Sand Pit Literature Review – 5th April 2002

1. **Behaviour of beach fill and borrow area at Prospect Beach, West Haven, Connecticut. (1961).** ***US Army Corps of Engineers (BEB). Tech Memo 127.***
   - Borrow area 450' wide & 2,000' long and dredged to an av. depth of 14.5'
   - located 1000' offshore
   - Infill at a relatively slow rate of 8000 cubic yards/year
   - Infill sediment is silt – part of which may be from the bottom area surrounding the pit and part of which from the fill material on the beach
   - None of the sand fraction from the beach transported far enough seaward
   - The field data available for this study are not sufficient to provide definite clarification of the mechanics of sediment movement in the borrow pit area, but it is thought that the shoaling (infilling) is a result of bottom sorting by waves and currents.
   - Seaward progression of the toe of the beach is 300-400' landward of the pit

2. **Behaviour of beach fill and borrow area at Seaside Park, Bridgeport, Connecticut. (1965).** ***US Army Corps of Engineers (CERC). Tech Memo 11.***
   - Borrow area = 350'x3700'
   - Borrow depth = 22.5' below mean low water
   - Borrow location = 1200' offshore
   - Infill rate = 14,450 cubic yards/year – still relatively slow.
   - Located far enough offshore to preclude its influencing beach and nearshore bottom slopes as shoaling of the pit has been limited to silty material
   - Similar situation to the previous article

3. **Behaviour of beach fill and borrow area at Sherwood Island State Park, Westpoint, Connecticut. (1967).** ***US Army Corps of Engineers (CERC). Tech Memo 20.***
   - Infill rate = 8,000 cubic yards/ year
   - Again similar processes to the previous article

4. **Behaviour of beach fill and borrow area at Harrison County, Mississippi. (1958).** ***US Army Corps of Engineers (BEB). Tech Memo 107.***
   - Borrow location = 1500' offshore
   - Borrow depth = 14'
   - None of the sand fraction of the original borrow material was transported from the beach zone back to the borrow pit.
   - Infill material = silt
   - Had the borrow pit been at a position 300-400' closer to the shore, the finer sand fraction of the beach fill would be depositing in the borrow pit.

5. **Bar topography changes associated with a dredged hole off the Niyodo River Mouth. (1995).** ***Uda, T., Takahashi, A. & Fujii, M. Coastal Engineering in Japan, 38(1). 63-89.***
   - Large (max depth = 14m) dredging hole was formed in front of the river mouth bar by offshore sand mining. Aprox. 600m offshore
   - Created concave offshore contours - accelerated the intrusion of refracted waves to the nearshore
   - Induced shoreline recession of 150m (maximum) and a concave shoreline formed behind the dredged hole
   - The hole being deeper than the critical depth for sand movement prevents beach materials deposited by floods from being returned to the river mouth bar by wave action.

6. **Beach changes caused by offshore dredging.** **(1986).** ***Uda, T., Agemori, C. & Chujo, N. Coastal Engineering in Japan, 29. 215-226.***
   - Study of the dredged hole off the Niyoda River Mouth and the surrounding area.
   - Deeper part of the hole filled slowly with time
   - The dredged hole located in the offshore zone deeper than 8m was refilled from the west side of the hole. This refilling is considered to be due to littoral drift directing east.
   - The shoreline behind the dredged hole retreated with time and space – due to the change of the wave refraction

7. **Physical impact on the reclamation area resulting from offshore dredging at the Changhwa coast, Taiwan.** **(1999).** ***Hsu, T-W. & Chang, H-K. Ocean Engineering, 28 (2). 235-252.***
   - Physical impact of offshore dredging on the reclamation area at the Changhwa coast is investigated using a 3-D movable-bed model test.
   - Wave energy is not attenuated due to a deeper bathometry.
   - On-offshore sediment is predominant in causing the seabed topographical changes.
   - Most of sand were carried offshore and deposited at deep water

8. **Behaviour of man-made beach and dune Grand Isle, Louisiana.** **(1987).** ***Combe, A. & Soileau, C. Coastal Sediments '87. 1232 –1233.***
   - Sand obtained from offshore borrow area = 3000' offshore
   - Cuspate bars began to form in the lee of the borrow areas with erosion occurring adjacent to and between the newly formed cuspate bars
   - Diffraction effect were clearly visible in aerial photos
   - Although significant infilling of the borrow pit has occurred, the cuspate bars remain fairly permanent fixtures of the coast.

