Preliminary Assessment of New York's Sand Needs

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Stony Brook University's COAST Institute

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INTRODUCTION

This document is a consideration of the volume and quality of sand needed along New York's ocean shoreline to support current and projected beach and dune construction practices. This assessment is intended to help New York's coastal communities in planning future renourishment projects using offshore sand resources that could be used to help address beach erosion brought on by natural processes and severe storms. These resources may be important in supporting coastal community resilience and coastal habitats.

The low-lying sandy beaches found all along a New York's ocean coast have been repeatedly threatened by erosion. Between 1983 and 2013 alone, the region has suffered through two hurricanes (Hurricane Gloria on 27 September, 1985 and Hurricane Bob on 19 August, 1991), two memorable Nor'easters (the "Halloween Storm" or "The Perfect Storm" on 30 October, 1991; the "Storm from Hell" on 11 and 12 December, 1992) and "Superstorm Sandy" on 29 October, 2012. "Superstorm" Sandy (October 29, 2012) caused unprecedented devastation. Winds in excess of 90 mph and high, spring tides, conspired to raise waves 9.7 m high and a storm surge reaching three meters in the region. A new inlet was opened on Fire Island. Breaching, overwash and erosion taxed the resilience of nature protected features all along the shoreline.

Threats to the coastline should be expected to increase in the future. The Intergovernmental Panel on Climate Change (2013) predicted that sea level along the New York coast may rise by 1.2 m by 2100 and recently, New York State is considering that all future planning projects consider the impacts of a rise of as much as 1.8 m. With increasing global temperatures, the frequency of Atlantic Hurricanes may also be increasing (Mann and Emanuel, 2006).

Beach renourishment, that is, artificially adding sand to an eroded system, is widely used and considered to be a technically sound shore-protection strategy (National Research Council 1995). As we shall show, it has been commonly used in New York. Three types of estimates of the demand for beach renourishment will be discussed:

- Nourishment at historical rates for previously designed projects.
- Pre-Sandy estimates for the Fire Island Inlet to Montauk Point Inlet

- Post-Sandy restoration Project

This information will be assimilated into annualized future demand taking into account sea level rise due to climate change, but they do not include estimates for reconstruction following extreme storms due to the uncertainty of their occurrence and scale of impacts. As we will discuss the historical demand for beach nourishments has been about 1.5 million cubic yards (CY) per year. The interannual variability has been large, but no multiyear trend was apparent. One time, large construction projects, renourishment after extreme events as encountered in the past, and sea-level rise, may increase future, annual demand to over six million CY.

Offshore sand to meet this demand has been found in State waters, that is, within three nautical miles of the shoreline. Additional sand reserves are known to exist, however, in Federal waters on the Outer Continental Shelf. For construction purposes borrow areas should be close to the area at risk and the sand taken from a borrow area should match as closely as possible the grain size distribution of the sand native to the beach which is in equilibrium with the wave climate. If it does not, that fraction of the borrow sand that is too fine grained will be winnowed away under the usual wave attack. That fraction of the sand that is too coarse grained will remain as a lay deposit on the beach or removed offshore during extreme events. The compatibility is measured by an "overfill factor" in construction design.

NOURISHMENT DEMAND

HISTORICAL BEACH NOURISMENT

Large beach nourishment projects have been done on New York beaches since at least about 1907 when several million CY of sediment was dredged by a real-estate developer to create Reynolds Channel and used to join together fragmented barrier island at Long Beach. In 1923, 1.7 million CY of sand was placed by the City at Coney Island. In 1928, Robert Moses had some 40 million CY of sediment dredged to create Jones Beach State Park. Federal involvement in shore protection was authorized by the River and Harbor Act of 1958. (U.S. Army Corps of Engineers [USACE] 1975).

Beach nourishment projects occur every year along New York's ocean shoreline over, at least, the last 64 years. Most of these, and in recent years those with the largest volumes are done by the U.S. Army Corps of Engineers (USACE). The record of beach nourishment projects, however, is incomplete. While federal projects are the largest and most frequent, beach renourishment projects are also done by local jurisdictions. Although all would have permits filed with the USACE and the New York State Department of Environmental Conservation, there does not seem to be any process to inventory and compile summary statistics. In addition, some projects had been documented as permitted volumes while others are in-place volumes, and, to make matters worse, projects that span calendar years may be double counted in some tabulation.

We have three inventories of beach nourishment projects to consider:

1. *International Council for the Exploration of the Seas (ICES).* Finally, since 2001, perhaps more consistent records for the New York ocean coast have been compiled by the International Council for the Exploration of the Seas' Working Group on the Effects of Extraction of Marine Sediments

on the Marine Ecosystem < http://www.ices.dk/community/groups/Pages/WGEXT.aspx > The United States is one of seventeen countries represented on this group which reports annually on marine sediment extraction, marine resource and habitat mapping, changes to the legal regime, and research projects relevant to the assessment of environmental effects. A list of projects reported by ICES since 2001 (Appendix 1) amounts to an average demand of 1,457,366 CY (CY) per year. The range of year-to-year variation however is large (Figure 1). The standard deviation of these annual values is 1,322,202 CY per year, almost as large as the mean itself. The annual variation is large (Figure 1) ranging from about four million CY in some years to near zero in others.

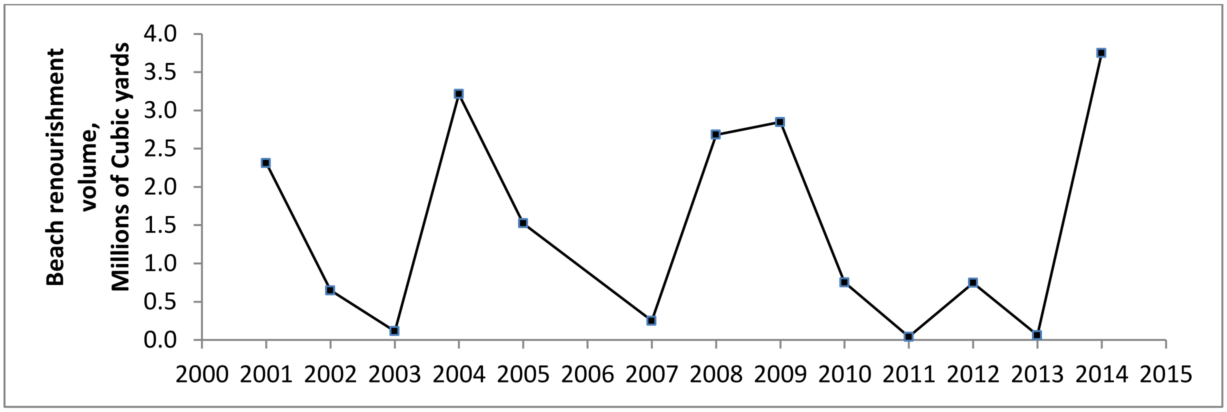

Figure 1. Renourishment volumes along the New York coast compiled by ICES.

2. *Kana 1995.* Kana (1995) had compiled beach renourishment volumes for location along Long Island's ocean shoreline between 1955 and 1989 in five-year increments. These include both Federal and local projects. In addition, "adjustments were made in the volumes where sediment quality was poor for nourishment, as in the case of fill containing mud (unpubl. records, Suffolk County Dept. Public Works). Based on updated review of beach fills impacting the project area (Suffolk County, 1985), up to 30% more beach-quality sediment was found to be deposited along the ocean shoreline than was reported in the RPI (1985) analysis" (Kana, 1995).

