Is Urban Marsh Sustainability Compatible with the Clean Water Act?

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The United States (US) Army Corps of Engineers and US Environmental Protection Agency share responsibility for regulating placement of fill material in coastal wetlands and open waters. However, achieving the goal of *no net wetland loss* has been difficult, particularly in urban regions where development pressures and environmental conditions have exacerbated wetland losses. Despite protections provided in the Clean Water Act, one significant wetland category is threatened by adherence to the rules regarding no discharge of fill: low-lying coastal wetlands subject to the effects of a changing climate, including rising sea level, higher storm surges, and flooding. Without inland migration or accretion of new sediments, coastal wetlands will be lost unless marsh surface elevations are raised. The northeastern US coastline is a hot spot that may be especially vulnerable to sea-level rise. To explore current restoration policy, three case studies were examined: Jamaica Bay, New York, disappearing marshes; Jersey City, New Jersey, Lincoln Park West marsh; and Kane Wetland Mitigation Bank in the New Jersey Meadowlands District. Questions related to projected sea-level rise, ecological topography and adjacencies, or the potential for extreme storm events and surges were not addressed in the designs of these recent restorations. Although placement of fill materials in wetlands, marshes, or open water can create unanticipated consequences, if there is stringent regulatory oversight and a transparent public process, allowing placement of fill to preserve coastal wetlands could increase coastal resiliency. We suggest that the greater danger is failing to acknowledge the predicted effects of a changing climate. Permitting decisions must take into account broader geographic areas, expanded time frames, and projected effects of climate change.

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Introduction

Land use activities are a major factor in the loss of urban marshes. Since colonial times, northeastern United States (US) marshes were drained for crop production and filled for housing, transportation, industrialization, and landfill, contributing to loss of half the US coastal marsh ecosystem during the 20th century (Kennish, 2001). Before 1994, New Jersey (NJ) was losing almost 809 wetland ha per year to development (Brouwer, 2002), and the state had lost 39% of its wetlands (salt marshes and freshwater combined) by the end of the 20th century (Dahl and Allord, 1999). These large-scale wetland losses have contributed to increased flooding, decreased water quality, and lost habitat values and ecosystem-level services [National Research Council (NRC), 2001].

Clean Water Act and Wetland Regulation

In an effort to stop wetland losses caused by human activities, the Clean Water Act (CWA), Section 404a and b gave joint responsibility for regulating placement of fill material in wetlands and open waters of the coastal zone to the US Army Corps of Engineers (USACE) and the US Environmental Protection Agency (USEPA) (*Federal*

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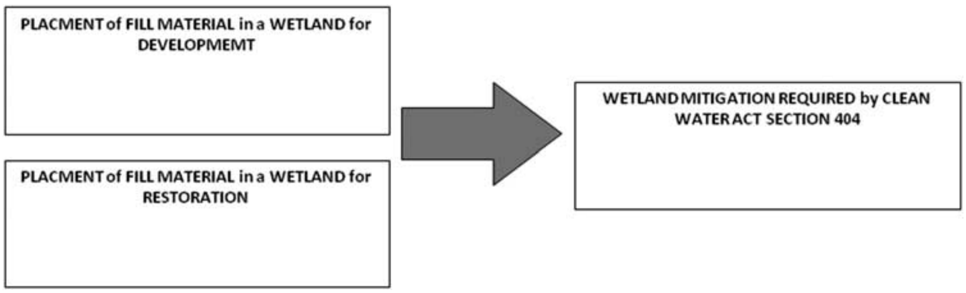

Figure 1. Clean Water Act Section 404 relationship between filling wetlands and mitigation requirement.

Register, 2002; Ruhl and Gregg, 2001). Section 404 prohibits discharge of materials, including soil or sand, into wetlands and open waters unless authorized by a permit issued under Section 404 (NRC, 2001). Supported by environmental laws, rules, and precedents (*Federal Register*, 2002; NRC, 2001; Ruhl and Gregg, 2001), protecting wetlands from discharges of fill material (Figure 1) has been a preferred approach for over two decades (Hough and Robertson, 2009), and this preference underlies federal regulatory policy. Despite the benefits provided by the "no discharge" prohibition, one significant wetland category is threatened by adherence to these regulations—low-lying coastal wetlands and wetland restorations likely to be subject to the effects of a changing climate that include sea-level rise (SLR) and storm surges associated with extreme weather events (Jones, Bosch, and Strange, 2009; Nicholls and Cazenave, 2010; Titus et al., 2009; Törnqvist and Meffert, 2008).

Regional Sea-Level Rise and the Hudson Raritan Estuary Coastal Wetlands

Accumulating evidence (Boon, 2012; Williams, 2013) suggests that the northeastern US coastline is a SLR hotspot (Kirshen et al., 2008; Sallenger, Doran, and Howd, 2012), and the location of this regional hotspot makes the Hudson Raritan Estuary (HRE) (Figure 2) especially vulnerable. A century of monitoring by the National Oceanic and Atmospheric Administration (NOAA) indicates that the sea level in New York City's low-lying areas is rising over 2 mm yr <MS> 1 and in portions of NJ almost 4 mm yr <MS> 1 (Gornitz, Couch, and Hartig, 2002; Zervas, 2009). Exacerbated by projected local temperature increases, northeast US sea level is expected to rise more than the global average, with the subsequent loss of existing wetlands (Karl, Melillo, and Peterson, 2009), threatening the long-term sustainability of the region's coastline and estuarine wetlands (Gornitz, Couch, and Hartig, 2002; Strauss et al., 2012; Titus et al., 2009).

The greater New York City region has approximately 2,400 km of shoreline; NJ has over 364,000 ha of remaining wetlands consisting of forest and salt marsh, the majority of which are in the coastal plain (Dahl and Allord, 1999). Regional coastal lands at elevations less than one meter above the local mean high-water total 178 km^2 in New York (NY) and 310 km^2 in NJ; this land area contains 240,000 residences that house a population of over 455,000 (Strauss et al., 2012). Wetlands in these low-lying areas are subject to loss if inundated.

