POPLAR ISLAND ENVIRONMENTAL RESTORATION PROJECT: DIKE CONSTRUCTION AND WETLAND DEVELOPMENT

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ABSTACT

Poplar Island is a 1,140-acre environmental restoration project located in Chesapeake Bay approximately 35 miles southeast of Baltimore in Talbot County, MD. The restoration of Poplar Island (to the approximate 1847 footprint) using dredged material was conceived by Maryland Port Administration (MPA) in cooperation with the U.S. Army Corps of Engineers, Baltimore District (CENAB), Maryland Environmental Service (MES), state agencies, federal agencies and local governments, citizens and private interest groups. The project is a beneficial-use site, using dredged material to create both uplands and intertidal wetlands with a focus on habitat diversity. Poplar Island will provide a total capacity of approximately 42 million cubic yards of dredged material. Creating the initial containment dike system (42,000 ft of perimeter dikes and 23,000 ft of interior dikes), involved the following construction elements: exterior stone toe dike, sand core, slope underlayer and slope armor stone. The sand core material (approximately 6 mcy) was excavated from sub aqueous borrow areas on site. Approximately 850,000 tons of stone was mined and transported to the project. Because of funding and schedule limitations, the project was designed for construction in two phases. Phase I (640ac) is the northern portion of the site and contains four remnant islands. Phase II (500ac) is the southern portion of the site. Wetland creation (570ac) is a top priority with several challenging engineering issues, including: construction and maintenance of diverse habitat features (high/low marsh, bird islands, ponds and tidal flats); optimization of dredged material dewatering/consolidation to achieve final target elevations; channel design and construction to achieve proper tidal flushing; evaluation and field-testing of planting/seeding methodologies, and design and implementation of effective monitoring to measure success. This paper will address the engineering issues associated with initial construction of the containment dikes, filling of the island, and development of the wetland cells.

Keywords: Consolidation, habitat, armor stone, stockpile, sand core

INTRODUCTION

Poplar Island is located in Chesapeake Bay about 32 miles southeast of Baltimore-Washington International Airport and 35 miles east of Washington D.C. The site is about 15 miles below the Bay Bridge and just west of Tilghman Island (see Figure 1). Formerly a 1,000-acre single island in 1847, Poplar Island had nearly disappeared by 1990 due to increasing natural erosion. Only four small remnants (about 5 acres) and Coaches Island existed in 1994, with a combined landmass of 79 acres. The U.S. Army Corps of Engineers, Baltimore District (CENAB) maintains more than 125 miles of federal navigation channels providing access to the Port of Baltimore. This unique environmental restoration project will re-establish habitats lost historically through erosion with dredged materials from these navigation channels. The Poplar Island restoration project involves creation of aquatic, inter-tidal wetland, and upland habitat for fish and wildlife. The concept to reconstruct Poplar Island using clean dredged material was developed through the cooperative efforts of several State and federal agencies and private organizations. Restoration of Poplar Island is part of the State of Maryland’s strategic plan for dredged material management, which provides a geographically balanced, environmentally sound, and cost effective solution to the Port of Baltimore's dredging needs. The Poplar Island restoration project was recommended by Maryland’s Governor Schaefer and the State’s Task Force on Dredged Material Management in February 1991 as a potential site for placement of dredged materials.

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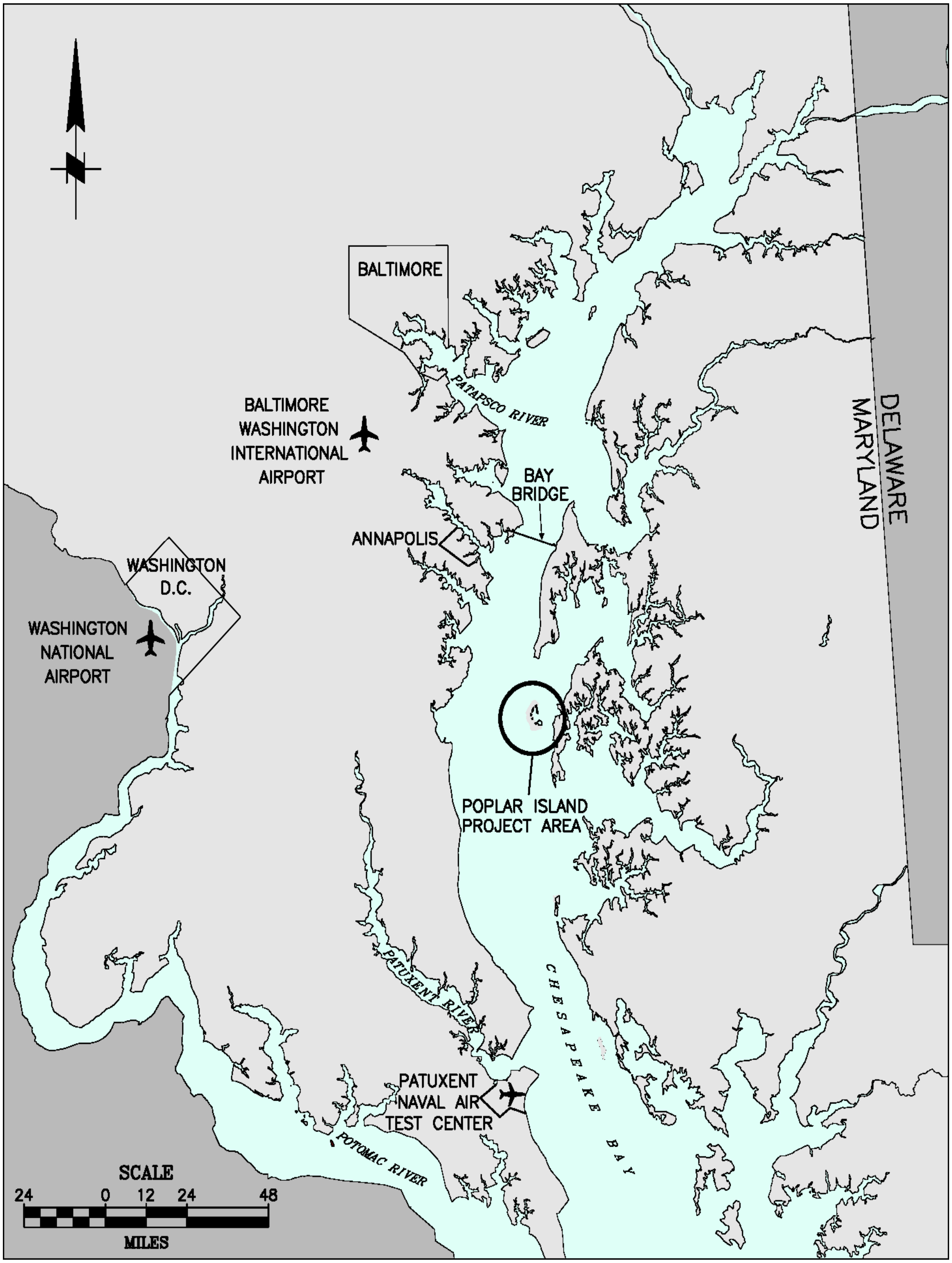


