FINAL FEASIBILITY REPORT AND INTEGRATED ENVIRONMENTAL ASSESSMENT

APPENDICES
B - G

LYNNHAVEN RIVER BASIN ECOSYSTEM RESTORATION

VIRGINIA BEACH, VIRGINIA

U.S. Army Corps of Engineers
Norfolk District
803 Front Street
Norfolk, Virginia 23510-1096

July 2013

LYNNHAVEN RIVER BASIN ENVIRONMENTAL RESTORATION
VIRGINIA BEACH, VIRGINIA
FINAL FEASABILITY REPORT APPENDICES

TABLE OF CONTENTS

APPENDIX B

ECONOMIC ANALYSIS

APPENDIX B

ECONOMIC ANALYSIS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES
(Cont'd)

LIST OF TABLES
(Cont'd)

LIST OF FIGURES

ECONOMICS APPENDIX

In order to make more informed decisions with regard to the development and eventual selection of the NER Plan, a cost effectiveness analysis and incremental cost analysis was conducted on the 1631 alternatives, in addition to the no action plan, that were carried forward for evaluation and comparison (see Attachment A to this appendix). As required by USACE Planning Guidance, these analyses were conducted utilizing annualized costs, annualized benefits, and the IWR-Planning Suite Software (version 1.0.11.0). Cost effectiveness analysis identifies the plan, or plans, that produce(s) the greatest level of environmental output for the least cost. The environmental outputs, however measured, in turn reflect the environmental benefits, such as biological diversity, fish and wildlife habitat, and nutrient cycling, provided by the plan or plans. Incremental cost analysis examines the changes in costs and the changes in environmental outputs for each additional increment of environmental output. The Best Buy Plans represent those plans that produce the greatest increases in environmental outputs for the least increases in cost.

DESCRIPTION OF COSTS

The costs for constructing the different alternatives, as discussed in the main report, were developed using the Micro-Computer Aided Cost Estimating System. These amounts represent total or fixed fee cost estimates, as detailed in Appendix A, and are a conceptual representation of the approximate order-of-magnitude costs associated with the design concepts described. These estimates were based upon representative unit costs for similar construction projects in the area. All costs used in this comparison between alternatives are in October 2010 (Fiscal Year 2011) price levels, with a 4-1/8-percent discount rate used in present value and annualized over a 50-year period of analysis with a base year of 2014. However, the recommended plan has been updated to October 2012 levels with a discount rate 3.75, as shown in the main report.

The costs for each alternative plan include the following: preconstruction, engineering and design (PED); real estate; construction and plantings; construction management; adaptive management; contingency; and annual monitoring.

PED would include such costs as field surveys and investigations; design; preparation of specifications and construction drawings; and the development, approval, and execution of the project partnership agreement. The PED costs for the wetland sites were estimated to be 12 percent of construction costs, while the PED costs for Fish House Island were 8 percent, and those for reef habitat, SAV, and scallops were estimated at 6 percent of construction costs.

Real estate costs cover lands, easements, and rights-of-way, (LER's). The real estate costs for the Lynnhaven River Basin Restoration study include private lands for the wetland sites oyster leased area within the reef habitat, SAV, and scallop sites. Real estate assumptions and estimates have been updated since this analysis and are defined in more detail in the Real Estate Appendix.

Construction management costs cover the contractor's management, supervision, and overhead. These costs were 14 percent of the total construction costs for wetland sites, 7 percent for Fish House Island, and 4 percent for reef habitat, SAV, and scallop sites.

Adaptive management (AM) costs are included in the construction costs for each of the alternatives. The AM costs for each of the measures are estimated at 10 percent of total project costs based on the following. AM of hard reefs could range from 2 percent of construction costs, if removing collected sediments from the structures is required, to 10 percent of construction costs. For SAV, adaptive management could range from 2 percent of initial seeding costs, for signage to prevent wake zones, to 5 percent, in order to seed adjacent areas, and up to 10 percent, for reseeding of areas that did not establish as expected. While AM for reintroduction of scallops could range from 5 percent of initial seeding costs, if fencing is used to prevent predation or if spat collection is required, to 10 percent, in order to restock scallops in conjunction with the predation prevention measures. The AM plan for the wetland sites includes, if conditions require, the annual application of herbicides to control the growth and spread of *P. australis* and the annual replacement of native plantings for the first ten years of the project. Activities necessary to maintain the integrity of the habitat features constructed at the wetland sites, which include physical alterations of the marsh, will be planned as needed every five years.

A contingency cost was also added to PED, construction, and construction management costs to reflect the effects of unforeseen conditions on estimates of these costs. These costs do not allow for inflation or for omissions of work items that are known to be required; rather, they take into account any unforeseen construction problems. A 15 percent contingency was added to wetland, island, and reef habitat sites. A 25 percent contingency was added to SAV sites. And, a 30 percent contingency was added to scallop sites. The higher contingencies used for the SAV and scallop sites are due to the increased risk of success and need for possible reseeding or stocking of these habitats.

After the total costs were determined, the cost of interest during project construction was calculated based on various periods of construction for each of the project measures and a 4-1/8-percent discount rate. The total costs plus the costs of the interest during construction yield the investment cost, as seen in the following table.

Table B-1. INVESTMENT COSTS OF MEASURES

Measure/ Site	First Cost ($)	Interest during construction ($)	Investment Cost
Wetlands Creation:			
Narrows to Rainy Gut	326,000	6,000	332,000
Lake Windsor	436,000	4,000	440,000
Fish House Island Large	4,305,000	81,000	4,386,000
Fish House Island Medium	3,315,000	62,000	3,377,000
Fish House Island Small	2,067,000	39,000	2,106,000
Wetlands with Phragmites Eradication:			
Princess Anne High School	908,000	8,000	916,000
Mill Dam Creek	38,000	500	39,000
Great Neck North	349,000	3,000	352,000
Great Neck South	333,000	3,000	336,000
Reef Habitat:			
Lynnhaven Bay and Broad Bay (normal and soft foundation)	21,725,000	134,000	21,859,000
Lynnhaven Bay and Broad Bay (normal foundation)	11,990,000	85,000	12,075,000
Broad Bay (normal and soft)	14,731,000	75,000	14,806,000
Lynnhaven Bay	6,994,000	59,000	7,053,000
Broad Bay (normal foundation)	4,996,000	25,000	5,022,000
Submerged Aquatic Vegetation:			
Suitable Main Stem/Suitable Broad Bay	3,016,000	26,000	3,041,000
Suitable Main Stem/Key Broad Bay	2,369,000	12,000	2,381,000
Key Main Stem/Suitable Broad Bay	1,767,000	9,000	1,776,000
Suitable Broad Bay	1,578,000	3,000	1,581,000
Key Main Stem/Key Broad Bay	883,000	2,000	885,000
Key Broad Bay	664,000	0	664,000
Scallops:			
Suitable Main Stem/Suitable Broad Bay	1,439,000	12,000	1,451,000
Suitable Main Stem/Key Broad Bay	1,165,000	6,000	1,171,000
Key Main Stem/Suitable Broad Bay	887,000	4,000	891,000
Suitable Broad Bay	793,000	1,000	794,000
Key Main Stem/Key Broad Bay	442,000	1,000	443,000
Key Broad Bay	327,000	0	327,000
No action plan	0	0	N/A

Monitoring Costs

Annual monitoring will be conducted for each of the measures to ensure that project objectives are being fulfilled. The cost associated with monitoring reef habitat is estimated to be $40,000 annually for the first 10 years of the project, and $10,000 per year for the remainder of the 50-year period of analysis. For SAV, the cost of monitoring is also estimated to be $40,000 per year for the first five years of the project. After this period, no money has been allocated for SAV monitoring because it is anticipated that the project areas will be incorporated into the annual SAV monitoring program conducted by VIMS. Monitoring cost included for scallop reintroduction is $50,000 annually for the first five years of the project and $15,000 per year for the remainder of the 50-year period of analysis. Annual costs of $7,600 over the first 10 years of the project, and $3,800 thereafter, are estimated to be the monitoring cost associated with the wetland sites. These estimated monitoring costs are for the combined maximum acreage of each measure at all sites. The estimated monitoring costs for individual sites in Table B-2 were pro-rated based on acreage.

Maintenance Costs

After the ten year adaptive management term is complete, it is anticipated the application of herbicides to control the growth and spread of *P. australis* will continue to be necessary every five years for the life of the project. The cost of each herbicide application is estimated to be $1,000 for each wetlands site. This cost is included in the average annual costs as subsequently discussed.

Average Annual Costs

Using the total investment costs and annual monitoring, the average annual equivalent costs were derived for each alternative plan, based on a 50-year period of analysis, a 4-1/8-percent discount rate, and October 2010 (FY 2011) price levels. The interest and amortization, average annual monitoring costs, and total average annual costs for the measures included in the alternatives carried forward for evaluation can be found in the following table.

Table B-2. AVERAGE ANNUAL COSTS OF MEASURES

Measure/ Site	Interest and amortization ($)	Average annual monitoring and maintenance ($)	Total average annual costs ($)
Wetlands Creation:			
Narrows to Rainy Gut	15,800	100	15,900
Lake Windsor	20,900	100	21,000
Fish House Island Large	208,500	600	209,100
Fish House Island Medium	160,600	400	161,000
Fish House Island Small	100,100	200	100,300
Wetlands Restoration/Diversitfication:			
Princess Anne High School	43,600	1,000	44,600
Mill Dam Creek	1,800	600	2,400
Great Neck North	16,700	3,200	19,900
Great Neck South	16,000	2,300	18,300
Reef Habitat:			
Lynnhaven Bay and Broad Bay (normal and soft foundation)	1,011,700	20,900	1,032,600
Lynnhaven Bay and Broad Bay (normal foundation)	564,800	13,900	578,700
Broad Bay (normal and soft)	676,300	13,700	690,000
Lynnhaven Bay	335,400	7,300	342,700
Broad Bay (normal foundation)	229,400	6,600	236,000
Submerged Aquatic Vegetation:			
Suitable Main Stem/Suitable Broad Bay	138,900	8,100	147,000
Suitable Main Stem/Key Broad Bay	108,700	5,900	114,600
Key Main Stem/Suitable Broad Bay	81,100	4,100	85,200
Suitable Broad Bay	72,200	3,600	75,800
Key Main Stem/Key Broad Bay	40,400	1,900	42,300
Key Broad Bay	30,300	1,400	31,700
Scallops:			
Suitable Main Stem/Suitable Broad Bay	63,700	20,500	84,200
Suitable Main Stem/Key Broad Bay	51,400	14,800	66,100
Key Main Stem/Suitable Broad Bay	39,100	10,400	49,500
Suitable Broad Bay	34,800	9,100	44,000
Key Main Stem/Key Broad Bay	19,400	4,700	24,200
Key Broad Bay	14,300	3,400	17,700
No action plan	0	0	N/A

DESCRIPTION OF ENVIRONMENTAL BENEFITS

Three environmental parameters were estimated for each of the measures related to SAV reseeding, reef habitat construction, bay scallops reintroduction, and the construction of tidal wetlands, as well as the corresponding without project conditions. These parameters were: secondary production, species diversity through a benthic index of biotic integrity (BIBI), and reduction of total suspended solids. Environmental benefits were estimated for measures related to the restoration of existing wetlands and the eradication of *Phragmites* using habitat diversity, which will described later in this section.

In order to assess whether greater importance should be given to any of these three parameters, a sensitivity analysis was completed. The sensitivity analysis demonstrated that if TSS is removed from consideration the conclusions of the original cost/benefit analysis are similar to when it is included. This is consistent with the fact that although water quality is important to habitat, it is not a direct measurement of habitat improvement. Therefore, only secondary production and species diversity were quantitatively used in plan selection for this project. The estimates for the parameters can be found in the following table. Details on how these numbers were calculated, can be found in Appendix C, Ecological Benefits

Table B-3. ANNUAL ESTIMATED BENEFITS PER ACRE FOR EACH PROJECT MEASURE

Measure	Secondary Production (kg/acre/yr)	BIBI (1-5)
Wetland creation	242	4
SAV	1,552	5
Scallops	229	3.5
Reef habitat high relief	4,457	5
Reef habitat low relief	3,601	5
Existing Condition/ Without Project	6.41	3

For each of the parameters, the estimates for the without project condition were subtracted from the output estimated for each of the measures to determine the net benefit associated with each measure. The estimates were then multiplied by the acreage for each specific site/scale for each measure to determine the total output for each specific site/scale of each measure. It is assumed that each of the estimated outputs is additive when specific measures are combined into the various alternatives, with no significant magnified effect from various measures being built together. Thus, the parameter output estimates for the appropriate measures were added together to determine the total benefits for each of the various alternatives. Secondary production benefits are calculated as average annual kg per acre, and BIBI benefits are calculated as an average annual index (1-5 scale per acre).

It was assumed each of the measures would take various amounts of time after construction to achieve the full level of estimated benefits. The time for each measure to attain its full environmental potential and appropriate growth rates, as determined by literature research, was applied to each of the measures over a 50-year period of analysis. A linear growth rate was assumed for the wetlands, reef habitat, SAV, and scallops with the same acreage as SAV. An exponential growth rate was assumed for the minimum amount of scallops when combined with the maximum amount of SAV for a given area. It is believed that the existing without project condition would stay relatively steady over the 50-year period of analysis, so the average annual outputs were assumed to be constant.

The average annual benefits for each alternative were derived by multiplying each of the parameter's annual output for each measure by the estimated percentage of output for each year of the 50-year period of analysis. The results for each year of the period of analysis were then averaged to determine the average annual benefit attributable to each scale of each measure for each of the parameters. The benefits for the appropriate measures were then summed to derive the average annual benefit for each of the parameters to determine the average annual benefits for each alternative. The average annual benefits for each measure can be seen in the following table.

Table B-4. AVERAGE ANNUAL BENEFITS

Measure/Site	Secondary Production (kg)	BIBI (Index Score)
WETLAND CREATION		
Narrows to Rainy Gut	29	0.18
Lake Windsor	39	0.24
Fish House Island : large	6456	8.50
Fish House Island: medium	4799	5.52
Fish House Island: small	3641	3.22
REEF HABITAT		
Lynnhaven Bay and Broad Bay (normal and soft foundation)	124185	60.75
Lynnhaven Bay and Broad Bay (normal foundation)	79068	40.15
Broad Bay (normal and soft foundation)	87681	40.04
Lynnhaven Bay	36504	20.71
Broad Bay (normal foundation)	42565	19.44
SUBMERGED AQUATIC VEG		
Suitable Areas Main Stem/Suitable Areas Broad Bay	141158	181.89
Suitable Areas Main Stem/ Key Areas Broad Bay	101984	131.42
Key Areas Main Stem/Suitable Areas Broad Bay	71677	92.36
Suitable Areas Broad Bay	62705	80.80
Key Areas Main Stem/ Key Areas Broad Bay	32502	41.88
Key Areas Broad Bay	23531	30.32
SCALLOPS		
Suitable Areas Main Stem/ Suitable Areas Broad Bay	20384	44.54
Key Areas Main Stem/ Key Areas Broad Bay	19579	42.78
Suitable Areas Main Stem/Key Areas Broad Bay	14727	32.18
Key Areas Main Stem/ Key Areas Broad Bay (with Suitable Areas SAV in Main Stem)	14279	31.20
Key Areas Main Stem/Suitable Areas Broad Bay	10351	22.61
Key Areas Main Stem/Key Areas Broad Bay (with Suitable Areas SAV in Broad Bay)	9993	21.93
Suitable Areas Broad Bay	9055	19.78
Key Areas Broad Bay (with Suitable Areas SAV)	8697	19
Key Areas Broad Bay/Key Areas Main Stem	4694	10.25
Key Areas Broad Bay	3398	7.42
No Action Plan	0	0

Wetland Restoration/Diversification Sites

The parameters used to assess benefits gained through the implementation of the other restoration measures are not able to adequately capture environmental improvements produced through the modification of the four wetland sites. Instead, the environmental benefits gained through the restoration/diversification of the wetland sites (Princess Anne, Great Neck North, Great Neck South, and Mill Dam Creek) were determined using a model developed by the USEPA. The model quantifies wildlife habitat value of "salt marshes based on marsh characteristics and the presence of habitat types that influence habitat used by terrestrial wildlife." The model and the application of the model to the Lynnhaven River Basin Restoration Project have been described in detail in Appendix C. The average annual benefits calculated using the EPA model can be found in the following table for each of the wetland restoration sites. The spreadsheets which include the individual component values for each site are included in the Environmental Appendix.

Table B-5. WETLANDS WITH PHRAGMITES ERADICATION SITES AVERAGE ANNUAL BENEFITS

Wetlands with *Phragmites* Eradication Site	Net Average Annual WetlandBenefits (With Project – Without Project Condition) (Assessment score on a 784-point scale)*
Princess Anne High School	85
Mill Dam Creek	66
Great Neck North	52
Great Neck South	75
No Action Plan	0

*Severely impaired marshes can receive scores below 100; while reference sites, which are high quality and relatively unimpaired, in the Lynnhaven River Basin received scores up to 552.

COST EFFECTIVE AND INCREMENTAL COST ANALYIS

The average annual costs and average annual benefits identified previously were used to conduct cost effectiveness and incremental cost analyses, using IWR Planning Suite version 1.0.11.0. For the CE/ICA, the following naming convention was used to indicate the measures included in each of the alternatives being analyzed.

Table B-6. FINAL ARRAY OF MEASURES COMBINED INTO ALTERNATIVES

Measure and Site/Scale	IWR Planning Suite Plan Code
Fish House Island (Wetland Creation) – 1 site, 3 scales	
Large Island	ISL1
Medium Island	ISL2
Small Island	ISL3
Reef Habitat – 2 sites, 5 scales	
Lynnhaven Bay and Broad Bay (normal and soft bottom)	RH1
Lynnhaven Bay and Broad Bay (normal bottom)	RH2
Broad Bay (normal and soft bottom)	RH3
Lynnhaven Bay	RH4
Broad Bay (normal bottom)	RH5
Submerged Aquatic Vegetation – 2 sites, 6 scales	
Suitable Main Stem/Suitable Broad Bay	SAV1,2,3
Key Main Stem/Suitable Broad Bay	SAV4,5,6
Suitable Main Stem/Key Broad Bay	SAV7,8,9
Suitable Broad Bay	SAV10,11,12
Key Main Stem/Key Broad Bay	SAV13,14
Key Broad Bay	SAV15,16
Scallops – 2 sites, 10 scales	
Suitable Main Stem/Suitable Broad Bay	SCL1
Key Main Stem (with Suitable SAV in Main Stem)/ Key Broad Bay (with Suitable SAV in Broad Bay)	SCL2
Key Main Stem/Suitable Broad Bay	SCL4
Key Main Stem/Key Broad Bay (with Suitable SAV in Broad Bay)	SCL5
Suitable Main Stem/Key Broad Bay	SCL7
Key Main Stem (with Suitable SAV)/Key Broad Bay	SCL8

Table B-6. FINAL ARRAY OF MEASURES COMBINED INTO ALTERNATIVES (Cont'd)

Measure and Site/Scale	IWR Planning Suite Plan Code
Suitable Broad Bay	SCL10
Key Broad Bay (with Suitable SAV in Broad Bay)	SCL11
Key Main Stem/Key Broad Bay	SCL13
Key Broad Bay	SCL15
Wetland Creation – 2 sites	
Narrows to Rainy Gut	NR
Lake Windsor	LW
Wetlands Restoration/Diversification – 4 sites	
Princess Anne High School (wetland restoration)	PA
South Great Neck (wetland restoration/diversification)	SG
Mill Dam Neck (wetland restoration/diversification)	MD
North Great Neck (wetland restoration)	NG

Multivariable Analysis

The average annual costs and average annual benefits identified previously were used to conduct cost effectiveness and incremental cost analyses for the 1631 alternative plans, as discussed previously, as well as the No Action Plan. In the case of alternative plans that include measures related to SAV, reef habitat, scallops, and wetland creation, three separate parameter outputs were initially used to indicate the environmental benefit associated with each of the alternatives under consideration.

Sensitivity Analysis on Weighting of Parameters

The original cost/benefits analysis was completed using three environmental parameters: secondary production, species diversity, and TSS. In order to assess the effect on the outcome of the CE/ICA if greater importance was given to any of the three original benefit parameters (shown in detail in subsequently in this Appendix) was performed to evaluate the effect of various weights on the results of the analysis. The analysis was rerun with the following weights;

- 50 percent TSS reduction, 50 percent secondary production, 0 percent BIBI
- 0 percent TSS reduction, 50 percent secondary production, 50 percent BIBI
- 50 percent TSS reduction, 0 percent secondary production, 50 percent BIBI
- 100 percent weight on TSS reduction
- 100 percent weight on Secondary Production
- 100 percent weight on the BIBI.

TABLE B-7. DESCRIPTION OF BEST BUY ALTERNATIVES

Alternative	SAV	Scallops	Reef Habitat	Wetland Creation
A	Suitable Areas in Main Stem and Broad Bay	Key Areas in Main Stem and Broad Bay	None	None
B	Suitable Areas in Main Stem and Broad ay	Key areas in Main Stem and Broad Bay	Broad Bay on normal foundation	None
C	Suitable Area SAV in Main Stem and Broad Bay	Key Areas Scallops in Main Stem and Broad Bay	Lynnhaven Bay and Broad Bay on normal foundation	None
D	Suitable Area SAV in Main Stem and Broad Bay	Key Areas Scallops in Main Stem and Broad Bay	Lynnhaven Bay and Broad Bay on normal and soft foundation	None
E	Suitable Area SAV in Main Stem and Broad Bay	Key Areas Scallops in Main Stem and Broad Bay	Lynnhaven Bay and Broad Bay on normal and soft foundation	Fish House Island (Large Design)
F	Suitable Area SAV in Main Stem and Broad Bay	Sustainable Areas Scallops in Main Stem and Broad Bay	Lynnhaven Bay and Broad Bay on normal and soft foundation	Fish House Island (Large Design)
G	Suitable Area SAV in Main Stem and Broad Bay	Sustainable Areas Scallops in Main Stem and Broad Bay	Lynnhaven Bay and Broad Bay on normal and soft foundation	Fish House Island (Large Design), and Lake Windsor
H	Suitable Area SAV in Main Stem and Broad Bay	Sustainable Areas Scallops in Main Stem and Broad Bay	Lynnhaven Bay and Broad Bay on normal and soft foundation	Fish House Island (Large Design), Lake Windsor, Narrows to Rainy Gut

Table B-8. SUMMARY OF SENSITIVITY ANALYSIS ON WEIGHTING (BEST BUY PLANS)

Best Buy Plans	Equal Weights (Main Analysis)	100% TSS	100% SP	100% BIBI	50% TSS/50%SP	50%TSS/50%BIBI	50%SP/50%BIBI
A	x		x	x	x	x	x
B	x	x	x	x	x	x	x
C	x	x	x	x	x	x	x
D	x	x	x	x	x	x	x
E	x	x	x	x	x	x	x
F**	x		x	x	x	x	x
G**	x		x	x	x	x	x
H**	x	x	x	x	x	x	x
I*			x				
J*		x					
K*			x				
L*		x					
M*		x					

*Plans not carried forward for consideration because only identified as best buy plan by one of the sensitivity analyses and not by the main CE/ICA.
**Plan not carried forward for consideration because of very high incremental costs

It was specifically identified through the analysis, using only secondary production and species diversity (0 percent weight on TSS reduction, 50 percent weight on secondary production, and 50 percent weight on BIBI), that the resulting best buy plans are the same when the benefits are analyzed with or without the TSS reduction parameter. This is because the MCDA scores, though different with and without inclusion of the TSS parameter, follow the same positively increasing pattern in output associated with each alternative plan under consideration. Therefore, as the TSS is not necessary for differentiating plans, and as it more of an indicator of water quality rather than a measurement of habitat improvement, it was not used in identification of the NER Plan.

Multi Criteria Decision Analysis

In the case of alternative plans that include measures related to SAV, reef habitat, scallops, and wetland creation, it was determined that more than one parameter output would best indicate the environmental benefit associated with each of the alternatives under consideration. The CE/ICA for plans that include wetland restoration measures is described in the following section.

Typically, CE/ICA is conducted on one benefit output and one cost output. Therefore, the CE/ICA analysis for this study was not as straightforward as with other studies. The Multi-Criteria Decision Analysis Module (MCDA) of IWR-Planning Suite was used as a means to combine the three parameters into one benefit metric to compare with costs in CE/ICA.

The MCDA Module of IWR-Planning Suite provides a numerical method for comparing benefit parameters with inconsistent units. The benefit values entered into the MCDA are evaluated as a matrix, with each row being an alternative and each column a benefit category. All of the values in the matrix are normalized and ranked to determine a single score for each alternative (or row) under evaluation. For this evaluation, the values were ranked using the weighted scoring ranking method and normalized using the normalization to range method. (U.S. Army Corps of Engineers Institute for Water Resources, IWR Planning Suite MCDA Module User's Guide, October 2010)

Ranking Method

Ranking methodology aims to find the relative minimum and maximum of each benefit category for all of the rows in a matrix (or planning set) in order to rank the rows from the optimal solution to the least optimal solution. There are several ranking methods available for use in the MCDA module: weighted scoring, compromise programming, and outranking. The weighted scoring technique, the ranking method used for this analysis, compares plans to one another and assumes higher benefit values result in a more beneficial plan. This particular ranking method was chosen for use due to its lack of complexity as compared to the other ranking methods. Weighted scoring of a planning set is performed as follows: values are normalized; values for maximized categories are multiplied by designated weights; weights for minimized categories are converted to negative and then multiplied by the criterion (benefit value); raw weighted values for alternatives are generated by adding together the score values for a particular row; these scores are then normalized once again to generate scores that fall between 0 and 1. (U.S. Army Corps of Engineers Institute for Water Resources, IWR Planning Suite MCDA Module User's Guide, October 2010)

Normalization Method

Normalization allows benefit categories with different units of measurement to be evaluated together in one analysis. The weighted scoring ranking method allows for use of three different normalization methods: normalization to maximum, normalization to range, and normalization to percent of total. The normalization to range method was chosen for this evaluation since this method assures that the values of zero and one will be included in the results; whereas, the other normalization methods do not guarantee this. In this study, a minimum raw value of zero was used in all instances for the No Action plan. So, the results of this normalization method are no different than would be found with the use of the normalization to maximum method. With the normalization by range method, the normalized value is calculated as follows:
$v = (a - \min a) / (\max a - \min a)$, where a = "raw" value of criterion. (U.S. Army Corps of Engineers Institute for Water Resources, IWR Planning Suite MCDA Module User's Guide, October 2010)

Weighting of Values

As discussed previously, MCDA allows for the use of weights to reflect the importance of each parameter under evaluation. The sensitivity analysis performed confirmed the assumption that none of the parameters have a significantly greater bearing on the overall value of the system. Due to this, and their joint, central importance to the ecological benefits model, it was decided to weight them equally.

Additionally, the Chesapeake Bay Program has also recently been given more attention by the current administration. EO 13508, Chesapeake Bay Protection and Restoration, outlines a strategy to improve the water quality, restore and protect watershed habitat, sub-aqueous habitat, and organisms that live in it. The selected parameters aid in meeting goals outlined in the Action Plan associated with EO 13508.

Example Score Calculations

A score for each alternative was calculated using the weighted scoring method andn normalized using the normalization to range method as discussed previously. The following is an example of how these scores were calculated within the MCDA module.

Plan NR0LW0ISL0SAVSCL14EFH2 average annual benefits:
TSS = 508181; SP = 111571; BIBI = 82

Values are normalized as follows:
Normalized TSS = (508181 – 0) / (1036344 – 0) = 0.49
Normalized SP = (111571 – 0) / (292235 – 0) = 0.38
Normalized BIBI = (82 – 0) / (296.10 – 0) = 0.28

Normalized values are multiplied by weight (equal weights int his case):
Weighted TSS = 0.49 * 1/3 = 0.16
Weighted SP = 0.38 * 1/3 = 0.13
Weighted BIBI = 0.28 * 1/3 = 0.09

Weighted values are summed:
Score = 0.16 + 0.13 + 0.09 = 0.38

Score is normalized again:
Nomalized Score = (0.38 – 0) / (1 – 0) = 0.38

Cost Effectiveness and Incremental Cost Analysis on MCDA Scores

A cost effectiveness and incremental cost analysis was conducted on the scores derived using the MCDA weighted scoring method with equal weighting, as discussed previously. The results of the cost effectiveness analysis using the MCDA weighted scoring method indicated 124 of the considered plans to be cost effective. The cost-effective plans can be found in the following table. Each of these plans is the least-costly means of providing the associated level of output or benefit.

Table B-9. RESULTS OF MCDA WEIGHTED SCORING COST EFFECTIVENESS ANALYSIS

Alternative Plan	Score	Cost ($)	Average Cost ($)
No Action Plan	0.00	0.00	
NR1LW0ISL0SAVSCL0RH0	0.00	16,000	18,308,000
NR0LW1ISL0SAVSCL0RH0	0.00	21,000	18,182,000
NR0LW0ISL0SAVSCL16RH0	0.06	32,000	496,000
NR0LW0ISL0SAVSCL14RH0	0.09	42,000	479,000
NR1LW0ISL0SAVSCL14RH0	0.09	58,000	652,000
NR0LW1ISL0SAVSCL14RH0	0.09	63,000	707,000
NR0LW0ISL0SAVSCL13RH0	0.11	66,000	590,000
NR0LW0ISL0SAVSCL12RH0	0.17	76,000	445,000
NR0LW0ISL0SAVSCL6RH0	0.19	85,000	438,000
NR0LW0ISL0SAVSCL11RH0	0.22	94,000	435,000
NR0LW0ISL0SAVSCL5RH0	0.25	109,000	444,000
NR0LW0ISL0SAVSCL9RH0	0.28	115000	414,000
NR1LW0ISL0SAVSCL9RH0	0.28	130,000	469,000
NR0LW1ISL0SAVSCL9RH0	0.28	136,000	487,000
NR0LW0ISL0SAVSCL8RH0	0.35	139,000	396,000
NR0LW0ISL0SAVSCL3RH0	0.38	147,000	383,000
NR1LW0ISL0SAVSCL3RH0	0.38	163,000	424,000
NR0LW1ISL0SAVSCL3RH0	0.38	168,000	437,000
NR0LW0ISL0SAVSCL2RH0	0.48	171,000	353,000
NR1LW0ISL0SAVSCL2RH0	0.49	187,000	385,000
NR0LW1ISL0SAVSCL2RH0	0.49	192,000	396,000
NR1LW1ISL0SAVSCL2RH0	0.49	208,000	428,000
NR0LW0ISL0SAVSCL1RH0	0.49	231,000	473,000
NR1LW0ISL0SAVSCL1RH0	0.49	247,000	505,000
NR0LW1ISL0SAVSCL1RH0	0.49	252,000	515,000
NR1LW1ISL0SAVSCL1RH0	0.49	268,000	546,000

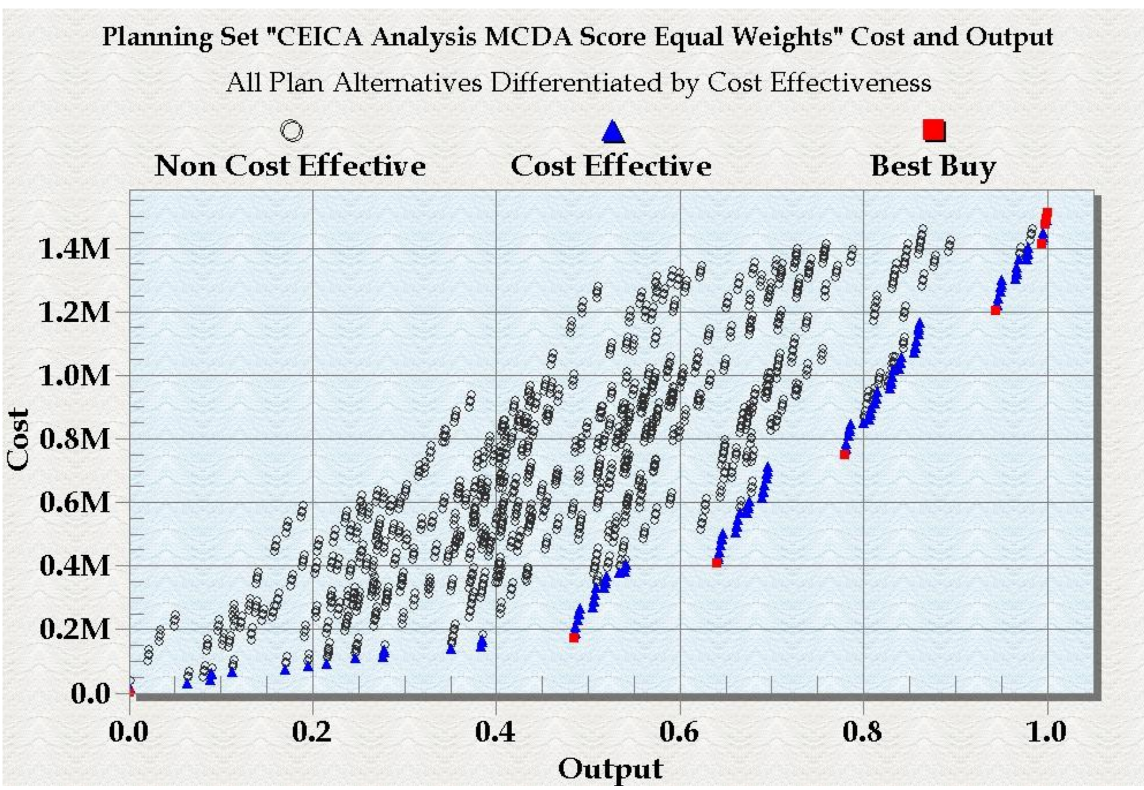
NR0LW0ISL3SAVSCL2RH0	0.50	272,000	538,000
NR1LW0ISL3SAVSCL2RH0	0.51	287,000	568,000
NR0LW1ISL3SAVSCL2RH0	0.51	293,000	578,000
NR1LW1ISL3SAVSCL2RH0	0.51	308,000	608,000
NR0LW0ISL3SAVSCL1RH0	0.51	332,000	651,000
NR0LW0ISL2SAVSCL2RH0	0.52	332,000	642,000
NR1LW0ISL2SAVSCL2RH0	0.52	348,000	672,000
NR0LW1ISL2SAVSCL2RH0	0.52	353,000	681,000
NR1LW1ISL2SAVSCL2RH0	0.52	369,000	710,000
NR0LW0ISL1SAVSCL2RH0	0.53	380,000	713,000
NR0LW0ISL0SAVSCL3RH5	0.54	383,000	710,000
NR1LW0ISL0SAVSCL3RH5	0.54	390,000	738,000
NR0LW1ISL0SAVSCL3RH5	0.54	404,000	747,000
NR0LW0ISL0SAVSCL2RH5	0.64	407,000	636,000
NR1LW0ISL0SAVSCL2RH5	0.64	423,000	660,000
NR0LW1ISL0SAVSCL2RH5	0.64	428,000	667,000
NR1LW1ISL0SAVSCL2RH5	0.64	444,000	691,000
NR0LW0ISL0SAVSCL1RH5	0.64	467,000	725,000
NR1LW0ISL0SAVSCL1RH5	0.65	483,000	748,000
NR0LW1ISL0SAVSCL1RH5	0.65	488,000	756,000
NR1LW1ISL0SAVSCL1RH5	0.65	504,000	779,000
NR0LW0ISL3SAVSCL2RH5	0.66	508,000	768,000
NR1LW0ISL3SAVSCL2RH5	0.66	523,000	791,000
NR0LW1ISL3SAVSCL2RH5	0.66	529,000	798,000
NR1LW1ISL3SAVSCL2RH5	0.66	544,000	821,000
NR0LW0ISL3SAVSCL1RH5	0.67	568,000	853,000
NR0LW0ISL2SAVSCL2RH5	0.67	568,000	844,000
NR1LW0ISL2SAVSCL2RH5	0.67	584,000	866,000
NR0LW1ISL2SAVSCL2RH5	0.67	589,000	873,000
NR1LW1ISL2SAVSCL2RH5	0.68	605,000	896,000
NR0LW0ISL1SAVSCL2RH5	0.69	616,000	893,000
NR1LW0ISL1SAVSCL2RH5	0.69	632,000	915,000
NR0LW1ISL1SAVSCL2RH5	0.69	637,000	922,000
NR1LW1ISL1SAVSCL2RH5	0.69	653,000	944,000
NR0LW0ISL1SAVSCL1RH5	0.69	676,000	975,000
NR1LW0ISL1SAVSCL1RH5	0.69	692,000	996,000
NR0LW1ISL1SAVSCL1RH5	0.70	697,000	1,003,000
NR1LW1ISL1SAVSCL1RH5	0.70	713,000	1,025,000
NR0LW0ISL0SAVSCL2RH2	0.78	750,000	962,000
NR1LW0ISL0SAVSCL2RH2	0.78	766,000	982,000
NR0LW1ISL0SAVSCL2RH2	0.78	771,000	988,000
NR1LW1ISL0SAVSCL2RH2	0.78	787,000	1,007,000
NR0LW0ISL0SAVSCL1RH2	0.78	810,000	1,034,000
NR1LW0ISL0SAVSCL1RH2	0.78	826,000	1,053,000
NR0LW1ISL0SAVSCL1RH2	0.78	831,000	1,059,000
NR1LW1ISL0SAVSCL1RH2	0.79	847,000	1,078,000

NR0LW0ISL3SAVSCL2RH2	0.80	850,000	1,063,000
NR0LW0ISL0SAVSCL2RH3	0.81	861,000	1,069,000
NR1LW0ISL0SAVSCL2RH3	0.81	877,000	1,087,000
NR0LW1ISL0SAVSCL2RH3	0.81	882,000	1,093,000
NR1LW1ISL0SAVSCL2RH3	0.81	898,000	1,111,000
NR0LW0ISL2SAVSCL2RH2	0.81	911,000	1,121,000
NR1LW0ISL2SAVSCL2RH2	0.81	927,000	1,140,000
NR0LW1ISL2SAVSCL2RH2	0.81	932,000	1,146,000
NR1LW1ISL2SAVSCL2RH2	0.81	948,000	1,164,000
NR0LW0ISL1SAVSCL2RH2	0.83	959,000	1,158,000
NR1LW0ISL1SAVSCL2RH2	0.83	975,000	1,175,000
NR0LW1ISL1SAVSCL2RH2	0.83	980,000	1,181,000
NR1LW1ISL1SAVSCL2RH2	0.83	996,000	1,199,000
NR0LW0ISL1SAVSCL1RH2	0.83	1,019,000	1,224,000
NR0LW0ISL2SAVSCL2RH3	0.84	1,022,000	1,218,000
NR1LW0ISL2SAVSCL2RH3	0.84	1,038,000	1,236,000
NR0LW1ISL2SAVSCL2RH3	0.84	1,043,000	1,242,000
NR1LW1ISL2SAVSCL2RH3	0.84	1,059,000	1,259,000
NR0LW0ISL1SAVSCL2RH3	0.86	1,070,000	1,251,000
NR1LW0ISL1SAVSCL2RH3	0.86	1,086,000	1,269,000
NR0LW1ISL1SAVSCL2RH3	0.86	1,091,000	1,274,000
NR1LW1ISL1SAVSCL2RH3	0.86	1,107,000	1,292,000
NR0LW0ISL1SAVSCL1RH3	0.86	1,130,000	1,315,000
NR1LW0ISL1SAVSCL1RH3	0.86	1,146,000	1,332,000
NR0LW1ISL1SAVSCL1RH3	0.86	1,151,000	1,338,000
NR1LW1ISL1SAVSCL1RH3	0.86	1,167,000	1,355,000
NR0LW0ISL0SAVSCL2RH1	0.94	1,204,000	1,274,000
NR1LW0ISL0SAVSCL2RH1	0.95	1,220,000	1,290,000
NR0LW1ISL0SAVSCL2RH1	0.95	1,225,000	1,295,000
NR1LW1ISL0SAVSCL2RH1	0.95	1,241,000	1,311,000
NR0LW0ISL0SAVSCL1RH1	0.95	1,264,000	1,332,000
NR1LW0ISL0SAVSCL1RH1	0.95	1,280,000	1,348,000
NR0LW1ISL0SAVSCL1RH1	0.95	1,285,000	1,353,000
NR1LW1ISL0SAVSCL1RH1	0.95	1,301,000	1,368,000
NR0LW0ISL3SAVSCL2RH1	0.97	1,304,000	1,351,000
NR1LW0ISL3SAVSCL2RH1	0.97	1,320,000	1,367,000
NR0LW1ISL3SAVSCL2RH1	0.97	1,325,000	1,371,000
NR1LW1ISL3SAVSCL2RH1	0.97	1,341,000	1,387,000
NR0LW0ISL3SAVSCL1RH1	0.97	1,364,000	1,407,000
NR0LW0ISL2SAVSCL2RH1	0.98	1,365,000	1,396,000
NR1LW0ISL2SAVSCL2RH1	0.98	1,381,000	1,411,000
NR0LW1ISL2SAVSCL2RH1	0.98	1,386,000	1,416,000
NR1LW1ISL2SAVSCL2RH1	0.98	1,402,000	1,431,000
NR0LW0ISL1SAVSCL2RH1	0.99	1,413,000	1,422,000
NR1LW0ISL1SAVSCL2RH1	0.99	1,429,000	1,436,000
NR0LW1ISL1SAVSCL2RH1	0.99	1,434,000	1,441,000

NR1LW1ISL1SAVSCL2RH1	1.00	1,450,000	1,456,000
NR0LW0ISL1SAVSCL1RH1	1.00	1,473,000	1,476,000
NR1LW0ISL1SAVSCL1RH1	1.00	1,489,000	1,491,000
NR0LW1ISL1SAVSCL1RH1	1.00	1,494,000	1,495,000
NR1LW1ISL1SAVSCL1RH1	1.00	1,510,000	1,510,000

Figure B-1 illustrates the cost-effective analysis results, showing average annual environmental benefits (horizontal axis) and average annual costs (vertical axis) of the 123 alternatives, as well as the No Action Plan, which is carried forward for comparison purposes only.

Figure B-1. MCDA WEIGHTED SCORING COST-EFFECTIVE PLANS

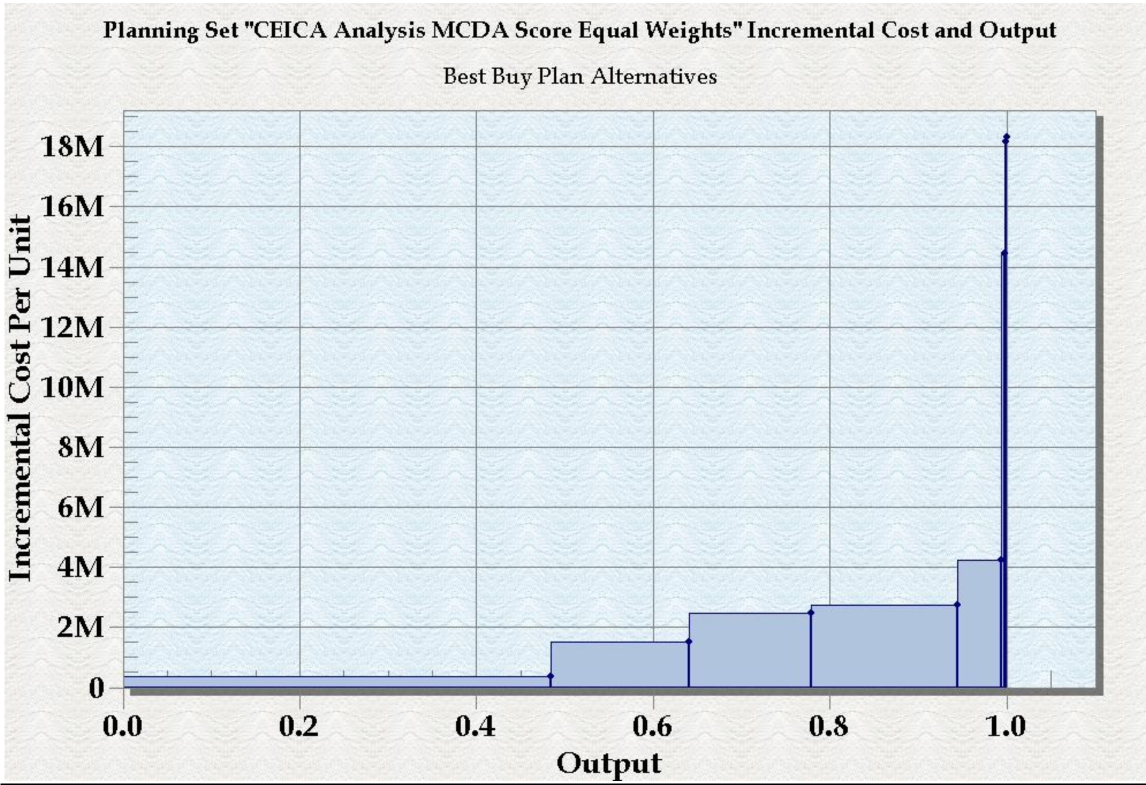


After conducting the cost effectiveness analysis, incremental cost analysis examines the changes in costs and changes in environmental benefits for each additional increment of output. For each best buy plan there are no other plans that will give the same level of output at a lower incremental cost. The plan with the lowest overall average cost per unit of output, advancing from the No Action Plan, is the first Best Buy Plan. After the first Best Buy Plan is identified, subsequent incremental analyses are done to calculate the change in costs and change in outputs of advancing from the first Best Buy Plan to all of the remaining (and larger) cost-effective plans. The results of the incremental cost analysis using the MCDA weighted scoring method indicated eight of the considered plans, in addition to the no action plan, to be best buy plans. The following table summarizes the information from the incremental cost analysis of the alternatives, and Figure 2 displays the information graphically.

Table B-10. RESULTS OF MCDA WEIGHTED SCORING INCREMENTAL COST ANALYSIS (BEST BUY PLANS)

Plan Alternative	**Score**	**Cost ($)**	**Average Cost ($)**	**Incremental Cost ($)**	**Inc. Output**	**Inc. Cost Per Output**
No Action Plan	0.00	0.00				
NR0LW0ISL0SAVSCL2RH0	0.48	171,000	353,000	171,000	0.4845	353,000
NR0LW0ISL0SAVSCL2RH5	0.64	407,000	636,000	236,000	0.1561	1,512,000
NR0LW0ISL0SAVSCL2RH2	0.78	750,000	962,000	343,000	0.1387	2,471,000
NR0LW0ISL0SAVSCL2RH1	0.94	1,204,000	1,274,000	454,000	0.1654	2,745,000
NR0LW0ISL1SAVSCL2RH1	0.99	1,413,000	1,422,000	209,000	0.0493	4,245,000
NR0LW0ISL1SAVSCL1RH1	1.00	1,473,000	1,476,000	60,000	0.0042	14,449,000
NR0LW1ISL1SAVSCL1RH1	1.00	1,494,000	1,495,000	21,000	0.0012	18,182,000
NR1LW1ISL1SAVSCL1RH1	1.00	1,510,000	1,510,000	16,000	0.0009	18,308,000

Figure B-2. MCDA WEIGHTED SCORING BEST BUY PLANS



Sensitivity Analysis on Importance of Parameters

As discussed previously, a sensitivity anlaysis was conducted on the weights applied to each benefit parameter. For the main analysis it is assumed TSS reduction, secondary production, and the BIBI are of equal importance on the overall value of the system, thus equal weights were applied to the parameters. Because of the uncertainty associated with this assumption, the application of weights was varied to examine how the resulting cost effective and best buy plans are affected as compared to the use equal weights. In order to assess the effect on the outcome of the CE/ICA, should greater importance be given to any of the three benefit parameters used in the analysis, the analysis was rerun with the following weights;

- 50 percent TSS reduction, 50 percent secondary production, 0 percent BIBI
- 0 percent TSS reduction, 50 percent secondary production, 50 percent BIBI
- 50 percent TSS reduction, 0 percent secondary production, 50 percent BIBI
- 100 percent weight on TSS reduction
- 100 percent weight on Secondary Production
- 100 percent weight on the BIBI.

The majority of the results of the sensitivity analysis on weighting supported the same best buy plans as those identified by the incremental cost analysis using the MCDA scores derived with equal weights on each parameter. There were several additional best buy plans identified by the analysis with varying weights, however these best buy plans were either less or greater in terms of output than those plans identified by the main analysis.

The results of the incremental cost analyses for each of the aforementioned weighting scenarios are presented in the following tables.

Table B-11. RESULTS OF 50 PERCENT IMPORTANCE ON TSS REDUCTION AND SECONDARY PRODUCTION INCREMENTAL COST ANALYSIS (BEST BUY PLANS)

Plan Alternative	**Score**	**Cost ($)**	**Average Cost ($)**	**Incremental Cost ($)**	**Inc. Output**	**Inc. Cost Per Output**
No Action Plan	0.00	0.00				
NR0LW0ISL0SAVSCL2RH0	0.35	171,000	493,000	171,000	0.3473	493,000
NR0LW0ISL0SAVSCL2RH5	0.55	407,000	742,000	236,000	0.2013	1,173,000
NR0LW0ISL0SAVSCL2RH2	0.72	750,000	1,039,000	343,000	0.1731	1,980,000
NR0LW0ISL0SAVSCL2RH1	0.93	1,204,000	1,288,000	454,000	0.2133	2,129,000
NR0LW0ISL1SAVSCL2RH1	0.99	1,413,000	1,421,000	209,000	0.0595	3,512,000
NR0LW1ISL1SAVSCL2RH1	1.00	1,434,000	1,440,000	21,000	0.0013	15,827,000
NR1LW1ISL1SAVSCL2RH1	1.00	1,450,000	1,455,000	16,000	0.0010	15,925,000
NR1LW1ISL1SAVSCL1RH1	1.00	1,5110,000	1,510,000	60,000	0.0033	18,422,000

Table B-12. RESULTS OF 50 PERCENT IMPORTANCE ON SECONDARY PRODUCTION AND BIBI INCREMENTAL COST ANALYSIS (BEST BUY PLANS)

Plan Alternative	**Score**	**Cost ($)**	**Average Cost ($)**	**Incremental Cost ($)**	**Inc. Output**	**Inc. Cost Per Output**
No Action Plan	0.00	0.00				
NR0LW0ISL0SAVSCL2RH0	0.65	171,000	262,000	171,000	0.6544	262,000
NR0LW0ISL0SAVSCL2RH5	0.76	407,000	536,000	236,000	0.1057	2,234,000
NR0LW0ISL0SAVSCL2RH2	0.86	750,000	874,000	343,000	0.0974	3,517,000
NR0LW0ISL0SAVSCL2RH1	0.97	1,204,000	1,242,000	454,000	0.1119	4,055,000
NR0LW0ISL1SAVSCL2R1	0.99	1,413,000	1,420,000	209,000	0.0254	8,233,000
NR0LW0ISL1SAVSCL1RH1	1.00	1,473,000	1,474,000	60,000	0.0044	13,792,000
NR0LW1ISL1SAVSCL1RH1	1.00	1,494,000	1,494,000	21,000	0.0005	44,465,000
NR1LW1ISL1SAVSCL1RH1	1.00	1,510,000	1,510,000	16,000	0.0004	44,846,000

Table B-13. RESULTS OF 50 PERCENT IMPORTANCE ON TSS REDUCTION AND BIBI INCREMENTAL COST ANALYSIS (BEST BUY PLANS)

Plan Alternative	**Score**	**Cost ($)**	**Average Cost ($)**	**Incremental Cost ($)**	**Inc. Output**	**Inc. Cost Per Output**
No Action Plan	0.00	0.00				
NR0LW0ISL0SAVSCL2RH0	0.45	171,000	379,000	171,000	0.4517	379,000
NR0LW0ISL0SAVSCL2RH5	0.61	407,000	664,000	236,000	0.1613	1,463,000
NR0LW0ISL0SAVSCL2RH2	0.76	750,000	989,000	343,000	0.1456	2,354,000
NR0LW0ISL0SAVSCL2RH1	0.93	1,204,000	1,295,000	454,000	0.1709	2,657,000
NR0LW0ISL1SAVSCL2RH1	0.99	1,413,000	1,424,000	209,000	0.0628	3,328,000
NR0LW0ISL1SAVSCL1RH1	1.00	1,473,000	1,477,000	60,000	0.0049	12,370,000
NR0LW1ISL1SAVSCL1RH1	1.00	1,494,000	1,496,000	21,000	0.0017	12,607,000
NR1LW1ISL1SAVSCL1RH1	1.00	1,510,000	1,510,000	16,000	0.0013	12,694,000

Table B-14. RESULTS OF 100 PERCENT IMPORTANCE ON TSS REDUCTION INCREMENTAL COST ANALYSIS (BEST BUY PLANS)

Plan Alternative	Score	Cost ($)	Average Cost ($)	Incremental Cost ($)	Inc. Output	Inc. Cost Per Output
No Action Plan	0.00	0.00				
NR0LW0ISL0SAVSCL0RH5	0.26	236,000	919,000	236,000	0.2569	919,000
NR0LW0ISL0SAVSCL2RH5	0.40	407,000	1,014,000	171,000	0.1446	1,184,000
NR0LW0ISL0SAVSCL2RH2	0.62	750,000	1,204,00	343,000	0.2212	1,549,000
NR0LW0ISL0SAVSCL2RH1	0.89	1,204,000	1,345,000	454,000	0.2722	1,668,000
NR0LW0ISL1SAVSCL2RH1	0.99	1,412,000	1,425,000	209,000	0.0970	2,156,000
NR0LW1ISL1SAVSCL2RH1	0.99	1,434,000	1,442,000	21,000	0.0025	8,332,000
NR1LW1ISL1SAVSCL2RH1	1.00	1,450,000	1,455,00	16,000	0.0019	8,384,000
NR1LW1ISL1SAVSCL1RH1	1.00	1,510,000	1,510,000	60,000	0.0038	15,969,000

Table B-15. RESULTS OF 100 PERCENT IMPORTANCE ON SECONDARY PRODUCTION INCREMENTAL COST ANALYSIS (BEST BUY PLANS)

Plan Alternative	Score	Cost ($)	Average Cost ($)	Incremental Cost ($)	Inc. Output	Inc. Cost Per Output
No Action Plan	0.00	0.00				
NR0LW0ISL0SAVSCL3RH0	0.48	147,000	304,000	147,000	0.4830	304,000
NR0LW0ISL0SAVSCL2RH0	0.55	171,000	311,000	24,000	0.0670	361,000
NR0LW0ISL0SAVSCL2RH5	0.70	407,000	585,000	236,000	0.1457	1,620,000
NR0LW0ISL0SAVSCL2RH2	0.82	750,000	914,000	343,000	0.1249	2,743,000
NR0LW0ISL0SAVSCL2RH1	0.97	1,204,000	1,235,000	454,000	0.1543	2,941,000
NR0LW0ISL3SAVSCL2RH1	0.99	1,304,000	1,321,000	100,000	0.0125	8,053,000
NR0LW0ISL1SAVSCL2RH1	1.00	1,413,000	1,417,000	109,000	0.0096	11,292,000
NR0LW0ISL1SAVSCL1RH1	1.00	1,473,000	1,473,000	60,000	0.0028	21,766,000
NR0LW1ISL1SAVSCL1RH1	1.00	1,494,000	1,494,000	21,000	0.0001	157,366,000
NR1LW1ISL1SAVSCL1RH1	1.00	1,510,000	1,510,000	16,000	0.0001	158,332,000

Table B-16. RESULTS OF 100 PERCENT IMPORTANCE ON BIBI
INCREMENTAL COST ANALYSIS (BEST BUY PLANS)

Plan Alternative	Score	Cost ($)	Average Cost ($)	Incremental Cost ($)	Inc. Output	Inc. Cost Per Output
No Action Plan	0.00	0.00				
NR0LW0ISL0SAVSCL2RH0	0.76	171,000	226,000	171,000	0.7588	226,000
NR0LW0ISL0SAVSCL2RH5	0.82	407,000	494,000	236,000	0.0657	3,595,000
NR0LW0ISL0SAVSCL2RH2	0.89	750,000	838,000	343,000	0.0699	4,899,000
NR0LW0ISL0SAVSCL2RH1	0.96	1,204,000	1,249,000	454,000	0.0696	6,525,000
NR0LW0ISL1SAVSCL2RH1	0.99	1,413,000	1,423,000	209,000	0.0287	7,285,000
NR0LW0ISL1SAVSCL1RH1	1.00	1,473,000	1,475,000	60,000	0.0059	10,094,000
NR0LW1ISL1SAVSCL1RH1	1.00	1,494,000	1,495,000	21,000	0.0008	25,890,000
NR1LW1ISL1SAVSCL1RH1	1.00	1,510,000	1,510,000	16,000	0.0006	26,123,000

Wetland Restoration/Diversification Sites

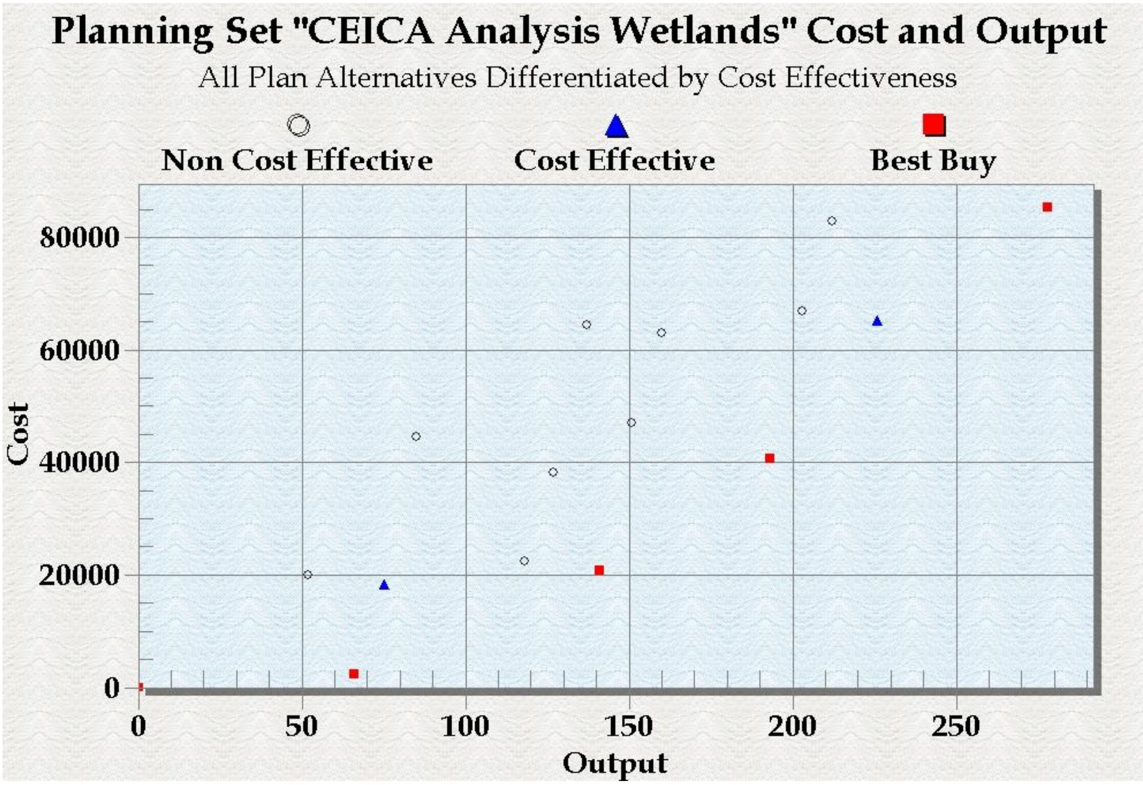
As discussed previously, the wetland restoration sites were valued using a different parameter than the rest of the restoration measures. Therefore, a separate CE/ICA was conducted on just these sites. The CE/ICA for the wetland restoration sites was relatively straight-forward, since only one output parameter was used to quantify the environmental benefits. Construction of each of the four sites are not considered mutually exclusive, so all possible combinations of the four sites were analyzed, resulting in a total of fifteen plans, in addition to the no action plan. The results of the cost-effective analysis indicate six plans, in addition to the no action plan, to be cost effective. The cost-effective plans can be found in the following table. Each of these plans is the least-costly means of providing the associated level of output or benefit for the wetland restoration sites.

Table B-17. RESULTS OF WETLANDS WITH RESTORATION COST EFFECTIVENESS ANALYSIS

Name	Wetland Function	Cost ($)	Average Cost ($)
No Action Plan	0.00	0.00	
PA0SG0MD1NG0	66.00	2,4.00	36
PA0SG1MD0NG0	75.00	18,300	244
PA0SG1MD1NG0	141.00	20,800	148
PA0SG1MD1NG1	193.00	40,700	211
PA1SG1MD1NG0	226.00	65,300	289
PA1SG1MD1NG1	278.00	85,300	307

Figure 3 illustrates the cost-effective analysis results, showing average annual environmental benefits (horizontal axis) and average annual costs (vertical axis) of the eight alternatives, as well as the No Action Plan, which is carried forward for comparison purposes only.

Figure B-3. WETLANDS RESTORATION COST-EFFECTIVE PLANS

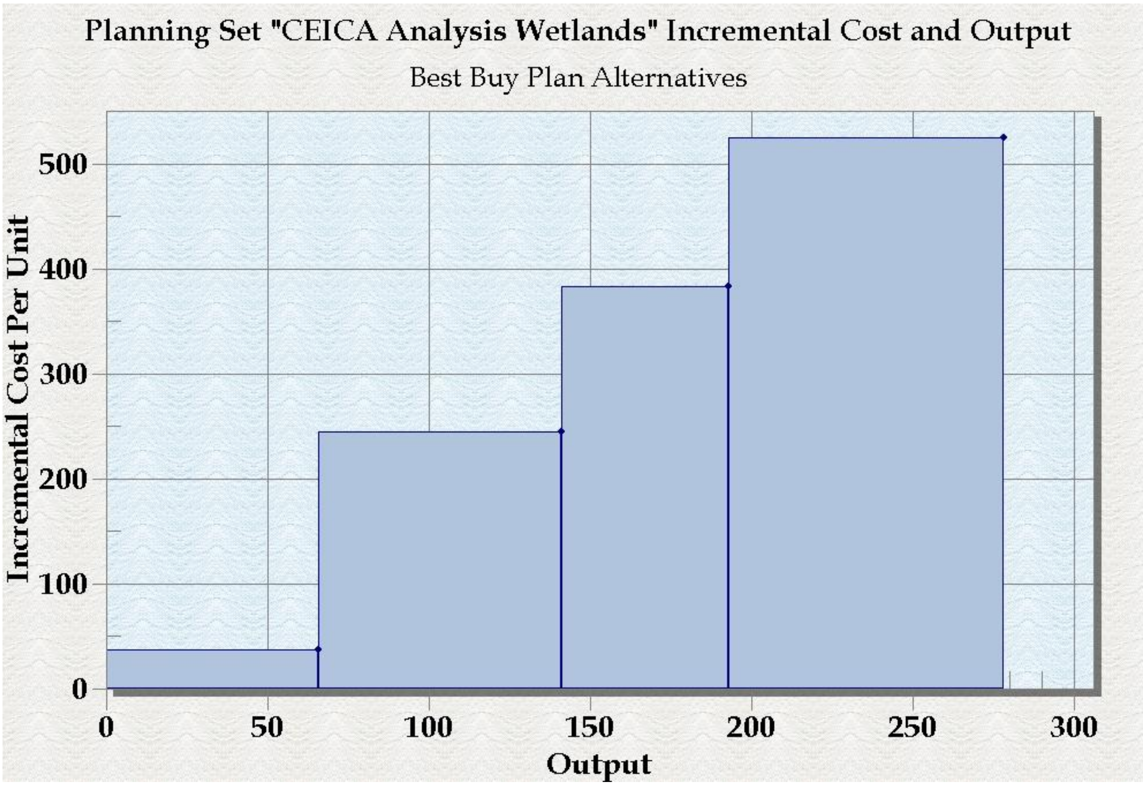


After conducting the cost effectiveness analysis, incremental cost analysis examines the changes in costs and changes in environmental benefits for each additional increment of output. The results of the incremental cost analysis on the wetland restoration sites indicated four of the considered plans, in addition to the no action plan, to be best buy plans. The following table summarizes the information from the incremental cost analysis of the alternatives, and Figure 4 displays the information graphically.

Table B-18. RESULTS OF WETLANDS RESTORATION INCREMENTAL COST ANALYSIS (BEST BUY PLANS)

Plan Alternative	Wetland Score	Cost ($)	Average Cost ($)	Incremental Cost ($)	Incremental Output	Incremental Cost per Output
No Action Plan	0.00	0.00				
PA0SG0MD1NG0	66.00	2,400	36	2400	66.0000	36
PA0SG1MD1NG0	141.00	20,800	148	18,300	75.0000	244
PA0SG1MD1NG1	193.00	40,700	211	19,900	52.0000	383
PA1SG1MD1NG1	278.00	85,300	307	44,600	85.0000	525

Figure 4. WETLANDS WITH PHRAGMITES ERADICATION BEST BUY PLANS



SELECTION OF AN ECOSYSTEM RESTORATION PLAN

When selecting a single alternative plan for recommendation from all those that have been considered, the criteria used to select the NER Plan include all the evaluation criteria discussed previously. Selecting the NER Plan requires careful consideration of the plan that meets planning objectives and constraints and reasonably maximizes environmental benefits while passing tests of cost effectiveness and incremental cost analysis, significance of outputs, acceptability, completeness, efficiency, and effectiveness.

The results of the cost effective and incremental cost analysis using the MCDA score derived using only secondary production and species diversity (0% weight on TSS reduction, 50% weighting on secondary production, and 50% weighting on species diversity) is used in selection of an NER plan. For plans including measures related to SAV, reef habitat, scallops, and wetland construction, the results of the cost effectiveness and incremental cost analyses indicate there are eight Best Buy Plans in addition to the No Action Plan. The results of this analysis were compared in conjunction with the results of the original analysis and the other sensitivity analyses. The cross-section of best buy plans from the different cost effectiveness and incremental cost analyses totaled 13 best buys plans, which include the following.

Table B-19. BEST BUY PLANS IDENTIFIED BY CE/ICA

Best Buy Plan	Description
RH5	Reef habitat in Broad Bay on normal foundation sites.
SAVSCL3	Suitable SAV in Main Stem and Broad Bay
*SAVSCL2	Suitable SAV in Main Stem and Broad Bay and Key Scallops in Main Stem and Broad Bay.
*SAVSCL2RH5	Suitable SAV in Main Stem and Broad Bay and Key Scallops in Main Stem and Broad Bay, and reef habitat in Broad Bay on normal foundation sites.
*SAVSCL2RH2	Suitable SAV in Main Stem and Broad Bay, Key Scallops in Main Stem and Broad Bay, and reef habitat in Lynnhaven Bay and Broad Bay on normal foundation sites.

*SAVSCL2RH1	Suitable SAV in Main Stem and Broad Bay, Key Scallops in Main Stem and Broad Bay, and reef habitat in Lynnhaven Bay and Broad Bay on both normal and soft foundation sites.
SAVSCL2RH1ISL3	Suitable SAV in Main Stem and Broad Bay, Key Scallops in Main Stem and Broad Bay, reef habitat in Lynnhaven Bay and Broad Bay on both normal and soft foundation sites, and Fish House Island (Small Design).
*SAVSCL2RH1ISL1	Suitable SAV in Main Stem and Broad Bay, Key Scallops in Main Stem and Broad Bay, reef habitat in Lynnhaven Bay and Broad Bay on both normal and soft foundation sites, and Fish House Island (Large Design).
*SAVSCL1RH1ISL1	Suitable SAV and Scallops in Main Stem and Broad Bay, reef habitat in Lynnhaven Bay and Broad Bay on both normal and soft foundation sites, and Fish House Island (Large Design).
SAVSCL2RH1ISL1LW1	Suitable SAV in Main Stem and Broad Bay, Key Scallops in Main Stem and Broad Bay, reef habitat in Lynnhaven Bay and Broad Bay on both normal and soft foundation sites, Fish House Island (Large Design), and Lake Windsor wetland.
*SAVSCL1RH1ISL1LW1	Suitable SAV and Scallops in Main Stem and Broad Bay, reef habitat in Lynnhaven Bay and Broad Bay on both normal and soft foundation sites, Fish

	House Island (Large Design), and Lake Windsor wetland.
SAVSCL2RH1ISL1LW1NR1	Suitable SAV in Main Stem and Broad Bay, Key Scallops in Main Stem and Broad Bay, reef habitat in Lynnhaven Bay and Broad Bay on both normal and soft foundation sites, Fish House Island (Large Design), Lake Windsor and Narrows to Rainy Gut wetlands.
*SAVSCL1RH1ISL1LW1NR1	Suitable SAV and Scallops in Main Stem and Broad Bay, reef habitat in Lynnhaven Bay and Broad Bay on both normal and soft foundation sites, Fish House Island (Large Design), Lake Windsor and Narrows to Rainy Gut wetlands.

*Best buy plans identified by the CE/ICA on MCDA scores with equal weighting of parameters and the CE/ICA on MCDA scores derived using only secondary production and species diversity (0% weight on TSS reduction).

Of these 13 plans, five plans were ruled out because each was identified by a best buy plan by only one of the sensitivity analyses and not by the CE/ICA using the MCDA score derived using only secondary production and species diversity (0% weight on TSS reduction, 50% weighting on secondary production, and 50% weighting on species diversity). These five plans are identified by a single asterisk in the previous table. Another three plans were ruled out based on significantly higher incremental cost per output as compared to other best buy plans. These three plans are identified by a double asterisk in the previous table. After this, five best buy plans were left to be carried forward for consideration. The plans carried forward for consideration include the following. Each of the plans carried forward for consideration was identified as a best buy plan by the main CE/ICA analysis with equal weights on the importance of each parameter as well as the CE/ICA using the MCDA score derived using only secondary production and species diversity (0% weight on TSS reduction, 50% weighting on secondary production, and 50% weighting on species diversity). .

Table B-20. ALTERNATIVE PLANS CARRIED FORWARD AFTER CE/ICA

Alternative plan	Code	Description
A	SAVSCL2	Suitable SAV in Main Stem and Broad Bay and Key Scallops in Main Stem and Broad Bay.
B	SAVSCL2RH5	Suitable SAV in Main Stem and Broad Bay and Key Scallops in Main Stem and Broad Bay, and reef habitat in Broad Bay on normal foundation sites.
C	SAVSCL2RH2	Suitable SAV in Main Stem and Broad Bay, Key Scallops in Main Stem and Broad Bay, and reef habitat in Lynnhaven Bay and Broad Bay on normal foundation sites.
D	SAVSCL2RH1	Suitable SAV in Main Stem and Broad Bay, Key Scallops in Main Stem and Broad Bay, and reef habitat in Lynnhaven Bay and Broad Bay on both normal and soft foundation sites.
E	SAVSCL2RH1ISL1	Suitable SAV in Main Stem and Broad Bay, Key Scallops in Main Stem and Broad Bay,

reef habitat in Lynnhaven Bay and Broad Bay on both normal and soft foundation sites, and Fish House Island (Large Design).

Of the Best Buy Plans, Alternative D best meets the planning objectives while reasonably maximizing the environmental benefits. This plan includes the Suitable SAV in both Broad Bay and the main stem, Key scallops in both Broad Bay and the main stem, and both low relief reef habitat and high relief reef habitat (on normal and soft foundations). In addition to being identified as a best buy plan by the CE/ICA on the MCDA score derived using only secondary production and species diversity (0% weight on TSS reduction, 50% weighting on secondary production, and 50% weighting on species diversity), this plan was also identified as a Best Buy Plan by all of the other CE/ICAs conducted for the sensitivity analysis on the weights applied to each benefit parameter.

The increase in average annual output outweighs the additional average annual cost for Alternatives A, B, C and D for all of the analyses, whereas this is not the case for Alternative E. For the MCDA analysis with 50% weighting on secondary production, and 50% weighting on species diversity, the incremental cost per output for Alternative E is $4,4,178,000 more than for Alternative D, which, in turn, would only increase secondary production by about 6,500 kg more on average annually. In addition to the considerably higher incremental cost per unit of output, the plan with the island has several significant risks involved with construction of the island.

The intent of the Fish House Island Plan is to restore pre-existing vegetated wetland habitat. Several conditions related to the adjacent Federal navigation channel and inlet orientation would present significant challenges to the constructability and maintenance of the proposed island. Swift currents in the vicinity would require substantial shoreline armoring to confine fill material within the historic footprint. The orientation of the inlet opening to the north allows a higher percentage of larger, northeast waves to impact the proposed island. Given the magnitude of all of these risks, Alternative E was, therefore, removed from consideration.

Alternative A includes only measures of SAV and scallops. While this alternative is efficient and effective, it is not complete in terms of fully meeting the objectives of the project. Because of this, the plan is not as acceptable as the other alternatives carried forward for consideration. Alternative A was, therefore, removed from consideration.

The average annual incremental cost per unit of output for Alternative D is approximately $540,000 more than the next lower output best buy plan, Alternative C. However, this plan includes both the normal and soft foundation sites for the reef habitat, rather than just the normal foundation sites. Inclusion of these soft foundation sites increases secondary production by 45,000 kg more on average annually. While the average cost per acre to construct the reef habitat sites with soft foundations is significantly higher as compared to the reef habitat sites with normal foundations, it is still worth it to produce this additional level of output when considered along with all the other components of the restoration project.

Wetland Restoration/ Diversification Sites

The results of the cost effectiveness and incremental cost analyses on the wetland restoration sites indicate there are seven cost-effective plans, of which there are four Best Buy Plans, in addition to the No Action Plan.

Table B-21. ALTERNATIVE PLANS CARRIED FORWARD AFTER CE/ICA

Alternative plan	Code	Description
1	PA0SG0MD1NG0	Mill Dam Creek site.
2	PA0SG1MD1NG0	South Great Neck and Mill Dam Creek sites.
3	PA0SG1MD1NG1	South Great Neck, Mill Dam Creek, and North Great Neck sites.
4	PA1SG1MD1NG1	Princess Anne High School, South Great Neck, Mill Dam Creek, and North Great Neck sites.

