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A Literature Review of the Beneficial Use of Dredged Material and Sediment Management Plans and Strategies

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A LITERATURE REVIEW OF THE BENEFICIAL USE OF DREDGED MATERIAL AND SEDIMENT MANAGEMENT PLANS AND STRATEGIES

January 26, 2016

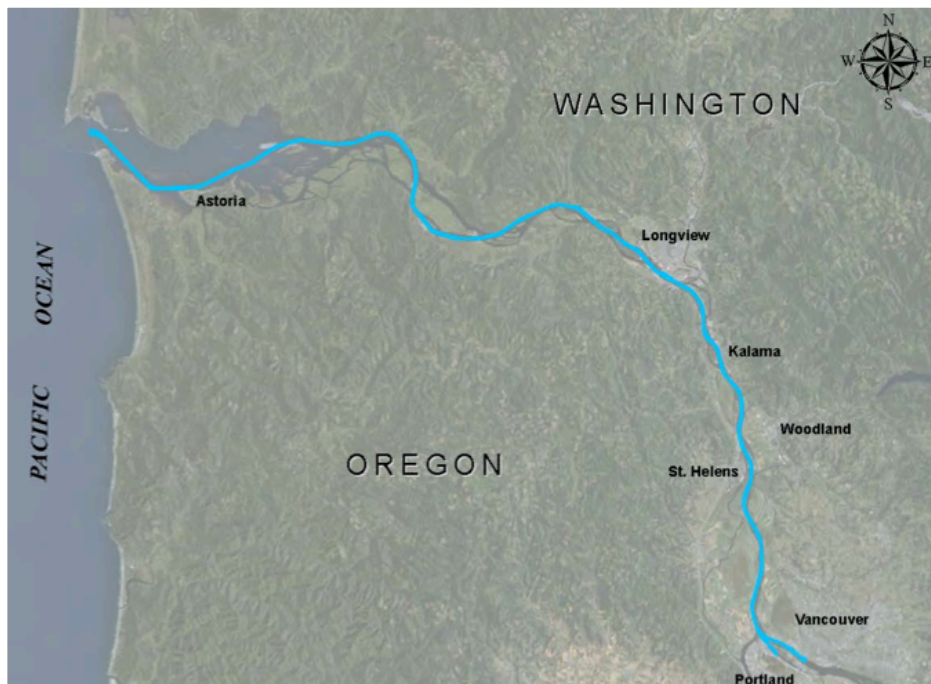


Figure 1: Lower Columbia River Project Area. Source: Portland District, US Army Corps of Engineers.

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LIST OF ACRONYMS AND ABBREVIATIONS

BCDC	Bay Conservation and Development Commission	LCSG	Lower Columbia Solutions Group
BMP	Best Management Practices	LRDMP	Long Range Dredged Management Plan
BU	Beneficial Use	LSR	Lower Snake River
CCMP	Comprehensive Conservation Management Plan	LSRP	Lower Snake River Plan
C&LW	Clackamas & Lower Willamette	LTMP	Long Term Management Plan
CPS	Center for Public Service	LTMS	Long Term Management Strategy
CRCIP	Columbia River Channel Improvements Project	MCBP	Maryland Coastal Bay Program
CWA	Clean Water Act	MCR	Mouth of the Columbia River
CY	Cubic Yards	NADAG	Navigational and Dredging Advisory Group
DMMO	Dredge Material Management Office	NDT	National Dredging Team
DMMP	Dredge Material Management Plan	NEP	National Estuary Program
DMMP/ SEIP	Dredge Material Management Plan/ Supplemental Environmental Impact Statement	NEPA	National Environmental Policy Act
DWS	Deep Water Site	NJS	North Jetty Site
EIS	Environmental Impact Statement	NMFS	National Marine Fisheries Service
EPA	Environmental Protection Agency	NOAA	National Oceanic and Atmospheric Administration
ESA	Endangered Species Act	NPCC	National Policy Consensus Center
FINN	Florida Inland Navigation District	NY/NJ	New York–New Jersey
FNC	Federal Navigational Channel	O&M	Operations & Maintenance
FREMP	Fraser River Estuary Management Program	PA	Placement Area
HEP	Harbor Estuary Program	PBC	Palm Beach County
IWG	Interagency Working Group	PSMP	Programmatic Sediment Management Plan
LCEP	Lower Columbia Estuary Partnership ¹	PSU	Portland State University
LCR	Lower Columbia River	RMO	Review Management Organization
LCRE	Lower Columbia River Estuary	RSMP	Regional Sediment Management Plan
LCREP	Lower Columbia River Estuary Plan ¹	RSMW	Regional Sediment Management Workgroup
		SAJ	South Atlantic Jacksonville District
		SWS	Shallow Water Site
		USACE	United States Army Corps of Engineers
		WQC	Water Quality Certificate

¹ The Lower Columbia River Estuary Partnership (LCEP) was formerly known as the Lower Columbia River Estuary Partnership (LCREP). As a convention in this document, and to avoid confusion with the Lower Columbia River Estuary Plan(s) (also LCREP), we refer to the organization as “LCEP” and the Lower Columbia River Estuary Partnership’s 2010 and 2011 plans as “LCREP.”

1. INTRODUCTION

Dredged sediment has a contradictory nature that challenges management: it is a valuable resource in some locations and an unwanted nuisance in others (RSMW, 2013). Nationwide, the US Army Corps of Engineers (USACE) dredges 300 million cubic yards (CY) of material annually to maintain the nation's navigation channels. Approximately five to ten percent of this material is unusable due to contamination. The remaining 90-plus percent can be re-used (IADC, 2009). This dredging is essential for the safe and efficient operation of the nation's 25,000 miles of navigable waterways, and 926 harbors, through which over two billion tons of commercial goods move annually (USACE, n.d.). As the agency responsible for maintaining federal waterways, USACE is also responsible for developing regional sediment management plans (RSMP) and dredge material management plans (DMMP). Among other factors provided for within some such plans is a strategy for the placement of dredged sediments to ensure that contaminated materials are properly contained and that non-contaminated material are beneficially placed where they can provide the greatest benefit to the environment.

USACE has had the authority to develop and maintain federal navigational waterways since 1824 (USACE, 2012a). USACE is authorized to maintain the Columbia and Lower Willamette (C&LW) federal navigation channel (FNC) project between Columbia river mile (RM) 3.0 and RM 106.5 to a depth of 43 feet and width of 600 feet (USACE, 2012a). Dredged materials found in the lower estuarine reach (RM 3-29) are predominantly clean quartz sand in the medium to fine-sand size range with generally less than 1% by weight of fines and organic content (USACE, 2012a). Overall, sediment samples collected from the Columbia River FNC from RM 3.0 to RM 106.5 in 2008 indicated a mean grain-size of 92% sand (USACE, 2014a). This is clean material considered suitable for unconfined aquatic placement, for construction projects, and other beneficial use (BU) options (USACE, 2012a).

The USACE's Portland District, located in Portland, Oregon, is responsible for maintaining the FNC in the Columbia River. The District engaged the National Policy Consensus Center (NPCC) at Portland State University (PSU) to assist in designing a collaborative process for development of a long-term RSMP for the C&LW project between RM 3 and RM 106.5.

The NPCC, in turn, contacted the Mark O. Hatfield School of

Government's Center for Public Service (CPS), also at PSU, to conduct a literature review to help inform the development of the LCR RSMP. Specifically, CPS was asked to:

- Review existing DMMP, previous modeling efforts on the LCR, morphology conditions, and current dredging practices.
- Evaluate BU opportunities for dredging and placement of material in the LCR, including in-water, shoreline, and upland placement.
- Research additional literature related to dredging and disposal activities in similar settings.
- Develop a report outlining the findings of said research and develop conclusions and recommendations to help inform future technical discussions.

This report summarizes key elements from the body of existing literature that addresses BU of sediments. The remainder of this introductory section discusses the commercial importance of dredging in the LCR, the environmental importance of the LCR as an ecological resource, and the importance of engaging stakeholders in developing sediment management plans. Section 2 defines BU and presents the BU placement options as may be applicable to the LCR.

The authors reviewed approximately 100 documents and reports for this project (see Appendix 1). Of these, approximately 50 were selected as useful references based on their relevance to sediment beneficial uses, collaborative strategies, and/or sediment management plans and strategies. Seventeen of those selected were reviewed in detail, and the results of that review are presented in Section 3. Section 4 presents this report's findings and conclusions, and Section 5 the recommendations.

This report does not review the myriad laws and regulations applicable to Lower Columbia River dredge sediment placement. However, the Lower Columbia Estuary Partnership provides a synopsis of those laws and regulations in their August 2010 draft plan (see Chapter 3, LCEP, 2010).

1.1 Dredging and the Lower Columbia River

Historically known as the “Grave Yard of the Pacific,” the mouth of the Columbia River is the most dangerous river entrance in the world (Clatsop County, 2012). Rapid and continual adjustments in channel configuration and shoaling patterns at the mouth of the Columbia River (MCR) have caused navigation problems since its discovery in 1792 (Byrnes, 2013). Jetties were constructed to improve safety through the channel from 1885-1939. Subsequent lower river navigation improvements include construction of a federally authorized 43-foot deep navigation channel from the mouth of the river to the city of Portland, Oregon. USACE maintains the federal channel through the use of jetties, pile dikes, creation of man-made islands, and dredging. Dredging involves the physical removal of sediments from one location and the placement of the material in another (Reed, n.d.). Once dredged material has been collected, it is placed in either designated open-water or confined disposal sites or employed for a variety of BU (Williams, 2005). Whereas USACE maintains the federal channel, river-side ports and communities may also engage in dredging to connect their facilities to the federal channel or for other purposes.

Dredging in the lower Columbia has long been a joint venture between the federal government and riverside ports. The Corps of Engineers maintains the federal channel to its authorized depths, employing a mix of Corp-owned and contracted privately-owned dredges. Ports and marinas conduct their own dredging operations to connect their facilities to the federal channel (Kleinfelder, et al., 2002).

The lower river is the gateway to the Columbia-Snake River Navigation System. The navigation system extends to Lewiston, Idaho. The system is the largest mover of wheat, wood products, and minerals in the nation, and the second largest mover of soy products (PNWA, 2014). Currently, \$16 billion worth of US products, 12,000 commercial vessels and 10,000 recreational and charter vessels pass through the lower river annually (Oregon Solutions Group, Cogan Owens Cogen and Institute for Natural Resources, 2011).

Maintaining the system is thus essential to the regional economy. However, the lower river is more than a critical commercial resource. It is also an ecological treasure used by numerous species of fish, wildlife, and birds of which many are protected under federal and state conservation laws and regulations.

1.2 The Lower Columbia River Ecology

The Columbia River is an interstate and international river, originating in Canada and flowing south 1,214 miles to the Pacific Ocean. The river has the second-largest volume of flow and the fourth-largest watershed of any river in the US, draining a total of 259,000 miles and receiving waters from seven states and one Canadian province (NSG, 2003). The Columbia River has the highest discharge level of any river entering the Northeast Pacific Ocean and has a higher sediment transport capacity than many typical estuaries (LCEP, 2010).

Estuaries are found where a river meets the sea (NSG, 2003). Bays, sounds, and other types of partly enclosed water bodies are all estuaries (NSG, 2003). In an estuary, freshwater from the river and salt water from the sea mix together. The ocean tide also affects estuary waters (NSG, 2003). Estuaries are among the most productive environment on earth, creating more organic matter each year than similarly-sized forests and agricultural areas (CBP, n.d.).

At the entrance to the ocean, the LCR forms a large estuary that is an important feeding and breeding area for oysters, clams, mussels, and Dungeness crab (NSG, 2003). There is an expanding body of research supporting the ecological importance of these habitats to salmon and steelhead (USACE & BPA, 2013). Research indicates that time spent by fish rearing in the estuary promotes survival, and those that spend more time in the estuary generally live longer than those that do not (USACE & BPA, 2013).

In 1987, Congress created the National Estuary Program (NEP) to protect and restore estuaries around the nation (LCEP, 2010). The LCR estuary was accepted into the NEP in 1995 (NSG, 2003) and the US Environmental Protection Agency (EPA) and governors from Oregon and Washington created LCEP as the regional entity of public stakeholders to increase integration and coordination. In 1999, the EPA and the governors of Oregon and Washington signed an implementation agreement making a commitment to adopting the mission of the LCEP. The LCEP's Comprehensive Conservation and Management Plan (CCMP) was the first regional, two-state plan addressing the importance of the estuary and what steps should be taken to protect ecosystem degradation. Among its provisions is a requirement that implementing mitigation and enhancement measures and/or restoring marsh and tidal areas must be consistent with the Lower Columbia River Estuary Plan (LCREP) (CH2MHILL, 2013a).

The National Oceanic and Atmospheric Administration (NOAA) is tasked with listing threatened and endangered species and critical habitats (NOAA, n.d.a). NOAA lists the LCR as a critical habitat for steelhead and Chinook, chum, and coho salmon all of which are listed as threatened under the Endangered Species Act (NOAA, n.d.a). A total of 76 species of fish have been documented in the estuary (CH2MHILL, 2013b). A great diversity of plants form the foundation for the lower river's rich ecosystem. Wetlands purify water by trapping sediments and pollutants in runoff, absorb stormwater and decrease flooding in inland areas (HEP, 2012). The LCRE is designated as critical habitat for 17 species of Endangered Species Act (ESA) listed fish (US Department of Commerce, 2012).