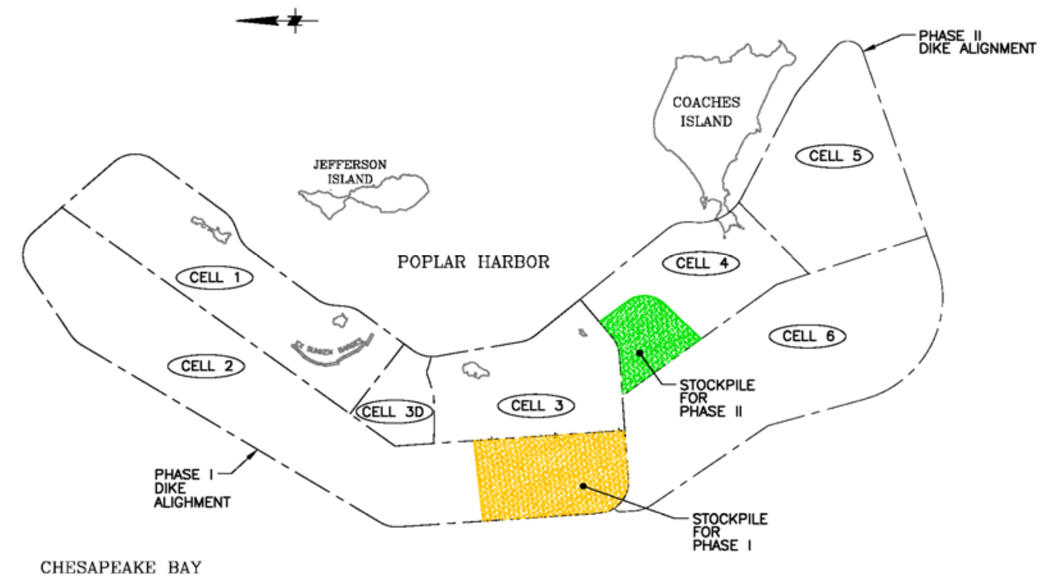
Figure 1. Poplar Island location map.

Detailed planning and design of the Project began in mid-1994 by a joint venture between Gahagan & Bryant Associates, Inc., and Moffatt & Nichol Engineers (GBA-M&N JV).

Because of funding and schedule limitations, the project was designed for construction in two phases. Phase I is the northern portion of the site and contains the four remnant islands. Phase I is partitioned into three cells, including two intertidal wetland cells and one upland cell. Phase II is partitioned into three cells, including two wetland cells and one upland cell. The restoration design is a total of 1,142 acres including, the Phase I area of 638 acres and the Phase II area of 504 acres (see Figure 3 and Table 1).

Filling of the Island began in 2001 with initial inflow into the proposed wetland development cell 3D (see Figure 2). During each inflow event, the contractor is often required to place various amounts of material within each cell. Cells are filled at particular locations along the dikes to provide topography as needed or fill holes within the site. Wetland cells are filled incrementally to allow for maximum consolidation over a relatively short period of time (1 to 2 years) prior to next inflow. Planning and scheduling of the filling process is critical to wetland development and maximizing Island capacity. Typical annual inflow volumes for the Island average approximately 1 Mcy to 2 Mcy. In 2001, approximately 8 Mcy were offloaded into the site into upland cell No. 2.

Wetland development at Poplar Island began with development Cell 4DX in 2003, constructed entirely with sand. Cell 4DX was constructed to help determine wetland cell constructibility and tidal channel hydraulics to address sediment transport issues, and to test tidal elevations at Poplar Island. The vegetative success achieved throughout Cell 4DX provided proof that elevation ranges reported in previous studies for acceptable elevation bounds for low and high marsh were accurate. The lessons learned from Cell 4DX were applied to the construction of Cell 3D in 2004, the first tidal wetland constructed with dredged material at Poplar Island.



CONSTR. PHASE	CELL NUMBER	TYPE OF CELL	APPROXIMATE SURFACE AREA (ACRES)
1	1	INTERTIDAL WETLAND	169
1	2	UPLAND	326
1	3	INTERTIDAL WETLAND	108
1	3D	INTERTIDAL WETLAND	35
1	4	INTERTIDAL WETLAND	115
1	5	INTERTIDAL WETLAND	146
1	6	UPLAND	243
TOTAL ACRES			1142

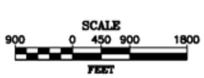


Figure 2. Poplar Island cell designation and characteristics.