The results of this analysis were analyzed to determine the plan with the best value of the plans evaluated. Of the Best Buy Plans, Alternative 4, with construction of all four wetlands with *P. australis* eradication sites, best meet the planning objectives while reasonably maximizing the environmental benefits. There is a significant difference in incremental cost per output between the alternative with construction of just Mill Dam Creek and the other alternatives. However, the Mill Dam Creek site is limited to less than one acre. When comparing the cost per acre of the most expensive site, the Princess Anne site, to the construction cost of the average wetland in the study area, the cost per acre of the Princess Anne site, just over $200,000, is seen as a considerable value. The Mill Dam Creek, North Great Neck, and South Great Neck sites would be considered an exceptional value, all under $40,000 per acre, in this comparison.

RISK AND UNCERTAINTY

Sensitivity Analysis on Uncertainty of Project Costs and Risk of Project Success

Risk and uncertainty were considered throughout the entire process of plan formulation and evaluation of the alternative plans. However, a sensitivity analysis was conducted on the results of the CE/ICA to account for any risk and uncertainty that could not be accounted for through the design of the projects or the estimation of the project benefits. The purpose of this sensitivity analysis is to validate the recommendation of the NER Plan with consideration of the uncertainty of project costs and the risk of project success.

The risk associated with success of the SAV component of the project is the highest. Scallops were considered to have a relatively high risk as well, due to their dependency on SAV as well as their own establishment. Therefore, CE/ICA was conducted with the costs for the SAV/scallop measures increased by 50 percent and again with costs increased by 100 percent. There was no effect on the outcome of the best buy plans identified to be carried forward for consideration with a 50 percent or 100 percent cost increase on the SAV/scallop measures. The results of the incremental cost analysis with SAV/scallop costs increased by 50 percent can be seen in the following table.

It is recognized that there is a risk associated with construction of the reef habitat. Therefore, CE/ICA was run with the costs for this measure increased by 50 percent to account for this risk. With a 50 percent increase in reef habitat costs, there was no change to the plans identified as best buy plans by the analysis.

A sensitivity analysis was also conducted on the separate wetland analysis. There is inherent risk associated with the success of growing native species in place of invasive species. To account for this, CE/ICA was rerun with a 25 percent cost increase applied to the Great Neck North and Princess Anne High School sites. This resulted in different incremental costs per output, but no change in the best buy plans identified by the analysis.

The results of the sensitivity analyses on uncertainty of costs and risk of project success can be seen in the following tables.

Table B-22. RESULTS OF 50 PERCENT COST INCREASE ON SAV/SCALLOPS INCREMENTAL COST ANALYSI

Plan Alternative	Score (Output)	Cost	Average Cost	Incremental Cost	Inc. Output	Inc. Cost Per Output
No Action Plan	0.00	0.00				
NR0LW0ISL0SAVSCL2RH0	0.48	257,000	530,000	257,000	0.4845	530,000
NR0LW0ISL0SAVSCL2RH5	0.64	493,000	769,000	236,000	0.1561	1,512,000
NR0LW0ISL0SAVSCL2RH2	0.78	835,000	1,072,000	343,000	0.1387	2,470,000
NR0LW0ISL0SAVSCL2RH1	0.94	1,289,000	1,365,000	454,000	0.1654	2,745,000
NR0LW0ISL1SAVSCL2RH1	0.99	1,499,000	1,508,000	209,000	0.0493	4,245,000
NR0LW1ISL1SAVSCL2RH1	0.99	1,520,000	1,527,000	201,000	0.0012	18,182,000
NR1LW1ISL1SAVSCL2RH1	1.00	1,535,000	1,542,000	16,000	0.0009	18,308,000
NR1LW1ISL1SAVSCL1RH1	1.00	1,625,000	1,625,000	90,000	0.0042	21,673,000

Table B-23. RESULTS OF 100 PERCENT COST INCREASE ON SAV/SCALLOPS INCREMENTAL COST ANALYSIS

Plan Alternative	Score (Output)	Cost	Average Cost	Incremental Cost	Inc. Output	Inc. Cost Per Output
No Action Plan	0.00	0.00				
NR0LW0ISL0SAVSCL2RH0	0.48	342,000	707,000	342,000	0.4845	707,000
NR0LW0ISL0SAVSCL2RH5	0.64	578,0.00	903,000	236,000	0.1561	1,512,000
NR0LW0ISL0SAVSCL2RH2	0.78	921,000	1,182,000	343,000	0.1387	2,471,000
NR0LW0ISL0SAVSCL2RH1	0.94	1,375,0.00	1,456,000	454,000	0.1654	2,745,000
NR0LW0ISL1SAVSCL2RH1	0.99	1,584,000	1,594,000	209,000	0.0493	4,245,000
NR0LW1ISL1SAVSCL2RH1	0.99	1,605,000	1,613,000	21,0000	0.0012	18,182,000
NR1LW1ISL1SAVSCL2RH1	1.00	1,621,000	1,628,000	16,000	0.0009	18,308,000
NR1LW1ISL1SAVSCL1RFH1	1.00	1,741,000	1,741,000	120,000	0.0042	28,898,000

Table B-24. RESULTS OF 50 PERCENT COST INCREASE ON REEF HABITAT INCREMENTAL COST ANALYSIS

Plan Alternative	Score (Output)	Cost	Average Cost	Incremental Cost	Inc. Output	Inc. Cost per Output
No Action Plan	0.00	0.00				
NR0LW0ISL0SAVSCL2RH0	0.48	171,000	353,000	171,000	0.4845	353,000
NR0LW0ISL0SAVSCL2RH5	0.64	525,000	820,000	354,000	0.1561	2,268,000
NR0LW0ISL0SAVSCL2RH2	0.78	1,039,000	1,3334,000	514,000	0.1387	3,706,000
NR0LW0ISL0SAVSCL2RH1	0.94	1,720,000	1,821,000	681,000	0.1654	4,118,000
NR0LW0ISL1SAVSCL2RH1	0.99	1,929,000	1,941,000	209,000	0.0493	4,245,000
NR0LW0ISL1SAVSCL1RH1	1.00	1,989,000	1,993,000	60,000	0.0042	14,449,000
NR0LW1ISL1SAVSCL1RH1	1.00	2,010,000	2,012,000	21,000	0.0012	18,182,000
NR1LW1ISL1SAVSCL1RH1	1.00	2,026,000	2,026,000	16,000	0.0009	18,308,000

Table B-25. RESULTS OF WETLANDS SENSITIVITY INCREMENTAL COST ANALYSIS

Plan Alternative	Wetland Function (Output)	Cost	Average Cost	Incremental Cost	Inc. Output	Inc. Cost per Output
No Action Plan	0.00	0.00				
PA0SG0MD1NG0	66.00	2,400	36.8788	2,400	66.0000	36
PA0SG1MD1NG0	141.00	20,800	147.1702	18,300	75.0000	244
PA0SG1MD1NG1	193.00	45,600	236.4948	24,900	52.0000	479
PA1SG1MD1NG1	278.00	101,400	364.6844	55,700	85.0000	656

APPENDIX C

ENVIRONMENTAL

APPENDIX C

ENVIRONMENTAL

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES
(cont)

APPENDIX C

ENVIRONMENTAL

PURPOSE

The purpose of this appendix is to provide detailed environmental information concerning aspects of the study area. More specifically, it includes tables referenced in the main body of the report, the Section 404(b)(1) evaluation, the NMFS essential fish habitat designations analysis, the adaptive management plan, the coastal zone management summary and the USFWS coordination act report.

TABLES

This section includes tables which have been referenced in the main body of the report. The tables describe the fauna that resides within the Lynnhaven River Basin.

Table C-1. INVERTEBRATES COLLECTED FROM SITES LOCATED IN THE LYNNHAVEN SYSTEM

		Study				
		Dauer *et al*	Touretellotte & Dauer	Dauer *et al*	Dauer *et al*	Dauer
Taxonomic Group	Scientific Name	1979	1983	1982a	1982b	2007
Cnidaria : Anthozoa	*Anthozoa spp.*					X
	Edwardsia elegans					X
	Haliplanella luciae				X	
Platyhelminthes : Turbellaria	*Stylochus ellipticus*					X
	Turbellaria spp.					X
Nemertea	*Nemertea spp.*		X			X
Annelida: Polychaeta	*Ancistrosyllis hartmanae*					X
	Ancistrosyllis jonesi					X
	Ancistrosyllis spp.					
	Ampharete americana					
	Apoprionospio pygmaea					X
	Arabella iricolor					X
	Asabellides oculata					
	Bhawania heteroseta					X
	Brania clavata					X
	Cabira incerta					X
	Capitella spp.		X			
	Capitella capitata	X	X			X
	Capitellid spp.		X			

Table C-1. INVERTEBRATES COLLECTED FROM SITES LOCATED IN THE LYNNHAVEN SYSTEM (Cont'd)

		Study				
		Dauer *et al*	Touretellotte & Dauer	Dauer *et al*	Dauer *et al*	Dauer
Taxonomic Group	Scientific Name	1979	1983	1982a	1982b	2007
Annelida: Polychaeta	*Capitella capitata*	X	X			X
	Capitellid spp.		X			
	Carazziella hobsonae					X
	Caulleriella killariensis					X
	Caulleriella sp.		X			
	Chautozone sp.					
	Cirrophorus furcatus					X
	Cirratulidae sp.					
	Cistena gouldii		X			
	Clymenella torquata		X	X	X	X
	Demonax microphthalmus					X
	Diopatra cuprea					X
	Dorvillea rudolphi					X
	Drilonereis longa					X
	Eteone heteropoda		X	X	X	X
	Eteone lactea					X
	Exogone dispar					X
	Glycera americana					X
	Glucera capitata		X			

C-1. INVERTEBRATES COLLECTED FROM SITES LOCATED IN THE LYNNHAVEN SYSTEM (Cont'd)

		Study				
		Dauer *et al*	Touretellotte & Dauer	Dauer *et al*	Dauer *et al*	Dauer
Taxonomic Group	Scientific Name	1979	1983	1982a	1982b	2007
Annelida: Polychaeta	*Glycera dibranchiata*		X			X
	Glycera spp.					X
	Glycinde solitaria		X	X		X
	Gyptis brevipalpa		X			
	Gyptis crypta					X
	Gyptis vittata			X	X	
	Harmothoe extenuata				X	
	Hauchiella sp.					X
	Heteromastus filiformis	X	X	X	X	X
	Hobsonia florida					X
	Hydroides dianthus		X		X	X
	Laeonereis culveri	X				X
	Leitoscoloplos spp.					
	Lepidonotus sublevis					X
	Loimia medusa					X
	Lysippides greyi					
	Macroclymene zonalis					X
	Magelona sp.					X
	Maldanidae spp.					X

C-1. INVERTEBRATES COLLECTED FROM SITES LOCATED IN THE LYNNHAVEN SYSTEM (Cont'd)

		Study				
		Dauer *et al*	Touretellotte & Dauer	Dauer *et al*	Dauer *et al*	Dauer
Taxonomic group	Scientific name	1979	1983	1982a	1982b	2007
Annelida: Polychaeta	*Malmgreniella taylori*					X
	Marenzelleria viridis					X
	Mediomastus ambiseta		X	X	X	X
	Microphthalmus aberrans					
	Microphthalmus similis		X			
	Nereis succinea	X	X	X	X	X
	Nephtys bucera					X
	Nephtys picta					X
	Notomastus sp. A Ewing					X
	Ophelia bicornia		X			
	Paraonis fulgens		X			X
	Parapionosyllis longicirrata		X			X
	Paraprionospio pinnata		X			X
	Pectinaria gouldii					X
	Peloscolex gabriellae	X				
	Phyllodoce arenae		X			X
	Podarke obcura		X		X	
	Podarkeopsis levifuscina					X
	Polydora cornuta					X
	Polydora lingi		X	X	X	

C-1. INVERTEBRATES COLLECTED FROM SITES LOCATED IN THE LYNNHAVEN SYSTEM (Cont'd)

		Study				
		Dauer *et al*	Touretellotte & Dauer	Dauer *et al*	Dauer *et al*	Dauer
Taxonomic group	Scientific name	1979	1983	1982a	1982b	2007
Annelida: Polychaeta	*Polydora websteri*				X	
	Potamilla sp.		X			
	Prionospio perkinsi					X
	Pseudoeurythoe ambigua					
	Sabaco elongatus					X
	Sabella microphthalma				X	
	Sabellaria vulgaris		X		X	X
	Schistomeringos rudolphi		X		X	
	Scolecolepides viridis		X			
	Scolelepis texana					X
	Scoloplos fragilis			X		X
	Scoletoma tenuis					X
	Sigambra tentaculata					X
	Sphaerosyllis hystrix		X			
	Spiochaetopterus costarum					X
	Spiochaetopterus oculatus			X		
	Spiophanes bombyx		X			X
	Streblospio benedicti	X	X	X	X	X
	Streptosyllis sp.		X			
	Strio pettiboneae					X

C-1. INVERTEBRATES COLLECTED FROM SITES LOCATED IN THE LYNNHAVEN SYSTEM (Cont'd)

		Study				
		Dauer *et al*	Touretellotte & Dauer	Dauer *et al*	Dauer *et al*	Dauer
Taxonomic group	Scientific name	1979	1983	1982a	1982b	2007
Annelida: Polychaeta	*Streptosyllis sp.*		X			
	Strio pettiboneae					X
	Syllides fulva					X
	Syllides verrilli				X	
	Travisia spp.			X	X	
	Travisia spp.					X
Annelida : Oligochaeta	*Oligochaeta spp.*					X
	Peloscolex gabriellae					
	Tubificoides heterochaetus					X
	Tubificoides sp.		X			
	Tubificoides spp. Group I					X
	Tubificoides wasselli					X
Mollusca: Gastropod	*Acteocina canaliculata*					X
	Crepidula fornicata				X	X
	Doridella obscura					X
	Gastropoda spp.					X
	Haminoea solitaria					X
	Ilyanassa obsoleta		X		X	X
	Mitrella lunata				X	

C-1. INVERTEBRATES COLLECTED FROM SITES LOCATED IN THE LYNNHAVEN SYSTEM (Cont'd)

		Study				
		Dauer *et al*	Touretellotte & Dauer	Dauer *et al*	Dauer *et al*	Dauer
Taxonomic group	Scientific name	1979	1983	1982a	1982b	2007
Mollusca: Gastropod	*Nassarius vibex*					X
	Nudibranchia spp.					X
	Odostomia spp.					X
	Polinices duplicata					X
	Rictaxis punctostriatus					X
	Sphaerosyllis taylori					X
Mollusca : Bivalvia	*Aligena elevata*					X
	Bivalvia spp.					X
	Cyrtopleura costata					X
	Gemma gemma		X			X
	Macoma balthica	X				X
	Macoma mitchelli					X
	Macoma tenta					X
	Mercenaria mercenaria					X
	Mulinia lateralis			X		X
	Mya arenaria	X				
	Mysella planulata					X
	Tagelus divisus					X
	Tagelus plebeius	X				X
	Tellina agilis		X	X		X

C-1. INVERTEBRATES COLLECTED FROM SITES LOCATED IN THE LYNNHAVEN SYSTEM (Cont'd)

		Study				
		Dauer *et al*	Touretellotte & Dauer	Dauer *et al*	Dauer *et al*	Dauer
Taxonomic group	Scientific name	1979	1983	1982a	1982b	2007
Mollusca : Bivalvia	*Tellinidae spp.*					X
Arthropoda: Isopoda	*Chiridotea nigrescens*		X			X
	Cyathura polita					X
	Edotea triloba				X	X
	Erichsonella sp.				X	
	Ptilanthura tenuis					X
Arthropoda: Amphipoda	*Acanthohaustorius intermedius*		X			X
	Acanthohaustorius millsi		X			X
	Ameroculodes species complex					X
	Ampelisca abdita					
	Ampelisca spp.					X
	Ampelisca verrilli					X
	Ampithoe valida					X
	Caprella penantis		X			
	Caprella sp.				X	
	Cerapus tubularis					X
	Corophium lacustre					X
	Corophium sp.					
	Corophium tuberculatum		X		X	
	Cymadusa compta				X	

C-1. INVERTEBRATES COLLECTED FROM SITES LOCATED IN THE LYNNHAVEN SYSTEM (Cont'd)

		Study				
		Dauer *et al*	Touretellotte & Dauer	Dauer *et al*	Dauer *et al*	Dauer
Taxonomic group	Scientific name	1979	1983	1982a	1982b	2007
Arthropoda: Amphipoda	*Elasmopus levis*				X	
	Erichthonius brasiliensis		X		X	X
	Gammarus mucronatus				X	
	Leptocheirus plumulosus				X	
	Listriella barnardi					X
	Listriella clymenellae		X			X
	Monocorophium tuberculatum					X
	Paracaprella tenuis		X			X
	Parametopella cypris		X			
	Protohaustorius deichmannae		X			
	Unicola serrata		X			
Arthropoda : Cumacea	*Cyclaspis varians*		X			X
	Leucon americanus					X
Arthropoda: Decapoda	*Alpheus heterochaelis*					X
	Callinectes sapidus			X	X	X
	Hippolyte pleuracanthus					X
	Ogyrides alphaerostris					X
	Palaemonetes pugio			X		
	Pagurus acadianus					X
	Pagurus longicarpus					X

C-1. INVERTEBRATES COLLECTED FROM SITES LOCATED IN THE LYNNHAVEN SYSTEM (Cont'd)

		Study				
		Dauer *et al*	Touretellotte & Dauer	Dauer *et al*	Dauer *et al*	Dauer
Taxonomic group	Scientific name	1979	1983	1982a	1982b	2007
	Pinnixa spp.					X
Arthropoda : Mysidacea	*Mysidopsis bigelowi*					X
Arthropoda: Tanaidacea	*Leptognatha caeca*					X
Phoronida	*Phoronis psammophila*			X		
	Phoronis spp.					X
Echinodermata : Holothuroidea	*Leptosynapta tenuis*					X
Echinodermata : Ophiuroidea	*Microphiopholis atra*					X
Chordata: Hemichordata	*Hemichordata spp.*					X
	Saccoglossus kowalevskii					X
Chordata : Cephalochordata	*Branchiostoma virginae*		X			X
Chordata : Urochordata	*Molgula lutlulenta*					X
	Molgula manhattensis		X		X	

Source: Dauer, D.M., W.W. Robinson, C.P. Seymour, and A.T. Leggett, Jr. 1979. Effects of nonpoint pollution on benthic invertebrates in the Lynnhaven River system. Bulletin of Virginia Water Resource Center 117:112, Tourtellotte, G.H. and D.M. Dauer. 1983. Macrobenthic communities of the lower Chesapeake Bay. II. Lynnhaven Roads, Lynnhaven River, Broad Bay, and Linkhorn Bay. Internationale Revue der gesamten Hydrobiologie (International Review of Hydrobiology) 68:59-72, Dauer, D.M., R.M. Ewing, G.H. Tourtellotte, W.T. Harlan, J.W. Sourbeer and H. R. Barker Jr. 1982a. Predation, resource limitation and the structure of benthic infaunal communities of the lower Chesapeake Bay. Internationale Revue der gesamten Hydrobiologie (International Review of Hydrobiology) 67(4):477-489, Dauer, D.M., G.H. Tourtellotte, and R.M. ewing. 1982b. Oyster shells and artificial worm tubes: The role of refuges in structuring benthic communities of the lower Chesapeake Bay. Internationale Revue der gesamten Hydrobiologie (International Review of Hydrobiology) 67(5):661-677, Dauer, D.M., 2007. Benthic biological monitoring of the Lynnhaven River. Old Dominion University, Norfolk VA.

Table C-2. MACROINVERTEBRATES OCCURRING OR POTENTIALLY OCCURRING WITHIN A 3 MILE RADIUS OF THE LYNNHAVEN RIVER INLET

COMMON NAME	SCIENTIFIC NAME
Mussel, eastern elliptio	*Elliptio complanata*
Crayfish	*Fallicambarus uhleri*
Crayfish	*Fallicambarus fodiens*
Crayfish, devil	*Cambarus diogenes diogenes*
Crayfish, no common name	*Cambarus acuminatus*
Crayfish, White River	*Procambarus acutus*

Source: VDGIF Online Database (latitude 36°51′59.7″ and longitude 76°03′ 54.9″), 2010.

Table C-3. FISH OCCURING OR POTENTIALLY OCCURRING WITHIN A 3 MILE RADIUS OF THE LYNNHAVEN RIVER INLET

COMMON NAME	SCIENTIFIC NAME
Bass, largemouth	*Micropterus salmoides*
Bass, smallmouth	*Micropterus dolomieu*
Bass, striped	*Morone saxatilis*
Bass, white	*Morone chrysops*
Bluegill	*Lepomis macrochirus*
Bowfin	*Amia calva*
Bullhead, brown	*Ameiurus nebulosus*
Bullhead, yellow	*Ameiurus natalis*
Carp, common	*Cyprinus carpio*
Catfish, channel	*Ictalurus punctatus*
Catfish, white	*Ameiurus catus*
Crappie, black	*Pomoxis nigromaculatus*
Dace, rosyside	*Clinostomus funduloides*
Darter, swamp	*Etheostoma fusiforme*
Gar, longnose	*Lepisosteus osseus*
Killifish, banded	*Fundulus diaphanus*
Killifish, marsh	*Fundulus confluentus*
Lamprey, sea	*Petromyzon marinus*
Minnow, eastern silvery	*Hybognathus regius*
Mosquitofish, eastern	*Gambusia holbrooki*
Mudminnow, eastern	*Umbra pygmaea*
Perch, white	*Morone americana*
Perch, yellow	*Perca flavescens*
Pickerel, chain	*Esox niger*
Pickerel, redfin	*Esox americanus americanus*
Pumpkinseed	*Lepomis gibbosus*
Shad, gizzard	*Dorosoma cepedianum*
Shad, threadfin	*Dorosoma petenense*
Shiner, golden	*Notemigonus crysoleucas*
Sunfish, bluespotted	*Enneacanthus gloriosus*
Sunfish, redear	*Lepomis microlophus*
Walleye	*Sander vitreus vitreus*
Warmouth	*Lepomis gulosus*

Source: VDGIF Online Database (latitude 36°54′28.1″ and longitude 76°05′ 29.4″), 2010.

Table C-4. FISH ASSEMBLAGES FOUND IN TIDAL CREEKS SURVEYED IN THE LYNNHAVEN RIVER,

COMMON NAME	SCIENTIFIC NAME
Atlantic Silverside	*Menidia menidia*
Bay anchovy	*Anchoa mitchilli*
Silver perch	*Bairdiella chrysoura*
Gizzard shad	*Dorosoma cepedianum*
Atlantic menhaden	*Brevoortia tyrannus*
Mummichog	*Fundulus heteroclitus*
Blue Crab	*Callinectes sapidus*
Spot	*Leiostomus xanthurus*
Striped mullet	*Mugil cephalus*
Striped anchovy	*Anchoa hepsetus*
Atlantic croaker	*Micropogonias undulatus*
Red drum	*Sciaenops ocellatus*
White perch	*Marone americana*
Striped killifish	*Fundulus majalis*
Spotfin mojarra	*Eucinostomus argenteus*
American eel	*Anguilla rostrata*
Striped bass	*Morone saxatilis*
Summer flounder	*Paralichthys dentatus*
Naked goby	*Gobiosoma bosc*
Blackcheek tonguefish	*Symphurus plagiusa*
Bluefish	*Pomatomus saltatrix*
Permit	*Trachinottus falcatus*
Sheepshead minnow	*Cyprinodon variegatus*
Crevalle jack	*Caranx hippos*
Hogchoker	*Trinectes maculatus*
Ladyfish	*Elops saurus*
Sharptail goby	*Gobionellus oceanicus*
Spotted seatrout	*Cynoscion nebulosus*
Tripletail	*Lobotes surinamensis*
Weakfish	*Cynoscion regalis*

Source: Bilkovic D. M., D. Stanhope and K. Angstadt. 2007. Shallow water fish communities and coastal development stressors in the Lynnhaven River. Virginia Institute of Marine Science, School of Marine Science, College of William and Mary, Gloucester Point, VA.

Table C-5. AVIAN RESOURCES OCCURRING OR POTENTIALLY OCCURRING WITHIN A 3 MILE RADIUS OF THE LYNNHAVEN RIVER INLET

COMMON NAME	SCIENTIFIC NAME
Anhinga	*Anhinga anhinga*
Avocet, American	*Recurvirostra americana*
Blackbird, Brewer's	*Euphagus cyanocephalus*
Blackbird, red-winged	*Agelaius phoeniceus*
Blackbird, yellow-headed	*Xanthocephalus xanthocephalus*
Bluebird, eastern	*Sialia sialis*
Bobolink	*Dolichonyx oryzivorus*
Bufflehead	*Bucephala albeola*
Bunting, indigo	*Passerina cyanea*
Bunting, lark	*Calamospiza melanocorys*
Bunting, Lazuli	*Passerina amoena*
Bunting, painted	*Passerina ciris ciris*
Bunting, snow	*Plectrophenax nivalis nivalis*
Canvasback	*Aythya valisineria*
Cardinal, northern	*Cardinalis cardinalis*
Chickadee, Carolina	*Poecile carolinensis*
Coot, American	*Fulica americana*
Cormorant, double-crested	*Phalacrocorax auritus*
Cormorant, great	*Phalacrocorax carbo*
Cowbird, brown-headed	*Molothrus ater*
Crossbill, white-winged	*Loxia leucoptera*
Crow, American	*Corvus brachyrhynchos*
Crow, fish	*Corvus ossifragus*
Cuckoo, black-billed	*Coccyzus erythropthalmus*
Curlew, long-billed	*Numenius americanus*
Dove, common ground	*Columbina passerina*
Dove, mourning	*Zenaida macroura carolinensis*
Dovekie	*Alle alle*
Dowitcher, long-billed	*Limnodromus scolopaceus*
Duck, Harlequin	*Histrionicus histrionicus*
Duck, long-tailed	*Clangula hyemalis*
Duck, ring-necked	*Aythya collaris*
Duck, ruddy	*Oxyura jamaicensis*
Duck, wood	*Aix sponsa*
Eagle, golden	*Aquila chrysaetos*
Egret, cattle	*Bubulcus ibis*
Egret, reddish	*Egretta rufescens rufescens*
Egret, snowy	*Egretta thula*
Eider, common	*Somateria mollissima*
Eider, king	*Somateria spectabilis*
Finch, house	*Carpodacus mexicanus*

Table C.5. AVIAN RESOURCES OCCURRING OR POTENTIALLY OCCURRING WITHIN A 3 MILE RADIUS OF THE LYNNHAVEN RIVER INLET (Cont'd)

COMMON NAME	SCIENTIFIC NAME
Flamingo, greater	*Phoenicopterus ruber*
Flicker, northern	*Colaptes auratus*
Flycatcher, ash-throated	*Myiarchus cinerascens*
Flycatcher, great crested	*Myiarchus crinitus*
Flycatcher, scissor-tailed	*Tyrannus forficatus*
Frigatebird, magnificent	*Fregata magnificens*
Fulmar, northern	*Fulmarus glacialis*
Gadwall	*Anas strepera*
Gallinule, purple	*Porphyrula martinica*
Gannet, northern	*Morus bassanus*
Gnatcatcher, blue-gray	*Polioptila caerulea*
Goldeneye, common	*Bucephala clangula americana*
Goldfinch, American	*Carduelis tristis*
Goose, Canada	*Branta canadensis*
Goose, greater white-fronted	*Anser albifrons flavirostris*
Goose, lesser snow	*Chen caerulescens caerulescens*
Goose, Ross'	*Chen rossii*
Goose, snow	*Chen caerulescens*
Grackle, boat-tailed	*Quiscalus major*
Grackle, common	*Quiscalus quiscula*
Grebe, eared	*Podiceps nigricollis*
Grebe, pied-billed	*Podilymbus podiceps*
Grebe, red-necked	*Podiceps grisegena*
Grebe, western	*Aechmophorus occidentalis*
Grosbeak, black-headed	*Pheucticus melanocephalus*
Grosbeak, blue	*Guiraca caerulea caerulea*
Grosbeak, evening	*Coccothraustes vespertinus*
Gull, black-headed	*Larus ridibundus*
Gull, Bonaparte's	*Larus philadelphia*
Gull, Franklin's	*Larus pipixcan*
Gull, glaucous	*Larus hyperboreus*
Gull, great black-backed	*Larus marinus*
Gull, herring	*Larus argentatus*
Gull, Iceland	*Larus glaucoides*
Gull, laughing	*Larus atricilla*
Gull, lesser black-backed	*Larus fuscus*
Gull, little	*Larus minutus*
Gull, ring-billed	*Larus delawarensis*
Gull, Sabine's	*Xema sabini*
Hawk, Cooper's	*Accipiter cooperii*

Table C-5. AVIAN RESOURCES OCCURRING OR POTENTIALLY OCCURRING WITHIN A 3 MILE RADIUS OF THE LYNNHAVEN RIVER INLET (Cont'd)

COMMON NAME	SCIENTIFIC NAME
Hawk, red-shouldered	*Buteo lineatus lineatus*
Hawk, red-tailed	*Buteo jamaicensis*
Hawk, rough-legged	*Buteo lagopus johannis*
Hawk, sharp-shinned	*Accipiter striatus velox*
Heron, great blue	*Ardea herodias herodias*
Hummingbird, ruby-throated	*Archilochus colubris*
Ibis, white	*Eudocimus albus*
Jaeger, parasitic	*Stercorarius parasiticus*
Jaeger, pomarine	*Stercorarius pomarinus*
Jay, blue	*Cyanocitta cristata*
Junco, dark-eyed	*Junco hyemalis*
Kestrel, American	*Falco sparverius sparverius*
Killdeer	*Charadrius vociferus*
Kingbird, gray	*Tyrannus dominicensis*
Kingbird, western	*Tyrannus verticalis*
Kingfisher, belted	*Ceryle alcyon*
Kinglet, ruby-crowned	*Regulus calendula*
Kite, Mississippi	*Ictinia mississippiensis*
Kite, swallow-tailed	*Elanoides forficatus forficatus*
Kittiwake, black-legged	*Rissa tridactyla*
Lark, horned	*Eremophila alpestris*
Longspur, Lapland	*Calcarius lapponicus*
Loon, common	*Gavia immer*
Loon, red-throated	*Gavia stellata*
Mallard	*Anas platyrhynchos*
Martin, purple	*Progne subis*
Merganser, common	*Mergus merganser americanus*
Merganser, hooded	*Lophodytes cucullatus*
Merganser, red-breasted	*Mergus serrator serrator*
Merlin	*Falco columbarius*
Mockingbird, northern	*Mimus polyglottos*
Murre, thick-billed	*Uria lomvia*
Nighthawk, common	*Chordeiles minor*
Nuthatch, white-breasted	*Sitta carolinensis*
Oriole, Baltimore	*Icterus galbula*
Oriole, orchard	*Icterus spurius*
Osprey	*Pandion haliaetus carolinensis*
Owl, barred	*Strix varia*
Owl, great horned	*Bubo virginianus*
Owl, short-eared	*Asio flammeus*
Pelican, American white	*Pelecanus erythrorhynchos*
Phalarope, red	*Phalaropus fulicarius*
Phalarope, red-necked	*Phalaropus lobatus*
Phalarope, Wilson's	*Phalaropus tricolor*
Pheasant, ring-necked	*Phasianus colchicus*

Table C-5. AVIAN RESOURCES OCCURRING OR POTENTIALLY OCCURRING WITHIN A 3 MILE RADIUS OF THE LYNNHAVEN RIVER INLET (Cont'd)

COMMON NAME	SCIENTIFIC NAME
Phoebe, eastern	*Sayornis phoebe*
Phoebe, Say's	*Sayornis saya*
Pigeon, rock	*Columba livia*
Pintail, northern	*Anas acuta acuta*
Pintail, white-cheeked	*Anas bahamensis*
Pipit, American	*Anthus rubescens*
Plover, semipalmated	*Charadrius semipalmatus*
Puffin, Atlantic	*Fratercula artica*
Redpoll, common	*Carduelis flammea*
Redstart, American	*Setophaga ruticilla*
Robin, American	*Turdus migratorius*
Ruff	*Philomachus pugnax*
Sanderling	*Calidris alba*
Sandpiper, least	*Calidris minutilla*
Sandpiper, pectoral	*Calidris melanotos*
Sandpiper, semipalmated	*Calidris pusilla*
Sandpiper, spotted	*Actitis macularia*
Sandpiper, western	*Calidris mauri*
Scaup, lesser	*Aythya affinis*
Scoter, black	*Melanitta nigra americana*
Scoter, surf	*Melanitta perspicillata*
Scoter, white-winged	*Melanitta fusca deglandi*
Screech-owl, eastern	*Megascops asio*
Shearwater, Audubon's	*Puffinus lherminieri lherminieri*
Shearwater, Cory's	*Calonectris diomedea borealis*
Shearwater, greater	*Puffinus gravis*
Shearwater, sooty	*Puffinus griseus*
Shoveler, northern	*Anas clypeata*
Siskin, pine	*Carduelis pinus*
Snipe, common	*Gallinago gallinago*
Sora	*Porzana carolina*
Sparrow, American tree	*Spizella arborea*
Sparrow, black-throated	*Amphispiza bilineata*
Sparrow, chipping	*Spizella passerina*
Sparrow, clay-colored	*Spizella pallida*
Sparrow, fox	*Passerella iliaca*
Sparrow, house	*Passer domesticus*
Sparrow, lark	*Chondestes grammacus*
Sparrow, Le Conte's	*Ammodramus leconteii*
Sparrow, Lincoln's	*Melospiza lincolnii*
Sparrow, savannah	*Passerculus sandwichensis*
Sparrow, song	*Melospiza melodia*
Sparrow, swamp	*Melospiza georgiana*
Sparrow, vesper	*Pooecetes gramineus*
Sparrow, white-crowned	*Zonotrichia leucophrys*

Table C-5. AVIAN RESOURCES OCCURRING OR POTENTIALLY OCCURRING WITHIN A 3 MILE RADIUS OF THE LYNNHAVEN RIVER INLET (Cont'd)

COMMON NAME	SCIENTIFIC NAME
Sparrow, white-throated	*Zonotrichia albicollis*
Starling, European	*Sturnus vulgaris*
Stilt, black-necked	*Himantopus mexicanus*
Stint, Temminck's	*Calidris temminckii*
Stork, wood	*Mycteria americana*
Swallow, barn	*Hirundo rustica*
Swallow, tree	*Tachycineta bicolor*
Swan, tundra	*Cygnus columbianus columbianus*
Tanager, summer	*Piranga rubra*
Tanager, western	*Piranga ludoviciana*
Teal, blue-winged	*Anas discors orphna*
Teal, green-winged	*Anas crecca carolinensis*
Tern, Arctic	*Sterna paradisaea*
Tern, bridled	*Sterna anaethetus*
Thrush, Swainson's	*Catharus ustulatus*
Titmouse, tufted	*Baeolophus bicolor*
Towhee, green-tailed	*Pipilo chlorurus*
Turkey, wild	*Meleagris gallopavo silvestris*
Turnstone, ruddy	*Arenaria interpres morinella*
Veery	*Catharus fuscescens*
Vireo, blue-headed	*Vireo solitarius*
Vireo, red-eyed	*Vireo olivaceus*
Vireo, white-eyed	*Vireo griseus*
Vulture, black	*Coragyps atratus*
Vulture, turkey	*Cathartes aura*
Warbler, bay-breasted	*Dendroica castanea*
Warbler, black-throated blue	*Dendroica caerulescens*
Warbler, blackburnian	*Dendroica fusca*
Warbler, blackpoll	*Dendroica striata*
Warbler, chestnut-sided	*Dendroica pensylvanica*
Warbler, hooded	*Wilsonia citrina*
Warbler, Nashville	*Vermivora ruficapilla*
Warbler, orange-crowned	*Vermivora celata*
Warbler, palm	*Dendroica palmarum*
Warbler, pine	*Dendroica pinus*
Warbler, Wilson's	*Wilsonia pusilla*
Warbler, yellow-rumped	*Dendroica coronata cornata*
Warbler, yellow-throated	*Dendroica dominica*
Waterthrush, northern	*Seiurus noveboracensis*
Waxwing, cedar	*Bombycilla cedrorum*
Whistling-duck, fulvous	*Dendrocygna bicolor*
Wigeon, American	*Anas americana*
Wigeon, Eurasian	*Anas penelope*
Willet	*Catoptrophorus semipalmatus semipalmatus*

Table C-5. AVIAN RESOURCES OCCURRING OR POTENTIALLY OCCURRING WITHIN A 3 MILE RADIUS OF THE LYNNHAVEN RIVER INLET (Cont'd)

COMMON NAME	SCIENTIFIC NAME
Woodpecker, downy	*Picoides pubescens medianus*
Woodpecker, hairy	*Picoides villosus*
Woodpecker, pileated	*Dryocopus pileatus*
Woodpecker, red-bellied	*Melanerpes carolinus*
Woodpecker, red-headed	*Melanerpes erythrocephalus*
Wren, Carolina	*Thryothorus ludovicianus*
Wren, house	*Troglodytes aedon*
Yellowlegs, greater	*Tringa melanoleuca*
Yellowlegs, lesser	*Tringa flavipes*
Yellowthroat, common	*Geothlypis trichas*

Source: VDGIF Online Database (latitude 36°54′28.1″ and longitude 76°05′ 29.4″), 2010.

Table C-6. TERRESTRIAL MAMMALS OCCURRING OR POTENTIALLY OCCURRING WITHIN A 3 MILE RADIUS OF THE LYNNHAVEN RIVER INLET

COMMON NAME	SCIENTIFIC NAME
Bat, big brown	*Eptesicus fuscus fuscus*
Bat, eastern red	*Lasiurus borealis borealis*
Bat, evening	*Nycticeius humeralis humeralis*
Bat, hoary	*Lasiurus cinereus cinereus*
Bat, northern yellow	*Lasiurus intermedius floridanus*
Bat, seminole	*Lasiurus seminolus*
Bat, silver-haired	*Lasionycteris noctivagans*
Bear, black	*Ursus americanus americanus*
Beaver, American	*Castor canadensis*
Bobcat, Florida	*Lynx rufus floridanus*
Chipmunk, Fisher's eastern	*Tamias striatus fisheri*
Cottontail, eastern	*Sylvilagus floridanus mallurus*
Coyote	*Canis latrans*
Deer, white-tailed	*Odocoileus virginianus*
Fox, common gray	*Urocyon cinereoargenteus cinereoargenteus*
Fox, red	*Vulpes vulpes fulva*
Mink, common	*Mustela vison mink*
Mole, eastern	*Scalopus aquaticus aquaticus*
Mouse, common white-footed	*Peromyscus leucopus leucopus*
Mouse, eastern harvest	*Reithrodontomys humulis humulis*
Mouse, house	*Mus musculus musculus*
Mouse, Lewis' golden	*Ochrotomys nuttalli nuttalli*
Mouse, meadow jumping	*Zapus hudsonius americanus*
Muskrat, large-toothed	*Ondatra zibethicus macrodon*
Myotis, northern	*Myotis septentrionalis septentrionalis*
Nutria	*Myocastor coypus*
Opossum, Virginia	*Didelphis virginiana virginiana*
Pipistrelle, eastern	*Pipistrellus subflavus subflavus*
Raccoon	*Procyon lotor lotor*
Rat, black	*Rattus rattus rattus*
Rat, hispid cotton	*Sigmodon hispidus virginianus*
Rat, marsh rice	*Oryzomys palustris palustris*
Rat, Norway	*Rattus norvegicus norvegicus*
Shrew, Dismal Swamp short-tailed	*Blarina brevicauda telmalestes*
Shrew, least	*Cryptotis parva parva*
Shrew, pygmy	*Sorex hoyi winnemana*
Shrew, southeastern	*Sorex longirostris longirostris*
Shrew, southern short-tailed	*Blarina carolinensis carolinensis*
Skunk, striped	*Mephitis mephitis nigra*
Skunk, striped	*Mephitis mephitis mephitis*
Squirrel, eastern gray	*Sciurus carolinensis carolinensis*
Squirrel, southern flying	*Glaucomys volans volans*
Vole, dark meadow	*Microtus pennsylvanicus nigrans*
Vole, pine	*Microtus pinetorum scalopsoides*
Weasel, long-tailed	*Mustela frenata noveboracensis*

Source: VDGIF Online Database, 2010.

Table C-7. REPTILES AND AMPHIBIANS OCCURRING OR POTENTIALLY OCCURRING WITHIN A 3 MILE RADIUS OF THE LYNNHAVEN RIVER INLET

COMMON NAME	SCIENTIFIC NAME
Amphiuma, two-toed	*Amphiuma means*
Bullfrog, American	*Lithobates catesbeianus*
Frog, Brimley's chorus	*Pseudacris brimleyi*
Frog, coastal plain cricket	*Acris gryllus gryllus*
Frog, northern green	*Lithobates clamitans melanota*
Frog, southern leopard	*Lithobates sphenocephalus utricularius*
Newt, red-spotted	*Notophthalmus viridescens viridescens*
Peeper, northern spring	*Pseudacris crucifer crucifer*
Salamander, Atlantic Coast Slimy	*Plethodon chlorobryonis*
Salamander, eastern red-backed	*Plethodon cinereus*
Salamander, four-toed	*Hemidactylium scutatum*
Salamander, marbled	*Ambystoma opacum*
Salamander, northern dusky	*Desmognathus fuscus*
Salamander, southern dusky	*Desmognathus auriculatus*
Salamander, southern two-lined	*Eurycea cirrigera*
Salamander, three-lined	*Eurycea guttolineata*
Toad, eastern American	*Anaxyrus americanus americanus*
Toad, eastern narrow-mouthed	*Gastrophryne carolinensis*
Toad, Fowler's	*Anaxyrus fowleri*
Toad, southern	*Anaxyrus terrestris*
Treefrog, Cope's gray	*Hyla chrysoscelis*
Treefrog, green	*Hyla cinerea*
Treefrog, pine woods	*Hyla femoralis*
Treefrog, squirrel	*Hyla squirella*
Brownsnake, northern	*Storeria dekayi dekayi*
Cooter, Coastal Plain	*Pseudemys concinna floridana*
Cooter, northern red-bellied	*Pseudemys rubriventris*
Copperhead, northern	*Agkistrodon contortrix mokasen*
Cottonmouth, eastern	*Agkistrodon piscivorus piscivorus*
Earthsnake, eastern smooth	*Virginia valeriae valeriae*
Earthsnake, rough	*Virginia striatula*
Gartersnake, eastern	*Thamnophis sirtalis sirtalis*
Greensnake, northern rough	*Opheodrys aestivus aestivus*
Kingsnake, eastern	*Lampropeltis getula getula*
Lizard, eastern fence	*Sceloporus undulatus*
Milksnake, eastern	*Lampropeltis triangulum triangulum*
Racer, northern black	*Coluber constrictor constrictor*
Racerunner, eastern six-lined	*Aspidoscelis sexlineata sexlineata*
Ratsnake, eastern	*Pantherophis alleghaniensis*
Skink, broad-headed	*Plestiodon laticeps*
Skink, common five-lined	*Plestiodon fasciatus*
Skink, little brown	*Scincella lateralis*
Skink, southeastern five-lined	*Plestiodon inexpectatus*
Snake, northern red-bellied	*Storeria occipitomaculata occipitomaculata*
Snake, northern ring-necked	*Diadophis punctatus edwardsii*

Table C-7. REPTILES AND AMPHIBIANS OCCURRING OR POTENTIALLY OCCURRING WITHIN A 3 MILE RADIUS OF THE LYNNHAVEN RIVER INLET (Cont'd)

COMMON NAME	SCIENTIFIC NAME
Snake, southern ring-necked	*Diadophis punctatus punctatus*
Stinkpot	Sternotherus odoratus
Turtle, eastern mud	Kinosternon subrubrum subrubrum
Turtle, eastern painted	Chrysemys picta picta
Turtle, eastern snapping	Chelydra serpentina serpentina
Turtle, striped mud	Kinosternon baurii
Watersnake, brown	Nerodia taxispilota
Watersnake, northern	Nerodia sipedon sipedon
Watersnake, red-bellied	Nerodia erythrogaster erythrogaster
Wormsnake, eastern	Carphophis amoenus amoenus

Source: VDGIF Online Database (latitude 36°51′59.7″ and longitude 76°03′ 54.9″), 2010.

Table C-8. INSECTS AND ARACHNIDS OCCURRING OR POTENTIALLY OCCURRING WITHIN A 3 MILE RADIUS OF THE LYNNHAVEN RIVER INLET

COMMON NAME	SCIENTIFIC NAME
Armyworm	*Pseudaletia unipuncta*
Borer, European corn	*Ostrinia nubilatis*
Butterfly, Aaron's skipper	*Poanes aaroni*
Butterfly, American copper	*Lycaena phlaeas*
Butterfly, American lady	*Vanessa virginiensis*
Butterfly, American snout	*Libytheana carinenta*
Butterfly, banded hairstreak	*Satyrium calanus*
Butterfly, black swallowtail	*Papilio polyxenes asterius*
Butterfly, Brazilian skipper	*Calpodes ethlius*
Butterfly, broad-winged skipper	*Poanes viator*
Butterfly, brown elfin	*Callophrys augustinus*
Butterfly, cabbage white	*Pieris rapae*
Butterfly, Carolina road-skipper	*Amblyscirtes carolina*
Butterfly, Carolina satyr	*Hermeuptychia sosybius*
Butterfly, checkered white	*Pontia protodice*
Butterfly, clouded skipper	*Lerema accius*
Butterfly, clouded sulphur	*Colias philodice*
Butterfly, cloudless sulphur	*Phoebis sennae eubule*
Butterfly, common buckeye	*Junonia coenia*
Butterfly, common checkered-skipper	*Pyrgus communis*
Butterfly, common sootywing	*Pholisora catullus*
Butterfly, common wood-nymph	*Cercyonis pegala*
Butterfly, confused cloudywing	*Thorybes confusis*
Butterfly, creole pearly-eye	*Enodia creola*
Butterfly, crossline skipper	*Polites origenes*
Butterfly, Delaware skipper	*Anatrytone logan*
Butterfly, Dion skipper	*Euphyes dion*
Butterfly, Dun skipper	*Euphyes vestris*
Butterfly, dusted skipper	*Atrytonopsis hianna*
Butterfly, eastern comma	*Polygonia comma*
Butterfly, eastern pine elfin	*Callophrys niphon*
Butterfly, eastern tailed-blue	*Everes comyntas*
Butterfly, eastern tiger swallowtail	*Papilio glaucus*
Butterfly, Eufala skipper	*Lerodea eufala*
Butterfly, falcate orangetip	*Anthocharis midea*
Butterfly, fiery skipper	*Hylephila phyleus*
Butterfly, gemmed satyr	*Cyllopsis gemma*
Butterfly, giant swallowtail	*Papilio cresphontes*

Table C-8. INSECTS AND ARACHNIDS OCCURRING OR POTENTIALLY OCCURRING WITHIN A 3 MILE RADIUS OF THE LYNNHAVEN RIVER INLET (Cont'd)

COMMON NAME	SCIENTIFIC NAME
Butterfly, gray hairstreak	*Strymon melinus*
Butterfly, great purple hairstreak	*Atlides halesus*
Butterfly, great spangled fritillary	*Speyeria cybele*
Butterfly, gulf fritillary	*Agraulis vanillae nigrior*
Butterfly, Hayhurst's scallopwing	*Staphylus hayhurstii*
Butterfly, Henry's elfin	*Callophrys henrici*
Butterfly, hoary edge	*Achalarus lyciades*
Butterfly, Hobomok skipper	*Poanes hobomok*
Butterfly, Horace's duskywing	*Erynnis horatius*
Butterfly, Juvenal's duskywing	*Erynnis juvenalis*
Butterfly, lace-winged road-skipper	*Amblyscirtes aesculapius*
Butterfly, least skipper	*Ancyloxypha numitor*
Butterfly, little glassywing	*Pompeius verna*
Butterfly, little wood-satyr	*Megisto cymela*
Butterfly, little yellow	*Eurema lisa*
Butterfly, long-tailed skipper	*Urbanus proteus*
Butterfly, monarch	*Danaus plexippus*
Butterfly, mourning cloak	*Nymphalis antiopa*
Butterfly, northern broken dash	*Wallengrenia egeremet*
Butterfly, northern cloudywing	*Thorybes pylades*
Butterfly, Ocola skipper	*Panoquina ocola*
Butterfly, olive juniper hairstreak	*Callophrys gryneus gryneus*
Butterfly, orange sulphur	*Colias eurytheme*
Butterfly, painted lady	*Vanessa cardui*
Butterfly, Palamedes swallowtail	*Papilio palamedes*
Butterfly, pearl crescent	*Phyciodes tharos*
Butterfly, pipevine swallowtail	*Battus philenor*
Butterfly, question mark	*Polygonia interrogationis*
Butterfly, red admiral	*Vanessa atalanta*
Butterfly, red-banded hairstreak	*Calycopis cecrops*
Butterfly, red-spotted purple	*Limenitis arthemis astyanax*
Butterfly, reversed road-skipper	*Amblyscirtes reversa*
Butterfly, sachem	*Atalopedes campestris*
Butterfly, salt marsh skipper	*Panoquina panoquin*
Butterfly, silver-spotted skipper	*Epargyreus clarus*
Butterfly, sleepy duskywing	*Erynnis brizo*
Butterfly, sleepy orange	*Eurema nicippe*

Table C-8. INSECTS AND ARACHNIDS OCCURRING OR POTENTIALLY OCCURRING WITHIN A 3 MILE RADIUS OF THE LYNNHAVEN RIVER INLET (Cont'd)

COMMON NAME	SCIENTIFIC NAME
Butterfly, southern broken dash	*Wallengrenia otho*
Butterfly, southern cloudywing	*Thorybes bathyllus*
Butterfly, southern hairstreak	*Satyrium favonius*
Butterfly, southern pearly-eye	*Enodia portlandia*
Butterfly, spicebush swallowtail	*Papilio troilus*
Butterfly, spring azure	*Celastrina ladon*
Butterfly, striped hairstreak	*Satyrium liparops*
Butterfly, swarthy skipper	*Nastra lherminier*
Butterfly, tawny emperor	*Asterocampa clyton*
Butterfly, tawny-edged skipper	*Polites themistocles*
Butterfly, variegated fritillary	*Euptoieta claudia*
Butterfly, viceroy	*Limenitis archippus*
Butterfly, white M hairstreak	*Parrhasius m-album*
Butterfly, Yehl skipper	*Poanes yehl*
Butterfly, Zabulon skipper	*Poanes zabulon*
Butterfly, Zarucco duskywing	*Erynnis zarucco*
Butterfly, zebra swallowtail	*Eurytides marcellus*
Deerfly	*Chrysops vittatus vittatus*
Earworm, corn	*Heliathis zea*
Gnat	*Culicoides debipalpis*
Gnat	*Culicoides stellifer*
Moth, codling	*Cydia pomonella*
Moth, gypsy	*Lymantria dispar*
Moth, pinkstriped oakworm	*Anisota virginiensis*
Moth, sweetbay silk	*Callosamia securifera*
Tick, American dog	*Dermacentor variabilis*
Tick, brown dog	*Rhipicephalus sanguineus*
Tick, lone star	*Amblyomma americanum*
Tick, rabbit	*Haemaphysalis leporispalustris*
Tick, winter	*Dermacentor albipictus*

Source: VDGIF Online Database (latitude 36°51′59.7″ and longitude 76°03′ 54.9″), 2010.

Table C-9. THREATENED AND ENDANGERED SPECIES AND SPECIES OF SPECIAL OCCURRING OR POTENTIALLY OCCURRING WITHIN A 3 MILE RADIUS OF THE LYNNHAVEN RIVER INLET

STATUS	COMMON NAME	SCIENTIFIC NAME
FE/SE	Woodpecker, red-cockaded	*Picoides borealis*
FE/SE	Tern, roseate	*Sterna dougallii dougallii*
FE/SE	Turtle, hawksbill (= carey) sea	*Eretmochelys imbricata*
FE/SE	Turtle, Kemp's (= Atlantic) Ridley sea	*Lepidochelys kempii*
FE/SE	Turtle, leatherback sea	*Dermochelys coriacea*
FT/ST	Turtle, loggerhead sea	*Caretta caretta*
FT/ST	Plover, piping	*Charadrius melodus*
FT/ST	Turtle, green sea	*Chelonia mydas*
SE	Turtle, eastern chicken	*Deirochelys reticularia reticularia*
SE	Plover, Wilson's	*Charadrius wilsonia*
SE	Bat, Rafinesque's eastern big-eared	*Corynorhinus rafinesquii macrotis*
SE	Rattlesnake, canebrake	*Crotalus horridus*
ST	Falcon, peregrine	*Falco peregrinus*
ST	Sandpiper, upland	*Bartramia longicauda*
ST	Shrike, loggerhead	*Lanius ludovicianus*
ST	Sparrow, Henslow's	*Ammodramus henslowii*
ST	Tern, gull-billed	*Sterna nilotica*
ST	Treefrog, barking	*Hyla gratiosa*
ST	Lizard, eastern glass	*Ophisaurus ventralis*
FS/ST	Eagle, bald	*Haliaeetus leucocephalus*
ST	Shrew, Dismal Swamp southeastern	*Sorex longirostris fisheri*
ST	Falcon, Arctic peregrine	*Falco peregrinus tundrius*
ST	Shrike, migrant loggerhead	*Lanius ludovicianus migrans*
FS	Spider, funnel-web	*Barronopsis jeffersi*
FS	Skipper, Duke's (or scarce swamp)	*Euphyes dukesi*
SS	Crossbill, red	*Loxia curvirostra*
SS	Sturgeon, Atlantic	*Acipenser oxyrinchus*
SS	Toad, oak	*Anaxyrus quercicus*
CC	Terrapin, northern diamond-backed	*Malaclemys terrapin terrapin*
SS	Heron, little blue	*Egretta caerulea caerulea*
SS	Owl, northern saw-whet	*Aegolius acadicus*
SS	Sparrow, saltmarsh sharp-tailed	*Ammodramus caudacutus*
SS	Tern, least	*Sterna antillarum*
SS	Warbler, Swainson's	*Limnothlypis swainsonii*
SS	Wren, winter	*Troglodytes troglodytes*
SS	Frog, carpenter	*Lithobates virgatipes*
CC	Turtle, spotted	*Clemmys guttata*
SS	Harrier, northern	*Circus cyaneus*
SS	Heron, tricolored	*Egretta tricolor*
SS	Ibis, glossy	*Plegadis falcinellus*
SS	Night-heron, yellow-crowned	*Nyctanassa violacea violacea*

Table C-9. THREATENED AND ENDANGERED SPECIES AND SPECIES OF SPECIAL OCCURRING OR POTENTIALLY OCCURRING WITHIN A 3 MILE RADIUS OF THE LYNNHAVEN RIVER INLET
(Cont'd)

STATUS	COMMON NAME	SCIENTIFIC NAME
SS	Owl, barn	*Tyto alba pratincola*
SS	Wren, sedge	*Cistothorus platensis*
SS	Creeper, brown	*Certhia americana*
SS	Tern, Forster's	*Sterna forsteri*
SS	Rabbit, marsh	*Sylvilagus palustris palustris*
SS	Dickcissel	*Spiza americana*
SS	Egret, great	*Ardea alba egretta*
SS	Finch, purple	*Carpodacus purpureus*
SS	Kinglet, golden-crowned	*Regulus satrapa*
SS	Moorhen, common	*Gallinula chloropus cachinnans*
SS	Nuthatch, red-breasted	*Sitta canadensis*
SS	Owl, long-eared	*Asio otus*
SS	Pelican, brown	*Pelecanus occidentalis carolinensis*
SS	Tern, Caspian	*Sterna caspia*
SS	Tern, sandwich	*Sterna sandvicensis acuflavidus*
SS	Thrush, hermit	*Catharus guttatus*
SS	Warbler, magnolia	*Dendroica magnolia*
SS	Mole, star-nosed	*Condylura cristata parva*
SS	Otter, northern river	*Lontra canadensis lataxina*

Source: VDGIF Online Database (latitude 36°54′28.1″ and longitude 76°05′ 29.4″), 2010.

KEY - FE=Federal Endangered; FT=Federal Threatened; SE=State Endangered; ST=State Threatened; FP=Federal Proposed; FC=Federal Candidate; FS=Federal Species of Concern; SC=State Candidate; CC=Collection Concern; SS=State Special Concern DEP = Depleted status under the Marine Mammal Protection Act (*status is not listed by VDGIF).

Table C-10. SPECIES IDENTIFIED BY THE VIRGINIA WILDLIFE ACTION PLAN OCCURRING OR POTENTIALLY OCCURRING WITHIN 3 MILE RADIUS OF THE LYNNHAVEN RIVER INLET

TIER	COMMON NAME	SCIENTIFIC NAME
I	Woodpecker, red-cockaded	*Picoides borealis*
IV	Tern, roseate	*Sterna dougallii dougallii*
I	Turtle, loggerhead sea	*Caretta caretta*
I	Plover, piping	*Charadrius melodus*
I	Turtle, eastern chicken	*Deirochelys reticularia reticularia*
I	Plover, Wilson's	*Charadrius wilsonia*
I	Bat, Rafinesque's eastern big-eared	*Corynorhinus rafinesquii macrotis*
II	Rattlesnake, canebrake	*Crotalus horridus*
I	Falcon, peregrine	*Falco peregrinus*
I	Sandpiper, upland	*Bartramia longicauda*
I	Shrike, loggerhead	*Lanius ludovicianus*
I	Sparrow, Henslow's	*Ammodramus henslowii*
I	Tern, gull-billed	*Sterna nilotica*
II	Treefrog, barking	*Hyla gratiosa*
II	Lizard, eastern glass	*Ophisaurus ventralis*
II	Eagle, bald	*Haliaeetus leucocephalus*
IV	Shrew, Dismal Swamp southeastern	*Sorex longirostris fisheri*
II	Spider, Funnel-Web	*Barronopsis jeffersi*
III	Skipper, Duke's (or scarce swamp)	*Euphyes dukesi*
I	Crossbill, red	*Loxia curvirostra*
II	Sturgeon, Atlantic	*Acipenser oxyrinchus*
II	Toad, oak	*Anaxyrus quercicus*
II	Terrapin, northern diamond-backed	*Malaclemys terrapin terrapin*
II	Heron, little blue	*Egretta caerulea caerulea*
II	Owl, northern saw-whet	*Aegolius acadicus*
II	Sparrow, saltmarsh sharp-tailed	*Ammodramus caudacutus*
II	Tern, least	*Sterna antillarum*
II	Warbler, Swainson's	*Limnothlypis swainsonii*
II	Wren, winter	*Troglodytes troglodytes*
III	Frog, carpenter	*Lithobates virgatipes*
III	Turtle, spotted	*Clemmys guttata*
III	Harrier, northern	*Circus cyaneus*

Table C-10. SPECIES IDENTIFIED BY THE VIRGINIA WILDLIFE ACTION PLAN OCCURRING OR POTENTIALLY OCCURRING WITHIN A 3 MILE RADIUS OF THE LYNNHAVEN RIVER INLET (Cont'd)

TIER	COMMON NAME	SCIENTIFIC NAME
III	Heron, tricolored	*Egretta tricolor*
III	Ibis, glossy	*Plegadis falcinellus*
III	Night-heron, yellow-crowned	*Nyctanassa violacea violacea*
III	Owl, barn	*Tyto alba pratincola*
III	Wren, sedge	*Cistothorus platensis*
IV	Creeper, brown	*Certhia americana*
IV	Tern, Forster's	*Sterna forsteri*
IV	Rabbit, marsh	*Sylvilagus palustris palustris*
I	Rail, black	*Laterallus jamaicensis*
I	Sapsucker, yellow-bellied	*Sphyrapicus varius*
I	Warbler, black-throated green	*Dendroica virens*
I	Warbler, Wayne's	*Dendroica virens waynei*
II	Bittern, American	*Botaurus lentiginosus*
II	Duck, American black	*Anas rubripes*
II	Oystercatcher, American	*Haematopus palliatus*
II	Rail, king	*Rallus elegans*
II	Skimmer, black	*Rynchops niger*
II	Tern, royal	*Sterna maxima maximus*
II	Warbler, cerulean	*Dendroica cerulea*
III	Turtle, eastern box	*Terrapene carolina carolina*
III	Bittern, least	*Ixobrychus exilis exilis*
III	Brant	*Branta bernicla brota*
III	Night-heron, black-crowned	*Nycticorax nycticorax hoactii*
III	Redhead	*Aythya americana*
III	Sparrow, Nelson's sharp-tailed	*Ammodramus nelsoni*
III	Tern, common	*Sterna hirundo*
III	Mouse, Pungo white-footed	*Peromyscus leucopus easti*
III	Butterfly, Hessel's hairstreak	*Callophrys hesseli*
III	Butterfly, little metalmark	*Calephelis virginiensis*
III	Butterfly, mottled duskywing	*Erynnis martialis*
III	Butterfly, Palatka skipper	*Euphyes pilatka*
IV	Alewife	*Alosa pseudoharengus*
IV	Chubsucker, lake	*Erimyzon sucetta*
IV	Eel, American	*Anguilla rostrata*
IV	Shad, American	*Alosa sapidissima*
IV	Sunfish, banded	*Enneacanthus obesus*

Table C-10. SPECIES IDENTIFIED BY THE VIRGINIA WILDLIFE ACTION PLAN OCCURRING OR POTENTIALLY OCCURRING WITHIN A 3 MILE RADIUS OF THE LYNNHAVEN RIVER INLET
(Cont'd)

TIER	COMMON NAME	SCIENTIFIC NAME
IV	Sunfish, mud	*Acantharchus pomotis*
IV	Swampfish	*Chologaster cornuta*
IV	Frog, little grass	*Pseudacris ocularis*
IV	Salamander, eastern mud	*Pseudotriton montanus montanus*
IV	Salamander, many-lined	*Stereochilus marginatus*
IV	Siren, greater	*Siren lacertina*
IV	Spadefoot, eastern	*Scaphiopus holbrookii*
IV	Lizard, eastern slender glass	*Ophisaurus attenuatus longicaudus*
IV	Mudsnake, eastern	*Farancia abacura abacura*
IV	Ribbonsnake, common	*Thamnophis sauritus sauritus*
IV	Scarletsnake, northern	*Cemophora coccinea copei*
IV	Slider, yellow-bellied	*Trachemys scripta scripta*
IV	Snake, common rainbow	*Farancia erytrogramma erytrogramma*
IV	Snake, eastern hog-nosed	*Heterodon platirhinos*
IV	Blackbird, rusty	*Euphagus carolinus*
IV	Bobwhite, northern	*Colinus virginianus*
IV	Catbird, gray	*Dumetella carolinensis*
IV	Chat, yellow-breasted	*Icteria virens virens*
IV	Chuck-will's-widow	*Caprimulgus carolinensis*
IV	Cuckoo, yellow-billed	*Coccyzus americanus*
IV	Dowitcher, short-billed	*Limnodromus griseus*
IV	Dunlin	*Calidris alpina hudsonia*
IV	Flycatcher, willow	*Empidonax traillii*
IV	Godwit, Hudsonian	*Limosa haemastica*
IV	Godwit, marbled	*Limosa fedoa*
IV	Grebe, horned	*Podiceps auritus*
IV	Grosbeak, rose-breasted	*Pheucticus ludovicianus*
IV	Heron, green	*Butorides virescens*
IV	Kingbird, eastern	*Tyrannus tyrannus*
IV	Knot, red	*Calidris canutus rufus*
IV	Meadowlark, eastern	*Sturnella magna*
IV	Nuthatch, brown-headed	*Sitta pusilla*
IV	Ovenbird	*Seiurus aurocapilla*
IV	Parula, northern	*Parula americana*
IV	Pewee, eastern wood	*Contopus virens*
IV	Plover, black-bellied	*Pluvialis squatarola*

Table C-10. SPECIES IDENTIFIED BY THE VIRGINIA WILDLIFE ACTION PLAN OCCURRING OR POTENTIALLY OCCURRING WITHIN A 3 MILE RADIUS OF THE LYNNHAVEN RIVER INLET
(Cont'd)

TIER	COMMON NAME	SCIENTIFIC NAME
IV	Rail, clapper	*Rallus longirostris crepitans*
IV	Rail, Virginia	*Rallus limicola*
IV	Rail, yellow	*Coturnicops noveboracensis*
IV	Sandpiper, purple	*Calidris maritima*
IV	Scaup, greater	*Aythya marila*
IV	Sparrow, field	*Spizella pusilla*
IV	Sparrow, grasshopper	*Ammodramus savannarum pratensis*
IV	Sparrow, seaside	*Ammodramus maritimus*
IV	Swallow, northern rough-winged	*Stelgidopteryx serripennis*
IV	Swift, chimney	*Chaetura pelagica*
IV	Tanager, scarlet	*Piranga olivacea*
IV	Thrasher, brown	*Toxostoma rufum*
IV	Thrush, Bicknell's	*Catharus bicknelli*
IV	Thrush, wood	*Hylocichla mustelina*
IV	Towhee, eastern	*Pipilo erythrophthalmus*
IV	Vireo, yellow-throated	*Vireo flavifrons*
IV	Warbler, black-and-white	*Mniotilta varia*
IV	Warbler, blue-winged	*Vermivora pinus*
IV	Warbler, Canada	*Wilsonia canadensis*
IV	Warbler, Kentucky	*Oporornis formosus*
IV	Warbler, prairie	*Dendroica discolor*
IV	Warbler, prothonotary	*Protonotaria citrea*
IV	Warbler, worm-eating	*Helmitheros vermivorus*
IV	Warbler, yellow	*Dendroica petechia*
IV	Waterthrush, Louisiana	*Seiurus motacilla*
IV	Whimbrel	*Numenius phaeopus*
IV	Whip-poor-will	*Caprimulgus vociferus*
IV	Woodcock, American	*Scolopax minor*
IV	Wren, marsh	*Cistothorus palustris*
IV	Lemming, southern bog	*Synaptomys cooperi helaletes*
IV	Mouse, cotton	*Peromyscus gossypinus gossypinus*
IV	Myotis, southeastern	*Myotis austroriparius*
IV	Butterfly, King's hairstreak	*Satyrium kingi*
IV	Butterfly, yucca giant-skipper	*Megathymus yuccae*

Source: VDGIF Online Database (latitude 36°54′28.1″ and longitude 76°05′ 29.4″), 2010

KEY = Tier I - Critical Conservation Need; II=VA Wildlife Action Plan - Tier II - Very High Conservation Need; III=VA Wildlife Action Plan - Tier III - High Conservation Need; IV=VA Wildlife Action Plan - Tier IV - Moderate Conservation Need.

SECTION 404 (b) (1) EVALUATION

SECTION 404 (b) (1) EVALUATION
LYNNHAVEN RIVER ENVIRONMENTAL RESTORATION
VIRGINIA BEACH, VIRGINIA

I. INTRODUCTION

This report concerns measures proposed as part of the Lynnhaven River Environmental Restoration Feasibility Study as submitted in accordance with Section 404 of the Clean Water Act of 1977 (Public Law 95-217).

The 404(b)(1) guidelines in 40 CFR 230 contain the substantive criteria for evaluation of proposed discharges of dredged or fill material under Section 404. The principle behind the criteria is that no discharge of dredged or fill material is permitted that would result in unacceptable adverse effects to the aquatic ecosystem. Compliance with the guidelines is evaluated by reviewing the proposed discharge with respect to the four restrictions in 40 CFR 230.10. These restrictions state that:

a) No discharge shall be permitted if there is a practicable alternative which would have less adverse impacts on the aquatic ecosystem.
b) No discharge shall be permitted if it violates state water quality standards, violates toxic effluent standards or prohibitions under Section 307 of Act, or jeopardizes the continued existence of threatened or endangered species as identified under the Endangered Species Act of 1973.
c) No discharge shall be permitted which will cause or contribute to the significant degradation of waters of the United States.
d) No discharge shall be permitted unless appropriate and practicable steps have been taken to minimize potential adverse impacts to the aquatic ecosystem.

II. PROJECT DESCRIPTION

A. Location

The project area is situated entirely within the boundaries of the city of Virginia Beach, Virginia. The city is located approximately 100 miles from the state capital of Richmond, Virginia in southeastern Virginia. The Lynnhaven River Basin is a 64-square-mile tidal estuary in the lower Chesapeake Bay. Representing one-fourth of the area of the city of Virginia Beach, the watershed, is the largest tidal estuary in the city, lying within the heart of the urbanized northern half of Virginia Beach. The estuary is composed of three branches: the Eastern, Western, and Broad Bay/Linkhorn Bay.

Refer to the Draft Feasibility Report and Integrated Environmental Assessment (DEA) dated April 2013, for specific information regarding this project, environmental data, and maps and photographs of the project area.

B. Description of Proposed Work

The recommended plan includes four elements that were developed for the environmental restoration of the Lynnhaven River Basin. These are submerged aquatic vegetation (SAV) plantings, bay scallop restoration, construction of reef habitat, and restoration/diversification of wetland sites.

1. SAV Restoration

The restoration of SAV in the Lynnhaven River Basin will cover approximately 94 acres, 52.1 acres in Broad Bay and 41.7 acres in the main stem of the Lynnhaven. Selected sites will be planted with the seeds of two species, *Ruppia maritima,* widgeongrass, and *Zostera marina,* eelgrass. Seeds will be distributed from small boats, likely Carolina skiffs, which are usable in shallow water. Seeds may also be planted using divers or a mechanical planter operated off a small boat. Due to the greater environmental tolerances of widgeongrass, early efforts will be more focused on restoring it, though eelgrass will be attempted simultaneously in sites where it has the greatest chance for establishment. It is expected that the SAV beds established in the Lynnhaven River will be a mix of widgeongrass and eelgrass, with widgeongrass dominating. No fill material will be added to the Lynnhaven system during SAV restoration efforts.

2. Bay Scallop Restoration

Restoration of the bay scallop, *Argopecten irradians*, will occur at the SAV restoration sites one year after SAV seeding has been completed and the beds have been allowed to become established. The scallop restoration effort will consist of two techniques: 1. brood stock adults kept in cages to provide for maximum spawning efficiency and 2. juvenile and adult animals direct stocked within restored SAV beds. No fill material will be added to the Lynnhaven system during bay scallop restoration efforts.

3. Reef Habitat Construction

Restoration of reef habitat in the Lynnhaven River Basin will cover approximately 31.4 acres, with approximately 20.8 acres in Broad Bay and Linkhorn Bay. Additionally, 10.6 acres will be constructed in the main stem and Pleasure House Creek. Reef habitat will be created by placing concrete structures called "reef balls" onto the floor of the Lynnhaven system. At one site where the bottom substrate it too soft to support the reef structures alone, 6ft x 6ft geomesh mats filled with #3 railroad ballast stone will be placed beneath the reef balls in order to prevent the reef structures from sinking.

4. Salt Marsh Restoration/Diversification

Four sites have been identities for salt marsh restoration. At two wetland sites, Princess Anne (PA) and the Great Neck North Sites (GNN), *Phragmites australis,* an invasive wetland plant species, will be eliminated using both physical alteration of the site and chemical application. Within areas that are dominated by *P. australis* and can be accessed by heavy construction equipment, the *P. australis* stands will be first treated with an herbicide approved for wetland use in order to kill existing foliage. Then, approximately 2 to 4 feet of the upper peat layer will be excavated in order to remove as much *P. australis* material, including rhizomes, roots, and foliage, as possible to prevent recolonization. Features such as shallow pools, upland islands, and channels will be created to increase the diversity of the marsh habitat and to allow seawater to flood the area. Finally, clean fill will be added to adjust the elevation of the site, and the bare substrate will be planted with native marsh plants. Exclusion techniques will be used to protect the young plants from grazing by geese and other herbivores, while best practices will be used to stop erosion and to control sediment. In areas that cannot be reached with heavy equipment or where small patches of *P. australis* are present, aquatic herbicides will be applied either through aerial or manual application.

At the remaining two wetland sites, Mill Dam Creek (MDC) and Great Neck South (GNS), the "restoration" goals do not include the establishment of a *Spartina spp.* dominated salt marsh. Instead, the ecological function of the two sites will be improved through habitat "diversification." Habitat features, including islands, channels, and pools, will be constructed to break up the homogeneous phragmites stands. Small drainage dikes will be widened into creeks to extend the range of tidal inundation. Shallow, open pools or "scraps" will be created by excavating the top layer of material. The material excavated from the tidal creeks and pools will be used to build upland mounts that will be planted with native shrubs or grasses. Some herbicide application may be necessary to kill phragmites rhizomes and foliage in the material used to create the upland mounds. Exclusion techniques will be used to protect the young plants from grazing by geese and other herbivores, while best practices will be used to stop erosion and to control sediment.

C. <u>Authority and Purpose</u>

This study is authorized by Resolution of the Committee on Transportation and Infrastructure of the U.S. House of Representatives, Docket 2558, adopted May 6, 1998. The authorization states:

Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, that the Secretary of the Army is requested to review the report of the Chief of Engineers on the Lynnhaven Inlet, Bay and *connecting waters, Virginia, published as House Document 580, 80th Congress, 2nd Session, and other pertinent reports, to determine whether any modifications of the recommendations contained therein are advisable at the present time in the interest of environmental restoration and protection and other related water resources purposes for the Lynnhaven River Basin, Virginia.*

D. General Description of Dredged or Fill Material

1. General Characteristics of Material

a. **SAV Restoration** – No fill material

b. **Bay Scallop Restoration –** No fill material

c. **Reef Habitat Construction –** The materials used to construction reef habitat are concrete reef balls of varying sizes. The reef balls used at for restoration would range in size approximately 2 feet in height and 3 feet in width to about 5 feet in width and 6 feet in height depending on the characteristics of each site.

