1 DREDGED MATERIAL MANAGEMENT PLAN

1.1 PURPOSE

The goal of this Dredged Material Management Plan (DMMP) is to develop a placement plan that will accommodate the placement of new work and maintenance dredged material over 50 years associated with the Freeport Harbor Channel Improvement Project General Revaluation Report (FHCIP GRR). Dredged material management planning for all Federal harbor projects is conducted by USACE to ensure that dredging activities are performed in an environmentally acceptable manner, use sound engineering techniques, are economically justified, and to ensure that long-term placement facilities are available. Ultimately, the DMMP identifies specific measures necessary to manage the volume of material likely to be dredged within the FHCIP project over the 50-year period of analysis included in the GRR.

This DMMP considers maintenance and new work dredging volume associated with the FHCIP GRR including: Existing channel to 46 feet MLLW; Proposed Turning Notch, Channel Widening, and Bend Easing to 46 feet MLLW. All new work dredging has an advanced maintenance depth of 2 feet and an allowable overdepth of 1 foot.

1.2 PLACEMENT AREAS

Dredged material placement areas near Freeport Harbor are shown in Figure 1. The Maintenance Ocean Dredged Material Disposal Site (ODMDS) and Placement Area 1 (PA1) are being considered as potential disposal sites in this DMMP. With the recommendation that all maintenance material be placed in the ODMDS, the overall volume of sediment requiring upland confined storage drops dramatically.

This DMMP considers the placement area requirements specifically for the GRR project features and was developed in a manner that avoids potential conflicts with the placement area needs outlined in the DMMP previously developed as part of the 2012 FHCIP Feasibility Study (USACE, 2012b).

1.2.1 MAINTENANCE OCEAN DREDGED MATERIAL DISPOSAL SITE (ODMDS)

The Maintenance ODMDS is located in the Gulf of Mexico, approximately 2.5 miles southwest from the mouth of the Jetty Channel and approximately 3 miles from shore. The site is located in a dispersive offshore environment with approximately 1,129 acres of bottom area. Due to its dispersive nature, the site can be assumed to have unlimited capacity. Coordinates of control points for the Maintenance ODMDS are presented in Table 1. The maintenance ODMDS previously had restrictions that limited placement to material from certain reaches of the channel. However, currently, 40 CFR 228.15 allows material from the entire channel to be placed offshore in the ODMDS.

Table 1 – Maintenance ODMDS Control Points

Control Point Number	Cartesian Coordinates (NAD83, Texas South Central, US Survey Feet)	
	Easting	Nothing
1	3,163,694	13,530,298
2	3,166,836	13,527,077
3	3,157,888	13,518,349
4	3,154,745	13,521,570

1.2.2 PLACEMENT AREA 1

PA1 is located in Freeport roughly 0.5 mile south of State Highway 36 and approximately 1,000 feet east of the Brazos River Diversion Channel (USACE 2012a). The PA is approximately 320 acres, with a perimeter length of approximately 20,310 linear feet. Existing ground elevation is approximately 21 feet NAVD (North American Vertical Datum of 1988) with a dike height of 25 feet NAVD. While the existing capacity of PA1 is approximately 0.8 mcy, the PA is estimated to provide up to 3.4 mcy of capacity if the dikes are raised to 31.5 feet NAVD. This DMMP proposes a dike elevation increase to 31.5 feet NAVD for PA1. This height includes 3 feet for ponding and freeboard above the targeted bulk dredged fill height. Dike raises within PA 1 have historically borrowed material from the interior of the placement area. There is considerable material within the site available for future raises particularly near the discharge site on the eastern section of the placement area. The dikes are scheduled to be raised in support of the Stauffer channel dredging, which is a new work project. This material will be available for future dike raises.