USACE defines the Columbia River estuary as "roughly the 150 miles of the Columbia River below Bonneville Dam that is subject to tidal influence, including both freshwater and salinity-influenced areas" (USACE & BPA, 2013, p.3). The LCRE is one of 28 estuaries in the NEP (EPA NEP, n.d.). Over time, the LCRE has been affected by significant developmental pressures. Fifty percent of original habitat in the LCR has been lost or degraded, and habitat loss is the most significant and pressing problem facing threatened and endanger species (LCEP, 2011). While there are discrepancies among existing resources on where the estuary morphology ends and river begins, there is no disagreement on the importance of the estuary as a resource for the survival of rare, threatened or endangered birds, fish and other wildlife (NOAA, n.d.a).

1.3 The Importance of Collaborative Engagement with Regional Stakeholders

Beneficial placement of sediment calls for putting those materials where they are most needed or where they would have the least potential for adversely affecting the river's environment. While there is an extensive body of literature that describes potential beneficial uses of dredged material, relatively few plans were found that appear to implement the practice. Common to the plans that do are a statement of purpose, an estimate of the amount of material to be removed, placement alternatives, and a methodology. Examples of such plans include the Fraser estuary in Canada, the Delaware estuary, and the New York/New Jersey (NY/NJ) estuary. Each incorporates an evaluation of alternatives for potential habitat benefits.

There is relatively little in the plans reviewed that addresses collaborative processes. Interestingly, those plans that do include provisions for BU tend to be the result of processes that incorporated collaborative input from relevant stakeholders. In these plans, stakeholders include evaluated the alternatives to dredging and placement, with the plans identifying placement options that were most efficient while providing the most benefit to the environment. The Oregon, Maryland, California, and NY/NJ include plans that have come together successfully utilizing collaborative efforts (Vogt, Inc. 2010). Provisions of those plans that may be applicable to the Lower Columbia River include:

- Establishment of the Lower Columbia Solutions Group (LCSG) and its Declaration of Cooperation that helped developed the USACE Mouth of the Columbia plan.
- The monthly newsletter that informs interested parties of progress found in Maryland's plan.
- The establishment of a Dredge Materials Management Office (DMMO) in the California plan, and
- The Harbor Estuary Program as found in the NY/NJ plan (Vogt, Inc., 2010).

Historically, local communities located along maintained waterways take great interest in dredging and sediment management activities. If not engaged constructively at the beginning of a project, and if proposed plans are at odds with local interests, stakeholders may hinder progress through litigation and/or engagement with political leaders. Sediment management thus includes a social dimension in addition to the technical and environmental issues. The constructive engagement with local stakeholders found in these plans illustrates how such engagement minimizes conflict over dredged material placement.

1.4 USACE Dredging and Beneficial Use

The USACE has long been the most active dredging organization in the US, as well as the primary regulator of dredging and dredge material disposal (EPA & USACE, 2007). Many new Civil Works navigation projects are multipurpose projects designed to accomplish both navigational and ecological goals (EPA & USACE, 2007). New laws have established authority for the USACE to use dredged materials for environmentally beneficial purposes (EPA & USACE, 2007). The placement options selected for projects should maximize both economic and environmental restoration benefits (EPA & USAC, 2007).

2. BENEFICIAL USES OF DREDGED MATERIALS

In a healthy estuarine ecosystem, there is a balance between the amount of sediment entering and exiting the system. Sediment naturally enters the system through upriver erosion in mainstem rivers and tributaries and eventually finds its way to the sea (HEP, 2012). This natural sediment cycle can be disrupted by shoreline development; land uses such as agriculture, timber, and mining; and construction of in-water or near-water structures such as dams, navigation channels, levees, shoreline rip-rap, pile dikes, and jetties. The results of such disruption can be significant. Too little sediment can lead to erosion of coastal areas, wetlands, islands, mudflats, and other aquatic habitats. On the other hand, too much sediment can bury or stress aquatic organisms and communities, among other negative effects (HEP, 2012; Roegner and Fields, 2014). The movement and placement of this material thus carries significant consequences for local communities and the natural environment.

This disruption in sediment flow can be offset by using dredge materials for a variety of beneficial purposes. Proper placement can nourish beaches, provide fill material for construction, develop or enhance habitat for fish, waterfowl, and animals. Dredging practices can also help maintain water quality by minimizing turbidity through proper placement locations and timing. Poor placement can smother spawning areas and food sources, block migration corridors or access to fish rearing areas, disrupt fish life-cycles, and weaken water quality through turbidity (Roegner and Fields, 2014).

Placements are dependent on the grain size, the volume of material to be removed and placed, the location of permitted placement sites, the availability of funding and the time of year the dredging is needed (NADAG, 2010). This section provides an overview of the types of beneficial uses to which non-contaminated dredged materials may be placed.

2.1. Beneficial Uses Defined

In 2007, the US EPA and USACE developed a BU Planning Manual to provide a framework for identifying, planning, and financing BU projects (EPA and USACE, 2007). The beneficial use of dredged material embraces the idea that dredge material from the USACE's Civil Works projects "can be used in a manner that will benefit both society and the natural environment" (EPA and USACE, 2007, p. 8). BU is defined as "the use of dredged materials, by placing them where they can maximize the most good, rather than wasting them by disposal" (Nightingale and Simenstad, 2001, p. 45). BU of sediments includes both environmental improvements and commercial activities, such as the use of dredged material for habitat restoration as well as construction fill (Nightingale and Simenstad, 2001).

Sediments can be used to enhance or create beach areas and/or shallow water habitat through the addition of sediment to shorelines (LCEP, 2010). The LCREP states "explore using dredged materials for beneficial uses — to promote wetland accretion, to create habitat suitable for native species, to provide beach nourishment, and to protect infrastructure or important habitats" and "create a regional plan for sediment management to compile sediment transport and distribution information and provided a decision making framework for sediment placement and flow management" (LCEP, 2011, p. 15).

2.1.1. Beach Nourishment

Beach nourishment is used to replenish eroded sand from beaches to stabilize the shoreline, moderate wave action, help with erosion control, and, for coastal beaches, to feed the littoral zone (Nightingale and Simenstad, 2001). In the Great Lakes, beach nourishment has been carried out with the use of berms both to decrease erosion by wave action and to supply sand to eroding beaches (EPA and USACE, 2007).

2.1.2. Habitat Restoration, Creation, and Development

Dredge material can be used to create, restore or maintain habitat to wetland, upland, island, and aquatic areas (EPA and USACE, 2007).

Wetland. Wetland habitat is a broad category of periodically inundated or saturated soils and plant communities that survive in wet soil (EPA and USACE, 2007). Dredged material can be used to create new or expand existing wetland areas. To develop wetland habitat, dredged material is used to fill areas to precise elevations to promote colonization by wetland vegetation (EPA and USACE, 2007).

Upland. Upland habitat includes vegetation not usually subject to inundation including, grasses, shrubs, and trees (EPA and USACE, 2007). Dredged sediments have been used to enhance or create habitat for eelgrass restoration on the Puget Sound (Fuller, n.d.).

Island. Dredged material can be used to create new islands (EPA and USACE, 2007). Dredged sediment from the CR has been used in numerous ways, and tidal marsh has developed on many dredge spoil islands (Fuller, 2015).

Aquatic. Dredged material can be used in submerged habitats to affect the bottom elevation or the condition of the submerged area. Potential aquatic habitats that could be developed using dredged material include seagrass meadows, oyster beds, fishing reefs, and freshwater aquatic plants (EPA and USACE, 2007). In rivers, dredged material can be used to create "Essential Fish Habitat" to support rearing of juvenile fish.

2.1.3. Structural and Shore Protection

Dredged materials can be used to cap contaminated sediments, for agriculture, forestry, horticulture, and parks and recreation (Nightingale and Simenstad, 2001). Dredged material has been used to reinforce the South and the North Jetties at the MCR. Coffee Pot Island (RM 42) and Eureka Island were both built as a flow control structure and have reduced maintenance of the channel parallel to them (LCEP, 2010). Dredged material can also be used in levee and dike construction (EPA and USACE, 2007).

2.1.4. Recreation

Dredge materials can be used as foundation for parks and recreational facilities (EPA and USACE, 2007). The creation or maintenance of recreational sites is one of the most prevalent BU's of dredged material (EPA and USACE, 2007). In the Great Lakes region, parks, marinas, fishing piers, and other recreational facilities have been built using dredged material (EPA and USACE, 2007). The Tennessee-Tombigbee Waterway used dredge material to control erosion and to provide wildlife food and habitat (EPA and USACE, 2007).

2.1.5. Agriculture, Forestry, Horticulture, Aquaculture

Dredge materials can be used to replace eroded topsoil, elevate the soil surface, or improve the physical and chemical characteristics of soil (EPA and USACE, 2007). Dredge material in river systems has been used for farming and livestock pasturage (EPA and USACE, 2007). Farmers have successfully incorporated dredged materials into marginal soils at orchards and nurseries to enhance production (EPA and USACE, 2007). By applying dredged material to farmland, topsoil can be conserved and reclaimed, while also improving drainage and reducing potential flooding (EPA and USACE, 2007).

2.1.6. Strip-Mine Reclamation and Solid Waste Management

Dredged materials can be used to reclaim strip-mines, to cap solid waste landfills or to protect landfills (EPA and USACE, 2007). In Illinois, a former coal strip-mine was re-contoured and covered with a layer of dewatered dredge material, buffering the acid runoff and the infiltration of water which allowed for the growth of grasses (EPA and USACE, 2007). In Marin California, a wetland is being developed from the covering of a sanitary landfill and the BU of dredge material is expected to shorten the time needed to fully develop the wetland (EPA and USACE, 2007).

2.1.7. Construction / Industrial Development

Dredge materials can be used to support commercial or industrial activities, primarily near waterways to expand or raise the height of the land base or provide bank stabilization and in construction material (EPA and USACE, 2007). Homes and businesses in many cities, such as Galveston, Texas and Portland, Oregon, have been constructed on dredged material foundations (EPA and USACE, 2007). Dredge material can be used for grading material (Vogt, Inc., 2010). The Bayonne Golf Club used 2 million CY from the NY/NJ harbor and the Riverwinds Golf Course on the Delaware Bay used 190,000 CY, and then the dredged material was covered with materials that supported growth of grass for golf course development (Vogt, Inc., 2010). The Jersey Garden Mall project is an example of a brownfields redevelopment success where dredge material was used to cap a former municipal waste landfill (EPA and USACE, 2007).

2.1.8. Summary of Beneficial Uses of Dredged Materials

Economic growth and environmental restoration are frequently incompatible objectives resulting in competing forces between stakeholders. BU of dredge materials can help bridge that divide. The challenge is selecting the placement of the sediments where they can provide the most benefit both economically, societally and environmentally to converge the interest of stakeholders. The dredging of ports, harbors and channels is economically necessary. Filling aquatic habitats with dredged material is significantly impacting species abundance and environmental quality (Reed, n.d.). Collaborative efforts between local, state, and federal agencies, along with competing stakeholder interests, can be used to develop sediment management plans that are both economical and environmentally sustainable, by combining the needed dredging with the sustainability of BU sediment placement.

3. REVIEW OF SEDIMENT MANAGEMENT PLANS AND STRATEGIES

3.1. Types of Sediment Management Plans

There are two types of sediment plans utilized by the Corps: Dredged Material Management Plans (DMMP) and Regional Sediment Management Plans (RSMP). Each are described in more detail below.

Other entities engaged in dredging activities, such as ports or marinas, may develop locally managed plans for material disposal. These plans are produced in accordance with state and/or local regulations and ordinances (RSMW, 2013).

3.1.1. Dredge Material Management Plans

The Corps conducts dredged material planning in accordance Engineer Regulation 1105-2-100. The intent of the regulation is to ensure that federal dredging activities are environmentally acceptable, use sound engineering techniques, are economically supported, and that sufficient disposal facilities are available for at least 20 years. The Corps prepares these plans in writing to address dredging needs, disposal capabilities and capacities, environmental compliance requirements, opportunities for beneficial usage, and economic indicators. The regulation also requires that DMMPs be updated periodically to reflect changed conditions (USACE, 2000).

A DMMP is project-specific. DMMPs may include sediment budgets. Sediment budgets are estimates of the capacity of a sediment placement site to accept material over the period of time. It also specifies the state and federally approved locations where specified amounts of the sediments will be placed. DMMPs also include an evaluation of different alternatives for material placement, how to apply criteria before selecting the alternative, and justification for the selected option.

The National Environmental Policy Act (1970) requires that an environmental impact statement (EIS) be prepared for federal projects that have an impact on the environment. Consequently, every DMMP needs to assess potential impacts to habitat including: (1) area, depth, volume, sediment character of the dredge footprint, including discrete samples characterizing the expected leave surface, and anticipated frequency and seasonality of maintenance dredging; (2) the anticipated suspension and deposition of sediments outside of the dredging footprint; (3) placement options of dredged materials, with preference for BU; and (4) river hydraulic model results to assess future changes in hydraulic patterns and channel morphology on site and within the impacted river reach over time, and to estimate maintenance dredging requirements (US Dept. of Commerce, 2012). Additionally, scientifically based seasonal construction windows may be required to minimize loss of habitat functions and values and the resources that might be harmed or displaced by dredging activities (US Dept. of Commerce, 2012).