Coastal marsh sustainability is determined by the ability of marsh surface elevations to rise as rapidly as SLR, the rate of marsh boundary erosion, and space for marsh migration inland (Jones, Bosch, and Strange, 2009; Tol, Klein, and Nicholls, 2008). However, the HRE's wetlands are not accreting new sediment fast enough to match rising seas (Gornitz, Couch, and Hartig, 2002; Kirshen et al., 2008; Nicholls and Cazenave, 2010; Scavia et al., 2002; Stammermann and Piasecki, 2012; Yin, Schlesinger, and Stouffer, 2009), and high-density coastal development precludes landward migration (Kennish, 2001). Therefore, survival of HRE coastal wetlands includes engineering to keep rising waters out (Nicholls, 2003), elevating marsh surfaces, or extending marshes into existing mudflats and/or open waters through placement of new substrate (Weinstein and Weishar, 2002). However, under Section 404 regulations, placement of new substrate in marshes or open waters would require mitigation for wetland fill (Figure 1).

The laudable goal of CWA Section 404 was to prevent filling wetlands to turn them into cities and shopping malls. However, current regulations create an interesting conundrum. In following the regulations, are restoration projects being permitted that will not be sustainable in the future? To save coastal marshes, should regulators revisit five decades of wetland policy and consider requiring placement of fill material in wetlands and/or open waters if a coastline is at risk? Replenishment has been an acceptable response for

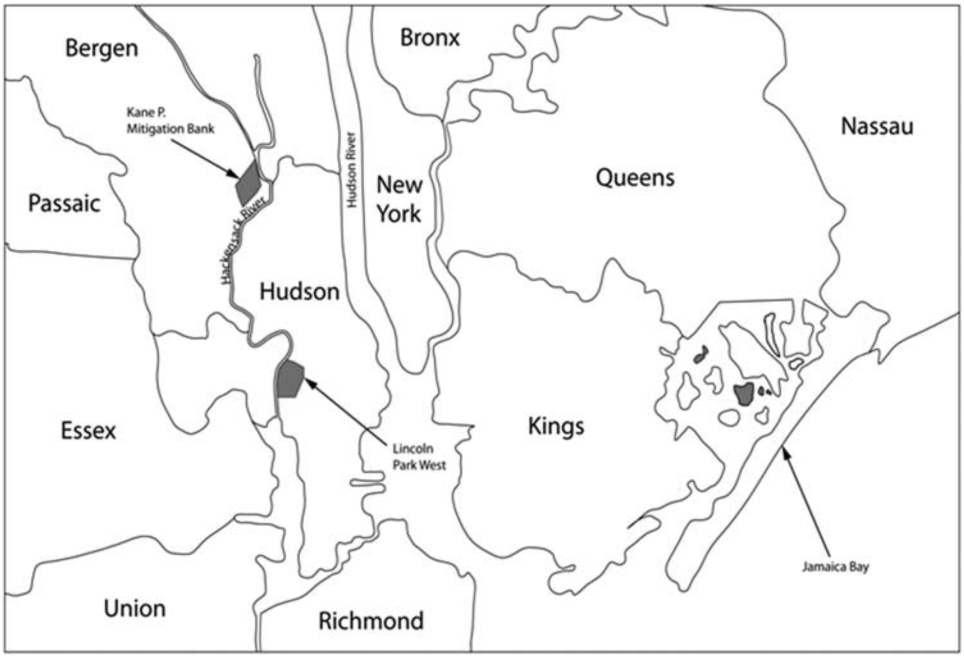

Figure 2. Map of Hudson Raritan Estuary showing the three restoration locations.

beaches and sand dunes lost to storm surges and rising sea levels (Finkl, 1996; Slott, Murray, and Ashton, 2010; Stive, Nicholls, and Devriend, 1991). However, if existing wetland regulations and policies are reexamined, does this produce a slippery slope that could once again allow inappropriate fill activities that would cause additional wetland losses? To probe these questions, we examined three case studies of recent HRE salt marsh restoration projects.

Methodology

We selected three HRE coastal wetland restoration projects that were recently completed: Jamaica Bay, NY, disappearing marshes; Jersey City, NJ, Lincoln Park West marsh; and the Kane Wetland Mitigation Bank in the NJ Meadowlands (Figure 2). To analyze alterations at the three sites, maps and aerial photographs were obtained and evaluated based on source, accuracy, and readability. Images selected for analysis were scaled in AutoCad (Autodesk, San Rafael, CA) to a common standard, land and marsh edges traced to delineate shorelines, and then scaled maps were chronologically overlain to determine temporal changes. Hydrologic and topographic differences were color coded to illustrate chronological differences.

We conducted site visits and interviews with the participants in each restoration project, including environmental consultants, engineers, and staff of the USACE (http://www.nan.usace.army.mil/Missions/CivilWorks/ProjectsinNewYork/EldersPointJamaicaBaySaltMarshIslands.aspx), NOAA, the NJ Department of Environmental Protection (NJDEP), and representatives of nongovernmental organizations. We also interviewed Captain Bill Sheehan, chairman of the Meadowlands Conservation Trust (MCT), owner of the Kane Mitigation Bank site; Robert Ceberio, retired executive director of the NJ Meadowlands Commission (regional regulatory authority for the Kane Tract site); and Teresa Doss, Senior Ecologist and Hudson River Bioregion Team Leader, Biohabitats, an environmental consulting firm engaged in NJ Meadowlands District and Jamaica Bay marsh restorations. In addition to interviews, a series of 14 questions (see the Supplemental Materials section) related to project objectives were answered by restoration project participants. Dr. Ravit also reviewed NJDEP Kane Mitigation Bank documents acquired through an Open Public Records Act (OPRA) request.

Although the sites and project objectives as described by these individuals and NJDEP documents were unique (Table 1), all restorations dealt with changes in topographic elevation and hydrologic period, which in conjunction with sediment availability determine long-term sustainability of a coastal marsh. Examined collectively, these projects are instructive in illustrating how regulatory, permitting, and financial considerations influenced HRE restoration project decision making.