3. *BOEM.* BOEM provide an undocumented GIS inventory of "Large Beach" projects nationwide. These seem to be Federal projects. Where available, the attribute table gives State, year, project name, volume, latitude and longitude of borrow sites, sand source, delivery method, local sponsor, cost, status, engineers and miscellaneous notes. Of the 2361 entries, 103 were in NY as early as 1930 (the Rockaways) to 2014. No summary, description or credits were provided in the metadata.

We have used the BOEM values where possible, adding Kana (1995) and ICES-WGEXT values for years not included in the BOEM data (Appendix 2). In some places and intervals, there are discrepancies between the volumes provided by BOEM and those of Kana (1995) or of ICES-WGEXT. Where those values provided are larger than the BOEM values it is likely because the other sources have recognized large private renourishment project that were not tabulated in a Federal inventory; where smaller than those tabulated by BOEM, it may be that data is already incorporated into the BOEM value, but we cannot be certain. Given all the uncertainties inherent in reconstructing the historical data, these values can only be interpreted in general magnitudes.

Although the record is flawed, several characteristics can be recognized. First, the annual demand for all years works out to be 1,242,202 CY per year ranging from a high value of 2,109,098 CY per year in the interval from 1975 to 1979, to a low value of 200,000 CY per year between 1950 and 1954 (Figure 2). This calculation agrees well with that obtained above from the ICES-WGEXT data alone of 1,457,366 CY per year.

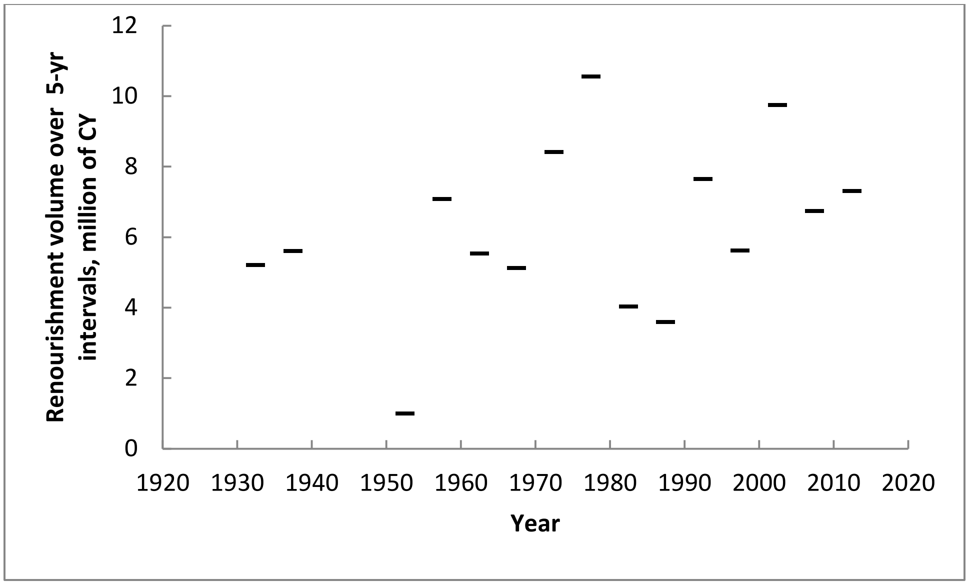

Figure 2. Total renourishment volumes over five-year intervals from a merger (Appendix 2) of ICES, Kana (1995) and BOEM records discussed in the text.

Second, although sand dredge in routine maintenance of inlets was only specifically identified in a few cases, it is likely that all, or almost all, renourishment on Rockaway Beach, Jones Beach, and around Shinnecock Inlet as well as a fair number of projects at the Smith Point County Park were supplied by inlet dredging rather than from offshore borrow areas. For example, between 1950 and 1995, 18,002, 419 CY had been placed on Jones Island. All of this sand had been provided by the maintenance dredging of Fire Island Inlet (Strong, 1997). During this period, the beach all along Jones Island accreted between 18.7 and 21 million CY, so apparently all the sand added by the renourishment projects was retained on the beach (Strong 1997 p. 74).

These are the projects that appear repeatedly because the channel needs to be maintained at regular intervals. Although only a few were so designated, sand from the maintenance dredging of inlets for navigation would seem to account for almost two thirds of the total demand (Kana 1995).

Third, extraordinary situations skew the annual demand in particular years. In the 1980's there was a moratorium on dredging Fire island Inlet resulting in lowered beach renourishment on Jones Beach. The closing of new inlets at Moriches in 1980, emergency nourishment along Jones Island in 1989 Westhampton Beach in 1993, and constructions at the Westhampton Groin field all increased demand at different times. Fourth, historically, about 500,000 CY per year of the total volume have been required east of Fire Island Inlet (Research Planning Institute, 1985); the historical distribution has been skewed towards the more populated, western beaches.

PRE-SANDY ESTIMATES

The Corps estimates the proposed "Fire Island Inlet to Montauk Point Storm Damage Reduction" (FIMP; Bocomazo et al. 2011) project would have required 55,000,000 CY over its 50 year lifetime, or 1.1 million CY/yr. This was based on the assumption that sea level is rising at a rate of 0.1 inch per year (3 millimeter per year). For planning purposes, these estimates might be revised upward by as much as a factor of six in direct proportion to new projections of sea-level rise (NYS DEC 2016) compiled under the Community Risk and Resiliency Act, (Table 1).

Table 1. Summary of sea-level rise projections http://www.dec.ny.gov/regulations/103877.html (NYS DEC 2016)

Time interval from 2004	Low projection		High projection	
years	inches/yr	mm/yr	inches/yr	mm/yr
25	0.08	2.0	0.40	10.2
50	0.12	3.0	0.60	15.2
85	0.15	3.9	0.68	17.3
105	0.14	3.6	0.69	17.4

POST-SANDY PROJECTS

After "Superstorm" Sandy, the two major extraordinary projects undertaken were those at Long Beach and the Fire Island National seashore. Long Beach required 4,720,000 CY over 35,000 feet of shoreline; renourishment is expected to require 1,770,000 CY over a five-year period, or 354,000CY/yr. Dune building and nourishment on Fire Island requires a total project fill volume of 6,992,145 CY over a 19-mile strand. The Corps anticipate maintaining certain beaches and dunes, as needed, based on comparison to the design template and dune sizes. These two projects alone would require 11,712,145 CY plus about 354,000 CY/yr for five years. If a Sandy-like event recurs once in 100 years, the annualized demand is about 120,500 CY/yr. At Smith Point County Park, the Corps' plan is to add 2,500,000 CY of sand along the five-mile coastline. Rockaway Beach and Westhampton were renourished in 2014 (Appendices 1 and 2). Renourishment is planned for Coney Island. Long-term Corps' projects at Rockaway are in the feasibility report phase, and Long Beach is in the construction phase. The South Shore of Staten Island project is also in the pre-construction phase. Projects are pending for Gilgo Beach, and the beach west of Shinnecock Inlet.