   At Site 8, located in Broad Bay Cove, the bottom substrate is made up of silt, clay, and silty sand and is judged to be too soft to support the reef balls. Mats of geomesh filled with #3 railroad ballast stone (between 1" to 2.5" in diameter) will be placed under each reef ball in order to prohibit the sinking of the structure into the sediment. The mats will be 6ft x 6ft in dimension.

d. **Salt Marsh Restoration/Diversification -** Material which is already on site will be excavated and used to create habitat features at two of the four wetland restoration sites (Mill Dam Creek and Great Neck South). At two of the restoration sites (Princess Anne and Great Neck North), the first 2-3 feet of substrate will be excavated from the marsh surface in order to remove the phragmites. This material will be removed from the project site and taken to an upland disposal area. Clean fill will be added to the site in order to attain an elevation optimal for the growth of native marsh plants.

2. Quantities of Material

a. **SAV Restoration -** No fill material

b. **Bay Scallop Restoration -** No fill material

c. **Reef Habitat Construction –** The estimated number of reef balls that will be placed at each site is listed in the table below.

		Number of Reef Balls			
Site		2'H X 3'W	4.3'H X5.5'W	4.5'H X 6'W	5'H X6'W
1		2428	-	-	-
2		13730	-	-	-
3		1928	-	-	-
4		3050	-	-	-
5		-	180	359	359
6		-	179	359	359
7		-	227	453	453
8	Normal Soil	-	358	715	715
	Soft Soil	-	1073	2146	2146
9		-	69	138	138

Approximately 75 percent of Site #8 consists of soft sediment, which will not support the weight of the concrete fish reefs. To ensure the stability of the reef balls, a 6ft x 6ft x 0.5 ft Geomesh mat, filled will #3 railroad ballast stone, will be placed under each reef ball. In total 5,365 concrete reef balls and mats will be placed on soft substrate in Broad Bay Cove. Each mat requires 0.67 yd^3 of stone, with a total of 3,577 yd^3 of stone necessary for the entire effort.

d. **Salt Marsh Restoration/Diversification -** The amount of material excavated and placed back on-site at the Mill Dam Creek site will be 600 cubic yards (CY), while 9,500 CY of material will be disturbed at the Great Neck South site. At the Princess Anne site, 26,500 CY of material will be excavated and removed from the site, and 2,000 CY of clean material will then be placed prior to replanting the area with native marsh plants. At Great Neck North, 1,900 CY will be excavated, with 2,000 CY of clean fill material brought onto the site.

3. Source of Material

Some material used at the wetland restoration sites will be excavated on-site and used to construct habitat features. Material obtained from the wetland sites will be tested for the presents of contaminants before it is excavated. If contaminants are found on-site, the material will not be disturbed. All new material to be used at the wetland sites and to build reef habitat will be obtained from commercial sources and will be free of contaminants.

E. General Description of the Discharge Sites

1. Location

a. SAV Restoration - No fill material

b. Bay Scallop Restoration - No fill material

c. Reef Habitat Construction – Nine sites within the Lynnhaven River Basin have been identified for the construction of reef habitat. These sites include approximately 31.4 acres of the Lynnhaven system. A list of the sites and their acreages are included in the table below.

Site	Location	Acres
1	Pleasure House Creek	1.21
2	Hill Point	6.87
3	Brown Cove	0.96
4	Brock Cove	1.53
5	Broad Bay North	1.79
6	Broad Bay North	1.79
7	Broad Bay Center	2.27
8	Broad Bay Cove	14.31
9	Linkhorn Bay	0.69

d. Salt Marsh Restoration/Diversification - All of the wetland sites are located in Virginia Beach, VA. The northern edge of the GNN site is defined by a bridge allowing Route 264/ Virginia Beach Expressway to cross the channel which connects the marsh to Linkhorn Bay. The southern limit of the site is established by Virginia Beach Boulevard. The GNS site is connected to GNN site via two, small culverts that run under Virginia Beach Boulevard. The PA site is located northeast of Virginia Beach Town Center in a highly developed area of the city. The northern edge of the MDC site is delineated by Mill Dam Road.

2. Size

The size of the Reef Habitat sites ranges from 0.69 to 14.31 acres. The specific areas are listed in the table above.

The GNN is the largest wetland site included in the Lynnhaven Restoration Project, consisting of 19.98 acres of tidal marsh, while the

MDC site is the smallest, with an area of 0.9 acres. The PA site is 3.82 acres in size and the GNS site includes 13.68 acres.

3. Type of Discharge Site

The Reef Habitat sites are subtidal areas within the Lynnhaven River with soft substrates. The wetland sites are areas of salt marsh that are located either intratidal or above the tide line.

4. Type of Aquatic Resources

The project area is located entirely within the Lynnhaven River Basin, which is the southernmost tributary to the Chesapeake Bay in Virginia. The Lynnhaven complex, which includes the mainstem, the Eastern Branch, the Western Branch, and the Broad Bay/Linkhorn Bay complex, is located in the city of Virginia Beach, along the southern shore of the Chesapeake Bay, between Cape Henry and the city of Norfolk. The basin occupies 64 square miles, which represents less than 0.4 percent of the area of Virginia and less than 0.2 percent of the Chesapeake Bay watershed. The river comprises over 5,000 acres of surface waters (VDEQ, 1999). The Lynnhaven River's major tributaries are London Bridge Creek (Eastern Branch), Wolfsnare Creek (Eastern Branch), Great Neck Creek (Eastern Branch), Thalia Creek (Western Branch), Buchanan Creek (Western Branch), and Pleasure House Creek. Land use in the basin is primarily residential.

This resource has 150 miles of shoreline and hundreds of acres of marsh, mudflat, and shallow water habitats. The river supports a tremendous level of recreational boating and fishing, crabbing, ecotourism, and general environmental observation. The navigational needs of the residents and users of the river are an integral part of the river's attraction. However, the river has become increasingly stressed, as the watershed has experienced a shift from a predominantly rural to a predominantly urban/suburban land use pattern. This conversion has subjected the river to the expected accompanying development pressures related to concurrent loss of natural buffers and increases in population and density.

5. Timing and Duration of Discharge

a. **SAV Restoration –** No fill material

b. **Bay Scallop Restoration -** No fill material

c. **Reef Habitat Construction –** Construction is expected to be completed in 24 months.

d. **Salt Marsh Restoration/Diversification –** The construction phase is expected to take 6 months at each site.

6. Description of Disposal Method

a. **SAV Restoration**
No fill material

b. **Bay Scallop Restoration**
No fill material

c. **Reef Habitat Construction**
A crane on a barge will be used to lower the reef balls into place on the river bottom. Underwater cameras will be used to monitor the positioning of the reef balls.

d. **Salt Marsh Restoration/Diversification**
The restoration and diversification of wetlands sites will require the use of excavation equipment to dig out the top layer of the marsh. This equipment will be used to either create habitat features at the GNS and MDC sites or load the material onto trucks to move it off site at the PA and GNN sites. Trucks and excavators will also be use to deliver clean fill to PA and GNN and then grade and contour the sites.

III. FACTUAL DETERMINATIONS

A. <u>Physical Substrate Determination</u>

1. Substrate Elevation and Slope

Less than 1 percent slope, with a 3-ft tidal range.

The SAV and scallop restoration efforts will not impact the elevation or slope present at those sites. Clean fill will be added to the GNN and PA sites in order to recreate the elevation necessary for the growth of native salt marsh plants. At the wetland sites where existing material will be used to create new habitat features (GNS and MDC), tiny changes in elevation will occur with the creation of channels, pools, and uplands. Reef balls will extend up to 5 ft in height; however, other naturally occurring structures and features from other restoration efforts currently within the system reach similar elevations.

6. **Sediment type**

a. **SAV Restoration –** N/A

b. **Bay Scallop Restoration –** N/A

c. **Reef Habitat Construction -**The substrate type present at each of the Reef sites is described in the table below.

Site ID	Location	Bottom Type	Description
EFH #1	Pleasure House Creek	SC	clayey sand
EFH #2	Hill Point	SP	poorly graded sand
EFH #3	Brock Cove	SC/SP	clayey sand/poorly graded sand
EFH #4	Brown Cove	CH/SC/SP	fat clay/clayey sand/poorly graded sand
EFH #5	Broad Bay	SW	well graded fine sand
EFH #6	Broad Bay	CH	fat clay
EFH #7	Broad Bay	CH/SP	fat clay/poorly graded sand
EFH #8	Broad Bay Cove	MH/CH/SM	high plasticity silt/fat clay/silty sand
EFH #9	Linkhorn Bay	SW	well graded fine sand

Concrete reef balls will be placed on the substrate at each reef site. For approximately 75 percent of the area of Site #8 the bottom substrate is too soft to support the weight of the reef ball. To support the reef structure, a 6ft x 6ft x 0.5 ft Geomesh mat fill with #3 railroad ballast stone will be placed under each reef ball.

a. Salt Marsh Restoration/Diversification – There will be no change in substrate type at GNS and MDC because the material used in the effort will come directly from the site. At the PA and GNN sites, clean, sand fill will be use to create a surface elevation optimal for the growth of native plants once the invasive plants have been removed. The material that is already on site includes sand, silt, peat, and other organic material.

3. **Dredged/Fill Material Movement**

a. SAV Restoration – N/A

b. Bay Scallop Restoration – N/A

c. Reef Habitat Construction – The reef balls are extremely large and heavy structures, weighing between 375 and 6,000 lbs. Each geomesh mat contains 0.67 CY of stone, weighing 1.2 tons each. The reef balls and geomesh mats will be moved to the reef site by barge and will be placed using a crane.

Once the mats and the reef balls are lowered into position, it is very unlikely that they will move out of position. Both the mats and the concrete balls are extremely heavy. Also, at sites where geomesh mats will not be used to support the reefs, the structures may sink slightly into the bottom substrate. The balls have flattened bottoms to further decrease the chances of the structures moving along the ocean floor.

d. **Salt Marsh Restoration/Diversification -** The sand fill that will be placed at the wetland sites will be planted with native salt marsh to prevent the fill from moving off-site. At sites where on-site material will be used to create new habitat upland features these areas will also be planted with native shrubs in order to keep the material in place. Best management practices will also be used to reduce the movement of fill material off-site.

4. Physical Effects on Benthos

The short term impacts to benthic communities would be both minor and temporary. Benthic invertebrates will be buried during the placement of geomesh mats and reef balls. Benthic organisms at the wetland sites will also be destroyed by construction activities. It is anticipated that losses to benthic populations will be quickly replaced. Benthic populations in areas adjoining project areas may be adversely affected by declines in water quality that will occur during construction; however, these impacts will last only during the construction phase, and normal conditions will return once construction has been completed.

5. Erosion and Accretion Patterns

No expected changes to erosion or accretion patterns will result from the reef habitat, bay scallop, or wetland elements of this project. SAV beds helps to stabilize the bottom over which they grow, preventing resuspension during tidal cycles and storm events, thus reducing erosion.

6. Actions Taken to Minimize Impacts.

Best management practices and reestablishment of vegetation would be used at the wetland sites during construction to minimize excess sedimentation during construction.

B. <u>Water Circulation, Fluctuation, and Salinity Determinations</u>

1. Water

a. **Salinity** – No effect

b. **Water Chemistry** – Minor and temporary effect on DO and biochemical oxygen demand during construction; temporary turbidity increase.

c. **Clarity** – Minor and temporary increase in turbidity will be generated during the construction phase.

d. **Color** – Minor and temporary change due to increase in turbidity.

e. **Odor** – Implementation of this project is not expected to alter odor levels.

f. **Taste**– Implementation of this project is not expected to alter water taste.

g. **Dissolved Gas Levels** – Minor and temporary decrease in DO during the construction phase.

h. **Nutrients** – Nutrient levels would increase during construction due to nutrients in disturbed soil sediment entering into the Lynnhaven River. Effects would be minor and temporary and levels would return to normal post-construction.

i. **Eutrophication** – The Lynnhaven River and surrounding wetlands would not become more eutrophic as a result of this project.

2. Current Patterns and Circulation.

a. **Current Patterns and Flow** – Reef habitat and SAV beds will cause changes; currents around reef structures and the grassbeds may be reduced from existing patterns. New channels will be built into the wetland sites, allowing increased tidal inundation.

b. **Velocity** – Changes, primarily reduction, due to wave and current energy baffling by SAV beds and reefs.

c. **Stratification** – No change.

d. **Hydrologic Regime** – Estuarine, no change.

e. **Aquifer Recharge** – No change.

3. Normal Water Level Fluctuations – No change.

4. **Salinity Gradients –** No change.

5. **Actions that will be taken to minimize impacts –** None.

C. Suspended Particulate/Turbidity Determinations.

1. **Suspended particulates and turbidity level**
Levels of suspended particulates and turbidity are expected to increase temporarily during construction. However, best management practices would minimize these effects. Turbidity is expected to return to normal levels soon after the completion of the project. Long-term improvements to suspended particulate and turbidity levels are a goal of the Lynnhaven Project.

2. **Effects on chemical and physical properties of the water column**

   a. **Light Penetration** – Increased suspended solid particulate and turbidity levels would reduce light penetration in the Lynnhaven Basin during construction. Impacts will be temporary and short in duration. Best management practices would be employed during construction to minimize turbidity levels.

   b. **Dissolved Oxygen** – Oxygen levels in the Lynnhaven Basin would be expected to decrease during construction due to increased suspended solids and turbidity, lowering the photosynthesis rate of aquatic vegetation. Levels would return to normal or improve following construction.

   c. **Toxic Metals and Organics** – SAV, bay scallop stocking and reef habitat will have no impact on current levels of toxic metals and organics present in the Lynnhaven system. At the wetland sites, sediment will be tested prior to excavation to ensure that no contaminants are present in the material that will be disturbed. Commercial sources will be used for fill material used during the project to ensure that it is clean and without contaminants.

   d. **Pathogens –** Fill materials will be clean and free of pathogens.

   e. **Aesthetics –** SAV, bay scallop stocking, and reef habitat will have no impact on long term aesthetics. The aesthetic nature of the wetland sites would be reduced during construction with the removal of vegetation. Long term aesthetics may change with the restoration of the wetland sites.

3. **Effects on Biota**

a. **Primary Production, Photosynthesis** –Temporary increase in suspended solids during construction would reduce light transmission and photosynthesis. There will be no significant long term effects.

b. **Suspension/Filter Feeders** – Temporary increase in suspended solids during construction would impact suspension and filter feeders. Long term effects of the project would be extremely positive to these organisms. Reef habitat and SAV beds will produce new habitats, while scallop stocking would re-establish a self-sustaining population of bay scallops that is not currently present in the system.

c. **Sight Feeders -** Temporary increase in suspended solids and decrease in water clarity may impact hunting and foraging behaviors of sight feeders. Also, the use of heavy equipment during construction may disrupt normal behaviors by scaring sight feeders out of the immediate project site. These impacts should end once the construction phase has been completed. Long term effects of the project would be extremely positive to these organisms. Reef habitat and SAV construction would provide habitats that support sight feeder communities.

4. **Action to Minimize Impacts.**

Best management practices will be used at the wetland restoration sites in order to reduce the amount of disturbed sediment entering the aquatic system.

5. **Contaminant determination.**

No significant effects. The results indicated no significant contamination in the sediment or overlying water.

D. <u>Contaminant Determination</u>

1. **Evaluation of the Biological Availability of Possible Contaminants in the Fill Material**

   a. **Physical Characteristics of the Fill Material -** Fill material and concrete reef balls would be obtained from commercial sources. At the GNS wetland site, where material will be reused, a small number of commercial businesses surround the marsh, while the PA site is located in highly developed area for Virginia Beach. Although there is no suspected presence of contaminants, substrate disturbed at these sites will be tested for possible contaminants prior to construction activities.

   b. **Hydrography in Relation to Known or Suspected Sources of Contamination** – There are no suspected sources of contamination.

   c. **Results from Previous Testing of the Material or Similar Material in the Vicinity of the Project** – Sediment from the wetland sites have not yet been tested.

   d. **Known, Substantive Sources of Persistent Pesticides from Land Runoff or Percolation** – None found.

   e. **Spill Records for Petroleum Products or Designated Hazardous Substances** – Records investigation found no instances of spills in or around the project area.

   f. **Other Public Records of Significant Introduction of Contaminants from Industries, Municipalities or Other Sources** – Investigation of public record found no records of significant introductions of contaminants in or around the project area.

   g. **Known Existence of Substantial Deposits of Substances Which Could Be Released in Harmful Quantities by Man-Induced Discharges** – Investigation of public records found no instances of substantial deposits of harmful substances in or around the project site.

2. **Contaminant Determination**

An evaluation of the appropriate information above indicates that there is reason to believe the proposed fill material would not be a carrier of contaminants.

E. Aquatic Ecosystem and Organism Determinations

1. Effects on Plankton

Turbidity levels may temporarily affect plankton populations through abrasions by suspended material and light transmission reduction. However, these impacts would be minor and temporary.

2. Effects on Benthos

There will be a loss of benthos during the placement of reef habitat and construction efforts at the wetland sites. Relative to the entire system, losses resulting from the project will be small and temporary in nature. The long term goal of the project is to create benthic habitats (hard reefs and SAV beds) that are currently limited within the Lynnhaven Basin and it is anticipated that invertebrate organisms will quickly populate these areas. Stocking of bay scallops will re-establish a self-sustaining population of shellfish which has been lost to the system.

3. Effects on Nekton

Effects would be minor and temporary since it is anticipated that these species would move out of the work areas when construction begins and would return once the project is complete. Fish would derive long-term benefits from the creation of reef habitat, restoration of the wetland sites, and establishment of SAV beds.

4. Effects on Aquatic Food Web

Populations in the Lynnhaven River will be reduced during construction of reef habitat and at the wetland sites. Once work is completed, the aquatic food web would return to normal. The long term effects on the aquatic food web will be overwhelmingly positive, as new habitat types, which are currently limited within the system, are constructed.

5. Effects on Special Aquatic Sites

a. **Sanctuaries and Refuges –** A 52-acre oyster sanctuary, created by the US Army Corps of Engineers, is present in the Lynnhaven River Basin system. Construction of the Lynnhaven River Environmental Restoration Feasibility Project may have temporary impacts on the sanctuary due to increases in turbidity and suspended solids. However, these impacts will be temporary and conditions will return to normal once the construction phase has been completed.

b. **Wetlands –** Four wetland sites have been included in this project in order to either restore the native plant community or to increase habitat diversity. Excavation, grading, and equipment staging are planned for this area. However, these activities are necessary to improve the conditions at each site. At the PA and GNN sites, sediment and exotic plant material will be excavated from the area, and clean, sand fill will be added to the site in order attain an elevation that will support the growth of native marsh plants. The area will then be vegetated with salt marsh plants. At the GNS and MDC sites, marsh substrate will be excavated and then used to create new habitat features, such as tidal creeks, open pools, and wooded islands. These activities will initially disturb the marsh, but the long term effect of the action will increase habitat diversity at a site which is currently a monoculture of the invasive species, *Phragmites australis*. During project implementation, BMPs would be used to minimize the potential for release of fuels and other petroleum products and to reduce the input of sediment into the aquatic environment.

c. **Mudflats – No impact**

d. **Vegetated Shallows** – There are almost no SAV beds currently growing in the Lynnhaven System. The project may have temporary impacts on the existing SAV habitat due to increases in water turbidity during the construction phase. Water clarity will return to normal once the construction phase has been completed. The long term impact of the project on the vegetated shallows within the system will be positive, as 94 acres of SAV beds will be created.

e. **Riffle and Pool Complexes** - N/A

6. Effects on Threatened and Endangered Species

The Lynnhaven Project will have no negative impacts on federally threatened or endangered species. The proposed project will affect tidal salt marshes and shallow subtidal areas within the Lynnhaven Basin. The listed species documented as occurring or may potentially occur in the project area include five sea turtle species, one terrestrial bird, and two shore birds. The terrestrial bird, the pileated woodpecker, inhabits forested areas. The piping plover is associated with sandy beaches and does not utilize habitat types found at the proposed project sites. The roseate tern is a marine species that nests in colonies and plunge dives for fish. This bird could possibly use the subtidal sites as feeding grounds; however, this species prefer open ocean habitats. The Red Knot is a transient species which is known to fly through the project area in order to reach the species'major North Atlantic staging areas located in the Delaware Bay and Cape May Penisula. While sea turtles may forage in area of the proposed project, but they are highly mobile and would be able to avoid impacts from construction. One of the primary benefits of the Lynnhaven Restoration Project is the increase in secondary production, resulting in larger populations of prey items for sea turtles and shore bird species that utilize the project area.

7. Effects on Other Wildlife

Potential short term impacts associated with the Lynnhaven Project will occur during construction and include injury to aquatic fauna from direct encounters during the placement of the reef balls, burial under the reef balls, disruption of normal behaviors during the construction phase, and increased turbidity and suspended solids. These impacts would be minor and temporary, and conditions will return to pre-construction levels.

8. Actions to Minimize Impacts

The proposed material placement activities would be accomplished under conditions that would minimize, to the extent practicable, adverse effects on aquatic ecosystem. Best management practices would be employed during the construction at the wetland sites to avoid sedimentation. Specific actions include:

- Fills would be limited to the amount necessary to achieve project objectives.
- Fill material would be clean and free of contaminants
- An erosion control plan would be implemented to control the entry of sediments into streams and their migration downstream of the work areas.
- Fill material would be placed during low-tide, dewatered periods.

F. Proposed Disposal Site Determinations

1. Mixing Zone Determination

a. **Depth of Water at the Disposal Site –** Depth of water varies from 1 to 13 feet at the sites where the reef habitat will be constructed (see the table below). The depth of the wetland sites will be less than one foot.

Site Number	Depth (ft)
EFH #1	2 to 4
EFH #2	3 to 5
EFH #3	3 to 6
EFH #4	3 to 5
EFH #5	3 to 5
EFH #6	3 to 5
EFH #7	6 to 8
EFH #8	8 to 13
EFH #9	1 to 3

b. Current Velocity – Variable, the velocity within the Lynnhaven System is dependent on the tides.

c. Degree of Turbulence – Negligible

d. Water Column Stratification – Negligible

e. Discharge Vessel Speed and Direction – N/A

f. Rate of Discharge – N/A

g. Dredged Material Characteristics – The material that will be placed to construct reef habitat consists primarily of large concrete reef structures. At Site #8, geomesh mats, consisting of a plastic mesh that encapsulates clean, #3 railroad ballast stone, will be placed under the reefs.

The material used at the wetland sites will be either clean, sand fill or material that is already present at the wetland sites.

h. Number of Discharges Per Unit of Time – Discharges would occur at intervals throughout the construction period.

2. Disposal Site and Size

Due to the unique characteristics of the project, there will be no mixing zone. The construction of reef habitat involves the placement of large structures on the ocean floor. These structures will not mix with the bottom substrate. At the wetland sites, clean fill material will be placed in areas that are either intertidal during low tide or above the tidal range; therefore, no mixing will occur.

3. **Actions to Minimize Adverse Discharge Effects**

The proposed material placement activities would be accomplished under conditions that would minimize, to the extent practicable, adverse effects on aquatic ecosystem. Best management practices would be employed to avoid sedimentation. Specific actions include:

- Fills would be limited to the amount necessary to achieve project objectives.
- Fill material would be clean and free of contaminants.
- Fill material would be placed during low-tide, dewatered periods.
- An erosion control plan would be implemented to control the entry of sediments into streams and their migration downstream of the work areas.

4. **Determination of Compliance with Applicable Water Quality Standards**

The project will comply with all applicable water quality standards.

5. **Potential Effects on Human Use Characteristics**

a. **Municipal and Private Water Supply –** The proposed project would not affect municipal or private water supplies.

b. **Recreational and Commercial Fisheries –** A number of impacts of the project may affect the fisheries of the Lynnhaven Basin. These include short-term and minor turbidity increases, minor impacts to benthos, movement of nekton out of the area, and restriction of recreational and commercial activities at the project sites when construction equipment is in use to ensure public safety. These impacts will last through the construction phase. Long term impacts to the system will be overwhelmingly positive as the creation of reef habitat, re-establishment of SAV beds, and restoration/diversifications of wetlands will improve environmental conditions and benefit the finfish and shellfish populations within the Lynnhaven Basin.

c. **Water-Related Recreation –** Water-related recreation, such as boating and fishing, would be restricted in project areas during the construction phase to ensure public safety. Once the construction phase has been completed, water related recreation will return to normal.

d. **Aesthetics of the Aquatic Ecosystem –** Restoration of SAV and bay scallops and the construction of reef habitat would have no impact on the aesthetic quality of the Lynnhaven Basin. The aesthetic nature of the wetland sites would be reduced during construction when the current vegetation is removed to either be replaced by native salt marsh plants or to create new habitat features.

e. **Parks, National and Historical Monuments, National Seashores Wilderness Areas Research Sites, and similar Preserves –** No Impact.

G. **Determination of Cumulative Effects of the Aquatic Ecosystem**
There are many stressors on the aquatic system of the Lynnhaven River Basin. Overfishing, reduction in water quality, continuing development, and sea level rise are examples of some of these pressures that have negatively impacted the system and may continue to play a role in the stability and vitality of the resource. However, recent actions by the city of Virginia Beach, private organizations, and Federal agencies have resulted in improvements to water quality and environment of the Lynnhaven Basin. The Lynnhaven restoration project will act in conjunction with the continued efforts by these organizations to enhance to Lynnhaven River Basin ecosystem.

H. **Determination of Secondary Effects on Aquatic Ecosystems**
None anticipated.

III. FINDINGS OF COMPLIANCE OR NONCOMPLIANCE WITH THE RESTRICTIONS ON DISCHARGE

A. Adoption of the Section 404(b)(1) Guidelines to this Evaluation

No significant adaptations of the guidelines were made relative to this evaluation.

B. Evaluation of the Availability of Practicable Alternatives to the Proposed Discharge Sites Which Would Have Less Adverse Impacts on the Aquatic Environment

A series of alternative of environmental restoration actions and features were developed and evaluated for feasibility. However, no other alternatives were found that would produce lesser adverse impacts on the aquatic environment.

C. Compliance with Applicable State Water Quality Standards

Fill activities have been coordinated with and are in conformance with the Commonwealth of Virginia standards. A 401 Water Quality Certification will be obtained from the Division of Water prior to construction.

D. Compliance with Applicable Toxic Effluent Standards or Prohibitions under Section 307 of the Clean Water Act

Section 307 of the Clean Water Act establishes limitation or prohibitions on the discharge materials containing certain toxic pollutants. The discharges associated with the proposed work would not contain these toxins, and, therefore, the project complies with Section 307.

E. Compliance with the Endangered Species Act of 1973

No threatened or endangered species or their critical habitat would be affected by the proposed project. This project complies with the stipulations of the Endangered Species Act.

F. Compliance with Specific Measures for Marine Sanctuaries Designated by the Marine Protection, Research, and Sanctuaries Act of 1972

Not applicable, the project does not involve the transportation or placement of dredged material in ocean waters pursuant to Sections 102 and 103 of the Act, respectively.

G. Evaluation of the Extent of Degradation of Waters of the United States

1. Significant Adverse Effects on Human Health and Welfare

a. Municipal and Private Water Supplies – The project would not affect municipal or private water supplies.

b. Recreational or Commercial Fisheries - Impacts to recreation and commercial fisheries will be minimal and temporary in nature.

c. Plankton – Adverse impacts will be minor and limited to the construction period.

d. Fish – Adverse impacts will be minor and limited to the construction period.

e. Shellfish – Adverse impacts will be minor and limited to the construction period.

f. **Wildlife -** Adverse impacts will be minor and limited to the construction period.

g. **Special Aquatic Sites** –Temporary adverse impacts to existing special aquatic sites in the Lynnhaven Basin are offset by predicted long-term benefits of environmental restoration.

2. Significant Adverse Effects on Life Stages of Aquatic Life and Other Wildlife Dependent on Aquatic Ecosystem

Direct and indirect negative impact to aquatic ecosystems would not be significant due to the project design and scope and measures taken to minimize impacts.

3. Significant Adverse Effect on Aquatic Ecosystem Diversity, Productivity, and Stability

The temporary and minor impacts which may result during the construction phase of the project will be minimal compared to the long term benefits that will be realized once the project has been completed. Implementation of the proposed project is expected to result in increases to diversity, productivity, and stability of the aquatic ecosystems.

4. Significant Adverse Effect on Recreational, Aesthetic, and Economic Values

Minor and temporary adverse effects to recreation and aesthetics are expected during the construction phase. These impacts will be eliminated once the construction phase has been completed. Long term impacts to recreation and aesthetics are expected to be overwhelmingly positive.

H. Appropriate and Practicable Steps Taken to Minimize Potential Adverse Impacts of the Discharge on the Aquatic Ecosystem

Appropriate steps to minimize potential adverse impacts from any discharges on aquatic systems have been incorporated.

I. Finding

The proposed discharges of fill material are specified as complying with the requirements of the 404(b)(1) Guidelines, with the inclusion of appropriate and practicable conditions as identified herein to minimize pollution or adverse effects on the aquatic ecosystem. These conditions will be attached and made part of the project record.

Approved by: ______________________________

Date: ______________________________

FISH AND WILDLIFE SERVICE PLANNING AID REPORT

FISH AND WILDLIFE SERVICE PLANNING AID REPORT

Lynnhaven River Basin Environmental Restoration
Planning Aid Report

Prepared for:
U.S. Army Corps of Engineers
Norfolk District

Prepared by:
U.S. Fish and Wildlife Service
Virginia Field Office

December 2010

Introduction

The Norfolk District of the U.S. Army Corps of Engineers is conducting a feasibility study, authorized by the Water Resources Development Act (WRDA) of 1986, as amended by WRDA 1992, 1996 to determine whether planning efforts to improve water quality, environmental restoration and protection for the Lynnhaven River, Virginia should proceed. The Corps proposes to focus restoration in the following areas: 1) submerged aquatic vegetation (SAV), 2) reef habitat, 3) tidal wetland restoration and diversification, 4) establishment of a self-sustaining population of bay scallops (*Argopecten irradians concentricus*), and the restoariton of Fish House Island. This report provides general information on the existing baseline conditions, resources in the area, including endangered species, and evaluation of the potential project impacts. It is provided in accordance with provisions of the Endangered Species Act (ESA) of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.) and the Fish and Wildlife Coordination Act (16 U.S.C. 661-667e, 48 Stat. 401) as amended.

Specific project details are as follows:

SAV Restoration

SAV restoration is targeted at twelve sites. Nine of the restoration sites are within the Lynnhaven Bay mainstem totaling 52 acres and three sites are in the Broad Bay/Linkhorn Bay complex totaling 42 acres. The restoration of SAV in the Lynnhaven River Basin will cover approximately 94 acres. There will be 52.1 acres in Broad Bay and 41.7 acres in the main stem of the Lynnhaven. The SAV sites will not be open to activities, such as oyster dredging or shelling for oyster reefs that could destroy the restoration project.

EFH Restoration

EFH will occur at nine sites which are divided by the different types of reef balls used. Restoration of EFH in the Lynnhaven River basin will cover approximately 31.4 acres, with approximately 20.8 acres in Broad Bay and Linkhorn Bay. Additionally, 10.6 acres would be constructed in the main stem and Pleasure House Creek. The main stem reef would consist of smaller “Bay” reef balls approximately 2-feet in height and 3-feet in width with 11-16 holes across the surface. Up to 2,000 “Bay” reef balls would be used in the main stem per acre.

The Broad Bay and Linkhorn Bay sites would consists of larger “Goliath”, “Super” and “Ultra” reef balls. The “Goliath” reef balls are approximately 5-feet in height and 6-feet in width. The “Super” reef balls are approximately 4.5-feet in height and 6-feet in width. The “Ultra” reef balls are approximately 4.3-feet in width and 5.5-feet in height. The reefs would consist of 200 “Goliath”, 200 “Super” and 100 “Ultra” reef balls per acre.

The reef sites would be open for recreational activities only. Commercial harvesting would not be allowed.

Wetlands Restoration

The wetlands restoration in the Lynnhaven River basin consists of two types of restoration, diversification of phragmites and eradication of the coomon reed (*Phragmites australis*). The Princess Anne (3.8 acres) and Great Neck North (19.9 acres) sites consist of eradication of phragmites with constructed tidal wetlands on site to replace it. The Mill Dam Creek (1 acre) and Great Neck South (13.7 acres) sites consist of diversification of the phragmites. The diversification of phragmites will be done by adding meandering channels, pools, and high marsh/upland areas. The high marsh will be constructed using the material excavated from the pools and channels created.

Bay Scallop Restoration

Restoration of the bay scallop will be done on the SAV sites one year after they are constructed. This will consist of holding them in racks at high density at several sites in the constructed SAV beds during the spawning season. Sites will be identified as source sites via hydrodynamic modeling. The SAV restoration sites will be permanent sanctuaries for the bay scallop.

Restoration of Fish House Island

Fish House Island is currently a 1.25 acre island near the mouth of the Lynnhaven Inlet. The restoration project will restore approximately 7.75 acres of salt marsh and high marsh habitat. The island will be protected by stone riprap and low sill breakwaters. It will not be available for public recreation.

Fish and Wildlife Resource Conditions

Threatened and Endangered Species

There are no federally listed threatened or endangered species that reside in the project area year round. However, transient species travel through the area include the piping plover (*Charadrius melodus,* LT), roseate tern (*Sterna dougallii dougallii*, LE), red knot (*Calidrus canutus rufa*, Candidate), and the shortnose sturgeon (*Acipenser brevirostrum*, LE). The piping plover is an uncommon summer resident in the lower Chesapeake Bay. They breed and forage in Virginia from March to October. The roseate tern used to breed on the Eastern Shore of Virginia barrier islands, but now would only be seen as they pass through the coastal area. Unpublished data indicate May and August are months in which the most sightings occur (Terwilliger et al. 1995). A roseate tern was last observed near the project area in 1981, approximately 700 feet north of Fish House Island. Red knots use the barrier islands along Virginia's Eastern Shore as a secondary staging area in the spring during their migration. The last reported observation of the shortnose sturgeon in the Chesapeake Bay was in 1998 in the Rappahannock River. Also, the species recently was reported in the Potomac River and it is believed to have passed through the Chesapeake Bay in order to reach the Potomac.

Sea turtle nesting falls under the jurisdiction of the U.S. Fish and Wildlife Service (Service) with respect to the ESA. The federally listed threatened loggerhead sea turtle (*Caretta caretta*), inhabits the continental shelves and estuarine environments along the margins of the Atlantic, Pacific, and Indian Oceans. On March 16, 2010 a proposed rule was published in the Federal Register to reclassify the loggerhead sea turtle through determination of the appropriate listing status for each of nine distinct populations of loggerhead sea turtle worldwide. Based on this proposed rule, the population affected by the proposed action is the north Atlantic population, and it is proposed for listing as endangered (72 FR 12598). Loggerhead sea turtles nest within the continental U.S. from Louisiana to Virginia. In Virginia, loggerhead sea turtles are found throughout the Chesapeake Bay, around the barrier islands off the Eastern Shore, and off the coast in the Atlantic Ocean, but nesting is limited to the Atlantic coastline, and nesting within the Chesapeake Bay is not known. The loggerhead is typically the only sea turtle that will nest as far north as Virginia. Loggerhead nesting in Virginia usually occurs from April through September. Females dig shallow pits on the beach to deposit their eggs. After hatching, hatchlings emerge and begin to crawl rapidly toward the ocean. Artificial lighting on the shoreline may disorient hatchlings and prevent them from safely reaching the water. The young can be found in Virginia waters from May through November of any given year. Although loggerheads nest in small numbers along Virginia's coast, there have been turtle nests along the Virginia Beach resort strip and in 2005 a federally listed threatened Green Sea turtle (*Chelonia mydas*) nested on Sandbridge Beach. A loggerhead sea turtle was observed in the mouth of Lynnhaven Inlet, approximately 1,000 north of the Fish House Island restoration site. There have been no reports of loggerheads nesting along the shoreline of the project site.

National Oceanic and Atmospheric Administration (NOAA) Fisheries has management responsibilities for threatened and endangered sea turtles when not on land. However, the Service has a vested interested in what affects sea turtles while at sea. The Chesapeake Bay is a foraging area for five species of sea turtles listed under the ESA. The loggerhead and the green sea turtle (*Chelonia mydas*) are listed as threatened, while the hawksbill (*Eretomchelys imbricata*), leatherback (*Dermochelys coriacea*), and the Kemp's ridley (*Lepidochelys kempii*) sea turtles are listed as endangered. All of these species are primarily oceanic but do forage within the Chesapeake Bay and nearshore Atlantic Ocean during the summer. The hawksbill and green turtles are infrequent in the Chesapeake Bay. The leatherback turtle is regularly found in the lower Bay during the summer in low numbers. Both juvenile loggerheads and Kemp's ridleys are found in relatively large numbers in the lower Bay. The Virginia Institute of Marine Science has conducted turtle surveys since 1979 in the Bay and estimates that up to 10,000 juvenile loggerheads and 500 to 700 Kemp's ridleys regularly use the Chesapeake Bay in the summer (Brown and Savitzky 1984). The turtles have been observed to forage primarily within the Chesapeake Bay proper. Loggerheads forage for benthic species, primarily horseshoe crabs and other shelled invertebrates, within the channels. Kemp's ridleys forage primarily in shallow areas and seagrass beds, feeding heavily on blue crabs.

Submerged Aquatic Vegetation

Preliminary results of the 2010 Virginia Institute of Marine Science (VIMS) SAV survey reported the presence of a 6.08 hectares SAV bed on the southern side of Broad Bay in the Lynnhaven River system (Figure 1; www.vims.edu/bio/sav/). The SAV density class was 0-10%. This bed was not reported in the 2009 survey but was reported in low numbers in the 2007 and 2008 surveys. Historically the Lynnhaven River supported SAV beds (www.vims.edu/bio/sav), which indicates the environmental conditions such as water clarity and substrate were appropriate for growth.

The SAV beds in the lower Chesapeake Bay are a mix of widgeon grass (*Ruppia maritima*) and eelgrass (*Zostera marina*), although eelgrass is the dominant species of SAV in the Chesapeake Bay. Eelgrass grows in distinct seasons. Maximum leaf biomass occurs in March and lasts until June. Minimal biomass occurs in August-September. The grass senesces at the end of June and growth slows during the winter months. Sexual reproduction begins in January and culminates in late May when seeds are released. One of the most important habitat criteria for SAV is water clarity because it affects the amount of light that reaches the plants. Other habitat conditions include water temperature, water depth, bottom sediment and wave action or turbulence. Many healthy SAV beds are situated behind sand bars due to the protection from turbulence the bar provides.

SAV beds provide important ecological roles for fish, blue crabs (*Callinectes sapidus*), waterfowl and infaunal species. Numerous studies have reported SAV bed use as refuge from predation by juvenile and adult finfish and shellfish (Orth et al. 1984, Rozas and Odum 1988, Ryer et al. 1990, Rooker et al. 1998). Juvenile fish such as striped bass (*Morone saxatilis*) will use SAV as a protective area until they grow out of their predator size range (Buckel and Stoner 2000), while blue crabs seek refuge in SAV beds when molting. SAV beds also act as nursery and settling areas for many species of drums (*Sciaenidae*) (Stoner 1983, Rooker et al. 1998) and juvenile blue crabs almost always are found in *Z. marina* beds (Perkins-Visser et al. 1996). It also plays an integral role in the life cycle of the bay scallop (*Aequipecten irradians*) by acting as a substrate on which the post-veliger larvae settle (Gutsell 1930, Connolly 1994, Irlandi 1996). SAV has been reported as the basis of the food chain by providing large amounts of detritus (Adams 1976, Bach et al. 1986). It also provides a direct food source for organisms higher in the food chain. Waterfowl such as the American wigeon (*Anas americana*), canvasback (*Aythya valisineria*) and green-winged teal (*Anas crecca*) feed on seeds and tubers during their fall and winter migration, where as others such as the redhead (*Aythya americana)* feed on the plant rhizomes. In addition, the infaunal community in SAV beds is distinct from unvegetated areas. There are increases in types of infaunal species and overall abundance inside SAV beds. The infaunal species increased sediment stability (Orth 1977) and food supply.

The Chesapeake Bay Program developed incremental measures of progress to approach SAV restoration in the Chesapeake Bay. The Tier 1 goal for the Lynnhaven River segment comprising the entire watershed is 71 acres and has not been met since aerial monitoring efforts were initiated in the 1970s. The Lynnhaven River contains ample restorable habitat for SAV due to its predominantly sandy substrate and shallow depths. However, because the SAV density is low and the Lynnhaven River is far from significant seed sources such that even if water quality permits, SAV is unlikely to re-establish itself in the project study area. In addition, in the Lynnhaven River, the extensive development of the local land mass caused extensive inputs of terrestrial sediments into the river basin, and are the primary cause of SAV declines in the river basin, and TSS levels in the water, along with eutrophication and slowly increasing water temperatures, all act along with a lack of a seed source to inhibit recovery (Cerco and Moore, 2001). Efforts have been initiated to restore this SAV via direct seeding of the shallow water habitat, and these efforts have been very successful (ERDC, 2008 – restoring eelgrass from seed: a comparison of planting methods for large-scale projects, Orth et al, 2006). These initial efforts indicate efforts towards the Chesapeake Bay Programs' SAV restoration goals area appropriate and feasible.

The mute swan (*Cygnus olor*) is a non-native ornamental waterfowl that was introduced in the 1800s. Since that time it has become established along the northeast Atlantic Coast and is one of four naturalized bird species that is considered invasive. The swans feed almost exclusively on submerged aquatic vegetation (Ciaranca et al. 1997). Fenwick (1983) determined that in the Chesapeake Bay, 81.8 percent of the mute swan diet consisted of SAV. He also calculated that males ate 34.6 percent of their body weight and females ate 43.4 percent of their body weight per day. Based on these numbers and the average body weight of a mute swan, the Service calculated that the current population of 3,6000 swans eats 10.5 million pounds of SAV from the Chesapeake Bay in a year (USFWS 2003). The quantity of SAV swans consume is not the only problem but also their behavior. The swans are sedentary with banded birds rarely moving more than 30 miles from their original banding location. Because of their sedentary behavior they can and will over-graze an area. Their grazing behavior is detrimental to the health of a SAV bed. The swans will consume immature seeds and uproot the entire plant instead of just eating the tops like other waterfowl.

SAV is protected by both state and Federal agencies. Federal agencies provide protection under Section 404 of the Clean Water Act (33 U.S.C. 1341-1987) and Section 10 of the Rivers and Harbors Act (33 U.S.C. 403), which regulate the discharge of dredged or fill material in the nation's wetlands and waters

Estuarine Fish/EFH

Anadromous fish, species that live in saline water and spawn in freshwater rivers, pass through the lower Chesapeake Bay area to reach their spawning and nursery grounds. These species include the Atlantic sturgeon (*Acipenser oxyrhynchus*), striped bass (*Morone saxatilis*), American shad (*Alosa sapidissima*), hickory shad (*A. mediocris*), blueback herring (*A. aestivalis*), alewife (*A. pseudoharengus*), gizzard shad (*Dorosoma cepedianum*), Atlantic herring (*Clupea harengus*) and white perch (*Morone americana*). The adults of these species enter the lower Chesapeake Bay area between February and April on their migration to their spawning grounds in the tidal Freshwater rivers.

Many species of finfish that spawn in the ocean or lower Chesapeake Bay utilize the estuary as a nursery area or as adults. Dominant species include: spot (*Leiostomas xanthurus*), Atlantic croaker (*Micropogonias undulatus*), Atlantic menhaden (*Brevoortia tyrannus*), weakfish (*Cynoscion regalis*), summer flounder (*Paralichthys dentatus*), bluefish *(Pomatomus saltatrix*), American eel (*Anguilla rostrata*), striped mullet (*Mugil cephalus*), silver perch *(Bairdiella chrysura*), black drum (*Pogonias cromis*), southern lungfish (*Menticirrhus americanus*), winter flounder (*Pseudopleuronectes americanus*), blue crab (*Callinectes sapidus*) and horseshoe crab (*Limulus polyphemus*).

NOAA Fisheries has designated areas in the lower Chesapeake Bay near the vicinity of the project area as Essential Fish Habitat (EFH) for many finfish species (Tables 1). Essential Fish Habitat is a designation that includes “those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity”. The designation was enacted in the 1996 amendment to the Fishery Conservation and Management Act of 1976 (90 Stat 331; 16 U.S.C. 1801 - 1882), as amended to preserve and conserve marine and estuarine habitat. The act requires Federal agencies to coordinate with NOAA Fisheries on all actions or proposed actions that may adversely affect EFH. For further information regarding consultation procedures, contact David O’Brian at the NOAA Fisheries office in Gloucester, Virginia (804-684-7228). General information on EFH can be obtained from; www.nero.nmfs.gov/ro/doc/newefh.html. Of particular importance is the identification of Habitat Areas of Particular Concern (HAPC). All borrow sites are within the vicinity of HAPC for the Sandbar shark (*Carcharhinus plumbeus*).

This area received this identification because it is an important nursery and pupping ground. Hard bottom 3-dimensional structures, reefs, are vital components in estuarine systems; they provide shelter, points of attachment for sessile organisms, and reduce water movement and energy. Reef habitat in estuaries generally consists of rocky bottom areas and in many regions, oyster reefs. In the Lynnhaven River, this habitat was historically oyster reefs, which in pre-colonial times were found both sub and inter-tidally throughout portions of the river where salinity levels were high enough to support oyster survival and growth. Today, most of these areas are either entirely lost (Chipman, 1948, Haven, 1979) or in some cases completely covered with considerable amounts of soft sediments (Dauer, pers. comm.). Extensive bottom surveys conducted in the course of oyster restoration planning (USACE, 2005) discovered two small (< 1 acre) natural oysters reefs, near the confluence of Lynnaven Bay and the western branch of the Lynnhaven River. These reefs were quite productive, containing approximately 250 adult oysters/square meter, indicating the subtidal hard substrate can still attract significant populations of oysters and other filter feeders, and in turn attract a wide variety of fin and shell fish species that utilize reef habitat.

Tidal Wetlands

Currently, the three of the four wetland restoration sites are almost exclusively dominated by common reed. Although some native plants are growing on the fringes of each site, specifically along the banks of the tidal creeks and along the borders of the uplands, the majority of these areas consist of dense, single-species stands of common reed. Tidal inundation is restricted to a large portion of each site. Sedimentation rates within common reed stands tend to be quite high, resulting in the decrease in water depths and the smoothing of the marsh surface. This process reduces the reach of sea water into the *Phragmites* stand, as compared to sites that are dominated by native plant species. In addition, two of the sites have been impounded due to roadways located at the head of the marsh. Small culverts are now the only connection that allows sea water to circulate into and out of the project sites. The current environmental conditions favor the continued growth of the common reed at these sites. If no action is taken, it is unlikely that site conditions will significantly change and the areas will continue to be comprised of dense monotypic stands of *P. australis*.

At the fourth site, large areas within the wetland are still comprised of indigenous salt marsh plants. However, *Phragmites* has begun to colonize areas within and surrounding the site. The marsh is not impounded, so there is little to no tidal restriction into the area. If no actions are taken, the areas adjacent to the tidal creeks that run through the site will remain vegetated with native species. However, in areas that have limited access to tidal flow the percentage of *P. australis* that makes up the plant community will increase until the invasive plant replaces the native species.

Bay scallops

Seaside lagoons once provided habitat for bay scallops until the 1930s when the habitat was destroyed by the "Storm King" hurricane (Seitz et al. 2009) and subsequent SAV die off. Since that time, scallops have not been present in the Lynnhaven Bay system or along other former habitat along Virginia's lower Eastern Shore. There are no scallop populations near enough to recruit to the area in any numbers. Left alone, it is unlikely scallops will recolonize the Lynnhaven Bay system River or any other nearby habitat.

Potential Biological Impacts

Endangered Species

Based on the project description, location, and the transient nature of federally listed species occupation of the area, we expect any federally listed species that approach the project area may avoid the vicinity during construction. Due to the expected avoidance behavior and low likelihood that federally listed species will be in the area during construction, we believe the affects of the project will be insignificant and discountable. Should project plans change or if additional information on the distribution of listed species or critical habitat becomes available, this determination may be reconsidered.

SAV

Once the widgeongrass is established, it should provide for more stable bottom and better water quality conditions conducive to the survival of eelgrass, which should then proliferate over a wider area. It is expected that the SAV beds established in the Lynnhaven River will be a mix of widgeongras and eelgrass, with widgeongrass dominating. Increasing SAV presence in the Lynnhaven system will provide nursery habitat and settling areas for many species of fish. SAV beds will also act as places of refuge, provide food sources, and when large enough, help dampen wave energy and slow shoreline erosion. The success of the SAV restoration will also dictate whether the Bay Scallops restoration efforts will succeed.

EFH

The installation of the reef balls may result in short term disturbance to motile species. We expect these species will avoid the reef balls as they are being lowered into the water and placed on the sediment. We expect long term impacts including burial and death to sessile species and slow moving motile species. These impacts will be limited to the footprint of the reef ball installed. Placement of the reef ball will stir up sedimentation that will impact near-by species. We expect impacts from sedimentation will be temporary and minor.

Long term impacts will primarily be beneficial to the aquatic species in the Lynnhaven Bay system. The reef balls will provide three-dimensional structure, which is currently limited. As mentioned above, these structures will provide shelter and points of attachment for sessile organism and egg masses.

Wetlands

Short term sedimentation will occur when grading the tidal marshes and creating habitat features. The earth disturbing activities will expose marsh sediment, which will create a higher erosion potential until the marsh plants become established. Motile species such as fish and birds that currently occupying the area will be temporarily displaced and fish will likely avoid the area during construction and subsequent sedimentation events. Sessile marsh species such as tidal plants and the Atlantic ribbed mussel (*Geukensia demissa*) or slow moving motile species, salt marsh periwinkles (Littoraria irrorata) will be up rooted, crushed, or buried. These impacts will be short term lasting the duration of the construction period.

Herbicide may kill non-targeted species if accidentally oversprayed or from drift. Adherence to spray conditions should minimize the risk.

In the long term the restoration should result in beneficial impacts to tidal marsh species inhabiting the sites and transient species that seasonally use the area. Restoration activities are also expected to attract a higher diversity of species and restore ecological function to the sites.

Bay Scallops

Few short term impacts are expected. We expect similar impacts from introducing the cages housing adult scallops as we described above from the installation of reef balls.

Long term affects of bay scallop reintroduction is increased water clarity and quality. Improved water conditions will provide positive benefits to other species in the system. We expect the SAV beds will expand, the planktonic food web will become more complex, and healthier conditions to other filter feeders. Bay scallops are a food source for aquatic predators, an increase in the scallop population will likely increase predator population levels.

Fish House Island

The short and long term impacts of the wetaland tidal marsh restoration are listed above. Short term impacts of building a breakwater would be the loss of benthos directly beneath the structure. However, the presence of breakwaters may create habitat for benthic species in the lee of the breakwater by reducing wave stress. The reduction in turbulence and shifting bottom may allow for the colonization of benthic species that cannot tolerate the current dynamic conditions. The actual breakwaters themselves will provide new structure for benthic organisms to colonize. The rocks that comprise the breakwaters will provide an attachment area for sessile organisms (Van Dolah et al. 1984). Some potential organisms that might colonize the breakwater structure include algae, barnacles, mussels, oysters, hydroids, bryozoans, and anemones. The interstitial spaces provide shelter for larger, motile organisms such as grass shrimp, mud and blue crabs, and a variety of small fish like blennies and gobies. The breakwaters may act as an artificial reef and attract larger fish since they house many prey species. Van Dolah et al. (1984) noted many recreationally and commercially important fish were attracted to the rocks after jetty construction. Although the construction of the breakwaters will negatively impact the benthic area directly beneath, it will create additional, dimensionally complex habitat.

Conclusion

The Service supports the Corps ecosystem restoration; the services provided from this project should increase the productivity of the Lynnhaven Bay system. We anticipate ecological benefits from the implementation of the project and thank you for the opportunity to coordinate with you.

Recommendations

$ The Service recommends monitoring wetland restoration sites to assess plant survival. Monitoring should occur frequently shortly after planting to determine if animal disturbance such as grazing will be a problem. If the site is being disturbed at such a level that will be detrimental to its success then additional protective measures should be considered. In addition, many contractors will provide a one-year guarantee that all plant material is healthy but do not specify who is responsible for monitoring for survival and if monitoring will be assessed following a specific protocol. If it is determined that re-planting is needed, the contract should guarantee the re-planted material for a year from when they are planted. The Service is also concerned about the potential for erosion and colonization by invasive species until the vegetation is established. A comprehensive monitoring program is needed to ensure the success of this restoration project.

$ Because the success of the Bay scallop restoration is contingent on successful SAV restoration, we recommend monitoring SAV health for a minimum of two years after restoration activities. Re-seed the SAV restoration sites if it does not meet the pre-established success criteria.

$ Aerial herbicide spraying should only be conducted if wind speeds are <5 miles per hour (mph). Wind direction is a lesser consideration because spraying will only occur at wind speeds of <5 mph. The likelihood of precipitation will should be considered when making the decision to spray. Weather forecasts and onsite conditions should be monitored before, during, and after spray operations. A chance of precipitation ≥30% within four hours prior to the start of spraying will result in a decision not to spray for that day. During herbicide treatment the wind speed and direction, aircraft speed, spray altitude, and spray mist/droplet size should be monitored continuously.

$ SAV restoration efforts could be hampered or negated by mute swans. Legislation HR 4114 is before Congress that proposes to remove protection of exotic species from the Migratory Bird Treaty Act. The Service recommends the mute swan population be monitored, and that the Corps work with the Service and the Virginia Department of Game and Inland Fisheries to develop a response plan if mute swans begin to negativity impact the restoration sites.

NMFS ESSENTIAL FISH HABITAT DESIGNATIONS

NMFS ESSENTIAL FISH HABITAT DESIGNATION

INTRODUCTION

This analysis includes the Essintial Fish Habitat (EFH) species that are found within the area of the proposed project. Each species summary includes a discussion of the life cycle and history of the animal, the status of the fishery, and how the animal will be affected by the proposed project.

Table 1. Summary of Essential Fish Habitat as designated by NOAA Fisheries for the Lynnhaven Inlet and Bay. The X indicates the lifestage for which this habitat is important.

Species	Eggs	Larvae	Juveniles	Adults
Red hake (*Urophycis chuss*)			X	X
Windowpane flounder (*Scopthalmus aquosus*)			X	X
Atlantic sea herring (*Clupea harengus*)				X
Bluefish (*Pomatomus saltatrix*)			X	X
Atlantic butterfish (*Peprilus triaccanthus*)	X	X	X	X
Summer flounder (*Paralicthys dentatus*)		X	X	X
Scup (*Stenotomus chrysops*)			X	X
Black sea bass (*Centrophristus striata*)			X	X
King mackerel (*Scomberomorus cavalla*)	X	X	X	X
Spanish mackerel (*Scomberomorus maculatus*)	X	X	X	X
Cobia (*Rachycentron canadum*)	X	X	X	X
Red drum (*Sciaenops occelatus*)	X	X	X	X
Sand tiger shark (*Odontaspis taurus*)		X		X
Atl.sharpnose shark (*Rizopriondon terraenovae)*				X
Dusky shark (*Charcharinus obscurus*)		X	X	
Sandbar shark (*Charcharinus plumbeus*)		HAPC	HACP	HACP

SANDBAR SHARK

Life Cycle and Habitat

This shark has designated HAPC (habitat area of particular concern) in the local area. This species is the principal species caught in the commercial shark fishery of the U.S. Atlantic coast and is also important recreationally (Conrath and Musick, 2007). It is a large coastal ranging species, with females growing up to 2.5 m and males up to 1.8 m total length. They typically roam in small groups or schools, segregated by sex, and undergo seasonal migrations to avoid overwintering in cold, northern waters. Due to this behavior, they range from Cape Cod to the western Gulf of Mexico, though they are not found north of the Carolinas in the winter months. Sandbar sharks, like many elasmobranch fishes, are viviparous, giving birth to live young. They typically give birth to less than 10 young, once per two years. The primary reason that the local waters are considered HAPC is because the lower Chesapeake Bay is one of the most important nursery grounds for this species on the U.S. East Coast. Female sharks give birth in the local area in large numbers, and the lower bay and lower Eastern Shore are important nursery grounds for the juveniles.

The Fisheries

The fishery is considered severely depleted. Restrictions on their take have been put in place to hopefully allow for species recovery. The status of the sandbar shark along much of the east coast is “protected,” meaning that there is no permitted commercial harvest of the species in Federal waters but harvest does continue to occur in state waters under a quota set by National Marine Fisheries Service (NMFS). It does continue to be taken incidentally. Current numbers are low and do not support wide scale commercial fishing at this time.

SAND TIGER SHARK

Life Cycle and Habitat

This large shark can grow up to 3.9 meters in length and is usually found in sandy bottom coastal waters. It eats primarily fish, though squid and crustaceans are also consumed. They are found along the Atlantic coast but are not common in the local area.

They, like many elasmobranchs, give birth to live young; this species gives birth to only two young at a time and typically once every two years. Juveniles can be found in estuaries such as the Chesapeake Bay. It undergoes seasonal migrations, preferring cooler waters and migrating to cooler more northern waters in the summer. Its range in the northwest Atlantic Ocean is from the Gulf of Maine to the northern Gulf of Mexico.

The Fisheries

It is currently considered a prohibited species by NMFS and, if caught, must be released with minimal harm to the shark by both commercial and recreational fishermen. This is due to the severe declines in their numbers (> 90 percent) from heavy commercial fishing for this species in the 1980's and 1990's. Today, the species shows few signs of recovery and remains a species of concern (identified as a Species of Concern in 1997).

ATLANTIC SHARPNOSE SHARK

Life Cycle and Habitat

This small species, with a maximum size of 1.2 meters in length, ranges from the Carolina coast southward to the Gulf of Mexico year round, and ranging farther north to the Bay of Fundy, Canada, in warmer months. This fish typically inhabits shallow coastal and nearshore waters. It is a short lived shark species, typically living from 9-12 years. They feed on crustaceans, worms, small fish, and mollusks. They give birth to live young in a litter of 3-7 pups, usually in an estuary which is then the juvenile nursery area. In the Chesapeake Bay region, we are likely to only encounter adults as they typically pup further south.

The Fisheries

This shark is caught in commercial and recreational fisheries in the North Atlantic. Unlike many other shark species, however, it remains very abundant and is not currently at risk for being overfished.

DUSKY SHARK

Life Cycle and Habitat

The dusky shark is a larger species, growing up to 4 meters in length. The female dusky shark gives birth to live young, typically a litter of 6-14 pups. They usually reproduce every 3 years. This species typically eats fish, including smaller elasmobranchs such as other sharks, skates, and rays; though other prey, such as squid and sea turtles, are taken on occasion. In the North Atlantic, they range from George's Bank through the Gulf of Mexico, preferring warm temperature waters. Due to this temperature preference, more northern populations undergo seasonal migrations. Dusky sharks prefer oceanic salinities and are not commonly found in estuaries. It inhabits waters from the coast to the outer continental shelf and adjacent pelagic waters. It is not a common shark, and its slow reproductive rate makes it vulnerable to over exploitation.

The Fisheries

The dusky shark is a Species of Concern and is considered overfished. There was a commercial fishery for this species, and its large fins make it very valuable in the shark-fin trade. This fishery has since stopped due to lack of sharks, and the principal threat to population recovery is the recreational fishery for this species. Because of its late age at first reproduction (about 20 years) and its long time between births, this species is particularly vulnerable to overfishing.

RED HAKE

Life Cycle and Habitat

Red Hake can be found in the local area as juveniles and adults, though it would be uncommon in the Lynnhaven River due to its preference for oceanic waters, though they can be found, especially as juveniles, in the Chesapeake Bay mainstem during the cooler months of the year. The species occurs from North Carolina to southern Newfoundland. They are primarily a demersal fish and are found on or near the bottom. They spawn offshore through the summer and fall primarily, although eggs can be found in the water column almost year round. Eggs are typically found floating mostly at the edge of the continental shelf. Larvae are planktonic and feed mostly on zooplankton. They metamorphose into bottom dwelling juveniles. Juveniles use structure as cover, including reefs, sea scallops, depressessions in the sediments made by other fish, and other structures that provide any bottom relief. Adults are often found on or near the bottom, on reefs, or utilizing other structure, though they create their own depressions in the sea bottom for cover. They can also be found in the water column actively swimming at times. Adults prefer cooler waters of 2-22 °C.

The Fisheries

Red hake are managed as two U.S. stocks. The local stock is considered the southern stock, extending from southern Georges Bank to the Middle Atlantic Bight, the southern end of its range. The southern stock is currently considered overfished.

ATLANTIC SEA HERRING

Life Cycle and Habitat

Atlantic herring is a schooling, coastal, pelagic species ranging from Labrador to Cape Hatteras. The species undergoes extensive migrations for feeding, spawning, and overwintering. They lay demersal eggs throughout the late summer to early winter on any hard substrate, preferring gravel but also utilizing rocks, shells, or macophyte algae in areas with strong currents. Larvae are planktonic and can drift into estuarine waters during their developmental phase. Juveniles are pelagic and can be found in large schools in coastal waters in New England. Only adults are found in the local region, as spawning takes place in more northern, colder waters. Larvae, juveniles, and adults all feed on zooplankton. Adults are typically found in oceanic waters of at least 28ppt and are unlikely to ever be found in the Lynnhaven River system, though they can be found in Chesapeake Bay mainstem waters that approach full seawater salinity.

The Fisheries

The fishery is considered under utilized in its entirety, though the Gulf of Maine portion is considered fully exploited.

WINDOWPANE FLOUNDER

Life Cycle and Habitat

According to Essential Habitat Designations within the Northeast Region (Maine to Virginia), NOAA and NMFS describe habitat conditions for life stages of windowpane flounder. Eggs are found in surface waters around the perimeter of the Gulf of Maine, on Georges Bank, southern New England, and the middle Atlantic south to Cape Hatteras. Eggs are found where sea surface temperatures are less then 20 °C and water depths are less than 70 meters. In the middle Atlantic, eggs are often observed from February to November with peaks in May and October.

Juveniles are found in bottom habitats consisting of a mud or fine-grained sand substrate around the Gulf of Maine, on Georges Bank, southern New England, and the middle Atlantic south to Cape Hatteras. Juveniles are found in waters with temperatures below 25 °C, depths from 1-100 meters, and salinities between 5.5-36 ppt.

Adults are found in areas with bottom habitats consisting of mud or fine-grained sand around the perimeter of the Gulf of Maine, on Georges Bank, southern New England, and the Middle Atlantic south to the Virginia-North Carolina border. Adults are found in waters with temperatures below 26.8 °C, depths from 1-75 meters, and salinities between 5.5 and 36 parts per thousand (ppt). Spawning occurs in waters with temperatures below 21 °C, depths from 1-75 meters, and salinities between 5.5 to 36 ppt. Windowpane flounder are most often observed spawning during the months of February through December, with a peak in May in the middle Atlantic (NOAA/NMFS, 1999).

KING/SPANISH MACKEREL

The king mackerel, *Scomberomorus cavalla*, and Spanish mackerel, *Scomberomorus maculatus*, are members of the mackerel family, Scombridae. Both species support major commercial and sport fisheries along the Atlantic Ocean and Gulf of Mexico; their visits to the Chesapeake Bay are generally confined to the middle and lower Bay.

Life Cycle and Habitat

King mackerel inhabit coastal waters from the Gulf of Maine to Rio de Janeiro, Brazil, and the Gulf of Mexico, and they are most commonly found from the Chesapeake Bay southward and occasionally in the upper Bay. King mackerel are solitary surface dwellers that tend to be found near shore, often among reefs, wrecks, or other underwater structures. Immature fish school and sometimes mix with schools of Spanish mackerel of similar sizes. King mackerel are migratory in response to water temperature and prefer temperatures no lower than 68 °F.

King mackerel appear to spawn over a protracted period, with several peaks. On the Atlantic coast, larvae have been collected from May through October. Larval distribution indicates that spawning occurs in the western Atlantic off the Carolinas, Cape Canaveral, and Miami. There does not appear to be a well-defined area for spawning. King mackerel prefer to consume fish but also have been known to eat shrimp and squid. Female king mackerel can live for up to 14 years.

Spanish mackerel live in the coastal waters of the western Atlantic Ocean, from the Gulf of Maine to the Yucatan Peninsula. They are a schooling fish, preferring neritic, or shallow, ocean coastal waters, but they freely enter tidal estuaries. These mackerel are found most frequently in water temperatures between 70 and 88 °F and rarely in waters below 64 °F. Spanish mackerel is a common visitor to the middle and lower Chesapeake Bay from spring to autumn, sometimes swimming as far north as the mouth of the Patuxent River. Like the king, Spanish mackerel is a surface-dwelling, near shore species that will migrate over long distances in large schools along the shore. As water temperatures in the south increase, it moves north, entering the Chesapeake Bay when temperatures exceed 63 °F. They spawn off of the coast of Virginia between late spring and late summer. Spanish mackerel consume small fishes, shrimp, and squid, and reach a maximum age of 8 years.

The Fisheries

King mackerel support an important commercial fishery along the Gulf of Mexico and South Atlantic coasts. In recent years, they have primarily been caught commercially in south Florida and increasingly off North Carolina and Louisiana. Historically, there was a small commercial fishery for king mackerel in the Chesapeake Bay when pound nets and gill nets were introduced in the 1880's. Total commercial catch appears to have an average of 4 million pounds during the 1920's and 1930's. Commercial landings fell to 2.5 million pounds by the 1950's and increased to 8 million pounds in the mid-1970's. Since 1985, the coastal fishery has been quota managed, and catches have averaged 3.5 million pounds. Commercial landings of king mackerel in both Maryland and Virginia are insignificant, although in some years Virginia supports a small directed hook-and-line fishery.

The Spanish mackerel commercial fishery was born around 1850 along the Long Island and New Jersey coasts, and by the 1870s was well-established in the Mid-Atlantic and Chesapeake Bay area. In 1880, the Chesapeake Bay area produced 86 percent of the total coastal catch of 1.9 million pounds. By 1887, this number had dropped to 64 percent, after areas of major production changed. This trend continued, and from 1950 through 1985, Florida accounted for more than 92 percent of the Spanish mackerel commercial landings. Since 1986, Florida's contribution to the commercial harvest has decreased due to increased landings along the south and Mid-Atlantic. Total commercial landings ranged between 5 million pounds and 18 million pounds, and between 1950 and 1983 averaged around 8 million pounds. The coastal landings have been quota-managed since 1986 (Chesapeake Bay Program, 1999).

SUMMER FLOUNDER

Summer flounder or fluke (*Paralichthys dentatus*) live in estuarine and coastal waters from Nova Scotia to Southern Florida, with greatest abundance between Cape Cod, MA and Cape Hatteras, NC. Most summer flounder inhabit Chesapeake Bay in the summer and move offshore to depths of 120 to 600 feet of water during the fall and winter. However, some summer flounder over winter in the Chesapeake Bay. Flounder are more common in the deep channels of the lower Chesapeake Bay than in the upper Bay, extending as far north as the Gunpowder River.

Like other flounders, this species is a bottom-dwelling predator, relying on its flattened shape and ability to change color and pattern on the upper (eyed) side of its body. A predator with quick movements and sharp teeth, the flounder is able to capture the small fishes, squid, worms, shrimp, and other crustaceans that comprise the bulk of its diet. Summer flounder can live to 20 years of age with females living longer and growing larger than males (up to 95 cm total length [3ft]).

Life Cycle and Habitat

Summer flounder spawn during their offshore migration, from late summer to midwinter. Larvae and post-larvae drift and migrate in shore, aided by prevailing water currents, and enter the Chesapeake Bay from October through May. Larval flounder, which have body symmetry and eyes on both sides of their heads, more closely resemble the larvae of other fishes than they do adult flounder. Upon reaching the estuaries, larval flounder undergo a metamorphosis to the post-larval stage. During metamorphosis, the right eye of the larval flounder gradually migrates to the left side of the head–the feature distinguishing summer flounder from winter flounder, whose eyes are on the right side–and the body takes on the flattened appearance that it retains as an adult fish. Once the metamorphosis is complete, the post-larval flounder assumes the adults' bottom-dwelling lifestyle. Juvenile summer flounder often live among eelgrass beds in the Chesapeake Bay.

The Fisheries

Summer flounder are of major recreational and commercial importance north of Cape Hatteras. Anglers catch summer flounder from the shore, piers, and boats with hook and line. The recreational catch far exceeds the commercial catch in the Chesapeake Bay and near shore coastal waters. The lower Chesapeake Bay and seaside inlets produce the bulk of the recreational landings. Between 1979 and 1985, the combined recreational harvest in Maryland and Virginia averaged 5.5 million pounds per year, with 90 percent taken from Virginia waters.

Commercial landings in Virginia have historically been greater than those in Maryland. Between 1981 and 1986, Virginia averaged 5.7 million pounds per year and Maryland averaged 583,000 pounds. However, more than 90 percent of the landings recorded for both states have come from outside state waters. The great bulk of the catch is produced by the winter trawl fishery that operates in mid-continental shelf waters. In the Chesapeake Bay, summer flounder are commercially-caught by haul seines, pound nets, and gill nets, but the species does not form a significant commercial fishery. In 1990, only 48,000 pounds of summer flounder were taken in Virginia's Chesapeake Bay and ocean waters. Since the mid-1980's, commercial and recreational catches have declined precipitously because of overfishing and year-class failure. The Chesapeake Bay record for summer flounder is a fish weighing 15 pounds, which was taken in Maryland waters (Chesapeake Bay Program, 1999).

BLUEFISH

Bluefish, *Pomatomus saltatrix*, is the sole representative of the family Pomatomidae and is closely related to the jacks, pompanos, and roosterfish. Commonly known as chopper, tailor, snapper, elf, skipjack, greenfish, and blue, the bluefish inhabits the continental shelf waters of temperate zones. Along the eastern United States, it is found from Nova Scotia to Texas and visits the Chesapeake Bay region from spring to autumn. The bluefish is abundant in the lower Bay and common most years in the upper Chesapeake Bay, although it is rare north of Baltimore.

Life Cycle and Habitat

Schools of like-sized bluefish can cover tens of square miles and undertake extensive coastal migrations. Adults overwinter off the southeastern coast of Florida and begin a northerly migration in the spring, following warmer water with local movements into and out of bays and sounds. Their movement patterns are complex and not well understood. Younger fish appear to follow different migratory routes than older fish.

Bluefish have a worldwide distribution with occurrences recorded in the Atlantic Ocean, the Mediterranean Sea, the Black Sea, and the Indian Ocean. Adult bluefish are found in a variety of habitats, usually in response to food availability and spawning cues. Bluefish are voracious predators and will feed on virtually any food they can catch and swallow, including butterfish, menhaden, sand lances, silversides, mackerel anchovies, sardines, weakfish, spotted seatrout, croaker, spot, white perch, shad, alewife, blueback herring, and striped bass. Due to their predacious nature, bluefish are in competition with adult striped bass, mackerel, and large weakfish. They have few predators and can live 12 years and weigh up to 20 pounds.

During the northward migration, a spring spawning period occurs from Florida to southern North Carolina. A second spawning occurs off the Mid-Atlantic coast during the summer. In the Chesapeake Bay area, peak spawning is in July and occurs over the outer continental shelf. Most bluefish mature at age two and have high fecundity. Females can produce 900,000 to 4,500,000 eggs. The distribution of bluefish eggs is related to temperature and salinity and can vary from year to year.

Bluefish larvae can be found offshore between Cape Cod, MA, and Palm Beach, FL, during every season of the year. After the spring spawn, bluefish move shoreward. The smaller fish generally enter the Chesapeake Bay, while the larger fish head farther north. Larval distribution is affected by the wind and currents. Larvae that originate from spawning off the Chesapeake Bay are carried south and offshore. As larvae grow and are able to swim, they leave the surface for deeper water and move in shore. Early juveniles (young fish whose fins have formed) enter the lower Chesapeake Bay and its tributaries in the late summer and fall where estuarine areas provide food and shelter. In the early autumn, bluefish begin to migrate out of the Chesapeake Bay and move south along the coast. Peak abundance near the Chesapeake Bay mouth occurs from April to July and again in October and November.

The Fisheries

The bluefish commercial fishery in Chesapeake Bay accounts for about 20 percent of the total US landings of bluefish. Commercial landings from the Chesapeake Bay were generally high during the 1930's, modest to poor from the 1940's through the 1960's, and again high from the early 1970's through the mid-1980's. In recent years, overfishing has become a concern. Historically, the commercial bluefish harvest has been more important in Virginia than in Maryland, with 10 times the landings of Maryland.

The predominant commercial gear used in harvesting bluefish from the Chesapeake Bay has been pound nets but other gear also is used, including gill nets, otter trawls, haul seines, and hand lines. Currently, all commercial gears, except Virginia's hook and line fisheries, are required to have a license. The bluefish's aggressive feeding habits and spirited fight make it a popular and important sportfish. Landings from the recreational fishery are five to six times that of commercial landings. In the Chesapeake Bay, bluefish ranked highest in both number and weight among sportfish nearly every year from 1970 to 1990. Due to the high recreational value, the conservation effort by anglers has been strong (Chesapeake Bay Program, 1999).

RED DRUM

Red drum (*Sciaenops ocellatus*) is a member of the family Sciaenidae. Also known as channel bass, redfish, bull redfish, drum, puppy drum, and spottail, red drum is 1 of 13 species of sciaenids that occur in the Chesapeake Bay region. The family includes the commercially and recreationally important seatrouts, spot, croaker, kingfishes, silver perch, and black drum. The largest recorded red drum was 59 inches and 98 pounds, and the fish can live as long as 35 years.

Life Cycle and Habitat

Red drum are found from the Gulf of Maine to the northern coast of Mexico but are most commonly found south of the Chesapeake Bay. Adult red drum occur in the Chesapeake Bay from May through November and are abundant in the spring and fall near the Chesapeake Bay mouth. Adults travel in large schools often in near shore marine waters, but a red drum population extends as far north in the Chesapeake Bay as the Patuxent River. During mild winters, red drum may overwinter in the Chesapeake Bay, but they usually migrate seasonally, moving in schools offshore and southward in the winter and in shore to the north in the spring. Juvenile red drum also move from bays and estuaries to deeper waters of the ocean in response to dropping water temperatures in the fall and winter.