Table 1. Description of New York/New Jersey harbor wetland restoration case study projects

Parameter	Jamaica Bay	Lincoln Park	Kane Tract
Permits required	NEPA environmental assessment	Solid waste landfill closure	USACE 404
	Water quality certificate	Nationwide 27 (permit)	Stormwater
	Nationwide permit—sand placement	General Permit 16	Section 7 USFWS clearance
	Special use permit	Waterfront development	Tidelands
		Flood hazard	Waterfront development
			Flood hazard
			MIMAC (IRT), NJWMC mitigation bank approvals
			Section 106 coastal resources clearance
Agencies involved	National Park Service	USACE	USACE
	USACE	NJDEP	NJDEP
	NYS DEC	NOAA	NOAA-NMFS
	NYC DEP	USFWS	NJMC
		Port Authority NY/NJ	NJWMC—freshwater
		Hudson County parks	MIMAC—saltwater
		Hudson County Improvement Authority	
Financing	Yellow bar	NOAA stimulus: $10.6 million	Privately financed by EnviroFinance
	Federal: $12,767,857	NRD—NJ: $0.6 million	Least payments to Meadowlands Conservation Trust
	Nonfederal: $6,875,000	NRD—Federal: $2.3 million	
	Black wall, rulers bar		
	Nonfederal: $341,1000		
Restoration acreage	154 acres	41.2 acres	240 acres salt marsh
			20 acres freshwater wetlands
Ratio low/high marsh		21.44:1.42	No high marsh
Open water/mudflat acres		11.29	Estimated 70:30 ratio low marsh/open water/mud flat
Off-site material used	~900,000 yd^3	339,235 yd^3	No off-site material used
Off-site material source	Ambrose Channel	Ambrose Channel	
	Rockaway Inlet		
	Amboy Aggregates		
Monitoring required	Elder: 5 years	No: Voluntary 3-year monitoring plan	5 years for mitigation banking credit release
			20 years active management by mitigation bank
Monitoring parameters		Vegetation structure and cover	Vegetation structure and cover
		Hydrology	Hydrology
		Macroinvertebrate, nekton, and avian species	Channel erosion
		Soil	Berm stability
		Qualitative	Mercury build up in food chain
Construction complete	Elders East: 2006	2011	2012 Followed by SuperStorm Sandy
	Elders West: 2010		2013 berm repair
	Yellow bar, black wall, bar: 2012		
Monitoring complete	Elders East: 2012	2013	2017 for mitigation bank credit release
			2032 for active management prior to site turnover to Meadowlands Conservation Trust

IRT, Interagency Review Team; MIMAC, Meadowlands Interagency Mitigation Advisory Committee; NEPA, National Environmental Policy Act; NJ, New Jersey; NJDEP, NJ Department of Environmental Protection; NJMC, NJ Meadowlands Commission; NJWMC, NJ Wetland Mitigation Council; NMFS, National Marine Fisheries Service; NOAA, National Oceanic and Atmospheric Administration; NRD, Natural Resource Damages; NY, New York; NYC DEP, New York City Department of Environmental Protection; NYS DEC, New York State Department of Environmental Conservation; USACE, US Army Corps of Engineers; USFWS, US Fish and Wildlife Service. From EarthMark (2013).

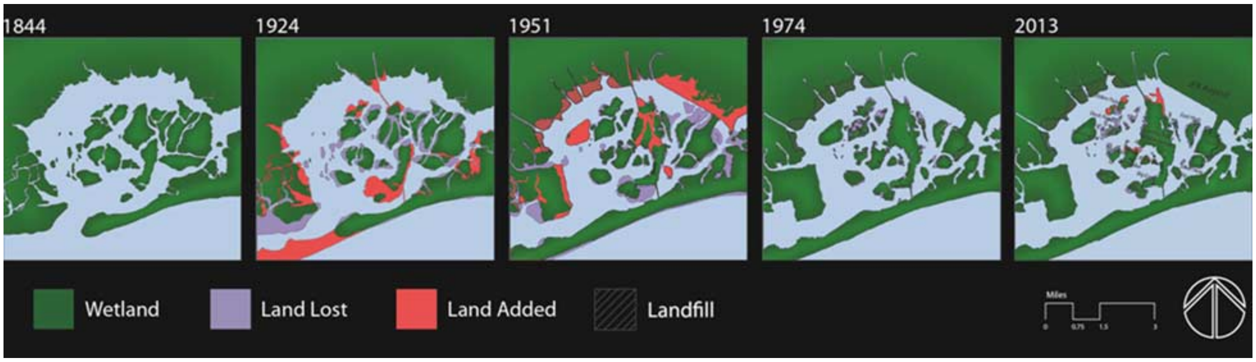

Figure 3. Jamaica Bay marsh topography, 1848–2013: **(a)** 1884—baseline, **(b)** 1924—development extends coastline into waters of the bay and extension of southern boundary configuring Rockaway Inlet, **(c)** 1951—addition of JFK Airport and loss of marsh island acreage, and **(d)** 1974—restoration target footprint; 2013—restoration actual footprint. Modified from *New York City Maps* (2013), http://maps.nyc.gov/doitt/nycitymap/ (accessed July 1, 2013); and *Google Earth*, http://www.google.com/earth/index.html (accessed July 1, 2013).

Restoration Project Descriptions

Jamaica Bay's Disappearing Marshes

Jamaica Bay is ~13 km long by 6.5 km wide, covers ~67 km^2, and opens into the Atlantic Ocean via Rockaway Inlet; Jamaica Bay's marshes have been subject to reconfiguration for more than a century (Figure 3). Chronological maps (1844–1974) show that the shoreline expanded into the open waters of Jamaica Bay, the southern shoreline was extended westward creating Rockaway Inlet, and large portions of the interior islands were submerged. In addition to changes in surface elevations, the bathymetry, hydrology, and biogeochemistry of Jamaica Bay were significantly altered when sand deposits were dredged, creating subaqueous borrow pits (Yozzo, Wilber, and Will, 2004). Although protected as part of the Park Service's Gateway National Recreation Area since 1972, low-marsh vegetation losses since 1974 averaged 38% (Hartig et al., 2002). In 1924–74, over 205 ha were lost (~4 ha $\mathrm{yr}^{\text{<MS>}1}$); losses accelerated in 1974–99, when 304 ha were lost (~12 ha $\mathrm{yr}^{\text{<MS>}1}$).