3.1.2. Regional Sediment Management Plans

A RSMP is a system-based approach (rather than site-by-site) that is designed to incorporate, in its implementation and monitoring, the interrelationships between inland, coastal and offshore sediments, and sediment pathways to and along the coast (USACE, 2004). They also take into account other Corps business lines, such as the Corps Regulatory permitting program.

Collaboratively designed RSMP have the capacity to be more effective and efficient because they leverage resources, forecast long-range implications, and utilize a network of sediment placement sites that are adjusted as needed (USACE, 2015b). RSMPs allow for data collection through monitoring how much material is dredged, where it is placed and where it migrates to. RSMPs with this monitoring and data collection process are more adaptive, they incorporate the data collected into improving the plan as the plan is being executed. For example, a recent study near Benson Beach on the Oregon coast traced the behavior of placed material within the active littoral inter-tidal zone of Benson Beach to evaluate the direction and rate of transport. If the placed sand moved in a coherent manner such that the littoral sediment budget along Long Beach peninsula could be augmented, an important option for beneficially using MCR dredged material could be validated and compared with other placement methods (Ott, Moritz, and Kaminsky, n.d.).

The National Dredging Team (NDT) was established in 1995 to support the implementation of the National Dredging Policy to promote consistency and provide a mechanism for issue resolution and information exchange among Federal, State, and local agencies and stakeholders (Pinole Shoal, 2006). The 1998 guidance called for development of twenty year horizon dredged management plans (NDT, 1998). The guidance provides a framework to: (1) assist in the formation of Local Planning Groups; (2) provide context regarding Local Planning Groups' relationship to other groups having different but the compatible purpose of a regional dredging plan; (3) establishing a planning process; and (4) develop and implement dredged material management plans.

One of the main intended outcomes of the federal dredge material management program is to encourage limited federal budgets to go further, by providing guidelines for USACE, EPA, and other federal agencies to take advantage of opportunities to collaborate on BU projects (EPA and USACE, 2007). The responsibility to protect, preserve and restore coastal and freshwater resources in the area of dredging and sediment placement, along with the required need for navigation through the channel, provides opportunities for creative partnerships to meet both environmental and economic objectives, including the BU of dredged material (EPA and USACE, 2007).

3.2. Plans and Strategies Reviewed and Lessons Learned

The dredging plans below include a diverse collection of plans, from site-by-site sediment strategies, to long term DMMPs. For each plan reviewed, background information about the location, who and how it was developed, and the main objectives of the plan are provided. Additionally, evaluations from available case studies are also included to provide the lessons learned from projects undertaken through these plans. Some plans were developed solely by the USACE, some plans were developed through a collaboration with the USACE, and other plans were developed by other governmental and non-governmental organizations.

Plans developed solely by the USACE include, the Columbia River Channel Improvement Project (1989–2010), Dredge Material Management Plan/Supplemental Environmental Impact Statement (2013–2018), Calcasieu River and Pass, Louisiana Dredged Material Plan and Environmental Impact Statement (EIS) (2010), and the DMMP Brazos Island Harbor, Texas Channel Improvement Study Final Integrated Feasibility Report and Environmental Assessment plan (2013).

Plans developed through a collaborative with the USACE include, the USACE Dredge Material Management BU Plan (2018-2038), Mouth of the Columbia River (MCR) Regional Sediment Management Plan (2011), USACE – Lower Snake River Programmatic Sediment Management Plan (2014), Long-Term Management Strategy (LTMS) for the placement of Dredged Material in the San Francisco Bay Region (2001), and the Cedar Bayou, Texas DMMP Galveston District (2012) plan.

Plans developed by other governmental and non-governmental organizations include, the LCEP Draft (August 2010), DRAFT Dredge Material Management Plan Oregon Liquid Natural Gas (LNG) Terminal (2013), Environmental Management Strategy for Dredging in the Fraser River Estuary, Delaware Estuary Regional Sediment Management Plan (2013), Navigation and Dredging Planning Guide for Maryland's Coastal Bays (2010), Long Term Management Strategy for Dredged Material in the Delta (Delta LTMS) draft Process Framework (2006) organizations, New York-New Jersey Harbor Estuary Program Regional Sediment Management Plan (2008), and the Long Range Dredged Material Management Program for the Atlantic Intracoastal Waterway in Florida (2000) plan.

3.2.1. USACE — The Columbia River Channel Improvement Project (1989–2010)

USACE worked for decades on a plan for deepening the FNC to 43 feet. The result was the Columbia River Channel Improvements Project (CRCIP), authorized in 1999. The feasibility study and Environmental Impact Statement for the CRCIP was completed in 2003 and included a dredged material management plan. Responding to concerns from regulatory agencies and others, USACE engaged an adaptive management team of regulatory agency representatives to help implement and monitor an adaptive management plan to ensure that actual environmental impacts from CRCIP were no greater than anticipated (PNWA, n.d.; personal communications with Portland District Staff).

3.2.2. USACE — Columbia River Federal Navigation Channel Interim Operations & Maintenance (O&M) Plan (2013–2018)

The 5-year interim plan forecasts the need to maintain the 43-foot channel from project completion until the next 20-year DMMP is developed. The forecast was based on the CRCIP DMMP and no new sites were added. Public involvement was limited to the public review of the environmental assessment related to the interim plan. Few comments were received. The interim plan uses a balance of different placement methods at different locations to meet channel maintenance needs and minimize effects (personal communications).

Shoreline or beach nourishment placement involves pumping dredge material through a floating discharged pipe to the shore where it is used to restore eroded beaches. Upland placement of dredged material removes that material from the river system so it is no longer a source for future shoaling and reduces need for FNC O&M dredging. Material placed upland is beneficially reused at some locations as construction fill. Beach nourishment and upland placement methods are being used to improve the habitat for the recently ESA-listed bird Streaked Horned Lark. In-water placement keeps material in the system and can enhance shallow water habitat for salmon (USACE 2015a).

In-water holding basins (sumps) are sometimes used for temporary storage of dredged material until it is moved to an upland placement site. This maximizes the efficient use of an upland placement site when shoaling is not located within direct pipeline dredge pumping distance. Temporary storage of dredged material at a sump also provides flexibility for dredges to be redirected to unexpected, urgent shoaling needs elsewhere in the Columbia River system (USACE 2015a; personal communications).

3.2.3. Mouth of the Columbia River (MCR) Regional Sediment Management Plan (2011)

The Lower Columbia Solutions Group worked with the states of Oregon and Washington, the EPA, and many others to develop a plan for the Mouth of the Columbia project, through a collaborative process, that would be financially, economically and socially sustainable (Oregon Solutions, Cogan Owens Cogan and Institute for Natural Resources, 2011). The MCR plan is multi-jurisdictional and is a regional, rather than a state-by-state, approach (Oregon Solutions, Cogan Owens Cogan and Institute for Natural Resources, 2011).

Currently USACE dredges approximately four million CY of sand from the MCR each year (Oregon Solutions, Cogan Owens Cogan and Institute for Natural Resources, 2011). The objective of the 2011 MCR plan was to utilize the dredge material in a beneficial way to replenish the one million CY of material lost annually from the littoral zone (Oregon Solutions, Cogan Owens Cogan and Institute for Natural Resources, 2011). The loss of sediments has left some traditionally sandy areas exhibiting mud, and this is particularly the case with the South Jetty, making it vulnerable to a breach (Oregon Solutions, Cogan Owens Cogan and Institute for Natural Resources, 2011). Placement of the materials included beach nourishment as well as jetty fortification.

The South Jetty was vulnerable to a possible breach and fortification of the jetty with sediment placement was needed (Oregon Solutions, Cogan Owens Cogan and Institute for Natural Resources, 2011).

The MCR plan covers the South Jetty and the North Jetty along with the mouth of the CR. When designing the regional sediment management plan for the Mouth the team looked at research from the past decade, and ultimately decided that a thin-layer disposal, at new BU sites, would address specific littoral sediment needs, while having limited risk of impact on navigational safety and biological resources (Oregon Solutions, Cogan Owens Cogan and Institute for Natural Resources, 2011). The plan was designed to avoid mounding which can lead to navigational safety issues caused by wave amplification, so by dispersing a thin-layer of sediment at sites and by rotation of the disposal sites, mounding could be avoided (Oregon Solutions, Cogan Owens Cogan and Institute for Natural Resources, 2011).

Dredging at the MCR is limited to June through November when wave conditions are favorable for working safely at the offshore bar (USACE, 2012a). Two hopper dredges are normally required to perform maintenance dredging; a government-operated dredge and a contractor-operated dredge, each with different capacities and operating characteristics (USACE, 2012a). Dungeness crab season ends in August, so some beneficial placement practices are further restricted to a working window of September through November. Along with crabs, fish runs are also considered when beneficial in-water placement is planned.

The goal of the MCR plan is to place sediments at authorized beneficial sites, in-water, at depth (sufficiently shallow) and distance (60-65 feet or shallower) that allows the sand to migrate to where it is most needed (Oregon Solutions, Cogan Owens Cogan and Institute for Natural Resources, 2011). Another significant aspect of the plan was that it identified multiple beneficial sites, so that the sites could be rotated. Specifically, the MCR plan expanded the existing network of sites to include four new BU sites including the South Jetty nearshore site, the North Head nearshore site, the South Jetty onshore site, and the Benson beach onshore site (Oregon Solutions, Cogan Owens Cogan and Institute for Natural Resources, 2011).

The collaborative management approach adopted by the MCR provides for developing a program of research and for monitoring of biological resources (Oregon Solutions, Cogan Owens Cogan and Institute for Natural Resources, 2011). Consistent with the requirement to monitor the sediments and the potential adverse effects, a Benthic Impact Study was written in 2014 that discusses testing done while sediments were being placed. The study monitored both fish and crab migration from and return to placement sites. In addition to the potential disturbance caused by the sediment placement, they also measured the depth of the sediment placed. While most of the experiments were done at the south jetty nearshore site, some were made at the DWS and the north head nearshore site. The collection of data, for fish and crabs, took place by using a video sled and campod (Roegner and Fields, 2014). Crabs were first tagged to track their migration (Roegner and Fields, 2014). The first year of data suggests that neither fish nor crabs seem to be adversely effected by the placement of sediments, rather, fish seem to be drawn to events and crabs seem to return quickly after a placement event (Roegner and Fields, 2014).

The MCR disposal sites at the South Jetty and North Jetty (SWS and NJS, respectively) have been limited because of potential for dredged material mounding (USACE, 2012a). In addition, if conditions at the bar are too rough, the SWS or NJS may not be able to be used, and so during those times the DWS has to be used (Neal, n.d.). Material placement in the authorized disposal sites seaward of the MCR has led to unacceptable mounding (Byrnes, 2013). Two problems have been created by the mounds: 1) dredged material extends beyond the designated disposal site limits, and 2) ships are reporting adverse sea conditions believed to be created by shoaling over the mounds (Byrnes, 2013). The amount of dredged material that can be disposed of at a particular site is limited by the site's capacity to accumulate material without negatively impacting the environment or navigation (from increasing wave heights) (Neal, n.d.). When site capacity is reached, BU of sediments becomes even more problematic than balancing the cost vs benefit and the open-water, last resort options become more likely.

Although there is public concern, in spite of extensive dredging carried out regularly by USACE in the LCRE, it has never been shown that dredging entrains significant numbers of sub-yearling salmonids (CH2MHILL, 2013a). National Marine Fisheries Service (NMFS) has acknowledged the low probability of dredging projects in the vicinity to significantly affect either individual fish or fish populations (CH2MHILL, 2013a). While the monitoring and data collection that has been done near Benson Beach suggests that crabs are not adversely effected, there has not been enough years of research and data collected (only one report for last year) to make a clear correlation between turbidity, sediment depth and crab morbidity (EPA and USACE, 2007). One of the lessons learned from the MCR plan was that more work needs to be done to reduce sediments placed on crab beds. The CR Crab Fisherman's Association believes more research is needed to address how thin of a layer of dredge material is thin enough for crab to survive and enter the fishery and how high is too high to stay within the standard of a maximum of 10% mound induced wave amplification guideline (Clatsop County, 2012).

3.2.4. Lower Columbia River Estuary Partnership Draft August 2010

While a lack of funding for a sediment transport model stopped the LCEP DRAFT August 2010 plan from moving forward, the work done by the Lower Columbia Regional Sediment Management Policy Committee in 2010 pools a vast amount of valuable work together and provides the framework for preparing a sediment management plan that takes into account the complex estuary environment (Catherine Corbett, personal conversation).

The draft plan's objectives provide for (1) an understanding of the past, current and future conditions of sediment management practices; (2) evaluating the ecosystem effects on alternatives to sediment management practices; and (3) developing an adaptive management plan with monitoring (LCEP, 2010).

The plan examines the MCR and eight river reaches found in the 145 miles below the Bonneville dam. The plan provides, on a reach-by-reach basis, information as to what has already been done, each reach's specific morphology, and what needs yet to be done and can be used to inform beneficial placement options for each reach of the river (see Appendices 2 and 3).

