A Cost Analysis of Rapid Land-Building Technologies for Coastal Restoration in Louisiana

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Introduction

Hurricanes Katrina and Rita have fundamentally altered the focus of coastal restoration efforts in coastal Louisiana. Prior to the summer of 2005, restoration efforts, namely those proposed and implemented through the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) and to a lesser extent the Louisiana Coastal Area Ecosystem Restoration Study (LCA), focused almost solely on improvement of the ecological services provided by coastal ecosystems.[1] However, with the destructive forces of hurricanes and the role of wetlands and other coastal lines of defense in mitigating those forces plainly illustrated during the 2005 hurricane season, there has been a call to better incorporate hurricane protection measures into ongoing and proposed coastal restoration programs.

The Coastal Protection and Restoration Authority of Louisiana was created by the 2005 Special Legislative Session and charged with "creating a master plan that fully integrates Louisiana's coastal restoration and hurricane protection efforts" (Louisiana Recovery Authority 2006). This formal integration of hurricane protection and coastal restoration has resulted in an expanded focus of the role of coastal wetlands. Whereas pre-Katrina restoration measures were decidedly ecosystem focused, hurricane-protection-driven restoration measures are decidedly human-focused. Incorporation of human-focused benefits could fundamentally alter the benefit-cost ratio of coastal restoration. Because such benefits can include reduced risk to human life and infrastructure, the net value of a given restoration measure may change considerably relative to what it was assumed to be prior to the 2005 hurricane season.

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[1] Specifically, benefits accruing due to project implementation under CWPPRA are estimated using the Wetland Value Assessment (WVA) method. WVA is derived from a habitat suitability framework, in which a suite of optimal environmental conditions is used to evaluate the forecasted conditions generated from a proposed wetland enhancement project. The output of WVA, expressed as dollars per Average Annual Habitat Unit ($/AAHU), has been the primary cost-efficacy metric upon which CWPPRA dollars have been allocated to date.

In light of this shift in emphasis toward human-focused benefits, a more aggressive policy is emerging that could result in the increased use of those restoration technologies with the potential to build land rapidly[2]. This change is evidenced in the initial draft of the CPRA State Master Plan, which focuses heavily on the direct use of sediment mining from the Mississippi River and offshore sources for wetland creation and barrier island restoration (Coastal Protection and Restoration Authority of Louisiana 2006). Additional evidence is found in the "BUDMAT" initiative (Beneficial Use of Dredge Spoil Material) sponsored by the United States Corps of Engineers (Corps) and the Louisiana Department of Natural Resources (LDNR). Public scoping meetings for this program were initiated by the Corps in September 2006, and research symposia on sediment management are currently in development at the regional national level[3].

It was the objective of this study to take a first cut at understanding the cost structure of coastal restoration technologies and to obtain some preliminary measures of cost-effectiveness of these technologies. This analysis focused on restoration projects funded by the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA, also known as the Breaux Act), the primary funding source for restoration projects in Louisiana. Projects chosen were those that included a component of dredging sediment with the explicit objective of increasing acreage in the project area, i.e., of building land. For the CWPPRA projects, this typically included those classified as "marsh creation" and "barrier-island" restoration. Data on line-item costs

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[2] Although many restoration methods are capable of long-term coastal land-building, the term "rapid land-building" as used here refers to those technologies with the potential for creating/restoring substantial amounts of wetland acreage within a very short time frame compared to other methods (i.e., months versus years). Examples of rapid land-building technologies include sustainable sediment mining and strategic deposition of dredge spoil.

[3] The Gulf of Mexico Foundation held a forum in early March 2007 that initiated the development of a Regional Sediment Mater Plan for the Northern Gulf of Mexico. A research symposium held at the December 2006 meeting of the 3rd National Conference of Estuarine Restoration focused on successes, challenges, lessons learned, and future needs of rapid-land-building technologies.

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(mobilization / demobilization, dredging, containment dikes, stone armoroing, etc.) and quantities (including sediment quantities required), initial acreage created and/or protected, net acreage after 20 years, and acreage losses and/or erosion rates under no-action were collected from project fact sheets, project manager technical fact sheets, contractor completion reports, agency monitoring and progress reports, and project bid data obtained from the Louisiana Department of Natural Resources and the USGS National Wetlands Research Center.

