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QUANTIFYING AND MANAGING THE COASTAL RESPONSE TO MAJOR OFFSHORE DEVELOPMENTS IN DUBAI

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INTRODUCTION

The coastline of Dubai has undergone rapid transformation over the last 20 years due to significant infra-structural development on its shores, including the construction of a number of fishing harbors and two major port facilities. These changes have interfered with the natural sediment transport processes and have resulted in beach erosion and loss of amenity value in places. A number of high profile developments involving extensive land reclamation in the offshore area have accelerated the rate of shoreline change in recent years. Steps taken by the Coastal Management Section of Dubai Municipality to address these issues include the set up of an extensive coastal zone monitoring program (http://www.dubaicoast.org/), numerical and physical modeling to assist in coastal process understanding and in developing and assessing coastal management options, and investigations into suitable sand sources for beach nourishment. This is done within the framework of a comprehensive Coastal Zone Management Plan and supporting legislation being drawn up for the region.

Features of the monitoring program include regular topographic and bathymetric surveys, remote video monitoring of Dubai beaches, satellite image analysis, sediment sampling and analysis, continuous nearshore directional wave and current recordings and wave and current measurement exercises at specific locations of interest.

Statutory efforts so far have led to the proclamation of a decree (Decree 22 (2001)) protecting all coastal sand resources in a zone stretching 10 nautical miles offshore and one kilometer inshore. In terms of the legislation any excavation, sand removal or dredging activities require the necessary prior approvals from the Municipality. The Municipality has first right on any excess sand not used on site and typically stockpiles material of suitable quality for nourishing beaches where required.

DUBAI COASTAL MANAGEMENT CONTEXT

Situated on the south-eastern end of the Arabian Gulf, the coastal regime of Dubai is characterised by weak tidal currents, a tidal range of approximately 1.0 m - 1.75 m and the occurrence of north-westerly (*shamal*) winds that blow along the length of the Gulf. These *shamals* are the principal wave generating force and mainly occur during the winter months. During *shamal* conditions wave periods are typically in the range of 7 s – 8 s, with significant wave heights in the range 1 m to 2 m. These events typically last for 1 to 3 days. Figure 1 depicts a prediction of wave heights from the US Navy

Oceanographic Office showing wave heights resulting from a severe *shamal* moving along the Arabian Gulf in February 2003. The accompanying table summarizes typical design wave heights.

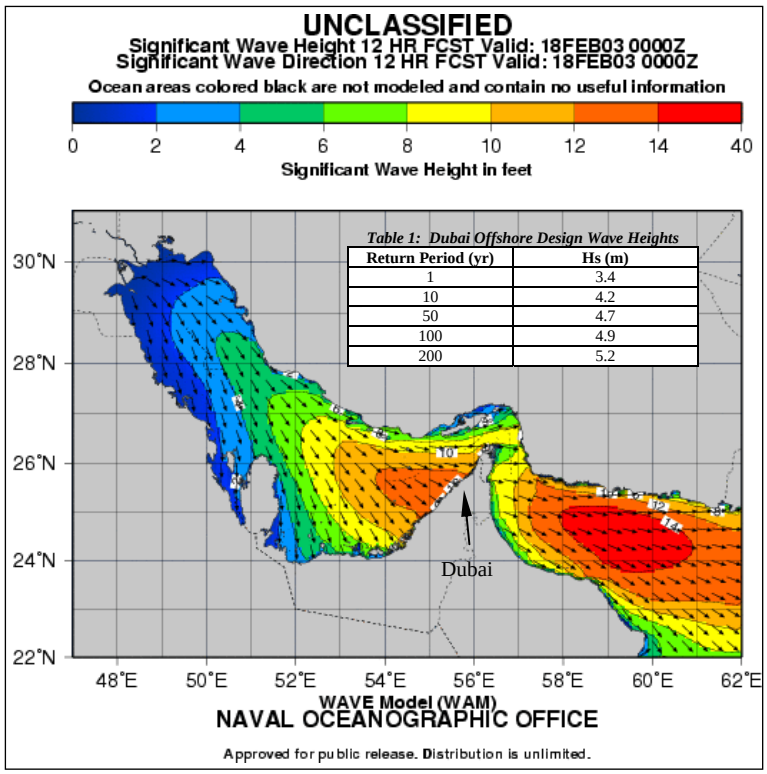

Figure 1: WAM model prediction of significant wave heights in Arabian Gulf.