DIKE CONSTRUCTION

The Island construction project consists of a containment dike system (42,000 ft of perimeter dikes and 22,000 ft of interior dikes), including exterior stone toe dike, sand core, slope underlayer, and slope armor stone. Figure 3 displays the typical northwest (high exposure) perimeter dike cross-section. This figure shows the need for the sand core to be placed prior to placement of the various layers of slope stone, which are positioned on top of the sand core. The sand core material was excavated from sub aqueous borrow areas on site. The various stone products were mined in quarries in West Virginia, and northern Maryland. Materials were railed to Baltimore (for the West Virginia Quarry) and then barged to the project site. Materials from the Maryland quarry were loaded directly onto a barge at the quarry site located at the confluence of the Chesapeake Bay and the Susquehanna River in Havre de Grace.

The site characteristics are given below:

Table 1. Site characteristics (GBA 1999).

Feature	Total Site
Length of Perimeter Dikes	42,000 ft
Length of Interior Dikes	22,000 ft
Initial upland dike elevation, average	10 ft
Design upland dike elevation, average	20 ft
Tidal wetland cells, average final elevation	1.5 ft
Tidal wetland cells, number and area	Four – 573acres
Upland cells, number and area	Two - 569 acres
Tidal wetland cells dredged material capacity	7.6 mcy
Upland cells dredged material capacity	32.4 mcy
Total site capacity for dredged material	40.0 mcy
Site Life	20 Years

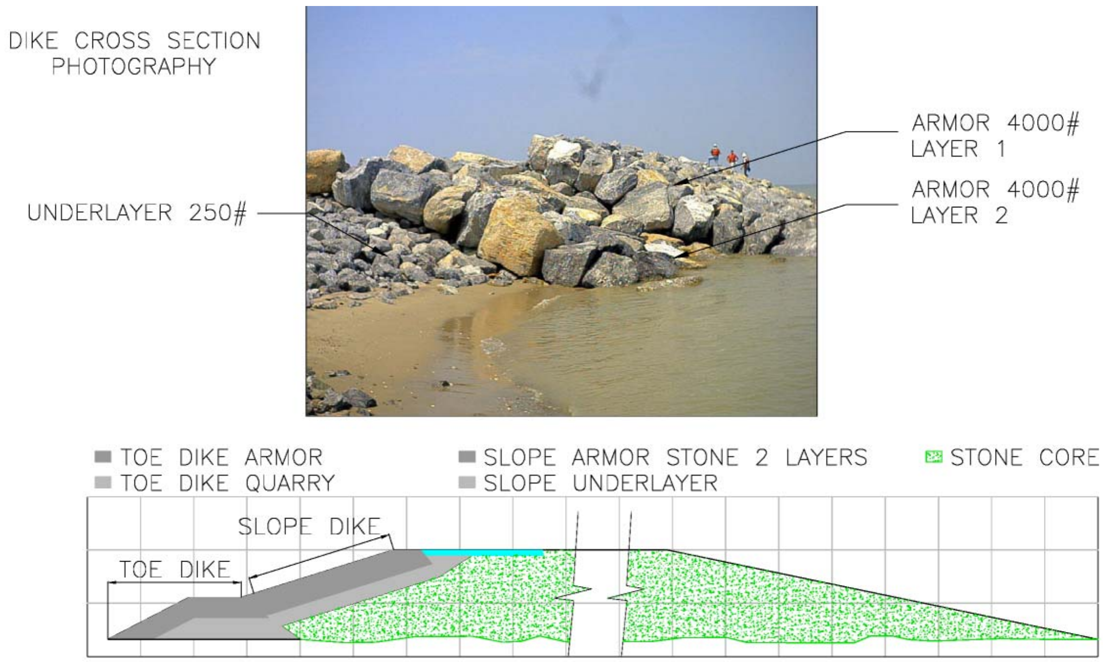


Figure 3. Typical perimeter dike cross section.

CONSTRUCTION ELEMENTS

Island construction elements are in this section.

Borrow Areas and Access Channel Excavation

The sand core of the dike was required to be placed ahead of the various layers of slope stone, and therefore, sand borrow was the first order of work. The borrow areas, for construction of the sand core, were located in open water in depths from about –2 to – 30 MLLW (see areas outlined in Figure 4). The access channel was a major source of the borrow material and also serves as a site access channel for hauling barges loaded with dredged material for filling of the site. The borrow sources were layered with seams of fine grained silts and clays and in some areas large pockets of fine grained material unsuitable for dike construction. The unsuitable fine-grained materials were placed in an approved placement area within the perimeter.

The Phase I contractor, started with mechanical excavation equipment to begin digging borrow materials. The mechanical equipment included a 10-cubic yard backhoe excavator mounted on a barge placing material into 100-ton dump trucks located on a modular barge made up of a series of "Flexi Floats". The modular barge was approximately 60 ft by 480 ft and served as a floating roadway to truck materials from within the borrow area to a temporary sand dike. The temporary sand dike was intended to eventually lead to the perimeter dike. In August 1998, (about 180 days from NTP) the contractor had built about 750 linear ft of the temporary sand dike (about 100,000 cubic yards). After these several months of minimal production, the contractor changed the construction method. The equipment used for excavation and transport of borrow materials was changed from the original mechanical method to hydraulic dredging. The hydraulic dredging method proved to be significantly more productive. The Phase II contractor started off with hydraulic dredging of borrow materials to a sand stockpile located within the proposed Phase II footprint.

Approximately 5 Mcy of sand borrow was stockpiled for the Phase I and II projects at 3 different intervals.