Male red drum begin maturing at age 1, while females mature at ages 4 to 5 in North Carolina and 2 to 3 farther south. Red drum are prolific spawners; large females are capable of producing nearly 2 million eggs in a single season. Spawning occurs in near shore coastal waters along beaches, and near inlets and passes from late summer and into the fall. Eggs spawned in the ocean are carried by currents into estuaries where they hatch.

Young-of-the-year appear in the estuary from August through September and newly hatched larval red drum are carried further by water currents toward fresher, shallower water. Juvenile drum in these areas feed on zooplankton and invertebrates such as small crabs and shrimp. Adults primarily feed on fish, crab, and shrimp.

The Fisheries

The commercial red drum fishery is not an important one in the Chesapeake Bay area. Virginia's commercial catch, once as high as 180,000 pounds per year, has been insignificant since 1965. Maryland's annual catch has not exceeded 2,000 pounds since 1954. Commercial landings of red drum baywide have been reported since the 1880s. The landings have varied widely, ranging from 4,400 pounds in 1973 to 1.7 million pounds in 1945. Landings in the Mid-Atlantic have declined since the 1930s. The fishery is generally nondirected, using pound-nets, shrimp trawls, hand lines, haul seines, and gill nets. Runaround gill nets were a dominant gear in Florida, taking 65 percent to 84 percent of the total catch, but that fishery has been closed due to concern that overfishing could cause stock collapse.

A modest recreational fishery exists. Most fish are taken by surf casting from seaside beaches and some by bait fishing along the Chesapeake Bay side of the lower Eastern Shore. The recreational fishery for red drum is a near shore fishery, targeting small "puppy drum" and large trophy fish. Trophy-size fish are caught along the mid- and south- Atlantic barrier islands, while smaller red drum are taken in shallow estuarine waters. The Chesapeake Bay size record is unknown, but the Virginia record is a fish weighing 85.3 pounds, which was taken from the seaside of Wreck Island in 1981. Since the 1980's the amount of fish caught for a given unit of effort has declined. Recreational catch peaked in 1984 at 9.96 million pounds.

Red drum on the Atlantic coast are managed jointly by the Atlantic States Marine Fisheries Commission (ASMFC) and the South Atlantic Fisheries Management Council (SAMFC). The commission wrote its Fisheries Management Plan (FMP) for Red Drum in 1984 and the council completed its own FMP in 1990. The Chesapeake Bay Program's FMP was completed in 1993. A serious problem in the fishery concerns intense fishing pressure on juvenile red drum in state waters, which results in significantly reduced recruitment to the spawning stock. Additionally, managers are concerned about the potential for a directed fishery outside state waters, which could directly reduce the spawning stock.

The goal for both the ASMFC and the SAMFC is to manage for sustained harvest by US fishermen, while maintaining the spawning stock biomass at 30 percent of the level that would occur with no fishing (30 percent SSBR). The objectives of the plans include: managing for 30 percent SSBR; providing a flexible management system that retains commission, council, and public input in the management process; and promoting cooperative research that will increase management decision making in the future. Research priorities for red drum are directed toward collecting the necessary data to perform an up-to-date stock assessment. This includes improved catch, effort and length/frequency statistics; increased data from night anglers; tagging of 3- to 5-year-old fish; standardized sampling of sub-adult fish; and developing an improved estimate of natural mortality (Chesapeake Bay Program, 1999).

COBIA

The cobia is the only species of the family *Rachycentridae* and is a migratory pelagic fish that is found in tropical, subtropical, and warm temperate waters throughout most of the world. However, they are not known to occur in the eastern Pacific. In the western Atlantic, they occur from Massachusetts and Bermuda to the Rio de la Plata of Argentina. They are seasonally common along the US coast from Virginia to Texas. Contrary to some earlier held beliefs, recent research has indicated that cobia frequenting US coastal waters maybe of a single genetic stock. This is supported by the fact that there is some movement between the Gulf of Mexico and Atlantic populations.

Life Cycle and Habitat

Cobia migrate north along the Atlantic coast from northern Florida to the Carolinas and then into the Chesapeake Bay by late May. Most fish depart Virginia coastal waters by late September/early October. However, it is unclear where cobia from the middle Atlantic US coast overwinter. Some findings suggest that after a southerly coastal migration, they may spend the winter on the outer half of the continental shelf. These movements are greatly affected by water temperature, with cobia entering the Chesapeake Bay after water temperatures exceed 67 °F. Adult cobia are coastal and continental shelf fish that occasionally enter estuaries. They may occur throughout the water column and over a variety of bottom habits including mud, rock, sand, and gravel; over coral reefs; in shore around pilings and buoys; and offshore around drifting and stationary objects.

Researchers believe the lower Chesapeake Bay may be an important spawning area. In Virginia, cobia are reported to spawn from late June through mid-August, with multiple spawnings in evidence. Eggs hatch within 36 hours of fertilization, with highest tank test hatching rates in water salinities of 33-35 ppt and a water temperature of approximately 79 °F. Female cobia appear to grow more rapidly and attain greater size than males. Females may reach maturity as early as 3 years of age at around 8 pounds and 28 inches. Some mature males have been noted at 2 years and 20 inches. Although some studies indicate the fish may live to upwards of 10 years, significantly more data is available on fish which have reached the age of 8 years: males average 42.5 inches and 33 pounds and females average 54 inches and 69 pounds. Of note, fish that weigh 45 pounds (minimum weight for Virginia Saltwater Fishing Tournament citations) are 5-6 year old females. The Virginia rod and reel state record cobia was a 103 pound (lb.), 8 ounce (oz.) fish caught in Mobjack Bay in 1980. While 114 lb. fish have been caught along the northern Gulf of Mexico coast, the world "all tackle" record is 135 lbs. 9 oz., recorded by an Australian angler in 1985.

To a large extent, cobia feed near the bottom, but they also take prey near the surface. They feed extensively on crabs and other crustaceans but also prey on other invertebrates and fish (Snider, 1996).

The Fisheries

Commercially, cobia have been an incidental catch in both hook-and-line and net fisheries, with the majority of fish taken from Gulf of Mexico waters. Research has also revealed there is a significant bycatch of cobia that occurs incidental to the bottom shrimp trawl fishery in the Gulf of Mexico. In the United States, recreational landings of cobia have not been historically well documented, although they have far exceeded commercial landings.

Recreational fishermen landed an estimated 216,000 cobia in US waters in 1965, while 119,000 were landed in 1970. During the period from 1984 through 1993, the number of fish caught along the Atlantic coast ranged from 29,199 in 1993 to 55,741 in 1992, with a yearly average of 37,521. The yearly average for this period in the Gulf of Mexico was 56,686. During the same period, the commercial catch in the Atlantic region ranged from 1,328 in 1985 to 6,078 in 1992, with a yearly average of 4,231. The yearly commercial average for the Gulf was 10,606.

Data on cobia landings in Virginia is sketchy at best. Figures from the VMRC depict the state commercial catch in pounds ranging from 545 lbs. in 1987 to 16,959 lbs. in 1990. Since 1993, any person desiring to catch and sell cobia in Virginia must possess a harvester registration card and a hook and line gear license. This requirement legally eliminates previous recreational fishermen who might have sold much of their catch.

In Virginia, as in most other states, the cobia is viewed primarily as a recreational fish. Fish receiving recognition in the state's Saltwater Fishing Tournament provide a barometer of the recreational catch in that they only reflect those fish over 45 lbs. (catch citation) and those over 48 inches (release citation implemented in 1991). The 300 citations each in 1962 and 1963 represent the largest numbers awarded prior to 1995. Between 1984 and 1995, the numbers ranged from 11 in 1984 to an unprecedented 603 in 1995 (Snider, 1996), with the number only slightly diminished in 1996 (Olney, 1998). Estimates of recreational catches are based on the NMFS Marine Fish Recreational Statistics Survey, which has not provided a consistently reliable reading of the Virginia catch (Snider, 1996).

In the US, the cobia is currently managed by the South Atlantic and Gulf of Mexico Fishery Management Councils. Although there is not a specific Cobia FMP, the species has been included within the FMP for Coastal Migratory Pelagic Resources. While most of the plan is dedicated to measures regarding king and Spanish mackerel, dolphin and cobia are also addressed (Snider, 1996).

BLACK SEA BASS

The black sea bass (*Centropristis striata*) is a member of the family Serranidae, or true sea basses. Also known in the Chesapeake Bay area as "black will," "chub," or simply sea bass, they are year-round inhabitants of the Mid-Atlantic region. These bass are bluish-black fish as adults and brownish as juveniles; they have scales with pale blue or white centers.

Life Cycle and Habitat

The black sea bass population extends from Maine to the Florida Keys and into the Gulf of Mexico. Black sea bass found north of Cape Hatteras are seasonally migratory and from a stock that is considered distinct from that south of the Cape. In the Chesapeake Bay, adults migrate offshore and south to overwinter in the deep, 100-meter waters off the Virginia and Maryland coasts. In spring the fish return to the mid and lower Chesapeake Bay, as far north as Solomon's Island, and remain there until late fall. Black sea bass have been captured as far north as the Chester River, but most fish encountered near the shore are juveniles (1 to 2 years old).

Adult black sea bass are considered a temperate reef fish and are most often found on rocky bottoms near pilings, wrecks, and jetties. Visual feeders during daylight hours, black sea bass rely on swift currents and their large mouths to capture their prey, which include other fish, crabs, mussels, and razor clams. Although they do not travel in schools, they can be found in large groups around structures or during in shore-offshore migrations.

Black sea bass are protogynous hermaphrodites, which means that initially they are females, but some larger fish (between 9 and 13 inches) reverse sex to become males. Thirty-eight percent of females in the Mid-Atlantic demonstrate sex reversal, usually between August and April, indicating that reversal takes place after spawning.

In the Mid-Atlantic continental shelf waters (59-148 ft deep), spawning begins in June, peaks in August, and continues through October. The fish, ages 2 to 5, produce approximately 280,000 eggs, which are buoyant and contain a single oil globule. Larvae develop in coastal waters 2 to 50 miles offshore at depths of up to 108 feet, preferring salinities of 30-35 ppt and temperatures of 58-82 °F. When they are about 13 milimeter (mm) (0.5 inches [in]), young black sea bass move in shore into estuaries, bays, and sounds, where they find shelter in beds of SAV, in oyster reefs, and among wharves, pilings, and other structures. Young black sea bass feed primarily on crustaceans, such as shrimp, amphipods, and isopods.

Juveniles migrate offshore in December, although some young-of-the-year may remain in the Chesapeake Bay throughout the winter. Black sea bass are reported to live as long as 20 years and reach a maximum adult size of two feet. However, individuals longer than 15 inches (approximately the size of an 8-year-old fish), are uncommon. Large fish are more common offshore than in the Chesapeake Bay.

The Fisheries

The black sea bass forms the base of an important recreational fishery. An estimated 1.5 million black sea bass were taken by anglers in the lower Chesapeake Bay in 1991. Anglers bottom fish using squid and other natural baits to catch this highly esteemed and flavorful fish. The commercial interest in the Chesapeake Bay is modest, however, with commercial landings averaging less than 2,275 kg (5,000 pounds) per year. Gear types include trawls, pots, and hook and line.

In 1996, the Chesapeake Bay Program developed the "Chesapeake Bay and Atlantic Coast Black Sea Bass Fishery Management Plan" to enhance and perpetuate black sea bass stocks in the Chesapeake Bay and its tributaries. Stock assessments before 1996 indicated that the species was being over-harvested in the Chesapeake Bay, which led the Mid-Atlantic Fishery Management Council/Atlantic States Marine Fisheries Commission to take several measures: implementing a 9-inch total length minimum size limit for 1996-97, with ensuing limits to be revised on an annual basis; requiring a 4-inch minimum mesh size for trawlers that harvest more than 100 pounds; and requiring all black sea bass pots to have escape vents and biodegradable hinges and fasteners. The goal is to reduce exploitation and to improve protection of the black sea bass spawning stock in the Chesapeake Bay and the Atlantic.

ATLANTIC BUTTERFISH

The Atlantic butterfish (*Peprilus triacanthus*) is a member of the family Stromateidae, of which two species are found within the Chesapeake Bay. Butterfishes are characterized as being very deep-bodied and highly compressed, with adults lacking pelvic fins (Murdy et al., 1997). The Atlantic butterfish is a fast-growing, schooling, pelagic fish that ranges from Newfoundland to the Gulf Coast of Florida, but is most abundant in the region from the Gulf of Maine to Cape Hatteras. It is a rather small fish, with maximum adult length reported as 30 centimeters (cm) (Murdy et al., 1997). Short-lived, butterfish rarely live beyond 3 years of age and attain sexual maturity at 1 to 2 years of age. Butterfish are typically found in euryhaline (5-32 ppt) environments (Musick, 1972).

Life Cycle and Habitat

Butterfish occur in large schools in bays and over continental shelves. They are a pelagic species, typically found in waters over shallow bottoms. The butterfish occurs in the Chesapeake Bay from March through November and is considered common to abundant in the lower bay. Within the bay, the butterfish move northward in the spring, first appearing in Virginia waters in March but not found above the Rappahannock River before May. All leave the bay by December, overwintering offshore in deeper water (590-690 feet) (Murdy et al., 1997).

Butterfish are broadcast spawners, and spawn offshore from May to July in the Chesapeake Bay. After hatching, juveniles move into the near-coastal waters, sometimes including bays and estuaries. The young often hide from predators in mats of floating seaweed or among the tentacles of jellyfish. Juveniles feed primarily on phytoplankton, while the adult diet is comprised mainly of jellyfish, small fishes, crustaceans, and worms. (Murdy et al., 1997).

The Fisheries

The butterfish fishery of the Chesapeake Bay is presently of minor commercial importance. Formerly, catches were much larger. For example, in 1920, Chesapeake Bay landings were reported as 590,000 kilograms (kg) (1.3 million pounds), with almost all catch from pound-nets. In contrast, the reported catch for 1990 was 9,100 kg (20,000 pounds). Catches occur in two peaks, the first occurring from April-May and the second occurring from September-October. Butterfish are of only minor interest to recreational fishermen, as they rarely take bait (Murdy et al., 1997). The butterfish stock is not overfished nor approaching an overfished condition (Cross et al., 1999; NMFS, 1997).

CLEAR NOSE SKATE

Life History and Habitat

This small elasmobranch skate occurs in the North Atlantic ranging from Nova Scotia to the Gulf of Mexico, though it is rare in the northern portion of its range and migrates from cooler northern waters as winter approaches. It is migratory in the local area, typically appearing in the Chesapeake Bay in April to November-December. In the Bay, the only records have been from the Bay mainstem; none have been caught in the tributaries. The maximum size is approximately 80 cm total length at an age of 5-6 years. They feed on small benthic organisms as well as on small fishes. Typical habitat is softer bottom areas along the continental shelf, though they can also be found in rockier habitat. As is common in skates, this species is an egg layer, typically laying up to 30 pairs of eggs in a season. Both juveniles and adults can be found in the Chesapeake Bay. They prefer higher salinity waters of > 22 ppt, with most being found in waters of at least 31 ppt.

The Fisheries

There is a commercial fishery for the clear nose skate. The primary means to capture them is via otter trawling, though they are also taken as bycatch in groundfish trawling and scallop dredging fisheries. This small species is typically used for bait, not human consumption. The current status is not overfished.

WINTER SKATE

Life History and Habitat

This small elasmobranch skate occurs from the coast of Newfoundland to Cape Hatteras. It prefers colder waters than many fish species found in the Chesapeake Bay area. In the local area, it can be found from December to April. Its maximum size is approximately 1.5 m in total length. Similar to most skates, it is an egg layer. It is not known to lay eggs in the local area, preferring colder waters to spawn in, and juveniles are not commonly found in the Chesapeake Bay area, only rarely being observed near the Bay mouth in the winter. It typically feeds on a wide variety of invertebrate benthic organisms but also takes small fish and squid. It prefers sand and gravel bottoms but can sometimes be found on mud bottom habitat. It typically buries itself in the sand during the day, feeding at night.

The Fisheries

Otter trawling is the main method to catch most skate species, including the winter skate. This species is also caught as bycatch during groundfish trawling and during sea scallop dredging. The skate fishery is mainly a bait fishery, though this larger species does have a commercial market for its wing meat for human consumption. As a result of these uses, fishing pressure grew intense and the winter skate was overfished. However, it has since recovered and although its biomass is still well below its original level (about 25 percent of the observed peak) and it is not currently considered to be overfished.

LITTLE SKATE

Life History and Habitat

This is a small elasmobranch species, and adult maximum size is approximately 60 cm. It occurs from Nova Scotia to Cape Hatteras and is very abundant. Like most skates, it is an egg layer and has been known to lay eggs throughout the year. This skate typically feeds upon small invertebrates, primarily crustaceans, squid, and polychates, though fish and other organisms are sometimes consumed. They prefer sand or gravel bottoms, as do many skate species, though they can also be found on mud bottom habitat. The often bury themselves in the sand during the day and feed at night.

The Fisheries

There is a commercial fishery for the clear nose skate. The primary means to capture them is via otter trawling, though they are also taken as bycatch in groundfish trawling and scallop dredging fisheries. This small species is typically used for bait, not human consumption. The current status is not overfished, and the population biomass is estimated to be a medium level.

REFERENCES

Chesapeake Bay Program, 1999. http://www.chesapeakebay.net/fish1.htm

Cross, J.N., C.A. Zeitlin, P.L. Berrien, D.L. Johnson, and C. McBride, 1999. National Oceanographic and Atmospheric Administration. National Marine Fisheries Service. Northeast Region. Essential Fish Habitat Source Document: Butterfish, *Preprilus triacanthus*, Life History and Habitat Characteristics. September 1999. NOAA Technical Memorandum NMFS-NE-145. Woods Hole, MA.

Grubbs, R.D., 1995. Preliminary recruitment patterns and delineation of nursery grounds for *Carcharhinus plumbeous* in the Chesapeake Bay. SB-III-11. Prepared for the 1996 NMFS Shark Evaluation Workshop, Miami, FL, as cited in Camhi, 1998.

International Shark Attack File, 2001. Administered by the Florida Museum of Natural History and the American Elasmobranch Society. Website: www.flmnh.ufl.edu/fish/Sharks/ISAF/ISAF.htm

Murdy, E.O., R.S. Birdsong, and J.A. Musick, 1997. Fishes of the Chesapeake Bay. Smithsonian Press, Washington, DC.

Musick, J.A., 1972. Fishes of the Chesapeake Bay and adjacent coastal plains. *In* M.L. Wass ed. A checklist of the biota of the Lower Chesapeake Bay, pp.175-212. Virginia Institute of Marine Science Special Scientific Report 65.

Musick, J.A., S. Branstetter, and J.A. Colvocoresses, 1993. Trends in shark abundance from 1974-1991 for the Chesapeake Bight region of the Mid-Atlantic coast. NOAA Technical Report NMFS 115, as cited in Camhi, 1998.

National Marine Fisheries Service, 1997. Report to Congress. Status of the fisheries of the United States: Report on the status of fisheries of the United States. September 1997. Available: http://www.nmfs.noaa.gov/sfa/Fstatus.html.

National Oceanic and Atmospheric Administration (NOAA)/National Marine Fisheries, March 1999. Guide to Essential Fish Habitat Designations in the Northeastern United States, Volume V: Maryland and Virginia.

Olney, J., 1998. Reproductive ecology of cobia in Chesapeake Bay. Virginia Institute of Marine Science website: http://www.vims.edu/adv/cobia/.

Rose, D.A., 1998. Shark fisheries and trade in the Americas. TRAFFIC North America, Washington, D.C., as cited in Food and Agriculture Organization of the United Nations, 1999, *Carcharhinus obscurus*, FAO website: http://www.fao.org/WAICENT/FAOINFO/FISHERY/sidp/htmls/sharks/ca_ob_ht.htm

Smith, S.E., D.W. Au, and C. Show, 1998. Intrinsic rebound potentials of 26 species of Pacific sharks. Marine and Freshwater Research. 49(7):663-678, as cited in Food and Agriculture Organization of the United Nations, 1999, *Carcharhinus obscurus*, FAO website: http://www.fao.org/WAICENT/FAOINFO/FISHERY/sidp/htmls/sharks/ca_ob_ht.htm

Snider, L., 1996. Fisheries Position Paper: Cobia (*Rachycentron canadum*). Coastal Conservation Association of Virginia. (http://www.virginiamag.com/cca/ppcobia.htm).

Virginia Institute of Marine Science, 1999. Virginia Institute of Marine Science website: http://www.vims.edu/cbnerr/species/sshark.html.

ADAPTIVE MANAGEMENT PLAN

ADAPTIVE MANAGEMENT PLAN

ADAPTIVE MANAGEMENT PLAN

INTRODUCTION

Project Description

The study area consists of the entire Lynnhaven River Basin, which is located in the city of Virginia Beach, Virginia. The Lynnhaven River, with its three branches (the Eastern, Western, and Broad Bay/Linkhorn Bay) encompasses an area of land and water surface that is approximately 64 square miles in area. The watershed, representing one-fourth of the city of Virginia Beach, is the largest tidal estuary in the city and lies in the heart of the urbanized northern half of Virginia Beach. This basin has 150 miles of shoreline and hundreds of acres of marsh, mudflat, and shallow water habitats. The river supports a tremendous level of recreational boating, fishing, crabbing, ecotourism, and general environmental observation. However, the river has become increasingly stressed as the watershed has shifted from predominantly rural to predominantly urban/suburban. Changes resulting from development of the surrounding uplands, such as loss of natural buffers, more impervious surfaces, and increases in population and density, have impaired the ecosystem within the river.

The Lynnhaven River Basin Restoration study identified specific areas of concern that must be addressed in order to restore environmental function and quality to the system. These areas of concern are reduced water quality, loss of tidal wetlands, loss of submerged aquatic vegetation (SAV), and the amount of siltation occurring in the system. The recommended plan developed by the United States Army Corps of Engineers (USACE) for the environmental restoration of the Lynnhaven River Basin is made up of four elements. These elements are SAV plantings, bay scallop restoration, construction of fish reefs, and restoration and diversification of wetland sites.

<u>Fish Reefs</u> in the Lynnhaven River Basin will cover approximately 31.4 acres, with approximately 20.8 acres in Broad Bay and Linkhorn Bay. Additionally, 10.6 acres will be constructed in the main stem and Pleasure House Creek. Fish Reefs will be created by placing concrete structures called of various types onto the floor of the Lynnhaven system, producing artificial, hard reef habitat. At sites where the bottom substrate it too soft to support the reef

structures, geomesh mats filled with stone will be place beneath them to prevent the structures from sinking into the substrate.

Submerged Aquatic Vegetation Restoration-The restoration of SAV in the Lynnhaven River Basin will cover approximately 94 acres: 52.1 acres in Broad Bay and 41.7 acres in the main stem of the Lynnhaven. Selected sites will be planted with SAV seeds of two species, widgeon grass *(Ruppia maritime*) and eelgrass (*Zostera marina*). Seeds will be distributed using small boats, likely Carolina skiffs, which are usable in shallow water. The seeds may also be planted using divers, or mechanical planters, operated off a small boat. Due to the greater environmental tolerances of widgeon grass, early efforts will be focused on restoring this species, though eelgrass will be attempted simultaneously in sites where it has the greatest chance for establishment. It is expected that the SAV beds established in the Lynnhaven River will be a mix of widgeon grass and eelgrass, with widgeon grass dominating.

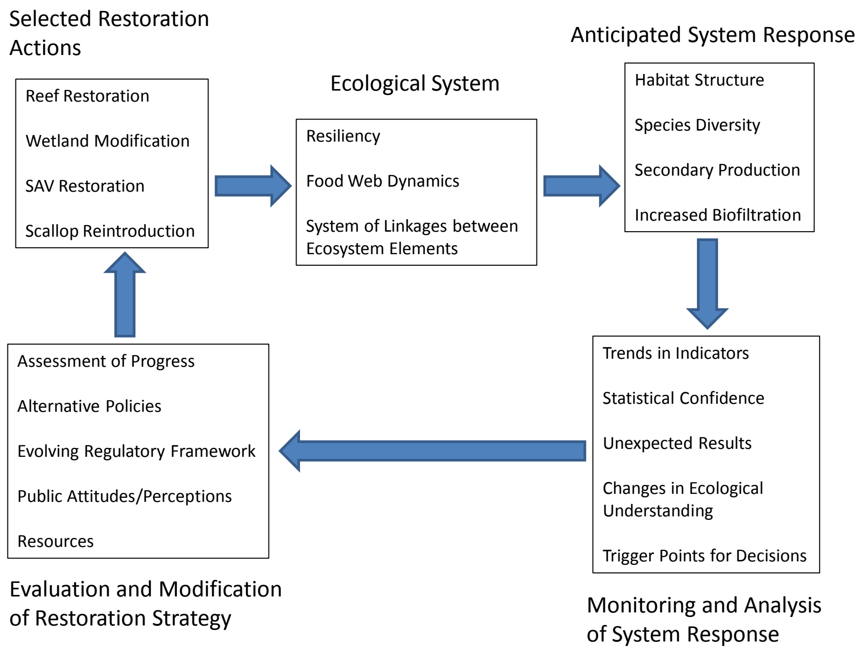
Bay Scallop Restoration-Restoration of the bay scallop will occur at the SAV restoration sites one year after SAV seeding has been completed and the beds have been allowed to become established. The scallop restoration effort will consist of two techniques; first, juveniles and adults will be direct stocked within restored SAV beds, and then brood stock adults will be kept in cages to provide maximum spawning efficiency.

Salt Marsh Restoration and Diversification-At two of the wetland sites, Princess Anne (PA) and the Great Neck North Sites (GNN), the population of the invasive plant species, common reed (*Phragmites australis*), will be eliminated using both physical alteration of the site and chemical application, and a indigenous salt marsh community will be established. Within areas that are dominated by *P. australis* and can be accessed by heavy construction equipment, the *P. australis* stands will be first treated with an herbicide approved for wetland use in order to kill existing foliage. Then, approximately 2 to 4 feet of the upper peat layer will be excavated in order to remove as much *P. australis* material, including rhizomes, roots, and foliage, as possible to prevent recolonization. Features such as shallow pools, upland islands, and channels will be created to increase the diversity of the marsh habitat and to allow seawater to flood the area. Finally, clean fill will be added to adjust the elevation of the site, and the bare substrate will be planted with native marsh plants. In areas that cannot be reached with heavy equipment or where small patches of *P. australis* are present, aquatic herbicides will be applied either through aerial or manual application.

The "Restoration" goals proposed for the Mill Dam Creek (MDC) and Great Neck South (GNS) sites do not include the establishment of a *Spartina spp.* dominated salt marsh. Instead, the ecological function of the two sites will be improved through habitat "diversification." Habitat features, including islands, channels, and pools, will be constructed to break up the homogeneous phragmites stands. Small drainage dikes will be widened into creeks to extend the range of tidal inundation. Shallow, open pools or "scraps" will be created by excavating the top layer of material. The material excavated from the tidal creeks and pools will be used to build upland mounts that will be planted with native shrubs or grasses. Some herbicide application may be necessary to kill phragmites rhizomes and foliage in the material used to create the upland mounds.

Adaptive Management

In order to adequately address the uncertainties inherent in a large environmental project and to improve the performance of the project, Adaptive Management (AM) has recently been developed and adopted by the USACE. AM replaces dependency on numerical models and traditional planning guidelines which were used in the past to manage the unpredictability of complex environmental projects and, instead, applies a focused "learning-by-doing" approach to decision-making. The "learning-by-doing" approach is proactive – it is an iterative and deliberate process using the principles of scientific investigation. Through a program of regular monitoring that allows a better understanding of the ecosystem and the projects place in the system, a project's design and operation are continuously refined. Information that can guide a project adaptive management plan (AMP) can include results from scientific research and monitoring, new or updated modeling information, and input from managers and the public. Potential applications of this "learning by doing" AM approach include: (1) transfer of lessons learned from one program/project to another to avoid pitfalls; (2) use of physical models/modeling to test possible outcomes of management decisions; and (3) incorporation of flexibility and versatility into project design and implementation. The basic process works as follows:



This AMP describes how the project elements of the Lynnhaven Restoration Project will be monitored and adjusted if long term monitoring finds adverse impacts on the native populations or if the project elements are not providing the benefits predicted in the integrated report. It describes the process for evaluating the results of the monitoring program, "triggers" or action points that would necessitate modifications to the project, and potential changes that would be implemented to improve the performance of the project. The monitoring program should accomplish the following:

- It should support *adaptive management* decisions by providing data on critical stages in the development of the reefs, scallops, SAV and wetlands that can guide the next steps in the restoration process. This monitoring should answer crucial questions that affect implementation decisions. For example: Did sufficient numbers of transplanted scallops survive and spawn to support continued stock development? Is the biomass on the reefs increasing? Are reef-dependent fish utilizing the reefs? Are the diversified wetlands maintaining the native vegetation along the re-graded contours or is it being re-invaded by Phragmites?

- It should evaluate intermediate conditions that help to *track progress* toward the final goals. For instance, are enhanced abundances of scallop larvae and new recruits observed in a tributary following seeding with broodstock? Are newly-seeded SAV beds increasing in shoot density per unit area of SAV bed annually? Is biomass increasing on the reefs on an annual basis as predicted? Such a monitoring objective permits setting *intermediate goals* and evaluating success in reaching those goals.

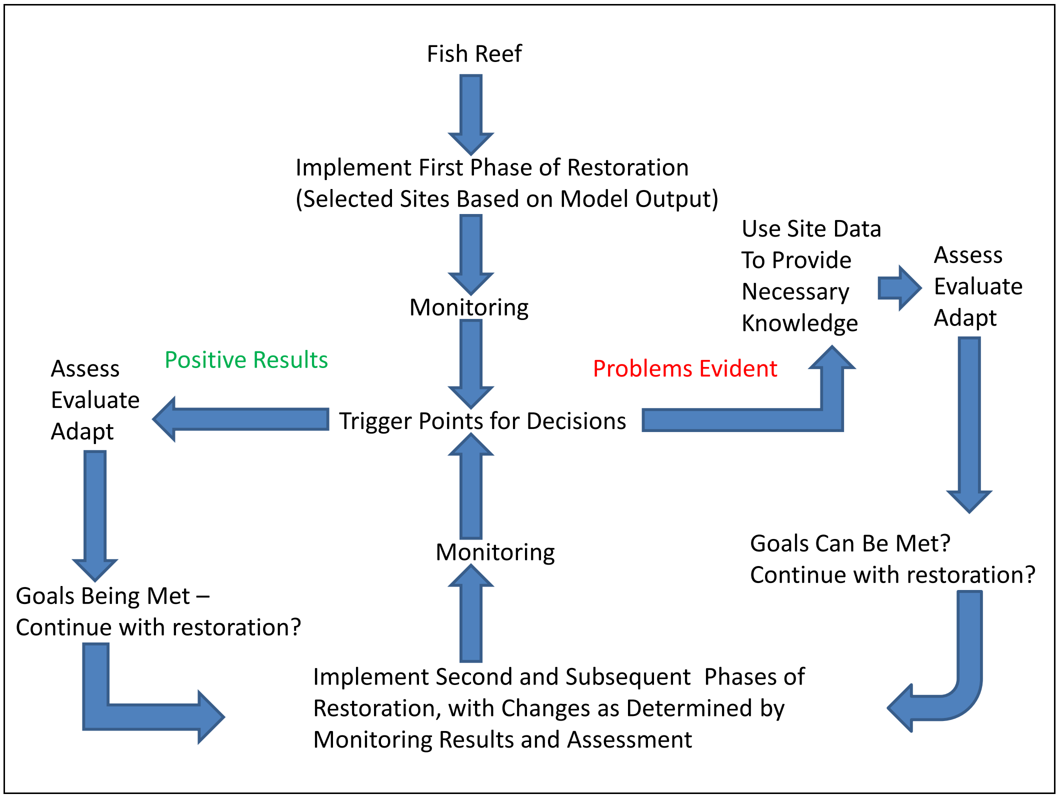
- It should measure specific elements necessary to evaluate *success criteria* established for the project. For instance, numbers and sizes of oysters and other sessile filter feeders are needed to evaluate the secondary production and filtration capacity of a restored multiple-use reef as proposed in the plan.

- It should aid in *identifying unexpected stresses*, environmental conditions, and/or ecological interactions that can affect the overall success of the project. For instance, water quality, particularly temperature, TSS and chlA, can be affected by a very wide range of factors; measuring all of which would be impractical, but having a monitoring program in place that could recognize when water quality problems affected the success of a project would be invaluable. Major storm events during periods where there are planktonic larvae of sessile filter feeders can significantly and negatively influence subsequent recruitment, which will result in lower than desired secondary production by the reefs. Droughts, on the other hand, can produce better conditions for recruitment.

As discussed in the risk analysis section, the risk varies with each project element, with scallop restoration having the highest risk, SAV moderate risk, and the fish reefs and wetlands diversification the lowest risk.

FISH REEF HABITAT

Once placed, fish reefs should need little intervention due to their durability. Due to the size of the project, though, there are opportunities to employ AM as the project will be phased in over a period of several years. The numbers of reef structures necessary will take several deployments prior to the settling season (spring-summer) of local sessile and reef-dependent species. Several types of structures should be placed, as current available research does not identify which one is best for local use. The basic reef AM process is as follows:



The first sites implemented will be based on prior model output and were identified as important source-sink areas for recruitment of oysters and other sessile life-forms that have a planktonic phase (Lipcius et al. 2008), with potential smaller-scale deployments in other areas if the leases are obtained and the bottom freed for use for the fish reefs.

Monitoring

The fish reefs will need to be assessed annually for up to 10 years post placement to determine the health of the sessile benthic community that grows upon them and also to determine nekton usage. Monitoring will likely be annual for the first five years, while bi-or triennial monitoring will be considered after that, depending on trends in the data. Monitoring will include sampling the benthic and nekton community on the reefs through physical sampling of the reef (e.g. scraping of randomly selected square areas of reef by divers on the reefs) in order to determine the species composition, biomass, and growth rates of the biota on the reefs. Random sampling on a small sub-set of reef structures at each proposed reef site will be necessary for a complete monitoring program. All surfaces of the reef (inside and out) are included in the random sampling design, as there may be differences in productivity between outer and inner reef surfaces. Sufficient samples will be taken to keep the SE (standard error) within 25% of the mean (average) value. For oyster reef restoration projects, to which these reefs are similar, this will require approximately 30-60 samples from the entire reef complex which includes all sites and types of structures throughout the river (not 30-60 per reef site). This should ensure sufficient statistical confidence in the results to clearly see trends in indicators to allow for proper documentation of project objectives and goals, as well as to decide whether or not to implement any adaptive management measures. The main management trigger point is secondary production, which is annualized for the reefs by utilizing the dry weight of the biota collected in the reef samples and the growth rates in species specific equations (available in literature) to estimate the annual secondary production. A guide to the procedure to estimate secondary production follows. A similar protocol will be followed for SAV and wetlands, though there are some differences that will be pointed out within their following sections of this plan. Biomas will be estimated by obtaining a discrete scraped area of reef (example, 0.25 square meters) and collecting all organisms and associated material. Macrofauna will then be collected by rinsing all of the collected material through a 1.0 mm mesh sieve. Oyster shells will be carefully broken apart and rinsed to remove polychates nd other small organisms that are often found living inside recently dead (but still intact) oyster shells. All live material will then be frozen and/or fixed in 10% formalin. Animals will be identified to the closest taxa possible and counted. Dry mass will be determined by drying in an oven at 60C for at least 48 hours and weighing to the nearest 0.1 mg (all animals will be weighed prior to placement in the oven). The difference in weight will be recorded as dry weight. The following table shows the expected values of secondary production over time. Failure to achieve a minimum of 50% of the annual metric will require re-visiting the project implementation schedule and construction plan, or implementation of adaptive management measures. Along with the data collected for the project data collected by other agencies (e.g. water quality, climate, etc) will be examined to attempt to determine why goals are not being met and if modifications of subsequent deployments are necessary (see Adaptive Management Section below).

Reef Secondary Production Over Time, High and (Low) Relief Reef	
Year	Secondary Production (kg/acre/year) for high and low (in parenthesis) reef habitat
0*	223 (180)
1	446 (360)
2	891 (720)
3	1783 (1440)
4	2897 (2341)
5	4457 (3601)

*assumes deployment prior to first settling season no later than April with first monitoring results for year 0 obtained from a fall survey. If deployment is later year 0 should be moved to one year later.

Also included in the secondary production estimate will be the presence of reef-dependent fish utilizing the reef structures and motile organisms living on the reef structures. This information can also be used to estimate increases in BIBI from the preconstruction conditions. While the species composition can be calculated during the physical sampling of the reefs, the reef fish assessment is recommended to be done using underwater video. If such species are not observed, credit for their secondary production should be reassessed (Peterson et al. 2003) and downgraded, as it is part of the goal metric secondary production. Small reef dependent species such as gobies, blennies, toadfish and clingfish should be observable on the reef. Larger structure using species, such as black sea bass, sheepshead, tautog, gag grouper, spottail pinfish, silversides, sheepshead minnow, pigfish, cobia, black drum, and others should also be observed utilizing the constructed reef habitat. From the video, record should be made of fish species observed and approximations of their numbers. If this proves insufficient, fish traps or other means to obtain physical samples should be considered. Estimates of the annual secondary production will be calculated using a species average weight and the numbers of that species observed. The other major component of the enhanced secondary production is an expected increase in blue crab and other crustacean production. Fishing records for blue crabs can be consulted to see if there is an increase in the area of the reefs, or if fishery independent data is desired, a separate study could be undertaken to assess blue crab density within the reef areas by comparing them to a sandy bottom open area without such structure. All three calculations of secondary biomass will be combined to compare to the goals. The fish reefs will be considered fully successful when biomass goals are being met for two or more years and marginally successful if at least 50% of the goal is being met for this same time span (this time span begins year 3) and federal interest in monitoring of the reefs will cease.

The estimated costs for this monitoring and associated documentation will be $40,000 per year. Extensive monitoring at this level would be needed for the first five-ten years post construction. Up to ten years is needed for this option due to the large number of reef structures and the probabililty to collect sufficient samples over a long enough period of time to meet the goals. The proposed reefs will likely take longer to mature than five years as a variety of species that use the reefs have longer life cycles, such as many of the larger reef-dependent fish species.. After that, assuming the reefs have matured, a smaller effort, primarily using a ROV, could be implemented at a lower cost of $10,000 per year, and done once every 2-3 years. This effort would be supported by the local sponsor, as after the initial 10 years the USACE will close out the project and all monitoring (including the fish reefs, wetlands, SAV and scallops) will be the responsibility of the local sponsor, the City of Virginia Beach. Monitoring will be done by specialists with the subject matter expertise and will be consistent throughout the monitoring period and with similar regional monitoring. These will likely be scientists from regional universities with published work and research relevant to the restoration effort.

Adaptive Management

Due to the size and scope of the proposed reef habitat, the structures will be placed over a period of several years, which provides opportunity to make adjustments based on lessons learned. The first placements are proposed in areas determined (Lipcius et al. 2008) to be highly likely to recruit sufficient sessile invertebrates, particularly oysters, to meet secondary production metrics. Also, several different types of reef structures will be deployed, so we can collect data on which structures are best in the Lynnhaven and for different uses, such as shallow nearshore vs. deep water subtidal deployment. Fish, which are highly motile, will be attracted the reefs wherever they are placed, since the sites selected all have appropriate salinity regimes for the various reef-utilizing species.

Based on the initial results, future reef placement will be considered and possibly modified in order to improve performance. Modifications could also include changing the shape, conformation and/or placement grid of the structures to improve performance as well as selecting alternative areas for placement. An additional measure would be to modify the design of the individual reef structures, as their shape can affect the surface area that is fully exposed to predation as well as sheltered internal areas not so exposed. Conformation changes could include changes in the concrete and stone mix to be more attractive to sessile larva for settlement or to enhance surface rugosity to provide for increased shelter for small post-settlement reef organisms. Extant reef structure, if failing to meet metrics, will also be considered for AM actions, of which there are primarily two: cleaning or moving to another location. However, before any AM action on placed structures is considered, all possible reasons for not meeting expected metrics should be considered as it is likely better to simply wait and give the reef habitat more time to produce expected benefits. Storms during times of recruitment, Bay-wide poor water quality (anoxia, high temperatures due to regional heat wave) can significantly lower recruitment and natural impacts to the reefs need to be considered prior to AM action other than waiting. Although there are other possible options available for improving the productivity of placed reef structures, two are described presently. If the reef structures become covered with sediment, divers could be hired to clean off the reef structures, or possibly a small dredge could be run in reverse, blowing off the sediments from the reef structures. This is not an expected maintenance event, and will only be done in the event a major storm results causes high enough sedimentation on the reefs that it overcomes the oysters' and other filter feeders' abilities to clear the reefs of the sediment. This clearance can take several months, so this action will not be triggered until at least a season of biological activity occurs post-storm on the reefs. A storm during the winter that deposits significant sediment on the reefs will not be removed by biological activity due to low metabolic rates of sessile reef organisms during the winter, though water currents may sweep the reefs clean despite the lack of biological activity prior to the spring warm up and resumption of activity by the reef organisms. While some small amount of settlement is anticipated, a few inches, if the concrete structures sink into bottom substrate more than that, the reef structures could be pulled up and placed in a more stable area. This could even be achieved before the construction is complete as the construction time frame is a long enough period for any settlement to occur. Construction will be sequenced for the larger, heavier reef structures to be placed first and the lighter, smaller reef structures done last. This would allow for monitoring to be done after placement to address any settlement issues for the larger reef structures. The smaller reef structures are less likely to settle into the substrate as they are much lighter but lessons learned in the placement of the larger reefs structures would be utilized in the placement of the smaller variety. Additionally, a local NGO, Lynnhaven River NOW has placed reef balls and other structures, including interlocking concrete "oyster castles" of the small variety that would be used in Lynnhaven Bay, in both nearshore and deeper water applications. The monitoring of these done by the NGO and the lessons learned they can provide would also serve to inform on what could be expected when placing the smaller reef structures and perhaps modify their placement area and design in order to achieve additional benefits, such as shoreline stabilization and increasing estuarine marsh acreage due to sediment accumulation and stabilization in the lee of the structures. Adaptive management measures will also be considered after major storm events, but only after ROV monitoring is done to assess the reefs and sufficient time passes to give the living organisms on the reefs to clean them off. Monitoring would be conducted after a storm event to determine if storm generated currents shifted or scowered underneath reef structures to cause shifting or settlement. Monitoring would generally be done in the latter part of the fiscal year but would be adjusted to react to a major storm event, which would typically be a hurricane. The results of the monitoring would determine the appropriate adaptive management measure as well as to inform if monitoring would be necessary after future storm events.

Associated Costs

Hiring divers to clean off the reef structures would add approximately 2 percent to construction costs. Removing the reef structures from the sediment and possibly moving them to a more stable location would add approximately 10 percent to construction costs. Modifying the placement and/or designs of the reef structures as the project is phased in to take advantage of lessons learned from prior deployments should not add significantly to the construction costs of the project. $1,534,098 has been budgeted for adaptive management of EFH.

SUBMERGED AQUATIC VEGETATION

SAV may require more extensive adaptive management than the other options of the selected plan. It is expected that once seeded, beds should persist and hopefully provide seed that will establish new beds in other locations in the river. Due to the technical challenges of SAV restoration, sequencing will be used during implementation. Initial construction sites of less than an acre will be seeded at several of the locations recommended in the proposed plan. These sites will, at first, be mostly to entirely *Ruppia*, due to its greater tolerance for higher water temperature and general hardiness compared to *Zostera*. Variations in current energy will be one of the variables assessed, as SAV may perform better in areas with lower than average (for the Lynnhaven River) wave and current energy in the river, though the opposite may also be true. The objective of the sequencing is to assess the seeding plan (density, depth, etc.) without making the large commitment to seed wholesale the proposed project areas and make final adjustments to the large-scale seeding using the results of the initial plantings. These results in additional decision points in the SAV AM plan, compared to the fish reef AM plan. The basic SAV AM plan is explained graphically below:

The additional steps are due to many reasons, the first of which are the more variable track record of SAV restoration in Chesapeake Bay, SAV populations have been in general decline in the Bay, no large-scale attempt to restore it has been made in the Bay in some time. Additionally, prior attempts were using the older methods of transplantation of mature plants, not the modern methodology of direct seeding as proposed in the present study and focused almost exclusively on eelgrass, *Zostera,* not the hardier widgeongrass, *Ruppia,* that the present study recommends. The first decision point occurs after the initial plantings. If the SAV grows and survives, the planting plan will be used to seed the whole site. If not, results will be evaluated, a cause determined, if possible, and adjustments made to planting plan. .. For the initial acreages, growth and survival of the SAV is the objective, so predator exclusion (cow-nose ray) netting may be installed in order to prevent the rays, whose foraging habits can be disruptive to SAV, from impacting the small-scale initial plantings. No specific density (shoots/m^2) is required for the initial acreages, though there are density objectives for the large-scale seeding as the density of SAV determines secondary production as well as the probability of long-term persistence. Further sequenced plantings and adjustments to seeding locations may be needed in the next phase, depending on what the cause was for the seeding failure. Reasons initial plantings may not work as well as desired include, but are not limited to, variance in seed viability, storm events immediately after seeding before seeds become anchored in the sediments, damage to new SAV beds by cow-nose rays or boat propellers (which can be extensive), excessive or insufficient water currents, or potentially a strong storm event such as a hurricane or Nor'Easter that could damage a newly established SAV bed. These can be fairly easy to determine and treat. Other reasons could be a local or regional decline in water quality, which would be more difficult to address.

Adaptive management measures would typically involve over-seeding beds to improve performance in the event that seeding does not take at desired densities in any selected area, abandoning a faltering site and moving a site or sites to regions of better current flow, anti-predator exclusion from the beds to discourage destructive foraging, better signage to discourage boat propeller damage or relocation of sites to areas of lower boat use. Passive actions are also possible, mainly waiting to see the results of a seeding and while gathering additional monitoring data to better influence decisions. The expected secondary production values for a fully successful SAV restoration attempt are displayed in the following table.

SAV Secondary Production Over Time

Year	Secondary Production (kg/acre/year)
0*	77.6
1	155.2
2	310.4
3	620.8
4	1008.8
5	1552.0

*year of large-scale seeding after initial acreages are completed with positive results

Monitoring

The SAV beds will need monitoring to assure long-term persistence and to measure any expansion or changes in density of the SAV over time. The monitoring program for SAV should include an annual survey to assess the extent, density, and secondary productivity of the vegetation of the SAV beds for five-ten years post construction. Extent of beds can be measured via areal photography or by piloting a boat with built in gps around the bed and recording the data to create a polygon that can then be used to estimate area using GIS software. Density of beds shall be estimated by randomly sampling a subset of the bed using quadrats of known area (example 0.5 square meters) and counting the vegetative shoots within this area and/or taking a photo to compare with SAV beds of known density to estimate the density within the random test plot (cut off values are 10, 40, 70 and 100% coverage, a healthy bed is definied as at least 50% density, which means vegetative shoots are present over 50% of the bottom sediment within the sample, the other 50% being open bottom). It should be noted that it is common to have a mix of shoots and open bottom within SAV beds. Secondary production will be estimated similarly to that of the fish reefs, with procedures in the lab remaining the same (though instead of oysters, clams, mussels and scallops would be the large bivalves). Samples should be collected throughout the bed randomly using a suction sampler that will sample a discrete area of the bed, and screened on site of sediment. Numbers of samples will be taken to achieve the desired SE (25% or less than the mean), similar to that of the fish reefs. It is expected that a somewhat larger number of total samples (perhaps 100) may be necessary to achieve this, due to the greater variability in habitat quality (shoot density) within even a healthy SAV bed. Remaining vegetation and attached fauna will then be taken to the lab and the fauna separated from the vegetation then assessed for secondary production. A water quality monitoring program is already in place and data collected from it will also be consulted, as SAV persistence is dependent on good water quality. In the Lynnhaven, the minimums for the more fragile SAV species, eelgrass, are 15% light penetration at 0.5 m depth, < 15 ug/l ChlA, < 0.15 DIN (mg/l) and <0.02 DIP (mg/l). Widgeongrass is considerably more tolerant of lesser water quality and should be easier to establish. It is important to note that these parameters are, on average, met in the areas of the Lynnhaven selected for restoration. SAV beds mature quickly, as do their associated benthic communities, and five years should be sufficient for the beds to mature and the benefits to match that of SAV beds located in small bays along Virginia's lower Eastern Shore. However, since the strategy focuses (especially at first) on a somewhat less persistent species, *Ruppia,* newly established SAV beds will need to be monitored for stability longer than the time needed to initially establish them, which may take only a year or two. After the first five year period, if the SAV beds are persistent, monitoring could be relegated to the annual monitoring program conducted by Virginia Institute of Marine Science (VIMS) that encompasses the entire Chesapeake Bay and includes the Lynnhaven River system. If not, it is recommended that the more extensive monitoring continue to be done for another five years for 10 years total monitoring. For the initial five year period, however, it is important to establish a more comprehensive monitoring program. Such a program would involve random samples within restored SAV beds, to determine both the health of the SAV as well as secondary production within the beds to ensure long-term project success and document that desired goals are achieved. Water quality data is already being collected by other agencies, though data on water currents may need to be collected in addition to this and such work would be funded under the present study's proposed plan.

For SAV, the cost of monitoring is also estimated to be $40,000 per year for the first five years of the project, which may be continued if necessary for another five years. After this period, no additional money has been allocated for SAV monitoring because it is anticipated that the project areas will be incorporated into the annual SAV monitoring program conducted by VIMS. Adaptive management may dictate otherwise but it is hopeful that this will not be needed. If desired shoot densities are achieved, and secondary production values are on track similar to those of the fish reefs with respect to the timing of the goals and year (starting year 3, 2 consecutive years should meet to secondary production goals), then this feature will be considered successful and monitoring can cease.

Adaptive Management

Seeding new areas that appear to be suitable but are not colonized by SAV could be implemented despite the success of the proposed beds in the selected plan. There may be subtleties in local hydrodynamics that prevent the propagules of successful beds from colonizing isolated regions of the river system, especially one as complex as the Lynnhaven.

Reasons a seeding may not work as well as desired are variance in seed viability, storm events immediately after seeding before seeds become anchored in the sediments, damage to new SAV beds by cow-nose rays or boat propellers (which can be extensive), or potentially a strong storm event such as a hurricane or Nor'Easter that could damage a newly established SAV bed. Summer heat waves can be challenging for SAV, especially *Zostera.* These can be fairly easy to determine and treat, except for weather-related impacts. Other reasons difficult to overcome via management decisions altering the construction plan could be a local or regional decline in water quality. In the cases involving physical damage to the beds, the cost to re-seed would approach 10% of the initial seeding costs to help low- shoot density SAV beds increase to the desired level faster, as the risk is that low density beds will continue to decline without intervention. Low density beds are those that have 10% or less of the area measured with SAV vegetation present.

Seeding in areas near established beds to encourage more rapid expansion could also beconsidered. This option would cost less, up to approximately 5% of initial seeding costs. This measure would be employed if bed expansion does not occur, but the established bed persists at above low shoot density (if it does not, the entire bed will have additional SAV seeds applied within it).

Another measure could be to seed new areas that appear to be suitable but are not colonized by SAV despite the success of the proposed beds in the selected plan. There may be subtleties in local hydrodynamics that prevent propagules from successful beds from colonizing isolated regions of the river system, especially one as complex as the Lynnhaven. Monitoring results that assess current speeds within areas that develop SAV could be used to refine these choices. Such an option could cost 10% or more of the initial seeding costs, depending on the number of areas to be seeded. These sites will be identified post-initial construction, as these areas will not be apparent until SAV beds are established and expansion of the beds into new areas is documented. This will take at least 2 years after initial seeding to observe. Temperature data will be consulted, as the Lynnhaven River is near the edge of eelgrass' (*Zostera marina*) range and if the restored eelgrass dies back and the problem can be identified as temperature stress, the re-seeding may either only be with the more temperature tolerant widgeongrass (*Ruppia maritima*) or seed with more temperature tolerant eelgrass, if such can be found. There is evidence that *Zostera marina* displays genetic differences regarding temperature tolerance (Ehlers et al 2008) but for local use no such strains have been identified at this time. Additional adaptive management actions could include signage requiring "no wake" zones over restored SAV beds, to reduce prop damage within the bed or possibly marking the SAV beds "off limits" to boat traffic, at least those located in shallow (< 3ft MLW) waters. This will be considered if prop damage to established SAV beds is observed. Such options would help existing, established beds maintain their integrity over time, as there is extensive boat traffic in the Lynnhaven. If the damage is due to cow-nose ray foraging, the only solutions are to protect the beds physically with nets or fencing, lower the numbers of rays (via a fishery, for example) attempt to restore SAV further upriver in lower salinity waters where cow-nose rays do not frequent (this option would likely preclude use of eelgrass and rely on widgeongrass only, as it is more tolerant of low salinity) and/or re-seed the beds. If the SAV declines or fails to establish and the cause is determined to be poor water quality, water quality monitoring data that is collected by the City of Virginia Beach will be reviewed for specific water quality issues.. Eutrophication can occur in the event of a drought followed by above average rain events, and this can cause spikes in ChlA, DIN and DIP above levels tolerable by SAV. These levels should abate with time and the SAV, if still present, can recover. If not, and water quality improves it could be re-seeded. If the decline is caused by other events, such as a decrease in overall Bay water quality, seeding with eelgrass may not be implemented and only widgeongrass, the more environmentally tolerant species, may be used until water quality improves sufficiently to warrant eelgrass establishment. If enough SAV can be established, these parameters are less likely to be exceeded as SAV itself utilizes the same nutrients that can cause phytoplankton blooms due to eutrophication.

In any area that is difficult to access by boat or if currents are strong or irregular, buoy deployed seeding would be utilized. This technique helps insure that the seeds, when dispersed, stay in an area around the buoy by releasing them slowly over time. This process lets the dispersal take place across a variety of conditions and would mitigate the risk of losing broadcast seeds due to storm events or currents shortly after the seeds were cast to the water (Pickerell, et al. 2006).

Decision points are after every year's monitoring. If results are at least 50% of expected secondary production values, the project will likely require no AM action other than continuing to monitor the site(s) to see how they progress. If the original effort to establish SAV is not successful, the project area will be reseeded unless it is determined that an underlying cause that cannot be addressed (such as unfavorable current velocity that could not be altered by additional reef placement or what appears to be a long-term regional decline in water quality (Bay-wide)), in which case a particular site(s) may be abandoned. Re-seeding should also take place if the SAV beds are only scarcely vegetated (density ≤ 10%), as additional seeding will help low-density SAV beds increase to the desired level faster and reduce the risk that the low density beds will continue to decline without intervention. If secondary production values are not meeting at least 50% of the objective, a decision point is reached. If this failure is due to disruption of the SAV by weather events, unless total loss occurs the likely decision will be to wait to see if enough seed and underground rhizomes remain to recover the bed, as SAV is resilient in the face of this type of event and can often recover, once established, on its own due to available seed and rhizomes, which often remain buried in the sediments while above ground biomass is swept away by the storm event. If the failure is determined to be from a water quality cause, such as a heat wave, waiting is the likely recommendation unless total loss of both above and below sediment SAV has occurred, in which case re-seeding is recommended. If the cause is physical damage (boat props and/or cow-nose rays) measures can be taken to discourage this, including signage and physical barriers.

Associated Costs

The cost to re-seed would approach 10 percent of the initial seeding costs, while seeding in areas near the established beds would cost less, up to approximately 5 percent of initial seeding costs. Seeding new areas, outside of the project site, could cost up to 10 percent of the initial seeding costs, depending on the number of areas to be seeded. “No wake” signage would have minimal associated costs, perhaps 1-2 percent of initial seeding costs. $190,520 is the estimated cost of adaptive management for SAV.

BAY SCALLOP RESTORATION

Scallop restoration will only be attempted if core bed acreage (the minimum SAV option as described in the attached report) is at least present, as scallops are highly (though not exclusively) dependent on SAV as shelter for their juvenile stage. Scallop restoration will only proceed if several beds of SAV can be restored and show persistence by surviving for several years. The scallop is a short-lived mollusk and in the Lynnhaven will essentially function as an annual crop, though some can survive for two years. Once established, and assuming the SAV persists, the scallops should persist along with the SAV. However, scallops are vulnerable to predation and possibly environmental disruptions, such as major storm events. The restoration efforts will, similar to SAV, begin with smaller level efforts and commence from there. The objectives of the initial efforts is to determine if scallops reproduce in the Lynnhaven as well as gather data on the most efficient means to restore a breeding population. It is expected that these efforts will be less and shorter in duration than those for SAV, as the Corps has already funded a large-scale study on scallops in the Lynnhaven River (Hernandez-Cordero et al. 2012). The results of this study indicated scallops can survive and grow in the Lynnhaven River on a variety of habitats, including oyster reefs, SAV, and macro-algae. The smaller initial efforts will focus on how best to implement wide-scale restoration, as there are a number of techniques available, including keeping spawning adults in cages so they spawn at high efficiency, release of juveniles and/or adults into SAV beds, to potentially releases late-stage larvae into SAV beds. It is expected that a combination of efforts, likely focusing on caged adults with some stocking of juveniles, is the likely restoration regime but the initial effort will assist in fully developing this plan. Expected productivity for scallops is described in the following table:

Scallop Secondary Production Over Time	
Year	Secondary Production (kg/acre/year)
0*	11.5
1	22.9
2	45.8
3	91.6
4	148.9
5	229

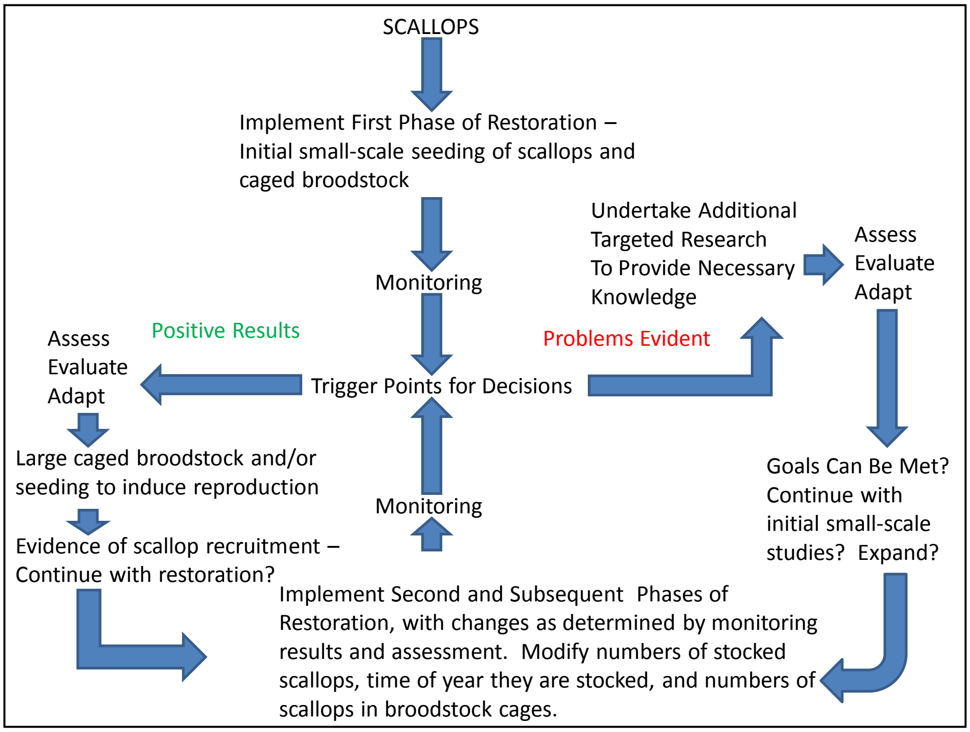
Monitoring

Scallop populations will need to be assessed in habitat they can colonize, which consists of SAV beds, gracilaria (macroalgae) beds, and oyster reef habitat. Monitoring can follow standard protocols for assessing scallops, which include counting them along transects or assessing their numbers in discrete sampled areas. Scallops are expected to colonize the SAV beds primarily, and the monitoring program for the SAV, which includes secondary production, will capture scallops during that sampling. Therefore, the primary scallop monitoring will be included within the SAV monitoring program. Scallops will be separated and evaluated separately from other fauna in the SAV samples and a separate secondary production number (and scallop population and density) can be developed from those samples. Recruitment outside the restoration areas can be measured by “spat bags,” which are loose bags of dense nylon nettings that scallop juveniles will set upon and grow. The objective with spat bag deployments is to determine two things: scallops are reproducing and recruitment is occurring outside the SAV beds. If the scallops recruit successfully, they should establish a self-sustaining population quickly, within five years of initial stocking. Monitoring should be more extensive during the first five-ten years, as this is the critical time for population establishment and deciding whether or not to implement various measures within the adaptive management plan. Monitoring costs for an annual scallop survey of juveniles and adults and an associated spat bag survey to assess abundance, dispersal, and recruitment, should be expected to cost approximately $40,000 to $50,000 annually for the five year period. After this, a smaller scale survey could be implemented to ensure the scallop population remains viable, and this smaller survey should cost no more than $15,000 per year. If the goals are not reached, however, the more extensive monitoring should remain in place for another five years while the adaptive management plan is implemented.

For all monitoring, if extensive adaptive management measures are needed, this would essentially re-set the "clock" on the monitoring plans. That is, if there was an extensive SAV die back during year 3 and complete re-seeding was needed, five years of extensive monitoring would be required, starting the year of the re-seeding. Similar to prior project options, if scallop secondary production goals are being met along with evidence of annual recruitment for at least 3 years, the monitoring program can cease.

Adaptive Management

Scallop restoration will only be attempted if core bed acreage (the minimum SAV option) is at least present, as scallops are highly (though not exclusively) dependent on SAV as shelter for their juvenile stage. Scallop restoration will only proceed if several beds of SAV can be restored and commence at least 1 year after successful SAV bed establishment. Once established, and assuming the SAV persists, the scallops should persist along with the SAV. They will also colonize other habitat, such as macroalgal beds (*Gracilaria* sp.), and oyster reefs in significant numbers. However, scallops are vulnerable to predation, and possibly environmental disruptions such as major storm events. The basic scallop AM decision tree is as follows:



There are several adaptive management measures that could be considered in scallop management, as follows. As with prior portions of the plan, the objective is to reach at least 50% of the secondary production goal. For scallops, evidence of successful reproduction is also a requirement and the establishment of a self-sustaining population is a primary objective, along with the secondary production goal.

In order to reduce risk from predation, limited areas (perhaps 10X10 square meter plots) within SAV beds, determined to be the main areas supplying scallop recruits to other areas, could be fenced off. The predator that can cause the most extensive damage to a scallop population, the cow-nose ray, would be kept out by such a measure. Preferentially stocking within these predator exclusion areas could be accomplished, in order to better insure initial survival. The corps could also stock at very high densities within these fenced areas, in order to improve reproduction of the scallops to enhance recruitment. This is a relatively inexpensive measure, and would be up to 5% of the initial seeding costs. This predator exclusion could also be done if re-seeding is required, and done more extensively. In this event, up to 10% of initial costs would be necessary; to cover the addition of hatchery produced juvenile scallops within the fenced-off areas. Other adaptive management actions could include collecting juvenile scallops on volunteer or contractor deployed spat bags placed under docks or within or near existing SAV beds and then stocking these juveniles more heavily within established SAV beds to increase the population density of the scallops in order to improve both the environmental benefits they provide as well as their reproductive efficiency. Due to the extensive environmental group membership in the local area, it is likely that such spat collecting done by volunteers could be quite extensive and contractor deployed spat collectors used less extensively as a result. Costs for spat collecting would likely be relatively small, perhaps up to 5% of initial seeding costs. This measure will likely be considered if recruitment does not seem sufficient or if the need to collect additional data on recruitment is needed beyond the scope of the proposed monitoring plan.

A further adaptive management measure would be to deploy scallops in cages at very high densities to maximize reproduction and subsequent recruitment. This will be considered both in the initial stocking as well as if recruitment does not appear to be adequate to establish a self-sustaining population and additionally seeding proves necessary. Such techniques are showing success on the lower Eastern Shore of Virginia in re-establishing scallops in restored SAV beds there.

Predator control via commercial fishing of the rays could also be considered, and is currently under discussion by the state fishery management agency (Virginia Marine Resources Commission (VMRC)). This is due to the noted increase in cow-nose rays in recent years, which also cause extensive mortality to clam beds and commercial oyster lease holds. Predator control would consist primarily of developing a commercial fishery for cow-nose rays, which, while not a USACE action, the USACE will provide input to VMRC.

After each year's monitoring, the scallop population will be assessed. Three basic questions will trigger decision points, and these are: Is there evidence of successful reproduction? Are numbers of adults increasing? Are secondary production goals being met? Failure to meet any of these three will trigger the AM plan.

In the event of unsuccessful reproduction, unless a weather event, such as a hurricane, can be identified as the cause, the likely cause is too few spawning adults. In either event, the appropriate response is to augment the spawning population the following year in order to avoid a population crash. This can be done using any of several techniques described above, particularly stocking of juveniles and/or adults directly into the SAV beds or placement of spawning adults in cages near SAV beds which will release larvae into them.

If the population of adults appears to be reproducing, but decreasing in numbers, this may trigger an AM response. SAV beds should first be assessed for their fitness, as decreasing shoot density exposes the scallops to increased rates of predation. Evidence of cow-nose ray feeding within SAV beds should also be assessed. Cow-nose rays disrupt the bottom when they feed, creating a hole approximately 1foot in diameter and 6" deep. Large numbers of these holes in SAV beds would identify the ray as the primary culprit in decreasing numbers of adult scallops despite successful reproduction. Anti-predator exclusion netting is the cheapest measure to discourage the rays, though if a fishery for them could be developed, this would also ease their predation pressure on the scallops as well as other benthic life in the Chesapeake Bay though this action is outside the AM plan. Other causes could be inadequate recruitment. This could be caused by poor water quality during the larval phase, particularly large inputs of freshwater which reduce larval survival and growth, as well as flush them out of the river into the Bay. The appropriate AM response in this case will be to augment the spawning stock by means already described.

Failure to meet secondary production goals will also trigger the AM plan. If the scallops appear to be reproducing and adults are surviving in adequate numbers to produce a self-sustaining population (or one that seems to be increasing) no action should be taken and a "wait and see" approach is recommended. Scallops may develop a stable population at a lower than expected level in the SAV beds, considering that they can survive on other substrate that is present in large amounts (macroalgal beds, oyster reefs) in the Lynnhaven River. These scallops on alternative substrates could provide significant secondary production such that goals are actually exceeded, though not exclusively via the scallops in the SAV beds habitat. Routine monitoring of the oyster reefs built under the 704(b) program would provide some data on scallops utilizing this habitat type. Additionally, this goal may need to be reassessed if this situation occurs, as the primary objective is to establish a self-sustaining population of scallops. The secondary production numbers were developed using more southern populations of scallops, and the numbers for Lynnhaven River's distinct scallop sub-population may be somewhat different.

Associated Costs

Fencing off areas within SAV beds is a relatively inexpensive measure, and would be up to 5 percent of the initial seeding costs. If predator exclusion is done in conjunction with SAV re-seeding, then the associated costs would be as high as 10 percent of initial costs to cover the addition of hatchery produced juvenile scallops within the fenced-off areas, while the costs associated with spat collection would likely be relatively small, perhaps 5 percent of initial seeding costs. 10 percent of the constructions costs, or $316,001, has been set aside for the adaptive management of bay scallops.

WETLANDS RESTORATION AND DIVERSIFICATION

The monitoring and adaptive management (AM) plans for the two different wetland treatments will vary slightly due to the overall project objectives.

Monitoring

The four wetland sites will be monitored twice annually. The monitoring efforts will be completed by either a USACE employee with a background in wetland function and plant identification or a contractor with a similar background. The results of monitoring efforts, whether they are completed by USACE staff or a qualified contractor, will be recorded and presented to the USACE within 30 days after monitoring has been completed to allow for the planning of adaptive management measures. The USACE, Norfolk District will maintain the monitoring data.

Restoration Sites

The project objectives for the Princess Anne (PA) and the Great Neck North (GNN) sites include the restoration of the indigenous salt marsh community and reduction of the invasive plant species, *Phragmites australis,* present on-site. The key parameters that will be monitored at these sites during the adaptive management phase will include:

1. The presence of *Phragmites australis* in the restoration site,
2. Success of native plantings,
3. Integrity of habitat features (streams, pools, islands, etc.).

These three parameters are directly related to the achievement of an indigenous community and eradication of the exotic species.

The presence of *P. australis* must be monitored regularly for two reasons. First, the eradication of this invasive is rarely accomplished in one season. Instead, an infestation of *P. australis* is eliminated in small increments over a series of years. Second, if any *P. australis* remains at a site, the plant will continue to spread and replace the native plants. The monitoring of *P. australis* will be considered successful and complete once it is clear that the native vegetation is growing healthily and *P. australis* is being out-competed by the native plants.

Monitoring the native plantings will be necessary to fulfill contractual obligations and to ensure the success of the project. The planting contract will stipulate that the contractor must replace plants if a certain percentage (15% typically) fail during the first year. Later, plant success was be monitored to ensure that the design of the project was correct. For example, native marsh plants will succeed in a narrow elevation range. Even if the design is correct, there are many hazards that could interfere with the success of the native plantings. The native plantings will be considered successful if 85% of the planted areas are covered with native marsh grasses for at least a two year period. Due to the expected growth rates of the plants, this 85% number is not expected to be reached during the first two years, as it will take time for the vegetation to mature and fill in bare areas within the initial plantings.

The final element of the monitoring plan will be assessing the constructed habitat features. Each feature will be observed to determine if it is structurally sound and functioning as intended. For example, tidal creeks and streams will be observed to make sure they have not become occluded and no longer allow the full tidal inundation. The upland mounts will be monitored to see if they remain at an elevation that supports upland plants and have those upland plants are not overrun by *P. australis.* This element of the project will be considered successful if the integrity of each habitat remained sound for three years and 85% of the upland island areas are covered with native plants for at least a two year period. Due to the expected growth rates of the plants, this 85% number is not expected to be reached during the first three years, as it will take time for the vegetation to mature and fill in bare areas within the initial plantings. This type of vegetation takes longer to mature compared to emergent marsh plants so an additional year will likely be needed to reach the 85% goal

Diversification Sites

The "restoration" goals proposed for the Mill Dam Creek (MDC) and Great Neck South (GNS) sites do not include the establishment of a *Spartina spp*. dominated salt marsh. Instead, the ecological function of the two sites will be improved through habitat "diversification," specifically habitat features, including islands, channels, and pools, will be constructed to break up the homogeneous *P. australis* stands. The key parameters during the AM phase to be measured at the sites where diversification has been implemented will include:

1. The presence of *Phragmites australis* in the constructed features that would impede the growth of native shrub plantings and would fill in tidal streams and pool,
2. Success of native plantings,
3. Integrity of features (streams, pools, islands, etc.).
4. Estimation of Secondary Production

Monitoring

The four parameters to be measured during monitoring ensure that the habitat features which have been created during the construction phase of the project remain viable. The monitoring activities and success criteria for the first three are described in the previous paragraphs. Annual costs of $7,600 over the first 10 years of the project, and $3,800 thereafter, are estimated to be the monitoring cost associated with the wetland sites. The maximum number of years (10) of monitoring is recommended for the wetland sites because the elimination of *phragmites* has been shown to be an ongoing process that requires many years of monitoring and removal efforts to be successful. Each cost estimate accounts for monitoring efforts required for the maximum acreage of each measure. For alternative plans with fewer sites, and thus less acreage, the monitoring amount was reduced accordingly.

Secondary production will also be assessed. Expected values are as follows:

Wetland Secondary Production Over Time	
Year	Secondary Production (kg/acre/year)
0*	12.1
1	24.2
2	48.4
3	96.8
4	157.3
5	242

These values are closely tied to the success of the plantings, and as wetlands restoration methods are much more well-established than other portions of the plan, it is expected that if the plantings survive, these values will be achieved. Sampling protocols and laboratory procedures will be similar to that of the other aspects of the selected plan (SE 25% or less of the mean, random samples of discrete areas taken, lab procedures to estimate secondary production).

Adaptive Management

Using the data collected through the monitoring program, USACE staff will be responsible for determining if AM is required at the wetland sites. The USACE will also select the AM measures, though other experts maybe consulted. Contractors with the appropriate background and expertise may be hired to implement the AM efforts; however the USACE will oversee the completion of adaptive management activities. AM measures are primarily herbicide application and replanting of native vegetation. Species of native vegetation may be altered, pending monitoring results, as different species than those initially selected may survive better considering the hydrology of the sites several years post-grading as well as the need to compete with other plants, including nearby *Phragmites.* Depending on the site, the replanting may vary the species in order to improve subsequent survival, as initial choices may not have been ideal, based on how the site performs over time.

A number of different strategies have been used to manage *Phragmites*. These include burning, mowing, manual removal of plant material and the application of herbicides. Since *Phragmites* management has been a recurring problem along the Eastern sea board for many years, other management plans have included common elements. So although any of previously listed actions will be available for AM of the wetland sites, it is highly probable that certain actions will be part of the plan. These actions, the application of herbicides, replanting native salt marsh vegetation, or repairing marsh features (pools, stream, or islands), are discussed in further detail in this report. However, this does not preclude the use of any effective strategy that will allow the project to fulfill the environmental objectives.

Restoration Sites

If *P. australis* is found within the restoration site, herbicide, approved for aquatic use, will be applied to the invasive species. The method of application (whether ground or aerial) will be determined by the location and density of invasive plants. The application of herbicide will occur when *P. australis* is still active, but when the native marsh plants have gone dormant, in order to reduce unintentional damage to the plantings and native plants. This period typically occurs during the last two weeks in September; however, this timing may be altered during drier years. The timing of herbicide application will be altered if annual precipitation levels are below normal levels.