3.2.5. DRAFT Dredge Material Management Plan Oregon Liquid Natural Gas (LNG) Terminal (2013)

The DMMP was developed by the LNG Development Company, LLC (doing business as Oregon LNG), which is described as a private liquefied natural gas company (CH2MHILL, 2013a). The DMMP was prepared for dredging management that will be needed with the construction of a terminal at RM 11.5 (CH2MHILL, 2013a). The DMMP calls for a plan that is consistent with the LCREP to contribute to the overall restoration of the LCR and to have a "high level of biological integrity" (CH2MHILL, 2013a). The plan involves an estimated 1.2 million CY of dredged material to be removed. The plan evaluates BU placement alternatives based on a scoring of multiple factors in selecting the best alternative. The screening criteria applied to each alternative material placement site includes distance from the site, permitting requirements, capacity, regulatory history, timing, and biological considerations (CH2MHILL, 2013a). The screening process for evaluation of alternatives were also weighted according to importance including 25% permitting issues, 20% biological issues, 20% habitat considerations, 20% available capacity, 10% dredging and transportation methods, 5% zoning (CH2MHILL, 2013a). The work window was decided to be from May 1 through September 30 (CH2MHILL, 2013a). One issue that may impact this plan is that a work window chart was not created to overlay against the dredge operational windows, and there may be additional fish and/or crab possible window restrictions. The hopper dredge, for example at the MCR, was only available to do in-water disbursement from July-November (Roegner Interview, 2015). In their evaluations, they looked at the successes and shortfalls from the MCR beneficial placement work and arrived at their selected beneficial sites most favorable to be the SWS and the South Jetty Nearshore Site at the MCR (CH2MHILL, 2013a).

3.2.6. USACE – Lower Snake River Programmatic Sediment Management Plan Final Environmental Impact Statement (2014)

The Lower Snake River Plan (LSRP) covers the navigational system from the confluence of the Snake and Columbia Rivers to Lewiston, Idaho (USACE, 2014b). The Lower Snake River (LSR) is the principle tributary to the Columbia River, draining approximately 109,000 square miles in Idaho, Wyoming, Utah, Nevada, Washington, and Oregon (USACE, 2002). To design the plan USACE and other agencies conducted extensive analysis of sediment loads and transports to support decision making on the management of sediment deposition that interferes with authorized purposes (USACE, 2014b). Prior to the LSRP, the USACE used either in-water within reservoirs or on upland sites (USACE, 2014b). The current plan utilizes a comprehensive approach which provides for multiple dredging alternatives, including managing sediment through structures or reservoir operations, and sediment placement options that include consideration of BU of dredged material (USACE, 2014b). USACE reports that dredged materials were used to construct additional shallow-water fish habitat near Knoxway Canyon (RM 116) (“2015 Columbia,” 2015).

USACE’s immediate needs addressed by the 2014 plan include deepening the downstream navigation lock approach at Ice Harbor Dam and the Confluence of the Snake and Clearwater rivers at the upstream end of Lower Granite Reservoir to its congressionally-authorized dimension of 14 ft. deep by 250 feet wide (USACE, 2002). In addition to the federal berth areas, the non-federal berths of ports of Lewiston and Clarkston also needed to be restored to depths necessary to support commercial navigation (USACE, 2014b).

After evaluating many alternatives, the option that was selected included: the navigational objective reservoir measure (adjusting the pool levels to meet authorized project purposes), dredging the navigation channel and other associated areas to achieve congressionally authorized depths or dredging to improve conveyance capacity, in-water or upland placement of dredged material, beneficial placement of dredged material, reservoir drawdown to flush sediments, reconfiguring or relocating facilities, raising Lewiston levees, placing bendway weirs, dikes, and dike fields in the river; agitating sediments, and trapping upstream sediment in reservoir. The plan also provides for long term monitoring. Also, by incorporating the LSR Programmatic Sediment Management Plan (PSMP), USACE can use triggers to identify and address sediment accumulation proactively to avoid accumulation (USACE, 2014c).

The measures implemented in the plan are those that are the least costly, technically feasible and environmentally acceptable.

The Snake River maintenance dredging and other dredging by USACE has been in ongoing litigation since 2005. The LSR navigation channel has not had any maintenance dredging done by USACE since the winter of 2005–2006. After one lawsuit settled, another lawsuit was filed, requesting an injunction to stop USACE’s PSMP for the LSR (US District Court for the Western District of Washington at Seattle, 2015). The plaintiffs pointed to a lack of consideration of alternatives to dredging which they alleged violated the National Environmental Policy Act (NEPA) and the CWA (US District Court for the Western District of Washington at Seattle, 2015). Specifically, the plaintiffs stated that dredging harms salmon and lamprey, and therefore the people who depend on those endangered and imperiled fish for their livelihoods, cultures, and recreation (US District Court for the Western District of Washington at Seattle, 2015). Their main allegation was that by failing to consider alternatives to dredging, the plan for a cycle of dredging and other channel maintenance was dictating a plan into the indefinite future (US District Court for the Western District of Washington at Seattle, 2015), (US District Court for the Western District of Washington at Seattle, 2015). Plaintiffs also took issues with what they describe as a cost vs benefit analysis and they suggested that the annual cost of the channel maintenance at \$7.6-\$12.6 million dollars each year is more than the estimated \$3.9-\$9.6 million dollars in benefits per year that the channel deepening provides (US District Court for the Western District of Washington at Seattle, 2015). Ultimately, the Court denied the plaintiffs’ request for a preliminary injunction that would have stopped needed maintenance of the FNC navigational channel and related port berthing areas (“2015 Columbia,” 2015). USACE will dredge in accordance with its PSMP during the annual winter in-water work window when salmonid fish are less likely to be present in the river (“2015 Columbia,” 2015).

The four federal dams in the LSR are pointed to as also contributing to the decline of salmon and steelhead in the LSR. (Hendrickson, 2015). Juvenile fish from the LSR drainage system may have to travel past as many as eight federal dams before reaching the Pacific Ocean (USACE, n.d.). The Ice Harbor Dam (RM 9.7), Lower Monumental Dam (RM 41.6), Little Goose Dam (RM 70.3) and Lower Granite Dam (RM 107.5) are the four facilities on the LCR (USACE, 2002,). The dams became operational between 1961 and 1975 (USACE, 2002). In the last 25 years, USACE has consistently investigated and adopted new technology for maximizing the number of fish that safely pass the dams in both directions (USACE, 2002).

Snake River fall Chinook, which were listed as threatened under the Endangered Species Act in 1992, are rebounding with the help of restoration efforts by the Nez Perce Tribe (one of the plaintiffs in the Snake River suit). The record total of Chinook at the MCR from August-December in 2013 was 1,268,400 fish (“2015 Columbia,” 2015). As of October 15, 2015, the total Chinook at the mouth of the Columbia is already at 1,224,300 fish and is expected to break the 2013 record (“2015 Columbia,” 2015).

3.2.7. Environmental Management Strategy for Dredging in the Fraser River Estuary (2006)

The Fraser River in Canada is an important waterway for both navigation and wildlife. The lower Fraser River provides a waterway for the transport of over 50 million tons of coastal and deep sea cargo annually (FREMP, 2006). The Fraser estuary is a major stopping point for migrating birds on the Pacific flyway including the largest population of wintering waterfowl in Canada among other rare, threatened or endangered species (FREMP, 2006).

The Environmental Management Strategy for Dredging in the Fraser River Estuary was developed by the Fraser River Estuary Management Program (FREMP) developed the Fraser plan through collaborative efforts (FREMP, 2006). The FREMP is a managing system that works to achieve the diverse interest of stakeholders through policy coordination and project review (FREMP, 2006).

The two main objectives for the Fraser River are to develop and maintain a functional navigational system that supports water-dependent development in a manner that protects the environmental quality, and to manage the removal of sediment from the river that balances with all components of the sediment budget of the river system (FREMP, 2006). Maintenance of the channel is combined with environmental management strategies that focus on habitat creation, restoration and maintenance to “ensure that dredging in the estuary proceeds in an environmentally sustainable manner” (FREMP, 2006, p. 2).

The FREMP was designed to take into consideration the complexity of an estuary ecology that differs greatly from one segment to the next. The river is divided into nine segments, and this strategy identifies the major natural features within each of the segments as a framework for addressing the needs and the alternative options for each segment (FREMP, 2006). For example, the brackish water of the estuary which gives juvenile salmon time to gradually adjust to saltwater conditions before they migrate to the ocean, has a very different environment than a segment of river farther downstream that is more salient (FREMP, 2006).

3.2.8. Delaware Estuary Regional Sediment Management Plan (2013)

The Delaware estuary is 130 miles long and includes trout fisheries and rare and endangered freshwater mussels (RSMW, 2013). More than 2,500 trout pass through the estuary annually. 2,500 vessels, supplying approximately 70 percent of the petrochemical gasoline and heating oil need to fuel the East Coasts, also pass through the estuary every year (RSMW, 2013).

The plan utilized a team of stakeholders, pulled together through focus groups, to work with USACE to facilitate the plan collectively (RSMW, 2013). The Delaware River Estuary RSM Plan was developed by the RSM workgroup (RSMW) (RSMW, 2013). The RSMW consists of Federal, State, Regional, non-governmental organizations and commercial entities (RSMW, 2013). Implementation of the plan required a cost-benefit accounting across multiple USACE business lines to find the necessary resources to implement and support the plan (RSMW, 2013).

The Delaware Estuary plan is designed to ensure that the benefits from the estuary are sustained for future generations (RSMW, 2013). The plan details a shared multi-objective vision involving navigation, commerce, flood control, and ecosystem restoration (RSMW, 2013). The plan incorporates a public outreach campaign to educate the public on opportunities and implementation (RSMW, 2013).

The plan’s objectives include evaluating options to effectively manage dredged sediment material on a regional basis to achieve a sustainable balance between ecological and economic activities (RSMW, 2013). The number one objective of the plan is to manage sediment and dredged material as resources, not wastes (RSMW, 2013). The plan details proactive approaches to maximize environmental benefits in areas of greatest need across the watershed by leveraging resources by coordinating projects and management activities that have complementary and additive benefits to the economy and to the environment as well (RSMW, 2013). The plan promotes proactive approaches to maximize environmental benefits in areas of greatest need across the estuary (RSMW, 2013).

Recent restoration efforts in Delaware include the improvement and maintenance of salt marsh habitats that have been eroding (GreenVest, 2014). As sea levels continue to rise and storms become more frequent and intense, salt marshes that cannot keep pace with sea level rise have been lost with the ecosystems they provided (GreenVest, 2014). In partnership with the USACE, through a National Fish and Wildlife Foundation Grant, a thin-layer marsh restoration project has produced habitat for economically

and ecologically important fish and shellfish, nesting and foraging habitat for migratory and resident birds and improved water quality through de-nitrification (GreenVest, 2014). By giving existing salt marshes a thin layer of sediment, the sinking marsh plain is raised up and the salt marsh can then act as a vital storm buffers and to protect infrastructures from flooding (GreenVest, 2014).

Restoration of one of the largest tidal marshes began this past summer in the Delaware area and will cover 4,000 acres. The restorations efforts are being undertaken through a collaborative process with the USACE, the expertise of the Atkins Global group that evaluated conditions and alternatives, along with funding from the Hurricane Sandy Disaster Relief Act (NWRD, 2015). The restoration of habitat and natural tidal water circulation will enable salt marsh vegetation to return and flourish, improving the resilience of the wetlands against future storms and sea level rise (NWRD, 2015).

3.2.9. Calcasieu River and Pass, Louisiana Dredged Material Plan and Environmental Impact Statement (EIS) (2010)

The Calcasieu Ship Channel is located in Louisiana near the Gulf of Mexico (USACE, 2010). The plan was developed by USACE through periodic interagency meetings (USACE, 2010). The plan evaluates four alternatives in reaches of the river, working upstream to downstream every 2-4 RM and provides support for the alternative chosen (USACE, 2010). Each reach of the river identifies specific details regarding that particular area and the needed restoration and BU in that area (USACE, 2010). The plan's objectives include 1) maintain the navigational channel to authorized dimensions; 2) place the dredged material in the most cost-effective location consistent with environmental requirements; 3) optimize the BU of dredged material; 4) maintain dredged material sites in a manner to optimize capacities and comply with sound economic and environmental principles; and 5) provide for the disposal of material dredged by private parties (USACE, 2010).

The plan creates 1,120 acres of vegetated marsh and it is also designed to nourish and protect existing marshes (Byrnes, 2011). Unique to this plan is a monitoring system that includes monitoring vegetation, surface elevation, accretion, salinity, and changes in morphology through aerial photography (Byrnes, 2011). It is expected that beneficial use of dredged sediment from the Calcasieu Ship Channel will continue to simultaneously produce hundreds of acres of restored/created wetlands and provide for options to placement of dredging materials removed during maintenance dredging (Byrnes, 2011).

3.2.10. Navigation and Dredging Planning Guide for Maryland's Coastal Bays (2010)

The Chesapeake Bay is the largest of more than 100 estuaries in the US (CBP, n.d.). The Chesapeake watershed spans 64,000 miles, covering parts of Delaware, Maryland, New York, Pennsylvania, Virginia and the District of Columbia (NOAA, n.d.b).

The Maryland Coastal Bay Program (MCBP) developed this long range master plan through cooperative efforts with the Navigational and Dredging Advisory Group (NADAG), across multiple jurisdictions, with a host of federal and state agencies and interested local groups working together to address the need to improve environmental safeguards related to dredging (NADAG, 2010). The MCBP culminated in a CCMP which identified strategic goals to preserve the coastal resource (NADAG, 2010).

The main objectives of the plan include placement sites and options, dredge material monitoring and evaluation, and sharing data and information to develop real solutions to the navigation and dredging problems outlined in the CCMP (NADAG, 2010). By implementing the NADAG's objectives, the outcomes anticipated include: improved navigation, reduced long-term dredging cost, improved environmental quality, improved boating safety, and increased island habitat for wildlife (NADAG, 2010).