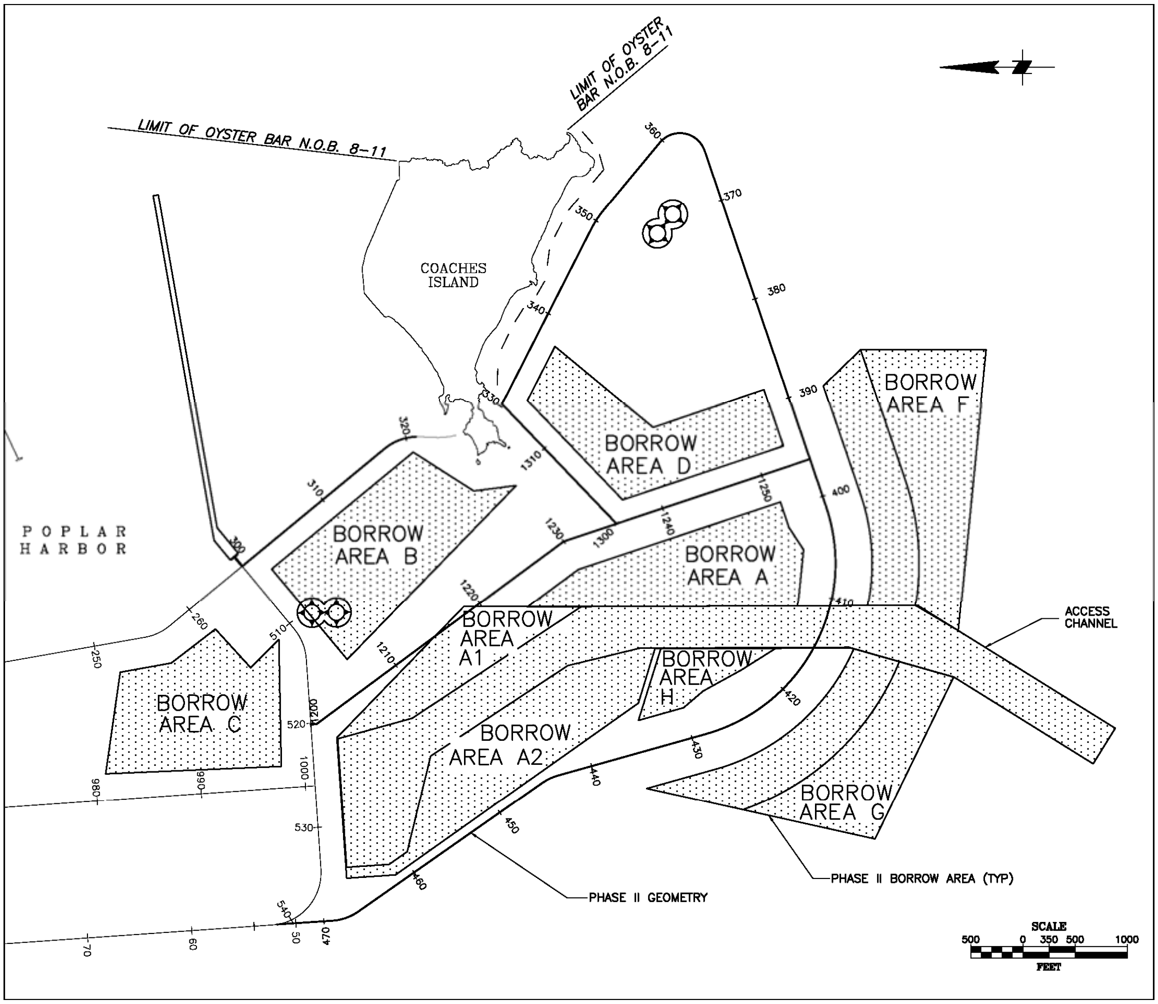


Figure 4. Borrow area locations and designations.

Excavation of Unsuitable Foundation Materials

Low-strength silt and clay foundation materials were removed prior to placement of the dike section. Sediments were removed from 11 locations (see Figure 5), about 341,000 cubic yards of material. These materials were placed in an approved open water placement area within the perimeter. These materials were excavated, transported and placed by two different methods. Mechanical methods and hydraulic methods were used to dredge the unsuitable material. The hydraulic dredging method proved to be more productive. The mechanical method involved a backhoe excavator mounted on a barge placing material into a shallow draft material barge, which was hauled to the placement area and then unloaded by the backhoe excavator. The hydraulic dredge excavated the material in section and transported materials by pipeline directly to the placement area.