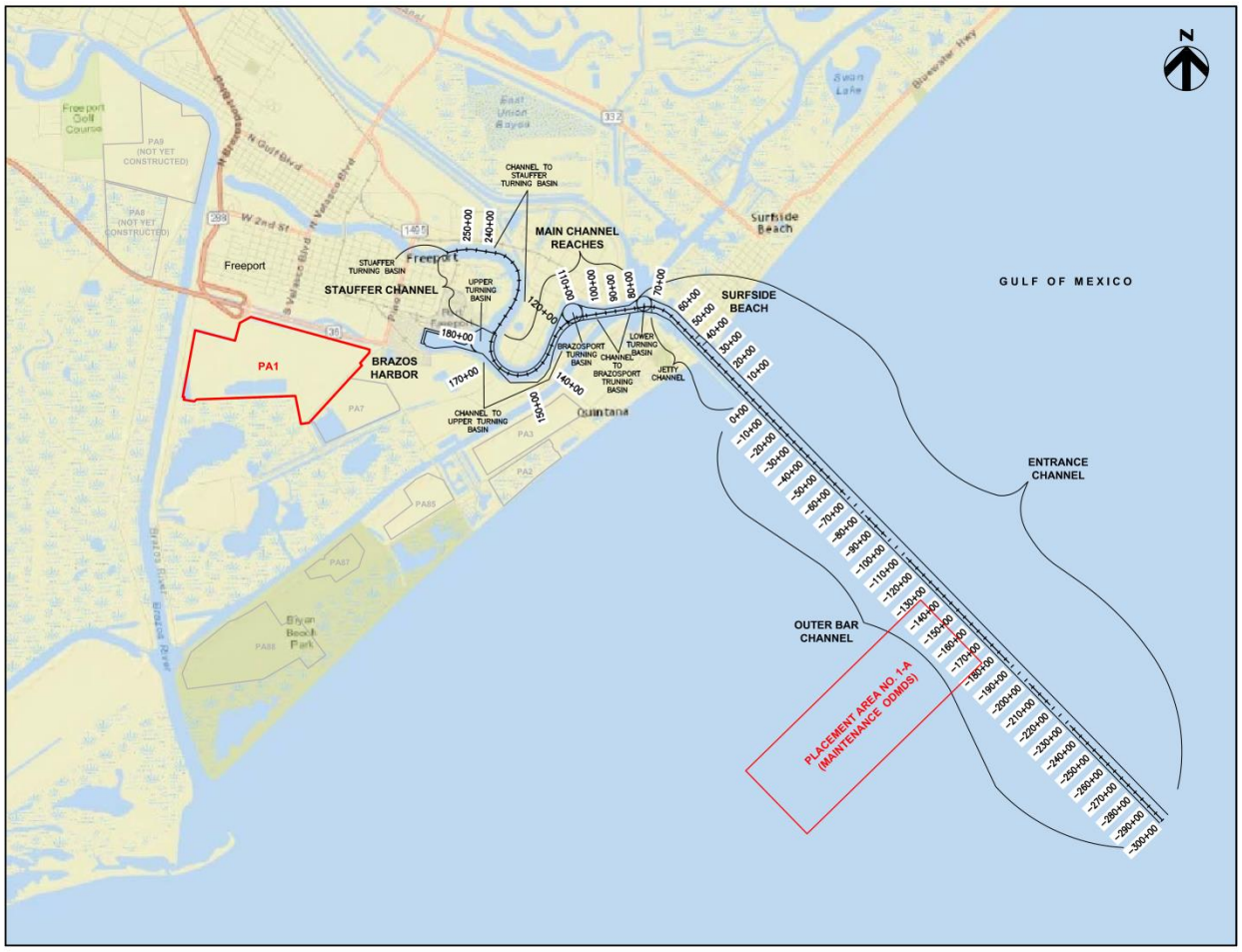

Figure 1 – Dredged Material Placement Areas at Freeport Harbor

1.3 DREDGED MATERIAL FACTORS

Bulking, retention, and shrinkage factors were calculated based on assumptions made by the USACE Galveston District during the 2012 FHCIP Feasibility Study (USACE, 2012a and USACE, 2012b). Average Bulking Factor for new work was then calculated based on bulking, retention, and shrinkage factors provided by USACE.