When sand from the NY/NJ Harbor Deepening Project became available, it was beneficially reused to restore acreage to Jamaica Bay's marsh islands (Table 1 and Figures 3 and 4). These projects restored marsh island footprints to 1974 dimensions (Lisa Baron, USACE, personal communication). Restoration designs and construction were completed before the current USACE official guidance for SLR (EC-1165-2-212) was issued (USACE, 2011), and cost constraints would have precluded building up higher elevations on the restored islands (Gail Woolley, USACE, personal communication). In 2006–7, the USACE restored ~16 ha of marsh at Elders Point East (Figure 4); in 2010, ~16 ha were restored at Elders Point West by placing dredged sand up to an elevation suitable for low-marsh growth. In 2012, ~287,000 m^3 of sand was placed at Yellow Bar Hassock Marsh Island, resulting in ~27 ha of restored marsh island and ~18 ha of wetlands; 118,506 m^3 of sand was also used to restore ~12 ha of marsh island at Black Wall and Rulers Bar (~72,633 m^3 of sand, ~4 ha). In 2013, restoration of ~11 ha on Rulers Bar and Black Wall islands was completed. The Black Wall restoration includes 8 ha at elevation 0.5 m or higher. The highest elevation on the island is 0.91 m, and 0.2 ha at this elevation (considered high marsh). The Rulers Bar restoration has 4 ha at elevation 0.5 m and above, including 0.24 ha at elevation 0.76 m, the island's highest elevation.

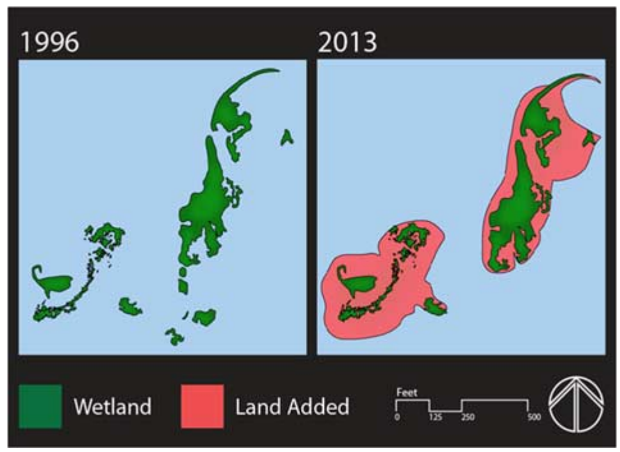

Figure 4. Elders Island **(a)** after submergence of center marsh area and **(b)** Elders East and Elders West restoration footprints. Modified from *New York City Maps* (2013), http://maps.nyc.gov/doitt/nycitymap/ (accessed July 1, 2013); and *Google Earth*, http://www.google.com/earth/index.html (accessed July 1, 2013).

Figure 5. Lincoln Park West **(a)** landfill, **(b)** prerestoration footprint, and **(c)** postrestoration footprint. Modified from *Google Earth*, http://www.google.com/earth/index.html (accessed July 1, 2013).

Jersey City Lincoln Park West

Wetlands on the ~40-ha Lincoln Park West restoration site were filled in the early 20th century, causing loss of a Hackensack River connection except during extreme high tides (Figure 5). Lack of tidal inundation reduced site salinity, and increased elevations and disturbed soils contributed to invasion by common reed (*Phragmites australis*) (USACE, 2013a). In 1999, the USACE began an environmental assessment (EA), and the project was in a competitive position when NOAA called for shovel-ready projects in 2009 (Table 1). The EA option of creating low marsh to maximize fishery habitat was selected (Carl Alderson, NOAA, personal communication).

The ~15-ha restoration, which enhanced the site's wetland connection to Hackensack River tide, included closure of a nonpermitted "orphan" landfill,[1] excavation of ~225,000 m^3 of solid waste from the former marsh plain (Donald Stevens, Louis Berger Project Manager, personal communication), and beneficial reuse of ~259,000 m^3 of federal navigational dredge material from Ambrose Channel (USACE, 2013b), the first approved beneficial reuse of dredged sand for wetland restoration in NJ (David Bean, NJDEP, personal communication). To ensure creation of maximum low-marsh acreage, the site was overexcavated to a depth of ~0.6 m below the garbage, and elevations were then raised through addition of sand.

Six *target parameters* (elevations, tidal inundation, plant survival percentages, presence of target species in ponds and in the wetlands, and site passability) were established to determine the project's success, and a three-year voluntary monitoring program was instituted by the NJDEP and USACE. Vegetation monitoring tracked trends in abundance and species composition and noted the presence of invasive species. Hydrologic success was evaluated by using time-lapse photographs of water movement through channels and across the marsh plain; visual observations were augmented by inundation and tide-height data recorded by pressure transducers. Avian, nekton, and macroinvertebrate measurements included presence/absence of key species, abundance, and size. Soil analyses included salt content, organic matter, pH, and fertility measurements [Louis Berger Group (LBG), 2011].

In 2012, approximately 700 shrubs and an herbaceous seed mix were replanted in response to first-year mortality. Second-year monitoring results indicated that areal plant cover (74%) would meet the 85% target; scrub-shrub density (587 stems) will not meet the third-year target of 698 stems; the hydrology and fiddler crab abundances met their targets, but ribbed mussel abundances did not; although low, target species nekton diversity was met. Invasive *Phragmites* was expanding in high-marsh areas, and unvegetated sand from the adjacent golf course was eroding (LBG, 2012). The restoration construction was completed and goose fencing removed in March 2013. Significant sections of *Spartina alterniflora* low marsh have been subsequently lost (Alderson, personal communication). Possible causes include herbivory by geese, hydrologic scouring, and/or subsidence (Alderson, personal communication; Kenneth Jennings, Director, Hudson County Parks, personal communication).