Policy Background

The programmatic shift towards land-building technologies actually predates the 2005 hurricanes. A recent economic evaluation of the CWPPRA program found that land-building projects - those relying primarily on the mechanical retrieval and placement of sediments - had become significant drivers of project selection during the 1999-2004 program period (Aust 2006). Aust documents an increasing preference for such projects despite their relative inefficiency on a $/AAHU basis. This pre-storm shift is also illustrated in the LCA Plan of 2004, which, in addition to a more long-term, natural systems approach, emphasized the need for implementing near-term restoration measures that provide more immediate benefits. The sustainable retrieval and placement of sediments from the Mississippi River and Gulf of Mexico is listed as one of the plan's 10 guiding principles (LCA Plan 2004).

Perhaps most indicative of the increasing trend towards land-building initiatives for coastal protection is the suite of projects recently proposed under the Coastal Impact Assistance Program (CIAP) Plan (LDNR 2007). The CIAP is part of the Energy Policy Act of 2005, enacted by Congress less than one month before landfall of Hurricane Katrina. Section 384 of the Act redirects $1 billion in federal royalties derived from outer continental shelf (OCS) oil and gas production towards six coastal states and 67 political subdivisions. A total of $250 million

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annually will be allocated under CIAP during the period 2007-2010, with Louisiana slated to receive the lion's share of this funding because of coastal impacts the state has incurred from its historical support of OCS activity.

An estimated $523 million will be appropriated in the next 4 years for CIAP projects in Louisiana - a sum that exceeds the total direct federal spending to date under CWPPRA since its formal inception in 1990. Thus, scrutiny of the program is expected to be particularly high, as initial spending will reflect the current balance and trade-offs between the ecological and economic drivers of coastal restoration and protection. The CIAP program is also likely to influence more than $30 billion in coastal impact funding that will flow to Gulf Coast states in the next three decades. This increased spending will emerge from a combination of the regular budget process, previous coastal restoration legislation, and the recent passage of the Gulf of Mexico Energy Security Act (GOMES) of 2006. As a large-scale expansion of the OCS royalty-sharing concept, GOMES is expected to direct more than $17 billion in coastal impact funding to Louisiana by the year 2020 (Sharp 2006).

The initial CIAP Draft Plan for Louisiana was developed during the 18 months following landfall of Hurricanes Katrina and Rita. The influence of that period is evidenced by a list of 23 proposed projects totaling $339 million. These projects constitute the mandated 65% of CIAP spending that is authorized for the projects initiated at the state level. It is noteworthy that nearly half of the state-level CIAP budget (48%) is directed towards projects involving the mechanical retrieval and placement of sediments for the creation, stabilization, and protection of coastal landscape features (LDNR 2007). As currently proposed, such projects constitute more than twice the spending and three times the number of projects proposing restoration and protection via freshwater diversions.

The projects proposed under the Draft CIAP Plan reflect the growing demand for rapid-land building alternatives. At least some of this demand stems from the notion that a more surgical or strategic approach to restoration is needed to reduce social and political opposition. Freshwater diversions - though widely advocated within the scientific community as the most sustainable method for coastal restoration - are often the projects most constrained by stakeholder conflict. Most of the opposition has historically centered on the issue of commercial fisheries displacement resulting from salinity changes in diversion outfall areas (Caffey and Schexnayder 2003). Socioeconomic constraints appear to increase disproportionately with project scale. Additional concerns stem from the higher cost of diversion projects and their relatively gradual rate of restoration compared to other methods. Despite these issues, a number of large-scale river diversion projects have been proposed in recent years. One such proposal, the Third Delta Conveyance Channel (TDCC), illustrates the challenges associated with restoration at the ecosystem scale.