Maryland develops their Best Management Practices (BMPs) on a project by project basis, evaluating the timing of activities, equipment, and the recommendations from the state, local and federal agencies, as well as the public (NADAG, 2010). Their collaboration and transparency includes a monthly newsletter (Vogt, Inc., 2010). The option for placement of the sediments is selected based on the best available protection to the environment, using a dredging window to limit negative impacts on specific species during their vulnerable stages (NADAG, 2010). Another BMP used by Maryland is the containment curtain to reduce turbidity by reducing the transport of suspended particles beyond the curtain area, and special dredging buckets which minimize the escape of dredge material, and reduce the potential for negative impacts on the environment (NADAG, 2010).

Unique to the Maryland plan is their restoration approach of using sediments equally, between tidal marsh and upland habitats, to increase habitat diversity (Vogt, Inc., 2010). The wetland areas are designed to be 80 percent low marsh and 20 percent high marsh to create even more habitat diversity (Vogt, Inc., 2010). Habitats are restored by constructing small ponds and wetlands in the upland areas (Vogt, Inc., 2010).

3.2.11. Long Term Management Strategy (LTMS) for Dredged Material in the Delta (Delta LTMS) draft Process Framework (2006)

The California (Sacramento) Delta estuary is the largest estuary on the West Coast (Pinole Shoal, 2006). The plan was developed by USACE, through a cooperative planning process, working with other federal and state agencies (Pinole Shoal, 2006). The Interagency Working Group (IWG) serves as the primary program manager of the Delta's LTMS process (Pinole Shoal, 2006). The IWG consists of staff from five agencies (Pinole, Shoal, 2006). The IWG works along-side the Management Committee and the Strategy Review Group and others with an interest in the Delta activities (Pinole Shoal, 2006). The Management Committee oversees the IWG (Pinole Shoal, 2006). The Strategy Review group works on addressing sediment issues through meetings with stakeholders, technical and scientific experts, and regulatory organizations (Pinole Shoal, 2006).

The dredging process is broken down into management and planning (Pinole Shoal, 2006). The management approach includes assessment, research and analysis, planning, implementation, evaluation and refinement (Pinole Shoal, 2006). The planning phases include evaluating management options, formulating LTMS alternatives, alternative analysis, LTMS implementation and reviewing and updating the LTMS (Pinole Shoal, 2006).

The Delta LTMS has four main objectives. These are: 1) managing sediments by use of BU of dredged material to maintain and stabilize levees; 2) managing dredging and BU to protect and enhance water quality; 3) manage dredge activities to maintain Delta channel functions for navigation, flood control, water conveyance, and recreation; and 4) manage dredging activities and BU to protect and enhance aquatic, wetland, and terrestrial ecosystems (Pinole Shoal, 2006).

Suisun Marsh is the largest contiguous estuarine marsh in the entire US. The Grizzly Island complex occupies about 15,300 acres of prime wildlife habitat (SSJDC, n.d.). Habitat restoration projects in the Delta's Suisun March include restoring marsh and tidal wetlands to areas where spoils have been deposited up to 20 feet above sea level (SSJDC, n.d.). Exotic weeds and grasses developed on the dry, upland site, provide little habitat value (SSJDC, n.d.). Uplands were irrigated to allow water delivery to existing wetlands (SSJDC, n.d.). Water levels in each unit are manipulated independently to restore, create and maintain the desired emergent wetland conditions (SSJDC, n.d.). The new channels meander through marsh, mudflat, willow and riparian forest providing complex, high value habitat (SSJDC, n.d.).

The restoration of the marshlands creates more natural Delta hydrodynamic processes and functions (SSJDC, n.d.). Tidal brackish marsh aids the recovery of listed plant and wildlife species while contributing to the primary productivity of the estuary (SSJD, n.d.). The SSJDC projects are part of an adaptive management approach to learn the relative benefits of different fish habitats, quantify the production and transport of food, and understand how fish species take advantage of new habitat (SSJD, n.d.).

3.2.12. Long-Term Management Strategy (LTMS) for the placement of Dredged Material in the San Francisco Bay Region (2001)

The San Francisco Bay, in California, consists of a 50,000 square mile Bay tributary area (USACE, 2001). Dredging and sediment disposal is ongoing because of continual shoaling that impedes navigation (USACE, 2001). Large volumes of sediment are transported in the waters of the Sacramento and San Joaquin rivers, which drain the Central Valley (USACE, 2001).

The plan is a signed agreement between USACE, the EPA, the San Francisco Bay Conservation and Development Commission (BCDC) and the San Francisco Bay Regional WQC Board (USACE, 2001). The plan utilizes the San Francisco BCDC for approval of activities concerning the Bay (USACE, 2001). Since the creation of the interagency Dredged Material Management Office (DMMO) the application and permitting process has been substantially streamlined (USACE, 2001). The average annual sediment load for the San Francisco Bay is eight million CY. (USACE, 2001). The post-LTMS indicates that volumes being disposed of into the Bay have been reduced by 50% (USACE, 2001).

The plan sets out 12 policy objectives, to be implemented by the BCDC, including issues regarding capacity, protecting natural resources, protecting underground fresh water reservoirs (aquifers), monitoring, consultations with regulatory authorities, the need to use dredged materials to improve Bay habitat, and the appropriate characteristics of locations in the Bay for projects and the potential impacts (USACE, 2001).

The plan restricts dredging during certain work windows in order to protect marine habitat, fish migration, fish spawning, shellfish harvesting, ocean, commercial and sport fishing, and estuarine habitat (USACE, 2001). The plan calls for an environmental windows and the requirement to work with US Fish and Wildlife Service and the NMFS in their review of the environmental impact statement pursuant to Section 7 of the ESA, to incorporate any requirements from project specific consultations (USACE, 2001).

3.2.13. Cedar Bayou, Texas DMMP Galveston District (2012)

Cedar Bayou is a natural stream originating east of Houston and flows approximately 45 miles to its confluence with the Galveston Bay (USAC, 2012b). The Texas Civil Works project is a federally authorized navigation channel that is currently maintained at a dimension of 10-feet deep and 100-feet wide (USAC, 2012b). The DMMP addresses changes and needs of placement area capacities since the recommended channel improvements above Mile 3 were approved in 2005 (USAC, 2012b).

The team effort in Galveston started in the 1990s and continues today in the Houston-Galveston area (Vogt, Inc., 2010). After an initial project proposed for open water in-bay disposal generated a huge controversy, a beneficial use plan was developed through the Beneficial Uses Group (BUG) and solutions were identified and funding was found (Vogt, Inc., 2010). The Galveston District historically dredges ~500,000 CY of material per year, and that equates to ~100,000 CY of shoaling annually (USACE, 2012b).

This DMMP was developed by USACE with a Review Management Organization (RMO) (USACE, 2012b). The RMO is a coordination of four reviewing levels from initial planning through design and operations (USAC, 2012b). The four levels include, the District Quality Control/Assistance, Agency Technical Review, Independent External Peer Review, and Policy Legal Compliance Review (USACE, 2012b). The RMO coordinates with the Cost Engineering Directory of Expertise to conduct agency technical review of cost estimates, construction schedules, risk analysis and total projected cost summaries and contingencies (USACE, 2012b).

The main objective of the plan was to include an assessment of potential beneficial use dredged material for environmental purposes, including fish and wildlife habitat creation and restoration/or hurricane and storm damage reduction (USACE, 2012b). The plan includes the recommendation of a 50-year DMMP and three Placement Areas (PAs) (USAC, 2012b). The plan recommends both economic and environmental considerations for sediment placement (USACE, 2012b).

One of the projects undertaken in Galveston District was re-creating the topography and vegetation of a natural ridge, to construct it so that it will supply optimal ecological services (Vogt, Inc., 2010). The building of the ridge was coupled with the building of a perimeter of marsh at the same time, by using an open ended containment design that allowed lighter sediments to float out to form the marsh and heavier sediments remained to form the ridge (Vogt, Inc., 2010). Marsh grass were planted on the interior levee side slopes to cut down on levee erosion on the interior cells (Vogt, Inc., 2010).

Nonprofit organizations and other organizations worked side-by-side to test plantings in the salty soil (Vogt, Inc., 2010). The plan involves increasing public access to the wetlands by creating footpaths and boardwalks to view birds and other creatures benefiting from the newly created marsh and ridge habitats (Vogt, Inc., 2010).

3.2.14. DMMP Brazos Island Harbor, Texas Channel Improvement Study Final Integrated Feasibility Report and Environmental Assessment (2013)

The Brazos Island Harbor project, also known as the Brownsville Ship Channel, is an existing deep-draft navigation project located on the Texas coast (USACE, 2013). The Channel has historically been maintained to the authorized 42-foot depth (USACE, 2013). The existing waterway consists of the Entrance Channel, Jetty Channel, Main Channel, Turning Basin Extension, and Turning Basin (USACE, 2013).

The Brazos Island or Brownsville Ship Channel project DMMP was developed by USACE (USACE, 2013). The plan accommodates a 50-year period of dredged material channel improvements taking into consideration cost and environmental concerns (USACE, 2013). The plan includes an assessment of potential BU of dredge material for environmental purposes including fish and wildlife habitat recreation and restoration (USACE, 2013). The plan describes in detail, by project area, the location (by reach), the size, the capacity, and the CY/year expected shoaling for each PA. The plan also includes a description (by reach) of the composition of the dredged material including, sand, silt, clay, and differing mixtures of those materials (USACE, 2013). Sand is used for nourishing eroding beaches, while clay is used for marshes (USACE, 2013).

The main objective of the plan is to restore material into the littoral zone (USACE, 2013). The plan includes upland, nearshore and offshore PAs (USACE, 2013). Offshore PAs have not been used in recent years because it is preferable to use the material beneficially (USACE, 2013). Dredged material can be placed offshore, in feeder berms or used to provide beach nourishment on the South Padre Island under a cost-sharing agreement with the General Land Office and the City of South Padre Island (USACE, 2013). The plan also calls for the use of pile dikes from a total elevation of 17 to 38 feet (USACE, 2013).

One project undertaken was to create a new grassland habitat on the upland areas of White Island as a mitigation for the construction of the nearby Gateway Retail Center (Vogt, Inc., 2010). The creation of a new grassland habitat was part of the permitting process for the Gateway Retail Center (Vogt, Inc., 2010). The phases of the project include removal of vegetation and capping with 150,000 CY of sediment in which to plant the desired grassland plants (Vogt, Inc., 2010).

3.2.15. New York–New Jersey Harbor Estuary Program Regional Sediment Management Plan (2008)

The NY/NJ watershed is approximately 16,300 square miles, with many sub-basins that influence the amount and quantity of sediments being delivered to the main tributaries and ultimately to the Harbor (HEP, 2008). The Regional Sediment Management Workgroup (Workgroup) was formed to develop a plan for a RSM Program that integrates sediment management activities in the NY/NJ Harbor Estuary (HEP, 2008). The Workgroup is comprised of agency representatives, technical experts and non-governmental organizations who are empowered to speak for their respective groups, and also have the ability to reach out to a large constituency for a variety of funding streams (HEP, 2008). The RSM Program was formed under the HEP to provide a regional approach to managing sediments to benefit the Harbor Estuary including: reducing re-handling, improving habitat quality, improving environmental conditions by reintroducing sediments into sand starved littoral systems, sharing regional scaled data, improving interagency and stakeholder relationships, and improving predictability of regulatory processes as a result of improved intergovernmental collaborations (HEP, 2008).

The NY/NJ plan increased public involvement to expand their funding streams, while simultaneously addressing environmental issues. Virtually all of the eelgrass beds had been destroyed by a mold infection (HEP, 2012). The absence of eelgrass beds in the water represents a loss of a key ecosystem service that purifies and oxygenates the water, provides food for fish and waterfowl, and stabilizes bottom sediments (HEP, 2012). Utilizing their public access work group for public outreach, they were able to increase oxygen levels by planting 8,000 plants at Breezy Point in Queens, and increase public access and awareness of the estuary at the same time (HEP, 2012).

3.2.16. Long Range Dredged Material Management Program for the Atlantic Intracoastal Waterway in Florida (2000)

The Atlantic Intracoastal and Okeechobee Waterways in Florida includes 374 miles of channel (FIND, 2000). The Florida Inland Navigation District (FIND) developed the Long Range Dredged Management Program (LRDMP) (FIND, 2000). The plan was developed through a collaborative process to address inlet management, stormwater control, and shoreline stabilization for the 50 year life of the plan (FIND, 2000). FIND's program was implemented in close cooperation with the Jacksonville District Corps of Engineers and was developed in three stages.

The first stage was the planning and development stage, the second was the permitting stage, and the third was the operations stage (FIND, 2000). Close to 2 million CY of sediment was moved and beneficially placed by the Corps of Engineers' Jacksonville District in 2013. In January of 2015 the Jacksonville District developed a Regional Technical Center of Expertise to assist the District as needed with implementation and to assist with stakeholder and partner coordination and communication, and to coordinate policy to support cross-mission authorities and funding (USACE, 2015b).

One of the main objectives of the Florida plan was to collect a large amount of data (county-by-county) on the waterway before any dredging or beneficial placement took place (FIND, 2000). Using county tax records, aerial maps, archival dredging records and channel surveys, sections of the waterway were identified and inventoried to identify characteristics of the sections including disposal sites, disposal capacity, predictable shoaling, and sediment chemistry as determined by sampling each section of the waterway (FIND, 2000).