SEA LEVEL RISE

Although predictions of shoreline recession due to a rise in sea level are elusive, the Bruun Rule is often used to estimate shoreline recession. The Bruun Rule assumes that the shape of the beach profile is invariant but merely shifts its position as sea level rises; the amount of erosion caused on the beach is balanced by deposition of the sand offshore. The major uncertainty in using the Bruun

Rule lies in its assumption that longshore transport is negligible. Even though this assumption is not true in most areas including New York's ocean shoreline, the Bruun Rule is used conventionally to approximate anticipated changes. In principle the position of the shoreline could be maintained by adding sand to the beach, as long as the property landward of the dune remained above both sea level and the groundwater table.

For a given rise in sea level (or rate of sea-level rise), s in ft/yr the estimate recession of the shoreline, r in ft/yr, would be approximated as

$$r=s*(h_c)/X_c \qquad [1]$$

Where h_c is the closure depth (Kraus et al. 1999) in feet, that is, where the water is too deep for the waves to alter the shape of the beach profile, and X_c is the distance offshore to reach the closure depth in feet. The volume of sand needed to recover a specified shoreline recession per foot of shoreline is estimated using the engineering expedient that one cubic yard of sand is required to increase the beach with by one foot for every foot of shoreline. This value is then multiplied by the shoreline length to estimate the total volume of sand needed to recover the beach lost to sea-level rise.

For the New York ocean coast, the data needed to apply the Bruun Rule has been provided by Batten (2003) based on measurements collected twice a year between 1995 and 2002 at 457 locations by the Atlantic Coast of New York Monitoring Program[1]. For an annual rise in sea level of one-eight inch (3.3 mm/year), 566,781 CY/yr of sand would be needed to combat sea-level rise (Table 2).

Table 2. Bruun rule estimate of renourishment needs due to a sea-level rise.

Location	Closure depth (NGVD)	Distance to closure	Bruun Rule recession rate,	Sand need,	Shoreline length	Sand need	
	feet	feet	ft/yr	CY/foot of beach	feet	CY/yr @ 3.3mm/yr	CY/yr @ 25 mm/yr
Coney Island	18	1,100	0.66	0.66	22,176	14,672	111,140
Rockaway	17	1,450	0.91	0.91	55,440	50,309	381,091
Long Beach	18	1,620	0.97	0.97	48,048	46,560	352,692
Jones Beach	18	1,946	1.17	1.17	76,032	88,995	674,137
Fire Island	21	1,745	0.89	0.89	161,040	143,513	1,087,111
Westhampton	22	1,960	0.96	0.96	80,784	77,220	584,942
Ponds	24	1,890	0.84	0.84	84,480	71,139	538,878
Montauk	30	1,900	0.70	0.70	10,6656	74,373	563,375
						Total: 566,781 CY/yr	**4,293,366 CY/yr**

Scenarios for future sea level rise vary considerably with sea levels projected for 2100 ranging from one foot to over seven feet higher than today (2015; Figure 3). Such estimates approximately correspond to annual rates of 3.6 mm/yr to over 25 mm/yr (Figure 3). The maximum estimate by

[1] http://dune.seagrant.sunysb.edu/nyshore/viewer.htm

NYS DEC (2015) was 17.4 mm/yr (NYS DEC 2015; Table 1). As a result, the above Bruun rule estimates to between 618,307 CY/yr and 4,293,366 CY/yr. with the maximum estimate by NYS DEC (2015) was 17.4 mm/yr (NYS DEC 2015; Table 1) corresponding to an equivalent total demand of 2,988,183 CY/yr.

In the longer term, we might expect that the task will become more difficult because the shoreface will gradually steepen and other strategies will be needed. Alternate methods may still require sources of sand. A tactic to simulate the rollover of a barrier beach in the face of sea-, level rise, for example, requires nourishment of the bay side shoreline, a process that might demand a million CY/yr for Fire Island (Bokuniewicz and Wolff, 1994).

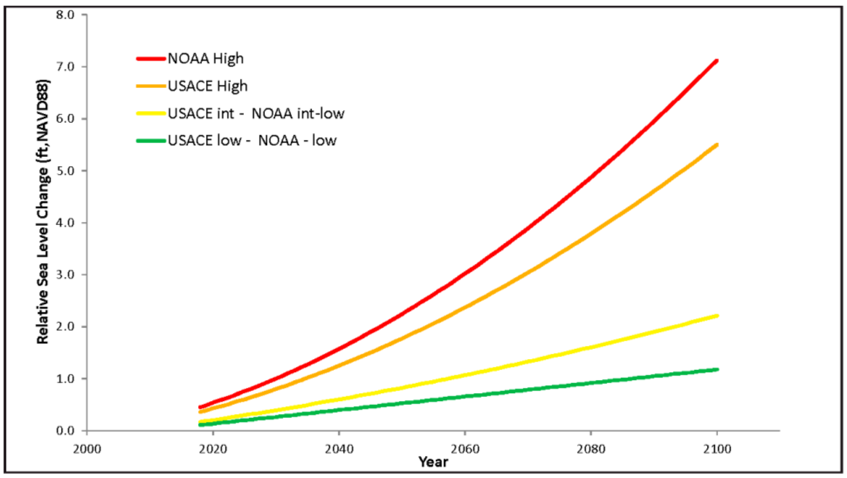

Figure 3. Forecast sea-level changes

Figure 3. Relative sea-level change projections for Sandy Hook (USACE 2015; http://www.nad.usace.army.mil/Portals/40/docs/NACCS/NACCS_main_report.pdf, accessed 2015).

DISCUSSION

There are several ways to look at future renourishment needs. Ordinary annual demand seems to be about 1,500,000 CY/yr, or 75,000,000 CY/50yr. The occurrence of extreme weather can raise an annual demand five-fold. In the time of record considered here, there have been two such extraordinary demands over the last 25 years once in the winter of 1992-1993 and "Superstorm" Sandy. So, for the 50-year period, the demand might reach 95,000,000 CY/50yr. By adding the highest (NOAA) estimate of a 25 mm/yr rate of sea-level rise, the maximum demand could reach 310,000,000 CY/50-yr or 6,200,000 CY/yr. Taking into account the suitability of the borrow sand, that is, the overfill factor as discussed below, the delivered volumes could be up to 30% higher.

Routine dredging of the inlets to maintain navigable waters historically has provided sand for nourishing the downdrift beaches. For example, about 200,000 CY per year is the present, and expected, dredging rate for Jones Inlet. Other deposits of more or less suitable and accessible sand resources are found all along the coastline but not uniformly distributed. Surficial sand resources are discussed in two categories. Pleistocene-aged sands (older sands deposited by glaciers) may be something like 30 to 100 feet thick, while Holocene-aged sands (sand deposited by more recent processes) are only about 3 to 10 feet thick and discontinuous. The Holocene-sand, considered the most suitable for beach nourishment is mostly found in ridges. (Questions regarding possible effects on sediment transport processes or on ecological communities from dredging these ridges are not addressed here.) Other regions do not have Holocene sand (http://pubs.usgs.gov/of/1999/of99-559/report.htm accessed January 2016) but the composition of the sea floor is still classified as sand; they are blanketed by Pleistocene sands at the surface. The Holocene-aged sands have been mapped recently by the USGS and are thickest in a series of offshore sand ridges. The volume of sand reserves has been estimated by several investigators. The answers, however, differ because they depend on the area considered, the data used, etc. Values ranged from 1.3 billion CY to 7.3 billion CY.