9. **A study in coast protection. (1978).** ***Newman , D.E. HR Wallingford Report IT174.***
   - The history of sea defence for the Bournemouth frontage – particularly the beach nourishment scheme
   - Sand offshore was dumped around 400m offshore mark. This was then pumped ashore by a secondary dredger.
   - Holes were dredged in order to contain the dumped sand
   - After being transferred ashore the holes had slow infill rates (0.5m/yr)

10. **Marine Aggregate dredging in the UK: A review. (2001).** ***Singleton, G.H. Journal of SUT. 25(1). 3-13.***
    - Technical review of the marine aggregate dredging industry in the uk

11. **Determining the limits of beach – nearshore sand systems and the impact of offshore coastal sand mining. (1996).** ***Hilton, M.J. JCR 12 (3). 496-519.***
    - A restudy of the impacts of mining at Pakiri-Mangawhai coast, New Zealand after the initial study for the EIA
    - Extractions occur a little seaward of the alongshore bar, 200-300m from high water in depths of 3-8m along a 9.5km length.
    - Any one borrow pit = 2m deep, 10's m wide/long and is rapidly obliterated during subsequent periods of sea wave activity over periods of hours-days.
    - In contrast to the EIA the coast shows no strong accretionary trend and is at best stable and possibly erosional
    - The offshore limit of the beach-nearshore system occurs in max water depths of around 25m. Also in contrast to the EIA sediment exchange across the 25m isobath is unlikely and almost certainly insignificant over time scales of 10-100's of years.

- Mining removes some of the sand that would otherwise be transported landwards.
- Not possible to prove a cause-effect relationship between coastal sand mining and beach nearshore process at Pakiri-Mangawhai, it is reasonable to hypothesise:
- That the weak recovery of the coast following the 1978 storms may be a consequence of sand mining.

12. <u>Sedimentological impact of artificial islands and pits, measured with sediment traps.</u> (1998). *Valeur, J. & Pejrup, M. JCR 14(4). 1334-1342.*

- Sediment traps applied in Oresund Sound in order to investigate the effect of a fixed link between Denmark and Sweden
- 4 test pits were dug in order to evaluate the effects of dredging on the environment.
- Pit 3 = 50m sides, 16m deep; dredged in a 4m thick clay till covering limestone bedrock; surrounding water depth of 3m;
- Infill rate Pit 3 = 2000g/(m^2.d) or 44cm/yr
- Sed type Pit 3 = well-sorted fine quartz sand (200*u*m) with low organic content (1%).
- Pit 5 = 4om sides, 22m deep; dredged in limestone bedrock; surrounding water depth of 10m.
- Infill rate Pit 5 = 100g/(m^2.d) or 2cm/yr
- Sed type Pit 5 = well-sorted fine quartz sand (160*u*m) with higher organic content (12%) but the flux of POM was about the same
- Differences in sedimentation are mainly caused by differences in seabed materials. – North of Pit 3 is a large sand bank which supplies sediment. The seabed around pit 5 consists of lag sediments with very little loose sediments available for transport.

13. <u>Wave attenuation over uneven seabed topography: A study of wave changes in relation to offshore dredging</u>. (1983) *HR Wallingford Report EX 1143.*

- A large hypothetical dredging area in the Shipway channel (9km offshore) was chosen to study the changes in wave refraction using mathematical models.
- Dredging uniformly by 1m over the area of 30 million square metres would not noticeably affect wave conditions at the shoreline.
- A brief examination of 2m seemed to be leading to a similar conclusion.

14.* <u>The effect of wave refraction over dredged holes. (1974).</u> *Motyka, J. & Willis, D. Proc. 14th Coastal Engineering conference. 1. 615-625.

- Preliminary results of a study of beach erosion caused by wave refraction over offshore dredged holes.
- Mathematical model was used of an idealised sand beach typical of English Channel and North Sea Coasts of GB.
- Beach erosion increased with increasing hole depth and decreasing original water depth.
- Beach erosion due to holes in water depths greater than ½ the length of "normal" waves and 1/5 the length of extreme waves was negligible.

15.* <u>The effect of dredging on coastlines.</u> (1978). *Price, W.A., Motyka, J.M. & Jaffrey, L.J. Proc. of 16th Coastal Engineering Conference. 1347-1358.

