TECHNICAL COMMUNICATION

Summary of Beach Replenishment Experience on U.S. East Coast Barrier Islands

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INTRODUCTION

Speaking in broad terms, one can say that our society has three avenues of response to an eroding shoreline. These options are (1) hard stabilization, *i.e.* seawalls and revetments; (2) soft stabilization, or beach replenishment; and (3) retreat or relocation of buildings. Because of the widely held perception that hard stabilization is destructive to recreational beaches, beach replenishment is often viewed as the national solution to the erosion problem. Two states, Florida and New Jersey, are planning large and costly beach replenishment programs for the future.

Along the East Coast of the United States, a great many beaches have been replenished, especially since the 1962 Water Resources Act. This national experience in artificial beach construction, however, is largely undocumented.

This paper summarizes data on the occurrence of beach replenishment on the U.S. East Coast, listing the date, volume, length, and cost of each emplacement operation, as well as funding source. Approximately 90 replenished beaches were identified, including 260 federal-, state-, and locally-funded individual pumping operations. The amount of data available on the various beaches is quite variable; much information is lacking. A "broad brush" overview of these data has previously been published (PILKEY and CLAYTON, 1987),[1] and more detailed analyses are presently in preparation.

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Data concerning the history of beach replenishment efforts are important for a number of reasons, including:

(1) The data set establishes a relatively complete picture of the extent of use of the beach replenishment alternative on East Coast barrier islands.

(2) The data provide a starting point for a study of beach durability and cost, and the role of various design parameters (*e.g.* beach length, "density," *etc*) in determining the success of artificial beaches.

(3) The data compilation provides an information base for and indicates information sources available to community planners and coastal zone managers, and therefore should help provide the basis for the formulation of national, state, and local policies toward beach replenishment as the "solution" to erosion.

NATURE OF THE DATA

An immediate discovery upon beginning this study was that data concerning beach replenishment is difficult to come by. In general, the most complete information is available for federal projects because of Congressional reporting requirements. Data concerning projects funded by states and communities is less readily available, and information about privately funded projects is often not available at all in the public domain. The data presented here, although extensive, are by no means complete.

Information was gleaned from a variety of sources. Information on federal projects was

obtained primarily from Congressional documents, Corps of Engineers' annual reports and district publications, and miscellaneous federal agency reports. State agency reports and files provided most of the data on state and locally funded beach replenishment projects, while consultants' reports were the principal source of information on private beach replenishment projects. In addition, we depended heavily upon personal communications with government employees at all levels, as well as conference proceedings, scientific papers, and news media reports.

CATEGORIES OF REPLENISHED BEACHES

The 90-some replenished beaches studied in this investigation can be conveniently divided into six categories. Several beaches fall into more than one category, having been funded by a variety of sources throughout their history, (*e.g.* Ocean City, NJ).

(1) **Long-Term Federal—complete.** The standard federal beach project consists of (a) a major initial restoration of the beach, followed by (b) smaller-volume periodic nourishments. The 17 beaches classified as "long-term federal—complete" are those which have been initially restored, and have been or are being subsequently nourished.

(2) **Long-Term Federal—incomplete.** The 7 beaches in this category are federal projects which have been replenished to varying degrees, but on which the initial major restoration has not been carried out due to various political or financial reasons.

(3) **Short-Term Federal.** This loosely-defined category consists of 20 beaches which include National Park Service shore protection projects, Corps of Engineers emergency shore protection projects, and beaches which receive sand from nearby navigation projects. With the exception of Sandy Hook, NJ, none of these replenishment projects is part of a continuing shore protection program.

(4) **State and Local.** These 34 beaches were replenished primarily with state and local community funding. With 7 exceptions, all are in Florida or New Jersey.

(5) **Private.** Most of the funding for these 5 beach nourishment projects came directly from private property owners, rather than through tax-funded government accounts.

(6) **1962 Storm Repair.** This category includes those 38 beaches, mostly in New Jersey, which were replenished to provide temporary storm protection after beach losses due to the 1962 Ash Wednesday Storm.

DATA SUMMARY

Table 1 contains the following information: name of beach or beach community, classification and funding of replenishment project, year of replenishment, length of beach replenished, cost and sources of information. The beaches in Table 1 are listed in north-to-south order. The study area from which the table is derived extends from the barrier island on the South Shore of Long Island to Key Biscayne, Florida. Not included are barrier islands of New England.