1.3.1 BULKING FACTOR

The bulking factor is a design parameter primarily used to develop containment dike height requirements for each dredge event. The bulking process is a result of the structural disruption of the dredged sediments and the entrainment of water into the sediments during dredging. This factor is traditionally defined as the ratio of the volume occupied by the dredged material in the placement area immediately after completion of dredging to the volume occupied by the same material in the channel before dredging.

$$\text{Bulking Factor} = \frac{\text{(Volume of Material in Placement Area)}}{\text{(Volume of Material in Channel prior to Dredging)}}$$

The amount of bulking varies with the type of sediments and the method of dredging (mechanical or hydraulic). Other factors that affect bulking include size of dredge, horsepower, and residence time in the pipeline. For this project, dredging will primarily be conducted hydraulically. The new work dredging for this project will consist of about 80 to 90 percent clays (of primarily stiff consistency with some traces of silts or clayey silts), and about 10 to 20 percent sands of various densities, based on available boring data from the Upper Turning Basin on out to sea.

Development of containment dike height requirements on this project was based on a bulking factor of about 1.3 for maintenance material and about 2 for the portion of new work material anticipated to go into a slurry state before final discharge at the disposal sites. The remaining portion of new work material that will come out of the dredge pipe in the form of solid clay fragments (informally referred to as "clay balls") or segregate from the dredge mixture soon after discharge (such as sands) is anticipated to remain fairly close to the original density from the channel.

1.3.2 RETENTION FACTOR

For calculations and quantities produced on this project, the definition adopted for the term "retention factor" is the fraction of new work material from the channel that, when dredged to the site, retains a degree of consistency from the original in situ state necessary for use as fill materials for hydraulic containment dike and containment dike foundation construction or future borrow for future mechanical containment dike construction; and that, when pumped to the site, tends to accumulate or stack within the general vicinity of the end of the dredge pipe

$$\text{Retention Factor} = \frac{\text{(Volume of Dredged Material Suitable for Containment Dike Fill Material)}}{\text{(Annual Dredging Quantity)}}$$

Variables that can influence this factor include original in situ material properties and consistencies, size of dredge, type and control of cutter head, horsepower, and pump distance. For feasibility level, a retention factor of about 0.5 was assumed for this project.

1.3.3 SHRINKAGE FACTOR

The shrinkage factor is a design parameter used to evaluate the long-term storage capacity of a PA for use in developing the DMMP. It is defined as the ratio of the long-term volume occupied by a certain quantity of dredged material in a PA, to the volume it occupied in the channel prior to dredging. Generally, this parameter is associated with maintenance material, but may also be associated with new work material.

$$\text{Shrinkage Factor} = \frac{\text{(Long-term Volume in Disposal Area)}}{\text{(Volume in Channel Prior to Dredging)}}$$

Items that affect the shrinkage include the soil composition, pan of evaporation rate, consolidation, desiccation, climatological conditions, drainage efficiency or dewatering measures implemented, and

dredging schedule of maintenance material placed at the sites. Determination of a precise shrinkage factor for a placement area can be a complex task and include modeling the consolidation and desiccation shrinkage based on laboratory test data, climatological data, drainage characteristics, and operational characteristics. For feasibility level, the development of the long-term storage capacity and containment dike height requirements on this project was based on a shrinkage factor of about 0.65 for maintenance material.

1.3.4 NEW WORK AVERAGE BULKING FACTOR

Assuming 85% clay and 15% sand and given the retention factor of 0.5 and the bulking factor of 2.0, it is expected that 50% of the clay material would expand by a factor of 2.0 while the rest of the clay and all the sand would retain their in situ density. This leads to a new work average bulking factor of 1.425 for placement. In other words, for the purpose of placement calculations, it is expected that the new work material would expand by a factor of 1.425.

For long term calculations, when the shrinkage factor of 0.65 is applied to the bulked clay material, it leads to a new work average bulking factor of 1.13. In other words. For the purpose of long term PA capacity calculations, it is expected that the new work material would expand by a factor of 1.13.

1.4 DREDGED MATERIAL CLASSIFICATION

New work dredged material to be removed for the FHCIP GRR is assumed to have consistent composition with the classification provided in the 2012 FHCIP Feasibility Study. The new work is expected to consist of 10-20 percent sand and 80-90 percent clay. Due to lack of boring data, soil classification was not performed for the new work on the Stauffer Channel.

