue Coastal\GIS\ChangeinShoreline.mxd

Appendix 4: SWM and Shoreline Erosion Control Concepts

100 50 0 100
Feet
1" = 100'

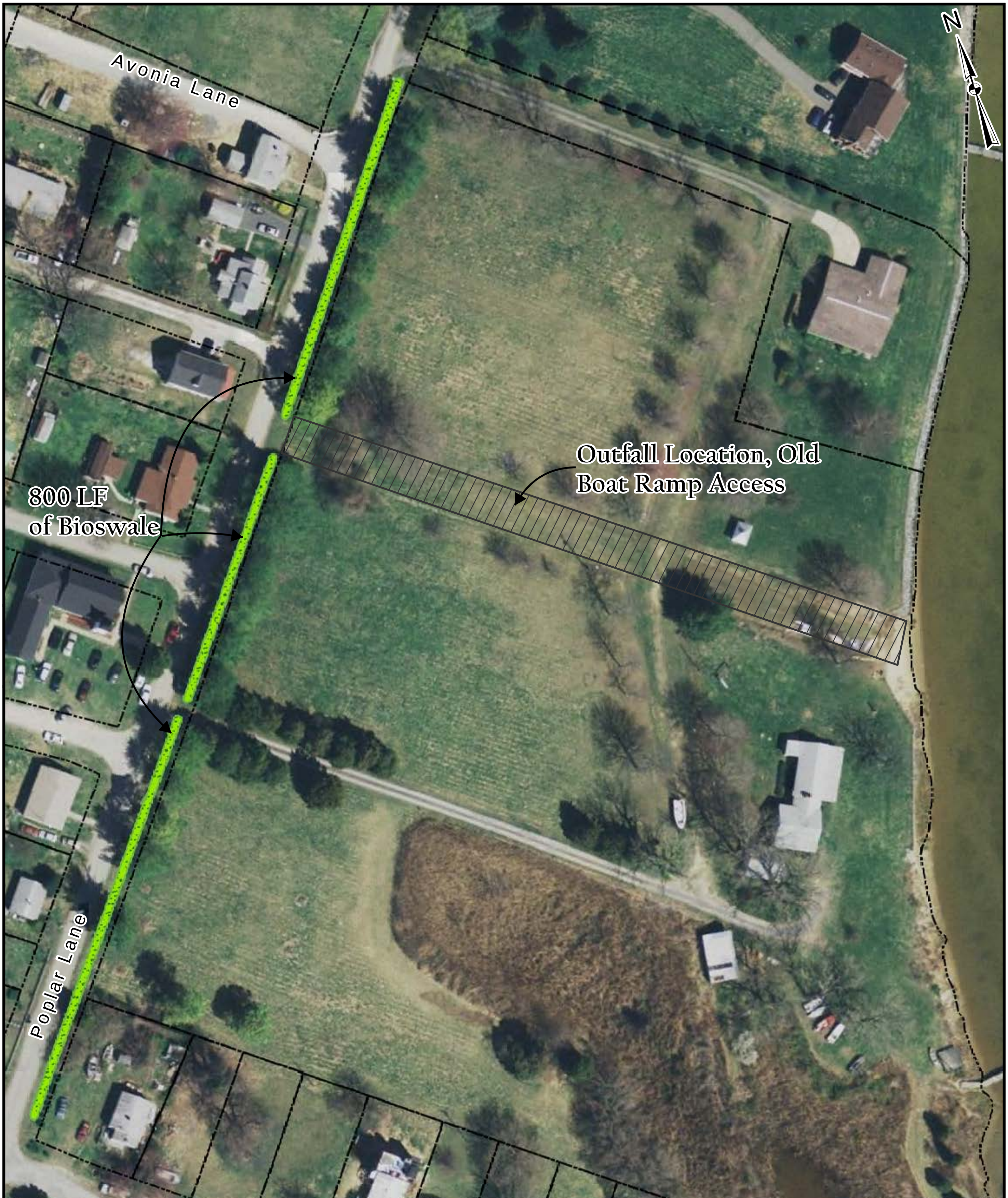
NOTES:

1. Aerial Photography from Talbot County GIS.

BayLand Consultants & Designers, Inc.
"Integrating Engineering and Environment"
1321 Mercedes Drive, Suite A
Hanover, Maryland 21076
Phone: (410) 694-9401
Fax: (410) 694-9405
bayland@baylandinc.com