In general, it is not possible to discern from this table the success or failure of individual beach replenishment projects. The time gap between subsequent replenishment operations on a particular beach is sometimes more a function of local politics and economics rather than the physical state of the preceeding artificial beach. For information on actual beach performance, the reader is referred to the original sources in the list of references and to PILKEY AND CLAYTON (1987; Reference #1) and PILKEY (1988; Reference #138).

ACKNOWLEDGEMENTS

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This study would not have been possible without the support and cooperation of many people along the East Coast. Especially helpful have been those at the University of Florida Coastal Archives, the U.S. Army Corps of Engineers, and state and local coastal zone management offices.

Table 1. (Continued). *List of beach replenishment projects on East Coast U.S. barrier islands. "Type" refers to funding source categories as follows (see explanation in text): (1) Long-term federal—complete; (2) Long-term federal—incomplete; (3) Short-term federal; (4) State and local; (5) Private, and (6) 1962 Storm repair. For federal projects, the funding justification is also listed: HP = Hurricane Protection; BEC = Beach Erosion Control; FC = Flood Control; Nav = Navigation; Emerg = Emergency; 111 = Section 111 (mitigation of damages caused by federal navigation projects).*

BEACH	YEAR	TYPE	VOLUME(cy)	LENGTH (mi)	COST ($)	REFERENCES

Table 1. *List of beach replenishment projects on East Coast U.S. barrier islands. "Type" refers to funding source categories as follows (see explanation in text): (1) Long-term federal—complete; (2) Long-term federal—incomplete; (3) Short-term federal; (4) State and local; (5) Private, and (6) 1962 Storm repair. For federal projects, the funding justification is also listed: HP = Hurricane Protection; BEC = Beach Erosion Control; FC = Flood Control; Nav = Navigation; Emerg = Emergency; 111 = Section 111 (mitigation of damages caused by federal navigation projects).*

BEACH	YEAR	TYPE	VOLUME(cy)	LENGTH (mi)	COST ($)	REFERENCES
Saganopack Pond area, NY	1962	6	70,000	0.6	$133,400	2
Mecox Bay area, NY	1962	6	175,000	1.3	$153,900	2
Southampton Beach, NY	1962	6	200,000	1.0	$96,600	2
Great South Beach, NY	1962	6	993,500	5.8	$844,100	2
Westhampton Beach, NY	1962	6	136,500	0.3	$93,600	2
	1969	2:FC	750,000			3
	1970	2:FC	1,100,000			3
	1984	3			$610,000	4
Brookhaven & Islip, NY	1962	6	715,000	7.0	$528,600	2
Jones Beach, NY	1927-1961	4	>40,000,000			5
Oak Beach, NY	1946					60
Oak Beach, Gilgo-	1946-1959		>1,000,000			6
Cedar Beach, NY	1960	2				7
	1974	2:BEC/Nav		1.7		8
	1975	2:BEC/Nav	931,310	2.1	$3,335,000	8,9
	1977	2:BEC/Nav	2,271,457	2.1	$9,017,963	10,11
Lido Beach, NY	1962	6	200,000	0.8	$249,500	2
Rockaway Beach, NY	1926-1930		5,200,000	4.9		12,13
(Rockaway Point)	1930-1936		5,000,000			12
(Jacob Riis Park)	1939	4	400,000	0.9	$60,000	12,14
(Far R'way & Edgemere)	1958		1,250,000			12
(Arverne)	1962	6	175,000	0.4	$135,500	2,12,15
	1967	4	300,000	0.7		15
	1975	1:BEC	3,668,700	3.0	$9,420,556	16,17,18,19
	1976	1:BEC	1,489,600	4.2	$2,204,467	17
	1977	1:BEC	1,000,000	2.0	$2,500,000	11.17
	1978a	3:emerg	460,400	1.2		20
	1978b	3:emerg	210,900	0.3		20,21
	1980	1:BEC	466,000	0.7		20,22,23
	1982a	1:BEC	903,100	1.0		20,24
	1982b	1:BEC	163,300	0.2	$427,000	24
	1984	1:BEC	1,677,900	1.1		19
	1986	1:BEC				19,25
Sandy Hook, NY	1975	3	191,447			26
	1976	3	198,276	0.6	$480,150	26,28
	1977	3	200,000	0.2	$770,500	27,28
(offshore)	1978	3	98,684			29
	1979	3				28
	1983	3	2,370,766	0.4		30
	1984	3	598,000	0.4		31
Seabright-Monmouth Bch, NJ	1963	6	1,433,000	5.1	$1,418,400	2
Long Branch, NJ (offshore)	1948		601,991			14
	post-1962	6			$25,751	2
Deal, NJ	post-1962	6				2
Shark River Inlet, NJ	Sand periodically bypassed					6
Avon & Belmar, NJ	1958	4			$226,544	32
Spring Lake, NJ	1969	4			$112,728	32
Sea Girt, NJ	1962	6			$25,751	32
	1966	3	425,211		$552,774	33