The TDCC concept involves creating a third deltaic lobe in coastal Louisiana between the Atchafalaya River and Mississippi River (Gagliano and van Beek 1999). This massive project proposes the diversion of up to 200,000 cfs of freshwater – one third of the average annual flow of the Mississippi River - into the Barataria and Terrebonne basins to the south and southeast of New Orleans. Sediment and nutrients carried through a 105 mile man-made channel would be used to restore and sustain the region's rapidly deteriorating coastal land. A recent feasibility study commissioned by the Louisiana Department of Natural Resources (LDNR) determined that the TDCC project would alter the drainage patterns in 80,000 acres of coastal land and directly impact 19,100 acres of developed property, undeveloped property, and open water. The TDCC would require extensive relocation of petroleum and petrochemical pipelines and would impact

several state and federal highways and regional and local roads. The project would require $8.7 billion dollars to implement and 15 years to construct[4]. The study indicates that an additional 25 years post-completion would be required before the land built by the TDCC project exceeded the land lost during construction. Beyond that point, the TDCC would build coastal land at a pace equal to one-third the land-loss rate projected for the Barataria-Terrebonne region (CH2M Hill 2006).

An alternative approach examined within the TDCC reconnaissance study considered the option of rapid land-building through a network of sediment-conveyance pipelines. Although considerably more expensive in terms of total construction costs ($9.4-$31.7 billion), the pipeline alternative was estimated to require less than one third of the time to construct, and would produce an estimated net gain of 200-400 square miles of coastal land during the 50-year project life span (CH2M Hill 2006). Despite the apparent advantages of the pipeline alternative, the authors of the TDCC study acknowledge that small freshwater diversions would be required to sustain the new land. Numerous questions also remain regarding the availability and suitability of riverine and coastal sediment sources required for such a large-scale application of this type of restoration technology. Ultimately, a more formal economic assessment is required to examine the true feasibility and optimal combinations of these methods over time.

Potential Sediment Sources

Taylor (2006) estimates that approximately 99 million cubic yards of sediment would be required to address one year (25 square miles) of land loss in Louisiana. According to Kindinger et al. (2001), between 396 and 532 million cubic yards of sand having the potential for shoreline restoration exists offshore in the Barataria Basin. They also estimate that a full 90 percent of the

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[4] The 15 year estimate of construction time represents the time required to build the TDCC after securing all land rights, rights of way, and settlement of predicted socioeconomic conflicts.

sand body areas will need approximately 570 million cubic yards of overburden sediment removed if the entire resource is mined.

According to Stone et al. (2004) approximately 12 million cubic yards of sand would be required to restore the Isles Dernieres to a configuration indicative of the late 1800s. van Heerden and DeRouen (1997) estimate a need of between 26 and 33 million cubic yards to restore the Isles Dernieres land bridge and associated barrier island chain. Stone et al. also report that several studies, mostly by MMS, indicate the potential to use Ship Shoal as a source of clean quartz sand (approx. 1.2 (Stone et al.) – 2.0 (van Heerden and DeRouen) billion cubic yards). According to Byrnes and Groat (1991), dredging of Ship Shoal appears to be both technically and economically feasible. However, CH2M Hill (2006) indicates that significant oil and gas infrastructure exist throughout Ship Shoal and only a small percentage of the volume may be available.

According to CH2M Hill (2006), there are a number of concerns regarding the use of offshore sediment resources. First, these resources are finite. Second, removal of offshore sediment will influence the wave climate shoreward of the borrow site. Stone et al. (2004) provide an analysis of the potential impacts. Third, there could be negative impacts on marine habitat and organisms.

The Committee on the Restoration and Protection of Coastal Louisiana (2006) offers the following estimates of sediment in the Mississippi River: 60 million cubic yards of suspended sediment (1963-1982); 116 million cubic yards (long-term suspended sediment); and 621 million metric tons (sediment discharge). Modeling by Louisiana Hydroelectric reported by CH2M Hill (2006), predicts 169 million cubic yards of suspended sediment load per day.

USACE estimates the annual yield for a sediment trap above Head of Passes to be approximately 9 million cubic yards (Taylor 2006). An investigation by Coastal Planning and Engineering, Inc. for the Riverine Sand Mining / Scofield Island Restoration (BA-40) CWPPRA project estimated the availability of sand deposits 20 and 35 miles upriver from Head of Passes, ranging from 6.15 to 20.5 million cubic yards appropriate for barrier island restoration.