- Approximate limit for onshore/offshore movement on the south coast is 10m below low water and this is taken as the minimum depth to ensure no beach drawdown occurs.
- The local increase in wave celerity due to an increase in water depth from a dredged hole causes change in the angle of wave approach to the beach.
- Such changes result in a variation in the rate of littoral drift along the shoreline and can cause either accretion or erosion (Botany Bay, Australia.

- A beach model indicates that the effects of wave refraction are insignificant when dredging takes place in water depths > 14m.
- If the beach is being fed from offshore by current and wave action then dredging may trap a proportion of this material and interrupt the supply to the shore.
- Tracer studies have shown that for the south coast wave climate and in regions of weak tidal currents shingle will not move in depths > 18m.

16. **Effects of dredging on the coast. (1987).** ***HR Wallingford Report IT 306.***
- Similar conclusions as previous article.

17. **The effect on coastline changes of wave refraction over dredged areas. (1976).** ***HR Wallingford Report EX 728.***
- Mathematical model is used to assess the effects.
- All dredged areas were rectangular in shape
- Inshore of 14m seabed contour erosion increases rapidly with reduced water depth (distance from the shoreline) and with increasing depth of the dredged hole.
- Erosion increased slowly with increased length of the dredged hole parallel to the coast.
- A change in the side slope of the dredged hole has little effect other than to increase the effective length of the hole
- The tests are believed to be conservative in that they over-estimate the effects of changes in the wave refraction pattern due to dredging

18. **Preliminary evaluation of impacts of sand extraction near Iles-de-la-Madeleine Archipelago, Quebec, Canada. (1990).** ***Anctil, F. & Ouellet Y. JCR. 6 (1). 37-51.***
- Two dredge sites were investigated to assess the impact on littoral drift
- Pit 1 = 16km^2 and located between the 5-10m seabed contour
- Pit 2 = 30km2 and is located between 10-20m seabed contour
- 3 schemes were modelled with varying different depths of the dredged areas
- It was found that 2m extracted from pit 2 would cause a 30% increase in littoral drift and is thought to have a major negative impact.

19. **Behaviour of offshore borrow zones in beach fill operations. (1963).** ***Watts ,G.M. Proc. of 10th Congress of the International Association for Hydraulic Research. 1. 17-24.***
- Dredging can be carried out as close inshore as 300m with no apparent detriment to the shoreline.
- Surveys of the pits showed a general infilling with silt sized material that would normally settle out further offshore
- An increase in fines can be undesirable from an amenity or fishery point of view.

20. Influence de l'extraction des granulats en mer sur l'equilibre du littoral. (1980). ***Migniot, c. & Viguier, J. Houille blanche. 35 (3). 177-194***
- After physical modelling they concluded that excavations in 6 and 11m depths could directly lead to beach drawdown.

21. **Offshore sand extraction and nearshore profile nourishment. (1990).** ***Van Alphen, J.S.L.J, Hallie, F.P., Ribberink, J.S., Roelvink, J.A. & Louisse, C.J. Proc. of 22nd Coastal engineering conference. 1998-2009***
- Mathematical models were run to obtain indications and quantitative estimates of the morphological effects of offshore sand extraction and nearshore profile nourishment.
- The direct effects of the studied sand extraction schemes (between the 10 and 20m isobath) on hydrodynamics (current and wave climate) are very local. On both sides

of the extraction pit the affected area has a width that is two times the extraction width
- Sand extraction landward of the 16m isobath may affect the coastline within a century by landward migration of the pit, leading to a deficit in the nearshore sand budget.
- Simultaneous extraction has no significant effects on the nourishment within a period of 6 years, but may have on a longer scale.

22. **A computer modelling tool for predicting the dispersion of sediment plumes from aggregate extraction activities. (2001).** ***CEFAS AE0910.***
    - Lagrangian computer model of dispersion of fine sediments.

23. **Environmental aspects of aggregate dredging. (1999)** ***Dearnaley, M.P., Stevenson, J.R., & Spearman, J. HRWallingford Report SR548.***
    - A study to improve the understanding of the processes associated with the release of fine material during aggregate dredging.
    - The initial momentum of the discharge and negative buoyancy are the most important factors in the initial dispersion phase.