An important NOAA goal for the restoration was creation of fishery habitat in the low marsh, which appears to have been achieved. The monitoring results indicated that the target goals for hydrology, low-marsh vegetation, and species' habitat values have been or will be met. Repair of substantial herbivory will require additional funds, new sand, and replacement of low-marsh plants. The scrub-shrub

Figure 6. **(a)** Empire Tract, **(b)** proposed conceptual restoration plan adapted from statement of qualifications and lease proposal for Richard P. Kane Natural Area Wetland Mitigation Bank, and **(c)** actual Kane Tract Wetland Mitigation Bank footprints. Modified from *Google Earth*, http://www.google.com/earth/index.html (accessed July 1, 2013).

vegetation target is not being met. Monitoring results suggest that *Phragmites* will need to be controlled in higher elevations. We note that damage to the newly constructed wetland during the Superstorm Sandy tidal surge was minimal. It is not possible to determine whether this initially successful wetland will eventually be lost by not having funds for repair and maintenance and/or a high-marsh buffer to allow migration.

Richard P. Kane Tract Wetland Mitigation Bank

The Richard P. Kane Natural Area in the Boroughs of Carlstadt and South Hackensack, NJ (Figure 6) is bounded by the Hackensack River (east), the New Jersey Turnpike (south), and highly urbanized development (west and north). The site was a fresh to low-salinity tidal marsh until 1913 (Figure 6a), when the site was diked and ditched and tide gates installed for mosquito control; water-control structures were maintained until 2005. The drier conditions allowed invasion of *Phragmites australis*. In 1994, the site was sold to a developer who planned to fill 53–83 ha of the *Phragmites*-dominated site.

However, an upland alternative was found, and the site was transferred in 2005 to the Meadowlands Conversation Trust (MCT). The MCT was required to provide mitigation banking credits for wetland impacts caused by the NJ Department of Transportation, the NJ Transit Authority, and the Port Authority of NY and NJ. In 2008, a total of 97 ha were leased to a private consortium that was awarded the lease to construct a wetland mitigation bank (Figure 6b). Designs (Figure 6c) were approved in 2010 and construction began, but the Access to the Region's Core Tunnel project was subsequently canceled. Without immediate need for mitigation credits to offset the planned tunnel's wetland impacts, a large gap was created in the consortium's financial position, causing a change in project ownership.

Because the restoration was developed as a for-profit mitigation bank, financial factors influenced design decisions. Actual site elevations were on average 6 inches lower than anticipated—a significant difference when engineering surface elevations and intertidal hydrology. The decision was made, influenced both by financial and regulatory concerns, that material to restore the marsh must come from on site. Bringing in fill materials would have increased construction costs, and regulations do not allow fill material to be placed in wetlands (Richard Mogensen, former EarthMark project manager, personal communication). However, the NJDEP stated during permitting discussions that they were aware of the low site elevations and would consider a "potential hardship waiver for fill," noting "NJDEP is open-minded as [this] is a wetland restoration" (NJDEP preapplication meeting notes). The USACE recommended increasing marsh acreage and decreasing mudflat and open-water acreage (USACE correspondence with the NJDEP). However, due to the low elevations, not enough material was on site to create the planned surface elevations and fill the proposed berm. Channels were added for drainage (Figure 6d) and to generate material needed to create elevations high enough to support low-marsh vegetation and provide material for berm construction (Mogensen, personal communication).

The restoration is surrounded by 2,134 m of berm. The decision was made to build Hesco concertina structures rather than an earthen berm, which requires a wide base that would have reduced restored acreage that determines the number of mitigation bank credits for sale. The US Fish and Wildlife Service (USFWS) also required removal of

~2294 m^3 of sediment containing <ME>0.7 ppb mercury, the effects range-median concentration for benthic organisms. To obtain fill material for berm construction, some of the open channels were excavated to a depth deeper than originally planned (Mogensen, personal communication). After the NJDEP raised questions about the Hesco berm (Mazzei, 2010), a 20-year active-management plan and long-term monitoring program were included in permit requirements.

Construction was completed in 2012. When Superstorm Sandy struck NJ, the berms were damaged, and local law suits related to flood damage are now pending. Prior to Superstorm Sandy, the Kane Tract freshwater restoration had 90% tree survival and *Spartina alterniflora* was establishing in the eastern marsh; however, it is too soon to predict whether vegetation coverage will meet targets. Prior to restoration of hydrologic connectivity to the majority of the site, 21 saltwater and 7 freshwater wetland mitigation credits were released for sale (Richard P. Kane Mitigation Bank, http://www.mitigationbanking.org/pdfs/rpkmb.pdf, 2013; USACE, 2013c).

Discussion

Were these three restorations successful? We suggest that the answer to this depends on the definition of success and the time frame, as well as the accuracy of predicted changes in coastal hydrology. We found no evidence that projected SLR, more frequent extreme storm events or surges, landscape patterns, or projected rates of sediment deposition were factors in the design of these three wetland restorations. It appears that financial considerations, substrate availability, and the desire for low-marsh habitat drove restoration designs.

The decision was made to "restore" the Jamaica Bay marsh footprints of 1974, a date prior to CWA prohibition of placing fill material in wetlands. However, given the amount of marsh loss far earlier than this date and accelerating Jamaica Bay marsh losses, it could be asked why the larger marsh island footprints were not used as the restoration target(s), why Elders East and West were not reconnected to restore the original single island, and why the high-marsh acreage was not greater. At Lincoln Park West, the NOAA preference for low-marsh fish-nursery habitat was the preferred EA alternative; premature removal of protective fencing in order to meet an arbitrary project end date may have contributed to significant marsh loss when young *Spartina* plants were grazed and uprooted (Alderson, personal communication).