If more than 15 percent of native plantings have failed, the dead vegetation will be replaced with plants for the same species. If it is concluded that replacing the original planting will ultimately be unsuccessful, then another solution (e.g. planting another species) may be implemented.

The tidal creeks and streams that were constructed or widened during the original construction effort will be observed to ensure that tidal water moves freely through the channel. If the stream is occluded, the feature will be repaired to allow flow.

The shallow pools should remain open and free from vegetation. If the areas are beginning to be colonized by *P. australis*, herbicide will be used to remove the invasive species unless a better solution is found to maintain the open pool habitats.

The upland islands will be checked for the success of native shrub plantings and re-colonization by *P. australis*. If 15 percent of the plantings have died, new individuals will be planted on site to replace the dead vegetation. If it is determined that new plantings would be unsuccessful, the site should be evaluated for another solution to vegetate the upland islands. If *P. australis* has re-colonized the upland islands, inhibiting the success of the native plantings, herbicide will be used to eliminate the plant from the habitat features.

Diversification Sites

The habitat features created at the GNS and MDC sites will be observed for colonization of *P. australis*. If *P. australis* is found on the upland islands, inhibiting the success of the native plantings, herbicide will be used to eliminate the common reed from the habitat features. The shallow pools and tidal creeks should remain open and free from vegetation. If the areas are recolonized by *P. australis*, herbicide will be used to remove the invasive species unless a better solution is found to maintain the open pool habitats.

The upland islands will be monitored for the success of native shrub plantings. If 15 percent of the plantings have died, new individuals will be planted on site to replace the dead vegetation. If it is determined that new plantings will be unsuccessful, the site should be evaluated for another solution to vegetate the upland islands.

The integrity of the habitat features will also be evaluated. The tidal creeks and streams that were constructed or widened during the original construction effort will be observed to ensure that tidal water flow moves freely through the channel. If streams are blocked, the feature will be repaired to allow flow. The integrity of the open pools and islands will also be observed to ensure that they are fulfilling their original purpose (i.e. increase habitat diversity at the site). If it is determined that the features are not improving the function of the site, they will be modified in order to meet project goals.The AM plan is triggered in the event of excessive casualties of the plantings, which directly relate to the values provided in the wetlands secondary production table.

Associated Costs

It is foreseen the certain adaptive management actions, such as the application of herbicide and the replacement of native plantings, will occur annually. Larger actions, such as the restoration the integrity of habitat features, requiring the physical alteration of the site will be planned every 5 years. The monitoring and adaptive management program will take place over a 10-year period.

The adaptive management costs associated with the wetland sites will be as follows:

Princess Anne - $53,160
Great Neck North - $11,757
Great Neck South - $13,273
Mill Dam Creek - $1,765

Adaptive Management Determination and Closeout

The monitoring program and pre and post construction surveys would be utilized to determine if any adaptive management is needed and what kind to proceed with. This determination would be made by the project delivery team made up of personnel from the Corps of Engineers and the City of Virginia Beach. Costs for the AM decision process have been included in monitoring cost estimates. AM measures will be implemented at any time over the first 10 years post construction by the USACE. After that, if AM is required, it will be the responsibility of the local sponsor, the city of Virginia Beach.

COASTAL ZONE MANAGEMENT SUMMARY CONSISTENCY DETERMINATION DESIGNATIONS

COASTAL ZONE MANAGEMENT SUMMARY CONSISTENCY DETERMINATION DESIGNATIONS

LYNNHAVEN RIVER BASIN
ENVIRONMENTAL RESTORATION PROJECT
VIRGINIA BEACH, VIRGINIA
SUMMARY CONSISTENCY DETERMINATION

CONSISTENCY REVIEW: Information presented in this summary consistency determination can be found in the accompanying Environmental Assessment, dated September, 2010.

PROJECT DESCRIPTION: This project will involve the restoration and protection of the water resources of the Lynnhaven River Basin. The project includes four elements. 94 acres in the main stem and Broad Bay will be seeded to produce submerged aquatic vegetation habitat. When SAV becomes established, bay scallops will be grown on site to build a self-sustaining population. Essential fish habitat will be constructed in Bread Bay and Lynnhaven Bay through the placement of concrete reefs. And, finally, restoration efforts will occur at four wetland sites.

PROPERTY CLASSIFICATION: The construction of reef habitat and restoration of submerged aquatic vegetation (SAV) will occur in areas that are state owned river bottom. The state has granted 10-year oyster/scallop ground leases in portions of these areas which will not be compatible with the project. As part of the project, oyster/scallop ground releases covering the remaining term of the existing leases will have to be acquired. The bay scallop restoration will be done on the SAV sites one year after they are constructed. The real estate interest acquired for the SAV restoration can be used for this portion of the project, and no additional interest will be required for this construction. The wetland sites are upland and will require a wetland easement for construction and maintenance.

IMPACTS TO RESOURCES/USES OF THE COASTAL ZONE: See table.

DETERMINATION: Based upon evaluation of impacts analyzed in the Environmental Assessment, the Norfolk District Corps of Engineers has determined that the proposed project will be undertaken in a manner consistent to the maximum extent practicable with the Commonwealth of Virginia's Coastal Zone Management Program.

FEDERAL CONSISTENCY DETERMINATION
COASTAL ZONE MANAGEMENT ACT OF 1972, AS AMENDED
VIRGINIA COASTAL RESOURCES MANAGEMENT PROGRAM
LYNNHAVEN RIVER BASIN, VIRGINIA BEACH, VIRGINIA

Enforceable Program	Approval/Permit Obtained
1. Fisheries Management	Finfish and Shellfish: Short-term negative impacts described in the EA. Long term goals of the project will be beneficial to finfish and shellfish TBT Regulatory Program: No TBT possession, sale, or use related to project (N/A).
2. Subaqueous Lands Management	Encroachment upon state-owned bottom – will obtain VMRC Permit. Activity involves discharge of fill into waters of the United States, specifically the placement of concrete reef balls and restoration of wetlands (addition of clean fill and alteration of marsh substrate). – State Water Quality Certification will be obtained from DEQ.
3. Wetlands Management	This project will result in impacts to tidal marsh. Some short-term, adverse impacts have been identified in the EA. However, long-term goals of the project include removal of an invasive plant species and/or increased habitat diversity. A Virginia Water Protection Permit will be obtained from DEQ.
4. Dunes Management	No destruction or alteration of primary dunes will occur as part of this project (N/A).
5. Non-point Source Pollution Control	Implementation of BMP's during construction.
6. Point Source Pollution Control	No VPDES impact. State Water Quality Certification under Section 401 of the Clean Water Act will be obtained. Involves discharges of fill material into waters of the United States.
7. Shoreline Sanitation	No activities related to installation of septic tanks (N/A).
8. Air Pollution Control	Although there will be minor air pollution increases from construction equipment, these increases will be short-term and below *de minimus levels*. Clean Air Act conformity determination completed in EA.

ECOLOGICAL BENEFITS

LYNNHAVEN ECOSYSTEM RESTORATION, BENEFITS MODEL INFORMATION

TABLE OF CONTENTS

LYNNHAVEN ECOSYSTEM RESTORATION, BENEFITS MODEL INFORMATION

ECOLOGICAL BENEFITS

For the proposed study, a wide variety of options were considered, including SAV (submerged aquatic vegetation) restoration, wetland restoration, fish reefs, scallop restoration, environmental dredging, and dam removal to restore freshwater impoundments to their former estuarine, tidal nature. Environmental dredging and dam removal were eliminated prior to forming alternative plans and will not be discussed further, nor were they considered in the model this document describes.

The options that were considered during the plan formulation include wetlands restoration, SAV restoration, fish reefs, and scallop restoration. A model was needed to relate these different options to each other, as well as to assess their environmental impacts to the Lynnhaven River system. Simple HU (habitat unit) approaches were not adequate for comparative purposes between these different habitat types. The cost to restore them also varied widely. A means to compare the ecological services they provide was needed. Several basic ecological benefits provided in various amounts by all the proposed restoration activities were considered. All of these benefits can be compared between the widely differing restoration activities in order to evaluate the benefits of each and various combinations of the proposed activities to arrive at a best buy plan.

Using functional endpoints, not structural, while different from the typical HU approach is not without precedent for the Corps or for the Chesapeake Bay. The Norfolk District's Craney Island Eastward Expansion (CIEE) project, approved in 2009, resulted in the take of open river bottom and water column above it to construct the new dredged material containment cell. The proposed mitigation plan assessed the lost secondary production because direct, in-kind mitigation was not possible because new open water habitat in the Elizabeth River system could only be created by either excavating nearshore lands or deliberately flooding them. This secondary production loss was then used to scale the replacement habitat to the level of loss of production. This approach was approved by the Corps, and the Commonwealth of Virginia. In

Maryland, the Chalk Point oil spill, which resulted in the release of 140,000 gallons of fuel oil into a tributary of the Patuxent river, impacted about 40 miles of creeks and shorelines. A significant portion of the accepted mitigation plan (2002) used lost secondary production to mitigate for lost ecological services because of the wide variety of benthic organisms and habitats that were affected by the oil. Due to the need to compare different habitat types in various configurations against each other in plan formulation, we decided to adopt this approach for the present study. Three parameters were selected, TSS (total suspended solids), Secondary Production (animal biomass produced per unit area) and BIBI (Benthic Index of Biotic Integrity, a measure of species diversity).

The proposed activities will work collectively to significantly decrease TSS, increase Secondary Production and improve the BIBI in the Lynnhaven River system. By improving these basic ecological parameters, the overall health of the Lynnhaven River is expected to improve significantly. Further, positive feedback loops exist between Secondary Production and TSS, the higher one is, the higher the other, and it is hoped that with enough restored habitat, these feedback loops will stimulate further, natural recovery in the river. These environmental benefits (TSS reduction, Secondary Production, and BIBI) are critical to the ecosystem but do not conform to a HU approach because they are functional, not structural.

The following figure is a Conceptual Model that explains how the proposed restoration can enhance the selected parameters we used in the benefits spreadsheet model found near the end of this explanatory narrative and within the report (pg. 81).

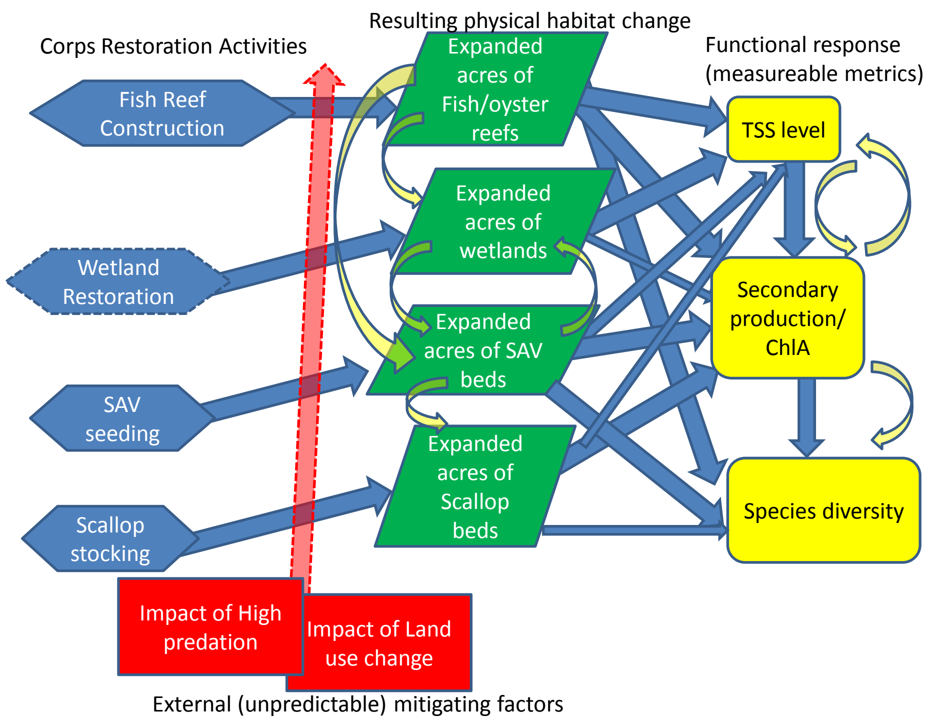


Figure 1. Conceptual Model for Environmental Benefits Model

The blue arrows represent linkages and the strength of that linkage. For example, SAV beds greatly increase secondary production but only moderately decrease TSS levels compared to other restoration options such as wetlands or reefs. Yellow arrows indicate a feedback exists, and the direction the arrow points in shows the direction of the feedback. In some cases, positive feedback loops between parameters exists. The following narrative first provides additional information on the benefit parameters selected (secondary production, TSS, and species diversity) and thier importance to the ecosystem. Following this, background information is provided on each restoration option considered, information on its potential to enhance the selected parameters, then the selection of the numbers found in the benefits spreadsheet.

Also, a means to link the project benefits to the VIMS hydrodynamic/water quality model was needed in order to assess impacts on Lynnhaven River water quality as a result of project implementation using the VIMS model. While improving water quality is not a primary objective, it is directly related to project implementation. It also serves as an indicator of the wide-scale benefits derived from project implementation. However, it is important to note that neither the VIMS model nor the model run results were used to make decisions on determining what the selected plan is.

The following sections provide background information on the selected parameters, describing their importance to the ecosystem.

SECONDARY PRODUCTION/CHLOROPHYLL A

Secondary production, that is, production of animal biomass, is often used as a standard measure of ecological health and productivity in environmental restoration work (McCay and Rowe, 2003, Peterson and Lipcius, 2003), as primary production can often be excessively enhanced by eutrophication, especially in the aquatic environment. Secondary production can be an important indicator of environmental health. It has the benefit of being a measurable, functional goal against which to judge success. Additionally, for the present study, secondary production was used as a proxy to determine how much phytoplankton was ultimately consumed to produce it. This, then, relates to the chlorophyll A parameter in the VIMS model. By reducing phytoplankton levels, local waters will become less eutrophic, which will improve water clarity and quality (Paerl et al., 2003). The secondary production will have a positive cascade of benefits for local waters, providing more animal biomass as prey to higher trophic levels, which will ultimately increase biomass of higher level predators, such as striped bass (*Morone saxitalis*), sharks, rays, drum fish (*Sciaenops ocellatus, Pogonias cromis*), cobia (*Rachycentron canadum*), blue fish (*Pomatomus saltatrix*), spotted sea trout (*Cynoscion nebulosus*), weakfish (*Cynoscion regalis*), and others. Local fisheries will also benefit. For secondary production, different environmental restoration options had their annual secondary production biomass estimated in AFDW (ash free dry weight, a measure of organic biomass produced independent of shells, water in tissues, or other materials). An annual production/biomass estimator was used to paramaterize the peak summer standing biomass to an annual production rate, which varied throughout the year with the primary driver being water temperature. The method used was adopted from work by Diaz and Schaffner (1990) for the Chesapeake Bay.

TOTAL SUSPENDED SOLIDS (TSS)

The second environmental parameter that will be improved by any of the environmental restoration options considered is TSS (total suspended solids) levels in local Lynnhaven River waters. TSS is a common measure to estimate negative human-induced impacts to aquatic ecosystems. Levels higher than pre-development levels of TSS have a number of negative impacts. TSS reduces gas exchange, increasing the chances for anoxia in tidal estuaries (Abril et al., 2009). TSS reduces water clarity, and its increase due to human impacts, primarily agriculture and urban development in the Chesapeake Bay watershed, have greatly reduced the available habitat for SAV and beneficial macroalgae due to reductions in light levels from high TSS (Tomasko et al., 2005). SAV acts to stabilize bottom sediments; its loss creates a negative feedback loop where TSS tends to increase further, making it increasingly difficult for light-dependent marine life to persist, especially rooted aquatics. Additionally, it reduces the available habitat for other photosynthetic life, such as benthic diatoms (Ulanowicz, 1994), altering the species composition, along with the associated local estuarine ecosystem and food webs. It also stresses filter feeding organisms, such as oysters, making them more susceptible to disease (Colosimo, 2007), which has been a major cause in their population collapse in recent decades. Additionally, oyster reefs can become covered with a fine layer of silt unless high densities of adult oysters are present per unit reef area, quickly rendering the reef substrate unusable for oyster larval attachment. However, functional oyster reefs or other hard substrate colonized by oysters and other filter feeders can substantially reduce TSS as they filter feed. TSS typically becomes incorporated into their waste, and often ends up deposited on the bottom, out of the water column. Fish species that require hard substrate for benthic egg laying can only use reef habitat for reproduction that is not covered with silt. Reef dependent species, such as naked gobies (*Gobiosoma bosc*), tautog (*Tautoga onitis*), and others suffer from this loss . Other filter feeders, such as clams and menhaden, are also negatively affected by high TSS levels, as they must process and eliminate the TSS during their filter feeding (Soniat et al., 1998), using energy that could be used for somatic growth or reproduction.

Another negative impact associated with high levels of TSS is increased levels of e. coli and other pathogenic bacteria. Such organisms are not commonly found free living in the water column, but instead attach to small particles of suspended sediment (Schillinger et al., 1985). Thus, lowering TSS levels may have some beneficial effects on pathogenic bacteria levels, lowering them and thereby improving water quality.

SPECIES DIVERSITY (BIBI)

Another important metric that is often used to define the health of an ecosystem is a species diversity index. Negative environmental impacts often act to reduce species diversity, as more sensitive species are often extirpated first, with increasingly less sensitive species remaining as a local ecosystem becomes more polluted, until finally only a small number of eurytopic species (tolerant of pollution and/or other adverse conditions) remain. This often results in losses of productivity as well, as in many aquatic systems pollution-tolerant species are often small nematodes and similar aquatic life, whereas larger more ecologically-important species, such as mussels and crustaceans, will not be able to tolerate such marginal environmental conditions. In these situations, species diversity declines with increasing negative environmental conditions and, conversely, improvements to the environment can be measured by increasing species diversity. Ecosystems with higher diversity are generally regarded as more mature, less polluted, and resilient, than those with low diversity (Didham et al., 2005, Suding et al., 2004). Resilience and trophic redundancy in an ecosystem are highly desirable traits. What this means is that there are typically a number of species present that could fill various ecological roles, such as filter feeding on phytoplankton in the estuarine environment. In a low-diversity ecosystem, only one or a few such species would be present, and any additional loss would tend to destabilize the ecosystem, perhaps altering its stable state to one less desirable. For example, the modern day Chesapeake Bay, has essentially lost the once-extensive oyster reefs that were formerly capable of exerting a significant effect on water quality in the Bay (Newell et al, 2007, Newell, 1988). In this case, anoxia might be the new state, as a lack of filter feeding could cause excess, unconsumed phytoplankton to die and decompose on the bottom, which could then further impact the ecosystem, until at last only the species most tolerant of poor water quality remain, if any remain. The low oxygen “dead zones” seen in the Chesapeake Bay each summer are partly due to the loss of once-extensive oyster reefs, which formerly consumed much of the spring phytoplankton crop in the Bay.

An extensive background survey of the present benthic fauna was undertaken during the scoping of the proposed project (Dauer, 2006). Additional shallow-water fish surveys were also conducted to assess nekton (Bilkovich, 2006). Both surveys showed that, in general, the Lynnhaven River is far from pristine system, habitat diversity is limited, and species diversity is considerably lower than reference, undisturbed aquatic habitat. Primary causes of this ecosystem state are loss of benthic habitat diversity, as well as the deposition of large amounts of terrestrial sediments over the sandy bottoms formerly found throughout most of the system, although extensive sandy areas are still found, particularly in portions of Broad Bay and the Lynnhaven Bay area near the river mouth.

The proposed project should act to improve the local ecosystem, and one of the expected benefits is to increase species diversity. For the present study, an index was considered, a BIBI (benthic index of biotic integrity) for the Lynnhaven River system. The BIBI for the Lynnhaven was estimated during the scoping phase of the project (Dauer, 2006). Fish diversity was also considered; however, it is not being specifically measured in the present study, though such indices have been used in other estuarine systems (Breine et al., 2010, Raposa et al., 2003, Meng et al., 2002, Deegan et al., 1997). Because the proposed project includes several components that will increase habitat for a variety of fish species, it was important to consider the impacts of the project on the local fish community. Secondary production does capture important aspects of this, but because species diversity will be increased by providing the new habitat, it is an important factor to consider in the present study.

The subsequent sections provide background information on each restoration option considered (SAV, Reefs, Scallops and Wetlands), then potential benefits numbers and restoration options. Benefits calculations then follow, along with the model spreadsheet to be certified.

SUBMERGED AQUATIC VEGETATION (SAV)

Background Information

The Lynnhaven River historically supported extensive SAV beds. Based on the salinity regime, these beds consisted of two species, eelgrass, *Zostera marina*, and widgeongrass, *Ruppia maritima*. The full extent of the original, pre-development SAV beds is not known. It is likely that they were several hundred acres in total extent. The oldest map dated from the early 1970's and shows more than 100 acres of SAV beds, mostly in Broad Bay and near the confluence of the eastern and western branches of the Lynnhaven River, including Lynnhaven Bay proper. Eelgrass in particular experienced a massive die-off in the late 1920's and early 1930's due to disease, a slime mold, *Labyrinthula zosterae*. Though never fully recovered, it did return to many areas within the Bay,where it was formerly found, by the 1950's. The SAV beds in the Lynnhaven declined dramatically between the 1970-2010 timeframe; today, less than one acre of eelgrass bed remains distributed in patchy areas, with scattered widgeongrass plants in shallow waters. The last year of significant cover was in 2005, when approximately 20 acres of SAV beds were found, mostly along the southern shore of Broad Bay. Record high temperatures caused a large die-back of SAV, particularly eelgrass, in the Chesapeake Bay in summer 2005. This affected the SAV beds in the Lynnhaven River, which lies at the southern end of the Chesapeake Bay. Distribution has been minimal and patchy in the Lynnhaven River since. Considering the distance to the nearest SAV beds that could possibly provide a significant source of drifting propagules, it is unlikely that either eelgrass or widgeongrass will be able to re-colonize the Lynnhaven River to any real extent without intervention. The USACE proposes to restore SAV to the Lynnhaven River. Eelgrass may be locally near the limit of its upper thermal tolerance (Kenneth A. Moore, Jessie C. Jarvis (2008) Environmental Factors Affecting Recent Summertime Eelgrass Diebacks in the Lower Chesapeake Bay: Implications for Long-term Persistence. Journal of Coastal Research: Vol. , Special Issue 55, pp. 135-147.). Overall water temperature data in the Lynnhaven River system(VIMS, 2003) indicate, on average, a slight warming trend, throughout the system. As such, there may be increased risk with relying on the common approach to SAV restoration in the saline portions of Chesapeake Bay, which is set to focus entirely on eelgrass restoration.

One possibility is that the USACE could consider using a more southern stock of eelgrass as a seed source, perhaps a stock native to North Carolina's coastal bays. Such a strain of eelgrass may be more thermally tolerant than the local stock as regional differences in temperature tolerance for *Zostera* has been documented (Beibl and McRoy, 1970), though confirmation of this trait would be required prior to use in the Lynnhaven.

Widgeongrass has not been the focus of SAV restoration efforts in the Chesapeake Bay due to an early decision by various technical work groups to focus on eelgrass instead. Both species are of great ecological value, though there are differences between the two. Eelgrass forms dense beds in typically deeper waters than widgeongrass. Eelgrass tends to form more persistent beds than widgeongrass, which is viewed as a more opportunistic, pioneer species with larger annual fluctuations in bed extent and location than the more stable eelgrass (Cho et al., 2009). Eelgrass transplanting efforts have shown limited promise, though a nearby local success (Naval Amphibious Base, Little Creek) does show that, if the right site is selected, such efforts could work in an area very similar to the Lynnhaven River. However, considering conditions in the modern-day Bay, and the likelihood of further increases in water temperature, it seems prudent to consider a shift in focus to a species that can persist better under what is becoming a warmer temperature regime. This trend has been observed in various areas due to warming water temperatures (Johnson, 2003) and may represent an unavoidable regime shift in species composition due to changing water parameters.

Of note in the Moore et al. (2008) study was that after the die-back induced by high temperatures in summer 2005, eelgrass recovered fasted in areas with higher water quality and more available light. High temperature stress is certainly a factor in eelgrass demise, but it is obviously compounded by additional stressors, such as less-than- optimal light energy levels and/or high nutrient levels, which encourage epiphytic growth on the SAV, inhibiting photosynthesis. These other factors could still inhibit recovery even after the temperature stress is removed. Thus, it is prudent to consider species other than the local strain of eelgrass for SAV restoration, such as the more environmentally-tolerant widgeongrass; we will make such a consideration in our proposed restoration plan. This will increase the chances for success of the SAV.

SAV Benefits

SAV is a highly productive habitat in the estuarine environment (Moore, 2004, Heck et al., 1995, Stevenson, 1988) and as such is of great ecological value. It is known that SAV provides critical nursery habitat for a wide variety of species, including blue crabs, *Callinectes sapidus*, and other crustaceans (Fonseca et al., 1996) as well as excellent foraging habitat for many fish species, including the summer flounder, *Paralichthys dentatus*, which has essential fish habitat (EFH) in the local project area. Many fish species utilize SAV during their larval phases (Olney and Boehlert, 1988). SAV, as noted above, also helps reduce suspended sediments, both by direct action and via stabilizing the bottom over which they grow, preventing resuspension during tidal cycles and storm events. SAV also uptakes organic compounds, particularly nitrogen and phosphorus from the water column, to aid in its own growth. It acts to stabilize bottom sediments, reducing re-suspension rates and improving water clarity.

Benefits for SAV were evaluated on an annual basis and converted into secondary production. During the winter, there is a low standing biomass within the SAV bed, whose own standing crop reaches a low in biomass over the winter. As waters warm in the spring, SAV begins to grow and, along with it, the associated animal biomass within the beds. This growth peaks in the summer, and declines in the fall. When possible, benefits were assessed using estimates developed for local SAV beds (Fredette et al, 1990).

SAV provides protection to nearby estuarine marsh and land by baffling wave energy (Koch and Gust, 1999; Fonseca and Fisher, 1986). This has increased rates of erosion in many nearshore areas once protected by SAV beds, increasing land loss and sediment input into the Chesapeake Bay. A negative feedback loop has been created, where loss of SAV leads to higher rates of erosion, which leads to additional loss of SAV. SAV also acts to increase water clarity in three ways. As water flows over an SAV bed, it is slowed, and TSS tends to precipitate out of the water column into the SAV bed. Second, SAV stabilizes bottom sediments, reducing scouring and related erosion, as well as re-suspension of bottom sediments (Wanless, 1981; Fonseca and Fisher, 1986; Koch and Gust, 1999). Third, SAV actively uptakes nutrients from the water column and competes with phytoplankton for these nutrients. This can lower the frequency and/or intensity of phytoplankton blooms, keeping the water lower in chlorophyll A and clearer due to smaller numbers of phytoplankton.

Loss of SAV directly increases TSS in the water column, and its absence can increase the rate and amount of marine sediments moved by typical current velocities, as well as during storm events. This loss of SAV then further impacts remaining, especially nearby, SAV beds, as they are now subject to increased rates of sediments being deposited in and upon them by typical currents, as well as wave energies and during storm events. This can result in further loss of SAV.

SAV, due to its ability to baffle wave energy, causes TSS to precipitate out of the water column into the SAV bed. Over time, this can result in significant increases in SAV bed elevation (Carpenter and Lodge, 1986). Despite sea level rise, SAV can, in many cases, maintain its position in the water column and continue to survive and even expand. In some cases, SAV beds become so high in the water column that semi-terrestrial wetland plants can colonize the area, eventually leading to a successional process where the SAV bed evolves into a wetland marsh. The increase in sea level rise in the Chesapeake Bay has been greater in recent decades than the ability of SAV to deposit sediments and organic matter sufficient to counter it, and some SAV loss can likely be attributed to this. In these cases, SAV beds often slowly move into formerly more shallow waters, as conditions become more suitable for their growth and survival. We would expect this to occur in the Lynnhaven River as sea level continues to rise over time.

FISH/OYSTER REEFS (EFH)

Background Information

Hard-structure habitat is of great ecological importance in the estuarine environment. It provides attachment surfaces for sessile organisms, cover and shelter for many species of fish and other motile invertebrates such as crabs and shrimp, attachment surfaces for benthic egg masses, produced by a wide variety of species ranging from mollusks (whelks) to fish (toadfish) in the Chesapeake Bay. Such habitat in estuaries generally consists of rocky bottom areas and in many regions, oyster reefs. In the Lynnhaven River, this habitat was historically oyster reefs which, in pre-colonial times, were found both sub- and inter-tidally throughout portions of the river where salinity levels were high enough to support oyster survival and growth. Today, most of these areas are either entirely lost (Chipman, 1948, Haven, 1979) or, in some cases, completely covered with considerable amounts of soft sediments (Dauer, pers. comm.). Extensive bottom surveys conducted in the course of oyster restoration planning (USACE, 2005) discovered two small (< 1 acre) natural oysters reefs, near the confluence of Lynnhaven Bay and the western branch of the Lynnhaven River. These reefs were quite productive, containing approximately 250 adult oysters/square meter, indicating the subtidal hard substrate can still attract significant populations of oysters and other filter feeders and, in turn, attract a wide variety of finfish and shellfish species that utilize reef habitat.

Unlike SAV, artificial reefs do not require a narrow set of environmental parameters in order to function. The main consideration is that the appropriate bottom type be used to place them, as excessive subsidence may result if softer bottom types with high percentages of fines are used. For this aspect of the project, extensive bottom surveys were conducted by the USACE, with additional consultation of sediment data (Dauer) supplementing bottom profile data collected by the USACE. Sites having high percentages of sand (> 80%) were preferentially selected to the extent possible, though some amount of clay is actually desirable as this component tends to make for a less shifting bottom and more conducive to placement of hard structure. Most of the acreage in the Lynnhaven River is currently leased for shellfish production. While most of these areas are not used, they have taken most of the high sand areas in the river. Due to this, several sites have < 80% sand and geotextile matting will be needed to fully support the reef structures. Many areas in the Lynnhaven River system have been severely impacted with terrestrial sediment deposition that resulted from large-scale, rapid urbanization of the watershed, resulting in a thick layer of soft muds over the original sandy bottom, rendering these areas unusable. However, there are still many sandy areas in the system, in particular along the banks in Linkhorn and Broad Bays, the confluence of the eastern and western branch, and within Lynnhaven Bay. Such sites were prioritized as potential fish reef placement locations in the present study. None of these areas are in the low salinity reaches of the upper Linkhorn Bay, eastern or western branches, so it is expected that all fish reefs will be in polyhaline (> 18 ppt) waters and, as such, will be populated heavily by estuarine and marine sessile life such as oysters, mussels, barnacles, sea squirts, bryozoans, and other more marine organisms rather than the much more limited fresh water sessile invertebrate assemblage.

The present study proposes to construct reefs for fish and sessile invertebrate use throughout the Lynnhaven River system. These reefs will likely be constructed out of various types of concrete reef balls and related reef-like structures, though granite rip-rap may be used as well. Artificial reefs have a long history of use (Jensen, 2002, Seaman and Sprague, 1991) worldwide and locally (Virginia Marine Resources Commission Artificial Reef Program, Lipcius and Burke, 2006). The proposed reefs will act as replacement structures for the lost hard structure no longer found in many areas of the Lynnhaven River, and are proposed to be built at considerable more relief from the bottom than the present restored oyster reefs constructed in 2007 and 2008 were built under the USACE oyster restoration program. While there is still some debate over whether or not artificial fish reefs serve to produce more fish (enhancement) or act simply to attract fish (attraction) (Powers et al., 2003, Wilson et al., 2001,), when such habitat is lost and then replaced, it does appear to actually enhance fish production (Wilson et al., 2002, DeMartini et al., 1994, Bohnsack and Sutherland, 1985). As a result, a decision was made to scale the benefits of the proposed fish reefs primarily via the secondary production of benthic macrofauna upon them (Svane and Petersen, 2001, Steimle et al., 2002) which then serve as food sources for motile fish. Additionally, fish reproduction will be enhanced by the hard structure, as many fish species require it to deposit their eggs or their larvae (Stephens and Pondella, 2002) and/or juveniles as well as adults utilize the hard structure for food and shelter (DeMartini et al., 1994).

Fish Reef Benefits

Fish reefs, as stated earlier in the report, will have their benefits scaled primarily by assessing the benthic community that will settle on and grow on the artificial reefs. For fish reef secondary production, the method used was similar to that developed to compensate for the impacts from the proposed Craney Island Eastward Expansion developed using a HEA approach (Ray, 2008 – ERDC-TN-EMRRP-EI-02, Peterson and Associates, 2003), with considerable data available on the benthic community associated with artificial reefs in the Lynnhaven (Burke, 2010) used to help develop the production estimates. It is assumed that benefits to fish will accrue at a rate of

10% trophic level transfer. For example, if a fish reef creates, via secondary production, a biomass of 50 kg, local fish will gain 5 kg in biomass. Fish and large motile crustacean (blue crab primarily) production should be significant (Peterson et al., 2003) and could be as high as 50 kg/m^2 of reef over a 30 year period. Additionally, reef-dependent fish, such as tautog, *Tautoga onitis*, black sea bass, *Centropristis striata,* and the naked goby, *Gobiosoma bosc*, should recolonize the Lynnhaven River. This would result in an increase in species diversity.

SCALLOPS

Background Information

The bay scallop, *Argopecten irradians concentricus,* is a mobile, benthic filter-feeding bivalve mollusk. Unlike most bivalves who have very limited motion via a muscular "foot" primarily used for digging, bay scallops can swim by clapping their valves together rapidly and expelling water in jets from their mantle cavity (Fay et al., 1983). This method of locomotion is used to move, or to escape predators or adverse environmental conditions. Though scallops can be found on other habitat (Pacheco, et al., 2006, Marshall, 1960), SAV beds are their primary habitat. They are rather short-lived for a larger bivalve, typically living one to two years, on average, and are reproductively capable within their first year of life. This is necessary, as scallops are essentially an annual crop. As is typical with most bivalves, their larvae are planktonic, allowing for dispersion over much wider areas than the adults could feasibly travel. The larval phase lasts for approximately 10 days, with settlement occurring in less than two weeks from hatching, on average (Fay et al., 1983). Larvae need higher salinties than adults, and experience mortality when salinity levels drop below 20 ppt. In the areas determined to be suitable for scallop restoration, salinities exceed 20 ppt, with most near the optimal salinity for larval development (Tettlebach and Rhodes, 1981) of 24 ppt (VIMS, 2003). Scallops prefer higher salinity waters within estuaries, doing best as waters approach polyhaline levels (USFWS, 1983). The Lynnhaven River is located near the confluence of the Atlantic Ocean and the Chesapeake Bay and, thus, has the appropriate salinity regime to support both larval and adult scallops. Other water quality parameters, including TSS, meet their life cycle criteria. Scallops are filter feeders throughout their lives, feeding on phytoplankton as both larvae and adults

(Parker 2006, Chipman and Hopkins, 1954). The types of phytoplankton scallops require are in large supply in the Lynnhaven River and throughout the lower Chesapeake Bay. Historically, the only records for scallops in the Chesapeake Bay were anecdotal. There was a small fishery for them, which lasted several years, in nearby coves on Virginia's lower Eastern Shore (Virginia Fish Commission Reports, 1928-1933). This fishery ceased when the massive die-off of SAV occurred in the early 1930's; scallops were extirpated from Virginia's waters at this time. The fishery never occurred in the Lynnhaven River, likely because this river was, at the time, highly productive for oysters. In fact, these oysters commanded the highest market price out of all Bay oyster sources. Little effort would have been made to fish for small numbers of less-valuable scallops, which had very limited market demand at the time. In total, the fishery operated for only four years, and was a fraction of 1% of the oyster fishery at that time. After the collapse of SAV, reports of the presence of scallops were limited and anecdotal. Such reports have indicated the presence of small numbers of scallops immediately outside the Lynnhaven River along the shoreline adjacent to the Lesner bridge. However, it has been noted that in several regions, of which Virginia is one, bay scallops did not recover once the population collapsed due to lack of adults to supply recruitment (Arnold et al., 1988). Without intervention, it is highly unlikely that the bay scallop will ever repopulate suitable habitat in the lower Chesapeake Bay, even if SAV recolonizes the region. The few anecdotal sightings are likely the occasional recruit swept into the Bay. Such a small population is unlikely to be capable of producing any recruitment and is almost certainly a sink for any scallops that recruit to the area.

Scallop Benefits

Bay scallops are a motile filter feeder, with adult scallops having a similar filtration rate compared to that of a market sized (76mm) oyster, with rates as high as 25 liters per hour for adult scallops of 65 mm in size (Chipman and Hopkins, 1954) during the summer, when water temperatures are at their warmest and the metabolic rate of the scallops is at their annual peak. Their average rate was approximately 15 liters per hour. Although the scallop is smaller compared to the oyster, their metabolic rate is higher due to their mobility and active lifestyle, as adult oysters are completely sessile. Similar to oysters, scallops remove TSS and phytoplankton from the water column, retaining the plankton as food and depositing the TSS in their pseudofeces, which is then eliminated and typically becomes incorporated into the sediments. Scallops improve water clarity with their filtration, and this improvement provides additional benefits such as allowing for SAV bed expansion, increased benthic diatom diversity and productivity, and improved filter feeding efficiency for other Bay filter feeders, as less TSS in the water requires less energy for processing and elimination. Therefore, lower TSS levels would allow for increased feeding efficiency for all filter-feeding life in local waters.

Bay scallops play an important role in the estuarine food web. In addition to providing a link between planktonic and benthic food webs via their filter feeding, scallops serve as a source of food for aquatic predators such as green crabs, rock crabs, mud crabs, blue crabs, sheepshead, cow-nose rays, drum fish and others (Seitz et al., 2009, Strieb et al., 1995, Pohle et al., 1991). A restored scallop population will then provide for increased secondary production via their own tissue and then throughout the estuarine food web as they serve as a prey item for a wide variety of nekton. As a conservative measure within the benefits model, scallops were assumed to be able to exist only within SAV beds. Population densities were estimated to be 12 adults scallops per square meter, about 50% of the documented population density from field observations of nearby North Carolina populations (Cooper and Marshall, 1963, Peterson et al., 1996, Seitz et al., 2009). This is a conservative estimate, but as the USACE expects the SAV beds to be a mix of eelgrass and widgeongrass, with the scallops exhibiting a preference for eelgrass, this seems reasonable.

WETLANDS

Background information

Wetlands restoration is extensively done in the Corps of Engineers. In the Lynnhaven River system, extensive development has impacted the wetlands severely. Earlier this century, much of the Lynnhaven wetlands were altered to become farmland. More recently, these areas were developed into urban zones, mostly residential housing as the City of Virginia Beach developed. Today, few wetlands remain, though thin fringes of wetlands are still present to varying extents in all branches of the Lynnhaven River system.

Wetland Benefits

Wetlands are highly productive nearshore habitat. They also stabilize the shoreline, protecting it from erosion. Surface runoff is filtered as it passes through wetlands, reducing nutrient levels, contaminant levels, and sediments prior to reaching the waterway on which the wetlands border. Thus, wetlands are capable of considerable TSS reduction due to their retentive nature and have considerable secondary production.

CALCULATING THE SECONDARY PRODUCTION AND TSS REMOVAL OF RESTORED SCALLOPS, REEFS, WETLANDS AND SAV FOR BENEFITS MODEL

Scallops Secondary Production Calculation

Scallops were taken to be, on average, consisting of a biomass that equates to 13 adults/m^2 of SAV. This is a median value of a reported maximum of approximately 25 adult scallops/m^2 (not counting juveniles, whose biomass is much less than an adult). As such, this number represents less than 50% of the maximum potential biomass, a conservative estimate. A full-sized adult scallop is estimated to be 1 g AFDW. The total biomass produced per acre of scallops is then slightly over 1,000,000 adult scallops at 1,030,000 scallops/acre/year, peaking in the summer months and declining to low values over the winter, where a small population of adults and much larger population of small juveniles overwinters until spring, when warming water temperatures greatly increase growth rates. For our biomass estimate, we take 90% of this, or 229 kg/acre/year of scallop production.

Scallop TSS Reduction Calculation

Scallops do filter TSS; however, they are not as efficient as oysters are in doing so. Reduction was assumed to be slightly less than oysters at 4.83, approximately 75% of the maximum expected rate of oysters. Both species preferentially filter and digest phytoplankton while excreting TSS as semi-solid waste.

Wetlands Secondary Production Calculation

Wetlands secondary production was assumed to be similar to that estimated by Peterson (2003), based on prior work estimating salt marsh primary, secondary, and tertiary production (Kneib, 2001). In this study, Peterson (2003) estimated the secondary herbivore production for *Spartina* marsh wetlands in the nearby Elizabeth River, VA. The numbers that resulted from it have been used for the Lynnhaven River wetlands, which are expected to perform in similar fashion.

The following text is taken from Peterson (2003):
"Kneib (2001) provides a careful synthesis of data on salt marsh primary, secondary, and tertiary production for the purposes of scaling marsh restoration after the Mulberry Phosphate spill near Tampa, Florida. This review provides the necessary scaling approach to estimate production credit for the Craney Island computations. First, we need an estimate of net annual production of the *Spartina* and other large marsh plants in a Chesapeake Bay salt marsh. Kneib's review implies a number of about 1 kg above-ground dry weight m^{-2}, but Robblee (1973) provides a more site-specific figure of about 1270 g m^{-2} for a *Spartina* marsh in the Southern Branch of the Elizabeth River. Second, we need to recognize that about 10% of that is consumed by grasshoppers and other terrestrial insects and herbivores. This production is not counted towards marine productivity. The remaining 90% enters a marine detrital pathway with 55% conversion to fungi, resulting in an estimated 629 g dry weight m^{-2} (1270 x 0.9 x 0.55) annually available to marine invertebrate consumers. Then if we assume that one third of this fungal production is consumed by herbivorous marine invertebrates at the standard ecological efficiency of 10%, then the marsh vascular plant production would be expected to yield 21 g dry weight m^{-2} (629 x 0.33 x 0.1) of herbivorous marine invertebrates."

"To this figure, we need also to add the marine invertebrate production that is derived from the two thirds of the original detritus that was not consumed as fungal biomass (629 x 0.67 = 419 g dry weight m^{-2}). This two thirds of the fungal production enters the sediment bacteria system, where much of it is respired but about 10% (or 42 g dry weight m^{-2}) is converted to bacterial biomass available to herbivorous (detritivorous) marine invertebrates. Bacterial biomass is, in turn, converted to marine invertebrate animal biomass with the standard ecological conversion efficiency of 10%, providing another 4.2 g dry weight of herbivorous marine invertebrates via the bacterial food chains. We further must account for the benthic microalgal production that occurs on the salt marsh. Kneib's (2001) review suggests that this production is about 25% of the above-ground vascular plant production or 318 g dry weight m^{-2} annually. Since the large majority of this material is grazed directly by marine herbivorous invertebrates without going through detrital food chains, this production is expected to yield at the standard 10% conversion efficiency another 32 g dry weight m^{-2} of herbivorous invertebrate production. The total of all three trophic pathways (Table 4) for marsh plant production is thus 57.2 g dry weight m^{-2} (21 + 4.2 + 32). Kneib's synthesis assumes that none of the below-ground production of *Spartina* enters into detrital food chains. This assumption does not hold for marshes in which fiddler crabs or geese are active because they excavate sediments during burrowing and bring up below-ground detritus where bacterial colonization and consumption by detritivores occurs. For *Spartina* marshes, net annual below-ground production is about 4 times as high as above-ground production (K. Boyer, pers. com., Univ. North Carolina). Assuming that about 5% of this below-ground production or 254 g enters the detrital food chains (C. Currin, pers. com, NOAA-Beaufort), and that this is converted to bacterial biomass at 10% efficiency and then to invertebrates at a subsequent 10% efficiency, another 2.5 g dry weight m^{-2} must be added to the total credit for restored salt marsh (Table 4). Consequently, if we assume that a restored salt marsh rapidly serves the full production and trophic transfer functions of a natural salt marsh habitat, then proper credit for restoration should be 59.7 g dry weight m^{-2} of marine herbivores produced annually (Table 4). At 4,046.86 m^2 per acre, this would yield an annual credit of 241.6 kg of marine invertebrate herbivore production per acre of restored salt marsh against which to scale the anticipated loss of annual zooplankton production." For the present study, this 241.6 kg/acre/yr value was selected for the model.

Wetlands TSS Reduction Calculation

"Wetlands are well known to act as sediment traps, and Wetlands TSS was estimated by taking a rather conservative value of the potential sedimentary deposition rate within a vegetated wetland of 2.3 mm/m^2/year. Estimates for sediment deposition rates and/or vertical accretion vary considerably: (4.7 to 6.3 mm/m^2/yr (Armentano and Woodwell, 1975) including sediments and organic material), up to 40 mm sediment/m^2/year in the Bay of Fundy (Chmura, G. L., Coffey, A. and R. Crago), a 1.2 mm/m^2/year of silt in estuarine marshes in the Netherlands over a 170 year period (Olff et al., 1997).A study done in the Lynnhaven River itself on sediment deposition rates in many sub tidal areas (Keuhl, 2008) found that sediment deposition rates in the Lynnhaven River itself varied from a low of 1.2 mm/m^2/year to a high of 8.4 mm/m^2/year on the river bottom. The material settling in the wetland was estimated to be 60% clay, 30% earth and 10% sand. The average weight of these three sediment types per cubic foot varies and is 68 lbs/cu ft dry clay, 100 lbs/cu ft for dry sand and 78 lbs/cu foot for earth. The average dry weight of the expected depositionary material, primarily clays and fine silts with a small sand component, is 74.2 lbs/ cu foot which equal 2,620.35 lbs/m^3. TSS was expected to deposit at a steady rate, as once vegetation is established, it remains constantly on site at high densities (*Spartina* marsh does not die back in winter, though it does become relatively dormant). So, TSS should deposit at a steady pace throughout the year. Based on the 2.3 mm/m^2/year rate of deposition, it is expected that the total weight of sediments deposited in an acre of restored wetlands annually is 11,052 kg/acre/year, which equals 921 kg/acre/month. On a per square meter basis, this equals 2.73 kg/m^2/yr. A study in northern waters of the Chesapeake Bay (Leonard et al., 2001) found that sediment deposition rates were approximately 2.6 mg/m^2/day, providing an annual deposition rate of 9.5 kg (dry weight) sediment/m^2/yr. This high rate occurs within several meters of the marsh edge that is in contact with open water and often greatly declines as you enter marsh interior far from either the water's edge or any tidal gut/creek. These high rates can be more typical on a restoration site if extensive tidal creeks, to improve water flow in the wetland, are incorporated into the design (Reed et al., 1999). The proposed project will do this to the extent practicable. Again, this is a rather conservative estimate, for example, wetlands in Louisiana Coastal marshes can accumulate up to 6.71 kg (dry weight)/m^2/yr (Reed, 1989), due to large sediment inputs from the Mississippi River."

SAV Secondary Production Calculation

For SAV restoration, the impact is primarily to increase the secondary production of what are now barren sand flats (bottom areas with at least 60% sand, the rest can be silt and/or clay) in the Broad Bay and Eastern Branch/Western Branch/Lynnhaven Bay region of the Lynnhaven River system.

For the pre-restoration conditions, Dan Dauer has conducted an extensive benthic survey that included biomass estimation. Taking all samples that met the sand % criteria, we obtain an average ash free biomass of 1.80296 g/m^2. The infauna was dominated by polychaetes, though a significant presence of crustaceans was noted. Diaz and Schaffner (1990) suggest a P:B ratio of 5.7 for crustaceans and 4.9 for polychaetes and 2.9 for mollusks. Taking an average between 4.9 and 5.7 gives us 5.3; multiplying this by the mean biomass of 1.80296 gives us an annual rate of 9.555688 g/m^2/year for the present habitat's benthic production. SAV was estimated to have approximately 200 g/m^2 for small epifauna living on SAV and small infauna (Fredette et al., 1990). Similar studies (Heck et al., 1995) found well over 100 g/m^2/year from SAV beds in Cape Cod, so this 200 g/m^2/year number for the more southern Bay with a longer growing season seems reasonable. At 9.56 g/m^2/yr for pre-restoration versus 200 g/m^2/yr post-restoration (which counts the 9.56 in the 200 total), the increase in benthic productivity is considerable. This amounts to 191.5 g/m2/yr which we round to 192. To this is added secondary production (collectively) of large crustacean, mollusk (hard and soft-shell clam) and fish production due to the SAV bed. Seagrass-based food webs can provide up to 70% of the nutrition of local fish (http://www.spooled.com.au/Article:1208) and the shelter and direct nutrition derived from feeding on animals found within SAV beds can easily produce fish and large crustacean biomass equal or greater than the selected number for this model (Johnson and Heck, 2006). Numbers for these vary widely, so it was decided to double the initial number for a total of 384 g/m2/yr for SAV secondary production to represent the productivity enhancements to finfish, large decapods, and bivalve molluscs other than scallops, which are treated as a separate restoration option in the present study.

SAV TSS Reduction Calculation

TSS removal was estimated based on the biomass of the SAV itself. SAV, due to their buffering effects on water speedcauses TSS to precipitate out of the water. Annual biomass of SAV peaks in summer, with a minimum in above ground vegetation in the winter, so TSS removal follows a similar curve as does biomass (Moore, 2004). SAV is not as effective at precipitating sediments as are wetlands, due to several factors. SAV standing vegetation drops significantly in winter, allowing for re-suspension of sediments. SAV is fully submerged at all times, subject to constant wave action, which inhibits long-term precipitation of sediments. Large animals regularly disturb SAV during foraging, re-suspending sediments that otherwise would have been permanently deposited. Despite this, SAV do retain significant amounts of TSS within beds, modifying the sediments significantly while they simultaneously increase water clarity (Katwyjk et al., 2010). SAV were assigned a value of 150 g of silts deposited annually per square meter

Fish/Oyster (EFH) Reefs Secondary Production Calculation

Secondary production was estimated by consulting the Peterson HEA as well as recent research on oysters colonizing hard substrate in the Lynnhaven River (Burke, 2010). For the high relief reef design, all reefs are well below MLW. A survey of rip rap in the Lynnhaven River in the low intertidal zone had an average peak biomass of 165.02 g AFDW/m^2. Subtidal production was estimated to be 50% of this production rate found in the low intertidal zone, primarily due to higher rates of predation in the subtidal environment. This can be easily observed in similar high-salinity waters (Nestlerode et al., 2007) though survival on alternative materials can be higher than that of shell in such a scenario as was documented in the lower Rappahannock River (Burke, 2010). Based on the available data, 50% seems to be a reasonable number. This gives us a value of 82.5. Applying a P:B ratio of 2.6 (Peterson, 2003) gives us an annual oyster production rate of 214.5 g AFDW/m^2/yr. However, the interior of a reef ball is expected to have a lower rate of production compared to the exterior (Burke, 2010). Interior surfaces will experience lower flow rates, and less available food. Burke (2010) estimated approximately 25% of the biomass on a granite block reef was on the interior surfaces of the granite. Because the reef balls are designed with larger interior spaces and openings for better flow than a small pile of loose granite, we doubled this rate to 50%. Therefore, reef balls will have an annual oyster production rate in AFDW of 147.9 g/m^2/yr. This is a very conservative estimate, and it could be much higher. Subsequent post-construction monitoring will quantify this production. Applying the same ratios used for meiofauna and macrofauna production on an oyster reef developed for the Elizabeth River by Peterson (2003), we arrive at 121.8 g AFDW/m2/yr for reef ball associated meiofauna and 34.7 g AFDW/m^2/yr for reef ball associated macrofauna/m^2/yr for a grand total of 304.4 g AFDW/m^2/yr for high-relief reef balls. The total surface area of the high-relief reef is 14,640 m^2/acre. Therefore, the total production/acre/yr in AFDW is 4457 kg/acre/yr. Low-relief fish reefs have a smaller surface area/acre (11,830 m2/acre) so had a lesser rate of production of 3601 kg/acre/yr.

Fish/Oyster (EFH) TSS Reduction Calculation

TSS reduction was estimated based primarily on the oysters, tunicates, mussels, and barnacles typically found on oyster reefs. There are additional small filter feeders found on oyster reefs, such as tube worms and sponges, but these were not considered. Oyster reefs were found to filter 6.48 times their weight in TSS, on an annual basis, with a peak in summer and low during the winter (Haven and Morales-Alamo, 1966). For the present study, a slightly lower and more conservative number was used, 95% of this or 6.16 times the secondary production on the reefs. It could actually be higher, however, as water in the Lynnhaven River may be slightly warmer than the Chesapeake Bay average, due to its southern location. Filtration (and secondary production) rarely ceases entirely in the Chesapeake Bay, as oyster reefs continued to filter until temperatures dropped below 2.8C (37.04F), a temperature that is rarely reached even in the coldest part of winter in the Bay. This is reflected in the low TSS and secondary production numbers in the winter months, not just for the fish reefs but for the other restoration options. Other studies (Cerco and Noel, 2005, Nelson et al., 2003), have noted significant decreases in chlorophyll A and TSS concentrations in the vicinity of oyster reefs in the field.

Outputs/Index Scores for each Measure

Measure	Secondary Production (kg/acre/yr)	TSS Reduction (kg/acre/yr)	BIBI (1-5)
Wetland creation	242	11,052	4
SAV	1,552	607	5
Scallops	229	1,106	3.5
EFH high relief	4,457	27,393	5
EFH low relief	3,601	22,137	5
Existing Condition/ Without Project	6.41	0	3

Table 1: Ecological Outputs for Various Restoration Options. Note that BIBI were ranked based on another system described in a separate document.

This table, along with the BIBI scores, as seen on pg. 81 of the main report, was used in plan formulation to determine alternative, then the tentatively selected plan. This information in Table 3 was provided to the Virginia Institute of Marine Science to run within their hydrodynamic water quality model. The model runs characterized the potential reductions in chlA and TSS in different regions of the Lynnhaven River as a result of several alternative plans. These represent "best-case" scenarios for each plan.

REFERENCES

Abril G., Commarieu M.V., Sottolichio A., Bretel P. and Guérin F. (2009) Turbidity limits gas exchange in a large macrotidal estuary. Estuarine Coastal and Shelf Science. 83: 342-348.

Armentano, T.V. and G.M. Woodwell. 1975. Sedimentation rate in a Long Island marsh determined by 210 Pb dating. Limnology and Oceanography. Vol. 20, No. 3, pp. 452-456.

Arnold, W. S., D. C. Marelli, C. P. Bray, and M. M. Harrison. Recruitment of bay scallops Argopecten irradians in Floridian Gulf of Mexico waters: Scales of coherence. Mar. Ecol. Prog. Ser., 170:143–157 (1998).

Bell, J. D., D. M. Bartley, K. Lorenzen, and N. R. Loneragan. Restocking and stock enhancement of coastal fisheries: Potential, problems and progress. Fish. Res., 80: 1–8 (2006).

Biebl, R. and C. P. McRoy. Plastmatic resistance and rate of respiration and photosynthesis of *Zostera marina* at different salinities and temperatures. Marine Biology, vol. 8(1): 48-56 (1970).

Bilkovic, D.M., D. Stanhope and K. Angstadt. 2007. Shallow water fish communities and coastal development stressors in the Lynnhaven River. Virginia Institute of Marine Science, Gloucester Point, Virginia.

Bohnsack, J. A., and Sutherland, D. L. 1985. Artificial reef research: a review with recommendations for future priorities. Bulletin Marine Science, 37: 11–39.

Botsford, L. W., F. Micheli, and A. Hastings. Principles for the design of marine reserves. Ecol. Appl., 13: S25–S31 (2003).

Breine, J. P. Quataert, M. Stevens, F. Ollevier, F. A.M. Volckaert, E. Van den Bergh and J. Maes. 2010. A zone-specific fish-based biotic index as a management tool for the Zeeschelde estuary (Belgium). Marine pollution bulletin.

Burke, R.P. 2010. Alternative Substrates as a Native Oyster (*Crassostrea virginica*) Reef Restoration Strategy in Chesapeake Bay. PHD Dissertation, The College of William and Mary, Virginia Institute of Marine Science, Gloucester Point, Virginia.

Carpenter, S. R. and D. M. Lodge. 1986. Effects of submersed macrophytes on ecosystem processes. Aquat. Bot., 26:341-370.

Cerco, C. F. and M. R. Noel. 2005. Evaluating Ecosystem Effects of Oyster Restoration in Chesapeake Bay. A report to the Maryland Department of Natural Resources, September 2005. US Army Engineer Research and Development Center, Vicksburg MS.

Cerco, C., and Moore, K. (2001) "System-wide Submerged Aquatic Vegetation Model for Chesapeake Bay," Estuaries 24(4): 522-534.

Chipman, W.A. and J.G. Hopkins. 1954. Water filtration by the bay scallop, *Pecten irradians*, as observed with the use of radioactive plankton. Biological Bulletin, Vol. 107: 80-91.

Chipman, W.A. 1948. Conditions affecting shellfish production in Lynnhaven Bay, Virginia, and the possibilities of improving them by increasing tidal flow. United States Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Cho, H.J., P. Biber and C. Nica. 2009. The Rise of Ruppia in Seagrass Beds: Changes in Coastal Enviroment and Research Needs. In: Handbook on Environmental Quality, E.K. Drury and T.S. Pridgen (eds.). Chapter 12, pp:1-15.

Cho, J.H. and Y.L. Sanders. 2009. Note on dormancy of estuarine Ruppia maritime L. seeds. Hydrobiologia 617:197-201.

Chmura, G. L., Coffey, A. and R. Crago. 2001. Variation in surface sediment deposition on salt marshes in the Bay of Fundy. Journal of Coastal Research, Vol. 17, No. 1, pp. 221-227)

Clarke S.M. 1987. Sediment-seagrass dynamics in Holdfast Bay: summary. *Safish* 11: 4-10.

Cliche, G., Vigneau, S. and Giguere, M. (1997) Status of a commercial sea scallop enhancement project in Iles-de-la-Madeleine (Quebec, Canada). Aquaculture International 5, 259–266.

Colosimo, S.L. 2007. Comparison of Perkinsus marinus infection and oyster condition in southeastern North Carolina tidal creeks. Master’s thesis, University of North Carolina, Wilmington.

Cooper, R.A. and N. Marshall. 1963. Condition of the bay scallop, *Aequipectan irradians*, in relation to age and the environment. Chesapeake Science. 4: 126-134.

Cowen, R. K., K. M. M. Lwiza, S. Sponaugle, C. B. Paris, and D. B. Olson. Connectivity of marine populations: Open or closed? Science, 287: 857–859 (2000).

Dauer, D.M. 2006. Benthic biological monitoring of the Lynnhaven River. Old Dominion University, Norfolk, Virginia.

Deegan, L.A., Finn, J.T., Ayvazian, S.G., Ryder-Kiefer, C.A., Buonaccorsi, J., 1997. Development and validation of an estuarine biotic integrity index. Estuaries 20, 601–617.

De Martini, E. E., Barnet, A. M., Johnson, T. D., and Ambrose, R. F. 1994. Growth and reproduction estimates for biomass-dominant fishes on a southern California artificial reef. Bulletin of Marine Science, 55: 484–500.

Diaz, R.J. and L.C. Schaffner. 1990. The functional role of estuarine benthos. Pp. 25-56 in *In* Haire, M. and E. C. Krome. (eds.). Perspectives on the Chesapeake Bay, 1990. Advances in Estuarine Sciences. United States Environmental Protection Agency. Gloucester Point, VA.

Didham, RK, Watts, CH and DA Norton. 2005. Are systems with strong underlying abiotic regimes more likely to exhibit alternative stable states? Oikos 110, 409-416.

Doherty, P. J. Spatial and temporal patterns in recruitment, pp. 261–293. In: The Ecology of Fishes on Coral Reefs. (Sale, P. F., Ed.). New York: Academic Press (1991).

Dynamic simulation of littoral zone habitats in lower Chesapeake Bay. II. Seagrass habitat primary production and water quality relationships. C. P. Buzzelli, R. L. Wetzel, and M. B. Meyers. Estuaries. 1998. 21: 673-689.

Ehlers, A., Worm, B. and B.H. Reutsch. 2005. Importance of genetic diversity in eelgrass *Zostera marina* for its resilience to global warming. Marine ecology progress series 355: 1-7

Falls, J.A. The Survival Benefit of Benthic Macroalgae Gracilaria vermiculophylla as an Altnerative Nursery Habitat for Juvenile Blue Crabs. 2008. MS Degree Thesis, The College of William and Mary, Virginia Institute of Marine Science, Gloucester Point, Virginia.

Fay CW, RJ Neves, and GP Pardue. 1983. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Mid-Atlantic) - bay scallop. U.S. Fish and Wildlife Service, Division of Biological Services, FWS/OBS-82/11.12. US Army Corp of Engineers, TR EL-82-4. 17pp.

Fegley, S.R., C.H. Peterson, N.R. Geraldi and D.W. Gaskill. 2009. Enhancing the potential for population recovery: restoration options for bay scallop populations, *Argopecten irradians concentricus*, in North Carolina. Journal of Shellfish Research, Vol. 28 No. 3: 477-489.

Fredette, T. J., R. J. Diaz, J. van Montfrans, and R. J. Orth. 1990. Secondary Production Within a Seagrass Bed (*Zostera marina* and *Ruppia maritima*) in Lower Chesapeake Bay. Estuaries. 13(4): 431-440.

Fonseca, M.S. and J.S. Fisher. 1986. A comparison of canopy friction and sediment movement between four species of seagrass with reference to their ecology and restoration. *Marine Ecology Progress Series* 29:15-22.

Fulford, R.S., D. L. Breitburg, **R. I. E. Newell**, W.M. Kemp and M.W. Luckenbach. 2007. Effects of oyster population restoration strategies on phytoplankton biomass in Chesapeake Bay: a flexible modeling approach. Marine Ecology Progress Series. 336:43-61.

Goldberg, R., J. Pereria and P. Clark. 2000. Strategies for enhancement of natural bay scallop, *Argopecten irradians irriadians*, populations: a case study in the Niantic River estuary, Connecticut, USA. Aquaculture International 8: 139-158.

Haven DS, Morales-Alamo R (1966) Aspects of biodeposition by oyster and other invertebrate filter feeders. Limnol Oceanogr 11:487–498

Haven, D. S., J. P. Whitcomb and P. C. Kendall. 1981. The Present and Potential Productivity of the Baylor Grounds in Virginia. Volumes I and II and Chart Supplement. Special Report No. 293 in Applied Marine Science and Ocean Engineering of the Virginia Institute of Marine Science, Gloucester Point, Virginia 23062.

Heck, K. L., K. Able, C. Roman, and M. Fahay. 1995. Composition, abundance, biomass and production of macro-fauna in a New England estuary: Comparisons among eelgrass meadows and other nursery habitats. *Estuaries* 18: 379-389.

Hernandez-Cordero, A.L. 2010. Exploring the potential for bay scallop, *Argopecten irradians concentricus*, restoration in the Lynnhaven River sub-estuary of Chesapeake Bay. Master's Thesis, College of William and Mary, Virginia Institute of Marine Science, Gloucester Point, VA.

Jensen, A. 2002. Artificial reefs of Europe: perspective and future. ICES Journal of Marine Science, 59: 3-13.

Johnson, M.R. and K.L. Heck. 2006.
Effects of habitat fragmentation per se on decapods and fishes inhabiting seagrass meadows in the northern Gulf of Mexico
Marine Ecology Progress Series, Vol. 306, pp. 233-246.

Johnson, M.R., S.L. Williams, C.H. Lieberman and A. Solbak. 2003. Changes in the abundance of the seagrasses Zostera marina L. (eelgrass) and Ruppia maritima L. (widgeongrass) in San Diego, California, following and El Nino event. Estuaries, Vol. 26. no. 1, pp:106-115.

Koch EW and Gust G. 1999. Water flow in tide and wave dominated beds of the seagrass *Thalassia testudinum. Mar Ecol-Prog Ser* **184**: 63–72.

Kuehl, S.A. 2008. Lynnhaven River Sedimentation Study. Virginia Institute of Marine Science, Gloucester Point, Virginia.

Leonard, L.A., Wren, P. A. and R. L. Beavers. 2002. Flow dynamics and sedimentation in *Spartina alterniflora* and *Phragmites australis* marshes of the Chesapeake Bay. Wetlands, Vol. 22, No. 2, pp. 415-424.

Lipcius, R.N., D.B. Eggleston, S.J. Schreiber, R.D. Seitz, J. Shen, M. Sisson, W.T. Stockhausen, and H.V. Wang. 2008. Metapopulation connectivity and stock enhancement of marine species. Reviews in Fisheries Science 16: 101-110.

Lipcius RN, Burke RP (2006) Abundance, biomass and size structure of eastern oyster and hooked mussel on a modular artificial reef in the Rappahannock River, Chesapeake Bay. Spec. Rept. Appl. Mar. Sci. Ocean Eng. No. 390, Virginia Institute of Marine Science, The College of William and Mary, Gloucester Point, VA 23062

McCay, D. F., P. Peterson and M. Donlan. 2002. Restoration Scaling of Benthic, Aquatic and Bird Injuries to Oyster Reef and Marsh Restoration Projects. Report prepared to mitigation Chalk Point Oil Spill, Maryland.

McCay, F.D.P and J.J. Rowe, 2003. Habitat restoration as mitigation for lost production at multiple trophic levels. Mar. Ecol. Prog. Ser. 264:235-249.

Meng, L., C.D. Orphanides and J. Christopher-Powell. 2002. Use of a fish index to assess habitat quality in Narragansett Bay, Rhode Island. Transactions of the American Fisheries Society 121:731-742.

Moore, K.A. and J.C. Jarvis. 2008. Environmental factors affecting recent summertime eelgrass diebacks in the lower Chesapeake Bay: Implications for long-term persistence. Journal of Coastal Research, Vol. 55, pp. 135-147.

Kenneth A. Moore (2004) Influence of Seagrasses on Water Quality in Shallow Regions of the Lower Chesapeake Bay. Journal of Coastal Research: Special Issue 45

Moore, K.A. 2004. Influence of seagrasses on water quality in shallow regions of the lower Chesapeake Bay. Journal of Coastal Research, Vol. 45, pp:162-178.

Nelson, K. A., Leonard, L. A., Posey, M. H., Alphin, T. D. and M. A. Mallin. 2003. Using transplanted oyster (*Crassostrea virginica)* beds to improve water quality in small tidal creeks: a pilot study. Journal of Experimental Marine Biology and Ecology. Vol. 298, No. 2, pp: 347-368.

Newell RIE, W. M. Kemp, J. D. Hagy III, C. F. Cerco, J. M. Testa , W. R. Boynton. 2007. Top-down control of phytoplankton by oysters in Chesapeake Bay, USA: Comment on Pomeroy et al. (2006). Mar. Ecol. Prog. Ser. 341: 293–298

Newell, RIE. 1988. Ecological changes in Chesapeake Bay: are they the result of overharvesting the Eastern oyster *Crassostrea virginica*? Pages 536-546 In: M.P. Lynch and E.C. Krome, (eds.) Understanding the Estuary: Advances in Chesapeake Bay Research. Chesapeake Research Consortium Publication 129 (CBP/TRS 24/88), Gloucester Point, VA.

Olff, H., De Leeuw, J., Bakker, J. P., Platerink, R. J. and H. J. van Wijnen. 1997. Vegetation Succession and Herbivory in a salt marsh: changes induced by sea level rise and silt deposition along an elevational gradient. Journal of Ecology, Vol. 85, No. 6, pp. 799-814.

Olney JE, Boehlert GW (1988) Nearshore ichthyoplankton associated with seagrass beds in the lower Chesapeake Bay. Mar Ecol Prog Ser 45:33–43

Orth, R., S. Marion, S. Granger and M. Traber. 2008. Restoring eelgrass (Zostera marina) from seed: a comparison of planting methods for large-scale projects. ERDC/TN SAV-08-01, March 2008.

Orth, R. J., M. L. Luckenbach, S. R. Marion, K. A. Moore, and D. J. Wilcox. 2006a. Seagrass recovery of in the Delmarva Coastal Bays, USA. *Aquatic Botany* 84: 26-36.

Peterson, C. H., Grabowski, J. H. and S. P. Powers. 2003. Estimated enhancement of fish production resulting from restoring oyster reef habitat: quantitative valuation. Marine Ecology Progress Series 264: 249-264.

Peterson, C.E. and R.N. Lipcius. 2003. Conceptual progress towards predicting quantitative ecosystem benefits of ecological restorations. Marine Ecology Progress Series 264: 297-307

Pacheco, A., and W.B. Stotz. 2006. Will providing a filamentous substratum in the water column and shell litter on the bottom increase settlement and post-larval survival of the scallop *Argopecten purpuratus*? Journal of Experimental Marine Biology and Ecology. 333: 27-39.

Paerl, H. W., L. M. Valdes, J. L. Pinckney, M. F. Piehler, J. Dyble,
and P. H. Moisander. 2003. Phytoplankton photopigments as indicators of estuarine and coastal eutrophication. BioScience 53: 953–964.

Parker K. 2006. Bay scallops saltwater early-warning systems. Florida Wildlife May/June 2006. pg 54-55.

Peterson, C. H., and Associates. 2003. Scaling compensatory restoration for the Craney Island expansion project in the Elizabeth River estuary. A report to the U.S. Army Corps of Engineers, Norfolk District, C.H. Peterson and Associates.

Peterson, C.H., H.C. Summerson and R.A. Luettich Jr. 1996. Response of bay scallops to spawner transplants: a test of recruitment limitation. Marine Ecology Progress Series. 132: 93-107.

Pohle D.G., V.M. Bricelj, and Z. Garcia-Esquivel. 1991. The eelgrass canopy: an above-bottom refuge from benthic predators for juvenile bay scallops *Argopecten irradians*. Marine Ecology Progress Series 74: 47-59.

Powers, S.P. J.H. Grabowski, C.H. Peterson, W.J. Lindberg. 2003. Estimating enhancement of fish production by offshore artificial reefs: uncertainty exhibited by divergent scenarios. Marine ecology progress series. Vol. 264: 265-277.

Ray, G.L. 2008. Habitat Equivalency Analysis: A Potential Tool for Estimating Environmental Benefits. ERDC TN-EMRRP-EI-02.

Reed, D. J., T. Spencer, A. L. Murray, J. R. French, and L. Leonard. 1999. Marsh surface sediment deposition and the role of tidal creeks: Implications for created and managed coastal marshes. Journal of Coastal Conservation 5:81–90.

Reed, D.J. 1989. Patterns of sediment deposition in subsiding coastal salt marshes, Terrebonne Bay, Louisiana: the role of winter storms. Estuaries. Vol. 12, No. 4, pp. 222-227.

Schillinger, J.E. and J.J. Gannon. 1985. Bacterial adsorption and suspended particles in urban stormwater. Journal of the water pollution control federation. Vol. 57, No. 5, pp. 384-389.

Schulte, D.M. and R.N. Lipcius. In preparation. Mechanisms of failed recruitment of selectively bred eastern oyster, *Crassostrea virginica*, in restoration.

Seaman, W. and L.M. Sprague. 1991. Artificial habitats for marine and freshwater fisheries. Academic Press, San Diego, California.

Seitz, R.D., R.N. Lipcius and A.L. Hernandez. 2009. Pilot field experiments on Bay scallop restoration in the Lynnhaven River subestuary. Final Report. Virginia Institute of Marine Science, Gloucester Point, Virginia.

Soniat, T.M., E.N. Powell, E.E. Hofmann and J.M. Klinck. 1998. Understanding the success and failure of oyster populations: The importance of sampled variables and sample timing. Journal of shellfish research. 17:1149-1165.

Stevenson, J. C. 1988. Comparative ecology of submersed grass beds in freshwater, estuarine, and marine environments.Limnology and Oceanography 33:867–893.

Steimle, F., K. Foster, R. Kropp and B. Conlin. 2002. Benthic macrofauna productivity enhancement by an artificial reef in Delaware Bay, USA. ICES Journal of Marine Science. 59: 100-105.

Strieb, M.D., V.M. Bricelj, S.I. Bauer. 1995. Population biology of the mud crab, *Dyspanopeus Sayi*, an important predator of juvenile bay scallops in Long Island (USA) eelgrass beds. Journal of Shellfish Research. 14: 347-357.

Stephens, J., Pondella, D., 2002. Larval productivity of a mature artificial reef: the ichthyoplankton of King Harbor, California, 1974–1997. ICES J. Mar. Sci. 59, S51–S58.

Stockhausen, W. T., and R. N. Lipcius. Single large or several small marine reserves for the Caribbean spiny lobster? Mar. Freshwater Res., 52: 1605–1614 (2001).

Suding, KN, Gross, KL and GR Housen. 2004. Alternative states and positive feedbacks in restoration ecology. Trends in Ecology and Evolution, Vol. 19 no. 1: 46-53.

Svane, I., Peterson, J., 2001. On the problems of epibioses, fouling and artificial reefs, a review. Mar. Ecol. 22, 169–188.

Tettelbach, S. T. & C. F. Smith. 2009. Bay scallop restoration in New York. Ecol. Res. 27:20–22.

Tettlebach ST and EW Rhodes. 1981. Combined effects of temperature and salinity on embryos and larvae of the northern bay scallop *Argopecten irradians concentricus*. Marine Biology 63:249-256.

Thomson, J.D. (1992) Scallop enhancement – how, and is it worth the effort? In: Recruitment Processes (ed. D.A. Hancock), A-station Government Printing Service, Canberra, pp. 183–186.

Tomasko, D. A., C. A. Corbett, H. S. Greening, AND G. E. Raulerson. 2005. Spatial and temporal variation in seagrass coverage in Southwest Florida: Assessing the relative effects of anthropogenic nutrient load reductions and rainfall in four contiguous estuaries. Marine Pollution Bulletin 50:797–805.

Ulanowicz, R.E. and J. Tuttle. The trophic consequences of oyster stock rehabilitation in Chesapeake Bay. Estuaries 15:298-306.

Virginia Fisheries Commission. 1928-1933. Annual Reports to the Governor. Special Archives at the Hargis Library, Virginia Institute of Marine Science, Gloucester Point, Virginia.