Sediment transport is predominantly wave-driven and generally directed from southwest to northeast. Potential transport rates vary between 20,000 m^3/yr in the north-east to 40,000 m^3/yr in the south-west, depending on the orientation of the coastline. The presence of numerous structures along the coastline has interrupted the natural littoral drift with resultant deposition of sediments on the updrift and erosion on the downdrift sides of these structures (see Figure 2).

Figure 2: Interruptions of the natural longshore drift of sediment (from south-east to north-west).

The Coastal Management Section of the Dubai Municipality is responsible for managing Dubai's coastline. The section has both an operational and strategic function. The operational role relates mainly to the management and technical review of coastal and marine engineering projects conducted under the authority of the Dubai Municipality. This extends to the monitoring and maintenance of past and ongoing projects. On a strategic level the Coastal Management Section has a primary responsibility to ensure sufficient expertise and knowledge (i.e. data) and analysis (i.e. modeling) resources are available within the Municipality. This includes the formulation and supervision of an ongoing Coastal Zone Monitoring Program (Smit, *et al*, 2003) and any necessary coastal development design studies. A further responsibility relates to the drawing up of coastal development guidelines for incorporation in codes of practice and eventual passage to legislation.

To ensure these responsibilities are met two units were established within the Section, namely the Marine Works Unit and the Coastal Monitoring and Design unit. Main functions of the Marine Works Unit include: managing and supervising current and future port, marine and coastal engineering projects; issuing of no-objection certificates (NOC) for coastal construction and dredging; providing for and supervising regular maintenance for all coastal and marine elements along the Dubai coastline; anticipating and mitigating against potential environmental impacts of coastal development projects; and supervising sand source surveys and investigations.

The Coastal Monitoring and Design Unit is responsible for: developing, implementing and maintaining a comprehensive field monitoring program and database; providing specialist advice to Municipality departments and other organizations in Dubai concerning marine and coastal issues; developing a thorough quantitative understanding of marine processes in the Dubai coastal zone; developing expertise within the Coastal Management Section through training and technology transfer; developing and applying analytical and numerical predictive modeling capabilities; and developing specifications, codes and guidelines for planning and legislation related to existing and future development in the coastal zone.

The staff in the Coastal Management Section has a high level of expertise, consisting of professional coastal and liaison engineers and proficient support staff.

COASTAL RESPONSE TO MAJOR COASTAL DEVELOPMENTS

A number of major coastal developments involving major dredging and reclamation are under way or have been announced for Dubai. The most significant of these are the Palm Islands and World developments shown in Figure 3. As a result of such developments the coastline has responded rapidly over the last couple of years. Depicted in Figure 4 below are surveyed coastlines (represented by the +2m DMD contour) for 1981, 1991, 1996, April 2000, August 2002, January 2003, April 2003, May 2004 and January 2005 of the beach southwest of the recreational harbour of Mina Al Seyahi. The area is located within the southwest shadow of Palm Jumeirah, as indicated on Figure 5, where net sediment transport is from southwest to northeast. The coastline had been slowly accreting with the beach building up next to the harbour breakwater between 1981 and 1991. Following the addition of the spur to the breakwater around 1994 the beach built up rapidly as indicated by the location of the 1996 coastline. The coastline then continued its slow build-up to reach the locations indicated by the April 2000 and September 2001 coastlines. With Palm Island taking shape in 2002 the situation changed and the coastline grew rapidly, as indicated by the August 2002 to January 2005 coastlines. The average shoreline accretion rate over this period in the area is in the range of 30 metres per year.