In the case of the Kane Tract, the option of bringing additional material on site to raise marsh elevations acknowledged to be too low was rejected. When dredge material was brought onto the Jamaica Bay and Lincoln Park West sites, it was not used to create high marsh, and none of the designs or permit requirements included high marsh to provide a buffer to allow the marsh to migrate in response to a changing climate. When higher elevation scrub-shrub vegetation was planted at Lincoln Park, survival and coverage did not meet projected restoration targets, a common occurrence when trying to engineer elevations and hydrology for high-marsh vegetation (NRC, 2001).

The Kane Mitigation Bank illustrates for-profit restoration consideration of financial as well as ecological factors. In their "Statement of Qualifications and Lease Proposal," the bank developers stated they would take into account "existing low elevation levels, sea level rise, and lack of historic berm maintenance" in their restoration design (EarthMark, 2008). Although the NJDEP also noted the low existing elevations and offered to take this into consideration during the permitting process, and USACE recommended decreasing mudflat and open-water acreage, project managers chose not to bring in off-site material. Regulatory agencies did not require increasing elevations as a permit requirement, and the USFWS required removal of mercury-contaminated sediments, further reducing the amount of sediment on site. Bringing in additional fill material would have increased the construction cost of a financially vulnerable project. It is impossible to predict the ecological trajectory of this low-lying marsh or to evaluate whether the hydrology and sediment transport will support the constructed elevations. Although the restoration's long-term success is unknown, regulatory agencies released mitigation credits to offset other coastal wetland destruction.

Without a federal regulatory policy that requires accounting for projected SLR when designing coastal wetlands, the decision to build at low elevations (low marsh, mudflats, open water) will continue to be made on a case-by-case basis for financial reasons, size constraints, the challenges of engineering complex high-marsh hydrology, and arbitrary habitat preferences. We do note that the USACE has the authority to approve and grant permits allowing fill materials to be placed in wetlands. However, granting such approvals without requiring compensatory mitigation might be politically sensitive without updating federal wetland policy. We also note that the USACE has issued two guidance documents [in 2009 and 2011 (Woolley, personal communication)] related to SLR. This guidance included three probability curves (high, intermediate, and low) that SLR will occur at a certain rate. We were told that the USACE will be incorporating greater ratios of high marsh into their future designs to increase marsh migration potential, which has not previously been considered to any great extent (Woolley, personal communication).

Federal law authorizes the beneficial use of dredged material for habitat development (Yozzo, Wilber, and Will, 2004), and this may result in expanding existing marshes and/or increasing marsh elevations. However, this mandate is driven by the need to dredge rather than the need to preserve coastal marshes, and once a dredging project is completed, the source of new substrate is gone. The state of NJ specifically "discourages" filling in open-water areas, and "filling wetlands areas is prohibited" (NJDEP, 1997), although the Lincoln Park West restoration used dredge materials generated by the NY/NJ Harbor Deepening Project, a positive step.

Slippery Slope Considerations

We acknowledge that encouraging placement of fill material in marshes or open waters can create unanticipated consequences, including further loss of wetland habitat if inappropriate fill activity is permitted. We also acknowledge that there are documented instances in the NY/NJ region where fill material was employed without adequate oversight [for examples and details, see Encap Project and Overpeck Project (Nussbaum, 2009)]. Bringing in off-site material would require significantly more monitoring and testing to ensure the material is clean. There is also the need to define the level of "clean" required, especially in urban environments, where sediments often contain high concentrations of historic contamination. It is problematic that there is no universally agreed standard with respect to future sea levels or tidal surge heights, and it is unknown how important a factor SLR is in the resiliency of a specific site (Terry Doss and Robert Ceberio, personal communications). There was agreement among all individuals interviewed that cost considerations drive restoration design decisions.

New Approaches

Federal and state regulations (Hedrick, 2000) governing beach replenishment are already in place. We suggest that similar federal guidelines are needed that would regulate *replenishment* when coastal wetlands are in danger of drowning or being created/restored. Such guidelines would need to address what constitutes acceptable fill material(s), allowable levels of contamination given local background contaminant levels, and other complex regulatory issues. We suggest the following be considered in federal permit requirements:

1. A model should be included describing how local SLR could affect restoration-site hydrology over an extended time frame, such as 30–40 years.
2. Site designs should be created incorporating elevations sustainable over the modeled time frame. A sediment-source evaluation and deposition rate should be included in the model.
3. Site topography and interactions within the surrounding landscape should be considered, as well as the inclusion of a high-marsh buffer that could convert to low marsh should SLR exceed the model projection.
4. Use of off-site material to achieve the modeled elevations *should not trigger* a Section 404 requirement to provide mitigation for wetland "fill activities."
5. Restoration projects that *lower* marsh surfaces (often due to *Phragmites* removal efforts) should no longer be permitted.
6. Monitoring and maintenance of site elevations should be a permit requirement.
7. Funding for long-term maintenance and repairs (20 plus years) should be a permit condition. A long-term bond or funds held in escrow would ensure that the costs of repairs and maintenance are covered.
8. A rigorous public comment process to allow public discussion of what fill material is necessary and appropriate for a specific site.

Conclusions

Urban coastal wetlands will be lost unless adaptive planning policies and regulations designed to increase marsh surface elevations are implemented. Permitting decisions must take into account broader geographic areas, expanded time frames, and projected effects of a changing climate. In short, we believe the prohibition against fill in wetlands and open water should be changed by using a *purpose dependent* guideline—following CWA fill regulations is necessary to prevent further development, but allowing replenishment of drowning or eroding marshes is equally necessary.

Note

1 *Orphan landfills* are properties where a current owner or responsible party cannot be identified.

Supplementary material

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S1466046614000301

References

Boon, J.D. 2012. Evidence of Sea Level Acceleration at U.S. and Canadian Tide Stations, Atlantic Coast, North America. *Journal of Coastal Research* 28(6):1437–1445.