COMPATIBILITY

The stability of construction on a particular beach requires a particular distribution of sand sizes which depends on the wind and waves. During the dredging operation, part of the fine-grained component of the sediment, that is silt and clay, will be washed out if overflow is allowed. Subsequently, when emplaced on the beach, sand grains that are too small, will be winnowed from the beach as the material is mobilized and reworked by waves or carried back to the dunes by the wind. A component of larger grains, bigger than those easily moved by the wind, waves and tide, will remain behind as a lag deposit and buried by more mobile sand.

To nourish a beach the rule of thumb is "one cubic yard per foot of beach width per foot of shoreline." Because of the mix of grain sizes both on the beach and at the borrow area, however, only part of the sand excavated from a borrow area will end up being suitable for nourishing the beach. The overfill factor accounts for the mismatch. For instance, if the borrow sand has an overfill factor of, say, 1.2 and you need 100,000 CY of sand on the beach, you will need to excavate 120,000 CY of sand from the borrow area. An overfill factor of 1.0 is ideal, but never attained.

The overfill factor is calculated by comparing the grain-size distribution of the borrow-area sand to that of the native sand on the beach. Two commonly used methods of calculating the suitability of sand for the renourishment of a particular beach are “Shore Protection Manual”, or “SPM”, method (USACE 1984) developed by Krumbein and James (1965, James 1974, 1975), and the Dean method (Dean 1974, 2000, 2002). The SPM method tends to give more conservative, that is larger, values of the overfill factor, because it assumes that both the fraction of borrow sand that is coarser than the native beach sand and the fraction of borrow sand that is finer than the native beach sand will be removed from the beach fill and ultimately will not contribute to the nourishment. On the other hand, the Dean method assumes that only the finer fraction will be lost. As a result, the Dean method tends to give less conservative (smaller) overfill factors.

As a screening tool, however, the Dean (2000) method is recommended because it depends on only three parameters. These are the mean phi-size of the beach (native) sand M_n, the mean phi-size of the borrow sand M_b and the standard deviation of the borrow area sand, σ_b. Through an alternative graphical alternative to the Dean formulation (Bodge 2006):, method, these can be combined into a single parameter

$$K=(M_b-M_n)/\sigma_b \qquad [2]$$

The ideal material would have a Dean overfill factor, K , less than or equal to 1.05, corresponding to a standard deviation at least nine times greater than the difference between the mean grain sizes, that is $(M_b-M_n)/\sigma_b = 0.11$. An overfill factor of 1.3 is considered acceptable (Bodge 2006); this corresponds to $(M_b-M_n)/\sigma_b < 0.4$ (Bodge 2006). From these rules-of thumb we can define a "suitability index" for screening purposes only. The most suitable material would have $(M_b-0.11\sigma_b) < M_n$. Adequate material would have $(M_b-0.4\sigma_b) < M_n$ and unsuitable material would have $(M_b-0.4\sigma_b) > M_n$ (Table 3).

Table 3. Screening criteria for the suitability of renourishment sands*.

Borrow sand	Suitability Index
Suitable	$(M_b-0.11\sigma_b)< M_n$
Adequate	$(M_b-0.4\sigma_b)< M_n$
Unsuitable	$(M_b-0.4\sigma_b)> M_n$

**the subscript "b" refers to the sand at the borrow site, "n" refers to the native material or in other words, the sand at the beach site to be renourished.*

NATIVE (BEACH) SAND CHARACTERISTICS

In 1982, sand was collected along 34 cross-shore transects between Fire Island Inlet and Montauk Point. Samples were taken from (1) the base of the dune, (2) the berm crest, (3) mean high water (Appendix 3), (4) mean low water, and at water depths of (5) two meters, (6) four meters, (7) six meters, (8) eight meters and (9) ten meters (Tsien, 1986).

In 2009, several beaches on Fire Island were renourished. The constructed beaches had the following grain sizes (Coastal Planning and Engineering, Inc. 2009a):

Project Area	Mean Grain Size, □
Western Fire Island SFD-5	0.86
Western Fire Island Sta. 29+00	0.94
Western Fire Island Sta. 60+00	1.47
Central Fire Island Sta. 26+00	0.92
Fire Island Pines Sta. 12+00	1.00
Davis Park Sta. 18+00	0.69

For the restoration project after "Superstorm" Sandy, the U.S. Army Corps of Engineers (USACE) designed beach renourishment based on grain-size models calculated from suites of samples for designated sections of the shoreline. In Long Beach Island, the modeled grain sizes (USACE 2014; Coastal Planning and Engineering Inc. 2009b) were:

Location	Median ☐Size	Location
City of Long Beach,	2.18	unspecified
Atlantic Beach	2.18	40.5857;-73.7291
Lido Beach	2.25	40.5857; -73.6231
Neptune Blvd	1.89	40.5831;-73.6467
Long Beach Blvd.	1.94	40.5832;-73.6582
Lindell Rd.	1.94	40.5837; -73.6812

For Fire Island, the median grain size modeled for west Fire Island was 1.36 Φ, and it was 0.94 Φ for east Fire Island (USACE, 2014b). Along the length of Fire Island, five grain size models were developed (USACE, 2014c). These were:

Native Beach Sample Models	Representative Profiles[2]	Location (NAD 83)	Mean Grain Diameter, ☐	Standard Deviation, ☐
GSB-D1	F1-F12	40.62060; -73.30649 to 40.63280; -73.20590	1.34	0.58
GSB-D2	F14-F35	40.63470; -73.19710 to 40.65790; -73.09360	1.33	0.64
GSB-D3	F36-F58	40.65910; -73.08610 to 40.68810; -72.99230	1.26	0.58
GSB-D4	F64-F68	40.71250; -72.92640 to 40.72320; -72.89430	1.25	0.68
MB-D1	F72-F79	40.73700; -72.85060 to 40.75490; -72.79230	1.25	0.68

POTENTIAL BORROW SITE (OFFSHORE) SANDS

Mean grain size and the standard deviation of potential borrow-site sands are needed to calculate suitability. Two data sets were examined. These were vibracore samples compiled by the USACE's Long Island Needs Assessment (LISNA) Program and sea bed samples compiled in usSEABED (Reid et al. 2005; http://pubs.usgs.gov/ds/2005/118/accessed 2015).

Before the program was terminated prematurely in 2011, the USACE's Long Island Needs Assessment (LISNA) Program provided data on 353 vibracores taken for individual project assessments along the Long Island ocean shoreline. These were entirely in State waters and tended to be concentrated near historical borrow sites. The database tabulated the mean Φ-size and the standard deviation (Appendix 4), as well as Φ16, Φ50, and Φ84.

usSEABED provides a digital, integrated database of existing physical data on sediment texture, composition for the entire U.S. Atlantic shelf. For this study the distribution of 200,000 sample

[2] From: http://dune.seagrant.sunysb.edu/nyshore/viewer.htm

locations was subsampled to identify those within the study area off the New York ocean shoreline to a depth of 40 m. The data are tabulated with the following categories:

- Latitude
- Longitude
- Water depth, meters
- Sampler type
- Gravel grain size fraction, %
- Sand grain size fraction, %
- Mud grain size fraction, %
- Clay grain size fraction, %
- Phi grain size
- Sorting, Phi (Standard Deviation)
- Facies
- Folk classification
- Shepard classification
- Organic carbon, %
- Porosity, %

In the study area shallower than 30 m, 891 samples were tabulated in usSEABED. The criteria used here is only a preliminary screening tool, but it suggests that about 70% of these samples may not represented a suitable replacement for any of the beaches between Fire Island inlet and Montauk Point (Tsien 1986). About 22% were suitable for beach nourishment for at least one beach location and an additional 9% were adequate for at least one beach location. Only 4% were adequate for all locations, but about 9% were suitable for almost all beach station and an additional 7% were adequate for almost all stations.