The reason for this rapid buildup is related to the differential wave sheltering effect of the offshore island. This is depicted in Figure 6 as a numerical wave refraction run indicating the wave shadow cast by Palm Island for waves approaching from the north-west, the principal offshore wave direction. The results are presented as a difference map indicating the difference in wave height with Palm Island excluded and included in the

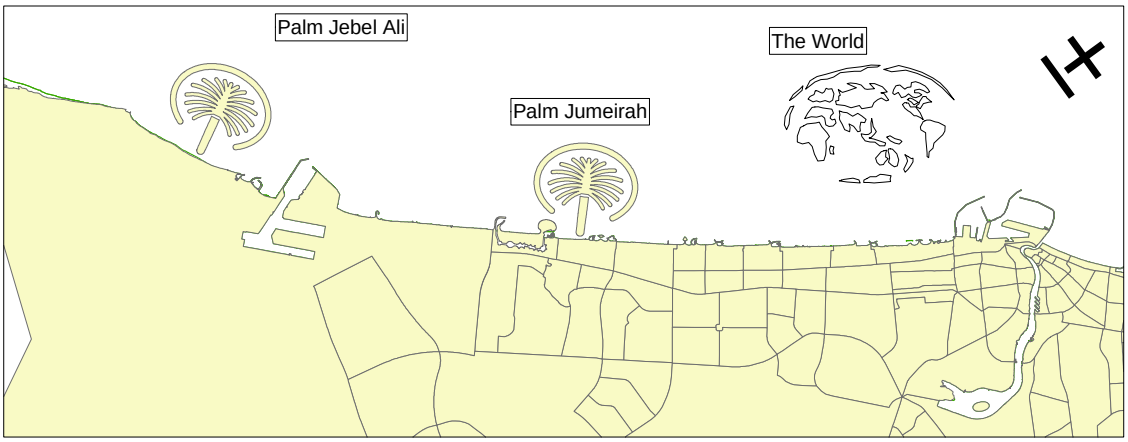

Figure 3: *Overview of major offshore development projects*

refraction model. The northerly waves are essentially removed from the nearshore wave regime at Mina Al Seyahi through the presence of Palm Island. These waves represent a transport component directed in the opposite direction of the net transport direction and provided a dampening of the net alongshore transport rate. With these waves removed from the nearshore environment the north-eastward directed net transport rate increased and the rapid build-up of the coastline occurred.

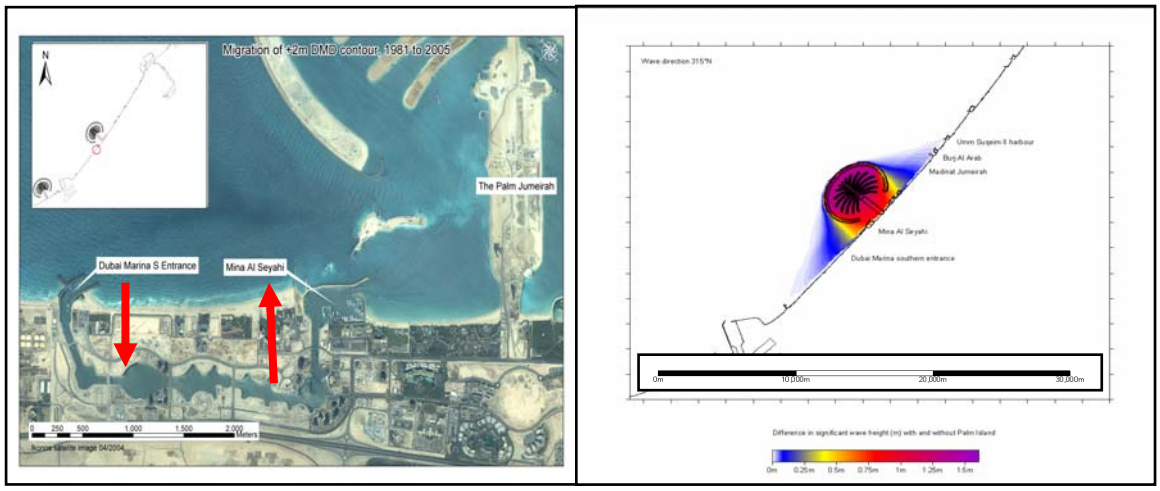

Figure 6: Influence of Palm Island on nearshore wave regime as calculated using refraction model for waves approaching from a direction of 315° N.