Brouwer, G. 2002. New Jersey Misses Mark in Mitigation. *Civil Engineering* 72(6):28.

Dahl, T.E., and G.J. Allord. 1999. *History of Wetlands in the Conterminous United States* [Technical Aspects of Wetlands]. US Geological Survey (USGS) Water Supply Paper 2425. USGS, Washington, DC. Available at http://water.usgs.gov/nwsum/WSP2425/history.html (accessed October 29, 2012).

EarthMark. 2008, September. *Statement of Qualifications and Lease Proposal for the Richard P. Kane Natural Area Wetland Mitigation Bank*. Submitted to the Meadowlands Conservation Trust (MCT). MCT, Lyndhurst, NJ. Available at http://www.mitigationbank.com/index.php?option=com_content&view=article&id=72&Itemid=59.

EarthMark. 2013. *Kane Mitigation Bank Fact Sheet.* Available at http://www.mitigationbank.com/index.php?option=com_content&view=article&id=72&Itemid=59 (accessed February 6, 2013).

Federal Register. 2002. Rules and Regulations 67(90):31129–31143.

Finkl, C.W. 1996. What Might Happen to America's Shorelines If Artificial Beach Replenishment Is Curtailed: A Prognosis for Southeastern Florida and Other Sandy Regions along Regressive Coasts. *Journal of Coastal Research* 12(1):R3–R9.

Gornitz, V., S. Couch, and E.K. Hartig. 2002. Impacts of Sea Level Rise in the New York City Metropolitan Area. *Global and Planetary Changes* 32(1):61–88.

Hartig, E.K., V. Gornitz, A. Kolker, F. Mushacke, and D. Fallon. 2002. Anthropogenic and Climate-Change Impacts on Salt Marshes of Jamaica Bay, New York City. *Wetlands* 22(1):71–89.

Hedrick, C. 2000. March. *State, Territory, and Commonwealth Beach Nourishment Programs: A National Overview*, W. Millhouser and J. Lukens (Eds.). Technical Document No. 00-01. Office of Ocean and Coastal Resource Management (OCRM) Program Policy Series. OCRM, National Ocean Service, National Oceanic & Atmospheric Administration, US Department of Commerce, Washington, DC, 118 pp. Available at http://coastalmanagement.noaa.gov/resources/docs/finalbeach.pdf (accessed May 14, 2013).

Hough, P., and M. Robertson. 2009. Mitigation under Section 404 of the Clean Water Act: Where It Comes From, What It Means. *Wetlands Ecologic Management* 17(1):15–33.

Jones, A.S., C. Bosch, and E. Strange. 2009. Vulnerable Species: The Effects of Sea Level Rise on Coastal Habitats. In *Coastal Sensitivity to Sea Level Rise: A Focus on the Mid-Atlantic Region*, J.G. Titus (Coordinating Lead Author), K.E. Anderson, D.R. Cahoon, D.B. Gesch, S.K. Gill, B.T. Gutierrez, E.R. Thieler, and S.J. Williams (Lead Authors). US Environmental Protection Agency, Washington DC, pp. 43–56. Available at http://papers.risingsea.net/coastal-sensitivity-to-sea-level-rise-5-vulnerable-species.html (accessed July 1, 2013).

Karl, T.R., J.M. Melillo, and T.C. Peterson (Eds.). 2009. *Global Climate Change Impacts in the United States*. Cambridge University Press, New York, 188 pp. Available at http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf (accessed October 20, 2012).

Kennish, M.J. 2001. Coastal Salt Marsh Stems in the U.S.: A Review of Anthropogenic Impacts. *Journal of Coastal Research* 17(3):731–748.

Kirshen, P., C. Watson, E. Douglas, A. Gonitz, J. Lee, and Y. Tian. 2008. Coastal Flooding in the Northeastern United States due to Climate Change. *Mitigation and Adaptation Strategies for Global Change* (Special issue: Assessment of Climate Change, Impacts, and Solutions in the Northeast United States) 13(5–6):437–451. Available at http://link.springer.com/article/10.1007/s11027-007-9130-5 (accessed July 1, 2013).

Louis Berger Group (LBG). 2011. *Lincoln Park Wetland Restoration Project Monitoring Plan: Jersey City, Hudson County, New Jersey*. Submitted to the New Jersey Department of Environmental Protection Office of Natural Resource Restoration, Trenton, NJ, and National Oceanic and Atmospheric Administration Restoration Center, Highlands, NJ. Prepared by the Louis Berger Group, Inc., Morristown, NJ.

Louis Berger Group (LBG). 2012. *Lincoln Park Wetland Restoration Year 2 Monitoring Report: Jersey City, Hudson County, New Jersey*. Submitted to New Jersey Department of Environmental Protection Office of natural Resource Restoration, Trenton, NJ, and National Oceanic and Atmospheric Administration Restoration Center, Highlands, NJ. Prepared by the Louis Berger Group, Inc., Morristown, NJ.

Mazzei, V.J., Jr. 2010. *Engineering Report*. NJDEP Kane Mitigation Bank Project Files. Obtained through an Open Public Records Act (OPRA) request to the New Jersey Department of Environmental Protection, April 15, 2013.

National Research Council (NRC). 2001. *National Research Council: Compensating for Wetland Losses Under the Clean Water Act*. National Academies Press, Washington, DC, 348 pp.

New Jersey Department of Environmental Protection (NJDEP). 1997. October. *The Management and Regulation of Dredging Activities and Dredged Material in New Jersey's Tidal Waters*. NJDEP, Trenton, NJ, 121 pp. Available at https://rucore.libraries.rutgers.edu/rutgers-lib/35173/ (accessed December 30, 2014).

Nicholls, R.J. 2003. *Case Study on Sea-Level Rise Impacts*, ENV/EPOC/GSP (2003)9/FINAL. Organization for Economic Co-operation and Development, Paris, 32 pp.

Nicholls, R.J., and A. Cazenave. 2010. Sea-Level Rise and Its Impact on Coastal Zones. *Science* 328(5985):1517–1520.