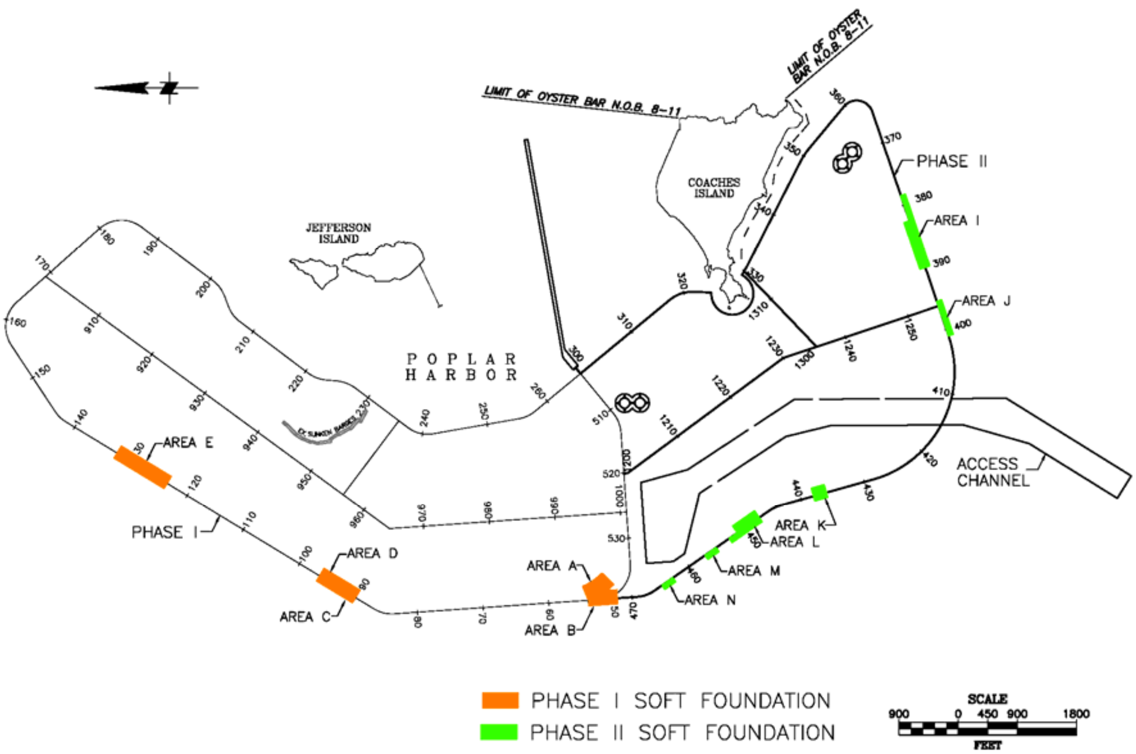


Figure 5. Soft foundation excavation areas.

Exterior Toe Dike

The exterior toe dike is a required structural element of the dike to protect the slope toe from erosion and undercutting caused by wave attack. The toe dike also had an added value, during construction, as a protective barrier against erosion of the sand core prior to placement of slope stone. Approximately 25,000 linear feet and about 179,000 tons of toe dike was constructed. Geotextile material for the toe dike was spooled off a barge onto the bay bottom. Stone for the toe dike was barged site, offloaded, and then trucked along the perimeter. Quarry run materials were dumped using a backhoe bucket and finally 2000-pound toe armor stone was placed by a backhoe or crane with a grapple.

Dike Core

The sand core portion of the dike required an in-section (neat) quantity of about 3.5 million cubic yards of suitable dike construction material (sand and silty sand). The dike core was constructed in two stages, because of construction scheduling and equipment production balance. Also, the contractor wanted to complete the perimeter as soon as possible to be protected from wave attack. The first construction lift was built up to about elevation +7.5 and about 60% of full width. The second lift was built up to +10.5 and to full width. Approximately 42,000 linear feet and about 4 million cubic yards of dike core was constructed. Dike core materials were hauled by off road trucks, primarily from the stockpile. The contractor dewatered and maintained water levels down to and below the Bay bottom. Additional materials were excavated in the “dry” state. The dewatering process also allowed for the 1 on 5 interior slope of the sand core to be shaped and graded down to the bay bottom by bulldozer.

Dike Slope Stone

The dike slope stone was constructed in two vertical stages, first up to about +7.5 and then up to the roadway elevation of about +10.5. The underlayer consists of a bedding layer of 3 to 6 inch stone and then one layer of 250-pound stone. The slope armor is 2 layers of either 3,000-pound or 4,000-pound stone. Approximately 42,000 linear feet and about 163,000 tons of underlayer stone was placed along the perimeter dike. Approximately 25,000 linear feet and about 278,000 tons of armor stone was placed along the perimeter. Stone for the dike slope was barged to the south end of the site and then trucked along the perimeter. Underlayer stone was placed by backhoe and a crane while armor stone was placed by backhoe outfitted with a grapple.

Crushed Stone Roadway

The roadway consists of 20-feet wide by 8-inch deep crushed stone. Geotextile material was placed between the sand core and the roadway. Approximately 64,000 linear feet and 23,000 tons of crushed stone roadways were constructed along the perimeter. The crushed stone was hauled by truck from the south end of Phase I.

Ancillary Items

Fifteen spillway structures were constructed to convey excess water between cells and directly to the bay. Approximately 2500 feet of sand filled geotextile bags (geotubes) were constructed along the south perimeter and along Coaches Island as temporary protection. Seven artificial 0.3-acre habitat islands were constructed in the two wetland cells. Two rock reefs were constructed as fish habitat. Two vegetation nursery areas were constructed along the east perimeter. Finally, a personnel pier was constructed in the southeast corner of Phase I.

INFLOW INTO THE ISLAND

The USACE in cooperation with the MPA and its consultants, jointly plan inflow events into the Island. Materials are offloaded almost every year into the Island. Materials are barged to the Island via jumbo hopper barges and are hydraulically offloaded. A pipeline transports the slurry to the appropriate cell. Selection of the proper cell to inflow dredged material into is critical for maximizing capacity within the Island while bringing wetland cells "online" in a timely manner. Overloading the wetland cells would leave the final marsh elevation to high and not allow proper inundation of the plants.

Cells are monitored on a quarterly basis to determine the elevation of the materials within the cell and the void ratio/moisture content. Void ratio information is collected within each wetland cell. Each sample location within the wetland cell represents approximately 7 acres. In the upland cell where prediction of consolidation is not as critical, each sample location represents approximately 27 acres of area. The void ratio sampling exercise helps to better predict consolidation (i.e. final elevation) and capacity (i.e. how many more CY can be added to the cell). To date, materials have been only offloaded into the Phase I project area (northern portion of the Island). This information is used to predict:

- When the cell can be filled again (time),
- When the cell is complete (i.e. target elevation for wetland cells is a final elevation of 1.5-feet MLLW),
- How many cubic yards went into the cell for a given inflow period, and
- How many cubic yards will go into the cell for the next inflow event.

As an example of a complex inflow event into Poplar Island the contractor was required to inflow at 10 different locations within the site during winter 2004/2005. Figure 6 below shows the complexity of piping locations that was required of the contractor.