USACE also partnered with Palm Beach County (PBC) Department of Environmental Management to restore and enhance the estuarine habitat in the Florida intercoastal waterway (PBC, n.d.). Extensive progress has been made in Jacksonville using project leveraged resources (USACE, 2015b). The plan includes wetland habitat creation involving removing upland materials and placing them in a hole and leveling the bottom of the upland island to a level that is even with the shoreline (Vogt, Inc., 2010). Once the upland site is downgraded, the wetland restoration continues with excavating tidal channels and ponds (Vogt, Inc., 2010). The wetland restoration also involves removal of invasive plants and the planting of native vegetation (Vogt, Inc., 2010).

The Munyon Island, Florida environmental restoration project was designed to provide habitat for fisheries and wildlife to rejuvenate Lake Worth Lagoon Estuary by increasing habitat and food supply for estuarine dependent fauna and flora (Vogt, Inc., 2010). Peanut Island, Florida was enhanced to include a boat dock, fishing pier, campsites, picnicking, grills, and restroom/shower facilities (Vogt, Inc., 2010). The FIND and the Port of Palm Beach are the primary land owners and made the perimeter of the island available to the public as a park (Vogt, Inc., 2010). Snook Island, Florida was improved by creating shallow-water lagoons which provide much needed seagrass and fisheries habitat (Vogt, Inc., 2010). The restoration continued with planting seagrasses and placing rock revetments to protect the newly constructed islands from waves (Vogt, Inc., 2010). The restoration projects completed in the Lake Worth Lagoon have enhanced the lagoon environment and have been showcases for restoration projects across the country (Vogt, Inc., 2010).

3.3. Long Range Dredged Material Management Program for the Atlantic Intracoastal Waterway in Florida (2000)

Plans are developed in a multitude of ways for a multitude of purposes, but the common thread supported by the available research is that all plans should include using sediments in the most beneficial way. Habitat restoration was the most common beneficial use found in the plans reviewed. By combining dredging with BU placement, and habitats can be created, restored, and maintained and other beneficial uses realized. BU of sediments allows for more options for placement of sediments, reducing the likelihood that sediments will be disposed of (wasted) in DWS ocean placement. The plans with the most collaboration provide the highest opportunities for strategic partnership funding. To create plans with the stakeholder buy-in, plans need to be collaborative, adaptive, economical, and sustainable. The plans that included collaborative processes tended to enjoy more stakeholder buy-in than plans that did not. Furthermore, collaborative plan development tended to include more robust beneficial use planning.

4. FINDINGS AND CONCLUSIONS

4.1. Findings

The most common placement methods historically used for C&LW dredged material disposal are in-water, at upland disposal areas, and along the river shoreline (personal communications with Corps personnel). The findings and conclusions which follow were selected based on either their relevance to these traditional C&LW project disposal locations or because they offer alternatives for discussion among regional stakeholders.

Our most surprising finding is that, while there are many resources supporting the BU of sediments, there are few plans that appear to actually implement the practice. A few case studies have been conducted that have evaluated the BU projects undertaken by plans throughout the US. Below is a list of findings that have been gathered through review and analysis of the plans and the case study lessons learned from those BU projects. Other findings:

The dredging issues in the Fraser River in Canada presents similarities to the issues faced in the Lower Columbia River. Stakeholders in the Fraser addressed their issues through the collaboratively produced Environmental Management Strategy for Dredging in the Fraser River Estuary.

- Those projects that employed collaborative processes tended to result in plans with more detailed beneficial use provisions than those that did not (USACE, 2012a; HEP, 2008; CBP, n.d.).

Marsh and tidal wetlands can be restored to areas where spoils

- have been deposited up to 20 feet above sea level allowing the estuary to resume more natural processes and functions (SSJDC, n.d.).

Finding willing strategic partners, along with grants and other

- funding streams, is more likely when plans include in the use of dredged sediments for environmental improvement projects, like irrigating and cutting in channels on upland disposal sites to create high quality habitat (GreenVest, 2014; NWRD, 2015).

By leveling the upland sediment placement to a level even with the surrounding area, excavating tidal channels and

- ponds, and planting native wetland vegetation, sand islands can be transformed into wetland habitat (PBC, n.d.; Vogt, Inc., 2010).

- Gathering information and then applying the productivity by habitat factor in evaluating all alternatives, including alternatives to dredging and beneficial use placement options, leads to habitat restoration projects that take into consideration the specific characteristics of the habitat in order to place the sediments where they can provide the most benefit (USACE, 2010; Byrnes, 2011).
- Planning on a river-reach basis (or dividing up long river reaches into smaller segments) allows for a more detailed information gathering and planning approach useful for evaluating material placement options (FREMP, 2006; LCEP, 2010).
- By increasing the factors monitored through the plan to include vegetation, surface elevation, accretion, salinity, and the morphology through aerial photography, more information can be gathered to assess the successes and failures of plans (Byrnes, 2011).
- Creating a local DMMP office can streamline the permitting process and improve public access and awareness (USACE, 2001).
- Dungeness crab research at the nearshore site by Benson Beach show that no more than 12 cm of deposition should occur during a single in-water placement event (Vogt Inc., 2010).
- Complex and competing stakeholder interests creates a challenge to the timing for dredging. However, using collaborative efforts to create a work window that involves the placement of sediments to when there is less fish migration and when the crab season is over, whenever possible, is beneficial (NADAG, 2010; USACE, 2001).
- Utilize the public, through public outreach campaigns, offices, groups or organized activities, to engage the public and increase public access, which can lead to more funding streams opportunities (HEP, 2008; HEP, 2012).

4.2. Conclusions

The FNC maintenance dredging is an ongoing Civil Works project that takes place all year long and all across the US. Dredging plans for the maintenance of the channel should be linked to BU placement of sediments. BU placement can help reduce costs by gaining stakeholder buy-in and providing more placement opportunities. Creating marsh, tidal and wetland areas improves habitat diversity, water quality, and protects against flooding.

The dredging of sediments for channel maintenance and BU placement need to be linked together to be environmentally sustainable. Plans need to be developed with biological integrity, to be both economically and environmentally conscious. Dredging and placement without BU is more cost effective compared to BU placement, but this process has created low value habitat. Many restoration projects have had success in restoring upland areas, created from channel maintenance, into tidal wetland and marsh areas that are now high quality habitat.

Oregon and Washington have had a long history of commitment to restoration and preservation of the estuary. Consistent with the LCEP's mission, USACE has been progressively moving in a more regional and collaborative direction since the 2010 MCR BU plan. The MCR plan involved a facilitator, a collaborative process, and team of stakeholders that were utilized to leverage funds and monitor the plan through regular meetings. USACE is planning to build on these current efforts by extending the collaborative strategy employed at the MCR to the rest of the deep draft navigation channel in the estuary up to Vancouver, WA.

The estuary is a valuable resource to be preserved. Sediment is a valuable resource that needs to be placed where its BU can be maximized to restore and preserve the estuary and other beneficial purposes. While existing resources suggest that evaluating sediment management alternatives solely on the basis of cost-effectiveness may be a challenge to overcome, the MCR plan's BU practices show that incorporating BU strategy brings benefits beyond cost avoidance.

Existing research supports developing a RSMP for the Lower Columbia River, through collaboration with federal, state and local agencies, along with non-governmental entities and public engagement, to create a plan that is not only collaborative and adaptive, but also sustainable (LCREP, 2011). Dredging should be linked to BU placement when possible

in order to improve sediment management in the system as a whole. Evaluation of placement alternatives should be based on the potential for productivity by habitat factors including, protecting and restoring wetland habitat conditions and functions, restoring tidal swamp, creating wetland/ riparian habitat and marsh habitat, and improving access to productive spawning and rearing habitat. The resulting RSMP will not only include valuable lessons learned, through years of improved integration with stakeholder and the usefulness of BU placement, but will also be in line with Washington and Oregon's long standing commitment to preserving the Lower Columbia River.

5. LESSONS LEARNED

The findings from the materials reviewed for this report support creating RSMPs and DMMPs to be collaborative, adaptive and sustainable. Based on the findings and conclusions of this effort, the USACE should continue to work collaboratively with C&LW stakeholders in development of a regional sediment management plan. The collaborative development of the RSMP should include an evaluation of BU placement based on factors that have the potential to improve the environment. The collaboration should include prioritizing projects based the best available information and knowing where BU placement will provide the most benefit.

Dredged materials from FNC maintenance should not be wasted. Sediment should be used to create, restore and maintain habitat. Marsh and tidal wetlands can be restored to areas where spoils have been deposited up to 20 feet above sea level allowing the estuary to resume more natural processes and functions (SSJDC, n.d.). By engaging in environmental improvement projects, like irrigating and cutting in channels on upland disposal sites, high quality habitat can be created (GreenVest, 2014; NWRD, 2015). By leveling the upland sediment placement to a level even with the surrounding area, excavating tidal channels and ponds, and planting native wetland vegetation, sand islands can be transformed into wetland habitat (PBC, n.d.; Vogt, Inc., 2010).

The following are provisions and/or actions drawn from the plans and strategies reviewed for this report. Recommend similar actions be considered as the Lower Columbia River sediment management plans are being developed:

- The Canada plan for the Frazer Estuary involves dividing the river into nine segments (FREMP, 2006). This strategy is used to assess major features of each segment to use when evaluating alternatives to sediment placement in those segments (FREMP, 2006). Incorporating this segment division of the river the LCR plan could increase the effectiveness of the beneficial placement within the LCR by allowing for more information to be evaluated before selecting placement options in those segments. Furthermore, the collaborative process and resulting plan developed for the Fraser should be studied for potential use in developing an RSMP for the Lower Columbia.
- The Delaware plan includes the improvement and maintenance of salt marsh habitats that have been eroding (GreenVest, 2014). In partnership with the USACE, through a National Fish and Wildlife Foundation Grant, a thin-layer marsh restoration project has produced habitat for economically and ecologically important fish and shellfish, nesting and foraging habitat for migratory and resident birds and improved water quality through de-nitrification (GreenVest, 2014). Restoration of one of the largest tidal marshes began this past summer in the Delaware area and will cover 4,000 acres. The restoration efforts are being undertaken through a collaborative process with the USACE, the expertise of the Atkins Global group that evaluated conditions and alternatives, and funding from the Hurricane Sandy Disaster Relief Act (NWRD, 2015). By engaging in environmental improvement projects, like those undertaken in Delaware, not only are strategic partners more likely, but so is access to grants and other funding streams.
- Looking at the proactive approach in Maryland where they use work windows, containment curtains, a strategy to increase habitat diversity, and close collaboration with regulators and stakeholders during the development of their BMPs, they have been able to gain more stakeholder support (NADAG, 2010). By engaging the stakeholders and regulators in the development of BMPs, this strategy in planning has the potential to gain more stakeholder support (NADAG, 2010). Sharing costs across a broader group of beneficiaries can also allow for greater collective benefits to the region (Martin, n.d.).
- The Louisiana plan includes an extensive monitoring system for vegetation, surface elevation, accretion, salinity, and aerial photography (Byrnes, 2011). The Louisiana plan adds several other important monitoring options to gauge the successfulness and potential failures of sediment placements (Byrnes, 2011).
- The San Francisco Bay plan calls for the creation of a DMMO to streamline the permitting process by having a “one stop shop” for Bay Area dredging permit applications (Vogt, Inc., 2010, p. ES-1). The advantage to creating a dredge management office in Oregon would be to increase the efficiency of the permitting process (Vogt, Inc., 2010). In a sense, the LCSG accomplishes the same purpose. Establishing a more formally institutionalized arrangement could allow for improved stakeholder access to information, increased transparency, and could provide organizations and the public a place to pledge their funding support for the project.