1.5 DREDGED MATERIAL QUANTITIES

The quantity of new work material for the proposed GRR widening at Freeport Harbor to achieve Alternative 2 at the Freeport Harbor Channel is approximately 1.734 mcy, as classified in The quantities were determined using the average end area method.

The quantity of maintenance material to be removed over the 50-year GRR 46 ft project life is estimated to be approximately 15.3 mcy, as presented in Table 3. These quantities were determined by reviewing maintenance dredging contracts within the project area for the last 20 years and applying an incremental increase in dredging due to the widened and deepened channel (HDR, 2016). This quantity includes 120,000 cy of maintenance dredged material estimated to be removed from the Lower Stauffer Channel. Lacking historical dredging records within the Lower Stauffer Channel, sedimentation rates (within the Lower Stauffer Channel) were estimated by reviewing maintenance dredging requirements within the adjacent portion of the Freeport Harbor main channel.

1.6 PLACEMENT PLANS

Placement plans are required to ensure that there is sufficient capacity within the designated placement areas necessary to contain both the new work dredged materials from the widening and deepening of the channel as well as future maintenance material from the repeated dredging of the channel to maintain navigable project depths over a 50-year period.

1.6.1 NEW WORK DREDGED MATERIAL PLACEMENT PLAN

All dredged material for GRR new work, totaling approximately 1.734 mcy, is designated for placement at PA1 by transfer through pipeline. For Placement Area capacity assessment purposes, this DMMP also considers an additional 270,000 cy of WIK dredging that is expected to emerge from new work at the Lower Stauffer Channel as part of the FHCIP. The Lower Stauffer Channel will be improved based on the WRRDA 2014 authorization (WRRDA, 2014).

To consider the material expansion for placement purposes, a combined average bulking factor of 1.425 was calculated and applied based on the information in Section 1.3, resulting in a bulked volume of approximately 2.47 mcy. Note that for long term Placement Area assessments, the average bulking factor was calculated as 1.13. Table 2 contains the placement plan for new work dredged material.

Table 2 – Placement Plan for New Work Dredged Material

Reach	Stations		In-place Vol. (cy)	Avg. Bulking Factor	Expanded Vol. (cy)	Disposal Site
	From	To				
Bend Easing	147+00	159+85	1,478,000	1.425	2,106,150	PA1
Turning Notch	175+77	181+41	106,000	1.425	151,050	PA1
Channel Widening	142+28	184+20	150,000	1.425	213,750	PA1
Total New GRR Work Dredged Material	**142+28**	**198+50**	**1,734,000**	**1.425**	**2,470,950**	**PA1**
Lower Stauffer Channel (WIK)*	184+20	198+50	270,000	1.425	384,750	PA1

* Not part of the GRR, provided for PA capacity assessment purposes only.

1.6.2 50-YEAR MAINTENANCE PLACEMENT PLAN

After the completion of new work dredging for the Freeport GRR and the Lower Stauffer Channel, the project will require periodic maintenance dredging to retain navigability. It is estimated that the Freeport Harbor Channel (Stations 71+52 to 184+20) will receive an annual shoaling volume of approximately 315,000 cy (HDR, 2016) pursuant to the implementation of the GRR features. Additionally, it is estimated that the Lower Stauffer Channel will receive an annual shoaling rate of approximately 2,500 cy. This DMMP is based on maintenance dredging in 3-year cycles for reaches below Station 184+20 and 12-year cycles for reaches above Station 184+20., resulting in a total dredged volume of approximately 15.3 mcy. All maintenance dredged volume is designated for placement at the Maintenance ODMDS. In

addition, there will be some residual capacity available at PA1 which is planned to be used for minor occasional maintenance dredging requirements. Table 3 contains the 50-year placement plan for the maintenance dredged material.