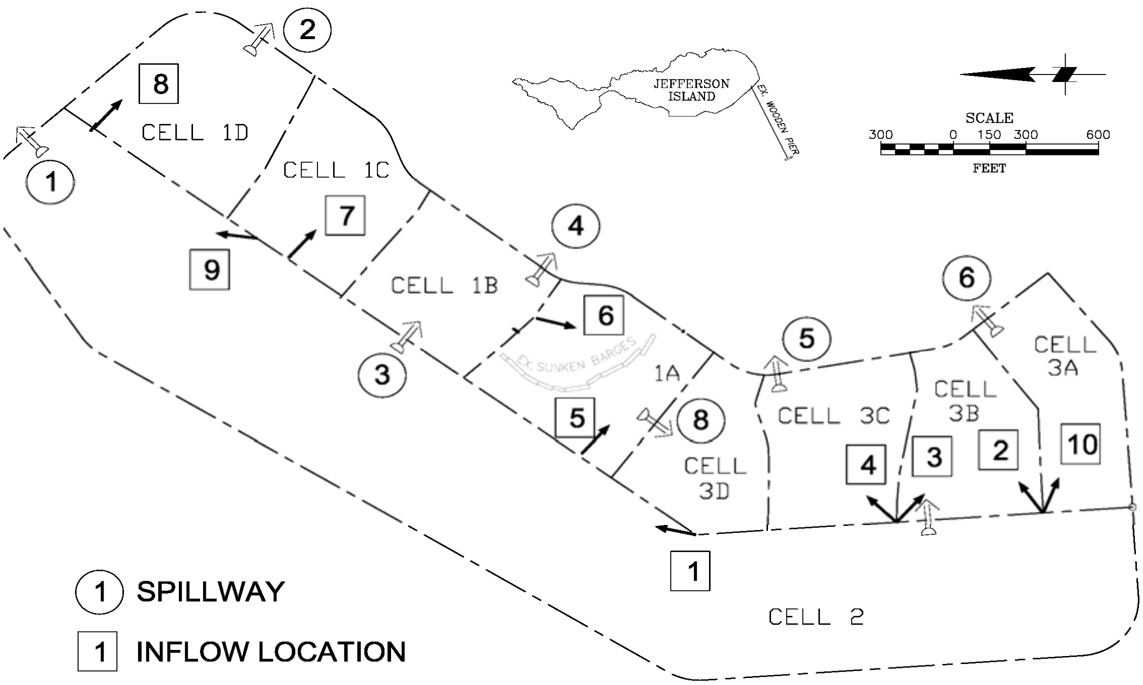


Figure 6. Poplar Island inflow locations 2004/2005 season.

Prior to the beginning of the job, USACE and the contractor perform a proofing of the scows to be used for transport of the dredged material. A proof is a quality control measure preformed to ensure that the draft readings (taken from markings on the sides of the scow) provide an accurate mass of displaced water and thus the material inside the barge. The proof is performed by taking draft and ullage readings, using the existing charts to determine the mass and volume, calculating the density, and comparing it to the density of the water in the scow.

The tracking of materials that goes into each cell is done by the contractor, USACE, MES, and MPA and its consultants by reading of the draft and ullage of the barges and recorded. These readings can be correlated to the proofing exercise to determine the quantity of material that is in each barge.

Table 2. Estimated capacity and inflow volumes.

Cell	1st Inflow	2nd Inflow	3rd Inflow	4th Inflow	5th Inflow	Volume Totals	Remaining Capacity[4]
	Cut *(mcy)*	Cut *(mcy)*	Cut *(mcy)*	Cut *(mcy)*	Cut *(mcy)*	Cut *(mcy)*	Cut *(mcy)*
1	-	0.7	-	0.78	.36	1.84	.44
2	2.45	2.9	1.28	-	1.71	8.34	7.0
3	0.66	-	-	0.05	.42	1.13	.43
3D	0.27	-	0.08	0.01	-	0.36	Filled
4	-	-	-	-	-	-	1.3
5	-	-	-	-	-	-	4.4
6	-	-	-	-	-	-	15.0
Total	3.38	3.6	1.36	0.84	2.48	**11.7**	**35.43**

Table 2 provides a summary of inflow events relative to the cut cy (in channel) and the reaming capacity within each cell. Tables similar to this are used each year to help plan for future inflow events.

WETLAND DEVELOPMENT

Prior to the development of inter-tidal wetland habitat, various design elements and features had to be determined. A project development team with input from various state and federal agencies studied surrounding Chesapeake Bay salt marshes, collecting hydraulics data and elevation ranges for three primary marsh zones. The marsh zones consisted of high marsh (+ 1.8 to 2.5 ft MLLW), low marsh (1.2 to 1.8 ft MLLW), and mud flats (0.9 to 1.2 ft MLLW). The cell development plan established targets for the final wetland design, which were required to be incorporated into each cell design. The first cell designed and completed with dredged material was Cell 3D.

Design requirements for Cell 3D referenced topography (80% Low Marsh, 20% High Marsh, Bird Island, Mud Flats) hydrodynamics (hydro-period, residence time, and max channel velocity), and flora coverage (species density and composition for each topographic region). Governed by the design requirements and agency commitments to habitat value and specific target species, the team developed various conceptual designs before accepting the final design (Figure 7) for Cell 3D to guide the site operations team through the development of the cell.