- In Texas, the Galveston and Bayou plan involves projects that include building a ridge at the same time as a perimeter marsh, and utilizing non-profits and other organizations to do test plantings to evaluate what plantings grow best in the salty soil (Vogt, Inc., 2010). The plan also involves increasing public access to the wetlands by creating footpaths and boardwalks to view birds and other creatures benefiting from the newly created marsh and ridge habitats (Vogt, Inc., 2010). By looking at the success of the Texas reconstruction projects, the LCR plan could benefit from partnering with non-profits and other organizations to engage in test planting efforts to stabilize and enhance the created habitat (Vogt, Inc., 2010).
- The Brownsville, Texas plan involves creating new grassland habitat on the upland areas of White Island as a mitigation for the construction of the nearby Gateway Retail Center (Vogt, Inc., 2010). The creation of a new grassland habitat was part of the permitting process for the Gateway Retail Center (Vogt, Inc., 2010). Learning from this example in Brownsville, the LCR plan could benefit by incorporating collaborative efforts associated with permitting and environmental harm mitigation (Vogt, Inc., 2010).
- Research, such as the NY/NJ plan, suggest utilizing working groups to identify restoration projects and prioritizing those BU alternative by applying habitat improvement criteria (HEP, 2012). They have three working groups, one works on identifying, prioritizing, monitoring and reviewing restoration efforts (HEP, 2012). The second, the Citizen Review Committee (CRC), incorporates public opinion by having an independent board of citizens reviewing the work of the HEP and providing the public with access to information (HEP, 2012). The third work group is a public access work group that helps to get the public involved in estuary projects and promotes access to the estuary.
- The NY/NJ plan increased public involvement to expand their funding streams (HEP, 2012). They also utilized their public access work group by involving the public to help restore water oxygenation by planting eelgrass beds (HEP, 2012). Eelgrass beds provide habitat and nursery grounds for fish, supply oxygen and food for fish and waterfowl, and stabilize bottom sediments (HEP, 2012). The 1994 Joint Venture Plan for the LCR recommended the eelgrass be inventoried, mapped, planted and monitored to establish eelgrass sanctuaries "area-wide" (Oregon Wetlands Joint Venture, 1994). As found in the New Jersey harbor's estuary plan (HEP, 2012), the restoration of healthy estuarine habitats benefit communities by providing cleaner air, water, improved aesthetic value, and greater recreational opportunities.
- In Florida, the waterway was sectioned off to inventory and identify characteristics of the sections including disposal sites, disposal capacity, predictable shoaling, and sediment chemistry as determined by sampling each section of the waterway (FIND, 2000). Looking at the process and success in Florida, by gathering as much information ahead of time in a proactive way, the knowledge of the sections of the river can be used to evaluate alternatives efficiently and also with the goal of using sediments where they can provide the most benefit to the environment (FIND, 2000).
- Florida's wetland restoration includes removal of invasive plants, leveling the upland sediment placement to a level even with the surrounding area, excavating tidal channels and ponds, and planting native wetland vegetation (Vogt, Inc., 2010). Florida utilized a partnership with the Palm Beach County Department of Environmental Management to restore and enhance three sand islands into wetland habitat for fisheries, wildlife, and increased public access and awareness by transforming one of the sand islands into a public park (Vogt, Inc., 2010). Learning from the successes of the Florida restoration and enhancement, the LCR plan could benefit from forming strategic partnerships (both public and private) to leverage resources and transform the sand islands that have been created into wetland habitat (Vogt, Inc., 2010). Learning from Florida's increase of public access, the LCR plan could benefit from increased public access and creating awareness of the importance of the estuary ecology, as well as increasing the possibility of additional funding streams through increased public accesses and awareness (Vogt, Inc., 2010).

Using the collaborative approach that was developed at the MCR, the USACE and the already established working group, can incorporate science-based practices into the long-term BU plan that is need in 2018 (HEP, 2012). Looking at the successes of plans that have been developed through a collaborative process, combining FNC dredging with BU placement strategies, it is highly recommended that the RSMP for the LCR estuary employ a sustainable approach to sediment management, by evaluating the options for BU placement, based on habitat productivity factors, and ensuring the biological integrity of the plan (RSMW, 2013). RSMPs that are both economical and environmentally conscious, result in less resistance and more stakeholder buy-in, leading to a much larger revenue stream (RSMW, 2013).

APPENDICES

Appendix 1: List of Documents and Reports Reviewed

- 2015 Columbia Fall Chinook Run Sets More Records
- Applications of the Regional Sediment Management Approach
- Aquatic Transfer Facility for the Hamilton Wetland Restoration Project Bel Marin Keys V Expansion
- Atlantic Intercostal Waterway
- Beneficial Re-use of Dredged Sediment to Enhance Stillaguamish Tidal Wetlands
- Beneficially Using Dredged Materials to Create/Restore Habitat and Restore Brownfields and Team Collaborative Efforts That Have Achieved Success (May 2010)
- Benefits of Habitat Improvements in the Lower Columbia River and Estuary: Results of Research, Monitoring and Evaluation
- Benson Beach Demonstration Project
- Bradwood Landing DEIS Initial comments from the Oregon Department of Environmental Quality (10/31/2007)
- Brazos Island Harbor, Texas Channel Improvement Study DMMP
- Calcasieu River and Pass Louisiana Dredged Material Management Plan and Supplemental Environmental Impact Statement - Final
- Chapter 10 Amendments to San Francisco Bay Plan, BCDC's Implementing Regulations, and the Water Quality Control Plan
- City of Astoria Comprehensive Plan Columbia River Estuary Land and Water Use
- Columbia River Estuary Ecosystem Classification— Concept and Application
- Columbia River Estuary Impact Assessment for the Oregon LNG Terminal
- Columbia River Estuary Regional Management Plan
- Columbia River Federal Navigation Channel Operations and Maintenance Dredging and Dredged Material Placement Network Update
- Columbia Snake River System Facts
- Coos County Comprehensive Plan
- Delaware Regional Sediment Management Workgroup
- Declaration of Cooperation Regional Sediment Management Plan
- Dredge management plan — construction dock Queensland Curtis LNG
- Dredging Materials and Environmental Restoration A Win-Win Story
- Dredged Material as a Resource
- Dredge Material Management Plan, Oregon LNG Terminal
- Dredged Material Management Plan (DMMP) Brazos Island Harbor, Texas Channel Improvement Study
- Dredged Material Evaluation and Disposal Procedures User Manual
- Effects of Burial by the Disposal of Dredged Materials from the Columbia River on Pacific Razor Clams (*Siliqua patula*)
- Environmental Management Strategy for Dredging in the Fraser River Estuary
- EPA NEP Website
- Erosion and Regional Sediment Management Memo
- Estuary Management in the Pacific Northwest
- Evaluation of Dredged Material Proposed for Disposal at Island, Nearshore, or Upland Confined Disposal Facilities — Testing Manual
- Executive Summary: Dredging Activities: Marine Issues.
- Executive Summary Enhancing Opportunities for Beneficial Use of Dredge Sediments
- Final Report Columbia River Estuary Impact Assessment for the Oregon LNG Terminal.
- Gulf Regional Sediment Management Master Plan Case Study Compilation
- Habitat Conservation and Restoration Program in Florida
- High County News Op-Ed: Why is bad science protecting the Lower Snake River dams?

- Identifying, planning, and financing beneficial use projects using dredge materials.
- Joint Venture Implementation Plans Lower Columbia River
Lakes, Estuaries and Lagoons
LCEP DRAFT August 2010
- Local Planning Groups & Development of Dredged Material Management Plans
- Long Range Dredged Material Management Program for Florida
- Lower Columbia River and Columbia River Estuary Sub-basin Summary
- Lower Columbia River and Estuary Ecosystem Restoration Program Reference Site Study: 2011 Restoration Analysis
- Lower Columbia River Ecosystem Restoration General Investigation Feasibility Study and Regional Sediment Management
- Lower Columbia River Estuary Plan Comprehensive Conservation and Management Plan 2011 Update
- Lower Columbia River Estuary Plan Website
- Lower Columbia River Partnership
- Lower Columbia River Sand Supply and Removal: Estimates of Two Sand Budget Components (2013)
- Lower Snake River Programmatic Sediment Management Plan Final Environmental Impact Statement
- Lower Snake River Programmatic Sediment Management Plan Executive Summary
- Lower Snake River Programmatic Sediment Management Plan, Final Environmental Impact Statement Record of Decision
- Marsh Restoration
- Mouth of the Columbia River Regional Sediment Plan
- Mouth of the Columbia River: Beneficial Sediment Deposition Project Benthic Impact Study 2014
- National Coastal Program Dredging Policies An Analysis of State, Territory, & Commonwealth Policies Related to Dredging & Dredged Material Management Volume I of II (April 2000)
- National Estuary Program Coastal Condition Report Chapter 6: West Coast National Estuary Program Coastal Condition, Lower Columbia River Estuary Partnership (June 2007)
- National Marine Fisheries Service (NMFS) Comments on Notice of Intent for the Oregon LNG Export Project, Oregon (Docket No. PF12-18-000) and Washington Expansion Project, Washington (PF12-20-000) (12/20/12)
- Navigation and Dredging Planning Guide for Maryland's Coastal Bays
- New York – New Jersey harbor estuary program regional sediment management plan
- NOAA Threatened and Endangered Species and Critical Habitat. Progress Report Mouth of the Columbia River Regional Sediment Management Plan Implementation
- Progress Report Mouth of Columbia River Regional Sediment Management Plan Implementation
- Proposed Nearshore Disposal Locations at the Mouth of the Columbia River Federal Navigation Project, Oregon and Washington
- Regional Analysis of Sediment Transport and Dredged Material Dispersal Patterns, Columbia River Mouth, Washington/Oregon, and Adjacent Shores
- Regional Sediment Management
- Regional Sediment Management And Engineering With Nature
- Regional Sediment Management Program Jacksonville District (SAJ) RSM-Regional Center of Expertise (RCX)
- Regional Sediment Management Program Portland District (NWP): Lower Columbia River – Regional Sediment Management Plan, Oregon
- Regional Sediment Management: Background and Overview of Initial Implementation
- Restoration Projects in the Delta and Suisun March
- Review Plan Cedar Bayou, Texas DMMP
- Rice Island Shoreline Placement and Howard Island In-Water Dredged Material Re-handling Site (Sump)

Sediment management handbook for dredge and fill products

Sediment Trends in Southwest Washington's Nearshore Zone A
Science-Policy Workshop

Streaked Horned Lark

Supplement to the Mainstream Lower Columbia River and
Columbia River Estuary Sub-Basin Plan

The Estuary System.

The Processing and Beneficial Use of Fine-Grained Dredged
Material A Manual for Engineers

The Southwest Washington Littoral Drift Restoration Project:
Evaluation of Intertidal Placement of Mouth of the Columbia River
Dredged Material on Benson Beach – Preliminary Result

The State of the Estuary

Thin Layer March

US Army Corps of Engineers Draft Environmental Assessment

US Army Corps of Engineers Navigational Portal

US District Court for the Western District of Washington at
Seattle, Case No. 2:14-cv-01800-JLR. (2015). Plaintiffs' Reply
Memorandum in Support of Motion for Summary Judgment and
in Opposition to Defendants' and Intervenors' Cross-Motions

USACE Beneficial Use Website

West Coast Governors' Agreement: Draft Action Plan Sustainable
Coastal Communities/Sediment

Western Basin Dredge and Disposal Plan

Where is the Largest Estuary in the United States

Appendix 2: Lower Columbia River Estuary Partnership Draft August 2010 Disposal Sites by River Reach

The LCEP began work on this 2010 draft, but budgeting issues resulted in the ending of this plan during the development stage. The process of segmenting the river by reach is common to estuary plans and is useful when evaluating alternative when prioritizing and identifying where sediments can be placed to provide the most benefit, both economically and environmentally. The LCEP Draft August 2010 focuses on evaluating the potential harm and comparing that to the benefits that can be gained, within each reach of the river, and in doing so has built the framework for developing a plan that is designed to be sustainable and have a high degree of biological integrity (LCEP, n.d.b)

Mouth of the Columbia River (MCR) (RM -3 to +3)

The MCR's littoral cell needs to be fed by sediment management at the in-water and nearshore sites. The North Jetty is also a place where sediment is needed. Placements of sediments at the Mouth is restricted by weather and Hopper dredge (split-hull or bottom-opening doors) availability, but further restrictions during crab and fish migrations reduce the opportunities for beneficial placement to a small work window. Uneven placement (mounding) can cause wave amplification and unpredictable currents at the Mouth as well (LCEP, 2010). Concerns over crab and bivalve burial have been alleviated through the use of thin-layer placement (Roegner and Fields, 2014)

Reach A: Lower Estuary (RM 3 to 14)

- River Mouth
- Clatsop Spit
- Trestle Bay
- Baker Bay
- Youngs Bay

This segment of the river includes, a brackish entrance to the Pacific Ocean, fragmented tidal marsh and tidal swap habitats, pile structures, ports and channels. The primary disposal site in reach A occurred at the in-water site at RM 5 (LCEP, 2010).

Reach B: Costal Upland Salinity Gradient (RM 14-38)

- Astoria Bridge (RM 14)
- Tongue Point (RM 18)
- Three Tree Point (RM35)
- Grays Bay on the Washington side
- Cathlamet Bay is located on the Oregon side
- Harrington Point Sump (RM 20.2-21.8)
- Rice Island (RM 21-22.4)
- Miller Sand Island (RM 25)
- Pillar Rock (RM 26.6-28)
- Fitzpatrick Island (RM 31)
- Skamokawa Vista Park (RM 33)
- Price Island (RM 34)
- Welch Island (RM 33-35)
- Upper Tenasillah Island

This area has high variations of salinity due to tides and river flows (LCEP, 2010). When river flow is low, there can be bi-directional flow causing two-way transport of sediments (LCEP, 2010). This segment of the river includes, pile dike fields, flooding problems, and tidal marsh habitat in the accreting bay (LCEP, 2010). The Cathlamet Bay has some of the most intact tidal march and swamp habitat remaining in the estuary and parts of the bay are protected as part of the Lewis and Clark National Wildlife Refuge (LCEP, 2010). The brackish zone may be an important transitional environment for juvenile anadromous fish from freshwater to saltwater (LCEP, 2010). Tidal swamp habitat has formed along the fringe of dredged material disposal locations (LCEP, 2010). Disposal of dredge material in reach B involves the use of the Hopper dredge to transport material to Harrington Point Sump (RM 20.2-21.8) and then the material is re-handled using a pipeline dredge to place materials at Miller Sand Island or Rice Island (RM 21-22.4) (LCEP, 2010). Rice Island was created with dredged materials using first in-water, then shoreline which created a land feature and next then upland placements increased the elevation of the Island (USACE, 2015). 800 CY was placed on the site from 2013-2014 (USACE, 2015).

There is also a deep-water disposal on the Washington side at RM 31-32 (LCEP, 2010). Skamokawa Vista Park, Miller Sands Spit, Pillar Rock, Price Island and Welch Island were all (BU) beach nourishment sites (LCEP, 2010). Price Island provides habitat for Great Blue Herons and Tenasillah Island is a Columbian white-tailed deer refuge and home to nesting bald eagles (LCEP, 2010). Restoration work is being proposed by USACE at Tenasillah Island that would allow juvenile salmonids improved access to tidal slough habitat (LCEP, 2010).