Wanless, H.R., 1981. Fining-upwards sedimentary sequences generated in seagrass beds. J. Sedim. Petrol. 51, pp:445–454.

Wilbur, A. E., S. Seyoum, T. M. Bert & W. S. Arnold. 2005. A genetic assessment of bay scallop (*Argopecten irradians*) restoration efforts in Florida's Gulf of Mexico coastal waters (USA). Conserv. Genet. 6:111–122.

Wilson, K. D., A.W.Y. Leung and R. Kennish. 2002. Restoration of Hong Kong fisheries through deployment of artificial reefs in marine protected areas. ICES Journal of Marine Science, 59: 157-163.

Wilson, J., C.W. Osenberg, C.M. St. Mary, C.A. Watson and W.J. Lindberg. 2001. Artificial reefs, the attraction-production issue, and density dependence in marine ornamental fishes. Aquarium Sciences and Conservation 3: 95-105.

Wong, M. C., M. A. Barbeau, A. W. Hennigar & S. M. C. Robinson. 2005. Protective refuges for seeded juvenile scallops (*Placopecten magellanicus*) from sea star (*Asterias* spp.) and crab (*Cancer irroratus* and *Carcinus maenas*) predation. Can. J. Fish. Aquat. Sci. 62:1766–1781.

USEPA SALT MARSH MODEL DESCRIPTION

USEPA Salt Marsh Model Description

1. INTRODUCTION

The parameters (i.e., TSS, BIBI and secondary production) used to assess benefits gained through the implementation of the other restoration measures are not able to adequately capture environmental improvements produced through the modification of the four wetland sites. Current research suggests that there is no difference in TSS reduction properties in *Phragmites australis* as compared to *Spartina alterniflora*, and the dominant vegetation type of a salt marsh does not significantly impact sediment transport, flow regime, and sediment deposition patterns (Leonard et al., 2002; Chambers et al., 1999). In the case of secondary production, available scientific literature presents little information on the comparative productivity of a *P. australis* versus a *S. alterniflora* dominant marsh. Studies have demonstrated that abundance within *P. australis* is dependent upon species and taxa (Chambers et al., 1999, Meyerson et al. 2000). For example, Krause et al. (1997) found that biomass of insects was high in *P. australis*, while Meyers et al. (2001) found no significant difference in nekton biomass between *P. australis* and *S. alterniflora* marshes. Currently, the shortage of quantitative productivity data makes comparisons of the two systems using secondary production infeasible.

2. MODEL DESCRIPTION

The environmental benefits gained through the restoration/diversification of the wetland sites (Princess Anne, Great Neck North, Great Neck South, and Mill Dam Creek) were determined using a model developed by the USEPA. The EPA model represents the first stand alone assessment tool based on wildlife habitat values of coastal wetlands. The model quantifies salt marsh health and function through the valuation of marsh characteristics and the presence of habitat types. Other tools use marsh functions, such as nutrient removal, to assess wetland sites. However, the creators of this model choose to focus on marsh habitat types, marsh morphology, and landscape setting. This particular marsh function was chosen to be used as the framework for the environmental model for a number of reasons. First, providing wildlife habitat is one of the most important functions shared by all marshes. Salt marshes are thought to be the most productive ecosystems on the world, providing substantial biodiversity, supporting numerous species from all of the major groups of organisms and providing both seasonal and year around habitat for many terrestrial and aquatic species. Next, available habitat is a function that is well suited for assessment. Almost all state and local wetland regulations include habitat protection goals. Of particular interest are wetlands or classes of wetlands that provide habitat for threatened and endangered species. Finally, wetland protection or restoration goals based on wildlife habitat targets are generally well received and understood by the public, particularly when the species of interest, such as large birds and mammals, are included in the project goals.

The USEPA model quantifies habitat values based on marsh characteristics and the presence of habitat types that contribute to use by terrestrial species. Model's developers identified 79 birds, 20 mammals, and 6 amphibian and reptile species that utilize New England salt marsh habitat at some life stage. Habitat requirements of these species were determined through a search of published literature, unpublished reports, anecdotal information from wetland ecologists and personal observations of the model's creators. From the available information, the developers identified common habitat types associated within salt marshes, or those that were reported as being used by at least 3 bird or mammal species. These habitat types, as well as the habitat requirements of salt marsh fauna, form the basis of the salt marsh assessment model.

The model consists of eight wetland and landscape components that are used to assess and evaluate salt marsh wildlife habitat values (Figure 1). Several of the components are directly based on the different habitat types found in and around marshes or ecosystems that are linked to salt marshes. Other components reflect the anthropogenic alteration of these habitats. The remaining components take into account the size, morphology, and landscape positions of the marsh, which may be important to territorial species and those that require adjacent upland habitats. The eight components are (1) marsh habitat types, (2) marsh morphology, (3) marsh size, (4) degree of anthropogenic modification, (5) vegetative heterogeneity, (6) surrounding land use, (7) connectivity, and (8) vegetation types. Each component, in turn, consists of several categories. For example, the "Habitat Type" component consists of ten categories including shallow open water, tidal flats, pannes, wooded islands, and low marsh. A complete description of each habitat component and the overall framework of this model are included in McKinney and Wigand (2006) paper.

Component	Categories	Criteria
I. Salt Marsh Size Class	Very small (under 5 ha) Small (5 – 25 ha) Medium-sized (26 – 125 ha) Large (126 – 200 ha) Very large (over 200 ha)	Marsh area
II. Salt Marsh Morphology	Salt meadow marsh Meadow / fringe marsh Wide fringe marsh Narrow fringe marsh Marine fringe marsh	Marsh morphology
III. Salt Marsh Habitat Types	Shallow open water Tidal flats Low marsh Trees overhanging water High marsh Pools Pannes Wooded islands Marsh-upland border Phragmites	Presence or abundance
IV. Extent of Modification	Little to no ditching Moderate ditching Severe ditching Little to no tidal restriction Moderate tidal restriction Severe tidal restriction	Degree of modification
V. Salt Marsh Vegetation	Aquatic plants Emergents Shrubs Trees Vines	Presence or abundance
VI. Vegetative Heterogeneity	High heterogeneity Moderate heterogeneity Low heterogeneity	Number of habitat edges
VII. Surrounding Land Cover	Open water Natural land Maintained open land Developed land	Presence or area
VIII. Connectivity	Sand or cobble beach Coastal dunes or overwash Other salt marsh wetland Brackish wetland or pond Freshwater wetland or pond Upland meadow Upland forest	Presence or area

FIGURE 1: WETLAND ASSESSMENT COMPONENTS AND THEIR ASSOCIATED CATEGORIES OF THE USEPA MODEL.

The model user assigns a rating of low, moderate, high or absent to each model category. The rating is given a numerical score and a weighting factor to reflect faunal habitat requisites, which can be found in Figure 2. For example, one category of the habitat component involves the presence of shallow water. If open shallow water habitat makes up >20% of the marsh, the category is given a numeric score of "5". If open shallow water habitat is absent from a salt marsh, the category is given a "0". The value of each category is multiplied by a weighting factor. The output produced by the USEPA model is a numerical score, an overall relative wildlife habitat assessment score for the marsh, which is calculated by summing subtotals for each of eight habitat components of the model (McKinney et al. 2009a). The maximum wildlife habitat assessment score possible from the USEPA model is 784, with small, impaired marshes receiving values below 100. The values and weighting factors assigned to each model component are given in the table below ((McKinney et al. 2009a).

The scores and weighting factors for each component were developed and tested on a group of 16 salt marshes in Narragansett Bay, Rhode Island. The study and resulting conclusions are described in two peer reviewed papers; "Assessing the wildlife habitat value for New England salt marshes: I. Model and application" and "Assessing the wildlife habitat value of New England salt marshes: II. Model testing and validation".

a) Pre-classification components

Component	Category	Weighting factor	Criteria (value)				
			High (5)	High/mod. (4)	Moderate (3)	Mod./low (2)	Low (1)
Size class	–	10	> 200 ha	126–200 ha	26–125 ha	5–25 ha	< 5 ha
Morphology	–	10	Salt meadow	Meadow/fringe	Wide or marine fringe	–	Narrow fringe

b) Assessment components

Component	Category	Weighting factor	Criteria (value)			
			High (5)	Moderate (3)	Low (1)	Absent (0)
Habitat type	shallow open water	7	>20% of marsh unit	10–20% of marsh unit	<10% of marsh unit	absent
	tidal flats	8	>30% of marsh unit	5–30% of marsh unit	<5% of marsh unit	absent
	low marsh	8	>15% of marsh unit	5–15% of marsh unit	<5% of marsh unit	absent
	trees overhanging water	5	>15% of marsh unit	5–15% of marsh unit	<5% of marsh unit	absent
	high marsh	8	>40% of marsh unit	5–40% of marsh unit	<5% of marsh unit	absent
	wooded islands	6	>15% of marsh unit	5–15% of marsh unit	<5% of marsh unit	absent
	phragmites	4	>3% of marsh unit	1–3% of marsh unit	<1% of marsh unit	absent
	pools	8	>10 pools/ha	2–10 pools/ha	<2 pools/ha	absent
	pannes	5	>10 pannes/ha	2–10 pannes/ha	<2 pannes/ha	absent
	marsh-upland border[a]	8				
	width		width >8 m	width 2–8 m	width <2 m	–
	length		>65% of perimeter	50–65% of perimeter	<50% of perimeter	–
	composition		>70% shrubs	50–70% shrubs	<50% shrubs	–
Anthropogenic modification	ditching	9	little to no ditching	moderate ditching	severe ditching	–
	tidal restriction	7	little to no restriction	moderate restriction	severe restriction	–

FIGURE 2: THE VALUES AND WEIGHTING FACTORS FOR EACH HABITAT CATEGORY USE IN THE USEPA MODEL

Vegetation	aquatic plants	2	>15% of marsh unit	5–15% of marsh unit	<5% of marsh unit	absent
	emergents	3	>90% of marsh unit	75–90% of marsh unit	<75% of marsh unit	absent
	shrubs	3	>20% of marsh unit	5–20% of marsh unit	<5% of marsh unit	absent
	trees	4	>15% of marsh unit	5–15% of marsh unit	<5% of marsh unit	absent
	vines	1	>15% of marsh unit	5–15% of marsh unit	<5% of marsh unit	absent
Vegetative heterogeneity	–	6	5 edge habitats	3–4 edge habitats	1 or 2 edge habitats	–
Surrounding land use	open water	6	>35% of buffer[b]	25–35% of buffer	<25% of buffer	–
	natural land	9	>25% of buffer	10–25% of buffer	<10% of buffer	–
	maintained open	5	<5% of buffer	5–15% of buffer	>15% of buffer	–
	developed land	9	<5% of buffer	5–35% of buffer	>35% of buffer	–
Connectivity[c]		9				
	habitat types in buffer[d]		>4	3–4	1–2	–
	average size		>3 ha	1–3 ha	<1 ha	–
	proportion of buffer		>30% of buffer	15–30% of buffer	<15% of buffer	–

FIGURE 2: THE VALUES AND WEIGHTING FACTORS FOR EACH HABITAT CATEGORY USE IN THE USEPA MODEL (Cont'd).

3. MODEL REQUIREMENTS

The USEPA designed the model to be an easily accessible tool to be used by field biologists and resource managers to perform office-based assessments that could be run in a relatively short amount of time using readily available data and software. The model designers intended that output produced by the model would be used to make planning and management decisions, such as "(1) prioritizing marshes for protection and restoration, (2) identify ecologically important marshes that could potentially harbor high biodiversity, and (3) monitor changes in habitat value over time, for example during the course of salt marsh restoration" (McKinney et al. 2009a).

The input data necessary for the application of the model is "at a minimum, aerial photographs showing each salt marsh to be assessed and the surrounding landscape at least 1km around each site are required to carry out the assessment. Digital land use and land cover in a GIS will aid in determining surrounding land use and associated habitats. Office-based aerial photo delineation to assess habitat type, vegetative structure, and vegetative heterogeneity should, if possible, be supplemented with field assessment" (USEPA, 2008).

Software and hardware required to run the EPA model are commonly available in an office setting. A personal computer increases the ease of using the model (in order to run a spreadsheet program); however it is not necessary to run the model. An Excel or any simple spread sheet software package can be used to calculate habitat assessment scores. The results of the USEPA model are extremely easy to export into a report since output data is produced using a spreadsheet program. The entire spread sheet can be imported into the body of the report or individual wildlife habitat assessment scores can be easily included in the text. If the user does not have access to a computer, a hand calculator can also be used to calculate habitat values. These calculations could even be completed using paper and pencil, if a researcher was in the field and had the corresponding values to each habitat component.

The model is easily accessible through the website of the Atlantic Ecology Division of the USEPA. The model is described in three papers, all of which are available on the USEPA website. A matrix, including the assessment components, and their associated weighting factors and scores, is available in McKinney and Charpentier's paper entitled "Assessing the wildlife habitat value of New England salt marshes: I. Model and application" (Figure 2). The paper was published in 2009 in the journal Environmental Monitoring and Assessment. An Excel spreadsheet which calculates individual wildlife habitat assessment scores is also available in the USEPA website, which is listed below. These calculations can be easily reproduced and verified using any spread sheet software or with a handheld calculator.

http://www.epa.gov/aed/html/research/wetland/saltmarsh/

There is no formal training associated with the USEPA model. Since the basis of the model is to assess marsh quality through available habitats, the model user must have an understanding of and the ability to recognize habitat types present in a salt marsh. The user must be able to differentiate, either from aerial photography or through field visits, vegetative structures and habitat types. The user must also be able to estimate the extent of habitat or vegetation types that make up each study site. The calculations used to produce the habitat scores are relatively simple, so users only need an understanding of basic algebra. If a spreadsheet program is available, then the user may also need to program functions and input data into a spreadsheet in order to calculate habitat values.

4. APPLICATION OF THE USEPA MODEL DURING THE LYNNHAVEN RIVER BASIN STUDY

The USEPA model was used to calculate environmental benefits that would be derived from restoration and diversification efforts at four wetland sites within the Lynnhaven River Basin throughout the 50 year lifespan of the Lynnhaven River Basin Restoration Project. The model was run twice for each site in order to produce the "Without Project" and "With Project" values. The data used to quantify the "With" and "Without Project" condition values was obtained through aerial photography, collected in 2007, and site visits to all four wetland sites during the winter of 2009.

The “Without Project” condition was determined using the current conditions found at each project site. The assumption intrinsic in the uses of current conditions when developing the “Without Project” condition is that the plant community is in equilibrium and the marsh will remain relatively stable over time. The inherent weakness of this assumption is that it does not account for possible disturbances (e.g. construction and development adjacent to the marsh, sea level rise) that have the potential to alter site conditions.

“With Project” values were developed using anticipated site conditions once restoration efforts have been completed. The future site conditions were determined using site conditions present at two high-quality, reference sites and the best professional judgment of the USACE biologist. The inherent weakness of forecasting future conditions is that there is no way to guarantee that optimal conditions will be established at the wetland sites. This uncertainty can be mitigated with the establishment of monitoring and adaptive management programs, as is required by USACE policy and has been included in the Lynnhaven Project report.

The difference between the “With” and “Without Project” conditions represents the environmental benefits that will be gained through the restoration of the wetland sites. Benefit gains were due to changes to only three model components, “Habitat Type,” “Vegetation,” and “Vegetative Heterogeneity.” The “Habitat Type” component assesses the presence of 10 distinct microhabitats found within a salt marsh (i.e. shallow open water, tidal flats, pannes, trees over hanging water, high marsh, phragmites, pools, marsh-upland border, wooded islands, and low marsh) by assigning values and weighting factors to the percentage of each microhabitat present at the site. The model also assigns value to the composition of the salt marsh plant community through the “Vegetation” component. The percentage of five plant groups (aquatic plants, emergents, shrubs, trees, and vines) within the marsh unit is captured in this component. The “Vegetative Heterogeneity” component accounts for the abundance and diversity of vegetative edges. An “edge” is defined as either an interface between two adjacent plant groups, as described in the “Vegetation” component, or between a plant group and a marsh habitat type, as described in the “Habitat Type” component.

Due to limits in project size and scope, certain model components were not affected by the proposed restoration treatments. For example, the restoration effort will have no effect on surrounding land use, marsh size, marsh morphology, or anthropogenic modification (e.g. tidal restriction and ditching). The efforts also will not affect marsh connectivity, which is "the functional relationship between adjacent habitats arising from their spatial distributions and the movement of organisms" (McKinney and Wigand, 2006). As a result, the values assigned to these components remained constant in both the "Without Project" and "With Project" conditions.

The spreadsheets completed for the wetland and reference sites are included at the end of this document. The scores described in this report have been summarized in Table 2, which is also placed at the end of the discussion.

The Great Neck North site scored highest of all four sites in the "Without Project" condition. It received a score of 384, which is 49 percent of the maximum possible value. This score resulted from the marsh morphology because the site falls into the "Salt Meadow/Fringe" category, which is a configuration that is considered highly valuable in the USEPA model. The site also scored highly because of the small amount of anthropogenic modification (no tidal constriction and little to no ditching) and relatively high levels of connectivity and vegetative heterogeneity. The site received a score of 436 for the "With Project" condition, which is 56 percent of the maximum, representing a 52 point gain. The increase was due to two model components. The "Habitat Type" component value increased from 107 in the "Without Project "condition to 147 in the "With Project" condition, while the "Vegetative Heterogeneity" component increased from a value of 18 to 30. Average annual benefits were calculated by subtracting the score of "Without Project" condition from the "With Project" condition. In the case of the Great Neck North site, the 52 units would be gained annually if restoration efforts were completed.

The Princess Anne site received the second highest "Without Project" condition score and the largest net benefit gain from restoration efforts. The site warranted 304 points for the "Without Project" condition and 389 points for the "With Project" condition. The site is a relatively small fringe marsh located in a highly developed area; therefore it received low scores for the “Size Class,” “Morphology,” “Connectivity,” and “Surrounding Land Use” components. However, the site is not ditched and has little to no tidal restriction. Even though *Phragmites* dominates the lower marsh, the site exhibits a relatively high level of vegetative heterogeneity. The site received high scores on the “Vegetative Heterogeneity” and “Habitat Type” components. The model components which accounted for the change between the “With Project” and “Without Project” conditions were the same as for the Great Neck North site. “Habitat Type” increased from 107 to 178, and “Vegetative Heterogeneity” increased from 18 to 30. The environmental impact resulting from the restoration of the Princess Anne site is predicted to be the greatest of all of the four wetland sits, with an average annual gain of 85 points.

The current conditions at the Great Neck South site resulted in a low “Without Project” condition score of 286, which is 36 percent of the possible maximum score. The marsh is a relatively large “salt meadow/fringe” exhibiting some habitat diversity within the buffer zone surrounding the site, so it received high values for the “Morphology” and “Connectivity” components. The site consists almost entirely of *Phragmites*, so “Habitat Type” and “Vegetative Heterogeneity” scores were low. The “With Project” conditions increased 75 points, to a score of 361. The components that were responsible for the change were “Habitat Type” (from 53 to 113), “Vegetative Heterogeneity” (from 6 to 18), and “Vegetation” (from 20 to 23). The environmental benefit gained through the restoration of the Great Neck South site is estimated to be 75 points.

The final site, Mill Dam Creek, had the lowest values both prior to and after the completion of the restoration efforts, earning 282 for the “Without Project” condition (36 percent of the total available score) and 348 for the “With Project” condition, only 44 percent of the possible maximum. The sites received low scores for most model components in its current conditions because the marsh is a small, fringe marsh that is completely dominated by common reed. The “Size Class,” “Morphology,” and “Vegetative Heterogeneity” components received the lowest values, only 20 percent of the maximum available value. The change in condition between “With Project and “Without Project” was observed in the “Habitat Type” (from 94 to 148) and the “Vegetative Heterogeneity” (from 6 to 18) components. The benefits gained from project implementation were 66 points.

The environmental benefits calculated using the EPA model can be found in the following table for each of the wetland restoration sites. The spreadsheets, which include the individual component values for each site are included at the end of this document.

Table 1. WETLANDS WITH PHRAGMITES ERADICATION SITES AVERAGE ANNUAL BENEFIT

Wetlands with Phragmites Eradication Site	Average Annual Wetland Benefits (With Project – Without Project Condition)
Princess Anne High School	85
Mill Dam Creek	66
Great Neck North	52
Great Neck South	75
No Action Plan	0

Limitations of the USEPA Model

One limitation of the model, the intended geographic range, led to consideration of the appropriateness of the model for the Lynnhaven Project. The model was designed to be used specifically on coastal salt marshes of New England, from Maine to New Jersey. The Lynnhaven River Basin Restoration Project is located in Virginia, outside of the proposed range of the model. Upon analysis of the model, a number of compelling arguments were found that supported its use for the Lynnhaven Project.

First, the model developers included a very general description of a New England marsh in the paper describing the model's framework. These wetlands were characterized as being "typically small and receive low suspended sediment loads from relatively small drainage basins, resulting in predominately organic peat substrates. Salt marsh morphology in this region reflects the relatively steep slope of New England estuarine coastlines, as well as the influence of development and modification by humans" (McKinney and Wigand 2006). Salt marshes within the New England region vary widely and an assessment tool must take into account naturally occurring variations in order to be effective. Although there may be some differenced between salt marshes of the two regions, such as peat/sediment ratios present in marsh substrates and tidal range, the marshes share more traits (e.g. plant community composition, habitat types and ecological functions) than differences and the habitat conditions found at the Lynnhaven Project wetland sites fall within the natural range of variation found salt marshes of New England.

Second, the model was developed using species that are found both in New England and Virginia. The model's framework is based on the habitat needs of 105 different terrestrial species (79 birds, 20 mammals, and 6 reptiles and amphibians). Of course, there are differences in wildlife population composition found in the marshes of New England and those located in Virginia. However, almost all of the species (96%) used to develop the USEPA model occur within Virginia and can be found utilizing salt marsh habitat of the state. Only four species (swamp sparrow, snowy owl, fisher and New England cottontail) do not have ranges that include territory within Virginia.

Finally, the model was also used to evaluate two reference sites, in addition to the four proposed project sites. The assessment results were examined to see if the model could differentiate between impaired and unimpaired salt marshes located in the Lynnhaven River basin. The two reference site earned scores of 447 points (57% of the maximum possible score) and 552 points (70% of the maximum possible score). The impaired sites earned scores between 282 (36% of the maximum possible score) and 384 (49% of the maximum possible score). The model was able to capture differences between impaired and unimpaired sites and it produced habitat values that were similar to the qualitative rankings of each site by the USACE staff working on the Lynnhaven Project. Therefore it was judged to be a useful and appropriate tool to predict potential benefits gained between the "Without Project" and "With Project" conditions.

5. REFERENCES

Chambers, R.M, L.A. Meyerson, and K.Saltonstall. 1999. Expansion of *Phragmites australis* into tidal wetlands of North America. Aquatic Botany 64:261-273.

Krause, L.H., Rietsma, C., Kiviat, E. 1997. Terrestrial insects associated with *Phragmites australis*, *Typha angustifolia*, and *Lythrum salicaria* in a Hudson River tidal marsh. In: Nieder, W.C., Waldman, J.R. (Eds.), Final Reports of the Tibor T. Polgar Fellowship Program, 1996. Hudson River Foundation and New York State Department of Environmental Conservation, pp.V-1 to V-35.

Leonard, L.A., P.A. Wren, and R.L. Beavers. 2002. Flow Dynamics and Sedimentation in Spartina alterniflora and Phragmites australis Marshes of the Chesapeake Bay. Wetlands 22(2): 415-424.

McKinney, R.A., and Wigand, C. 2006. A framework for the assessment of the wildlife habitat value of New England salt marshes. EPA/600/R-06/132. Office of Research and Development. Washington, DC 20460.

McKinney, R.A., Charpentier, M.A., and Wigand, C. 2009a. Assessing the wildlife habitat value of New England salt marshes: I. Model and application. Environmental Monitoring and Assessment. 154:29-40.

McKinney, R.A., Charpentier, M.A., and Wigand, C. 2009b. Assessing the wildlife habitat value of New England salt marshes: II. Model testing and validation. Environmental Monitoring and Assessment. 154:361-371.

Meyer, D.L., J.M Johnson and J.W. Gill. 2001. Comparison of nekton use of *Phragmites australis* and *Spartina alterniflora* marshes in the Chesapeake Bay, USA . Marine Ecology Progress Series 209: 71-84.

Meyerson, L.A., K. Saltonstall, L. Windham, E. Kiviat and S. Findlay. 2000. A comparison of Phragmites australis in freshwater and brackish marsh environments in North America. Wetlands Ecology and Management 8:89-103.

USEPA, Salt Marsh Wildlife Habitat. Link: http://www.epa.gov/aed/html/research/wetland/saltmarsh/index.html Last updated September 22, 2008.

Table 2: The scores given to each wetland and reference site using the USEPA Model in the Lynnhaven River Basin Restoration Study.

Site:	Princess Anne		Mill Dam Creek		Great Neck South		Great Neck North		Ref Site 1	Ref Site 2
Project Condition:	Without Project	With Project	Without Project	With Project	Without Project	With Project	Without Project	With Project		
Habitat Component										
Size Class	10	10	10	10	20	20	20	20	10	20
Morphology	10	10	10	10	30	30	40	40	30	50
Habitat Type	107	178	94	148	53	113	107	147	118	145
Modification	80	80	45	45	45	45	80	80	62	80
Surrounding Land	41	41	67	67	85	85	75	75	133	145
Connectivity	9	9	27	27	27	27	27	27	45	45
Vegetative Heterogeneity	18	30	6	18	6	18	18	30	18	30
Vegetation	29	31	23	23	20	23	17	17	31	37
Total:	304	389	282	348	286	361	384	436	447	552
Percent of Maximum:	39%	50%	36%	44%	36%	46%	49%	56%	57%	70%
Environmental Benefit:		85		66		75		52	-	-
(With project - Without Project Condition)										

Site: Princess Anne
Condition: Without Project

Pre-classification:

	Score:	5	4	3	2	1	
	Weight	> 200 ha	126-200 ha	26-125 ha	5-25 ha	< 5 ha	Total
Size Class	10					X	10
	Weight	Salt meadow	Meadow / fringe	Wide fringe; marine fringe		Narrow fringe	
Morphology	10					X	10

Beneficial categories:

	Score:	0	1	3	5	
	Weight	Absent	Low	Moderate	High	Total
Habitat Type						107
Shallow open water	7			X		21
Tidal flats	8	X				0
Low marsh	8			X		24
Trees overhanging water	5		X			5
High marsh	8		X			8
Wooded islands	6			X		18
Pools	8		X			8
Pannes	5	X				0
Marsh upland border	8		X			8
Phragmites	4				X	20
Vegetation						29
Aquatic plants	2	X				0
Emergents	3				X	15
Shrubs	3			X		9
Trees	4		X			4
Vines	1		X			1

Beneficial categories:

	Score:	0	1	3	5	
	Weight	**Absent**	**Low**	**Moderate**	**High**	**Total**
Surrounding Land						27
Open water	6			X		18
Natural land	9		X			9
Connectivity	9		X			9
Vegetative Heterogeneity	6			X		18
Detrimental categories:						
	Score:	**5**	**5**	**3**	**1**	
	Weight	**Absent**	**Low / no**	**Moderate**	**High**	**Total**
Modification						80
Ditching	9		X			45
Tidal restriction	7		X			35
Surrounding Land						14
Maintained open	5				X	5
Developed land	9				X	9

Site: Princess Anne
Condition: With Project

Pre-classification:

	Score:	5	4	3	2	1	
	Weight	**> 200 ha**	**126-200 ha**	**26-125 ha**	**5-25 ha**	**< 5 ha**	**Total**
Size Class	10					X	10
	Weight	**Salt meadow**	**Meadow / fringe**	**Wide fringe; marine fringe**		**Narrow fringe**	
Morphology	10					X	10

Beneficial categories:

	Score:	0	1	3	5	
	Weight	**Absent**	**Low**	**Moderate**	**High**	**Total**
Habitat Type						178
Shallow open water	7				X	35
Tidal flats	8		X			8
Low marsh	8				X	40
Trees overhanging water	5	X				0
High marsh	8			X		24
Wooded islands	6			X		18
Pools	8			X		24
Pannes	5		X			5
Marsh upland border	8			X		24
Phragmites	4	X				0
Vegetation						31
Aquatic plants	2		X			2
Emergents	3			X		9
Shrubs	3				X	15
Trees	4		X			4
Vines	1		X			1

Beneficial categories:

	Score:	0	1	3	5	
	Weight	**Absent**	**Low**	**Moderate**	**High**	**Total**
Surrounding Land						27
Open water	6			X		18
Natural land	9		X			9
Connectivity	9		X			9
Vegetative Heterogeneity	6				X	30
Detrimental categories:						
	Score:	**5**	**5**	**3**	**1**	
	Weight	**Absent**	**Low / no**	**Moderate**	**High**	**Total**
Modification						80
Ditching	9		X			45
Tidal restriction	7		X			35
Surrounding Land						14
Maintained open	5				X	5
Developed land	9				X	9

Site: Mill Dam Creek
Condition: Without Project

Pre-classification:

	Score:	5	4	3	2	1	
	Weight	**> 200 ha**	**126-200 ha**	**26-125 ha**	**5-25 ha**	**< 5 ha**	**Total**
Size Class	10					X	10
	Weight	**Salt meadow**	**Meadow / fringe**	**Wide fringe; marine fringe**		**Narrow fringe**	
Morphology	10					X	10

Beneficial categories:

	Score:	0	1	3	5	
	Weight	**Absent**	**Low**	**Moderate**	**High**	**Total**
Habitat Type						94
Shallow open water	7			X		21
Tidal flats	8	X				0
Low marsh	8			X		24
Trees overhanging water	5			X		15
High marsh	8	X				0
Wooded islands	6		X			6
Pools	8	X				0
Pannes	5	X				0
Marsh upland border	8		X			8
Phragmites	4				X	20
Vegetation						23
Aquatic plants	2	X				0
Emergents	3				X	15
Shrubs	3		X			3
Trees	4		X			4
Vines	1		X			1

Beneficial categories:

	Score:	**0**	**1**	**3**	**5**	
	Weight	**Absent**	**Low**	**Moderate**	**High**	**Total**
Surrounding Land						33
Open water	6		X			6
Natural land	9			X		27
Connectivity	9	X		X		27
Vegetative Heterogeneity	6		X			6
Detrimental categories:						
	Score:	**5**	**5**	**3**	**1**	
	Weight	**Absent**	**Low / no**	**Moderate**	**High**	**Total**
Modification						45
Ditching	9	X				45
Tidal restriction	7				X	0
Surrounding Land						34
Maintained open	5		X			25
Developed land	9				X	9

Site: Mill Dam Creek
Condition: With Project

Pre-classification:

	Score:	5	4	3	2	1	
	Weight	**> 200 ha**	**126-200 ha**	**26-125 ha**	**5-25 ha**	**< 5 ha**	**Total**
Size Class	10					X	**10**
	Weight	**Salt meadow**	**Meadow / fringe**	**Wide fringe; marine fringe**		**Narrow fringe**	
Morphology	10					X	**10**

Beneficial categories:

	Score:	0	1	3	5	
	Weight	**Absent**	**Low**	**Moderate**	**High**	**Total**
Habitat Type						**148**
Shallow open water	7				X	35
Tidal flats	8	X				0
Low marsh	8			X		24
Trees overhanging water	5			X		15
High marsh	8	X				0
Wooded islands	6		X			6
Pools	8			X		24
Pannes	5	X				0
Marsh upland border	8			X		24
Phragmites	4				X	20
Vegetation						**23**
Aquatic plants	2	X				0
Emergents	3			X		9
Shrubs	3			X		9
Trees	4		X			4
Vines	1		X			1

Beneficial categories:

	Score:	**0**	**1**	**3**	**5**	
	Weight	**Absent**	**Low**	**Moderate**	**High**	**Total**
Surrounding Land						33
Open water	6		X			6
Natural land	9			X		27
Connectivity	9			X		27
Vegetative Heterogeneity	6			X		18
Detrimental categories:						
	Score:	**5**	**5**	**3**	**1**	
	Weight	**Absent**	**Low / no**	**Moderate**	**High**	**Total**
Modification						45
Ditching	9	X				45
Tidal restriction	7				X	0
Surrounding Land						34
Maintained open	5		X			25
Developed land	9				X	9

Site: Great Neck South
Condition: Without Project

Pre-classification:

	Score:	5	4	3	2	1	
	Weight	**> 200 ha**	**126-200 ha**	**26-125 ha**	**5-25 ha**	**< 5 ha**	**Total**
Size Class	10				X		20
	Weight	**Salt meadow**	**Meadow / fringe**	**Wide fringe; marine fringe**		**Narrow fringe**	
Morphology	10			X			30

Beneficial categories:

	Score:	0	1	3	5	
	Weight	**Absent**	**Low**	**Moderate**	**High**	**Total**
Habitat Type						53
Shallow open water	7		X			7
Tidal flats	8	X				0
Low marsh	8		X			8
Trees overhanging water	5		X			5
High marsh	8	X				0
Wooded islands	6	X				0
Pools	8		X			8
Pannes	5		X			5
Marsh upland border	8	X				0
Phragmites	4				X	20
Vegetation						20
Aquatic plants	2	X				0
Emergents	3				X	15
Shrubs	3	X				0
Trees	4		X			4
Vines	1		X			1

Beneficial categories:

	Score:	**0**	**1**	**3**	**5**	
	Weight	**Absent**	**Low**	**Moderate**	**High**	**Total**
Surrounding Land						33
Open water	6		X			6
Natural land	9			X		27
Connectivity	9			X		27
Vegetative Heterogeneity	6		X			6
Detrimental categories:						
	Score:	**5**	**5**	**3**	**1**	
	Weight	**Absent**	**Low / no**	**Moderate**	**High**	**Total**
Modification						45
Ditching	9	X				45
Tidal restriction	7				X	0
Surrounding Land						52
Maintained open	5		X			25
Developed land	9			X		27

Site: Great Neck South
Condition: With Project

Pre-classification:

	Score:	5	4	3	2	1	
	Weight	**> 200 ha**	**126-200 ha**	**26-125 ha**	**5-25 ha**	**< 5 ha**	**Total**
Size Class	10				X		20
	Weight	**Salt meadow**	**Meadow / fringe**	**Wide fringe; marine fringe**		**Narrow fringe**	
Morphology	10			X			30

Beneficial categories:

	Score:	0	1	3	5	
	Weight	**Absent**	**Low**	**Moderate**	**High**	**Total**
Habitat Type						113
Shallow open water	7			X		21
Tidal flats	8	X				0
Low marsh	8		X			8
Trees overhanging water	5		X			5
High marsh	8	X				0
Wooded islands	6		X			6
Pools	8			X		24
Pannes	5		X			5
Marsh upland border	8			X		24
Phragmites	4				X	20
Vegetation						23
Aquatic plants	2	X				0
Emergents	3			X		9
Shrubs	3			X		9
Trees	4		X			4
Vines	1		X			1

Beneficial categories:

	Score:	0	1	3	5	
	Weight	**Absent**	**Low**	**Moderate**	**High**	**Total**
Surrounding Land						33
Open water	6		X			6
Natural land	9			X		27
Connectivity	9	X		X		27
Vegetative Heterogeneity	6			X		18
Detrimental categories:						
	Score:	**5**	**5**	**3**	**1**	
	Weight	**Absent**	**Low / no**	**Moderate**	**High**	**Total**
Modification						45
Ditching	9	X				45
Tidal restriction	7				X	0
Surrounding Land						52
Maintained open	5		X			25
Developed land	9			X		27

Site: Great Neck North
Condition: Without Project
Pre-classification:

	Score:	5	4	3	2	1	
	Weight	**> 200 ha**	**126-200 ha**	**26-125 ha**	**5-25 ha**	**< 5 ha**	**Total**
Size Class	10				x		20
	Weight	**Salt meadow**	**Meadow / fringe**	**Wide fringe; marine fringe**		**Narrow fringe**	
Morphology	10		X				40

Beneficial categories:

	Score:	0	1	3	5	
	Weight	**Absent**	**Low**	**Moderate**	**High**	**Total**
Habitat Type						107
Shallow open water	7		X			7
Tidal flats	8		X			8
Low marsh	8				X	40
Trees overhanging water	5		X			5
High marsh	8	X				0
Wooded islands	6		X			6
Pools	8		X			8
Pannes	5		X			5
Marsh upland border	8		X			8
Phragmites	4				X	20
Vegetation						17
Aquatic plants	2	X				0
Emergents	3		X			3
Shrubs	3			X		9
Trees	4		X			4
Vines	1		X			1

Beneficial categories:

	Score:	**0**	**1**	**3**	**5**	
	Weight	**Absent**	**Low**	**Moderate**	**High**	**Total**
Surrounding Land						33
Open water	6		X			6
Natural land	9			X		27
Connectivity	9			X		27
Vegetative Heterogeneity	6			X		18
Detrimental categories:						
	Score:	**5**	**5**	**3**	**1**	
	Weight	**Absent**	**Low / no**	**Moderate**	**High**	**Total**
Modification						80
Ditching	9		X			45
Tidal restriction	7		X			35
Surrounding Land						42
Maintained open	5			X		15
Developed land	9			X		27

Site: Great Neck North
Condition: With Project

Pre-classification:

	Score:	5	4	3	2	1	
	Weight	**> 200 ha**	**126-200 ha**	**26-125 ha**	**5-25 ha**	**< 5 ha**	**Total**
Size Class	10				X		20
	Weight	**Salt meadow**	**Meadow / fringe**	**Wide fringe; marine fringe**		**Narrow fringe**	
Morphology	10		X				40

Beneficial categories:

	Score:	0	1	3	5	
	Weight	**Absent**	**Low**	**Moderate**	**High**	**Total**
Habitat Type						147
Shallow open water	7		X			7
Tidal flats	8		X			8
Low marsh	8				X	40
Trees overhanging water	5		X			5
High marsh	8		X			8
Wooded islands	6		X			6
Pools	8			X		24
Pannes	5		X			5
Marsh upland border	8			X		24
Phragmites	4				X	20
Vegetation						17
Aquatic plants	2	X				0
Emergents	3		X			3
Shrubs	3			X		9
Trees	4		X			4
Vines	1		X			1

Beneficial categories:

	Score:	0	1	3	5	
	Weight	**Absent**	**Low**	**Moderate**	**High**	**Total**
Surrounding Land						33
Open water	6		X			6
Natural land	9			X		27
Connectivity	9			X		27
Vegetative Heterogeneity	6				X	30
Detrimental categories:						
	Score:	**5**	**5**	**3**	**1**	
	Weight	**Absent**	**Low / no**	**Moderate**	**High**	**Total**
Modification						80
Ditching	9		X			45
Tidal restriction	7		X			35
Surrounding Land						42
Maintained open	5			X		15
Developed land	9			X		27

Site: Reference Site #1

Pre-classification:

	Score:	5	4	3	2	1	
	Weight	**> 200 ha**	**126-200 ha**	**26-125 ha**	**5-25 ha**	**< 5 ha**	**Total**
Size Class	10					X	10
	Weight	**Salt meadow**	**Meadow / fringe**	**Wide fringe; marine fringe**		**Narrow fringe**	
Morphology	10			X			30

Beneficial categories:

	Score:	0	1	3	5	
	Weight	**Absent**	**Low**	**Moderate**	**High**	**Total**
Habitat Type						118
Shallow open water	7	X				0
Tidal flats	8	X				0
Low marsh	8				X	40
Trees overhanging water	5		X			5
High marsh	8			X		24
Wooded islands	6		X			6
Pools	8	X				0
Pannes	5			X		15
Marsh upland border	8			X		24
Phragmites	4		X			4
Vegetation						31
Aquatic plants	2	X				0
Emergents	3			X		9
Shrubs	3			X		9
Trees	4			X		12
Vines	1		X			1

Beneficial categories:

	Score:	**0**	**1**	**3**	**5**	
	Weight	**Absent**	**Low**	**Moderate**	**High**	**Total**
Surrounding Land						63
Open water	**6**			X		18
Natural land	**9**				X	45
Connectivity	**9**	X			X	45
Vegetative Heterogeneity	**6**			X		18
Detrimental categories:						
	Score:	**5**	**5**	**3**	**1**	
	Weight	**Absent**	**Low / no**	**Moderate**	**High**	**Total**
Modification						62
Ditching	**9**			X		27
Tidal restriction	**7**		X			35
Surrounding Land						70
Maintained open	**5**		X			25
Developed land	**9**	X				45

Site: Reference Site #2

Pre-classification:

	Score:	5	4	3	2	1	
	Weight	**> 200 ha**	**126-200 ha**	**26-125 ha**	**5-25 ha**	**< 5 ha**	**Total**
Size Class	10				X		20
	Weight	**Salt meadow**	**Meadow / fringe**	**Wide fringe; marine fringe**		**Narrow fringe**	
Morphology	10	X					50

Beneficial categories:

	Score:	0	1	3	5	
	Weight	**Absent**	**Low**	**Moderate**	**High**	**Total**
Habitat Type						145
Shallow open water	7			X		21
Tidal flats	8		X			8
Low marsh	8				X	40
Trees overhanging water	5		X			5
High marsh	8			X		24
Wooded islands	6		X			6
Pools	8		X			8
Pannes	5		X			5
Marsh upland border	8			X		24
Phragmites	4		X			4
Vegetation						37
Aquatic plants	2	X				0
Emergents	3			X		9
Shrubs	3				X	15
Trees	4			X		12
Vines	1		X			1

Beneficial categories:

	Score:	**0**	**1**	**3**	**5**	
	Weight	**Absent**	**Low**	**Moderate**	**High**	**Total**
Surrounding Land						75
Open water	**6**				X	30
Natural land	**9**				X	45
Connectivity	**9**	X			X	45
Vegetative Heterogeneity	**6**				X	30
Detrimental categories:						
	Score:	**5**	**5**	**3**	**1**	
	Weight	**Absent**	**Low / no**	**Moderate**	**High**	**Total**
Modification						80
Ditching	**9**		X			45
Tidal restriction	**7**		X			35
Surrounding Land						70
Maintained open	**5**	X				25
Developed land	**9**	X				45

PHASE I HTRW ENVIRONMENTAL SITE ASSESSMENT

Summary
A phase 1 Environmental Site Assessment (ESA) was performed at the four wetland restoration sites proposed for the Lynnhaven River Basin Restoration Study. The site assessment included a site reconnaissance and review of government and historical documents relating to the sites and surrounding areas. All practices conformed to the recommendations of American Society of Testing Materials (ASTM) standard 1527-00 "Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process."

All four sites are estuarine wetlands located in the Lynnhaven River Basin. No areas of concern were identified.

Document and database reviews indicated a low probability that a recognized environmental condition exists at the sites due to contamination from surrounding properties. There are no structures located with the wetland sites and no history of use because of the nature of the sites (estuarine wetlands) that would pose a threat of environmental hazard to people living adjacent to the project sites or the Lynnhaven River Basin ecosystem.

1.0 INTRODUCTION

This report summarizes the findings of the Phase I Environmental Site Assessment (ESA) at the four wetlands restoration/diversification sites proposed for the Lynnhaven River Basin Restoration Study. The ESA was performed in accordance with the recommended practices described in the ASTM Standard E 1527-00: "Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process." The purpose of the ESA is to determine the existence of or potential for any recognized environmental conditions. A recognized environmental conditions is defined as :"the presence or likely presence of any hazardous substances or petroleum products on the property under conditions that indicate an existing release, a past release, or a material threat of a release of any hazardous substances or petroleum products into structures on the property or into the ground, ground water, or surface water of the property" (ASTM E1527-00)

The ESA was only performed on the wetland project areas and not on the areas proposed for the other restoration measures due to the fact that these sites are subaquatic and the proposed treatments will not involve the removal of sediment.

The ESA for the four wetland sites was conducted by performing a site reconnaissance and records review. The site conditions (e.g. dense vegetation, deep mud and limited access due to private property and the nature of the sties) limited the reconnaissance that could be completed at the sites. However, the edges of the wetland were investigated as much as physically possible and the areas were viewed from adjacent sites of higher elevation, such as bridges and overpasses. Detailed notes and photographs were taken to corroborate any observations made.

Records were obtained from government and historical sources. Government records included searches of entities or conditions surrounding the property. Historical records were reviewed to determine all past uses on the property and any pertinent practices in the surrounding area that indicated a recognized environmental condition on the property.

2.0 SITE DESCRIPTION AND SURROUNDING PROPERTIES

2.1 Princess Anne Site

The Princess Anne site (PA) is “half moon” shaped, with a fringe marsh, and approximately 3.82 acres in size (Figure 1). The site is located northeast of Virginia Beach Town Center, in a highly developed area of the city. The regions south and west of the site are highly urbanized, consisting of large, multistoried buildings and impervious surfaces, such as parking lots and roadways. The areas situated to the north and east of the PA site are made up of residential neighborhoods of single family housing units.

The western edge of the PA site flanks Princess Anne High School and Thalia Lynn Baptist Church. A 50 to 100-foot wide forested buffer zone separates the marsh from the large parking lots, buildings, and recreational fields of the school and church. Thurston Branch runs along the eastern edge of the site. On the opposite shore across from the PA site, a single line of trees separates Thurston Branch from Thalia Elementary School. The school property is comprised of numerous buildings, a parking lot, and maintained lawn. A drainage channel separates the PA site from another fragment of salt marsh approximately 1 acre on the site’s southern edge.

2.2 Great Neck North Site

Great Neck North (GNN) is the largest wetland site included in the Lynnhaven Restoration Project, consisting of 19.98 acres of tidal marsh (Figure 2). The GNN site is a long, narrow salt meadow running north to south. It is approximately .33 miles in length, and varies between .05 and 0.16 miles in width. The northern edge of the GNN site is defined by a bridge allowing Route 264/ Virginia Beach Expressway to cross the channel which connects the marsh to Linkhorn Bay. Tidal flushing of the site is not restricted by the bridge. The southern limit of the site is established by Virginia Beach Boulevard. A Dominion Power right-of-way defines the entire western edge of the site. The upland beyond the right-of-way is made up of a narrow, forested border, and the buildings, lawns, and paved parking lots of the two apartment complexes and the self storage business that have been constructed adjacent to the site. The eastern side of the GNN site is developed with an apartment complex, a police academy, a trailer park, and a small number of single family houses. Most of the eastern edge has a narrow buffer zone separating the marsh from the developed upland. Beyond the buffer, the upland adjacent to the site is composed of maintained lawns, structures, and impervious surfaces.

2.3 Great Neck South Site

Great Neck South (GNS) site is connected to GNN via two, small culverts that run under Virginia Beach Boulevard (Figure 3). The culverts that link the sites restrict tidal flow between the two marshes. The GNS site is a large (13.68 acres), narrow salt meadow running from north to south. The site has similar dimensions as GNN, being about 0.32 miles in length and varying between 0.05 and 0.16 miles in width. The northern edge of the site is defined by Virginia Beach Boulevard and the southern edge is marked by a railroad trestle. The Dominion Power right-of-way present at the GNN site continues along the entire western edge of the GNS site. Beyond the right-of-way, the land adjacent to the western edge contains two large commercial properties, one of which is an auto salvage yard. This area consists of large parking lots, commercial buildings, wooded uplands, and a containment pool. The eastern edge of the GNS site contains two relatively large wooded areas, one being approximately 7.5 acres in size and the other being about 5.5 acres. Three commercial properties are also located in the eastern tract, including two self storage businesses. The area consists of wooded uplands, impervious surfaces, commercial buildings, maintained lawn, and about 1.5 acres of bare earth.

2.4 Mill Dam Creek Site

The wetland site with the smallest area is Mill Dam Creek (MDC) site, approximately 0.9 areas in size (Figure 4). The site is a long, narrow marsh running from north to south. The northern edge of the site is delineated by Mill Dam Road. The southern edge of the site consists of wooded uplands. Both the eastern and western edges of the site abut residential property. The area surrounding the site consists of wooded upland, manicured lawns, single family houses, and roadways. Culverts that run under Mill Dam Road connect the site to Mill Dam Creek, which eventually empties into Broad Bay.

3.0 RECORDS REVIEW

3.1 Physical Setting

3.1.1 Topography. The descriptions of each wetland site are presented in Section 9.2. and a topographic map of each wetland restoration site is included below. Each site is made up of salt marsh that is tidally influenced. Two sites, Great Neck South and Mill Dam Creek, have restricted tidal innundation due to roads have been constructed along the seaward edge of the site. The wetlands are connected to the Lynnhaven system by relatively small culverts that severely limit the movement of water into and out of marsh.

Figure 1: TOPOGRAPHY MAP OF THE PRINCESS ANNE WETLAND RESTORATION SITE

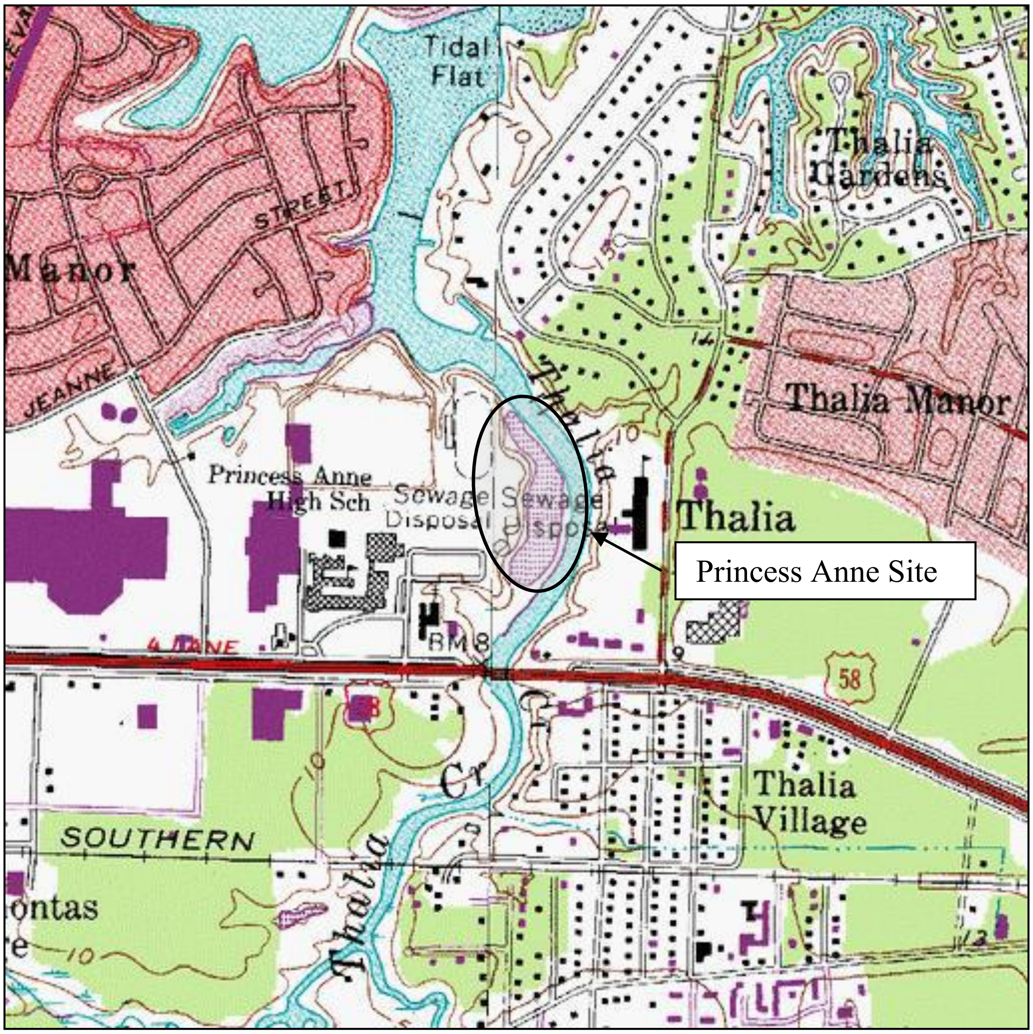
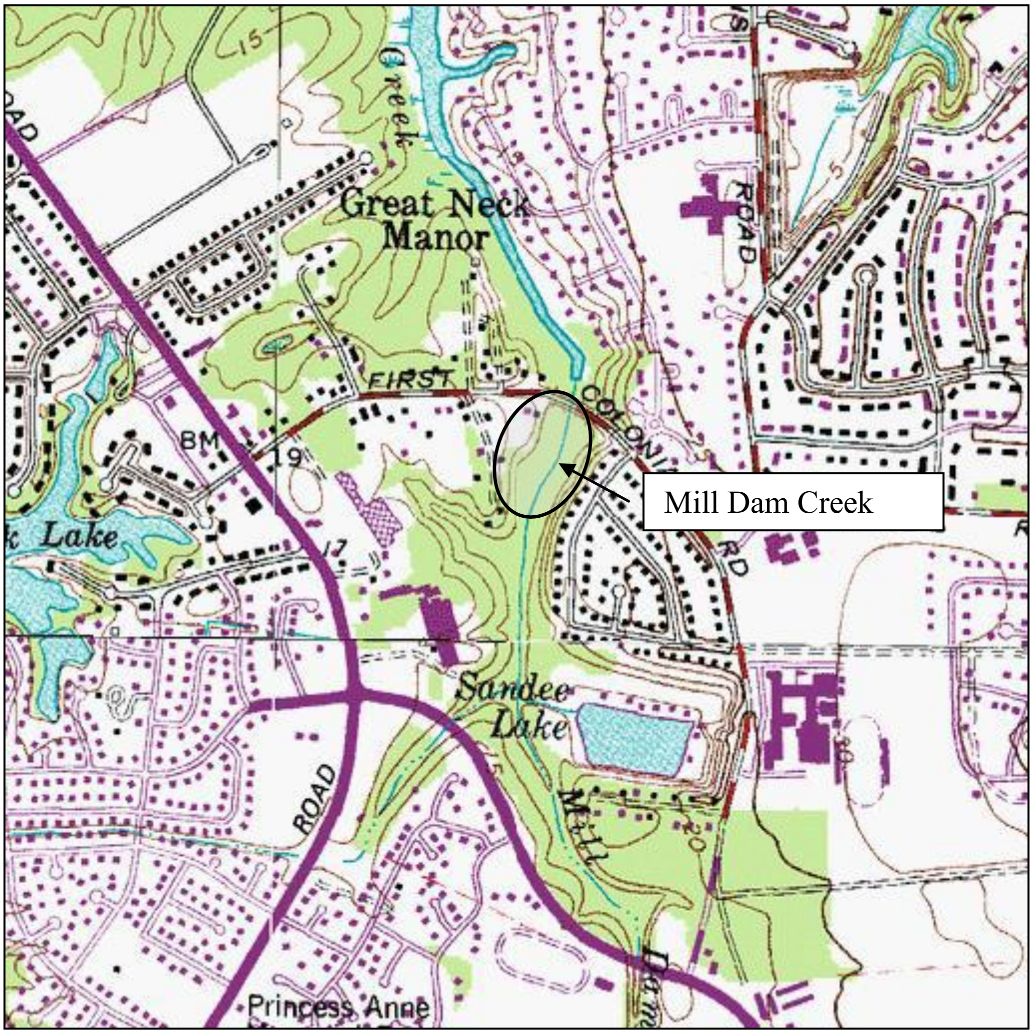


Figure 2: TOPOGRAPHY MAP OF THE GREAT NECK NORTH RESTORATION SITE AND THE GREAT NECK SOUTH DIVERSIFICATION SITE

Figure 3: TOPOGRAPHY MAP OF THE MILL DAM CREEK DIVERSIFICATION SITE



3.1.2 Geology and Soils. In geologic terms, the Chesapeake Bay is very young. During the latter part of the Pleistocene epoch, which began one million years ago, the area encompassing the Chesapeake Bay was alternately exposed and submerged as massive glaciers advanced and retreated up and down North America. This movement caused sea levels to rise and fall in response to glacial expansion and contraction. The region still experiences changes in sea level, which have been observed over the past century.

The most recent retreat of the glaciers, which began approximately 10,000 years ago, marked the end of the Pleistocene epoch and resulted in the birth of the Chesapeake Bay. The melting glacial ice caused an increase in sea level that submerged the coastal regions, including the ancient Susquehanna River Valley along with many of the river's tributaries. The resulting complex of drowned stream beds now forms the Chesapeake Bay and its tidal tributaries, which includes the Lynnhaven River (USEPA, 1989).

Soils in the Lynnhaven River basin are generally characterized as loams and sandy loams, which overlie deep deposits of unconsolidated stratified lenticular sand and silt, with some gravel and clay. The Virginia Beach area contains five major soil associations, as mapped by the Natural Resources Conservation Service of the U.S. Department of Agriculture (USDA). The Newhan-Duckston-Corolla association is found in the northern coastal areas along the Chesapeake Bay. This association is characterized by very permeable soils on nearly level to steep grass and shrub covered dunes, flats, and depressions with slopes ranging from 0 to 30 percent. The soils within this association range from excessively drained to poorly drained, with a sandy substratum. The State-Tetotum-Augusta association occurs in the northern part of the city, on nearly sloping to gently sloping areas on broad ridges and side slopes. The soils in this association are characterized as well-drained to somewhat poorly drained with loamy substrates. The Acredale-Tomotley-Nimmo association occurs mainly in the southern part of the city in broad, flat areas, with slopes ranging only from 0 to 2 percent. The soils of this association are characterized as poorly drained with a loamy substrate. The Dragston-Munden-Bojac association is found on narrow ridges and side slopes in various areas of the city. The soils in this association are characterized as nearly level, well to moderately well drained, with a loamy substrate. The last found within Virginia Beach is Udorthents-Urban. These soils are characterized as being formed through activities such as excavation and filling and are often covered by impervious surfaces, such as structures or roadways. They are nearly level to steep, well to moderately well drained soils with loamy substrates (USDA, 1985; Maguire Associates, 1993).

3.2 Environmental Records

3.2.1 Brownfields. There are no records of Brownfield grants or Brownfield properties in Virginia Beach currently listed by the USEPA.

3.2.2 National Priorities List. One site in Virginia Beach is listed on the National Priorities List (NPL). The Naval Amphibious Base Little Creek facility is located on Little Creek Cove, which is north of the Lynnhaven system. Seven sources of contamination were evaluated on the facility, including the Naval Amphibious Base Landfill, Driving Range Landfill, Sewage Treatment Plant Landfill, School of Music Plating Shop Contaminated Soil and Debris, School of Music Plating Shop Neutralization Tank, Exchange Laundry Waste Disposal Area, and the PCP Dip Tank and Wash Rack Area. Wastes that have been generated and disposed at the Little Creek facility include: pesticides, paints, solvents, inorganics, heavy metals, polychlorinated biphenyls, mixed municipal wastes, nickel plating baths, chromic acid, silver cyanide, copper cyanide, lacquer stripper, perchloroethylene sludge, dyes and degreasers. Contaminates migrating from the facility have impacted or might impact fisheries and sensitive environments located down gradient from the facility. The site was proposed for the NPL on July 28 1998 and the first cleanup actions were initiated in March of 1999. Due to its location, the contamination at this facility will have little to no impact on the Lynnhaven River system.

3.2.3 Comprehensive Environmental Response Compensation Liability Information System.

A search of the Comprehensive Environmental Response Compensation Liability Information System (CERCLIS) conducted May 15th, 2012 of Virginia Beach, Virginia resulted in 8 matches (Table 2). The sites which may impact the wetland restoration sites include Mount Trashmore and the USN Oceana Naval Air Station due to the fact that both sites are upstream of the Lynnhaven Project area; however it is unlikely due to the distance between the CERCLIS list sites and the restoration sites.

3.2.4 Toxic Substances Control Act. The Toxic Substances Control Act (TSCA) provides the Environmental Protection Agency (EPA) with the authority to require reporting, record-keeping, testing requirements and restrictions related to chemical substances and/or mixtures. TSCA addresses the production, importation, use and disposal of specific chemicals including polychlorinated biphenyls, asbestos, radon and lead-based paint. There are no facilities within Virginia Beach that are monitored by the USEPA under TSCA.

3.2.5 Toxic Release Inventory. The Toxic Release Inventory (TRI) contains information on more than 650 toxic chemicals that are used, manufactured, treated, transported or released into the environment. Two results were found in a search of the area surrounding the Lynnhaven River Basin. The first release was reported by the Navy Joint Expeditionary Base at Fort Story Firing Range. 25.1 pounds (lbs) of lead were released into the environment in 2010, with and additional 28.8 lbs of lead being recycled off-site. No discharges in to streams or bodies of water were reported by this facility between the years of 1987 and 2010. The second release was reported by Virginia Beach Marble. This facility released between 2800 and 7100 lbs of styrene into the air from 2001 through 2007.

3.2.6 Resource Conservation and Recovery Act. The Resource Conservation and Recovery Act Information (RCRAInfo), a national program management and inventory system about hazardous waste handlers, provides the public with hazardous waste information. In general, the Resource Conservation and Recovery Act (RCRA) requires that all generators, transporters, treaters, storers, and disposers of hazardous waste provide information about their activities to state environmental agencies. These agencies, in turn, pass on the information to regional and national EPA offices. 555 RCRA permitted facilities located in Virginia Beach. There are a smaller number of facilities immediately adjacent to each of the wetland sites. There are three facilities immediately adjacent to the Great Neck South site, four adjacent to the Great Neck North site, 14 near the Princess Anne site and seven near the Mill Dam Creek Site (Table 1).

Table 1: SITES LISTED BY RCRAINFO THAT ARE IMMEDIATELY ADJACENT TO THE WETLAND RESTORATION SITES.

Wetland Site Name	RCRA Facility	Generator Type
Great Neck South	FAST FARE INC T/A CROWN VA-529	Small Generator
	LEE PAPPAS BODY SHOP	Conditionally Exempt Small Generator
	SEA ATTACK AUTO AND TIRE CENTER	Conditionally Exempt Small Generator
Great Neck North	AMOCO #60086-TANKS	Small Generator
	FAST FARE INC T/A CROWN VA-529	Small Generator
	LEE PAPPAS BODY SHOP	Conditionally Exempt Small Generator
	SEA ATTACK AUTO AND TIRE CENTER	Conditionally Exempt Small Generator
Princess Anne	ALBANO CLEANERS INC	
	DOMINION CHRYSLER PLYMOUTH INC	Small Generator
	EXXON CO USA #26015	Conditionally Exempt Small Generator
	EXXON CO USA 27294	Conditionally Exempt Small Generator
	FOTEK CORP T/A THE FILM FACTORY	Small Generator
	KMART #3801	Small Generator
	PEARLE EXPRESS	Conditionally Exempt Small Generator
	PRINCESS ANNE HIGH	Conditionally Exempt Small Generator, Transporter
	SEARS ROEBUCK & CO	Conditionally Exempt Small Generator
	SHELL OIL CO	Small Generator
	SHERWIN-WILLIAMS CO THE	No Designation Given
	PEMBROKE W SHOPS	No Designation Given
	TIRE KINGDOM INC. # 416	Conditionally Exempt Small Generator
	VIRGINIA INHALATION THERPY SV	No Designation Given
Mill Dam Creek	AMOCO #60180-TANKS	Small Generator
	ENGINUITY	Small Generator
	EXXON CO U S A RA527766	Small Generator
	EXXON CO USA #27766	Small Generator
	FIRST COLONIAL HIGH	Conditionally Exempt Small Generator, Transporter
	STAR ENTERPRISE	No Designation Given
	TEXACO STATION-TANKS	Small Generator

3.2.7 Resource Compensation Recovery Act Corrective Action Facilities. The EPA website lists two facilities in Virginia Beach as a RCRA corrective action facility. The first is Controls Corporation of America (CONCOA). The EPA issued its Final Decision regarding the facility on June 16, 2009 stating that Corrective Action was "Completed without Controls". The second is the Naval Air Station Oceana. The site was first listed in August 30, 1988 and was not identified for corrective action.

3.2.8 Hazardous Waste Report (Biennial Report). The Hazardous Waste Report (Biennial Report) contains data on the generation, management, and minimization of hazardous waste from large quantity generators and data on waste management practices from treatment, storage, and disposal facilities. Data about hazardous waste activities is reported for odd number years (beginning with 1989) to EPA. In 2009, the most recent data available, there are four facilities in Virginia Beach which required to provided data to the Biennial Report. None of the sites are adjacent to the four wetland sites.

3.2.9 State Superfund. Three sites located in Virginia Beach are state listed Superfund sites. This includes the Oceana Naval Air Station, the Naval Amphibious Base, and Oceana Salvage. The Oceana Naval Air Station contains an open pit where 110,000 gallons of waste oil and fuels were disposed between the mid-1950's and the early 1960's. The site also contains a building where waste solvents and oils were poured into a waste oil tank for disposal and soil around the tank was contaminated. Hazardous substances of concern that were detected at the site include hydraulic fluid, chlorinated and aromatic hydrocarbons, jet fuel, solvents, asbestos, waste oil, PCBs, pesticides, VOCs, agitine and free phase diesel fuel. The Little Creek Naval Amphibious Base is included on the National Priorities List and is described in a previous section of this document. Investigation of the Oceana Salvage property in 1997 found surface soils contaminated with lead, PDBs, PAHs and petroleum products.

3.2.10 Permit Compliance System and Integrated Compliance Information System. PCS/ICIS lists 14 facilities that currently hold National Pollutant Discharge Elimination System (NPDES) permits water discharge permits issued within Virginia Beach. Three of which are considered major dischargers. Five facilities are located in the area surrounding the Lynnhaven River Basin. The facilities which have been issued the permits are the Air Nation Guard, Coastal Walk Condominiums, HRSD Chesapeake-Elizabeth Waste Water Treatment Plant, US Navy Air Station Oceana Base and the US Navy Little Creek Amphibious Base.

4.0 FINDINGS AND OPINIONS

4.1 Contaminant release mechanisms

The only project measure which may result in negative environmental impacts due to HRTW is the restoration of the wetland sites. The construction of the reef habitat, planting of submerged aquatic vegetation, and stocking of bay scallops are not be expected to result in the generation and/or disturbance of hazardous materials or solid waste. Habitat restoration of the wetland sites will involve the physical alteration of four sites.

Of the four wetlands restoration sites, Princess Anne and Great Neck North, will involve the excavation and removal of approximately 2 to 4 ft of the upper peat layer. The material will be excavated in order to remove as much invasive vegetation, including rhizomes, roots and foliage, as possible to prevent recolonization. The site will then be grated to the elevation optimal for the growth of *Spartina alterniflora,* a native salt marsh grass that inhabits the lower marsh. Materials generated from sediment excavation activities at the wetland restoration sites will be evaluated as a solid waste in accordance with HTRW guidance as appropriate prior to disposal at a landfill facility.

The ecological function will be improved at the diversification sites, Great Neck South and Mill Dam Creek, through the habitat "diversification." Habitat features, including islands, channels, and pools, will be constructed to break up the homogeneous *P. australis* stands. Small drainage dikes will be widened into creeks to extend the range of tidal inundation. Shallow, open pools or "scraps" will be created by excavating the top layer of material. The material excavated from the tidal creeks and pools will be used to build upland mounds that will be planted with native shrubs or grasses.

4.2 Exposure Routes

If contaminants are present in the sediment of the salt marsh sites, routes of exposure for those contaminates would include direct contact with the contaminated soils, contact with dissolved contaminants if soil is released into the water column or through breathing in contaminates evaporating into the air once the compounds are exposed.

4.3 Potentially Exposed Populations

The populations that could be at risk of exposed would depend on the route the material is released into the environment. The population at risk of direct exposure would include the workers who are doing the restoration work and members of the general public who are using the wetland sites while construction is taking place. People living adjacent to the site and construction workers on-site would be at risk of inhalation of airborne contaminants. Members of the public who come in direct contact with water of the Lynnhaven River system would be exposed to chemicals released into the water column. In addition, flora and fauna in the Lynnhaven River system would be exposed to the dissolved contaminants. Once incorporated into the organisms in the system, fishermen and other people who ingest those organisms would be exposed to the contaminants.

4.4 Contamination from Surrounding Properties

The investigation into the existing records of the area surrounding the proposed project sites revealed a low probability that the areas contain a recognized environmental condition due to contamination of the surrounding area. The predominant land use surrounding the Lynnhaven River Basin is suburban residential, with a limited amount of commercial development located in the area. There is a single site, the Naval Amphibious Base Little Creek, in Virginia Beach which is included on the National Priorities List of the Superfund Program; however this site is not located within the project area. At the writing of this report, there is no know hazardous, toxic, or radioactive waste (HTRW) issues that occur within the boundaries of the project area which would halt the feasibility phase of this project.

Table 2: THE RESULTS OF A SEARCH OF THE COMPREHENSIVE ENVIRONMENTAL RESPONSE COMPENSATION LIABILIT INFORMATION SYSTEM (CERCLIS) CONDUCTED MAY 15TH, 2012 FOR VIRGINIA BEACH, VIRGINIA

Search Criteria:
County: *VIRGINIA BEACH*
State(s): *Virginia*

Found **8** site(s) that match above search criteria:

EPA ID	Site Name	City	Non-NPL Status Code	Non-NPL Status Date	NPL Status Code
VA6210020875	FORT STORY	VIRGINIA BEACH	Other Cleanup Activity: Federal Facility-Lead Cleanup	9/27/2004	N
VAD981739238	LYNN HAVEN BAY SITE	LYNN HAVEN SHORES	NFRAP-Site does not qualify for the NPL based on existing information	10/22/1992	N
VAD988196739	MT. TRASHMORE	VIRGINIA BEACH	Other Cleanup Activity: State-Lead Cleanup	4/10/2002	N
VA5170022482	NAVAL AMPHIBIOUS BASE LITTLE CREEK	VIRGINIA BEACH	[Blank Code]	[Blank Date]	F
VAN000306180	OCEANA SALVAGE	VIRGINIA BEACH	Removal Only Site (No Site Assessment Work Needed)	1/30/2006	N
VA1170090012	USN CAMP PENDLETON	VIRGINIA BEACH	Other Cleanup Activity: Federal Facility-Lead Cleanup	9/27/2004	N
VA5170022938	USN FLEET COMBAT TRAINING CENTER	VIRGINIA BEACH	Other Cleanup Activity: Federal Facility-Lead Cleanup	9/27/2004	N
VA2170024606	USN NAVAL AIR STN OCEANA	VIRGINIA BEACH	Fed Fac Preliminary Assessment Review Start Needed	10/4/2000	N

APPENDIX D

CULTURAL RESOURCES

CULTURAL RESOURCES

The following description of Native American culture in the Virginia Beach area is taken from the following report " *Phase I Archaeological Survey of Twelve Acres and Phase II Archaeological Significance Evaluation of 44VB240, 44VB241, and 44VB242 at the Great Neck Point Disposal Area, City of Virginia Beach"* (McDonald and Laird, 1996).

The earliest inhabitants of southeastern Virginia were Native Americans, who were present in the area before 8000 B.C. The oldest cultural remains found in the area are from the Paleo-Indian period, which is the time period before 8000 B.C. The most common site of this type found in Virginia is the isolated projectile point, and in southeastern Virginia these sites are most commonly found in locations associated with the Dismal Swamp and its western border. However, several of these sites have been found in the Lynnhaven watershed, specifically in the Great Neck area, at First Landing State Park, and at the former Bayville Farm property.

Archaeological sites from the Archaic time period, which extends from approximately 8000-1200 B.C., are more common than those from the Paleo-Indian period. By this time, the Indians were making use of a greater variety of plants and habitats. The population density increased across Virginia, including the Coastal Plain. Within southeastern Virginia the large base camps that existed on the edges of the Dismal Swamp were being abandoned seasonally as the large groups split into smaller camps and moved into estuarine areas. Typical sites of this era that have been found in Virginia Beach include various camp sites and quarry sites for extracting quartz and quartzite.

The vast majority of the prehistoric sites in the Lynnhaven area date to the Woodland period (1200 B.C.-1607). This period is characterized by a more sedentary lifestyle increasingly dependent on agriculture and a more complex social organization. There is more focus on riverine and estuarine settings and subsistence resources and an increase in material culture, especially ceramics. Several significant sites found in the watershed that date to the Early and Middle Woodland period are estuarine-oriented base camps that were occupied most of the year. These sites contained ceramics and shellfish remains, and one site contained human remains. By the Late Woodland period, Native Americans were cultivating maize in addition to the major use of marine and river resources. Other food items being consumed were native berries, nuts, fish, shellfish, birds, bird eggs, deer, and small mammals. By 1500, Native Americans in this region had established permanent villages for agriculture.

By 1600, the Indian society in the Coastal Plain had evolved into a chiefdom society with Powhatan as the top chief of about 31 tribes. During the 1500s, the area occupied today by the cities of Norfolk, Virginia Beach, Chesapeake, and Portsmouth was occupied by the Chesapeake Indian tribe. Maps of the late 1500s show possible Chesapeake Indian villages in the Virginia Beach region. The village named "Apasus" appears on the western side of the Western Branch of the Lynnhaven River on a 1590 map attributed to Theodor de Bry (McSherry, 1993). By the time the English colonists arrived in 1607, the Chesapeake tribe in southeastern Virginia had been eliminated by Powhatan and the area resettled by the Nansemonds, who were also a part of the Powhatan confederacy (McDonald et al., 1996). John Smith's early explorations in the Virginia Beach area in 1608 did not result in his encountering any Indian settlements. (Frazier Asso.,) In 1609, English colonists went 6 to 7 miles up the Lynnhaven or Elizabeth River and found a few Indian houses but no inhabitants (McDonald and Laird, 1996).

Virginia Beach's recorded history generally begins in 1607 with the landing at Cape Henry by the English settlers who eventually established the first permanent colony at Jamestown. Although the first colonists settled inland away from the coast, by 1635 settlers had started to move into the Hampton Roads area, settling along the Elizabeth, Lynnhaven, and North Landing Rivers and the north-south ridges of arable land (Frazier Asso., 1992). The initial settlement of the Lynnhaven took place along the branches and coves of the river since the water was the main source of transportation, trade, and communication. Many of the early land patents noted the sites of former Indian settlement on the patent, and these early colonial settlements tended to be in areas that had been previously cleared by the Indians (McDonald and Laird, 1996).