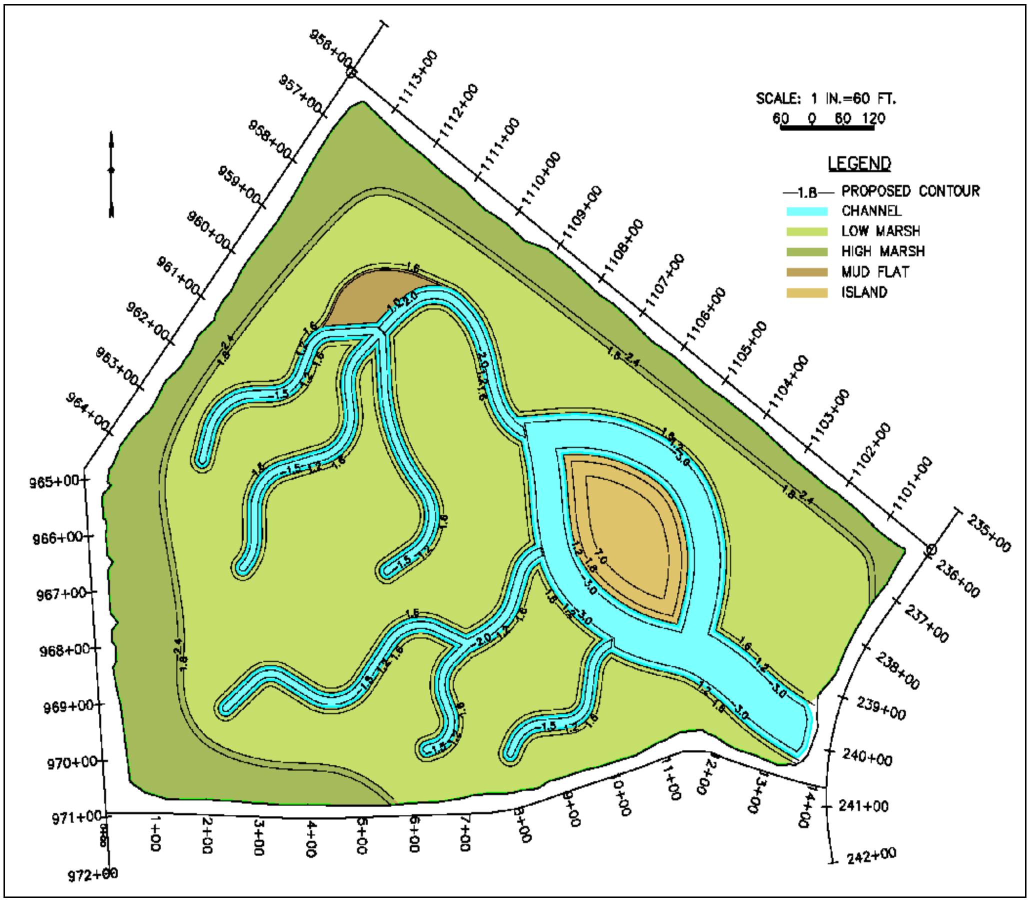


Figure 7. **Final wetland design for Cell 3D.**

During PIERP Phase I, the partitioning dikes of Cell 3 were constructed to an elevation of +8 ft with a top berm/roadway width of 20 ft and 3:1 side slopes. The dike which partitions Cell 3D from the remaining portion of Cell 3 was constructed to an elevation of +8 ft, with a berm width of 12 ft and 3:1 side slopes. With the addition of the partitioning dike in the winter of 2000-2001, Cell 3D was fully enclosed by 4800 linear ft of dike. Besides the dike construction no initial site preparation was required to alter the interior of Cell 3D prior to wetland development. The natural bay bottom in the region of Cell 3 was naturally shallow and flat, ranging from el –4 ft to –5 ft MLLW.

The development of the wetland cell can be subdivided into a four phase process: Phase 1, Inflow & Crust Management; Phase 2, Grading & Channel Development; Phase 3, Inlet Structure Design & Construction; and Phase 4, Planting.

Inflow and Crust Management

The inflow of dredged material and ensuing crust management began in the Spring of 2001 and continued into the construction phase. The majority (75%) of material was hydraulically placed into the cell in 2001 and each subsequent year saw a dramatic decrease of inflow volume (2002 - 20% and 2003 - 5%, see Table 3). This allowed the majority of the material more time to consolidate towards a steady state, while not overflowing the perimeter dikes and preventing major elevation fluctuations after the completion of the cell.

Table 3. Inflow events for Poplar Island.

Inflow Event	Date	Cut Volume Placed (cy)
1	April 2001 – July 2001	175,312
		90,719
2	**No Placement Cell 3D**	
3	November 2002	77,260
4	November 2003	9,312
	Total	**352,603**

Source: PIERP Inflow Report (GBA 2004)

Inflow locations varied in Cell 3D to help meet the designed slopes across the cell. The dredge material settled out of suspension across the cell at a gradual slope of at least 800 linear feet to one vertical foot, depending upon material characteristics and whether the material was above or below the cell water surface. Cell 3D design dictated higher perimeter elevations and a shallow center. Therefore, perimeter inflow locations were chosen to better emulate features and elevations of this design with reduced effort. This minimized the amount of material to be re-handled to meet design specifications.

Each year, multiple sampling and survey events occurred to provide insight for the following year's inflow plan. RTK surveys and placed material void ratios (generated through sampling) allowed estimates of remaining capacities and current cell elevations. The estimates provided accurate and repeatable estimates of the material placed in the cell and thus the remaining fill required to meet the estimated capacity. Exceeding or not fulfilling specific volumes within the cell can result in unnecessary cost and a prolonged time frame for construction.

Considerable effort was also applied towards dewatering and crust management, specifically after Inflow 4. To promote dewatering of the cell, a series of shallow parallel trenches were dug throughout the cell. The trenches led water from the interior portions of the cell to the larger perimeter trench maintained along the base of the surrounding dike structure. The perimeter trench drained into sumps located at the southeast and southwest corners of the cell where pumps transferred the water into Cell 3C. These trenches were maintained between inflow events and throughout the wetland construction.

Interior trenches were cut using pontoon trenchers, while the perimeter trench was developed and maintained by various excavators. Excavators were able to be used due to the trench's proximity to the dike and were the preferred method because the depths maintained around the perimeter were unattainable by trenchers.