Concept 2

P:\8_12501_Talbot Communities-Bellevue Coastal\GIS\Concept_2.mxd



100 50 0 100
Feet
1'' = 100'

NOTES:

1. Aerial Photography from Talbot County GIS.

BayLand Consultants & Designers, Inc.
"Integrating Engineering and Environment"
1321 Mercedes Drive, Suite A
Hanover, Maryland 21076
Phone: (410) 694-9401
Fax: (410) 694-9405
bayland@baylandinc.com

Concept 3

P:\18_12501_Talbot Communities-Bellevue Coastal\GIS\Concept_3.mxd

50 25 0 50
Feet
1" = 50'

NOTES:

1. Aerial Photography from Talbot County GIS.

BayLand Consultants & Designers, Inc.
"Integrating Engineering and Environment"
1321 Mercedes Drive, Suite A
Hanover, Maryland 21076
Phone: (410) 694-9401
Fax: (410) 694-9405
bayland@baylandinc.com

Concept 4 & 5

P:\8_12501_Talbot Communities-Bellevue Coastal\GIS\Concept_4_5.mxd

100 50 0 100
Feet
1'' = 100'

NOTES:

1. Aerial Photography from Talbot County GIS.

BayLand Consultants & Designers, Inc.
"Integrating Engineering and Environment"
1321 Mercedes Drive, Suite A
Hanover, Maryland 21076
Phone: (410) 694-9401
Fax: (410) 694-9405
bayland@baylandinc.com

Concept 6

P:\8_12501_Talbot Communities-Bellevue Coastal\GIS\Concept_4.mxd

50 25 0 50
Feet
1'' = 50'

NOTES:

1. Aerial Photography from Talbot County GIS.

BayLand
Consultants & Designers, Inc.
"Integrating Engineering and Environment"
1321 Mercedes Drive, Suite A
Hanover, Maryland 21076
Phone: (410) 694-9401
Fax: (410) 694-9405
bayland@baylandinc.com

Concept 7

P:\8_12501_Talbot Communities-Bellevue Coastal\GIS\Concept_7.mxd

50 25 0 50
Feet
1" = 50'

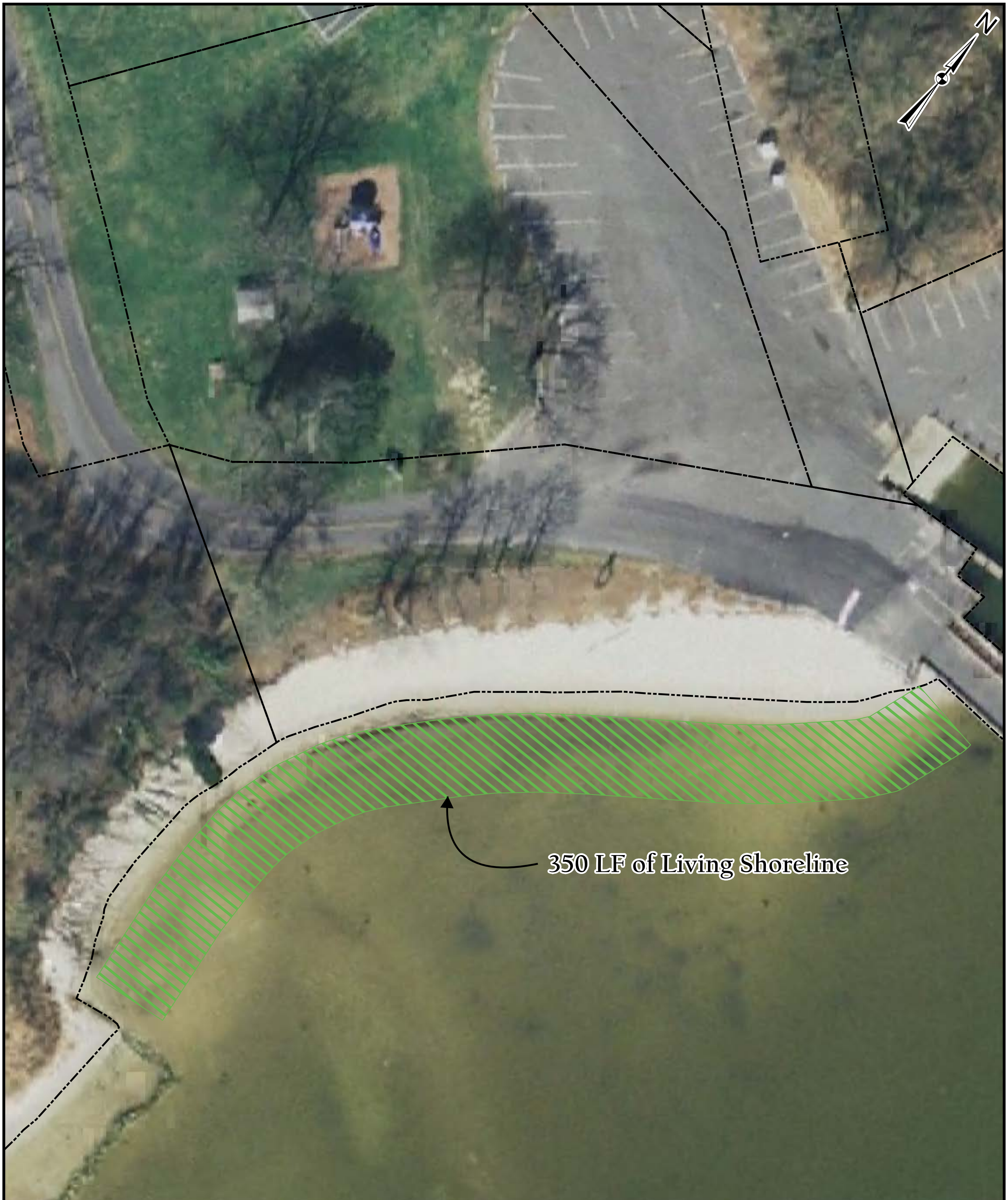
NOTES:

1. Aerial Photography from Talbot County GIS.

BayLand
Consultants & Designers, Inc.
"Integrating Engineering and Environment"
1321 Mercedes Drive, Suite A
Hanover, Maryland 21076
Phone: (410) 694-9401
Fax: (410) 694-9405
bayland@baylandinc.com

Concept 8

P:\18_12501_Talbot Communities-Bellevue Coastal\GIS\Concept_6.mxd



50 25 0 50

Feet

1" = 50'

NOTES:

1. Aerial Photography from Talbot County GIS.

BayLand Consultants & Designers, Inc.
"Integrating Engineering and Environment"
1321 Mercedes Drive, Suite A
Hanover, Maryland 21076
Phone: (410) 694-9401
Fax: (410) 694-9405
bayland@baylandinc.com

Concept 9

P:\18_12501_Talbot Communities-Bellevue Coastal\GIS\Concept_9.mxd

1" = 50'

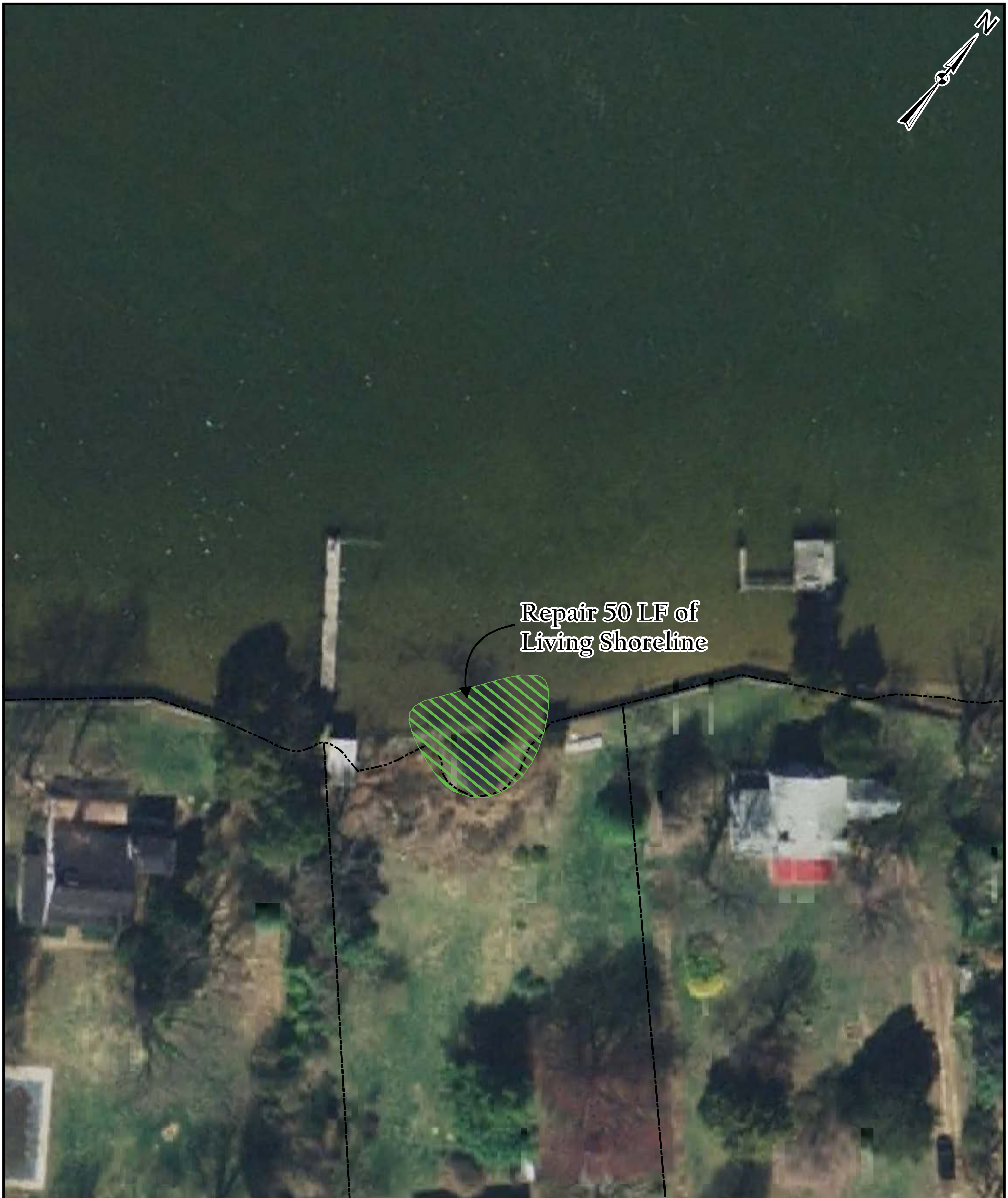
NOTES:

1. Aerial Photography from Talbot County GIS.

BayLand Consultants & Designers, Inc.
"Integrating Engineering and Environment"
1321 Mercedes Drive, Suite A Hanover, Maryland 21076
Phone: (410) 694-9401
Fax: (410) 694-9405
bayland@baylandinc.com

Concept 10

P:\8_12501_Talbot Communities-Bellevue Coastal\GIS\Concept_10.mxd