RISK ASSESSMENT

An earlier study (Batten, 2003) looked for high-risk beaches along the Long Island ocean shoreline by examining 44 parameters of individual beach profiles. High risk beaches were those vulnerable to storm events or persistent erosion. From Shinnecock Inlet to Montauk Point, areas of high vulnerability were located 3.9 km and 4.2 km from Montauk Point, in Hither Hills State Park; between Georgica Pond and Sagaponack, and west of Shinnecock Inlet. Along the barrier island, high vulnerability areas corresponded with areas identified as possible breach locations. Areas classified as vulnerable will be discussed first, and then compared to breach vulnerability areas as identified in the USACE (1996) breach contingency plan. In general, the eastern portion of Smith Point Park; Old Inlet; in the vicinity of Davis Park (houses were lost and moved in this area during a nor'easter in 1996); between the Fire Island Pines and Talisman; the eastern boundary of the Seaview (houses had been lost and overwash occurred here during the nor'easter of December, 1992); west of Democrat Point at the eastern end of Jones Beach in the Fire Island Inlet channel;

and the western section of Coney Island. Several locations of previous breaching or chronic erosion, for example, West of Shinnecock, Smith Point County Park, Old Inlet, and Long Beach, appeared in this analysis. Jones Beach did not, probably because it has been routinely nourished (Strong 1997). Notably, however are the multiple areas on the south fork especially the large areas in the Hamptons, like that between Georgica Pond and Sagaponack, and also those areas just west of the Fire Island Lighthouse because these areas are not usually subject to beach renourishment. It may therefore be prudent to identify sand resources in these locations anticipating some future need.

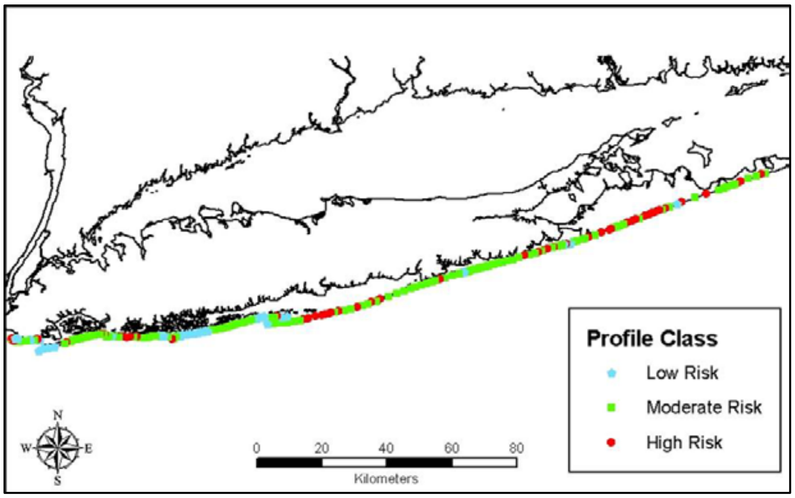

Figure 3. Vulnerability analysis based on 2002 beach profiles (Batten 2003)

RECOMMENDATIONS

This exercise has shown that recreating an inventory of past activity is both difficult and time-consuming. Data in project reports and permits are not routinely compiled or summarized in one place after the fact. Going forward, it would be helpful to develop an active database of projects in a standard format as they are completed. This might include the dates of placement, the volume of material placed, the beach location of the placement, and the borrow area location and dimensions.

It would be prudent for the state and local government to undertake other adaptive actions to reduce risk at known vulnerable locations. From a strategic perspective the best results are obtained by reducing weaknesses and improving strengths. Locations that are naturally vulnerable to erosion and breaching are good candidates for uses other than buildings and infrastructure. Active engineering and sand management should be temporary alternatives pending the implementation of other adaptive measures and weather events.

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Preliminary Assessment of New York's Sand Needs: Appendices

Appendix 1. Beach Renourishment compiled by ICES-WGEXT since 2001

Date	Location	C.Y
2014	Westhampton Dunes	750,000
2014	Rockaway Beach	3,000,000
2012	Cupsogue	167,077
2012	Smith Point	55,000
2012	West of Shinnecock	335,000
2012	Tiana Beach	62,000
2013	Tiana Beach	62,000
2012	Plumb Beach	127,188
2010	Orchard Beach	238,000
2011	Orchard Beach	30,000
2011	Lake Montauk Harbor	12,000
2010	Orchard Beach, Bronx, NY	240,061
2010	Smith Point, NY (Moriches Inlet)	21,000
2010	Gilgo Beach & Robert Moses Field 5	254,017
2009	Shinnecock Inlet (West)	487,205
2009	Fire Island	1,899,729
2009	Smith Point	460,000
2008	Point Lookout	624,826

2008	Westhampton	626,996
2008	Fire Island	729,996
2008	Long Beach	699,996
2007	Smith Point	224,968
2007	Fire Island	26,159
2005	Westhampton	759,153
2005	Shinnecock Inlet (West)	764,831
2004	West of Shinnecock and Westhampton	2,520,421
2004	Fire Island	693,214
2003	East Rockaway	114,917
2002	Great Kills	133,000
2002	Jamaica Bay (bay side)	375,000
2002	East Rockaway Inlet	140,000
2001	Gilgo Beach 1	600,000
2001	Gilgo Beach II	1,400,000
2001	Robert Moses State Park	164,000
2001	Smith Point	43,000
2001	Sea Gate (Coney Island)	105,000
	Average c.y./year	1,457,366

Appendix 2. Renourishment in five-year intervals

5-Year Interval	Location	Volume, CY	*Kana (1995), **ICES,	Discrepencies, CY	Sand_Source
1990-'94	Breezy Point	199,000			
1930-'34	Rockaway Beach	5,200,000			
1935-'39	Rockaway Beach	5,600,000			
1955-'59	Rockaway Beach	1,250,000			
1960-'64	Rockaway Beach	175,000			
1965-'69	Rockaway Beach	300,000			
1975-'79	Rockaway Beach	6,829,600			
1980-'84	Rockaway Beach	3,363,300			
1985-'89	Rockaway Beach	2,511,000			
1990-'94	Rockaway Beach	153,000			
1995-'99	Rockaway Beach	340,000			
2000-'04	Rockaway Beach	2,392,658	**	254,917	
2005-'09	Rockaway Beach	220,000			
2010-'14	Rockaway Beach	3,627,000	**	3,000,000	East Rockaway Inlet
1960-'64	Lido Beach	200,000			
1950-'59	Jones Beach	4,000,000			
1970-74	Jones Beach	4,123,000			
1990-'94	Jones Beach	388,000			