Reach C: Volcanics Current Reversal (RM 38-64)

- Puget Island (RM 38.7)
- Wallace Island
- Fisher Island
- Lord Island
- Coffee Pot Island (RM 42)
- Brown Island (RM 46.3)
- Jones Beach
- Eureka Island
- Portland General Electric (RM 53.5)
- Crims Island (RM 54.9)
- Hump Island (RM 59.7)
- Walker Island
- Lord Island (RM 61.8)
- Barlow Point (RM 62.0)
- Slaughter Bar (RM 63.6-64.37)
- Dibblee Point (RM 64.8)

This reach of the river is dominated by tidal swamp habitat along a narrow channel (LCEP, 2010). This segment of the river includes, swamp habitat, large mid-channel islands, and pile dikes (LCEP, 2010). The disposal site for Reach C is at Puget Island, but disposal at this site requires diking to prevent impingement on wetlands (RM 38.7) (LCEP, 2010). There are also beach nourishment, in-water flow lane and upland disposal sites at RM 40.4 and RM 42.9 (LCEP, 2010). Beach nourishment occurs at Puget Island, Westport Dike

(RM 45.1 and Jones Beach where the NOAA Fisheries conducts fish seining (RM 46.8) (LCEP, 2010). Disposal activities at RM 50.9 have benefited wetland habitat (LCEP, 2010). The Hump Island disposal site is said to help avoid juvenile salmonid stranding (LCEP, 2010).

Reach D: Western Cascade Tributary Confluences (RM 64-74)

- Mount Coffin (RM 63.5)
- Collins Island (RM 70.1)
- Sandy Island
- Rainer Industrial (RM 64.8)
- Rainer Beach (RM 67)
- Howard Island (68.7)
- International Paper (RM 67.5)

This reach of river is in the confined valley at the Kalama River and extends into the Cowlitz River (LCEP, 2010). This segment of the river has had extensive diking and filling around Longview and the mouth of the Cowlitz and Kalama rivers (LCEP, 2010). A large disposal site a RM 73.5 receives dredge material from USACE and private operations and the fill is used for local commercial development (LCEP, 2010). Disposal for reach D is currently in-water at RM 72.2-73.2, Rainer Beach (RM 67), Howard Island, Cottonwood Island (RM 70.1), and Northport (RM 71.9) (LCEP, 2010).

Reach E: Tidal Floodplain Basin Constriction (RM 74-85)

- Sandy Island
- Goat Island
- Deer Island
- Martin Island (RM 80.3)
- Burke Island

This segment of the river includes hydropower development of the Lewis River, reduced transport of sediment, and extensive diking has occurred on Deer Island and around Woodland which has significantly reduced overbank flooding (LCEP, 2010). Disposal for Reach E requires upland disposal at the International Paper site (RM 67.5) and at the Port of Kalama site (RM 73.2).

Reach F: Middle Title Floodplain Basin (RM 85-102.5)

This reach of the river extends from St. Helens through a wide valley bound by the Willamette River, Salmon Creek, and Lewis River (LCEP, 2010).

- Sand Island (RM 86.2)
- Austin Point (RM 86.5 and 86.9)
- Bachelor Island
- Fazio Sand & Gravel (RM 97.1)
- RR Corridor (RM 87.8)
- Lonestar (RM 91.5)
- Gateway (RM 101)

This reach of the river is in a wide valley bounded by Salmon Creek and ending upstream of Washougal and the Sandy Rivers (LCEP, 2010). Beach nourishment occurs in this segment of river at Sand Island Austin Point (RM 86.5), Sauvie Island (RM 87-100.8), and Bachelors Island (89.1) (LCEP, 2010). Dredging requirements are substantially lower upstream of RM 106.5 (LCEP, 2010).

Reach G: Upper Title Floodplain Basin (102.5-127)

- Hayden Island
- Government Island (RM 13-119.2)
- Reed Island Bar (124.5-125.5)
- Lady Island
- Reed Island

Reach H: Western Columbia River Gorge (RM 127-145)

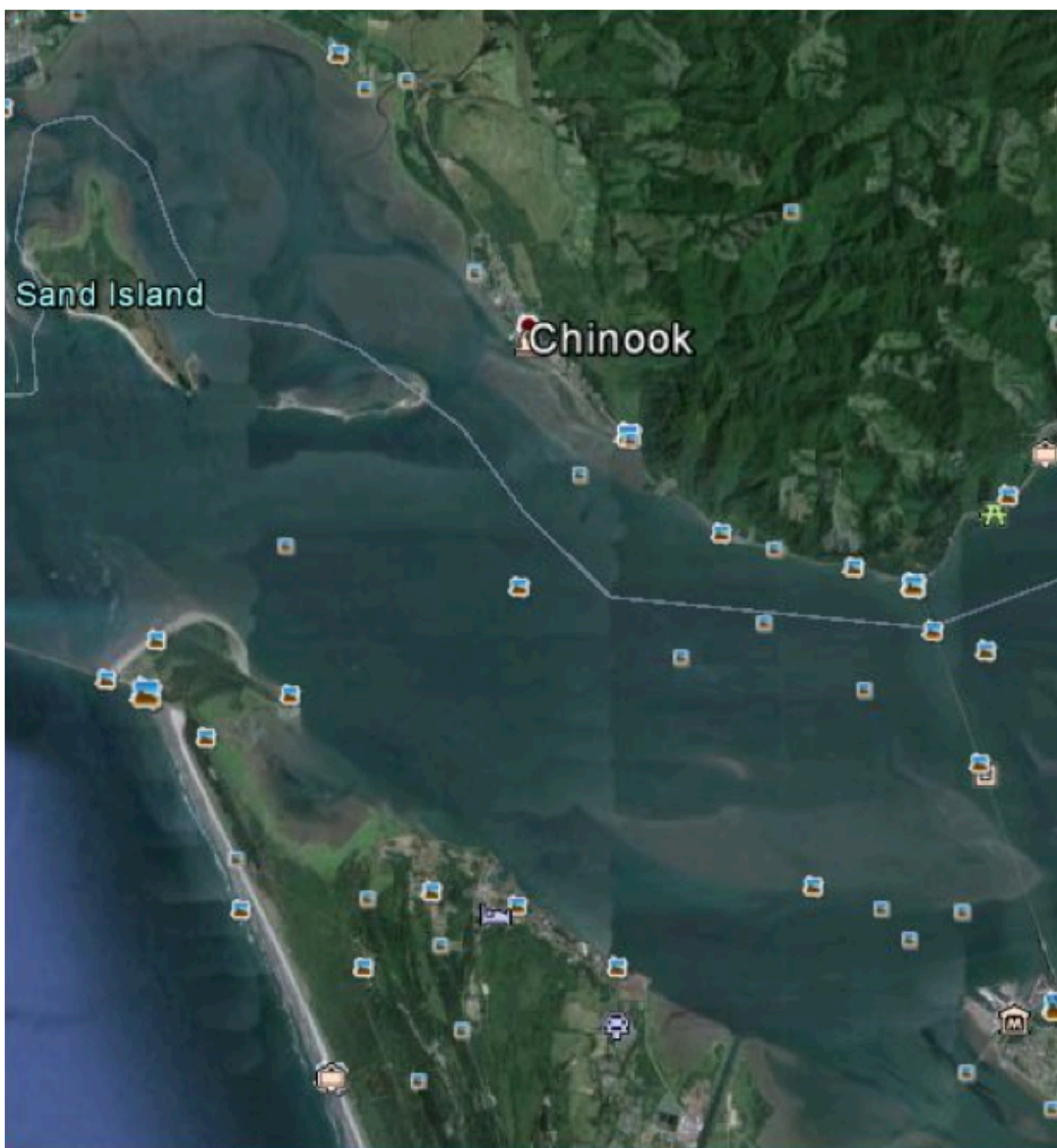
- Bonneville Dam (RM 145)

This reach spans from Reed Island to Bonneville Dam and includes water being received from Gibbons, Duncan, Hamilton, Hardy and Multnomah Creeks (LCEP, 2010).

There is no regular dredging in this range (LCEP, 2010).

Appendix 3: Maps of Lower Columbia River Reaches (RM 3 to RM 145)

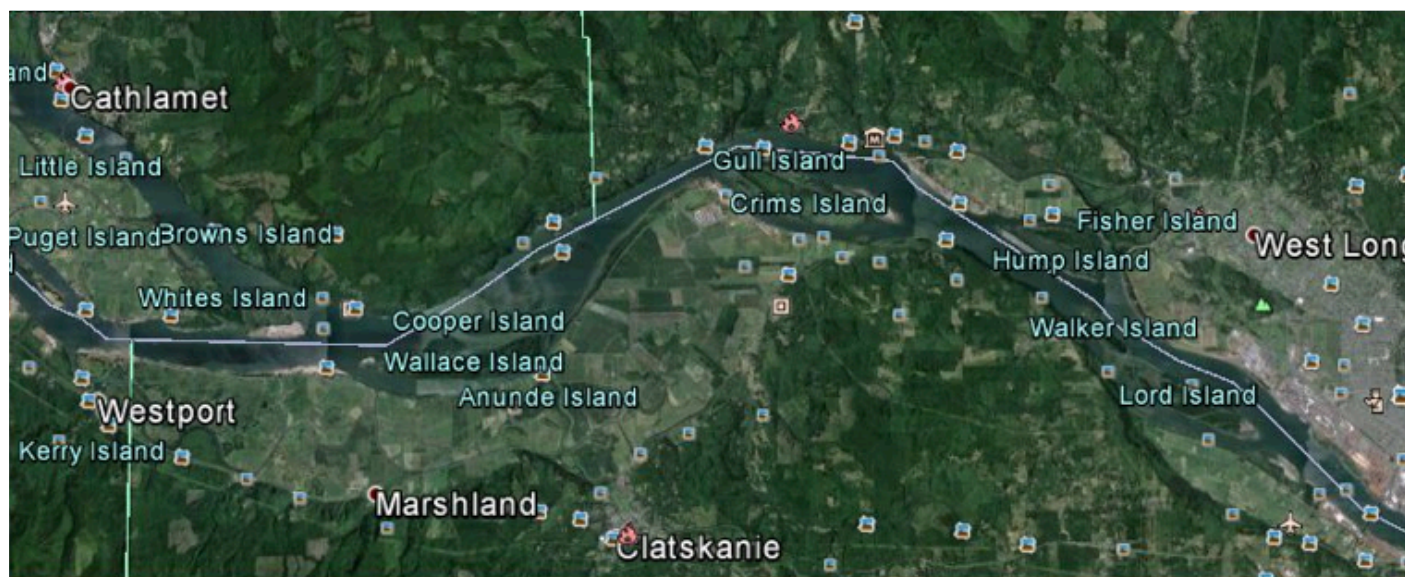
Reach A: MCR (RM 3 to 14)



Reach B: Costal Upland Salinity Gradient (RM 14-38)



Reach C: Volcanics Current Reversal (RM 38-64)



Reach D: Western Cascade Tributary Confluences (RM 64-74)



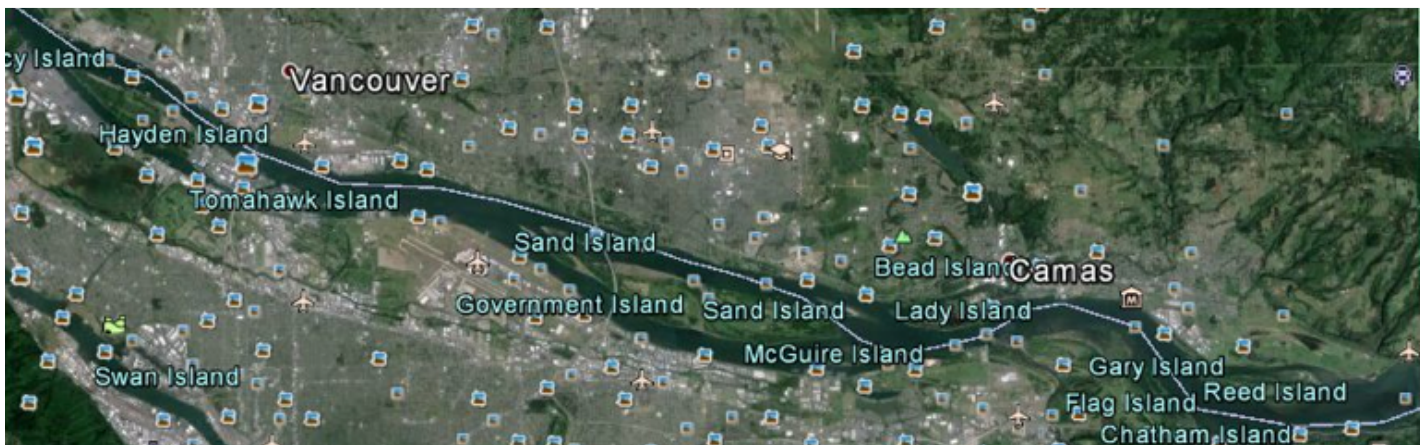
Reach E: Tidal Floodplain Basin Constriction (RM 74-85)



Reach F: Middle Title Floodplain Basin (RM 85-102.5)



Reach G: Upper Title Floodplain Basin (102.5-127)



Reach H: Western Columbia River Gorge (RM 127-145)



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