50 25 0 50 Feet

1" = 50'

NOTES:

1. Aerial Photography from Talbot County GIS.

BayLand Consultants & Designers, Inc.
"Integrating Engineering and Environment"
1321 Mercedes Drive, Suite A
Hanover, Maryland 21076
Phone: (410) 694-9401
Fax: (410) 694-9405
bayland@baylandinc.com

Concept 11

P:\8_12501_Talbot Communities-Bellevue Coastal\GIS\Concept_11.mxd

50 25 0 50 Feet

1" = 50'

NOTES:

1. Aerial Photography from Talbot County GIS.

BayLand Consultants & Designers, Inc.

"Integrating Engineering and Environment"

1321 Mercedes Drive, Suite A
Hanover, Maryland 21076

Phone: (410) 694-9401
Fax: (410) 694-9405

bayland@baylandinc.com

Concept 12

P:\8_12501_Talbot Communities-Bellevue Coastal\GIS\Concept_12.mxd

100 50 0 100
Feet
1'' = 100'

NOTES:

1. Aerial Photography from Talbot County GIS.

BayLand
Consultants & Designers, Inc.
"Integrating Engineering and Environment"
1321 Mercedes Drive, Suite A
Hanover, Maryland 21076
Phone: (410) 694-9401
Fax: (410) 694-9405
bayland@baylandinc.com

Concept 13

P:\8_12501_Talbot Communities-Bellevue Coastal\GIS\Concept_13.mxd