24. **A criterion for determining the impact on shorelines caused by altering wave transformation. (2001).** ***Maa, J.P.-Y., Hobbs, C.H. & Hardaway, S. JCR. 17(1). 107-113.***
    - A mathematical study of the effects of wave transformations due to dredging at an offshore (5km) deposit (shoal) at Sandbridge Hole.
    - The dredge site is sufficiently deep not to be affected by short period waves
    - If a central part of the shoal is left, the changes of breaking wave height modulation for all wave conditions are negative.
    - If the whole shoal is removed it will not cause a negative impact to the nearby beach.

25. **Numerical modelling evaluation of the cumulative physical effects of offshore sand dredging for beach nourishment. (2001).** ***Kelly, S.W., Ramsey, J.S. & Byrnes, M. Final report for MMS.***
    - A study to examine the potential negative impacts due to long term dredging and significant removal of shoals offshore southern New Jersey.
    - The most effective means of quantifying incremental and cumulative physical environmental effects of sand dredging from shoals on the continental shelf is through the use of wave transformation numerical modelling tools that recognise the random nature of incident waves as they propagate onshore
    - Seaward limit of all borrow sites is 30km and located between the 10 and 20m depth contours.
    - The depth of excavation is between 2 and 4m
    - Evaluation of an idealised borrow pit (350m offshore, 10m depth contour, 3m excavation) was performed.
    - The nearshore location of the borrow site creates a rather limited longshore region of influence.
    - Peak transport rates would increase to nearly 100,000 cu m annually at an alongshore distance of approximately 350 m from the centre of the borrow site
    - Due to wave focusing caused by the borrow site configuration, increased erosion occurs along the shoreline on either side of the borrow site. Material eroded from these two areas feeds the central "shadow zone", as well as shoreline regions further from the borrow site centre.
    - Post dredging wave model outputs for the 4 sites illustrates reduced wave heights landward of borrow sites and increased wave heights at the longshore limits of the borrow sites. This effect is magnified for larger waves and longer period waves.

- Wave refraction bends waves away from the centre of the borrow site towards the edges.
- This creates a shadow zone of reduced wave energy immediately landward of the borrow site and a zone of increased wave energy updrift and downdrift of the borrow site.
- This alters nearshore wave patterns responsible for longshore sediment transport.
- Cumulative effects of multiple borrow pits were examined and results show that borrow sites located in close proximity illustrate additive impacts and for multiple dredging at one site the impacts on the sediment transport along the shoreline become greater with increasing depth.

26. **Environmental Survey of Potential Sand Resource Sites: Offshore New Jersey. (2000).** ***Byrnes, M.R. & Hammer, R.M. Report for MMS.***
    - Three independent sediment transport analyses were completed to evaluate impacts due to sand mining
    - Initially, sediment transport at borrow sites will experience rapid changes after sand dredging is complete
    - Sediment that replaces the dredged material will fluctuate based on location, time of dredging, and storm characteristics following dredging episodes
    - Average transport rates range from a minimum of 28 m^3/day (about 10,000 m^3/yr; to a high of 450 m^3/day (about 164,000 m^3/yr).
    - the infilling time varies between 54 to 303 years
    - For average annual conditions, mean longshore sand transport rates were approximately equal landward of proposed borrow sites.
    - The absolute value of the mean difference between existing and post-dredging conditions was relatively consistent, ranging between 9,000 (20.0%) and 14,900 m^3/yr (7.2%) along the New Jersey shoreline
    - under normal wave conditions, average change in longshore sand transport is about ±13% of existing conditions
    - Ecological

27. **Environmental survey of identified sand resource areas offshore Alabama. (1999).**

28. **Development and design of biological and physical monitoring protocols to evaluate the long-term impacts of offshore dredging operations on the marine environment. (2001).**

29. **Environmental survey of potential sand resource sites offshore delaware and Maryland. (2000).**

30. **Environmental report: Use of offshore sand resources for beach restoration in New Jersey, Maryland, Delaware, and Virginia. (1999).**

31. **Environmental Studies relative to potential sand mining in the vicinity of the city of Virginia Beach, Virginia. (1998).**

32. **Multiplepit Breakwaters. (1996).** ***McDougal, W.G.,Williams, A.N. & Furukawa, K. Journal of Waterways, Port, Coastal and Ocean Engineering (ASCE). 122(1), 27-33.***