One of the earliest settlements in the area took place on the 5,350 acres of land Adam Thoroughgood owned at the mouth of the Western Branch of the Lynnhaven River. An Episcopal Church was established here in 1640, and the settlement became a small commercial center for the surrounding countryside throughout the century. Thoroughgood was instrumental in establishing the boundaries for this Episcopal parish, and these boundaries later became the boundaries for Princess Anne County, which would ultimately make up most of the city of Virginia Beach. The first county courthouse was built in this area along the river at the site of a ferry landing. In 1691, it became the county seat for Princess Anne County and the business and social center of the county. When the courthouse was relocated in 1751 to the Newtown community, which is located southwest of the Lynnhaven area, the Lynnhaven community lost much of the activity associated with being the county seat (Frazier Asso., 1992).

In general, Princess Anne County, which had been agricultural from its origins, remained primarily agricultural through the 18^{th} and 19^{th} centuries. By 1750, agriculture had become more diversified in response to the soil depletion from extensive tobacco farming. The farming of grains, especially corn, became more prevalent. After the Revolutionary War, the county's population declined for several decades as residents began migrating west to the Piedmont areas of Virginia and North Carolina in search of more economic and social opportunities (McDonald et al., 1996). Those farmers who remained tended to be small planters or tenant farmers rather than plantation owners although there were still some such as Thomas Walke III, who built Upper Wolfsnare on the Lynnhaven River in 1759 and owned 7,000 acres. By the mid-1800s farmers began to truck farm, and logging of pine and cypress was taking place (Goode and Dutton, 1999).

Neither the Revolutionary or Civil Wars affected Princess Anne County the way they did other parts of the state that were the sites of major battles. Lord Dunmore came through the county just before the Revolutionary War to collect arms, ammunition, and supplies, but no other significant action took place during the war itself. During the Civil War, the Federal army took control of the county in 1862 and maintained without major incident throughout the war (Goode and Dutton).

The original town of Virginia Beach began as a small settlement near the Seatack Life Station, which is located near the Oceanfront. Toward the end of the 19^{th} century, the town began to grow quickly as hotels and vacation cottages were constructed. By 1906, Virginia

Beach had become an incorporated town, and in 1923, it annexed a small part of the county. In 1963, Princess Anne County and the town of Virginia Beach merged to become the city of Virginia Beach with its current boundaries (Frazier Asso., 1992).

The following table lists the historical resource sites that have been recorded in the vicinity of the potential restoration sites. This table includes cultural resource sites near two restoration sites that were not included in the tentatively selected plan (Narrows to Rainey Gut and Fish House Island).

CULTURAL RESOURCES SITES NEAR POTENTIAL RESTORATION SITES

Potential Restoration Site	VDHR Site #	Description	NHRP Recommendation	Distance to Restoration Site(ft.)(approx.)
Milldam Creek	134-0049	18th c. house	None	2,300
Milldam Creek	44VB0059	18th c. dwelling, site totally destroyed	None	2,300
Milldam Creek	44VB0102	19th c., map projection	None	2,500
Narrows to Rainey Gut	134-0099	Seashore State Park Historic District	Listed	adjacent
Narrows to Rainey Gut	44VB0040	Woodland camp	None	265
Narrows to Rainey Gut	44VB0041	Woodland shells, prehistoric pottery	None	525
Narrows to Rainey Gut	44VB0096	19th c., map projection	None	2,285
Narrows to Rainey Gut	44VB0100	19th c., map projection	None	880
Narrows to Rainey Gut	44VB0359	Mixed prehistoric (lithic scatter) & 19th-20th c. pieces of glassware, ceramics, brick:site heavily destroyed	None	950
North Great Neck	134-0123	1936 house	Not eligible	2,500
North Great Neck	134-0124	1935 house	None	2,000
North Great Neck	134-0132	house, no date given	None	1,100
North Great Neck	134-0135	house, no date given	None	1,100
North Great Neck	134-0137	1930 house	None	2,400
North Great Neck	134-0138	1900 house	None	1,300
North Great Neck	134-0164	1900 house	None	650
North Great Neck	134-0165	1900 house	None	1,100
North Great Neck	134-0567	1920 church	None	1,365
North Great Neck	134-0941	1940 house	Not eligible	2,500
North Great Neck	134-0943	1940 house	Not eligible	1,800
North Great Neck	134-5017	1940 house	None	2,200
North Great Neck	134-5020	1940 house	None	1,800
North Great Neck	134-5058	1943 house	Not eligible	1,300

North Great Neck	134-5059	1935 house	Not eligible	2,000
North Great Neck	134-5060	1945 house	Not eligible	2,100
North Great Neck	134-5061	1940 house	Not eligible	1,600
North Great Neck	134-5062	1945 house	Not eligible	1,600
North Great Neck	134-5064	1940 house	Not eligible	1,800
North Great Neck	134-5065	1950 house	Not eligible	1,500
North Great Neck	134-5067	1945 house	Not eligible	1,100
North Great Neck	134-5068	1950 house	Not eligible	1,600
North Great Neck	134-5069	1950 house	Not eligible	1,700
North Great Neck	134-5071	1945 house	Not eligible	1,900
North Great Neck	134-5072	1940 house	Not eligible	1,700
North Great Neck	134-5073	1940 house	Not eligible	1,700
North Great Neck	134-5076	1945 house	Not eligible	1945
North Great Neck	134-5077	1950 house	Not eligible	1,300
North Great Neck	134-5078	1940 house	Not eligible	1,600
North Great Neck	134-5145	Norfolk and Virginia Beach Railroad	Eligible	1,600
Princess Anne H. S.	134-0605	1930 Tidewater Tuberculosis Hospital	None	800
Princess Anne H. S.	134-5145	Norfolk and Virginia Beach Railroad	Eligible	1,900
South Great Neck	134-0124	1935 house	None	1,300
South Great Neck	134-0135	house, no date given	None	2,300
South Great Neck	134-0138	1900 house	None	600
South Great Neck	134-0140	house, no date given	None	1,400
South Great Neck	134-0163	1900 house	None	625
South Great Neck	134-0164	1900 house	None	600
South Great Neck	134-0165	1900 house	None	600
South Great Neck	134-0567	1920 church	None	1,700
South Great Neck	134-0937	1940 house	Not eligible	1,600
South Great Neck	134-0938	1920 house	Not eligible	1,500
South Great Neck	134-0939	1940 house	Not eligible	1,300
South Great Neck	134-0940	1940 house	Not eligible	1,400
South Great Neck	134-0941	1940 house	Not eligible	900
South Great Neck	134-0943	1940 house	Not eligible	700
South Great Neck	134-5015	1930 house	None	500
South Great Neck	134-5016	1930 house	None	500

South Great Neck	134-5017	1940 house	None	1,700
South Great Neck	134-5018	1940 house	None	1,600
South Great Neck	134-5019	1940 house	None	700
South Great Neck	134-5020	1940 house	None	1,700
South Great Neck	134-5059	1935 house	Not eligible	1,500
South Great Neck	134-5060	1945 house	Not eligible	1,100
South Great Neck	134-5061	1945 house	Not eligible	1,100
South Great Neck	134-5062	1940 house	Not eligible	1,200
South Great Neck	134-5063	1945 house	Not eligible	1,200
South Great Neck	134-5064	1950 house	Not eligible	1,200
South Great Neck	134-5065	1950 house	Not eligible	900
South Great Neck	134-5067	1945 house	Not eligible	700
South Great Neck	134-5068	1950 house	Not eligible	1,500
South Great Neck	134-5069	1950 house	Not eligible	1,500
South Great Neck	134-5071	1945 house	Not eligible	1,600
South Great Neck	134-5072	1940 house	Not eligible	1,700
South Great Neck	134-5073	1940 house	Not eligible	1,900
South Great Neck	134-5076	1945 house	Not eligible	1,600
South Great Neck	134-5145	Norfolk and Virginia Beach Railroad	Eligible	adjacent
Fish House Island	134-5167	1927 restaurant	Not eligible	350
Fish House Island	134-5168	1945 house	Not eligible	1,300
Fish House Island	134-5171	1958 bridge	Not eligible	650
EFH 1	44VB0077	Woodland site with bifaces, points, flakes, pottery	Eligible	600
EFH 2	44VB0080	Woodland ceramics, flakes, and bifaces	None	2,500
EFH 4	134-0081	1920 house	None	500

Source: Virginia Department of Historic Resources

APPENDIX E

REAL ESTATE PLAN

Lynnhaven River Basin Ecosystem Restoration Project, Virginia Beach, Virginia

UNITED STATES ARMY CORPS OF ENGINEERS
NORFOLK DISTRICT
LYNNHAVEN RIVER BASIN ECOSYSTEM RESTORATION STUDY
REAL ESTATE PLAN

TABLE OF CONTENTS

PARAGRAPH TITLE PAGE

EXHIBITS

NORFOLK DISTRICT, CORPS OF ENGINEERS, LYNNHAVEN RIVER BASIN ECOSYSTEM RESTORATION STUDY REAL ESTATE PLAN

1.0 AUTHORIZATION

The Lynnhaven River Basin Ecosystem Restoration Study ("Project") is authorized by Resolution of the Committee on Transportation and Infrastructure of the U.S. House of Representatives, Docket 2558, adopted May 6, 1998. The authorization states:

> *Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives that the Secretary of the Army is requested to review the report of the Chief of Engineers on the Lynnhaven Inlet, Bay and connecting waters, Virginia, published as House Document 580, 80th Congress, 2nd Session, and other pertinent reports, to determine whether any modifications of the recommendations contained therein are advisable at the present time in the interest of environmental restoration and protection and other related water resources purposes for the Lynnhaven River Basin, Virginia.*

2.0 PURPOSE

This Real Estate Plan is for planning purposes and supports the Lynnhaven River Basin Ecosystem Restoration Study for the Lynnhaven River in Virginia Beach, Virginia. The figures in this report are subject to changes as the project is refined during the next phase of Pre-Construction Engineering and Design.

3.0 LOCATION

The study area is located wholly within the boundaries of the City of Virginia Beach, Virginia. The City of Virginia Beach is located in Southeastern Virginia, approximately 100 miles from the state capital in Richmond, Virginia. The Lynnhaven River Basin is a 64-square mile tidal estuary in the lower Chesapeake Bay Watershed.

4.0 BACKGROUND AND PROJECT DESCRIPTION

The Restoration Measures of the Tentatively Selected Recommended Plan are made up of four types of restorations. They are: (1) Sub-aquatic Vegetation (SAV) Restoration, (2) Bay Scallop Restoration, (3) Reef Habitat Creation, and (4) Wetlands Restoration. The general locations of these restoration sites are shown in Exhibit "A." The SAV, Bay Scallop Restoration, and Reef Habitat Projects will be constructed on river bottoms owned and managed by the Commonwealth of Virginia ("Commonwealth"). The Non-Federal Sponsor (NFS) for this Project is the City of Virginia Beach, Virginia. The NFS will obtain any required permits, including a permit for work on state-owned river bottoms from the Virginia Marine Resources Commission (the "Commission" or "VMRC"). The Norfolk District Project Manager (PM) for this Project has confirmed that the VMRC permit is appropriate and will apply to the Project activities. Some of the identified parcels for SAV, scallop, and reef habitat are currently leased by the Commonwealth of Virginia for the purposes of oyster harvesting.

Description of the Project

Submerged Aquatic Vegetation (SAV). Sites will be located in Broad Bay (approximately 44.3 acres) and the Lynnhaven Mainstem (approximately 41.3 acres). The sites will be planted with SAV seeds from small boats. Seeds may also be planted using divers or mechanical planters operated from a small boat. Monitoring will be done to determine the full extent of the SAV beds. The SAV will also be adaptively managed and re-seeded if necessary.

Reintroduction of Bay Scallops. The sites selected for reintroduction of the bay scallop are located within the SAV restoration sites (approximately 22 acres). The SAV beds would be restored first, as bay scallops are known to prefer it to other substrates. Two main techniques are used in restoring bay scallops, direct stocking and cages on the river bottom.

Reef Habitat. The proposed sites will be located in the Lynnhaven Mainstem and the Broad Bay/Linkhorn complex. The sites in the Lynnhaven total approximately 8.345 acres. The sites in the Broad Bay/Linkhorn complex total approximately 15.99 acres. One site in Broad Bay has some soft bottom that would first require the placement of rock filled mats on the bottom with the reef balls being placed on top to prevent subsidence. This site is approximately ten acres in size.

Wetland Restoration/Diversification. Four sites within the Lynnhaven River Basin have been identified for restoration or diversification of wetlands in the Lynnhaven Restoration Project. Two sites, the Princess Anne (3.82 acres) and the Great Neck North Sites (19.89), are selected for restoration of the indigenous salt marsh community and reduction of the population of invasive plant species. Habitat restoration will involve both physical alteration of the site and herbicide application. Features, such as shallow pools, upland islands, and channels will be created to increase the diversity of the marsh habitat and to allow seawater to flood the area.

Ecological function at two other sites, Mill Dam Creek (0.95 acres) and Great Neck South (13.71 acres) sites, will be established by increasing habitat diversity. Ecological function will be increased through the construction of habitat features, including islands, channels, and pools. Small drainage dikes will be widened into creeks to extend the range of tidal inundation. Shallow, open pools or "scraps" will be created by excavating the top layer of material.

There are a total of 41 river bottom sites and 28 wetlands sites for a total of 69 sites needed for this project. The local sponsor will acquire the sites through donation, negotiation, and, as a last resort, condemnation.

Operations and Maintenance

Operations and maintenance (O&M) requirements for the wetland sites include annual inspections of the areas for a period of fifty years to ensure native plant growth and no encroachment of invasive plant species. The inspection would determine if additional sprig plants or the application of herbicides is necessary to restore the required wetland function. An assessment of the rock structures for displacement from wave action and/or settlement due to long term consolidation of the subgrade should also be included in the inspection. Annual inspections of the areas restored with Sub-aquatic Vegetation (SAV) Restoration, Reef Habitat Restoration, and Bay Scallop Restoration are also required for a period of fifty years.

After the initial 10 year's the USACE will close out the project and all monitoring (including the fish reefs, wetlands, SAV and scallops) will be the responsibility of the NFS, Virginia Beach. Protective measures may also be required of the NFS in conjunction with the U.S. Coast Guard (USCG) and the Commonwealth. Such adaptive management actions could include signage requiring "no wake" zones over restored SAV beds to reduce prop damage within the bed, or possibly marking the SAV beds "off limits" to boat traffic, at least those located in shallow (> 3ft MLW) waters. This will be considered if prop damage to established SAV beds is observed. Enforcement of these measures will be the responsibility of the NFS, the USCG, and/or the state.

5.0 PROJECT LANDS, EASEMENTS, RIGHTS-OF-WAY, RELOCATIONS AND DISPOSAL AREAS (LERRD)

5.01 Sub-aquatic Vegetation (SAV) Restoration and Bay Scallop Restoration Projects and, Reef Habitat

a. These components will be constructed on state-owned river bottoms. The NFS, in coordination with NAO Planning and Policy, will obtain any necessary environmental or construction permits, including, if needed, a VMRC permit.

b. The standard estate required for environmental restoration projects is fee. Pursuant to section 28.2-1200.1 of the VA Code, the Commonwealth shall not convey fee simple title to state-owned bottomlands covered by waters, but the Commonwealth may grant a lease, easement, or other limited interest in state-owned bottomlands covered by waters as long as the property is used by a governmental entity for the performance of a governmental activity. Thus, the standard estate, fee, required by regulation for environmental restoration projects, is not available for the SAV, reef habitat and scallop restoration. The NFS will acquire from the Commonwealth of Virginia a non-standard perpetual easement over the river bottom required for the project. Exhibit D is a map that shows the location of the proposed sites for the SAV, reef habitat and scallop restorations. There are a total of approximately 109.968 acres comprised of 41 different parcels. These 41 parcels are currently leased by third parties. Exhibit E is a list of the 41 parcels, showing the acreage of each parcel, for a total of 109.968 acres. The NFS will acquire these parcels and will obtain four easements in perpetuity from the Commonwealth for river bottom parcels that are a part of the Project.

c. The proposed sites for SAV, scallop and reef habitat are currently leased for oyster harvesting. The NFS will acquire or terminate these leases by donation, negotiation or, as a last resort, condemnation.

d. No Temporary Work Area Easements are anticipated to be required for these activities as all construction and access will take place from work boats in public access waterways.

5.02 Wetlands Restoration Project

a. The Wetlands Restoration will be constructed on 38.4 acres of land owned by the NFS and by private property owners. Exhibit B shows the 28 sites that are proposed for the Wetlands Restoration and whether the site is owned by the NFS or by private owners. For sites owned by private parties, the NFS will acquire by donation, negotiation/purchase or condemnation. The NFS, in coordination with the Norfolk District Planning and Policy Section, will obtain any necessary environmental and construction permits.

b. The standard estate required for environmental restoration projects is fee. However, it is proposed that the NFS will obtain a non-standard wetlands easement in perpetuity over the wetlands restoration sites identified in Exhibit B for the Wetlands Restoration Project in order to provide perpetual protection of the Project on the property as shown on the map at Exhibit C. This non-standard estate is recommended because it will grant the same protection that could be obtained for the project through a fee estate; namely, protection in perpetuity for the functions and values of the Project. The use of a non-standard wetlands easement would provide required protection while allowing the property owners to continue ownership and use of the property for activities that would have no impact on the Project. Acquisition of a fee simple interest would add no significant value to the Project, would add more acquisition expense to the Project, would eliminate the value of having owners provide long-term stewardship of the Project, may create unnecessary obligations or added expenses for the NFS, may create a burden and detriment to the current owners, and may create a disincentive to owners to participate in the Project. In sum, there is no appreciable gain to the Project from a fee interest as opposed to a non-standard wetlands easement in perpetuity, yet there are numerous detriments. A non-standard wetlands easement can be development to protect every element, function and value that is needed for the Project. The gross appraisal indicates that the use of the wetland easement estate would allow the sites to continue to support the parent tract as open space and for passive recreational activities. The Project cost for fee is estimated to be approximately four times the easement values. The appraiser justified the use of the 25% as follows:

"Impact to the underlying fee land is minimal as the proposed subject easement areas are in the flood hazard zone and CBPA areas. A weight of 25% is therefore applied on the unit of estimated wetland fee value of $6,700 per acre for an indication of subject perpetual easement value of $1,675 per acre (25% of $6,700/acre)."

The Estate used for the appraisal is as follows:

WETLAND EASEMENT: A perpetual and assignable right and easement to construct, operate, and maintain wetland restoration improvement works on, over and across (the land described in Schedule A) (Tracts Nos. , and) for the purposes as authorized by the Act of

Congress approved, including the right to clear, cut, fell, remove, excavate, and dispose of any and all timber, trees, underbrush, buildings, improvements and/or other obstructions there from; plant phragmites, eradication of phragmites; place stone riprap and/or low sill breakwaters to excavate, dig, anchor, dredge, cut away, and remove any or all of said land and to place thereon dredged material, ''Bay'' and/or ''Goliath'' and/or ''Ultra'' reef balls, right of ingress/egress for annual inspections and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

c. Temporary Work Area Easements, using the standard estate, will be obtained for construction, laydown and staging of construction materials and equipment needed to develop the wetland areas, and for access during construction. These interests will be acquired by donation, negotiation, or condemnation.

Project acreages and Estates

Project Activity	Acreage – approximate	Real Estate LERRD
SAV	Lynnhaven Mainstem and Broad Bay (85.6)	Easements in perpetuity (State-owned river bottoms)
Bay Scallops	Included with SAV sites (22)	Easements in perpetuity (State-owned river bottoms)
Reef Habitat	Lynnhaven Mainstem and Broad Bay (24.3)	Easements in perpetuity (State-owned river bottoms)
Wetlands Restoration	Princess Dam (3.82) Great Neck North (19.9) Mill Dam Creek (0.95) Great Neck South (13.7)	Wetlands Easements in perpetuity; Temporary Work Area Easements

Note: The 22 acres of Bay Scallops are being placed within the SAV sites and are included the 109.9 acres of SAV and Reef Habitat easement acreage (85.6 +24.3). The total Wetlands acreage is rounded to 38.4 acres.

5.03 Non-Standard Estates Proposed For This Project

a. **Easements for SAV, Scallops and Reef Habitat**. Easements in perpetuity will be obtained by the NFS to protect the SAV, scallops and reef habitat restoration. Approval of the form of these easements will be sought later after locations and acreages are finalized in the design phase. This non-standard estate, an easement in perpetuity, will be sufficient to meet the needs of the Project in that the easements will provide all necessary measures and restrictions to protect and preserve the Project in perpetuity. The purpose of the easements is to preserve and protect the ecologic and conservation values of the Project by imposing restrictions and providing for enforcement. The conservation values of the Project are to restore the functions and values of SAV, scallops and reef habitat.

b. **Wetlands Easement**. The wetlands easement in perpetuity needed for the Wetlands Restoration Project will be obtained by the NFS to protect the Wetlands Restoration. Approval of the form of this wetlands easement will be sought later after locations and acreages are finalized in the design phase. This non-standard estate, a wetlands easement in perpetuity, will be sufficient to meet the needs of the Project in that it will provide all necessary measures and restrictions to protect and preserve the Project in perpetuity. The purpose of the wetlands easement is to preserve and protect the conservation values of the Project in perpetuity by imposing restrictions on the use of the Property and providing for enforcement. The conservation values of the Project are to restore the functions and values of the wetlands. A request for approval of the non-standard estate is to be submitted to HQUSACE for review and approval in June 2013.

5.04 Standard Estates to Be Used For This Project

Access and Temporary Work Area Easements

Location. Locations of Temporary Work Area Easements will be determined during the design phase of the Project. These easements will also provide needed access and is temporary to cover the period of construction. Access is not needed after the Wetlands Restoration is constructed because the wetlands easement will allow for required access.

Temporary Work Area Easement: Temporary easement and right-of-way in, on, over and across (the land described in Schedule A) for a period not to exceed three years, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a work area, including the right of access and the right to move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the Lynnhaven River Basin Ecosystem Restoration Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

6.0 MAPPING

Mapping is included in Exhibits A, C, and D. Exhibit A is a Project Map of the proposed Lynnhaven River Ecosystem Restoration Sites, Virginia Beach, VA. Exhibit C is a map of the proposed Wetland Restoration Sites, Virginia Beach, VA. Exhibit D is a map showing the proposed sites for the SAV/Scallop Restorations and Reef Habitat. During the next phase of the Project, maps will be updated if necessary if any changes were made to the proposed sites.

7.0 FEDERAL AND NON-FEDERAL SPONSOR PROJECT LAND OWNERSHIPS

7.1 FEDERALLY OWNED LAND and FEDERAL PROJECTS

There are no federally owned lands within the Project area. There are three federally authorized projects in the Lynnhaven watershed, the Lynnhaven Inlet project, Virginia Beach Canal No. 2, and the Lynnhaven Oyster Restoration project. These projects are shown in Figure 3 of the Main Report. The Lynnhaven Inlet navigation project provides for an entrance channel that is 10 feet deep and 150 feet wide extending 1 mile from that depth in the Chesapeake Bay to a mooring area and turning basin that is 10 feet deep, 1,250 feet long, and 700 feet wide in Lynnhaven Bay, just upstream from the Lesner Bridge at the mouth of the inlet. Virginia Beach Canal No. 2 has been constructed in the Southern part of the city providing flood control. The Lynnhaven Oyster Restoration consisted of the construction of 58 acres of oyster habitat in various locations in Linkhorn Bay, Broad Bay, the Eastern Branch, and the Lynnhaven Bay. Federal project activities are not anticipated to conflict with this environmental restoration Project.

7.2 NON-FEDERAL SPONSOR PROJECT LAND OWNERSHIPS

The City of Virginia, the Non- Federal Sponsor owns two (2) parcels of land and the Virginia Beach School Board owns one (1) parcel of land required for the Ecosystem Restoration Project Wetlands Easements. These three parcels comprise a total of 8.04 acres. They have no ownership rights in the state river bottom or leasehold interst in the river bottom.

8.0 NAVIGATIONAL SERVITUDE

Navigational Servitude does not apply to this project, due to there not being any commerce or navigation purpose for this Project.

9.0 PUBLIC LAW 91-646

Public Law 91-646 will apply to NFS acquisitions, and the NFS has been advised of P.L. 91-646 requirements, understands, and will fulfill those requirements. Pursuant to section 211(b) of the Act, "No payment or assistance under this title or title III of this Act shall be required to be made to any person or included as a program or project cost under this section, if such person receives a payment required by Federal, State, or local law which is determined by the head of the Federal agency to have substantially the same purpose and effect as such payment under this section." The NFS has provided confirmation that all payments made for acquisition of any parcels for the Project will include all necessary components under PL 91-646. It is therefore anticipated that payments made by the NFS will have substantially the same purpose and effect as such payment under PL 91-646.

10.0 INDUCED FLOODING

The intended effects of this project are not expected to cause flooding in this area.

11.0 REAL ESTATE COST ESTIMATE

The real estate costs for this project are shown on Exhibit B, which shows the wetlands baseline costs estimates and on Exhibit G which is the Chart of Accounts. The costs are estimated as follows:

a. Wetlands Restoration. The USACE Baltimore District, Real Estate Division, Technical Services Branch, Appraisal Staff has reviewed the wetlands interest requirement and provided a gross appraisal of the value for the wetlands real estate acquisitions, to be $71,880 based on use of the wetlands easement estate. This includes $13,474 for acquisition of public parcels; $50,789 for acquisition of private parcels; 15% contingency on acquisition of private parcels for $7,618; all totaling $71,880. The NFS administrative costs of $28,000 as estimated in the Gross Appraisal are not included in the $71,880. The Norfolk District's estimated real estate administrative cost is $49,840.28.

b. SAV, Scallop, Reef Habitat. No value is placed on the state-owned river bottom to be acquired under easement for the Project. However, because some parcels are currently under lease to third parties, the NFS must acquire the leasehold interests, either by donation, purchase or through eminent domain proceedings, as well as easements in perpetuity from the Commonwealth of Virginia. The NFS has estimated its total costs, including its, land acquisition, and all relocation and damages, at $450,000.00. The NFS has estimated its administrative cost at $50,000.00. The Norfolk District's estimated real estate administrative cost is $72,980.41.

c. Public Law 91-646 Relocation Cost

As explained in Section 9.0, there are no costs for PL 91-646 because any actions that would invoke PL 91-646 will necessarily include payment by the NFS that is required under Virginia State law that has substantially the same purpose and effect as payment under PL 91-646: "If any existing leases must be terminated or condemned, the NFS will utilize State eminent domain proceedings. Public Law 91-646 will apply to such eminent domain proceedings, and the NFS has been advised of P.L. 91-646 requirements, understands, and will fulfill those requirements. Pursuant to section 211(b) of the Act, 'No payment or assistance under section 210 or 305 shall be required or included as a program or project cost under this section, if the displaced person receives a payment required by the State law of eminent domain which is determined by such Federal agency head to have substantially the same purpose and effect as such payment under this section, and to be part of the cost of the program or project for which Federal financial assistance is available.'" Thus, pursuant to the application of section 211(b), there are no additional payments or assistance required under P.L. 91-646.

12.0 ZONING ENACTMENTS

There are no zoning changes or enactments that are needed for this project.

13.0 MINERAL ACTIVITY

No future mineral activities or other subsurface minerals or timber activities are involved in this project.

14.0 PUBLIC FACILITY RELOCATIONS

No utility or other public facilities relocations are required for the construction of this project.

15.0 NEPA, NHPA & HTRW

The environmental report prepared for this project indicated there are no hazardous, toxic or radioactive waste known to exist on the real property needed for this project.

16.0 ASSESSMENT OF NON-FEDERAL SPONSOR'S ACQUISITION CAPABILITY

The NFS is the City of Virginia Beach. The Norfolk District has worked with the City on several Local Cooperation Projects within the city, which include the Lynnhaven River Dredging Project, Rudee Inlet Dredging Project, the Virginia Beach Seawall and Beach Nourishment Project and the Sandbridge Beach Nourishment Project. Many of the intended sites for restoration of SAV, scallops and reef habitat are currently under lease to oyster harvesters by the VMRC. The City has affirmed its intent to acquire the real estate interests required to construct and maintain the Project, as required for local cooperation, and has confirmed that it possesses the necessary human and financial resources and legal authorities (including authority and willingness to condemn the leasehold interests) required to do so. An assessment of NFS's Real Estate acquisition capability and the NFS assurance letter are attached as Exhibit F.

17.0 PROJECT SCHEDULE

Real Estate Acquisition Schedule

Project Partnership Agreement for Construction	4 months post authorization
NTP with real property acquisition	1 month post-executed PPA date
Real Estate Acquisition Complete	2 years post-executed PPA date
Certification of Chief of Real Estate	1 month after completion of acquisition
Authorization for entry for construction	1 week
Construction	2 years

18.0 PUBLIC SUPPORT OR OPPOSITION

There is no known opposition for the current lands needed for the project.

19.0 RECOMMENDATION

a. It is recommended that this Real Estate Plan be approved with the condition that the proposed non-standard estates be submitted for review and approval during the Pre-Construction Engineering and Design Phase of the Project.

b. This report was prepared in accordance with Corps of Engineers Regulation 4051-12.

Prepared by:

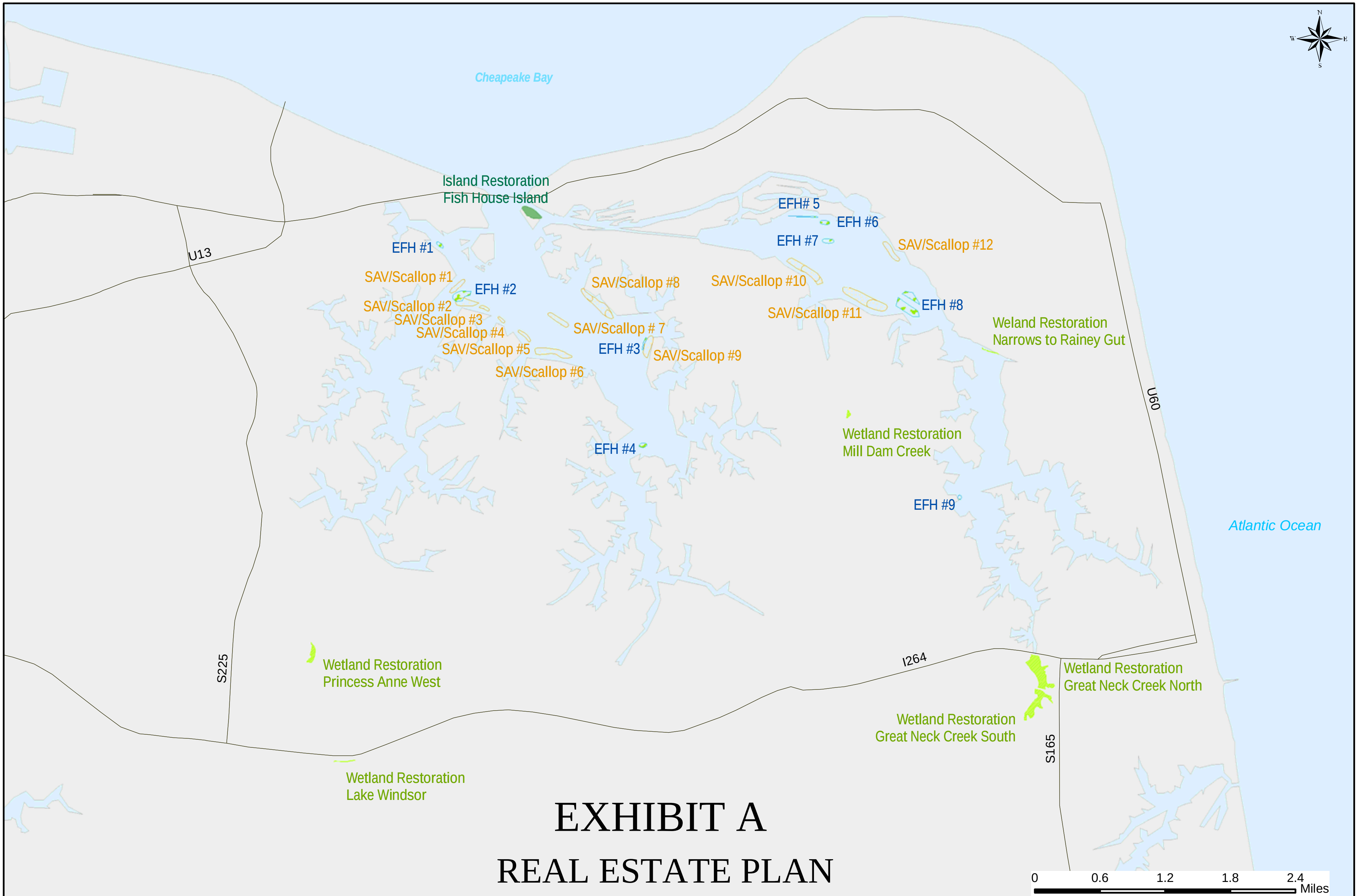
David B. Parson
Realty Specialist

Approved by:

Donna Carrier-Tal
Chief, Real Estate Office

EXHIBIT A

REAL ESTATE PLAN



US Army Corps of Engineers
Norfolk District

Lynnhaven River
Ecosystem Restoration
Proposed Sites
Virginia Beach, VA

Ecosystem Restoration Area
- EFH Site
- Island Restoration
- SAV scallop site
- Wetland Restoration

Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet

Shoreline:
Census 2000 TIGER/Line
100K County GIS files

Project Manager: Brian Rheinhart
E-mail: Brian.K.Rheinhart@usace.army.mil
Phone: (757) 201-7768
Fax: (757) 201-7036

Prepared by: Karin Dridge
Geospatial Services Section

Map File: Lynn_Wetlands_Rest_Server.mxd
Map Date: 4 March 2010

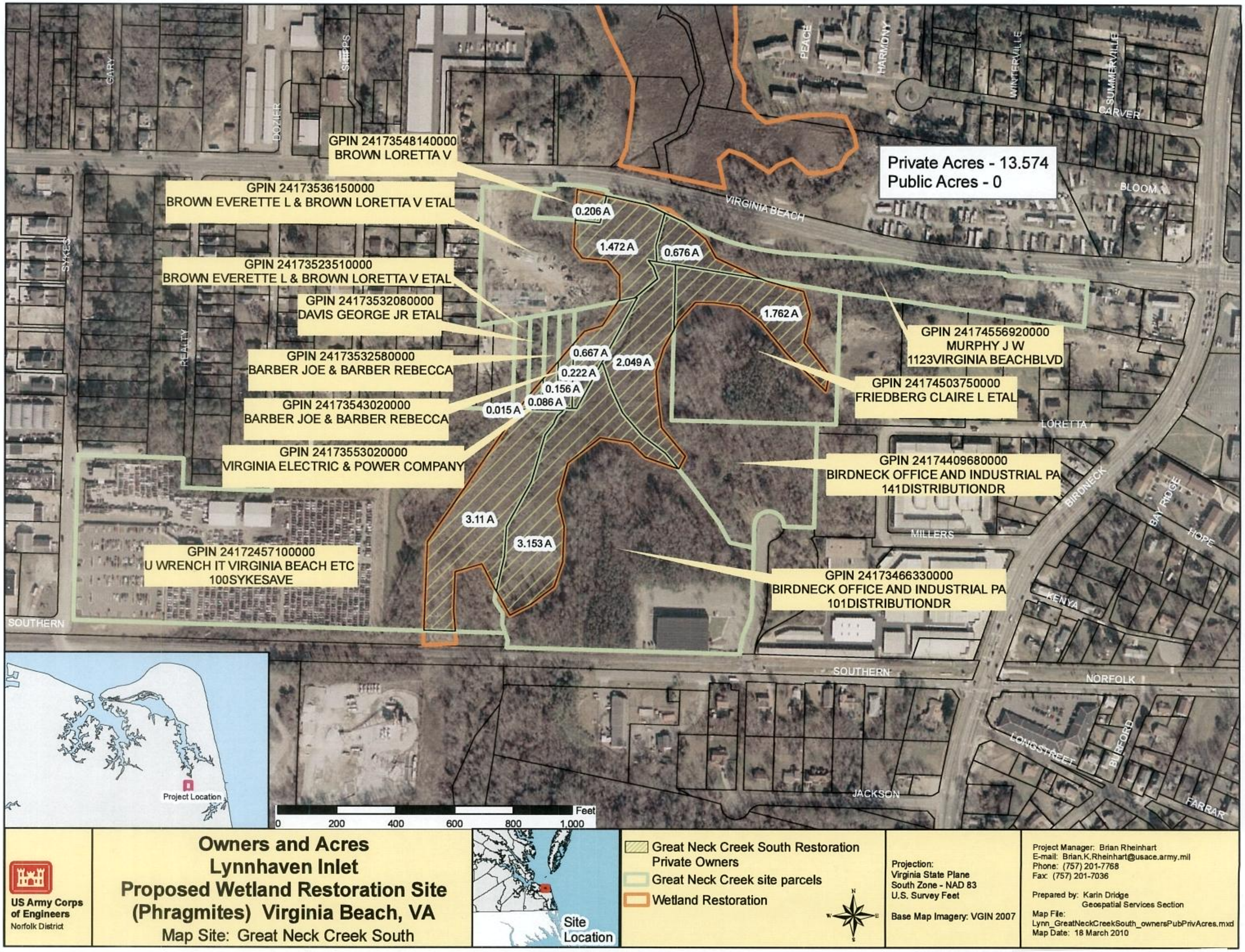
LYNNHAVEN RIVER BASIN ECOSYSTEM RESTORATION STUDY

OWNERS OF PROPOSED WETLANDS EASEMENTS SITES

	LYNNHAVEN INLET					
	PROPOSED WETLAND RESTORATION SITE					
				Esmt	Easement	Easement
No	OWNER	GPIN	Location	Acreage	Public ACRES	Private Acres
1	Loretta Brown	24173548140000	Great Neck - S	0.206	None	0.206
2	Everette Brown	24173536150000	Great Neck - S	1.472	None	1.472
3	Everette Brown	24173523510000	Great Neck - S	0.015	None	0.015
4	George Davis	24173532080000	Great Neck - S	0.086	None	0.086
5	Joe Barber	24173532580000	Great Neck - S	0.156	None	0.156
6	Joe Barber	24173543020000	Great Neck - S	0.222	None	0.222
7	VEPCO	24173553020000	Great Neck - S	0.667	None	0.667
8	U Wrench It	24172457100000	Great Neck - S	3.110	None	3.110
9	J.W. Murphy	24174556920000	Great Neck - S	0.676	None	0.676
10	Claire Friedberg	24174504630000	Great Neck - S	1.762	None	1.762
11	Birdneck Office and Industrial Park	24174409680000	Great Neck - S	2.049	None	2.049
12	Birdneck Office and Industrial Park	24173466330000	Great Neck - S	3.153	None	3.153
13	No Data	0	Great Neck - S	0.138	None	0.138
	Great Neck South		**Subtotal**	**13.712**	**None**	**13.712**
14	Piper Apartments	24172782540000	Great Neck - N	5.041	None	5.041
15	CCT LC	24173643050000	Great Neck - N	2.918	None	2.918
16	EMS LLC	24173641740000	Great Neck - N	0.021	None	0.021
17	Foundation for Applied Christians	24173662520000	Great Neck - N	1.064	None	1.064
18	City of Virginia Beach	24173792600000	Great Neck - N	2.877	2.877	None
19	J W Murphy	24174588810000	Great Neck - N	2.410	None	2.410
20	Friendship Village	24174624720000	Great Neck - N	0.692	None	0.692
21	Ong Arenio M &Kyle T	24173697430000	Great Neck - N	0.841	None	0.841
22	John Owens	24173689810000	Great Neck - N	1.062	None	1.062
23	City of Virginia Beach	24173684430000	Great Neck - N	1.332	1.332	None
24	No Parcel Data			1.631	None	1.631
	Great Neck North		**Subtotal**	**19.889**	**4.209**	**15.680**
25	City of Virginia Beach	24083875950000	Mill Dam Creek	0.020	0.02	None
26	John Elko	24083899640000	Mill Dam Creek	0.830	None	0.83
27	Glenn Cherry	24083879560000	Mill Dam Creek	0.100	None	0.10
	Mill Dam		**Subtotal**	**0.950**	**0.02**	**0.93**
	Princess Anne West					
28	Virginia Beach Public Schools	14777694480000	Princess Anne West	3.815	3.815	None
	Grand Totals	**Public**	**$ 13,474**	8.04	Acres	
		Private	**$ 50,789**	30.32	Acres	
		Total	**$ 64,263**	38.36	Acres	

(Rounded 38.4 Acres)

EXHIBIT "B"



Private Acres - 13.574
Public Acres - 0
GPIN 24173548140000
BROWN LORETTA V
GPIN 24173536150000
BROWN EVERETTE L & BROWN LORETTA V ETAL
GPIN 24173523510000
BROWN EVERETTE L & BROWN LORETTA V ETAL
GPIN 24173532080000
DAVIS GEORGE JR ETAL
GPIN 24173532580000
BARBER JOE & BARBER REBECCA
GPIN 24173543020000
BARBER JOE & BARBER REBECCA
GPIN 24173553020000
VIRGINIA ELECTRIC & POWER COMPANY
GPIN 24172457100000
U WRENCH IT VIRGINIA BEACH ETC
100SYKESAVE
GPIN 24174556920000
MURPHY J W
1123VIRGINIA BEACHBLVD
GPIN 24174503750000
FRIEDBERG CLAIRE L ETAL
GPIN 24174409680000
BIRDNECK OFFICE AND INDUSTRIAL PA
141DISTRIBUTIONDR
GPIN 24173466330000
BIRDNECK OFFICE AND INDUSTRIAL PA
101DISTRIBUTIONDR
0.206 A
1.472 A
0.676 A
1.762 A
0.667 A
2.049 A
0.222 A
0.156 A
0.086 A
0.015 A
3.11 A
3.153 A
VIRGINIA BEACH
SOUTHERN
NORFOLK
BIRDNECK
LORETTA
MILLERS
KENYA
LONGSTREET
BUFORD
FARRAR
JACKSON
HOPE
BAY RIDGE
BLOOM
CARVER
SUMMERVILLE
WINTERVILLE
HARMONY
PEACE
SHIPPS
DOZIER
REALTY
GARY
SYKES
Project Location
Feet
0 200 400 600 800 1,000
US Army Corps of Engineers
Norfolk District
Owners and Acres
Lynnhaven Inlet
Proposed Wetland Restoration Site
(Phragmites) Virginia Beach, VA
Map Site: Great Neck Creek South
Site Location
Great Neck Creek South Restoration Private Owners
Great Neck Creek site parcels
Wetland Restoration
Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet
Base Map Imagery: VGIN 2007
Project Manager: Brian Rheinhart
E-mail: Brian.K.Rheinhart@usace.army.mil
Phone: (757) 201-7768
Fax: (757) 201-7036
Prepared by: Karin Dridge
Geospatial Services Section
Map File:
Lynn_GreatNeckCreekSouth_ownersPubPrivAcres.mxd
Map Date: 18 March 2010

EXHIBIT " C"

US Army Corps of Engineers
Norfolk District

Owners and Acres
Lynnhaven Inlet
Proposed Wetland Restoration Site (Phragmites) Virginia Beach, VA

Map Site: Great Neck Creek North

Wetland Restoration

Great Neck Creek Site Parcels

Great Neck Cr North Restoration Site Owners

No Data

Private

Public

Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet

Base Map Imagery: VGIN 2007

Project Manager: Brian Rheinhart
E-mail: Brian.K.Rheinhart@usace.army.mil
Phone: (757) 201-7768
Fax: (757) 201-7036

Prepared by: Karin Dridge
Geospatial Services Section

Map File:
Lynn_GreatNeckCreekNorth_ownersPubPrivAcres.mxd
Map Date: 18 March 2010

EXHIBIT "C"

US Army Corps of Engineers
Norfolk District

Owners and Acres
Lynnhaven Inlet
Proposed Wetland Restoration Site (Phragmites) Virginia Beach, VA
Map Site: Mill Dam Creek

Site Location

Wetland Restoration
Mill Dam Creek parcels
Mill Dam Creek Restoration Site Owners
Private
Public

Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet

Base Map Imagery: VGIN 2007

Project Manager: Brian Rheinhart
E-mail: Brian.K.Rheinhart@usace.army.mil
Phone: (757) 201-7768
Fax: (757) 201-7036

Prepared by: Karin Dridge Geospatial Section
Map File:
Lynn_eco_restMillDamCreek_owners.mxd
Map Date: 3 April 2012

EXHIBIT " C"

US Army Corps of Engineers
Norfolk District

Lynnhaven Inlet
Virginia Beach, VA

Wetland Restoration
Map Site: 1 Princess Anne West

Site Location

Wetland Restoration
Property GPIN, Owner, Address

0 200 400 600 Feet

Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet

Base Map Imagery:
VGIN 2007

Project Manager: Greg Steele
E-mail: Gregory.C.Steele@nao02.usace.army.mil
Phone: (757) 201-7589
Fax: (757) 201-7646

Prepared by: Karin Dridge Geospatial Section
Map File:
Lynn_Wetlands_PrincessAnne_acres_apr12.mxd
Map Date: 3 April 2012

EXHIBIT "C"

US Army Corps of Engineers
Norfolk District

Lynnhaven River
Ecosystem Restoration
Proposed Sites
Virginia Beach, VA

Site Location

LEGEND

- Lease Area Needed for EFH/SAV
- EFH (Fish Haven)
- SAV/Scallop Site
- Lease Boundary

Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet

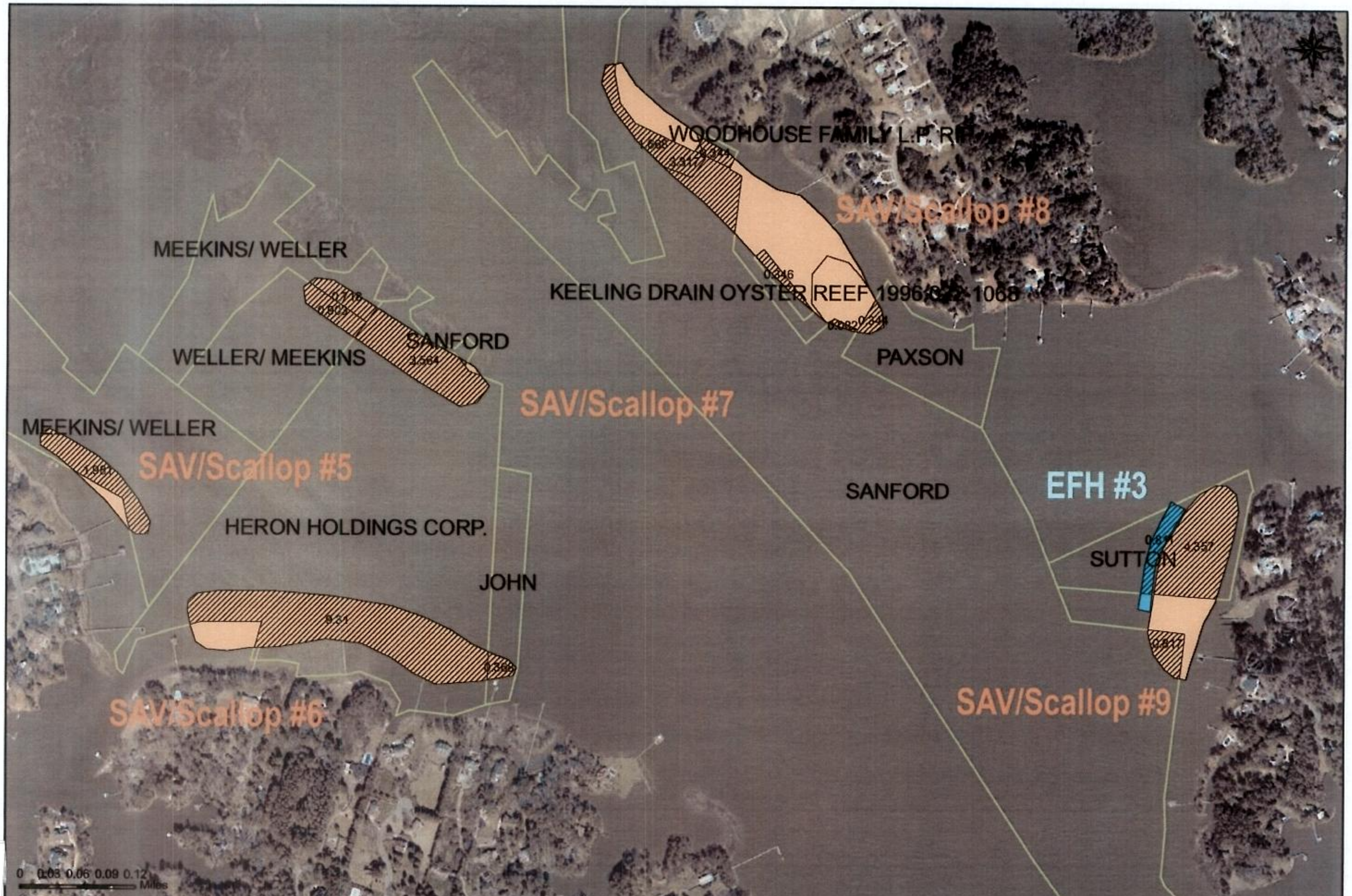
Imagery Source:
VGIN 2007

Project Manager: Brian Rheinhart
E-mail: Brian.K.Rheinhart@usace.army.mil
Phone: (757) 201-7768
Fax: (757) 201-7036

Prepared by: Karin Dridge
Geospatial Services Section

Map File:
Lynn_Eco_EFH_SAVLynnWestLeaseOwners.mxd
Map Date: 6 April 2010

EXHIBIT "D"



US Army Corps of Engineers
Norfolk District

Lynnhaven River Ecosystem Restoration Proposed Sites Virginia Beach, VA

Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet

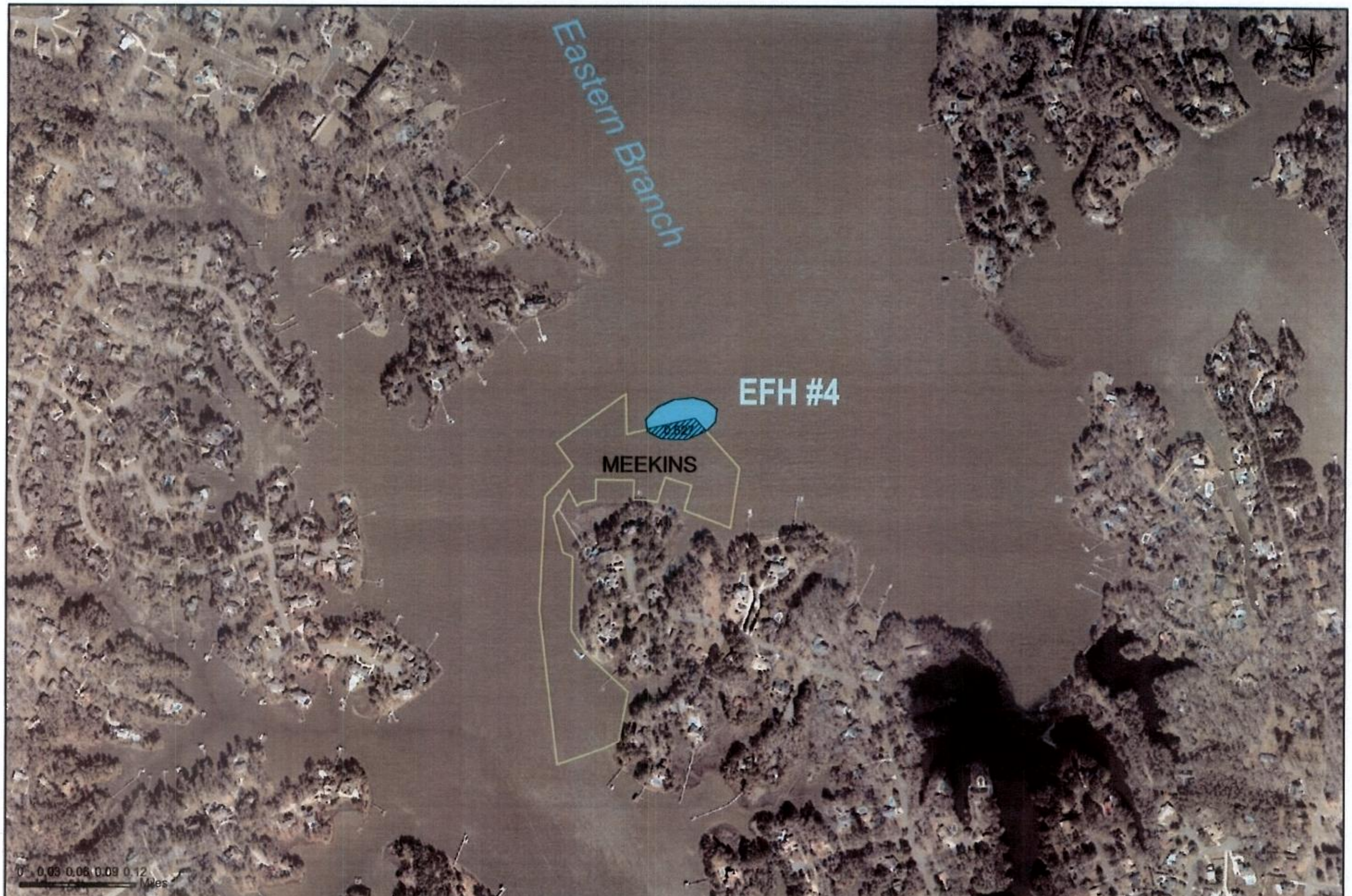
Imagery Source:
VGIN 2007

Project Manager: Brian Rheinhart
E-mail: Brian.K.Rheinhart@usace.army.mil
Phone: (757) 201-7768
Fax: (757) 201-7036

Prepared by: Karin Dridge
Geospatial Services Section

Map File:
Lynn_Eco_EFH_SAVLynnEastLeaseOwners.mxd
Map Date: 6 April 2010

EXHIBIT "D"



US Army Corps of Engineers
Norfolk District

Lynnhaven River
Ecosystem Restoration
Proposed Sites
Virginia Beach, VA

LEGEND

- Lease Area Needed for EFH/SAV
- EFH (Fish Haven)
- SAV/Scallop Site
- Lease Boundary

Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet

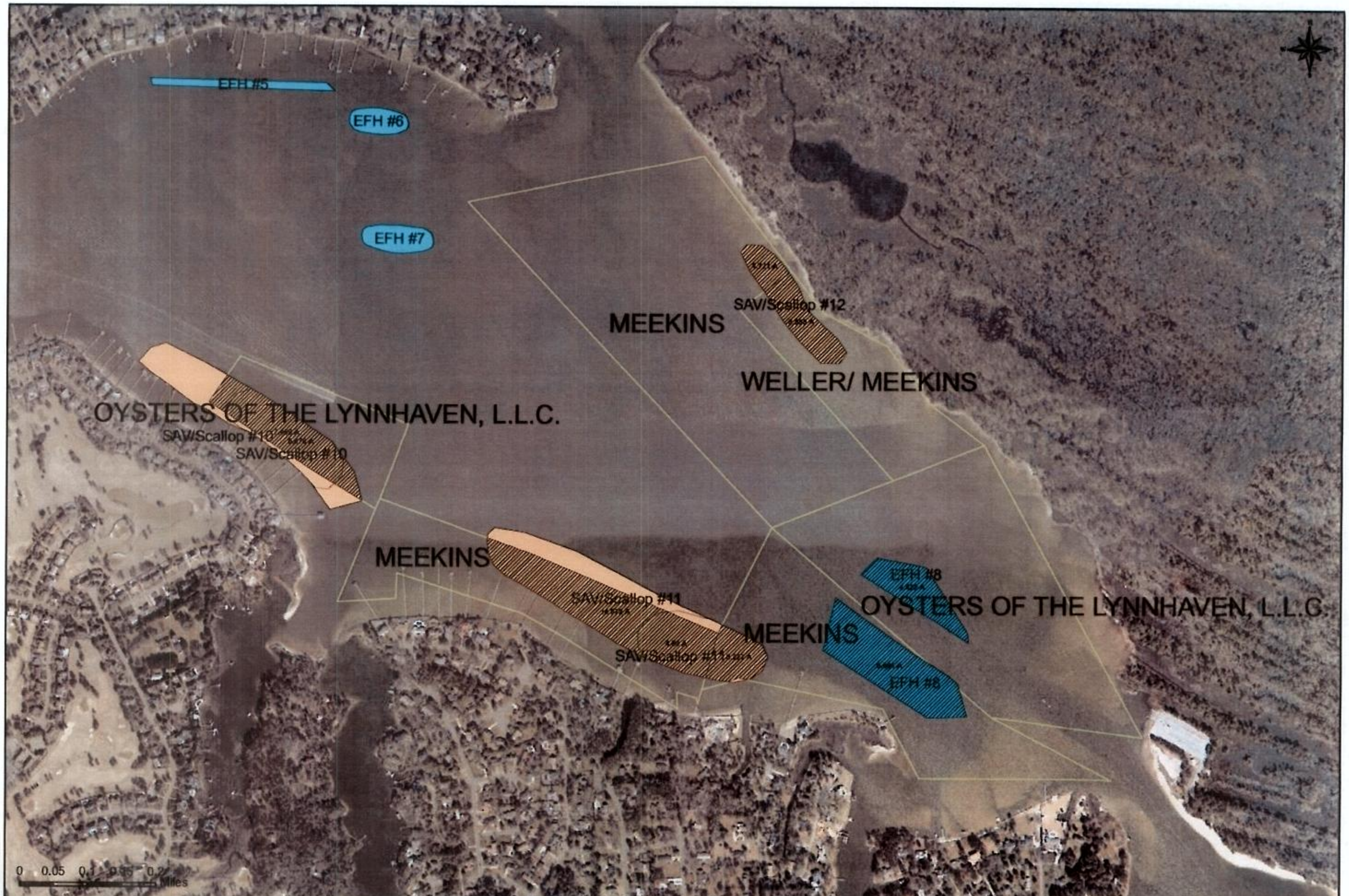
Imagery Source:
VGIN 2007

Project Manager: Brian Rheinhart
E-mail: Brian.K.Rheinhart@usace.army.mil
Phone: (757) 201-7768
Fax: (757) 201-7036

Prepared by: Karin Dridge
Geospatial Services Section

Map File:
Lynn_Eco_EFH_No4LeaseOwner.mxd
Map Date: 6 April 2010

EXHIBIT "D"



US Army Corps of Engineers
Norfolk District

Lynnhaven River Ecosystem Restoration Proposed Sites Virginia Beach, VA

Site Location

LEGEND
- Lease Area Needed for EFH/SAV
- EFH (Fish Haven)
- SAV/Scallop Site
- Lease Boundary

Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet

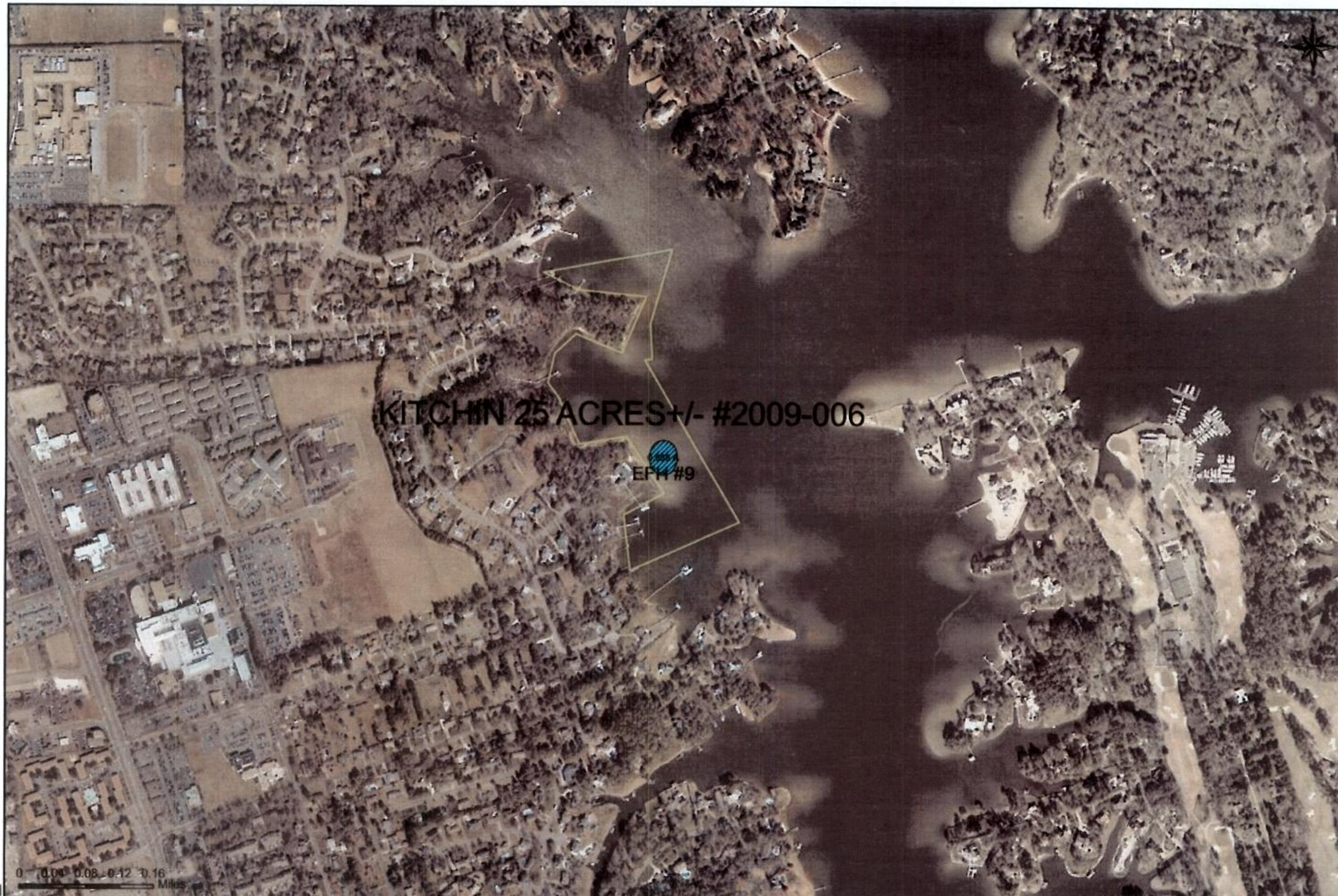
Imagery Source:
VGIN 2007

Project Manager: Brian Rheinhart
E-mail: Brian.K.Rheinhart@usace.army.mil
Phone: (757) 201-7768
Fax: (757) 201-7036

Prepared by: Karin Dridge
Geospatial Services Section

Map File:
Lynn_Eco_EFH_SAV_BroadBayLeaseOwners.mxd
Map Date: 6 April 2010

EXHIBIT "D"



US Army Corps of Engineers
Norfolk District

Lynnhaven River Ecosystem Restoration Proposed Sites Virginia Beach, VA

LEGEND

- Lease Area Needed for EFH/SAV
- EFH (Fish Haven)
- SAV/Scallop Site
- Lease Boundary

Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet

Imagery Source:
VGIN 2007

Project Manager: Brian Rheinhart
E-mail: Brian.K.Rheinhart@usace.army.mil
Phone: (757) 201-7768
Fax: (757) 201-7036

Prepared by: Karin Dridge
Geospatial Services Section

Map File:
Lynn_EcoEFH_SAVSites_EFH#9LeaseOwner.mxd
Map Date: 6 April 2010

EXHIBIT "D

LYNNHAVEN OYSTER LEASE SITES

*	DESC_	Rest_Type	Site_Name	ACRES
1	Pleasure House Creek	Fish Reef Low Profile	Reef Habitat #1	1.142
2	Hill Point	Fish Haven	Reef Habitat #2	2.068
3	Hill Point	Fish Haven	Reef Habitat #3	4.797
4	Brock Cove	Fish Reef Low Profile	Reef Habitat #4	0.811
5	Brown Cove	Fish Reef Low Profile	Reef Habitat #5	0.527
6	Broad Bay Cove	Fish Haven	Reef Habitat #6	4.422
7	Broad Bay Cove	Fish Haven	Reef Habitat #7	9.884
8	Linkhorn Bay	Fish Reef High Profile	Reef Habitat #8	0.688
			TOTAL	24.339
9	Western Branch Lynn 1	SAV scallop site	SAV/Scallop #1	0.599
10	Western Branch Lynn 1	SAV scallop site	SAV/Scallop #1	3.033
11	Western Branch Lynn 2	SAV scallop site	SAV/Scallop #2	4.354
12	Western Branch Lynn 2	SAV scallop site	SAV/Scallop #2	2.215
13	Western Branch Lynn 2	SAV scallop site	SAV/Scallop #2	0.103
14	Eastern Branch Lynn 1	SAV scallop site	SAV/Scallop #3	0.149
15	Eastern Branch Lynn 1	SAV scallop site	SAV/Scallop #3	1.244
16	Eastern Branch Lynn 2	SAV scallop site	SAV/Scallop #4	0.492
17	Eastern Branch Lynn 2	SAV scallop site	SAV/Scallop #4	0.558
18	Eastern Branch Lynn 3	SAV scallop site	SAV/Scallop #5	1.981
19	Eastern Branch Lynn 4	SAV scallop site	SAV/Scallop #6	0.368
20	Eastern Branch Lynn 4	SAV scallop site	SAV/Scallop #6	9.31
21	Eastern Branch Lynn 5	SAV scallop site	SAV/Scallop #7	0.903
22	Eastern Branch Lynn 5	SAV scallop site	SAV/Scallop #7	0.718
23	Eastern Branch Lynn 5	SAV scallop site	SAV/Scallop #7	3.564
24	Eastern Branch Lynn 6	SAV scallop site	SAV/Scallop #8	0.344
25	Eastern Branch Lynn 6	SAV scallop site	SAV/Scallop #8	3.317
26	Eastern Branch Lynn 6	SAV scallop site	SAV/Scallop #8	0.346
27	Brock Cove SAV	SAV scallop site	SAV/Scallop #9	4.357
28	Brock Cove SAV	SAV scallop site	SAV/Scallop #9	0.817
29	Eastern Branch Lynn 6	SAV scallop site	SAV/Scallop #8	0.344
30	Eastern Branch Lynn 6	SAV scallop site	SAV/Scallop #8	0.082
			TOTAL	39.198
31	Broad Bay 1	SAV scallop site	SAV/Scallop #10	7.469
32	Broad Bay 3	SAV scallop site	SAV/Scallop #11	14.072
33	Broad Bay 2	SAV scallop site	SAV/Scallop #12	1.721
34	Broad Bay 2	SAV scallop site	SAV/Scallop #12	3.853
35	Broad Bay 3	SAV scallop site	SAV/Scallop #11	3.227
			TOTAL	30.342
36	Eastern Branch Lynn 6	SAV scallop site	SAV/Scallop #8	0.344
37	Eastern Branch Lynn 6	SAV scallop site	SAV/Scallop #8	0.082
38	Eastern Branch Lynn 6	SAV scallop site	SAV/Scallop #8	1.668
			TOTAL	2.094
39	Broad Bay 1	SAV scallop site	SAV/Scallop #10	5.878
40	Broad Bay 3	SAV scallop site	SAV/Scallop #11	4.89
41	Broad Bay 3	SAV scallop site	SAV/Scallop #11	3.227
			TOTAL	13.995
			GRAND TOTAL	109.968
		EXHIBIT "E"		

LYNNHAVEN OYSTER LEASE SITES

#	DESC_	Rest_Type	Site_Name	ACRES	Value	
1	Pleasure H	Fish Reef Low Profile	Reef Habitat #1	1.142	$23,380.37	$ 20,473.18
2	Hill Point	Fish Haven	Reef Habitat #2	2.068	$42,338.54	$ 20,473.18
3	Hill Point	Fish Haven	Reef Habitat #3	4.797	$98,209.84	$ 20,473.18
4	Brock Cove	Fish Reef Low Profile	Reef Habitat #4	0.811	$16,603.75	$ 20,473.18
5	Brown Cov	Fish Reef Low Profile	Reef Habitat #5	0.527	$10,789.37	$ 20,473.19
6	Broad Bay	Fish Haven	Reef Habitat #6	4.422	$90,532.40	$ 20,473.18
7	Broad Bay	Fish Haven	Reef Habitat #7	9.884	$202,356.91	$ 20,473.18
8	Linkhorn B	Fish Reef High Profile	Reef Habitat #8	0.688	$14,085.55	$ 20,473.18
			TOTAL	24.339	$498,296.73	$ 20,473.18
						#DIV/0!
9	Western B	SAV scallop site	SAV/Scallop #1	0.599	$12,263.43	$ 20,473.17
10	Western B	SAV scallop site	SAV/Scallop #1	3.033	$62,095.15	$ 20,473.18
11	Western B	SAV scallop site	SAV/Scallop #2	4.354	$89,140.23	$ 20,473.18
12	Western B	SAV scallop site	SAV/Scallop #2	2.215	$45,348.09	$ 20,473.18
13	Western B	SAV scallop site	SAV/Scallop #2	0.103	$2,108.74	$ 20,473.20
14	Eastern Bra	SAV scallop site	SAV/Scallop #3	0.149	$3,050.50	$ 20,473.15
15	Eastern Bra	SAV scallop site	SAV/Scallop #3	1.244	$25,468.64	$ 20,473.18
16	Eastern Bra	SAV scallop site	SAV/Scallop #4	0.492	$10,072.80	$ 20,473.17
17	Eastern Bra	SAV scallop site	SAV/Scallop #4	0.558	$11,424.03	$ 20,473.17
18	Eastern Bra	SAV scallop site	SAV/Scallop #5	1.981	$40,557.37	$ 20,473.18
19	Eastern Bra	SAV scallop site	SAV/Scallop #6	0.368	$7,534.13	$ 20,473.18
20	Eastern Bra	SAV scallop site	SAV/Scallop #6	9.31	$190,605.31	$ 20,473.18
21	Eastern Bra	SAV scallop site	SAV/Scallop #7	0.903	$18,487.28	$ 20,473.18
22	Eastern Bra	SAV scallop site	SAV/Scallop #7	0.718	$14,699.74	$ 20,473.18
23	Eastern Bra	SAV scallop site	SAV/Scallop #7	3.564	$72,966.41	$ 20,473.18
24	Eastern Bra	SAV scallop site	SAV/Scallop #8	0.344	$7,042.77	$ 20,473.17
25	Eastern Bra	SAV scallop site	SAV/Scallop #8	3.317	$67,909.54	$ 20,473.18
26	Eastern Bra	SAV scallop site	SAV/Scallop #8	0.346	$7,083.72	$ 20,473.18
27	Brock Cove	SAV scallop site	SAV/Scallop #9	4.357	$89,201.65	$ 20,473.18
28	Brock Cove	SAV scallop site	SAV/Scallop #9	0.817	$16,726.59	$ 20,473.18
29	Eastern Bra	SAV scallop site	SAV/Scallop #8	0.344	$7,042.77	$ 20,473.17
30	Eastern Bra	SAV scallop site	SAV/Scallop #8	0.082	$1,678.80	$ 20,473.17
			TOTAL	39.198	$802,507.71	$ 20,473.18
						#DIV/0!
31	Broad Bay	SAV scallop site	SAV/Scallop #10	7.469	$152,914.18	$ 20,473.18
32	Broad Bay	SAV scallop site	SAV/Scallop #11	14.072	$288,098.59	$ 20,473.18
33	Broad Bay	SAV scallop site	SAV/Scallop #12	1.721	$35,234.34	$ 20,473.18
34	Broad Bay	SAV scallop site	SAV/Scallop #12	3.853	$78,883.16	$ 20,473.18
35	Broad Bay	SAV scallop site	SAV/Scallop #11	3.227	$66,066.95	$ 20,473.18
			TOTAL	30.342	$621,197.23	$ 20,473.18
						#DIV/0!
36	Eastern Bra	SAV scallop site	SAV/Scallop #8	0.344	$7,042.77	$ 20,473.17
37	Eastern Bra	SAV scallop site	SAV/Scallop #8	0.082	$1,678.80	$ 20,473.17
38	Eastern Bra	SAV scallop site	SAV/Scallop #8	1.668	$34,149.26	$ 20,473.18
			TOTAL	2.094	$42,870.84	$ 20,473.18
						#DIV/0!
39	Broad Bay	SAV scallop site	SAV/Scallop #10	5.878	$120,341.35	$ 20,473.18
40	Broad Bay	SAV scallop site	SAV/Scallop #11	4.89	$100,113.85	$ 20,473.18
41	Broad Bay	SAV scallop site	SAV/Scallop #11	3.227	$66,066.95	$ 20,473.18
			TOTAL	13.995	$286,522.15	$ 20,473.18
						#DIV/0!
			GRAND TOTAL	109.968	$2,251,394.66	$ 20,473.18

EXHIBIT "E"

ASSESSMENT OF NON-FEDERAL SPONSOR'S REAL ESTATE ACQUISITION CAPABILITY

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes?
YES
Does the sponsor have the power of eminent domain for this project?
YES

b. Does the sponsor have "quick-take" authority for this project?
YES

c. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary? NO

d. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? YES: The NFS cannot condemn the oyster grounds owned by the Commonwealth of Virginia.

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? NO

b. If the answer to II.a. is "yes," has a reasonable plan been developed to provided such training? N/A

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? YES

d. Is the sponsor's projected in-house staffing level sufficient considering its other work load, if any, and the project schedule? YES

e. Can the sponsor obtain contractor support, if required in a timely fashion? YES

f. Will the sponsor likely request USACE assistance in acquiring real estate? NO: The City can condemn privately held leasehold interests, even if the lessor is the State. The Corps will not be required to conduct any required condemnations. .

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? YES

b. Has the sponsor approved the project/real estate schedule/milestone?