Nussbaum, A. 2009. A Windfall from Waste. *NorthNewJersey.com*, August 10. Available at http://www.northjersey.com/news/environment/a-windfall-from-waste-1.995013 (accessed July 1, 2013).

Richard P. Kane Mitigation Bank. 2013. http://www.mitigationbanking.org/pdfs/rpkmb.pdf (accessed February 6, 2013).

Ruhl, J.B., and R.J. Gregg. 2001. Integrating Ecosystem Services into Environmental Law: A Case Study of Wetland Mitigation Banking. *Stanford Environmental Law Journal* 20:365–392. Available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1354787 (accessed October 10, 2012).

Sallenger, A.H., Jr., K.S. Doran, and P.A. Howd. 2012. Hotspot of Accelerated Sea-Level Rise on the Atlantic Coast of North America. *Nature Climate Change* 2(12):884–888.

Scavia, D., J.C. Field, D.F. Boesch, R.W. Buddenmeier, V. Burkett, D.R. Cayan, M. Fogarty, M.A. Garwell, R.W. Howarth, C. Mason, D.J. Reed, T.C. Royer, A.H. Sallenger, and J.G. Titus. 2002. Climate Change Impacts on U. S. Coastal and Marine Ecosystems. *Estuaries* 25(2):149–164.

Slott, J.M., A.B. Murray, and A.D. Ashton. 2010. Large-Scale Responses of Complex-Shaped Coastlines to Local Shoreline Stabilization and Climate Change. *Journal of Geophysical Research-Earth Surface* 115(F3) F03033 (20 pp.), doi:1029/2009JF001486.

Stammermann, R., and M. Piasecki. 2012. Influence of Sediment Availability, Vegetation, and Sea Level Rise on the Development of Tidal Marshes in the Delaware Bay: A review. *Journal of Coastal Research* 28(6):1536–1549.

Stive, M.J.F., R.J. Nicholls, and H.J. Devriend. 1991. Sea-Level Rise and Shore Nourishment: A Discussion. *Coastal Engineering* 16(1):147–163.

Strauss, B.H., R. Ziemlinski, J.I. Weiss, and J.T. Overpeck. 2012. Tidally Adjusted Estimates of Topographic Vulnerability to Sea Level Rise and Flooding for the Contiguous United States. *Environmental Research Letters* 7(1):014033 (12 pp.), doi:10.1088/1748-9326/12/014033.

Titus, J.G. (Coordinating Lead Author), K.E. Anderson, D.R. Cahoon, D.B. Gesch, S.K. Gill, B.T. Gutierrez, E.R. Thieler, and S. J. Williams (Lead Authors), for the Climate Change Science Program (CCSP). 2009. *Coastal Sensitivity to Sea Level Rise: A Focus on the Mid-Atlantic Region*. A Report by the US CCSP and the Subcommittee on Global Change Research. US Environmental Protection Agency, Washington D.C., 320 pp. Available at http://downloads.globalchange.gov/sap/sap4-1/sap4-1-final-report-all.pdf.

Tol, R.S.J., R.J.T. Klein, and R.J. Nicholls. 2008. Towards Successful Adaptation to Sea-Level Rise along Europe's Coasts. *Journal of Coastal Research* 24(2):433–442.

Törnqvist, T.E., and D.J. Meffert. 2008. Sustaining Coastal Urban Ecosystems. *Nature Geoscience* 1(12):805–807.

US Army Corps of Engineers (USACE). 2011, October 1. *Sea-Level Change Considerations for Civil Works Programs*. Circular 1165-2-212, expires September 30, 2013. USACE, Washington, DC, 32 pp. Available at http://planning.usace.army.mil/toolbox/library/ECs/EC11652212Nov2011.pdf

US Army Corps of Engineers (USACE). 2013a. *Fact Sheet—Lincoln Park West, NJ*. USACE, New York. http://www.nan.usace.army.mil/Media/FactSheets/FactSheetArticleView/tabid/11241/Article/8324/fact-sheet-lincoln-park-west-nj.aspx (accessed February 6, 2013).

US Army Corps of Engineers (USACE). 2013b. *Fact Sheet—New York & New Jersey Harbor (50 Ft Deepening)*. USACE, New York. http://www.nan.usace.army.mil/Media/FactSheets/FactSheetArticleView/tabid/11241/Article/8427/fact-sheet-new-york-new-jersey-harbor-50-ft-deepening.aspx (accessed February 6, 2013).

US Army Corps of Engineers (USACE). 2013c. *Regulatory In-Lieu Fee and Bank Information Tracking System*. USACE, Washington, DC. Available at https://rsgisias.crrel.usace.army.mil/ribits/f?p=107:10:4927008929032337::NO::P10_BANK_ID:1745 (accessed February 22, 2013).

Weinstein, M.P., and L.L. Weishar. 2002. Beneficial Use of Dredged Material to Enhance the Restoration Trajectories of Formerly Diked Lands. *Ecological Engineering* 19(3):187–201.

Williams, S.J. 2013. Sea-Level Rise Implications for Coastal Regions. *Journal of Coastal Research* (Special Issue: Understanding and Predicting Change in the Coastal Ecosystems of the Northern Gulf of Mexico) 63:184–196.

Yin, J., M.E. Schlesinger, and R.J. Stouffer. 2009. Model Projections of Rapid Sea-Level Rise on the Northeast Coast of the United States. *Nature Geoscience* 2(4):262–266.

Yozzo, D.J., P. Wilber, and R.J. Will. 2004. Beneficial Use of Dredged Material for Habitat Creation, Enhancement, and Restoration in New York–New Jersey Harbor. *Journal of Environmental Management* 73(1):39–52.

Zervas, C. 2009. December. *Sea Level Variations of the United States 1854–2006*. NOAA Technical Report NOS CO-OPS 053. US Department of Commerce National Ocean Service Center for Operational Oceanographic Products and Services, Silver Spring, MD, 194 pp. Available at http://tidesandcurrents.noaa.gov/publications/Tech_rpt_53.pdf

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