33. **Physical impact of waves on adjacent coasts resulting from dredging at Sandbridge Shoal, Virginia.** **(1998).** ***Maa, J.P.-Y Hobbs, C.H. JCR. 14(2). 525-536***

34. **Impact of offshore dredging on beaches along the Genkai Sea, Japan. (1987).** ***Kojima, H., Ijima, T. & Nakamuta, T. Proc. 20th Coastal Engineering Conference 2. 1281-1295***

- Comprehensive coastal engineering studies were carried out over 4 years to evaluate the impact of offshore dredging on shorelines
- There are five offshore dredge areas at the depth of 15-20m.
- In certain regions of the coast the beaches suffered a sharp shoreline recession after the offshore dredging started
- Dredged holes above 30m depth were found to trap sand from the neighbouring bed
- Profile changes illustrated infilling from the onshore side
- The dredge holes are thought to be interrupting the beach littoral system by trapping sand which may travel in the on-offshore or alongshore direction and causing a steeper beach slope in the long run.
- Changes in beach profiles at 35-40m seemed to be insignificant and dredged holes kept their shape.
- The results of florescent tracer experiments indicated that bottom sediment movement above 35m could be significant.

35. **Dredging in a trench across the surf zone at an exposed coast. (1986).** ***Magnor, K. Proc. of 11th World Dredging Congress. 85-96.***

36. **Seabed sand mining in Japan. (1988).** ***Tsurusaki,K., Takashi, I & Arita, M. Marine Mining. 7. 49-67.***

- A review of the aggregate industry in Japan
- At 10m depth a pit 15 x 10 x 3m (length, width, depth) was excavated to monitor the refill caused by waves. After one month no refill had occurred.
- At 30m depth a pit 20m diameter 5m deep was dug to monitor the effect of tidal currents. Again after one month no refill had occurred.

37. **Nearshore wave transformation altered by sand volumes removed from borrow areas for beach nourishment. (1998).** ***Basco, D.R. & Lonza, F.R. Ocean wave measurements and analysis 1. Proc. 3rd international symposium: Waves 97. 93-48.***

- A presentation of early results of a 2 year study using numerical models to investigate the effect of borrow pits on wave transformation.
- Under some combination of variables where sand mining may occur, the volume of material removed over the long term will alter the wave transformations shoreward of the borrow site to create a relatively excessive change in nearshore wave climate.

38. **Estuarine dredge and fill activities: a review of impacts. (1981*). Environmental Management, 5(5). 427-440.***

- A review of mostly ecological impacts within estuaries

39. **Benthic Fauna of an offshore borrow area in Broward County, Florida. (1982).** ***US Army (CERC). Misc. reports 82-1***

- Ecological

40. **Ecological evaluation of a beach nourishment project at Hallandale, Florida. (1982).** ***US Army (CERC). Misc. reports 80-1***

- Ecological

41. **Benthic community response to dredging borrow pits, Panama City Beach, Florida. (1982).** ***US Army (CERC). Misc. reports 82-3***
    - Ecological

42. **Workshop on ecological quality objectives for aggregate extraction areas. (2001)** ***CEFAS.***
    - Ecological

43. **Assessment of the re-habilitation of the sea-bed following marine aggregate dredging. (2001).** ***CEFAS AE0915.***
    - Ecological

44. **Mapping of gravel biotopes and an examination of the factors controlling the distribution, type and diversity of their biological communities. (2001).** ***CEFAS AE0908.***
    - Ecological

45. **Presaging beach renourishment from a nearshore dump mound, Mt Manuganui Beach, New Zealand. (1996).** ***JCR 12(2).***

46. **Beach and borrow site sediment investigation for a beach nourishment at Ocean City, Maryland. (1990).** ***US Army (CERC). Tech memo 90-5.***

47. **Exploration and sampling methods for borrow areas. (1990).** ***US Army (CERC). Tech memo 90-18***

48. **http://www.ucl.ac.uk/civileng/RRS/cimpact_rep.htm**
    - Coastal Impact Report

49. **http://sciweb.science.adelaide.edu.au/marecol.nsf/pages/dredge**
    - Ecological

50. **http://members.aol.com/ruraleye/dc3.htm**
    - North Sea Action Group
    - Correlation of offshore dredging levels with coastal losses