1990-'94	Point Lookout/Jones Inlet	913,000			
1995-'99	Point Lookout/Jones Inlet	459,000			
2005-'09	Point Lookout/Jones Inlet	624,826	**		
1950-'59	Gilgo/Oak Beach	1,000,000			
1970-'74	Gilgo/Oak Beach	954,000			
1975-'79	Gilgo/Oak Beach	3,202,767			
1985-'89	Gilgo/Oak Beach	1,000,000			
1990-'93	Gilgo/Oak Beach	3,812,000			
2000-'04	Gilgo/Oak Beach	3,311,094	**	2,000,000	
2005-'09	Gilgo/Oak Beach	550,000			Fire Island Inlet
2010-14	Gilgo/Oak Beach	1,900,000			
1960-'64	Robert Moses	214,829	*		
1970-74	Robert Moses	249,800	*		
2000-'04	Robert Moses	300,777	**	164,000	
2010-'14	Robert Moses	254,017	**		
1955-'59	Fire Island	447,018	*		
1960-'64	Fire Island	1,974,400	*	453,138	
1965-'69	Fire Island	135,300	*	691,543	
1970-'74	Fire Island	174,100	*	137,490	
1975-'79	Fire Island (Saltaire)	9,992	*		
1980-'84	Fire Island	10,000	*	48,962	
1990-'94	Fire Island	608,000			
1995-'99	Fire Island	652,800			
2000-'05	Fire Island	1,180,000	**	693,214	
2005-'09	Fire Island	1,899,277	**	2,655,884	
1955-'59	Smith Point County Park	404,226	*		
1960-'64	Smith Point County Park	379,057	*		
1965-'69	Smith Point County Park	467,021	*	478,978	
1970-'74	Smith Point County Park	165,468	*		
1995-'99	Smith Point County Park	640,000			
2000-'05	Smith Point County Park	43,000	**		
2005-'09	Smith Point County Park	460,000	**	684,968	Moriches Inlet
2010-'14	Smith Point County Park	76,000	**		
1960-64	Moriches Inlet	1,014,024	*		
1965-'69	Moriches Inlet	828,900	*	943,532	
1970-'74	Moriches Inlet	135,000	*	583,326	
1975-'79	Moriches Inlet	218,500	*	113,516	
1980-'84	Moriches Inlet	592,027	*		
1955-'59	Westhampton Beach	486,361	*		
1960-'64	Westhampton Beach	136,500	*	940,183	
1965-'69	Westhampton Beach	624,763	*		

1970-74	Westhampton Beach	1,950,000	*	247,314	
1975-'79	Westhampton Beach	177,215	*		
1990-'94	Westhampton Beach	1,567,000			
1995-'99	Westhampton Beach	3,529,530			
2005-'09	Westhampton Beach	2,367,000	**	1,386,149	
2010-'14	Westhampton Beach	1,000,000	**	750,000	
2000-'04	Shinnecock & Westhampton	2,520,421	**		
1955-'59	Shinnecock Inlet	493,006	*		
1960-'64	Shinnecock Inlet	378,214	*		
1965-'69	Shinnecock Inlet	967,222	*		
1970-'74	Shinnecock Inlet	582,029	*		
1975-'79	Shinnecock Inlet	107,414	*		
1980-'84	Shinnecock Inlet	42,466	*		
1985-'89	Shinnecock Inlet	84,933	*		
2005-'09	Shinnecock Inlet	610,000	**	1,252,036	Shinnecock Inlet
2010-'14	Shinnecock Inlet	450,000	**	335,000	
1960-'64	Southampton	375,000			
1965-'69	Southampton	1,800,000	*	199,840	
1980-'84	Southampton	18,786	*		
1960-'64	Mecox Bay	174,861	*		
1970-'74	Mecox Bay	71,043	*		
1960-'64	Bridgehampton	70,000			
1960-'64	Georgica Pond	449,641	*		

Appendix 3 . Characteristics of beach sand at mean high water (Tsien 1986)

Station	graphic mean, phi	graphic standard deviation, phi	inclusive graphic standard deviation, phi
001-3	0.63	0.47	0.45
004-3	1.07	0.37	0.40
007-3	0.99	0.39	0.40
009-3	1.56	0.36	0.37
012-3	1.39	0.32	0.32
015-3	1.36	0.32	0.32
018-3	1.24	0.52	0.52
020-3	1.46	0.31	0.32
023-3	1.46	0.31	0.32

026-3	1.20	0.36	0.36
029-3	1.41	0.50	0.51
031-3	1.00	0.39	0.38
032-3	0.62	0.43	0.44
032A3	1.19	0.29	0.30
034-3	1.62	0.25	0.26
608-3	0.71	0.38	0.42
038-3	1.13	0.47	0.50
040-3	1.56	0.29	0.30
042-3	0.80	0.56	0.63
044-3	0.30	0.27	0.26
045-3	0.91	0.45	0.44
046-3	1.32	0.29	0.28
047-3	1.83	0.17	0.17
047A3	1.33	0.33	0.33
048-3	0.76	0.24	0.26
050-3	1.05	0.31	0.31
052-3	1.32	0.23	0.24
054-3	1.22	0.28	0.28
056-3	1.22	0.30	0.31
058-3	0.49	0.70	0.80
062-3	0.66	0.92	0.85
066-3	0.78	0.33	0.32
072-3	1.03	0.46	0.52
078-3	1.68	0.20	0.25

Appendix 4. Grain-size data for vibracores compiled by USACE's LISNA Program.

Easting	Northing	Core_ID	Mphi	SDphi
1389367	239781	CB-1	2.35	0.35
1385067	237980	CB-2	1.6	0.6
1380667	236180	CB-3	1.2	0.9
1375867	234480	CB-4	1.075	1.175
1372017	233030	CB-5	1.6	0.65
1367767	231330	CB-6	1.425	1.425
1363317	229730	CB-7	1.05	0.85
1358867	227980	CB-8	1.275	1.025
1354117	226180	CB-9	1.775	1.125
1387967	237281	CB-10	1.45	0.95
1383492	235730	CB-11	0.9	1.25

1378992	233980	CB-12	0.85	0.55
1374642	232480	CB-13	0.85	0.75
1369992	230980	CB-14	1.225	0.925
1366117	229130	CB-15	1.2	1.2
1361742	227355	CB-16	1.15	0.85
1357267	225730	CB-17	1.4	0.7
1352367	223855	CB-18	1.15	0.9
1359742	226605	CB-19	1.4	0.9
1381867	233105	CB-21	1.475	0.725
1377492	231730	CB-22	1.325	0.825
1373117	229980	CB-23	1.375	0.725
1368867	228230	CB-24	1.3	1
1364492	226605	CB-25	1.6	0.65
1360367	224980	CB-26	1.425	0.725
1355367	223355	CB-27	1.625	0.725
1388742	234480	CB-28	1.4	0.8
1380367	230980	CB-30	1.55	0.75
1375867	224230	CB-31	1.675	0.725
1371867	227480	CB-32	1.925	0.525
1367367	225980	CB-33	1.85	0.55
1363117	224180	CB-34	1.825	0.475
1358617	222730	CB-35	1.1	0.85
1353617	220855	CB-36	1.9	0.55
1338117	219480	CB-37	0.825	1.325
1342617	221605	CB-38	1.2	1.7
1347117	223605	CB-39	1.35	1.3
1350117	222980	CB-40	1.05	1.05
1345617	220980	CB-41	1.025	1.275
1340992	218980	CB-42	0.8	1.1
1339242	216480	CB-43	0.675	1.075
1343742	218480	CB-44	1.875	0.825
1348367	220480	CB-45	2.075	0.575
1351367	219855	CB-46	1.875	0.575
1346742	217980	CB-47	1.85	0.9
1342242	215855	CB-48	2.1	0.65
1199521	151059	Icons15	1.64	0.58
1174224	132921	Icons16	1.69	0.52
1245984	170439	Icons18	1.25	0.85
1251698	175436	Icons19	0.89	0.8
1245290	174696	Icons20	1.97	0.84
1260591	184303	Icons21	1.33	0.66