Table 3 – 50-Year Placement Plan for Maintenance Dredged Material

Reach	Stations		Annual Vol. (cy)	Cycle Length (year)	Vol. per Cycle (cy)	No. of Cycles	Total Vol. (cy)	Disposal Site
	From	To						
Bend Easing	147+00	159+85	30,900	3	92,700	16	1,483,200	Maintenance ODMDS
Turning Notch	175+77	181+41	10,800	3	32,400	16	518,400	Maintenance ODMDS
Channel Widening	142+28	184+20	12,900	3	38,700	16	619,200	Maintenance ODMDS
Existing Harbor Channel	71+52	184+20	261,000	3	783,000	16	12,528,000	Maintenance ODMDS
Lower Stauffer Channel	184+20	198+50	2,500	12	30,000	4	120,000	Maintenance ODMDS
Total Maintenance Dredged Material	**71+52**	**198+50**	**318,100**	**VARIES**			**15,268,800**	**Maintenance ODMDS**

1.7 BENEFICIAL USE OPPORTUNITIES

A comparison of potential Beneficial Use (BU) opportunities to upland confined placement has been performed and can be found in Attachment 8 of FHCIP GRR Engineering Appendix. Total costs have not been estimated, rather a comparison of the work required for each has been conducted.

The current GRR plan contains approximately 1.7 mcy of new work material. Potentially viable options in the project vicinity for BU could include either beach nourishment or marsh nourishment. Due to low sand content of the dredged material, only marsh nourishment projects appeared viable. A potential BU site was identified and shown in on northeast of the project feature at the intersection of Texas State Highway 332 and Casko Road. The site was selected based on its proximity to the dredge site, no data (geotechnical, biological or survey) information has been collected and very limited real estate coordination has been conducted for the site. Amid the unknown existing elevation within the BU site, an average fill height of 3 feet was assumed. Based on this fill height the potential BU site can contain roughly 0.7 mcy of dredged material. The BU site does not have sufficient area to hold all 1.7 mcy of new work material; therefore, the remaining 1.0 mcy of new work material needs to be placed at PA1. A natural meandering channel, currently passes through the BU site. In order to retain the existing channel, the BU site was split in to two (2) parcels. A map of the potential BU site is presented in Figure 2