IV. Overall Assessment:

a. Has the sponsor performed satisfactorily on other USACE projects? YES

b. With regard to this project, the sponsor is anticipated to be: highly capable/fully capable/moderately capable/marginally capable/insufficiently capable. (If the sponsor is believed to be "insufficiently capable," provide explanation)

V. Coordination:

a. Has this assessment been coordinated with the sponsor? Yes
b. Does the sponsor concur with this assessment? Yes

Prepared by:

David B. Parson
Realty Specialist

Approved by:

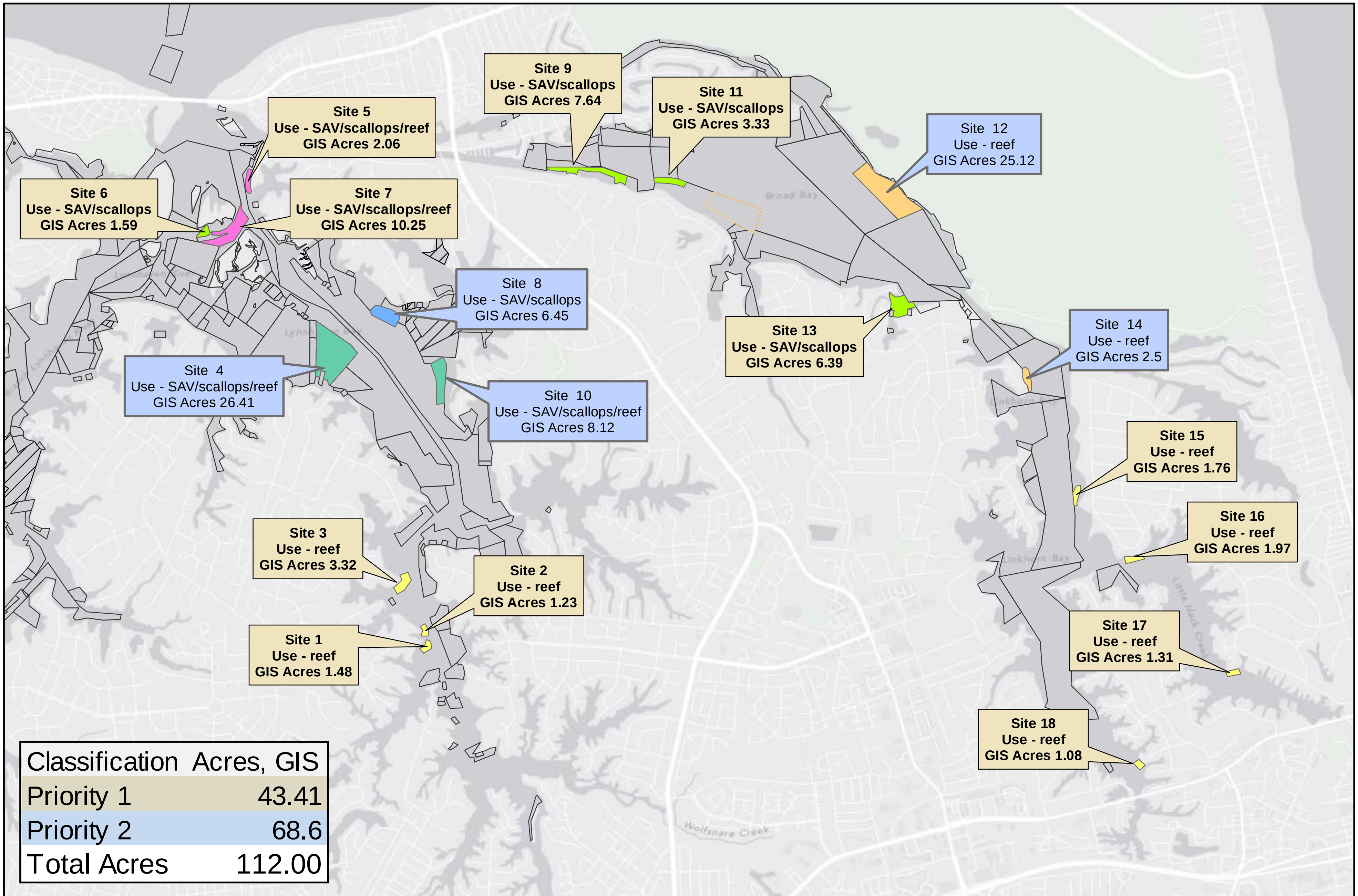
Donna Carrier-Tal
Chief, Real Estate Office

EXHIBIT "F"

Feasibility Study Cost Estimate-MCACES Format
Real Estate Acquisition Requirements

		Private			Commercial			Public			Requirement			
		#	$ each	req	#	$ each	req	#	$ each	req	Base	Contingency	Total	
0102-------	ACQUISITIONS													
010201---	By Government	0	0	0	0	0	0	0	0	0				
010202---	By Non-Federal Sponsor (NFS)	0	0	0	0	0	0	0	0	0	0	0	0	0
01020201	Survey and Legal Descriptions	56	305	17,080	9	305	2,745	4	305	1,220	21,045	3,157	24,202	0.15
01020102	Title Evidence	56	255	14,300	9	255	2,298	4	255	1,021	17,619	2,643	20,262	0.15
01020203	Negotiations	56	228	12,768	9	228	2,052	4	228	912	15,732	2,360	18,092	0.15
010203---	By Government on Behalf of NFS													
010204---	Review of NFS													
01020401	Survey and Legal Descriptions	56	500	28,000	9	500	4,500	4	500	2,000	34,500	5,175	39,675	0.15
01020402	Title Evidence	56	250	14,000	9	250	2,250	4	250	1,000	17,250	2,588	19,838	0.15
01020403	Negotiations	44	250	11,000	5	250	1,250	4	250	1,000	13,250	1,988	15,238	0.15
	SUBTOTAL										119,396	17,909	137,306	
0103-------	CONDEMNATIONS	0	0	0	0	0	0	0	0	0	0	0	0	0.15
010301---	By Government	0	0	0	0	0	0	0	0	0	0	0	0	0.15
010302---	By Non-Federal Sponsor (NFS)	12	305	3,660	4	305	1,220	0	0	0	4,880	732	5,612	0.15
010303---	By Government on Behalf of NFS	0	0	0		0	0		0		0	0	0	0.15
010304---	Review of NFS	12	1,000	12,000	4	1,000	4,000	0	0	0	16,000	2,400	18,400	0.15
	SUBTOTAL										20,880	3,132	24,012	
0105-------	APPRAISALS	0	0	0	0	0	0	0	0	0	0	0	0	
010501---	By Government	0	0	0	0		0	0	0	0	0	0	0	
010502---	By Non-Federal Sponsor (NFS)	56	272	15,232	9	272	2,448	4	272	1,088	18,768	2,815	21,583	0.15
010503---	By Government on Behalf of NFS	0	0	0		0	0		0	0	0	0	0	0.15
010504---	Review of NFS	56	200	11,200	9	200	1,800	4	200	800	13,800	2,070	15,870	0.15
	SUBTOTAL										32,568	4,885	37,453	
0106-------	PL 91-646 ASSISTANCE	0	0	0	0	0	0	0	0	0	0	0	0	
010601---	By Government	0	0	0	0	0	0	0	0	0	0	0	0	
010602---	By Non-Federal Sponsor (NFS)	0	0	0	0	0	0	0	0	0	0	0	0	0.15
010603---	By Government on Behalf of NFS	0	0	0	0	0	0	0	0	0	0	0	0	0.15
010604---	Review of NFS	0	0	0	0	0	0	0	0	0	0	0	0	0.15
	SUBTOTAL										0	0	0	
0107-------	TEMPORARY PERMITS/LICENSES/RIGHTS-OF-WAY													
010701---	By Government	0	0	0	0	0	0	0	0	0	0	0	0	0.15
010702---	By Non-Federal Sponsor (NFS)	0	0	0	0	0	0	0	0	0	0	0	0	0.15
010703---	By Government on Behalf of NFS	0	0	0	0	0	0	0	0	0	0	0	0	0.15
010704---	Review of NFS	0	0	0	0	0	0	0	0	0	0	0	0	0.15
010705---	Other	0	0	0	0	0	0	0	0	0	0	0	0	0.15
010706---	Damage Claims	0	0	0	0	0	0	0	0	0	0	0	0	0.15
	SUBTOTAL										0	0	0	
0115-------	**REAL ESTATE PAYMENTS**													
011501---	Land Payments	0	0	0	0	0	0	0	0	0	0	0	0	
01150101	By Government	0	0	0	0	0	0	0	0	0	0	0	0	
01150102	By Non-Federal Sponsor (NFS)	56	7,453	417,373	9	7,453	67,078	4	7,453	29,812	514,263	321	514,584	0.00
01150103	By Government on Behalf of NFS	0	0	0	0	0	0	0	0	0	0	0	0	0.00
01150104	Review of NFS	56	200	11,200	9	200	0	4	200	800	12,000	0	12,000	0.00
														0.15
011502---	PL 91-646 Assistance Payments							0	0	0	0	0	0	15.00
01150201	By Government	0	0	0	0	0	0	0	0	0	0	0	0	0.15
01150202	By Non-Federal Sponsor (NFS)	0	0	0	8	0	0	0	0	0	0	0	0	0.15
01150203	By Government on Behalf of NFS	0	0	0	0	0	0	0	0	0	0	0	0	0.15
01150204	Review of NFS	0	0	0	8	0	0	0	0	0	0	0	0	0.15
011503---	Damage Payments	0	0	0	0	0	0 0	0	0	0	0	0	0	0.15
01150301	By Government	0	0	0	0	0	0 0	0	0	0	0	0	0	0.15
01150302	By Non-Federal Sponsor (NFS)	0	0	0	0	0	0 0	0	0	0	0	0	0	0.15
01150303	By Government on Behalf of NFS	0	0	0	0	0	0 0	0	0	0	0	0	0	0.15
01150304	Review of NFS	0	0	0	0	0	0 0	0	0	0	0	0	0	0.15
	SUBTOTAL										526,263	321	526,584	
Account 02	Facility/Utility Relocations (Construction cost only)											0	0	0.15
	REAL ESTATE ACQUISITION TOTAL										**$699,107**	**$26,248**	**$725,355**	

EXHIBIT "G"

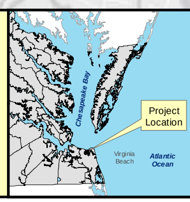


Classification	Acres, GIS
Priority 1	43.41
Priority 2	68.6
Total Acres	112.00

US Army Corps of Engineers
Norfolk District

Virginia Beach, Virginia

Lynnhaven Ecosystem Restoration
Additional Suitable Sites
Lynnhaven River
April 2013



0 2,000 4,000 Feet

N
W E
S

Legend

Reef priority April 2013
Priority, Suitable Measure
- 1, reef
- 1, SAV/scallops
- 1, SAV/scallops/reef
- 2, reef
- 2, SAV/scallops
- 2, SAV/scallops/reef

VMRC GIS Data
- Baylor
- Private
- Application

Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet

Base Map:
ESRI 2011

Project Manager: Jen Armstrong
E-mail: jennifer.r.armsrong@usace.army.mil
Phone: (757) 201-7704

Prepared by: Karin Dridge
Geospatial Section

Map File: Priority_sites_April8_2013.mxd
Map Date: 8 April 2013

EXHIBIT "H"

APPENDIX F

CORRESPONDENCE

APPENDIX F

CORRESPONDENCE

TABLE OF CONTENTS

#42

City of Virginia Beach

VBgov.com

OFFICE OF THE CITY MANAGER
(757)385-4242
FAX (757) 385-5626
TDD: 711

MUNICIPAL CENTER
BUILDING 1, ROOM 234
2401 COURTHOUSE DRIVE
VIRGINIA BEACH, VIRGINIA 23456-9001

May 9, 2012

Colonel Paul B. Olsen
District Commander
U.S. Army Corps of Engineers
Norfolk District
803 Front Street
Norfolk, VA 23510-1096

RE: Lynnhaven River Basin Restoration

Dear Colonel Olsen:

The City of Virginia Beach has reviewed the *Alternative Formulation Briefing Draft Feasibility Report and Integrated Environmental Assessment for the Lynnhaven River Basin, Virginia Beach, Virginia, Ecosystem Restoration Project* dated August 2011. We support and fully intend to participate in the project as described in the report. Further, we acknowledge our responsibilities as outlined in the Recommendations section of the report.

Implicit in our statement of support for the project is a willingness to enter into a Project Partnership Agreement with the Federal Government at the start of the next phase of the project, the Design/Implementation Phase. We understand the existing cost-sharing policies established in the Water Resources Development Act of 1986 (Public Law 99-662), as amended. Further, we understand that the total contribution for our share of the design and construction of this project is currently estimated to be $9,383,500, to include $447,000 for lands, easements, rights-of-way and relocations. The City of Virginia Beach has the financial capability to provide its share of the project cost through its normal budgetary and appropriation process. I am forwarding an executed Self-Certification Form for your use.

We are aware that this letter serves as an expression of intent and not a contractual obligation and that either party may discontinue the effort at any stage before construction begins. The City's participation is conditioned upon approval of the project and appropriation of necessary funds by the Virginia Beach City Council.

Should your staff have any questions, please have them call our Chief Water Resources Engineer, Phillip J. Roehrs, P.E., or the City's Virginia Pollutant Discharge Elimination System Administrator, William J. Johnston, P.E., at 757-385-4131, if you have any questions.

Sincerely,

James K. Spore

James K. Spore
City Manager

JKS/DLH/SGM/s

c: David L. Hansen, Deputy City Manager
Phillip A. Davenport, Interim Public Works Director
John E. Fowler, P.E., City Engineer
Phillip J. Roehrs, P.E., Chief Water Resources Engineer
William J. Johnston, P.E., VPDES Administrator

CITY OF VIRGINIA BEACH, VIRGINIA

NON-FEDERAL SPONSOR'S
SELF-CERTIFICATION OF FINANCIAL CAPABILITY
FOR DECISION DOCUMENTS

I, James K. Spore, do hereby certify that I am the City Manager of the City of Virginia Beach (the "Non-Federal Sponsor); that I am aware of the financial obligations of the Non-Federal Sponsor for the AFB Draft Feasibility Report and Integrated Environmental Assessment, Lynnhaven River Basin Ecosystem Restoration, Virginia Beach, Virginia August 2011; and that the Non-Federal Sponsor will have the financial capability to satisfy the Non-Federal Sponsor's obligations of the project. I understand that the Government's acceptance of this self-certification shall not be construed as obligating either the Government or the Non-Federal Sponsor to implement a project. The City's participation is conditioned upon approval of the project and appropriation of necessary funds by the Virginia Beach City Council.

IN WITNESS WHEREOF, I have made and executed this certification this 9th day of May, 2012.

BY: James K. Spore

TITLE: City Manager

DATE: May 9, 2012

City of Virginia Beach

VBgov.com

OFFICE OF THE CITY MANAGER
(757) 385-4242
FAX (757) 427-5626
TTY: 711

MUNICIPAL CENTER
BUILDING 1
2401 COURTHOUSE DRIVE
VIRGINIA BEACH, VA 23456-9001

April 10, 2013

Colonel Paul B. Olsen
District Engineer
Norfolk District Corps of Engineers
803 Front Street
Norfolk, Virginia 23510-1096

RE: Lynnhaven River Basin Ecosystem Restoration

Dear Colonel Olsen:

The City of Virginia Beach greatly appreciates the work done by the Corps of Engineers in developing the final feasibility study for the Lynnhaven River Basin Ecosystem Restoration project. We are pleased that the project is nearing readiness for consideration by Congress for authorization.

We understand that concerns exist regarding the City's ability to accomplish the real estate acquisition that may be necessary for the project. Please be assured that we have reviewed the potential real estate requirements identified in the District's letter dated March 12, 2013. We acknowledge that the provision of all real estate interests necessary for the construction, operation, maintenance, repair, rehabilitation, and replacement of the project will be the responsibility of the City of Virginia Beach as the Non-Federal Sponsor for this project It is understood that the procurement of real estate interests may include acquiring or terminating existing oyster leases, acquiring permanent real estate interests from private and public property owners for wetlands restoration, and securing permanent easements over state-owned river bottoms to support the parts of the project involving submerged aquatic vegetation restoration, bay scallops reintroduction, and reef habitat creation.

Please be assured that the City of Virginia Beach has the legal authority, technical capability, and financial resources to acquire the necessary real estate interests. The City of Virginia Beach supports and fully intends to provide the necessary real estate interests for the project features identified in the recommended plan following the execution of a Project Partnership Agreement (PPA) for construction of the project.

Should the occasion arise, the City of Virginia Beach understands, acknowledges, and accepts the risks associated with acquiring any necessary real estate interests before the execution of the PPA and before the formal notice to proceed with real estate acquisition.

Please understand that this letter serves as an expression of intent and is not a contractual obligation and that either party may discontinue the effort at any stage before construction begins.

In closing, our relationship with the Corps of Engineers and the Norfolk District extends back through our entire 50-year history as the City of Virginia Beach. We have been the non-federal sponsor on a number of significant and important Civil Works projects. The provision of the required real estate has always been a non-federal responsibility, and I hope and trust a review of our past, and current, partnerships completely supports our capability statements herein.

We again would like to express our gratitude to the entire Corps of Engineers organization for bringing this project toward fruition.

Sincerely,

James K. Spore
City Manger

c: Honorable Mayor William D. Sessoms, Jr.
and Members of City Council
Mark Stiles, City Attorney

Comments on Lynnhaven Draft Feasibility Report and Integrated Environmental Assessment Released for Public Review April 26 – May 26

Comments on the Draft Feasibility Study and Integrated EA were received from only two external organization, the Virginia Institute of Marine Science (VIMS) and the Virginia Marine Resource Commission. VIMS sent two letters – after the first was received, the Norfolk District PDT met with VIMS to discuss their concerns. VIMS then sent a second letter based on that discussion. The comments in those letters are summarized below along with District response.

Commenter: VIMS #1
Although the objectives expressed in the Report are commendable, our review has revealed shortcomings in the proposed strategies that could significantly compromise the project's success.

USACE RESPONSE 1: Based on these concerns, USACE and VIMS had a meeting on May 31st at VIMS. We appreciate the discussion with VIMS scientists, and look forward to working together as we move forward into PED. We received e follow-on letter dated 20 June 2013 which provides specific paths forward for the identified issues, as well as the statement "VIMS supports these types of focused efforts and we support the Norfolk District's desire to enhance the Lynhaven River Basin." USACE discusses each concern in more detail in the comments and responses below, and believes that the majority of the issues are addressed through a combination of adaptive management, some revisions to the report that have occurred, and a continued commitment to seek the guidance of VIMS on technical issues as we move forward.

Commenter: VIMS #1
Though the Report states that water quality improvement is not a primary objective of this project, much of the rationale for the proposed activities described in sections 3 & 4 appears to be based upon presumed water quality benefits resulting from these activities. It is important for all stakeholder groups to understand that, even if complete success were achieved for all elements of the proposal, the enhanced resources likely will contribute little in addressing the required total maximum daily loads (TMDL) nutrient reductions in the Lynnhaven watershed.

USACE RESPONSE 2: Based on this comment as well as our internal USACE review, the discussion of water quality has been adjusted significantly so that it is very clear that this project was not formulated for water quality improvements. The locality is entirely responsible for required water quality improvements through separate projects and programs. However, incidental water quality benefits are anticipated as a result of the project.

Commenter: VIMS #1
In summary, we conclude that the proposed projects have a low likelihood of successfully achieving the stated objectives for the following reasons.

> Existing water quality conditions and future sea level and water temperature scenarios do not favor the establishment, proliferation, and stability of submerged aquatic vegetation (SAV). This ultimately compromises the objective of establishing healthy populations of bay scallops, which depend on SAV beds for nursery areas.

USACE RESPONSE 3: USACE disagrees that the required water quality conditions and temperature do not favor SAV establishment, proliferation and stability. SAV has been abundant in the Lynnhaven at many times, and is currently established in small pockets in the Lynnhaven, though not in large enough areas to develop a self-sustaining population. However, based on discussions with VIMS staff, the implementation and adaptive management plans will be adjusted to stagger the planting of the SAV and ensure that success criteria are being met for several years before scallops are attempted.

> **COMMENT:** Given the ephemeral nature of Ruppia maritima and high inter-annual variability in persistence of newly established Zostera marina beds, we strongly recommend that bay scallop restoration not be initiated until large SAV beds dominated by eelgrass show 3-5 years of sustained presence at healthy densities.

USACE RESPONSE 4: The implementation and adaptive management plans have been adjusted to reflect a sustained presence of SAV before scallops are introduced. For the SAV and scallops, pilot programs (test plots) will be implemented, as suggested, before larger-scale restoration is attempted.

> **COMMENT:** Most notably, bay scallop introduction/restoration is a very young science in Virginia, and without large native populations from which to harvest and transplant there are significant supply issues that have not been addressed in the Report, including the acquisition and maintenance of broodstock with sufficient genetic diversity, quarantine facilities for holding spawning stocks brought from other regions (which can contain epibionts not native to Virginia), and the production facilities for producing the 100's of thousands, if not millions, of scallops that will likely be required to establish a self-sustaining population.

USACE RESPONSE 5: Noted. USACE concurs that such a large-scale restoration will indeed inherently have supply concerns. This has already been considered in the cost estimates and risk assessments, and will continue to be a consideration as the project moves forward into PED.

> **COMMENT:** The Report proposes the planting of eelgrass (Zostera marina) and widgeongrass (Ruppia maritima) seeds. While VIMS faculty and staff have significant understanding of the requirements for restoring eelgrass, very little is known for widgeongrass.

USACE RESPONSE 6: Noted. However, there are benefits to including several potential types of grasses, and the adaptive management plan will allow the project to adjust based on the success of each species at various locations.

> **COMMENT:** The transformation of intertidal salt marshes from common reed (Phragmites australis) to native Bay marsh species that primarily includes saltmarsh cordgrass (Spartina alterniflora) will likely not result in enhanced ecosystem function and may result in short-term loss of ecosystem function. Left alone these areas will surely undergo natural progression to dominance by saltmarsh cordgrass over time due to sea level rise.

USACE RESPONSE 7: There is differing opinions in the scientific communities on the benefits and detriments of phragmites. USACE feels confident in the phragmites eradication plan and has calculated the benefits and feels strongly that this is an appropriate restoration technique.

> **COMMENT:** Reefs are proposed to be constructed using expansive applications of formed concrete and the accompanying assumption that natural fouling, especially by oysters, will create unique Essential Fish Habitat (EFH). Neither the proposed locations nor densities of the reefs were established with the aid of existing hydrodynamic and water quality models developed specifically for the Lynnhaven River and thus may not be positioned for the optimum development of reef communities, including oysters.

USACE RESPONSE 8: We do not concur with this comment. The reefs were placed using results from several previous model runs, although it is true that only limited model runs were completed (due to funding constraints). Also, the locations of all measures were also dependent on available bottom as well as appropriate substrate and hydrodynamics. As stated previously, USACE will continue to work with VIMS as we move forward into implementation.

Commenter: VIMS #1

The management approach described in the Report is not an iterative process that builds on the monitoring information base, but rather assesses the outcomes of the monitoring and relies on the lone strategy of moving the activities to another location in the watershed if monitoring data do not meet expectations. The aggressive approach outlined in the Report has an overall low likelihood of success. It is our collective opinion that an adaptive management strategy should be considered in which the chosen, or alternative, actions of the project are initiated on smaller scales over longer timeframes, and are either increased in stages, altered, or even abandoned based on monitoring data that address specific questions and issues.

USACE RESPONSE 9: Based on this and other comments, the adaptive management and implementation plans have been modified. The adaptive management has been expanded, and includes pilot studies (test plots) to try small-scale implementation before large-scale restoration is established.

Commenter: VIMS #2
First, I would like to thank you for the opportunity to discuss the Lynnhaven Report and our comments in greater detail with you and your staff on May 31st. The conversations were productive in helping us better understand the flexibility that you have at later stages to modify the design details and employ adaptive management.

USACE RESPONSE 10: We found the meeting to be very productive and appreciate the VIMS staff taking the time to meet with USACE on this important project. We look forward to continuing to work together as we move towards implementation.

Commenter: VIMS #2
It is our opinion that if you are able to implement the SAV restoration in a manner consistent with our discussions, your likelihood of success with this phase of the project will be substantially enhanced. Specifically, we recommend (1) that site selection be driven by current water quality, depth and bottom conditions and (2) that small test plots be established initially to validate survival for a full year prior to larger scale seeding of an area. Concurrent monitoring of water quality at the test plot sites would provide valuable insights into to the conditions responsible for the success or failure of individual plots.

USACE RESPONSE 11: We will be doing pilot studies (test plots) before large scale restoration is attempted. We cannot do water quality monitoring, as that is a responsibility of the locality, but we will use available water quality monitoring data. The site selection was based on appropriate substrate, depth, hydrodynamics and available bottom. We will continue to use the best available information, as well as seek advice from VIMS, as we move forward towards implementation.

Commenter: VIMS #2
We stand by our previous recommendation that bay scallop restoration not proceed until eelgrass beds have persisted for a minimum of 3 years and recommend, even in that case, that serious consideration be given to the scale of the grass beds that have been established. Though we do not know the minimum grass bed size required to support a sustainable population of bay scallops, it is clear that more than a few small patches will be necessary.

USACE RESPONSE 12: The implementation and adaptive management plan has been adjusted to allow for pilot studies of the measures as well as several years of successful SAV before scallops are initiated.

Commenter: VIMS #2
We do not question the technical feasibility of deploying reef balls or that oysters and other epibenthic organisms will attach to and grow on these structures. We recommend, however, that careful consideration be given to the specific ecosystem responses that are anticipated from this activity, how those differ from or enhance those resulting from the substantial amount of anthropogenic hard substrate already in the system, and how these specific responses will be measured.

USACE RESPONSE 13: Noted, however the stated desired end goal is an increase in secondary production. Some examples are noted in the report, but further identification of potential epibenthic organisms was not included in this study. USACE commits to continuing to discuss this topic with VIMS.

Commenter: VIMS #2
Watershed-scale restoration and enhancement efforts are an important part of Chesapeake Bay restoration and, if designed and implemented properly, can provide real and significant benefits to the littoral marine environment and the local watershed-based community. Our previous comments address only the feasibility of the proposed technical elements and should not be interpreted as a commentary on the project's intent or concept. VIMS supports these types of focused efforts and we support the Norfolk District's desire to enhance the Lynnhaven River basin. We are well aware that this is a broadly shared desire as evidenced by the strong community support for a healthier Lynnhaven River, which ultimately is critical to project acceptance, momentum, and success.

USACE RESPONSE 14: Thank you and we look forward to continuing to coordinate with you on this important project.

Commenter: VMRC

Any proposal to impact, encroach, fill, or dredge such submerged bottomlands must first garner an exemption or permit from the Commission. For every permit request the Commisssion reviews the proposal and attempts to identify potential benefits and detriments for the marine resource and the public utilizing and enjoying such resource.

USACE RESPONSE 15: Noted. We look forward to coordinating with VMRC on this project.

Commenter: VMRC
The proposal to install concrete oyster reefs and establish SAV habitat areas in various areas of the Lynnhaven system may conflict with current shellfish-lease activities, as most of the lower Lynnhaven system is currently leased for commercial shellfish production. Any such request to impact existing leases will require a notification to the record leaseholder(s), and confirmation that they agree with the proposal on their lease. Although it may be legally possible for the locality to acquire or condemn existing private leases for governmental purposes, it is unclear at this time if the City of Virginia Beach will support such initiatives for the "restorative" purposes identified in this study.

USACE RESPONSE 16: Noted. We look forward to working with VMRC on this project. The City of Virginia Beach does support restoration initiatives, as evidenced by their letter of support and their continued partnership on all aspects of this project.

Commenter: VMRC
Along with your proposed SAV habitat areas, you have proposed to introduce scallops as a new marine species in the Lynnhaven. Notwithstanding the fact that the proposed SAV must succeed and thrive for a few growing seasons before scallops can be introduced, such a species introduction may raise additional management issues. Proposed SAV areas and future scallop production, although signs of a healthy ecosystem, may further limit existing shellfish aquaculture activities as well as public access to areas within the Lynnhaven system. The benefits and detriments of such a proposal will need to be ultimately weighed by the Commission before a permit decision can be reached.

USACE RESPONSE 17: The Bay Scallop is a re-introduction in the Lynnhaven, as there is evidence that it was historically present. VMRC staff has been and will continue to be a member of the project steering committee, and it is anticipated that any concerns will be brought about first through this venue. USACE looks forward to working with VMRC on this project as it moves forward.

Commenter: VMRC
We note that VIMS has pointed out several items of concern with the overall projected success of the concrete reefs, SAV, and even scallop populations.

USACE RESPONSE 18: Please see USACE Response #14 above. VIMS and USACE held a meeting on May 31, 2013 and talked though many of the issues. Although VIMS still has concerns with some portions of the proposal, USACE has adjusted the implementation and adaptive management plans to help reduce the risk on some of these project features. In addition, many of the recommendations by VIMS can be considered and incorporated as appropriate during the PED stage.

20 May, 2013

Janet Cote
Ecologist
US Army Corps of Engineers
Norfolk District
Planning and Policy Branch
803 Front Street
Norfolk, VA 23510-1096

Dear Ms. Cote:

This letter communicates the collective analysis of the *Lynnhaven River Basin Ecosystem Restoration Draft Feasibility Report and Integrated Environmental Assessment* (the Report) by faculty and staff of the Virginia Institute of Marine Science (VIMS). The Report outlines an ambitious plan to establish stable and sustainable populations of native estuarine fishery and vegetation resources that could provide beneficial ecosystem services towards improved estuarine habitat and water quality. VIMS' long history of comprehensive research and resource management experience in the greater Chesapeake Bay region includes long-term and continuing attention specific to the Lynnhaven watershed, which began with water quality surveys requested by the State Water Control Board in 1961. We trust that the following observations and comments can add value to the objectives and approaches proposed in the Report.

Although the objectives expressed in the Report are commendable, our review has revealed shortcomings in the proposed strategies that could significantly compromise the project's success. Though the Report states that water quality improvement is not a primary objective of this project, much of the rationale for the proposed activities described in sections 3 & 4 appears to be based upon presumed water quality benefits resulting from these activities. It is important for all stakeholder groups to understand that, even if complete success were achieved for all elements of the proposal, the enhanced resources likely will contribute little in addressing the required total maximum daily loads (TMDL) nutrient reductions in the Lynnhaven watershed. In summary, we conclude that the proposed projects have a low likelihood of successfully achieving the stated objectives for the following reasons. Existing water quality conditions and future sea level and water temperature scenarios do not favor the establishment, proliferation, and stability of submerged aquatic vegetation (SAV). This ultimately compromises the objective of establishing healthy populations of bay scallops, which depend on SAV beds for nursery areas. The transformation of intertidal salt marshes from common reed (*Phragmites australis*) to native Bay marsh species that primarily includes saltmarsh cordgrass (*Spartina alterniflora*) will likely not result in enhanced ecosystem function and may result in short-term loss of ecosystem function. Left alone these areas will surely undergo natural progression to dominance by saltmarsh cordgrass over time due to sea level rise. Reefs are proposed to be constructed using expansive applications of formed concrete and the accompanying assumption that natural fouling, especially by oysters, will create unique Essential Fish Habitat (EFH). Neither the proposed locations nor densities of the reefs were established with the aid of existing hydrodynamic and water quality models developed specifically for the Lynnhaven River and thus may not be positioned for the optimum development of reef communities, including oysters. A more detailed synopsis of our analyses follows.

Submerged Aquatic Vegetation

VIMS' continuing involvement in SAV transplanting/restoration (Orth *et al*. 2010, Orth *et al*. 2012) began in 1978, and Bay-wide SAV distribution has been monitored by VIMS since 1984 (http://web.vims.edu/bio/sav/index.html). Additionally, VIMS faculty and staff were principal contributors in the development of Virginia's water quality standards for water clarity, which are based on habitat requirements for SAV. Based on our collective experience we are well aware of the challenges associated with maintaining current SAV resources, and establishing new sustainable populations. Indeed, there are few successful SAV restorations in Chesapeake Bay relative to the number and scale of attempts, which suggests that any attempt to establish SAV should be approached carefully and with buffered expectations. These expectations should especially be considered with respect to sea level rise and increasing water temperatures in the mid-Atlantic region and Chesapeake Bay. The Report proposes the planting of eelgrass (*Zostera marina*) and widgeongrass (*Ruppia maritima*) seeds. While VIMS faculty and staff have significant understanding of the requirements for restoring eelgrass, very little is known for widgeongrass. Widgeongrass beds can undergo large annual changes in size and distribution (i.e. it is considered a "boom or bust" species) in Chesapeake Bay, including Broad Bay, as shown in the VIMS aerial surveys. Similar to eelgrass, widgeongrass has beneficial functions for water quality and habitat; however, it is entirely possible that widgeongrass could show initial success followed by large-scale die-off with the likelihood of no return.

Water quality characteristics in many areas within the Lynnhaven system show significant challenges for SAV. Our annual monitoring has never shown SAV to occur in the Lynnhaven River. Modest yet declining populations have been observed in Broad Bay since 1984, and VIMS' monitoring (http://web.vims.edu/bio/sav/SegmentAreaChart.htm) shows a maximum of approximately 110 acres in 1986 and 1994. These data suggest that habitat requirements for SAV are not now being met in many areas throughout this system. The Report appears to overestimate the existing habitat conditions relative to SAV success, and we do not agree that the Lynnhaven system currently shows similarities in habitat and water quality with the Virginia Coastal Bays where we have restored approximately 4,800 acres of eelgrass. The target sites for SAV establishment were based on bottom condition and a 1971 aerial survey unknown to VIMS faculty and staff that sets the amount of SAV in the Lynnhaven watershed at 175 acres. A hydrodynamic model was referenced to infer seed dispersal and bed spreading once populations were established. Bottom conditions and historical abundance and distribution have been used to guide past SAV restoration efforts with marginal success. Moreover, we note that two of the largest areas identified in Broad Bay for SAV transplanting appear to be in water depths too deep to support SAV. If the decision is made to move forward with SAV restoration, we strongly recommend that an emphasis be placed on monitoring SAV habitat requirements during the growing season for several years prior to seeding or transplanting. Should these data show that suitable habitat requirements exist, we then recommend that small-scale restoration efforts be undertaken with success determined as survival of plants for a minimum of two years. Larger-scale efforts can then be planned with greater confidence of success and return on investment.

Bay Scallops

We note that the Report states that “successful reintroduction of bay scallops to the Lynnhaven River is highly dependent on the establishment of robust seagrass beds within the project area” (pp. 74-75) and we concur. While the bay scallop has been found to exploit habitats other than SAV beds (Carroll *et al*. 2010, Cordero *et al*. 2012, Carroll *et al*. 2013), these are not preferred habitats and are unlikely to support the Report objective of establishing a sustainable scallop population. We further note that the Report indicates that scallop restoration will not be initiated “until a minimum of one year after SAV restoration begins” (p. *v*). Given the ephemeral nature of *Ruppia maritima* and high inter-annual variability in persistence of newly established *Zostera marina* beds, we strongly recommend that bay scallop restoration not be initiated until large SAV beds dominated by eelgrass show 3-5 years of sustained presence at healthy densities. Even without the compounded risk of establishing sustainable SAV beds at a scale that can support bay scallop habitat requirements, the attempt to introduce and create a sustainable population of bay scallops carries its own inherent risks. Most notably, bay scallop introduction/restoration is a very young science in Virginia, and without large native populations from which to harvest and transplant there are significant supply issues that have not been addressed in the Report, including the acquisition and maintenance of broodstock with sufficient genetic diversity, quarantine facilities for holding spawning stocks brought from other regions (which can contain epibionts not native to Virginia), and the production facilities for producing the 100’s of thousands, if not millions, of scallops that will likely be required to establish a self-sustaining population.

Wetlands Restoration

The Report’s objective of restoring the function of vegetated tidal wetlands through eradication of common reed (*Phragmites australis*) and establishing vegetative diversity with plants native to Chesapeake Bay marshes is problematic and may not provide the desired return on investment. Primarily, common reed has been demonstrated to have numerous ecosystem service benefits that approach the functional levels of the tidal marsh vegetation native to Chesapeake Bay (Wainwright *et al*. 2000, Weis *et al*. 2002, Weiss and Weis 2001, Windham *et al*. 2001, 2003, Windham & Meyerson 2003, Yuhas *et al*. 2005, Hershner & Havens 2008). Therefore, it is highly likely that substrate removal will degrade, or eliminate, ecosystem services for an extended period of time, with no certainty that the replacement community will provide significantly enhanced functions. Lowering the elevation of the marsh substrate will certainly reduce the habitat suitability for common reed, but VIMS faculty and staff are aware of no evidence that suggests physical modification of the supporting substrate alone results in effective eradication, especially since the roots and rhizomes of common reed can extend meters below the soil surface (Haslam 1971). There is evidence that an introduction of sulfides (i.e. enhanced saltwater input) in conjunction with reductions in marsh elevation prohibits re-colonization by common reed, but this may be impracticable at the target sites. If removal of the road culverts responsible for limiting the tidal exchange at two of the sites would increase salinity and tidal exchange, then we recommend revisiting this option. Without an increase in salinity to complement lowering the marsh elevation, there is an increased probability that common reed will reestablish over a few growing seasons.

The targeted sites are expected to be inundated under normal high tide conditions by the year 2040 (Berman and Berquist 2009), thus there is a high probability that marshes dominated by common reed will convert to saltmarsh cordgrass due to the respective changes in habitat suitability. An alternative strategy that recognizes and utilizes inevitable sea level rise, provides flexibility in dealing with marshes dominated by common reed, and also addresses the desire to increase the ecosystem services provided by native tidal marshes is the acquisition of upland open spaces at marsh margins to allow retreat. We recommend consideration of this strategy to replace or complement the proposed approach.

Essential Fish Habitat

The Report proposes large-scale placement of concrete structures (commonly known as "reef balls") in varying water depths to promote the establishment of reef habitat. Reef balls and other materials have been used in numerous places throughout Virginia's portion of Chesapeake Bay with the intent of providing three-dimensional substrate for oyster settlement. Varying degrees of success have been realized from these efforts. The scale of this plan element is large and the Report does not sufficiently address what communities are targeted for restoration with these structures. However, if a primary intent of reef creation is to facilitate sustainable oyster habitat and not merely to provide three-dimensional habitat for nekton, then these structures should be located in a manner that takes advantage of flow patterns that can optimize the dispersal, recruitment and interconnectivity of the reefs. The proposed placement may be sub-optimal since the selection of these sites was not guided by the hydrodynamic and water quality models that were developed specific to the Lynnhaven system. We recommend completing this exercise and adjusting the locations accordingly. Alternative structures should also be considered since reef balls were originally designed to mimic coral reef habitats and are not the most realistic mimic of temperate oyster reefs and structured habitats. Depending on the objectives of this element of the plan, there are numerous structures of various materials and designs available that can address a range of intended outcomes. Native oyster shell should also be a candidate material. We further recommend, as discussed below, that the scale and aggressiveness of this plan element be revisited and planned in an appropriate adaptive management framework incorporating a staged approach. Related to adaptive management and monitoring, the Report appears unclear regarding the success criteria for this plan element. Success criteria should be developed, and a removal plan should be incorporated into the Report in the event of failure.

Promoting Future Success

Successful establishment/enhancement/restoration requires robust supporting monitoring and an adaptive management structure committed to success. Projected annual monitoring costs presented in the Report are approximately $140,000 for the first five years, $64,000 for the next five years, and $10,000 for the next 40 years. These are dispersed amongst EFH, SAV, bay scallops, and wetland restoration sites with varying monitoring timeframes. We are unable to determine if these levels are sufficient; however, the monitoring timeframes assume an immediacy in resource establishment and function that is highly unlikely. Robust monitoring is necessary for all scales of ecosystem enhancement and restoration, especially at the large scale proposed for the Lynnhaven system. Monitoring should be designed to support an adaptive management strategy. We also are unable to determine whether or not the resources available for monitoring support the proposed approach since we do not view the proposed management approach as truly adaptive. The management approach described in the Report is not an iterative process that builds on the monitoring information base, but rather assesses the outcomes of the monitoring and relies on the lone strategy of moving the activities to another location in the watershed if monitoring data do not meet expectations. The aggressive approach outlined in the Report has an overall low likelihood of success. It is our collective opinion that an adaptive management strategy should be considered in which the chosen, or alternative, actions of the project are initiated on smaller scales over longer timeframes, and are either increased in stages, altered, or even abandoned based on monitoring data that address specific questions and issues.

Thank you for allowing VIMS the opportunity to provide comments. VIMS faculty and staff share in the desire to see improvement in Chesapeake Bay watersheds and offer to contribute our expertise in the Lynnhaven and other watersheds of concern as a partner with the Norfolk District Corps of Engineers.

Sincerely,

Mark Luckenbach

Dr. Mark Luckenbach
Associate Dean of Research
& Advisory Services

References

Berman M. and H. Berquist. 2009. The effects of sea level rise on tidal wetlands in the Lynnhaven River watershed. Virginia Institute of Marine Science, School of Marine Science, College of William and Mary, Gloucester Point, VA. 63 pp.

Carroll, J. M., Peterson, B. J., Bonal, D., Weinstock, A., Smith, C. F., & Tettelbach, S. T. (2010). Comparative survival of bay scallops in eelgrass and the introduced alga, *Codium fragile*, in a New York estuary. *Marine Biology*, *157*(2), 249-259.

Carroll, J. M., & Peterson, B. J. (2013). Comparisons in demographic rates of bay scallops in eelgrass and the introduced alga, *Codium fragile*, in New York. *Marine Biology*, 1-13.

Cordero, A. L. H., Seitz, R. D., Lipcius, R. N., Bovery, C. M., & Schulte, D. M. (2012). Habitat affects survival of translocated bay scallops, *Argopecten irradians concentricus* (Say 1822), in lower Chesapeake Bay. *Estuaries and Coasts*, *35*(5), 1340-1345.

Haslam, S.M. 1971. Community regulation in *Phragmites communis* Trin.: Monodominant stands. Journal of Ecology 59(1): 65-73.

Hershner, C. and K. J. Havens. 2008. Managing invasive aquatic plants in a changing system: Strategic consideration of ecosystem services. Conservation Biology 22(3): 544-550.

Orth, R.J., S.R. Marion, K.A. Moore, D. J. Wilcox. 2010. Eelgrass (*Zostera marina* L.) in the Chesapeake Bay Region of Mid-Atlantic Coast of the USA: Challenges in Conservation and Restoration. Estuaries and Coasts 33:139-150.

Orth, R. J., K. A. Moore S. R. Marion, D. J. Wilcox, and D.B. Parrish. 2012. Seed addition facilitates eelgrass recovery in a coastal bay system. Marine Ecology Progress Series 448:177-195.

Wainwright, S., M. Weinstein, K. Able and C. Currin. 2000. Relative importance of benthic microalgae, phytoplankton and the detritus of smooth cordgrass *Spartina alterniflora* and the common reed *Phragmites australis* to brackish-marsh food web. Mar. Ecol. Prog. Ser. 200:77-91.

Weis, J.S. and P. Weis. 2001. Behavorial responses and interactions of three animals with an invasive marsh plant: a laboratory analysis. Biol. Invasions: 2: 305-314.

Weis, J.S., L. Windham and P. Weis. 2002. Growth, survival and metal content in marsh invertebrates fed diets of detritus from *Spartina alterniflora* and *Phragmites australis* from metal-polluted and clean sites. Wetlands Ecology and Management 10: 71-84.

Windham, L. J.S. Weis and P. Weis. 2001. Patterns and processes of mercury release from leaves of two dominant salt marsh macrophytes, *Phragmites australis* and *Spartina alterniflora*. Estuaries 24: 787-795.

Windham, L. and L. Meyerson. 2003. Impacts of *Phragmites australis* expansions on nitrogen dynamics of tidal marshes. Estuaries 26: 452-464.

Windham, L. J.S. Weiss and P. Weis. 2003. Uptake and distribution of metals in two dominant salt marsh macrophytes, *Spartina alterniflora* (cordgrass) and *Phragmites australis* (common reed). Estuarine and Coastal Shelf Science 56:63-72.

Yuhas, C., J.M. Hartman and J.S. Weis. 2005. Benthic communities associated with *Spartina alterniflora* and *Phragmites australis* in the Hackensack Meadowlands of NJ. Urban Habitats 31: 158-191.

VIMS | WILLIAM & MARY
VIRGINIA INSTITUTE OF MARINE SCIENCE

20 June 2013

Gregory C. Steele, P.E.
Chief, Planning and Policy
US Army Corps of Engineers
Norfolk District
803 Front Street
Norfolk, VA 23510-1096

Dear Mr. Steele:

This letter supplements, but does not replace, the May 20th, 2013 comments by the Virginia Institute of Marine Science (VIMS) regarding the *Lynnhaven River Basin Ecosystem Restoration Draft Feasibility Report and Integrated Environmental Assessment*.

First, I would like to thank you for the opportunity to discuss the Lynnhaven Report and our comments in greater detail with you and your staff on May 31st. The conversations were productive in helping us better understand the flexibility that you have at later stages to modify the design details and employ adaptive management. It is my hope that they were equally helpful to you and your staff in recognizing our willingness to provide technical expertise to assist you in the design and implementation of the project.

It is our opinion that if you are able to implement the SAV restoration in a manner consistent with our discussions, your likelihood of success with this phase of the project will be substantially enhanced. Specifically, we recommend (1) that site selection be driven by current water quality, depth and bottom conditions and (2) that small test plots be established initially to validate survival for a full year prior to larger scale seeding of an area. Concurrent monitoring of water quality at the test plot sites would provide valuable insights into to the conditions responsible for the success or failure of individual plots.

We stand by our previous recommendation that bay scallop restoration not proceed until eelgrass beds have persisted for a minimum of 3 years and recommend, even in that case, that serious consideration be given to the scale of the grass beds that have been established. Though we do not know the minimum grass bed size required to support a sustainable population of bay scallops, it is clear that more than a few small patches will be necessary. I reiterate our willingness to provide technical assistance with the acquisition of broodstock and the rearing of scallops once you reach that phase in the project.

As discussed in our meeting, there are alternative approaches to wetlands enhancement and diversification that are likely within your range of design options in the next phase of this process. Our wetlands scientists are willing to assist your team on this in the design and implementation phases of this element of the plan.

We do not question the technical feasibility of deploying reef balls or that oysters and other epibenthic organisms will attach to and grow on these structures. We recommend, however, that careful consideration be given to the specific ecosystem responses that are anticipated from this activity, how those differ from or enhance those resulting from the substantial amount of anthropogenic hard substrate already in the system, and how these specific responses will be measured.

Watershed-scale restoration and enhancement efforts are an important part of Chesapeake Bay restoration and, if designed and implemented properly, can provide real and significant benefits to the littoral marine environment and the local watershed-based community. Our previous comments address only the feasibility of the proposed technical elements and should not be interpreted as a commentary on the project's intent or concept. VIMS supports these types of focused efforts and we support the Norfolk District's desire to enhance the Lynnhaven River basin. We are well aware that this is a broadly shared desire as evidenced by the strong community support for a healthier Lynnhaven River, which ultimately is critical to project acceptance, momentum, and success.

As stated in our previous comments, we look forward to working with the Norfolk District and the City of Virginia Beach in applying the principles of sound science to this project.

Sincerely,

Mark Luckenbach

Dr. Mark Luckenbach
Associate Dean of Research
& Advisory Services

Cc: Mr. Tony Watkinson, Chief, Habitat Management, VMRC
Mr. Clay, Administrator, Environment and Sustainability Office, City of Virginia Beach

PO Box 1346 • 1375 Greate Road • Gloucester Point, Virginia 23062-1346 USA
804.684.7000 • FAX 804.684.7097 • www.vims.edu

COMMONWEALTH *of* VIRGINIA

Marine Resources Commission

2600 Washington Avenue
Third Floor
Newport News, Virginia 23607

Douglas W. Domenech
Secretary of Natural Resources

Jack G. Travelstead
Commissioner

May 24, 2013

Janet Cote
Ecologist
US Army Corps of Engineers
Norfolk District
Planning and Policy Branch
803 Front Street
Norfolk, VA 23510-1096

Re: Lynnhaven River Basin Ecosystem Restoration Feasibility Study

Dear Ms. Cote:

Thank you for the opportunity to comment on the Corps' study to help restore the Lynnhaven River Ecosystem within the City of Virginia Beach. As you know, in accordance with Chapter 12 of Section 28.2 of the Code of Virginia, all of the submerged bottomlands of the Lynnhaven system channelward of the mean low water mark remain the property of the Commonwealth, and therefore fall under the regulatory jurisdiction of the Virginia Marine Resources Commission (Commission). Any proposal to impact, encroach, fill, or dredge such submerged bottomlands must first garner an exemption or permit from the Commission. For every permit request the Commission reviews the proposal and attempts to identify potential benefits and detriments for the marine resource and the public utilizing and enjoying such resource. As in any application, the specific goal and purpose of the proposal must be clearly identified. When Commission permits are required, a public interest review is undertaken, including specific agency requests for comments and questions. For the purpose of this response, I would like to focus on a few of the Study's proposals which will eventually require the submittal of Joint Permit Applications and the issuance of Commission permits.

The proposal to install concrete oyster reefs and establish SAV habitat areas in various areas of the Lynnhaven system may conflict with current shellfish-lease activities, as most of the lower Lynnhaven system is currently leased for commercial shellfish production. Any such request to impact existing leases will require a notification to the record leaseholder(s), and confirmation that they agree with the proposal on their lease. Although it may be legally possible for the locality to acquire or condemn existing private leases for governmental purposes, it is unclear at this time if the City of Virginia Beach will support such initiatives for the "restorative" purposes identified in this study.

Along with your proposed SAV habitat areas, you have proposed to introduce scallops as a new marine species in the Lynnhaven. Notwithstanding the fact that the proposed SAV must succeed and thrive for a few growing seasons before scallops can be introduced, such a species introduction may raise additional management issues. Proposed SAV areas and future scallop production, although signs of a healthy ecosystem, may further limit other existing shellfish aquaculture activities as well as public access to areas within the Lynnhaven system. The benefits and detriments of such a proposal will need to be ultimately weighed by the Commission before a permit decision can be reached. Overall, the Corps and City, as well as all participating regulatory agencies, should expect several questions and possibly even protests to components of the overall proposal. These questions and protests may come from a variety of sources such as commercial waterman, riparian property owners, waterfront businesses and contractors, and even other regulatory agencies and governmental representatives.

As is the case for any large restoration proposal, we all benefit from the involvement and recommendations provided by our scientific experts with the Virginia Institute of Marine Science (VIMS). Setting aside our specific and mandatory permit requirements for the Joint Permit Application process, we have carefully reviewed VIMS'overall comments regarding the proposed restoration efforts. We note that VIMS has pointed out several items of concern with the overall projected success of the concrete reefs, SAV, and even scallop populations. While we do not want to discourage you or the City in any way from proposing restorative initiatives, we think you should carefully consider the expert advice provided by VIMS, an institute with a long and well-documented history of scientific research within the Lynnhaven system. It also should be pointed out that quite often the Commission relies upon VIMS for advice and guidance when it comes to permitting decisions. The Corps and the City, and any other applicant for that matter, may certainly apply for any use of State-owned submerged bottomlands, however the full Commission will no doubt give great weight to the advice and guidance from VIMS.

As for the proposed wetlands restoration sites identified in the study, provided that all efforts and impacts occur on City-owned or leased wetlands, the City's Wetlands Board will not need to hear and permit the projects. You will need to work closely with the City's Wetlands Board Staff to ensure that your proposals qualify for local exemptions. We will provide oversight assistance to the City, however, they will make final decisions regarding local jurisdiction.

Again, thank you for the opportunity to provide comments on the Corps' proposal. If you or anyone from the City has questions regarding these comments or the Commission's jurisdiction and permitting responsibilities, please feel free to contact us.

Sincerely,

Tony Watkinson

Tony Watkinson
Chief, Habitat Management

TW/jdw:and
HM

cc: Jack Travelstead, Commissioner
Rob O'Reily, Chief, Fisheries Management
Clay Bernick, City of Virginia Beach
B. Kay Wilson, City of Virginia Beach
Steve McLaughlin, City of Virginia Beach
Mark Luckenbach, VIMS
Virginia Department of Health – Shellfish

Cote, Janet NAO

From: Rudnick, Barbara [Rudnick.Barbara@epa.gov]
Sent: Tuesday, September 03, 2013 11:36 AM
To: Cote, Janet NAO
Cc: Magerr, Kevin; Petrow, Carol; Poeske, Regina; Martinsen, Jessica
Subject: [EXTERNAL] RE: US Army Corps of Engineers_Lynnhaven River Basin Ecosystem Restoration_Public Review Period (UNCLASSIFIED)

Janet,

Thank you for your inquiry about EPA's interest in reviewing the plans for the Lynnhaven Ecosystem restoration project. As you are aware, EPA is often not able to review EAs as they come in, based on work load. We did not have a chance to review this project when it was forwarded to us in spring. I am forwarding it to EPA staff to see if they would like to review the action, and as the project develops, provide insight or recommendations, as time allows.

Thank you for reaching out to EPA.

Regards,
Barbara

Barbara Rudnick, P.G.
NEPA Team Leader
EPA Region III
1650 Arch Street (3EA30)
Philadelphia, PA 19103
215-814-3322

-----Original Message-----
From: Cote, Janet NAO [mailto:Janet.Cote@usace.army.mil]
Sent: Tuesday, May 21, 2013 3:04 PM
To: mike_barbachem@urscorp.com; jbarney@barneyenvironmental.com; cbernick@vbgov.com; donnab@vims.edu; JCARLOCK@hrpdcva.gov; ddauer@odu.edu; sdrzal@vbgov.com; kforget@lynnhaven2007.com; noah.hill@dcr.virginia.gov; sumalee_hoskin@fws.gov; jshowell@deq.virginia.gov; JTRIBO@hrpdcva.gov; bjohnsto@vbgov.com; kuo@vims.edu; smclaugh@vbgov.com; jsmcpher@vbgov.com; david.l.o'brien@noaa.gov; walter.priest@noaa.gov; proehrs@vbgov.com; sisson@vims.edu; keith.skiles@vdh.virginia.gov; Dan.Horne@vdh.virginia.gov; jwaller@vbgov.com; justin.worrell@mrc.virginia.gov; Rudnick, Barbara; mason@vims.edu; emily@vims.edu; lyle@vims.edu; DiPasquale, Nicholas; john.thomas@mail.house.gov; Caitlin_Runyan@warner.senate.gov; andrea_trotter@kaine.senate.gov; Justin.Worrell@mrc.virginia.gov
Subject: US Army Corps of Engineers_Lynnhaven River Basin Ecosystem Restoration_Public Review Period (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Good Afternoon,

As a reminder, the public Review Period for the Lynnhaven River Basin Ecosystem Restoration Study will be ending on May 26th, 2013. Please provide any comments, please to Ms. Janet Cote of the U.S. Army Corps of Engineers, Norfolk District, at:

LynnhavenRiver.BasinRestorationProject@usace.army.mil

The feasibility report, EA and appendices can be viewed at:
http://www.nao.usace.army.mil/Missions/CivilWorks/LynnhavenRiverBasinStudy.aspx

Thank you,

Janet Cote
Ecologist
US Army Corps of Engineers
Norfolk District
Planning and Policy Branch
803 Front Street
Norfolk, VA 23510-1096
757-201-7837

Classification: UNCLASSIFIED
Caveats: NONE

Cote, Janet NAO

From: Christine Vaccaro - NOAA Federal [christine.vaccaro@noaa.gov]
Sent: Tuesday, August 27, 2013 4:06 PM
To: Cote, Janet NAO
Subject: [EXTERNAL] Re: Lynnhaven River Basin Ecosystem Restoration Study (UNCLASSIFIED)

Hi Janet,
No problem. Based on the nature of and location of the project, we do not expect any species listed under the ESA by NMFS to be affected by the project. We have no objections to the ACOE making a "no effect" determination.

-Chris

Chris Vaccaro
Fisheries Biologist
Protected Resources Division
NOAA Fisheries/NERO
Gloucester, MA
Phone: 978-281-9167
Email: christine.vaccaro@noaa.gov

On Tue, Aug 27, 2013 at 4:02 PM, Cote, Janet NAO <Janet.Cote@usace.army.mil> wrote:

Classification: UNCLASSIFIED
Caveats: NONE

Chris,

Thanks for taking the time this afternoon to discuss ESA coordination with regards to the Lynnhaven River Basin Ecosystem Restoration Study. I have attached a map of the project area and the executive summary USACE had determined that the plan will have no significant impact on the marine threatened and endangered species that may be present in the project area.

Thanks,
Janet

Janet Cote
Ecologist
US Army Corps of Engineers
Norfolk District
Planning and Policy Branch
803 Front Street
Norfolk, VA 23510-1096
757-201-7837

Classification: UNCLASSIFIED
Caveats: NONE

Appendix G
Chesapeake Bay References
Executive Order 13508:
Chesapeake Bay Protection and Restoration

Chesapeake Bay References

Chesapeake Bay Program: http://www.chesapeakebay.net/about
The Chesapeake Bay Program is a unique regional partnership that has led and directed the restoration of the Chesapeake Bay since 1983. The Chesapeake Bay Program partners include the states of Maryland, Pennsylvania and Virginia; the District of Columbia; the Chesapeake Bay Commission, a tri-state legislative body; the Environmental Protection Agency, representing the federal government; and participating citizen advisory groups. For more, visit our overview of the Chesapeake Bay Program.

Chesapeake Bay Foundation: http://www.cbf.org/
Saving the Bay through education, advocacy, litigation, and restoration.

Chesapeake 2000, Chesapeake Bay Agreement:
http://www.epa.gov/region03/chesapeake/grants/2013Guidance/Attachment1_Chesapeake_2000_Agreement.pdf

Chesapeake Bay Protection and Restoration, Executive Order 13508:
http://executiveorder.chesapeakebay.net/default.aspx
On May 12, 2009, President Barack Obama signed an Executive Order that recognizes the Chesapeake Bay as a national treasure and calls on the federal government to lead a renewed effort to restore and protect the nation's largest estuary and its watershed. The Chesapeake Bay Protection and Restoration Executive Order established a Federal Leadership Committee that will oversee the development and coordination of reporting, data management and other activities by agencies involved in Bay restoration. The committee will be chaired by the Administrator of the Environmental Protection Agency and include senior representatives from the departments of Agriculture, Commerce, Defense, Homeland Security, Interior, Transportation and others. Full text located in this Appendix. Links to documents supporting the Executive Order are below:

> Strategy for Protecting and Restoring the Chesapeake Bay Watershed:
> http://executiveorder.chesapeakebay.net/file.axd?file=2010%2f5%2fChesapeake+EO+Strategy%20.pdf
>
> 2013 Action Plan: http://executiveorder.chesapeakebay.net/EO_13508_FY13_Action_Plan.pdf
>
> 2012 Annual Progress Report:
> http://executiveorder.chesapeakebay.net/EO_13508_FY13_Action_Plan.pdf

THE WHITE HOUSE
Office of the Press Secretary
For Immediate Release May 12, 2009
EXECUTIVE ORDER

- - - - - - -

CHESAPEAKE BAY PROTECTION AND RESTORATION

By the authority vested in me as President by the Constitution and the laws of the United States of America and in furtherance of the purposes of the Clean Water Act of 1972, as amended (33 U.S.C. 1251 *et seq*.), and other laws, and to protect and restore the health, heritage, natural resources, and social and economic value of the Nation's largest estuarine ecosystem and the natural sustainability of its watershed, it is hereby ordered as follows:

PART 1 – PREAMBLE

The Chesapeake Bay is a national treasure constituting the largest estuary in the United States and one of the largest and most biologically productive estuaries in the world. The Federal Government has nationally significant assets in the Chesapeake Bay and its watershed in the form of public lands, facilities, military installations, parks, forests, wildlife refuges, monuments, and museums.

Despite significant efforts by Federal, State, and local governments and other interested parties, water pollution in the Chesapeake Bay prevents the attainment of existing State water quality standards and the "fishable and swimmable" goals of the Clean Water Act. At the current level and scope of pollution control within the Chesapeake Bay's watershed, restoration of the Chesapeake Bay is not expected for many years. The pollutants that are largely responsible for pollution of the Chesapeake Bay are nutrients, in the form of nitrogen and phosphorus, and sediment. These pollutants come from many sources, including sewage treatment plants, city streets, development sites, agricultural operations, and deposition from the air onto the waters of the Chesapeake Bay and the lands of the watershed.

Restoration of the health of the Chesapeake Bay will require a renewed commitment to controlling pollution from all sources as well as protecting and restoring habitat and living resources, conserving lands, and improving management of natural resources, all of which contribute to improved water quality and ecosystem health. The Federal Government should lead this effort. Executive departments and agencies (agencies), working in collaboration, can use their expertise and resources to contribute significantly to improving the health of the Chesapeake Bay. Progress in restoring the Chesapeake Bay also will depend on the support of State and local governments, the enterprise of the private sector, and the stewardship provided to the Chesapeake Bay by all the people who make this region their home.

PART 2 – SHARED FEDERAL LEADERSHIP, PLANNING, AND ACCOUNTABILITY

Sec. 201. Federal Leadership Committee. In order to begin a new era of shared Federal leadership with respect to the protection and restoration of the Chesapeake Bay, a Federal Leadership Committee (Committee) for the Chesapeake Bay is established to oversee the development and coordination of programs and activities, including data management and reporting, of agencies participating in protection and restoration of the Chesapeake Bay. The Committee shall manage the development of strategies and program plans for the watershed and ecosystem of the Chesapeake Bay and oversee their implementation. The Committee shall be chaired by the Administrator of the Environmental Protection Agency (EPA), or the Administrator's designee, and include senior representatives of the Departments of Agriculture (USDA), Commerce (DOC), Defense (DOD), Homeland Security (DHS), the Interior (DOI), Transportation (DOT), and such other agencies as determined by the Committee. Representatives serving on the Committee shall be officers of the United States.

Sec. 202. Reports on Key Challenges to Protecting and Restoring the Chesapeake Bay.

Within 120 days from the date of this order, the agencies identified in this section as the lead agencies shall prepare and submit draft reports to the Committee making recommendations for accomplishing the following steps to protect and restore the Chesapeake Bay:
(a) define the next generation of tools and actions to restore water quality in the Chesapeake Bay and describe the changes to be made to regulations, programs, and policies to implement these actions;
(b) target resources to better protect the Chesapeake Bay and its tributary waters, including resources under the Food Security Act of 1985 as amended, the Clean Water Act, and other laws;
(c) strengthen storm water management practices at Federal facilities and on Federal lands within the Chesapeake Bay watershed and develop storm water best practices guidance;
(d) assess the impacts of a changing climate on the Chesapeake Bay and develop a strategy for adapting natural resource programs and public infrastructure to the impacts of a changing climate on water quality and living resources of the Chesapeake Bay watershed;

(e) expand public access to waters and open spaces of the Chesapeake Bay and its tributaries from Federal lands and conserve landscapes and ecosystems of the Chesapeake Bay watershed; 3

(f) strengthen scientific support for decisionmaking to restore the Chesapeake Bay and its watershed, including expanded environmental research and monitoring and observing systems; and

(g) develop focused and coordinated habitat and research activities that protect and restore living resources and water quality of the Chesapeake Bay and its watershed.

The EPA shall be the lead agency for subsection (a) of this section and the development of the storm water best practices guide under subsection (c). The USDA shall be the lead agency for subsection (b). The DOD shall lead on storm water management practices at Federal facilities and on Federal lands under subsection (c). The DOI and the DOC shall share the lead on subsections (d), (f), and (g), and the DOI shall be lead on subsection (e). The lead agencies shall provide final reports to the Committee within 180 days of the date of this order.

Sec. 203. Strategy for Protecting and Restoring the Chesapeake Bay.

The Committee shall prepare and publish a strategy for coordinated implementation of existing programs and projects to guide efforts to protect and restore the Chesapeake Bay. The strategy shall, to the extent permitted by law:

(a) define environmental goals for the Chesapeake Bay and describe milestones for making progress toward attainment of these goals;

(b) identify key measureable indicators of environmental condition and changes that are critical to effective Federal leadership;

(c) describe the specific programs and strategies to be implemented, including the programs and strategies described in draft reports developed under section 202 of this order;

(d) identify the mechanisms that will assure that governmental and other activities, including data collection and distribution, are coordinated and effective, relying on existing mechanisms where appropriate; and

(e) describe a process for the implementation of adaptive management principles, including a periodic evaluation of protection and restoration activities.

The Committee shall review the draft reports submitted by lead agencies under section 202 of this order and, in consultation with relevant State agencies, suggest appropriate revisions to the agency that provided the draft report. It shall then integrate these reports into a coordinated strategy for restoration and protection of the Chesapeake Bay consistent with the requirements of this order. Together with the final reports prepared by the lead agencies, the draft strategy shall be published for public review and comment within 180 days of the date of this order and a final strategy shall be published within 1 year. To the extent

practicable and authorized under their existing authorities, agencies may begin implementing core elements of restoration and protection programs and strategies,
in consultation with the Committee, as soon as possible and prior to release of a final strategy.

Sec. 204. Collaboration with State Partners. In preparing the reports under section 202 and the strategy under section 203, the lead agencies and the Committee shall consult extensively with the States of Virginia, Maryland, Pennsylvania, West Virginia, New York, and Delaware and the District of Columbia. The goal of this consultation is to ensure that Federal actions to protect and restore the Chesapeake Bay are closely coordinated with actions by State and local agencies in the watershed and that the resources, authorities, and expertise of Federal, State, and local agencies are used as efficiently as possible for the benefit of the Chesapeake Bay's water quality and ecosystem and habitat health and viability.

Sec. 205. Annual Action Plan and Progress Report. Beginning in 2010, the Committee shall publish an annual Chesapeake Bay Action Plan (Action Plan) describing how Federal funding proposed in the President's Budget will be used to protect and restore the Chesapeake Bay during the upcoming fiscal year. This plan will be accompanied by an Annual Progress Report reviewing indicators of environmental conditions in the Chesapeake Bay, assessing implementation of the Action Plan during the preceding fiscal year, and recommending steps to improve progress in restoring and protecting the Chesapeake Bay. The Committee shall consult with stakeholders (including relevant State agencies) and members of the public in developing the Action Plan and Annual Progress Report.

Sec. 206. Strengthen Accountability. The Committee, in collaboration with State agencies, shall ensure that an independent evaluator periodically reports to the Committee on progress toward meeting the goals of this order. The Committee shall ensure that all program evaluation reports, including data on practice or system implementation and maintenance funded through agency programs, as appropriate, are made available to the public by posting on a website maintained by the Chair of the Committee.

PART 3 - RESTORE CHESAPEAKE BAY WATER QUALITY

Sec. 301. Water Pollution Control Strategies. In preparing the report required by subsection 202(a) of this order, the Administrator of the EPA (Administrator) shall, after consulting with appropriate State agencies, examine how to make full use of its authorities under the Clean Water Act to protect and restore the Chesapeake Bay and its tributary waters and, as appropriate, shall consider revising any guidance and regulations. The Administrator shall identify pollution control strategies and actions authorized by the EPA's existing authorities to restore the Chesapeake Bay that:

(a) establish a clear path to meeting, as expeditiously as practicable, water quality and environmental restoration goals for the Chesapeake Bay;

(b) are based on sound science and reflect adaptive management principles;

(c) are performance oriented and publicly accountable;

(d) apply innovative and cost-effective pollution control measures;

(e) can be replicated in efforts to protect other bodies of water, where appropriate; and

(f) build on the strengths and expertise of Federal, State, and local governments, the private sector, and citizen organizations.

Sec. 302. Elements of EPA Reports. The strategies and actions identified by the Administrator of the EPA in preparing the report under subsection 202(a) shall include, to the extent permitted by law:

(a) using Clean Water Act tools, including strengthening existing permit programs and extending coverage where appropriate;

(b) establishing new, minimum standards of performance where appropriate, including:

(i) establishing a schedule for the implementation of key actions in cooperation with States, local governments, and others;

(ii) constructing watershed-based frameworks that assign pollution reduction responsibilities to pollution sources and maximize the reliability and cost-effectiveness of pollution reduction programs; and

(iii) implementing a compliance and enforcement strategy.

PART 4 – AGRICULTURAL PRACTICES TO PROTECT THE CHESAPEAKE BAY

Sec. 401. In developing recommendations for focusing resources to protect the Chesapeake Bay in the report required by subsection 202(b) of this order, the Secretary of Agriculture shall, as appropriate, concentrate the USDA's working lands and land retirement programs within priority watersheds in counties in the Chesapeake Bay watershed. These programs should apply priority conservation practices that most efficiently reduce nutrient and sediment loads to the Chesapeake Bay, as identified by USDA and EPA data and scientific analysis. The Secretary of Agriculture shall work with State agriculture and conservation agencies in developing the report.

PART 5 – REDUCE WATER POLLUTION FROM FEDERAL LANDS AND FACILITIES

Sec. 501. Agencies with land, facilities, or installation management responsibilities affecting ten or more acres within the watershed of the Chesapeake Bay shall, as expeditiously as practicable and to the extent permitted by law, implement land management practices to protect the Chesapeake Bay and its more

tributary waters consistent with the report required by section 202 of this order and as described in guidance published by the EPA under section 502.

Sec. 502. The Administrator of the EPA shall, within 1 year of the date of this order and after consulting with the Committee and providing for public review and comment, publish guidance for Federal land management in the Chesapeake Bay watershed describing proven, cost-effective tools and practices that reduce water pollution, including practices that are available for use by Federal agencies.

PART 6 – PROTECT CHESAPEAKE BAY AS THE CLIMATE CHANGES

Sec. 601. The Secretaries of Commerce and the Interior shall, to the extent permitted by law, organize and conduct research and scientific assessments to support development of the strategy to adapt to climate change impacts on the Chesapeake Bay watershed as required in section 202 of this order and to evaluate the impacts of climate change on the Chesapeake Bay in future years. Such research should include assessment of:
(a) the impact of sea level rise on the aquatic ecosystem of the Chesapeake Bay, including nutrient and sediment load contributions from stream banks and shorelines;
(b) the impacts of increasing temperature, acidity, and salinity levels of waters in the Chesapeake Bay;
(c) the impacts of changing rainfall levels and changes in rainfall intensity on water quality and aquatic life;
(d) potential impacts of climate change on fish, wildlife, and their habitats in the Chesapeake Bay and its watershed; and
(e) potential impacts of more severe storms on Chesapeake Bay resources.

PART 7 – EXPAND PUBLIC ACCESS TO THE CHESAPEAKE BAY AND CONSERVE LANDSCAPES AND ECOSYSTEMS

Sec. 701. (a) Agencies participating in the Committee shall assist the Secretary of the Interior in development of the report addressing expanded public access to the waters of the Chesapeake Bay and conservation of landscapes and ecosystems required in subsection 202(e) of this order by providing to the Secretary:
(i) a list and description of existing sites on agency lands and facilities where public access to the Chesapeake Bay or its tributary waters is offered;

(ii) a description of options for expanding public access at these agency sites;
(iii) a description of agency sites where new opportunities for public access might be provided;
(iv) a description of safety and national security issues related to expanded public access to Department of Defense installations; 7
(v) a description of landscapes and ecosystems in the Chesapeake Bay watershed that merit recognition for their historical, cultural, ecological, or scientific values; and
(vi) options for conserving these landscapes and ecosystems.
(b) In developing the report addressing expanded public access on agency lands to the waters of the Chesapeake Bay and options for conserving landscapes and ecosystems in the Chesapeake Bay, as required in subsection 202(e) of this order, the Secretary of the Interior shall coordinate any recommendations with State and local agencies in the watershed and programs such as the Captain John Smith Chesapeake National Historic Trail, the Chesapeake Bay Gateways and Watertrails Network, and the Star-Spangled Banner National Historic Trail.

PART 8 – MONITORING AND DECISION SUPPORT FOR ECOSYSTEM MANAGEMENT

Sec. 801. The Secretaries of Commerce and the Interior shall, to the extent permitted by law, organize and conduct their monitoring, research, and scientific assessments to support decisionmaking for the Chesapeake Bay ecosystem and to develop the report addressing strengthening environmental monitoring of the Chesapeake Bay and its watershed required in section 202 of this order. This report will assess existing monitoring programs and gaps in data collection, and shall also include the following topics:
(a) the health of fish and wildlife in the Chesapeake Bay watershed;
(b) factors affecting changes in water quality and habitat conditions; and
(c) using adaptive management to plan, monitor, evaluate, and adjust environmental management actions.

PART 9 – LIVING RESOURCES PROTECTION AND RESTORATION

Sec. 901. The Secretaries of Commerce and the Interior shall, to the extent permitted by law, identify and prioritize critical living resources of the Chesapeake Bay and its watershed, conduct collaborative research and habitat protection activities that address expected outcomes for these species, and develop a report addressing these topics as required in section 202 of this order. The Secretaries of Commerce and the Interior shall coordinate agency activities related to living resources in estuarine waters to ensure maximum benefit to the Chesapeake Bay resources.

PART 10 – EXCEPTIONS

Sec. 1001. The heads of agencies may authorize exceptions to this order, in the following circumstances:
(a) during time of war or national emergency; 8
(b) when necessary for reasons of national security;
(c) during emergencies posing an unacceptable threat to human health or safety or to the marine environment and admitting of no other feasible solution; or
(d) in any case that constitutes a danger to human life or a real threat to vessels, aircraft, platforms, or other man-made structures at sea, such as cases of *force majeure* caused by stress of weather or other act of God.

PART 11 – GENERAL PROVISIONS

Sec. 1101. (a) Nothing in this order shall be construed to impair or otherwise affect:
(i) authority granted by law to a department, agency, or the head thereof; or
(ii) functions of the Director of the Office of Management and Budget relating to budgetary, administrative, or legislative proposals.
(b) This order shall be implemented consistent with applicable law and subject to the availability of appropriations.
(c) This order is not intended to, and does not, create any right or benefit, substantive or procedural, enforceable at law or in equity, by any party against the United States, its departments, agencies, or entities, its officers, employees, or agents, or any other person.

BARACK OBAMA
THE WHITE HOUSE,
May 12, 2009.
# # #