USACE dredges between 15 and 20 million cubic yards per year from the lower Mississippi River Head of Passes to Southwest Pass (CH2M Hill 2006). The USACE-Mississippi Valley, New Orleans District excavates an average of 70 million cubic yards of material annually in maintenance dredging of navigation channels. However, a large share of this total is either re-suspension or hopper dredged material, and is therefore now available for beneficial placement (USACE 2004). Taylor (2006) reports that only 14.5 million cubic yards of this total were used beneficially in 2004. Annual volume varies depending upon the type of dredging and environmental setting. Thus, the FY 2006 plan included dredging and disposal of over 109 million cubic yards. At most, roughly 50 percent of the 2006 dredged material volume was planned for reuse. Taylor (2006) estimates that a conservative estimate is that the New Orleans District average annual dredged volume could address nearly 70 percent of the annual land loss, whereas the USACE estimates that placing 60 million cubic yards of material in water bodies up to three feet deep (and including compaction, subsidence, and consolidation) would result in rougly 4,300 acres, or 28 percent of the annual land loss.

According to Taylor (2006), approximately 13.8 million tons of sediment are delivered to the Illinois Waterway valley annually; 5.6 million tons are carried to the Mississippi River, with the remaining 8.2 million ton deposited into the valley, including backwater and side-channel

lakes. Efforts are underway to restore the Illinois River ecosystem by removing the accumulated sediment, with at least 118 million cubic yards available for beneficial use.

A USACE study is underway to evaluate deepening the navigation channel of the McClellan-Kerr Arkansas River Navigation System (MKARNS). It is estimated that approximately 11 million cubic yards of material is expected to be dredged for this purpose. Additionally, approximately 300,000 cubic yards of material is dredged annually to maintain navigation by the Tulsa and Little Rock Districts, with an additional 820,000 cubic yards due to deepening the channel. Thus, approximately 1.12 million cubic yards would be dredged annually and potentially available for beneficial use (Taylor 2006).

Taylor (2006) indicates that a sustainable source of sediment is using sand dredged by the Mobile District to maintain the Black Warrior – Tombigbee (BWT) River system. The Mobile District maintains 27 upland storage locations along the BWT for dredged material. These sites range from 22 to 70 acres, and contain nearly 30 million cubic yards of material in dry storage. Approximately half of the stored material is located within 108 river miles upstream of Mobile, AL. Because the material is primarily sand, the most compatible application would be barrier island restoration (Taylor 2006).

Results

Itemized cost data were collected on 8 marsh-creation and 9 barrier-island projects. If actual completed project costs were available, it was used. Otherwise, project costs were taken as the average of the contract bids offered. Completed project data were obtained from the USGS National Wetlands Research Center (2009); bid data were obtained from the Louisiana Department of Natural Resources (2009).

We found that, on average, sediment dredging cost accounted for 61 percent of the total cost of marsh-creation projects, followed by mobilization/demobilization costs (14 percent), containment dikes (10 percent), and stone armoring (7 percent). All other costs accounted for 2 percent or less each. For barrier-island projects, sediment dredging cost accounted for 71 percent, followed by mobilization/demobilization (13 percent), and containment dikes (4 percent). All other costs accounted for 2 percent or less each. Thus, roughly three cost items account for nine-tenths of the total cost of a project in either case.

Focusing on the major cost components, we calculated average per-unit costs. For marsh-creation projects, the average mobilization/demobilization cost (per project) was $2.749 million. Sediment dredging averaged $2.85 per cubic yard, containment dikes averaged $39.21 per linear foot, and stone armoring averaged $35.28 per ton. For barrier-island projects, mobilization/demobilization averaged $1.648 million per project, dredging averaged $3.40 per cubic yard, containment dikes averaged $25.60 per linear foot, and stone armoring averaged $52.50 per ton. Although sediment dredging cost were not very different across the two project types, there was greater variation in dredging cost for barrier-island projects. Dredging cost for marsh-creation projects had a mean cost of $2.85 per cubic yard, with a standard deviation of $0.94, whereas for barrier-island projects, mean dredging cost was $3.40 per cubic yard, with a standard deviation of $2.65.