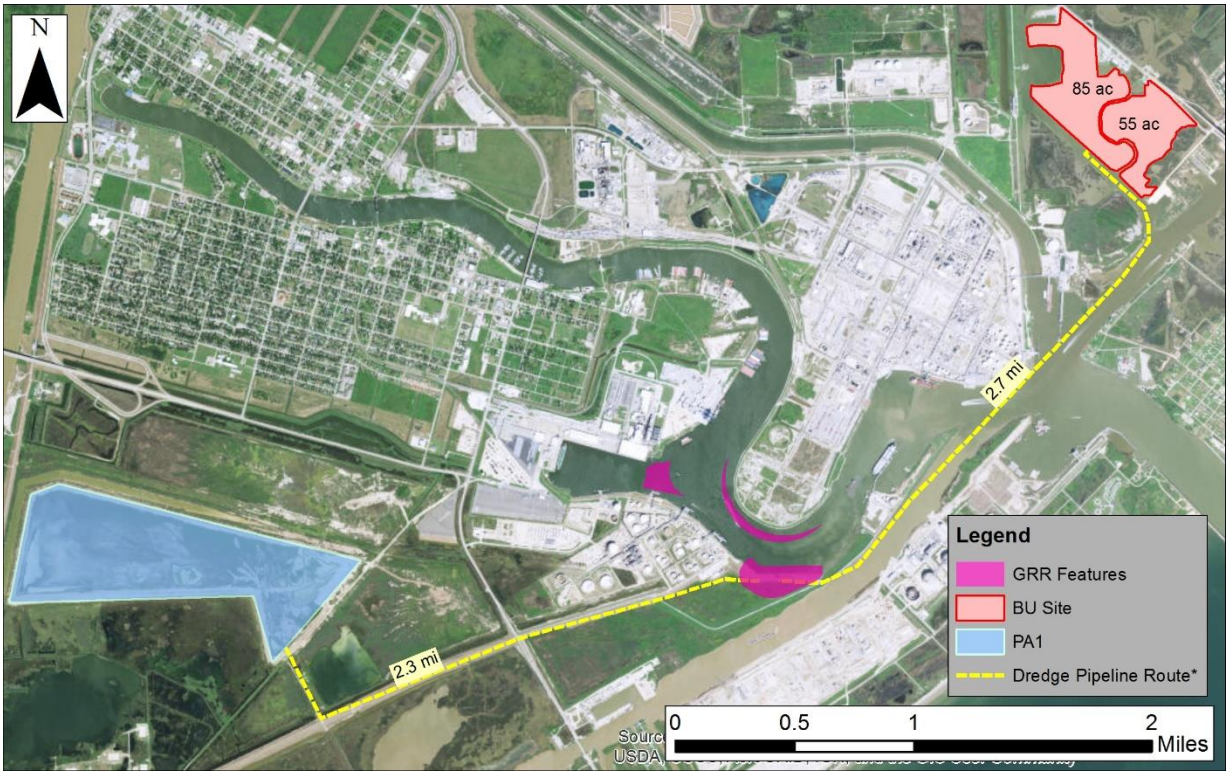

Figure 2 – Project features, placement area, and potential BU site.

***Note: Dredge pipeline routes are assumed and may differ with actual pipeline routes.**

The work required for each scenario (i.e. upland placement vs beneficial use) was estimated by listing all of the necessary activities for placement of the estimate 1.7 mcy of new work material. Table 4 and Table 5 contain an itemized list of the required work for each case.

Table 4 – Work Estimate for Disposal of All Material in PA1.

10026951
6/12/2017

Prepared: SA
Checked: BLG
Project Manager: TNM

US ARMY CORPS OF ENGINEERS
FREEPORT HARBOR CHANNEL IMPROVEMENT PROJECT
GRR BENEFICIAL USE OF NEW WORK COMPARISON - PLACEMENT AT PA1

CONSTRUCTION ITEMIZATION AND QUANTIFICATION

	ITEM	QUANTITY	UNIT
1.	Dredge Mobilization / Demobilization	1	LS
2.	Construction Surveying - PA1 Levees	1	LS
3.	Construction Surveying - GRR Features	1	LS
4.	Dredging and Dredged Material Placement to PA1	1,700,000	CY
5.	PA Levee Raising	170,000	CY

DEFINITIONS

1. Includes transporting personnel, equipment, supplies and incidentals to and from the site, establish offices, buildings, and other facilities necessary, obtain bonds, required insurance, perform cleanup, and any other efforts necessary.
2. Includes initial and final surveys of the PA levees. It is assumed that surveys are not required for documenting elevations and extents of dredged material discharged within the placement area.
3. Includes initial, interim, and final surveys of GRR features.
4. Includes dredging GRR new work material and placing all material within PA1.
5. Includes raising of levees around PA1. Quantity is estimated assuming 20,310 linear feet of levee with two (2) feet of freeboard and two (2) feet ponding. Levee section is assumed to have a crest width of 10 feet and side slopes of 3H:1V.

Table 5 – Work Estimate for Including Beneficial Use of Dredged Material.

10026951
6/12/2017

Prepared: SA
Checked: BLG
Project Manager: TNM

US ARMY CORPS OF ENGINEERS
FREEPORT HARBOR CHANNEL IMPROVEMENT PROJECT
GRR BENEFICIAL USE OF NEW WORK COMPARISON - PLACEMENT AT PA1 AND BENEFICIAL USE

CONSTRUCTION ITEMIZATION AND QUANTIFICATION

	ITEM	QUANTITY	UNIT
1.	Dredge Mobilization / Demobilization	1	LS
2.	Additional Pipeline Mobilization / Demobilization	1	LS
3.	Construction Surveying - PA1 Levees	1	LS
4.	Construction Surveying - Marsh Parcels	1	LS
5.	Construction Surveying - GRR Features	1	LS
6.	BU Site Decant Structures	5	LS
7.	Dredging and Dredged Material Placement to BU Site	700,000	CY
8.	Dredging and Dredged Material Placement to PA1	1,000,000	CY
9.	Marsh Containment Dikes	165,000	CY
10.	PA Levee Raising	90,000	CY