Channel Development

Once inflowing of material was ceased, a construction plan/methodology was required to recreate the cell design. The nature and conditions of Cell 3D provided a challenge in the construction of a wetland cell to stringent design specifications. With a substrate consolidating to a stable steady state through out the cell, several theories concerning channel development and meeting acceptable marsh elevations were discussed. To reduce risk of elevation failure, meet the stringent design requirements, and simplify construction methods, it was recommended that the cell be constructed by operating with conventional land development methodologies.

After the final inflow event, the material was desiccated through intensive crust management until the material could support equipment for mechanical excavation of channels and grading of the marsh surface.

Excavation and grading efforts were implemented to achieve targeted design elevations and channel widths and depths. Cell 3D's marsh zones and channels are critical to providing tidal inundation. Tidal inundation is the most influential hydraulic factor in a tidal marsh. The frequency and duration of tidal flooding determines the extent of the inter-tidal zone. Physical factors including elevation, topography, and slope directly dictate the rate and duration of inundation.

The final channel layout, and excavation plans were prepared to meet the design requirements for wetland development established at the beginning of the restoration project. The wetland is composed of 1st, 2nd, and 3rd order channels, high and low marshes, a moat protected habitat island, and a small mudflat area. Target elevations for the low marsh and high marsh are 1.5 ft and 2.4 ft MLLW, respectively. The bird-nesting island is at elevation 7.0 ft, while the mudflat is designed to be at elevation 1.0 ft.

As result of a successful crust management effort, equipment could transverse the cell by early Spring 2004, only 4 months after the final inflow. In addition to consolidation through the crust management effort, the equipment use further consolidated and compacted the dredged material. This method increased the rate of final consolidation and initiated compaction.

Simultaneously, work began around the bird-nesting island. The large third order channels surrounding the bird nesting island were the deepest by design (-3 ft per agency guidance and recommendations). Excavation was performed incrementally to allow the underlying material to further desiccate once exposed by the pontoon excavators. The short and long reach pontoon excavators gradually worked through the cell, and up into the first order channels. The excavated material would be placed along side the channel for fill or hauled away by a Low Ground Pressure (LGP) track dump. The LGP dump would relocate the material to locations requiring fill. In addition to cutting channels, excavators were also required to shape the channel transitions into the low marshes to the design requirements.

The track dozers served three separate but sometimes simultaneous tasks: grading, compacting, and sealing. The primarily purpose was to grade the wetland marshes, cutting the higher than design elevations and filling the low regions all while trying to create a steady gradient with positive drainage towards the channels. As a result of the travel and vibrations of the dozers performing cuts and fills, the material substrate consolidated faster and compacted, providing a more stable working condition throughout the site. The dozers were also used to track over and seal dredged material before rain events were predicted. Wet regions of Cell 3D were tilled to promote desiccation, but rain events would have the reverse effect if the tilled areas were to become infiltrated with significant volumes of water. The tracking of the dozers re-compacted the tilled material before this could occur.

Access within the site was limited by the structural stability of the material. Equipment with a low ground pressure could access the site sooner and reduce grading disturbances with its movements, such as rutting.

Inlet Structure Design and Construction

Gated culvert pipes were installed in order to maintain control of sediment delivery to Poplar Harbor during the development phase of Cell 3D. Numerous hydrodynamic modeling efforts determined that four 48-in pipes would cause a reduction in tidal exchange, and twelve pipes would provide no significant increase on the tidal prism. It was determined that the use of eight 48-in HDPE culvert pipes with 48-in spacing provided a sufficient entrance to the cell. The culvert pipes were fabricated to accommodate weir boards.

The culvert pipes will eventually be removed and the channel entrance will more closely resemble a natural channel entrance in structure. This will not be completed until agencies are under agreement that significant amounts of previously dredged material will not regularly be eroded from the cell and transported back into the Chesapeake Bay by the tidal events.

Planting

Wetland planting occurred in the spring of 2005, after the grading and channel development was complete and tidal exchange was established. Once established, the cell vegetation will begin to establish a natural root mat, necessary for the stability of the soil (i.e. erosion control). This also is vital to the energy transfer between the bay and the marsh.

Planting marks the end of cell development, and the beginning of a process in which the cell's life should begin to emulate the ecosystem within a natural tidal wetland. Vegetation has thrived since the planting occurred. Monitoring of the vegetation within Cell 3D is currently ongoing.

Figure 8. Cell 3D as of July 2006.

SUMMARY

The Island and wetland construction was accomplished with a unique combination of mechanical and hydraulic equipment groups. Rock was transported to the site by way of rail and then barged to the site. The rock was trucked from the offloading area to the dike section or stockpiled for later trucking. The toe dike was built slightly ahead of the sand core and provided a barrier to protect against erosion of the sand. Sand core borrow material was excavated and placed in stockpiles by a 30 inch hydraulic cutter-suction dredge. Stockpiled sand was excavated by backhoe and trucked to the dike section. Extensive dewatering of the site began when the perimeter of each cell was constructed. Additional sand borrow was excavated from the Bay bottom "in the dry" by dewatering the site and maintaining water levels down to and below the Bay bottom (elevation –7 to –15 mllw). The dewatering process also allowed for shaping and grading the interior slopes of the sand dike.

Filling of the Island requires careful planning and continuous monitoring of the material. Topographic surveys of the cells are completed on a quarterly basis as well as material sampling to determine the void ratios. All of this information is used to better predict how much material will be inflowed each season.

Wetland Cell 3D was open to inter-tidal flushing in the spring of 2005, once planting was completed. All parties involved have deemed the cell a success; vegetation flourishes, elevations are stable, dredged material remains in place, hydrodynamic models proved sufficient, and fauna has discovered this new sanctuary and thrived. Monitoring currently continues, as Cell 3D provides lessons learned for the future creation of wetland cells on the Poplar Island Environmental Restoration Project and future projects within the Chesapeake Bay.

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