We next calculated some measures of cost-effectiveness to compare the two technologies. Marsh-creation projects required approximately 18,078 cubic yards of sediment to create an acre of land using the WVA acreage estimate, or 16,571 cubic yards per acre using the 20-year benefit estimate. Barrier-island projects required 89,551 cubic yards per acre under the WVA

acreage estimate, or 74,287 cubic yards per acre under the 20-year benefit estimate. Thus,

barrier-island project required vastly more sediment to create a given acre of land.

In terms of total project cost per cubic yard of sediment dredged, i.e., if we consider the

total cost of the entire operation of moving a unit of sediment, marsh-creation projects average

$4.69 per cubic yard, whereas barrier-island projects average $4.78 per cubic yard. In terms of

acres created, marsh-creation projects require an average of $73,580 per acre, using the WVA

acreage estimate, or $64,574 per acre using the 20-year benefit estimate. Barrier-island projects

require $227,357 per acre using the WVA acreage estimate, or $184,513 per acre using the 20-

year benefit estimate.

Results of Comparison with Other non-dredge-material-placement technologies

This section reports the results of a comparison of the aforementioned dredge-material-

placement technologies with other non-dredge-material land-creating ones. Results for the

marsh-creation and barrier-island projects will not match those reported earlier because this

comparison was made using a different data source. This was necessary for consistency within

comparison, but creates a disparity between the figures shown here with those in the preceding

section. These data were obtained from Aust (2006). Table 1 shows the number of projects, the

aggregate number of acres of land created, aggregate cost, and aggregate cost per acre across

each of the major project types. The aforementioned technologies, namely, marsh creation and

barrier-island restoration, rank eighth and eleventh, respectively, out of twelve. Note, however,

that although vegetative planting, terracing, and outfall management are relatively more cost-

effective, they create very few acres. Ignoring those, marsh creation still ranks behind riverine

diversions, hydrological management, sediment trapping, sediment diversions, and hydrologic

restoration, with barrier-island restoration also ranking behind freshwater diversions.

Table 1. Aggregate acreage created, cost, and cost per acre created by project type for authorized CWPPRA projects.

Project Type	Count	Agg. Ac. Created	Agg. Cost	Cost / Ac. Created
Riverine Diversion	2	12,031	$25,147,985	$2,090
Veg. Planting	3	320	$2,351,329	$7,348
Hydrol.Mgmt	20	6,263	$102,403,387	$16,351
Sediment Trapping	3	3,417	$56,234,169	$16,457
Terracing	2	516	$8,757,174	$16,971
Sediment Diversion	7	12,189	$247,800,113	$20,330
Hydrologic Restoration	13	4,201	$102,235,680	$24,336
Marsh Creation	17	6,158	$167,245,110	$27,159
Outfall Management	2	310	$17,510,993	$56,487
Freshwater Diversion	10	2,041	$166,784,097	$81,717
Barrier Island	11	1,983	$238,930,571	$120,489
Shoreline Protection	30	2,101	$536,700,307	$255,450

Concluding Comments

This paper provides a preliminary analysis of cost for coastal restoration projects in Louisiana. Results indicate that sediment dredging accounts for the lion's share of the total cost of marsh creation and barrier-island restoration projects. Although sediment costs do not differ substantially between the two project types, sediment costs are more variable for barrier-island restoration projects. Further, although there was not much difference is total project cost per unit of sediment dredged and placed, results indicate that barrier-island restoration projects require significantly greater quantities of sediment per acre of land created, and thus, cost per acre created are substantially higher for barrier-island projects as well. Finally, based on the comparison with other project types, neither marsh creation nor barrier-island restoration ranked high in terms of cost-effectiveness in creating land. Marsh creation did, however, outperform freshwater diversions.

Some caveats must be noted here. First, cost data were not adjusted for inflation, primarily because we could not identify an appropriate index with which to do so. This must be addressed, especially given the likelihood that construction costs increased substantially post-2005. Additionally, the authors wish to make clear that this is a very preliminary analysis, and that these results should not be used without great caution, and only then as a rough indicator of costs. As noted earlier, this is but the first step in a long process to better understand the economics of coastal restoration technologies in Louisiana.

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