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BEACH	YEAR	TYPE	VOLUME(cy)	LENGTH (mi)	COST ($)	REFERENCES
Bay Head, NJ	1963	6			$217,551	32
Lavallette, NJ	1963	6			$186,225	32
Seaside Heights, NJ	1963	6			$154,498	32
Seaside Park, NJ	1963	6			$99,443	32
Berkeley Township, NJ	1962	6			$12,628	32
	1968	4			$71,566	32
South Seaside Park, NJ	1978	4				34
Barnegat Light, NJ	1963	6			$67,309	32
	1966	4			$65,481	32
Long Beach Island, NJ	pre-1963	2	66,000			35
(northern end)	post-1972		dredging of Barnegat Inlet		36	
	1979	3:emerg	1,000,000	2.8	$4,600,000	37
Harvey Cedars, NJ	1962	6	715,000	3.6	$759,700	2
	1963	6			$282,770	32
	1967	4			$39,484	32
Surf City, NJ	1963	4			$220,170	32
Ship Bottom, NJ	1956	4	182,000			38
	1963	6			$161,659	32
Brant Beach, NJ	1956	4	115,000			38
Union Township, NJ	1966	4			$12,142	32
Island Heights, NJ	1962	6			$18,300	32
Long Beach, NJ	1959	4			$72,025	32
	1962	6			$28,690	32
	1963	6			$1,008,050	32
Beach Haven, NJ	1963	6			$70,589	32
Brigantine, NJ	1962	6	392,500	3.4	$503,700	2
	1963	6			$186,623	39
	1966	4			$131,162	39
Atlantic City, NJ (offshore)	1936		792,000			14
(offshore)	1937		900,000			14
(offshore)	1938		500,000			14
	1942	3	1,362,000			14
	1948	2:BEC	1,073,684	1.1	$826,737	14,40
	1963	2:BEC	580,000	0.7		41,42,43
	1970	3:emerg	830,000	0.9		41,43,44
	1979	4	4B,158			39,40
	1986	4	1,000,000		$7,000,000	45,46,47
Ocean City, NJ	1952	2:BEC	2,550,000	1.8	$1,912,500	48
	1959	2:BEC	1,618,000		$469,008	48,49
	1962	6				49
	1966a	4			$97,899	50
	1966b	4			$40,226	50
	1970	4	475,270			49
	1971	4	237,900			49
	1972	4	543,650			49
	1973	4	347,341			49
	1974a	4	12,388			49
	1974b	4	10,553			49
	1974c	4	144,608			49
	1975a	4	26,310			49
	1975b	4	18,220			49
	1975c	4	122,269			49
	1976a	4	34,034			49
	1976b	4	35,555			49
	1976c	4	12,067			49
	1977	4	169,949			49
	1978a	4	79,478			49