1259513	181528	Icons22	1.45	0.69
1262047	179500	Icons23	1.24	0.94
1231230	170013	Icons24	1.39	0.77
1283783	166022	Icons25	1.64	0.4
1284805	169245	Icons26	2.02	0.57
1286167	172127	Icons27	0	0.83
1288079	197479	Icons28	1.67	0.57
1337048	218055	Icons29	1.04	0.61
1319886	214377	Icons30	1.57	0.93
1329575	212458	Icons31	1.79	0.56
1334147	212178	Icons32	1.55	0.79
1338658	204704	Icons33	1.87	0.58
1357332	217370	Icons34	1.14	0.64
1392600	240800	Icons35	1.24	0.68
1375500	221900	Icons36	2.16	0.77
1377600	233900	Icons37	2.8	0.64
1482300	270300	Icons38	1.88	0.74
1454700	265400	Icons39	0	0
1452800	259100	Icons61	1.97	0.67
1442700	256300	Icons62	1.45	0.62
1431700	255600	Icons63	1.47	0.51
1411300	247700	Icons64	1.7	0.57
1408500	243300	Icons65	2.84	0.62
1432600	256400	Icons66	1.82	0.77
1407700	245600	Icons67	1.3	0.69
1415500	251400	Icons68	2.09	0.8
1416700	235200	Icons69	2.26	0.52
1521900	284200	Icons70	2.35	1.14
1501100	283000	Icons71	1.03	0.57
1495000	269400	Icons72	2.57	0.59
1513600	276500	Icons73	0	0
1523800	279300	Icons74	2.16	0.96
1588200	313900	Icons75	2.13	0.63
1584900	307000	Icons76	2.5	0.78
1573600	307200	Icons77	2.01	0.61
1567600	306000	Icons78	1.63	0.71
1559400	305200	Icons79	0	0
1127681	121591	Icons110	0	0
1135156	100235	Icons111	0	0
1166009	106530	Icons112	0	0
1178449	117024	Icons113	0	0

1569200	301100	Icons114	1.67	0.58
1563100	295300	Icons115	1.56	0.74
1543900	297000	Icons116	1.67	0.8
1542100	293000	Icons117	2.45	0.56
1538000	280200	Icons118	1.74	0.62
1532300	283600	Icons119	1.71	0.67
1530400	288600	Icons120	0	0
1532700	294000	Icons121	0	0
1413270	247608	SHIN 01	1.27	0.73
1414998	243974	SHIN 02	1.53	0.76
1415409	246369	SHIN 03	0.45	1.37
1416049	250112	SHIN 04	-0.74	2.34
1417726	248753	SHIN 05	1.12	0.8
1420749	244642	SHIN 06	1.33	0.88
1419311	252554	SHIN 07	0.93	0.89
1423098	247615	SHIN 08	1.36	0.85
1422860	251868	SHIN 09	1.03	0.86
1425202	251866	SHIN 10	1.13	0.75
1425981	248861	SHIN 11	1.54	0.7
1426508	253735	SHIN 12	-0.37	1.85
1419630	251561	SHIN 13	1.11	0.8
1428214	256476	SHIN 14	-0.59	2.27
1431146	255513	SHIN 15	0.91	0.94
1236410	173439	SHIN 16	0.68	0.94
1240525	175126	SHIN 17	-0.48	1.96
1243085	175337	SHIN 18	0.02	1.22
1229611	173324	FII1	1.66	1.4
1231459	170298	FII2	0.75	0.67
1232251	171855	FII3	1.37	1.83
1233012	173408	FII4	1.72	1.33
1233804	174965	FII5	1.49	1.43
1235665	171973	FII6	1.38	0.61
1236478	173520	FII7	0.81	0.93
1237206	175085	FII8	0.87	1
1237958	176617	FII9	0.87	0.93
1238055	172920	FII10	1.67	0.96
1240603	175128	FII11	0.74	0.92
1241339	176731	FII12	1.83	1.2
1242149	178243	FII13	1.53	0.94
1243987	175236	FII14	0.74	0.89
1244759	176784	FII15	1.31	0.9

1187903	162081	1--1	2.06	0
1193689	163349	1--3	1.51	0
1198420	162914	1--5	1.89	0
1200766	165501	1--6	2.21	0
1203697	166210	1--7	1.99	0
1206850	167392	1--8	3.73	0
1207372	163449	1--9	2.39	0
1204702	160749	1--10	1.62	0.67
1201449	161832	1--11	1.43	0.82
1195907	160005	1--12	1.22	0.56
1189045	158264	1--14	1.68	0.73
1248161	183379	2--1	1.42	0.58
1242817	177493	2--3	1.37	0.88
1246580	180903	2--4	1.63	0.84
1234364	174840	2--6	1.06	1.21
1227651	172780	2--7	1.94	0.53
1229187	171361	2--8	1.28	0.39
1231476	169646	2--9	0.48	1.81
1239317	169696	2--11	1.52	0.52
1247809	171978	2--12	1.69	0.65
1236447	173448	2--14	1.25	0.55
1231445	174108	2--15	1.47	1.74
1275011	191924	3--2	1	1.38
1267126	188188	3--4	0.83	1.24
1272037	186093	3--6	0.53	1.47
1276534	187956	3--7	1.12	0.84
1280344	191734	3--9	-1.01	1.72
1271882	190402	3--10	3.06	0
1313186	206649	4--2	1.5	1
1309453	207563	4--4	1.57	0.65
1305223	205899	4--6	1	0.75
1303166	202829	4--8	1.41	0.87
1301046	204199	4--9	1.6	0.65
1381810	234242	5--1	1.7	0.68
1385467	235430	5--2	0	0
1389485	233781	5--4	0	0
1388697	236611	5--5	0	0
1456081	268739	6--2	1.51	0.62
1456647	264121	6--3	1.21	0.82
1452527	262241	6--4	1.7	0.56
1452070	266699	6--5	1.32	0.76

1444761	263471	6--8	1.28	0.76
1442467	259911	6--9	0.95	0.55
1440368	256446	6--11	1.26	0.78
1436257	254511	6--12	1.09	0.91
1435932	259343	6--13	1.28	0.76
1433821	255742	6--14	0	0
1433056	253056	6--16	1.48	0.83
1427809	253008	6--17	1.4	2.05
1424008	253794	6--18	1.07	0.95
1492768	288482	7--3	1.36	1.25
1492738	284502	7--4	1.57	0.76
1486987	285242	7--7	1.17	0.82
1485257	280472	7--8	1.7	0.56
1483730	283465	7--9	1.34	0.82
1525258	302303	8--1	-0.4	1.83
1520288	302133	8--7	1.06	1.65
1523391	301288	8--8	1.05	1.03
1511999	298430	8--9	0.75	1.05
1517025	298570	8--10	1.53	0.93
1219300	166226	vc98-1	1.75	0.51
1193438	153693	vc98-2	1.8	0.62
1243527	172202	vc98-3	1.66	0.64
1250009	171725	vc98-4	1.61	0.83
1249984	171724	vc98-4R2	1.4	1
1254002	178001	vc98-5	1.4	0.69
1254045	177990	vc98-5R2	1.48	0.48
1255003	181569	vc98-6	1.3	0.64
1255029	181579	vc98-6R2	1.24	1.14
1280664	193360	vc98-7	0.55	0.87
1291974	195687	vc98-8	1.8	0.74
1291969	195718	vc98-8R2	0	0
1298307	200069	vc98-9	1.22	1.04
1298325	200069	vc98-9R2	0	0
1313517	202801	vc98-10	2.02	0.7
1313576	202793	vc98-10R2	0	0
1337385	215658	vc98-11	1.39	0.53
1340243	220936	vc98-12	0.71	0.93
1343031	219920	vc98-13	1.67	0.65
1357682	222312	vc98-14	1.3	0.87
1357679	222331	vc98-14R2	0	0
1359138	221853	vc98-15	1.99	0.58