DEFINITIONS

1. Includes transporting personnel, equipment, supplies and incidentals to and from the site, establish offices, buildings, and other facilities necessary, obtain bonds, required insurance, perform cleanup, and any other efforts necessary.
2. Includes additional efforts to mobilize pipelines between PA1 and BU site. Also includes activities for end of pipeline management during placement at the BU.
3. Includes initial and final surveys of the PA levees. It is assumed that surveys are not required for documenting elevations and extents of dredged material discharged within the placement area.
4. Includes initial, interim, and final surveys of containment dikes and interior of the marsh parcels.
5. Includes initial, interim, and final surveys of GRR features.
6. Includes installation of structures necessary to dewater the BU site during construction.
7. Includes dredging and placement of material to the potential BU site.Quantity has been estimated assuming an average fill thickness of three (3) feet on the BU parcels shown in Exhibit 1.
8. Includes dredging remaining new work material and placing the material in PA1.
9. Includes establishment of containment dikes around the marsh parcels shown in Exhibit 1. Quantity is estimated assuming 21,100 linear feet of containment dike with three (3) feet of freeboard above three (3) feet of interior fill thickness (total dike height of 6 feet). Dike section is assumed to be trapizoidal, with crest width of five (5) feet and side slopes of 5H:1V.
10. Includes raising of levees around PA1. Quantity is estimated assuming 20,310 linear feet of levee with two (2) feet of freeboard and two (2) feet ponding. Levee section is assumed to have a crest width of 10 feet and side slopes of 3H:1V.

Table 6 compares the required work which effectively translates into cost requirements for the purpose of this comparison.

Table 6 – Required Work/Cost Comparison

Metric	Upland Placement (PA 1)	Least Cost	Benefical Use Placement (BU) & PA 1
Sufficent Capacity	Yes	**n/a**	No, identified BU site can only hold 0.7 MCYs additional non-BU site required. PDT was not able to identify another BU site in proximity.
Construction Surveys	One	**PA 1**	Two
PA/BU Constructing Moblization and Demobilzation	Once	**PA 1**	Twice (For BU and again for PA 1)
Dredge Mobilization and Demobilization	Once	**Same**	Once
Pipeline Mobilization and Demobilization	Once	**PA 1**	Twice (For BU and again to PA 1)
Pumping Distance	2.3 miles	**PA 1**	.7 MCY for 2.7 miles to BU site and 1 MCY PA 1 for 2.3 miles to PA 1 = (2.5 miles weighted average)
New Decant Structures	No, existing	**PA 1**	Yes, five (5) for BU Site
Sensitive Resources	None remaining, covered by previous EA/EIS	**PA 1**	No evaluation of resources conducted on BU Site, not necessary on PA 1,
Geotechnical Surveys	Conducted and Completed	**PA 1**	None existing on BU Site, will require investigation
Real Estate Easement	Existing Easement owned by NFS	**PA 1**	No easement on BU Site, underlaying land owned by multiple non-NFS entities
PA 1 Levee Raising (CYs)	170,000	**BU**	165,000
Marsh Levee Raising (CYs)	0	**PA 1**	90,000
Bankline Stabilization	No	**PA 1**	Yes
Least Cost Placement Alternative	**YES**	***	**NO**

After a careful consideration and comparison of the required work and specifics to construct the placement area and to discharge the material, it has been determined that the placement of the entire 1.7 mcy of new work into PA 1 would be the least cost placement alternative. While the BU site is a potential placement area it cannot handle the required volume, nor is there any other potential BU area in the proximity for use. Additionally, the cost for acquiring the land for the BU, if able to do so, would likely greatly exceed the cost associated with PA1.

1.8 REFERENCES

HDR Engineering Inc. 2012; "Dredged Material Placement Area Capacity Assessment." HDR Project 173803 presented at the Meeting with Freeport LNG, Freeport, TX; February 24, 2012.

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USACE, 2012c; "Final Environmental Impact Statement, Freeport Harbor Channel Improvement Project, Brazoria County, TX", Volume I; Galveston TX

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