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BEACH	YEAR	TYPE	VOLUME(cy)	LENGTH (mi)	COST ($)	REFERENCES
	1978b	4	34,115			49
	1978c	4	8,093			49
	1979a	4	3,555			49
	1979b	4	5,333			49
	1979c	4	51,288			49
	1979d	4	11,601			49
	1979e	4	52,925			49
	1980a	4	26,510			49
	1980b	4	35,780			49
	1980c	4	37,405			49
	1980d	4	43,610			49
	1980e	4	6,710			49
	1982	4	1,200,000		$5,200,000	49,51
Ludlum Beach Island, NJ	1962	6	905,082	6.7	$809,300	2
Upper Township, NJ	1966	4				50
	1984	4	1,600,000			52
Strathmere, NJ	1982	5			$90,000	53
Sea Isle City, NJ	1965	4			$63,845	50
	1980's	4	700,000			52
	1987		158,000			136
Avalon, NJ	1987	4	1,300,000		24,000,000	61
Stone Harbor, NJ	1968	4			$255,464	50
North Wildwood, NJ	1966	4			$5,698	50
Wildwood	1963	6			$24,298	50
Lower Township, NJ	1969	4			$89,455	50
Cape May Point, NJ	1962	6	156,656	1.6	$358,600	2
	1967	4			$2,427	50
	1969	4			$256,495	50
Ft Miles-Indian R Inlet, DE	1962	6	901,709	5.7	$811,100	2
Indian River Beach, DE	1957	2				54
	1963	2			$326,114	54
	1973	2		(feeder)		54
	post-1974	2:emerg		(feeder)		54
	1978	2:emerg		(feeder)	$872,297	21,55
	1984	2:emerg				54
Beach Cove-Bethany Bch, DE	1962	6	106,780	1.8	$171,300	2
S. Bethany-York Beaches, DE	1962	6	429,280	4.7	$696,700	2
Ocean City, MD	1963	6	1,050,000	8.0	$1,517,600	2
Virginia Beach, VA	FY1951		20,000			59
	FY1952		1,363,000			59
	FY1954		138,000			59
	FY1955	4	47,500			56
	FY1956	4	35,000			56
	FY1957	4	124,000			56
	FY1958	4	120,000			56
	FY1959	4	129,000			56
	FY1960	4	132,000			56
	FY1961	4	153,000			56
	FY1962		472,000			59
	FY1963	4	121,000			56
	FY1964	4	215,000			56
	FY1965	4	218,000			56
	FY1966	4	174,000			56.57
	FY1967	4	177,500			56,57
	FY1968	4	147,400			56,57
	FY1969	4	100,500			56
	FY1970	4	247,800			56

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BEACH	YEAR	TYPE	VOLUME(cy)	LENGTH (mi)	COST ($)	REFERENCES
	FY1971	4	230,600			56
	FY1972	4	489,800			56,58
	FY1973	4	358,600			56,58
	FY1974	4	167,500			56
	FY1975	4	273,430			56
	FY1976		241,610			56
	FY1977		289,488			59
	FY1978		259,992			59
	FY1979		295,040			59
	FY1980		266,150			59
	FY1981		332,494			59
	FY1982		319,578			59
	FY1983		317,395			59
	FY1984		351,399			59
	FY1985		384,453			59
	FY1986		396,046			59
Sandbridge, VA	1962	6	262,000	2.1	$508,700	2
Cape Hatteras, NC	1966	3	312,000			63
	1972	3	200,000			63
	1973	3	1,300,000	1.5	$4,000,000	64,65
Ft. Macon State Park, NC	1978	3:nav				66
Atlantic Beach, NC	1986	3:nav	3,600,000		$4,750,000	67
Figure Eight Island, NC	1985	5	46,300	0.4		68
	1986	5	250,000	0.4		69
Wrightsville Beach, NC	1939		700,000	2.6	$98,000	14,70
	1955		38,000			71
	1956	4	35,000			71
	1957		304,000			71
	1959		100,000	1.5		71
	1965	1:FC	2,993,100		$739,339	36,72,73
	1966a	1:FC	319,408		$39,193	72,74,75
	1966b	1:FC	42,700		$8,448	74
	1970	1,3:FC,nav,emerg	1,436,553	3.2	$518,775	76.77
	1980	3:emerg	540,715	1.3	$520,456	78
	1981	1,3:FC/nav/111	1,249,699	1.3	$4,427,792	78
	1986	3,4:nav/111/BEC	900,000		$1,209,000	79,80
Masonboro Island, NC	1986	3:nav	1,120,000			79
Carolina Beach, NC	1955	3	252,000		$50,000	81,82
	1956	4	200,000			81,82
	1965	1:FC	3,597,362	1.9	$925,506	35
	1967a	1:emerg	441,000	0.8	$206,398	74,83,84
	1967b	3:nav	115,000			75
	1968	3:nav	97,000		$291,159	75
	1970		346,000	0.8		75,76,83
	1971	1,3:FC, emerg	760,000	2.2	$517,897	75,85
	1981	3:emerg	406,000		$679,985	22,81
	1982	1:FC	3,662,181	2.7	$8,800,000	86,87
	1985	1:FC	764,162		$1,652,004	88
New River Inlet, NC		3				16
Long Beach, NC	1986	3:nav	130,000		$215,000	89,90,91
Myrtle Beach, SC	1986-87	4	850,000	6.0	$4,500,000	92
Edisto Beach, SC	1954	4	830,000	0.9		93
Hunting Island, SC	1968	1:BEC	750,000		$609,000	94,95
	1971	1:BEC	761,324	1.9	$534,000	95
	1975	1:BEC	613,000		$872,000	94,95
	1980	1:BEC	1,400,000		$2,107,053	96,97
Hilton Head Island, SC	pre-1973	5				93