1359136	221871	vc98-15R2	0	0
1359528	223099	vc98-16	1.67	0.61
1358487	224658	vc98-17	1.43	0.88
1358451	224636	vc98-17R2	0	0
1358493	224633	vc98-17R3	0	0
1363478	228292	vc98-18	0.89	1.05
1364255	228303	vc98-18R2	1.32	0.82
1365912	230596	vc98-19	0.88	0.97
1362294	228580	vc98-20	1.26	0.77
1362291	228550	vc98-20R2	0.68	1.2
1376050	232109	vc98-21	1.21	0.79
1372631	232030	vc98-22	0.77	1.09
1380401	234109	vc98-23	1.16	0.89
1380410	234101	vc98-23R2	0	0
1377114	233999	vc98-24	0.67	1.2
1377144	233973	vc98-24R2	0	0
1400963	242421	vc98-25	1.56	0.79
1400967	242420	vc98-25R2	0	0
1403261	242423	vc98-26	1.88	0.1
1407231	240912	vc98-27	0	0
1407240	240915	vc98-27R2	0	0
1409142	244039	vc98-28	2.05	0.09
1410094	246502	vc98-29	2.6	0.73
1410104	246495	vc98-29R2	0	0
1460217	271934	vc98-30	0.71	1.15
1460183	271900	vc98-30R2	0	0
1468136	275915	vc98-31	1.33	0.79
1475978	279748	vc98-32	0.98	1.14
1497362	290442	vc98-33	0.96	0.93
1505261	294713	vc98-34	0.48	1.51
1539619	312210	vc98-35	0.64	1.11
1328032	217008	vc98-36	1.71	0.54
1330023	218040	vc98-37	1.61	0.89
1173373	164969	vc98-38	2.29	0.44
1173371	164967	vc98-38R2	0	0
1176367	165202	vc98-39	2.36	0.52
1227032	166167	vc97-1	1.6	0.8
1233852	166587	vc97-2	1.38	0.76
1222067	171790	vc97-3	1.28	0.63
1190659	152518	vc97-4	1.39	0.85
1256631	169179	vc97-5	1.33	0.73

1210423	166331	vc97-6	1.6	0.76
1403348	245440	vc97-7	1.19	0.88
1407067	247477	vc97-alt or alt 1	0.42	1.13
1405792	245304	vc97-alt 2	0.22	2.4
1406934	246463	vc97-10	1.5	0.58
1245975	177717	FIVC-01-08	0	0
1247714	177425	FIVC-01-10	0	0
1246778	177030	FIVC-01-13	0	0
1248789	177521	FIVC-01-14	0	0
1249676	177186	FIVC-01-17	0	0
1250549	177644	FIVC-01-18	0	0
1222994	169484	FIVC-01-05	0	0
1224402	169132	FIVC-01-12	0	0
1223533	168604	FIVC-01-15	0	0
1225494	169435	FIVC-01-16	0	0
1405184	252713	SI_1	1.52	0.53
1405885	253498	SI_2	1.48	0.62
1406547	252027	SI_3	1	0.75
1406037	251866	SI_4	0.89	0.75
1403640	250463	SI_5	1.17	0.59
1403016	251182	SI_6	1.21	0.56
1402384	252024	SI_7	1.53	0.59
1406511	250890	SI_8	1.68	0.54
1404894	250826	SI_9	0.35	1.02
1401009	247375	SI_10	1.08	0.45
1401008	247290	SI_11	1.18	0.54
989367	143279	C6	1.72	0.64
984267	139075	C7	1.95	0.45
986541	139578	C8	1.92	0.62
988364	139564	C9	1.65	0.65
987263	138038	C10	1.93	0.43
988897	138084	C11	1.84	0.35
990244	135063	C12	1.66	0.41
987256	136568	C13	1.75	0.45
988764	135802	C14	1.86	0.34
990112	133579	C19	1.06	0.81
1099293	146218	C-1	2.02	0.78
1097553	146663	C-2	2.64	0.59
1095376	147455	C-3	1.245	1.125
1095370	145518	C-4	1.625	1.025
1091368	147507	C-5	2.25	0.43

1091351	145490	C-6	1.79	0.89
1087351	147503	C-7	2.34	1.07
1087366	145492	C-8A	0.795	1.965
1085357	147521	C-9	2.04	1.01
1083357	145518	C-10	0.515	1.685
1081373	147467	C-11	0.94	1.47
1089351	145468	C-12	1.74	0.4
1083375	147444	C-13	1.585	1.125
1093400	147489	C-14	0.95	0.73
1093363	145454	C-15	2.37	0.33
978404	139277	Core 230	2.45	0.55
980426	140364	Core 229	2.735	0.435
979253	136937	Core 228	1.965	0.465
980220	138528	Core 227	2.73	0.45
981275	136329	Core 226	1.895	0.515
982481	133305	Core 224	2.07	0.5
983313	131191	Core 223	1.575	0.675
986182	131268	Core 222	2.59	0.58
984436	134407	Core 221	1.985	0.515
983586	136464	Core 220	1.9	0.55
982617	138425	Core 219	1.86	0.51
986488	136408	Core 218	2.185	0.455
985432	137473	Core 217	2.05	0.53
984567	139471	Core 216	1.995	0.555
987487	138377	Core 215	2.005	0.525
988449	135431	Core 214	1.825	0.525
987517	133338	Core 213	1.725	0.775
988174	130290	Core 212	1.92	0.65
988364	128207	Core 211	1.645	0.605
991650	129258	Core 209	2.075	2.075
990728	132468	Core 208	1.745	1.745
992611	131660	Core 207	2.05	2.05
990385	134275	Core 206	1.835	1.835
990195	137333	Core 205	1.955	1.955
989681	139507	Core 204	1.87	1.87
993296	133415	Core 203	1.91	1.91
992525	136496	Core 202	2.06	2.06
991565	138808	Core 201	2.155	2.155
991373	140535	Core 225	1.695	0.935
997929	143154	Core 102	2.45	0.612
999408	141714	Core 103	1.715	0.995

1001430	143602	Core 104	1.785	0.585
996497	142422	Core 101	2.005	0.795
1028686	142880	Core 1	1.95	0.75
1031400	141195	Core 2	1.5	0.9
1032874	142904	Core 3	1.6	0.85
1034487	144372	Core 4	2.13	0.635
1036817	143675	Core 5	1.65	0.85
1038929	144034	Core 6	1.975	0.625
1040280	145659	Core 7	2.025	0.725
1041986	147515	Core 8	2.105	0.725
1042665	145242	Core 9	2.2	0.92
1044254	146701	Core 10	2.11	0.77
1045642	148661	Core 11	1.795	0.505
1048175	148056	Core 12	2.045	0.725