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BEACH	YEAR	TYPE	VOLUME (cy)	LENGTH (mi)	COST ($)	REFERENCES
	1982		800,000			98
Tybee Island, GA	1976	1:BEC	2,300,000	3.5	$3,600,000	99,100,101
	1987	1:BEC	1,000,000		$3,700,000	102
Sea Island, GA	1964	3	150,000	0.8	$175,000	103
	1986	5	100,000	0.5		104
Mayport Naval Station, FL	1972	3	1,600,000			105
	1974	3	400,000	1.5		105
Jacksonville Beach, FL	1963	3:emerg	320,000			93
	1974	3:nav				33
	1979-81	1:BEC	2,300,000	7.3		105,106
	1986	1:BEC		5.0		107
St. Augustine Beach, FL	1963	3	50,000		$95,000	93
Brevard County, FL	pre-1972	3,4,5	minor			93
Cape Canaveral Beach, FL	1972		>200,000			94
	1975	1,3:BEC/nav	2,715,000	2.1	$1,050,000	108,109
Indialantic-Melbourne, FL	1981	1:BEC	540,000	2.1	$3,582,000	110,111
Sebastian Inlet, FL	1972		423,684			111
	1986		178,900	0.6		112
Indian River County, FL	pre-1972	4				113
Vero Beach, FL	1979	4				114
	1984	4				115
Ft. Pierce, FL	1971	1:BEC	718,000	1.3	$621,288	94,108
	early 1980's	1:BEC	346,000	1.3	$1,559,431	116
Lions Club Beach Park, FL	pre-1972		minor			93
Jupiter Island, FL	1955-57	4	250,000			93
	1963a		60,000	0.4		94
	1963b		4,644			94
	1964		118,312			94
	1967		60,000	feeder	$30,000	94,117
	1973-74	4	3,488,759	4.9	$4,046,960	117,118
	1978	4	1,327,289	5.0		118,119,120
	1983		1,000,000	5.0	$2,400,000	119,121
	1987		1,100,000	2.5	$3,500,000	147,148
Jupiter Inlet, FL	sand occasionally bypassed to beach south of Jupiter Isle					93
Palm Beach Island, FL	1944	4	300,000	feeder	$105,000	14
	1948	4	2,335,930	4 feeders	$478,659	14
	1949	4	480,000	2 feeders		14
	1953		463,000			93
	1975	4		1.2		122
South Lake Worth Inlet, FL	fixed sand bypassing plant					93
Delray Beach, FL	1973	1:BEC	1,634,513	2.7	$3,015,383	94,108,123
	1978	1:BEC	701,266	1.7	$1,660,584	116,124,125
	1984	1:BEC	821,551	2.6	$3,949,117	107,108,121
Boca Raton Inlet, FL	periodically bypassed					93,121,126
Pompano Beach, FL	1964	4			$3,677	127
	1970	1:BEC	1,076,000	3.2	$1,873,437	94,128
PB-Lauderdale-by-the-Sea, FL	1983	1:BEC	1,909,000	5.3	$10,273,340	108,129
Hillsboro Beach, FL	1972		500,000	1.0		128
Hillsboro Inlet, FL	intermittently bypassed					93
Port Everglades, FL	occasionally bypassed					93
John U. Lloyd State Park, FL	1977	1:BEC	1,090,000	1.5	$2,945,262	108,116
Hallandale Beach, Fl	1971	1:BEC	370,000	0.8	$779,977	108,128
Hollywood-Hallandale, FL	1979	1:BEC	1,980,000	5.3	$7,743,376	108,129
Haulover Park, FL	1960	4	180,000			93
	1978	1:BEC				130
	1980	3:nav	80,000			131
Bal Harbour, FL	1960	4	86,000			93

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	1961	4	25,000			132
	1963-73	4	305,000			93
	1974-75	1:BEC	1,700,000	0.8	$5,047,000	94
Miami Beach, FL	1979-82	1:BEC	12,000,000	10.5	$55,000,000	133,134
Val. Key-Key Biscayne, FL	1969	1:BEC	373,000	2.5	$577,075	94,108
Virginia Key, FL	1974	1:BEC	500,000	1.3	$2,381,742	116
Key Biscayne, FL	1987		360,000	2.4	$2,600,000	107,133,137

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