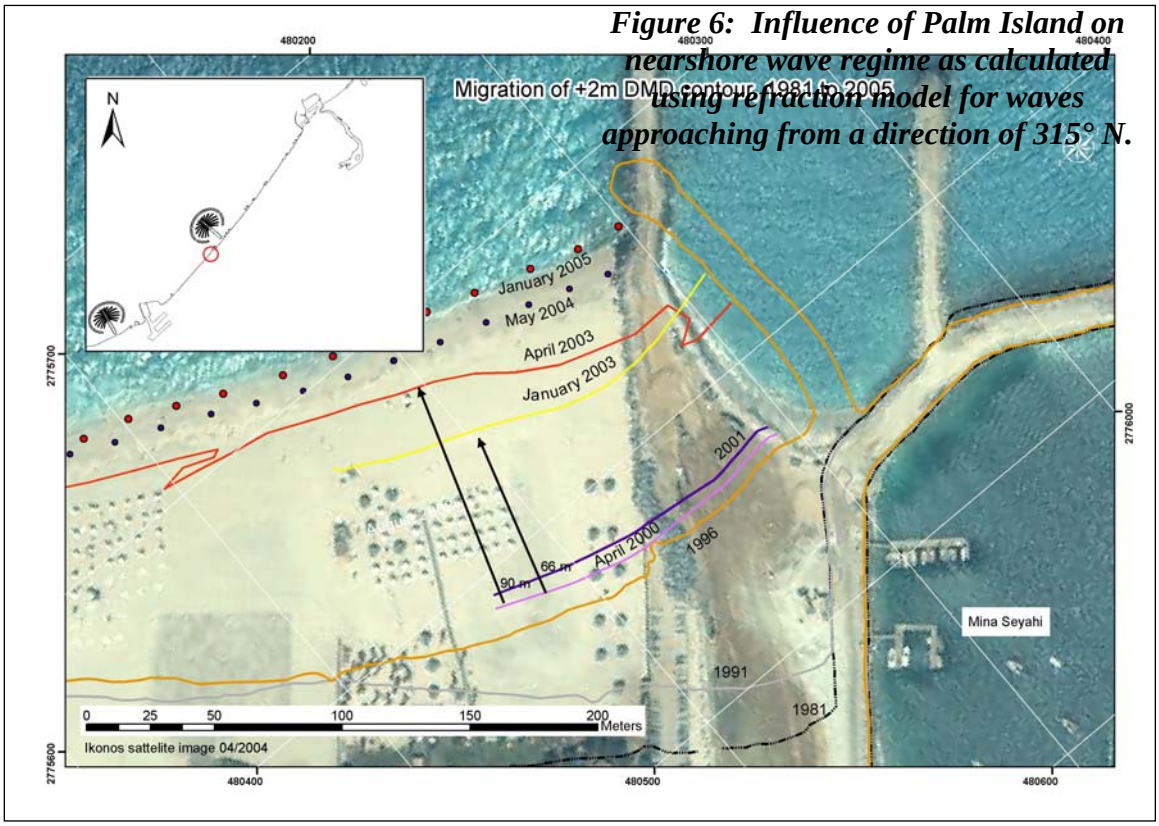

Figure 4: Surveyed coastlines southwest of Mina Al Seyahi for period 1981 to 2003.

The accumulation of sediment updrift of Mina Al Seyahi harbour is balanced by a loss of sand along the shoreline to the south. The Coastal Management Section has drawn on this qualitative information gained from the monitoring program to screen applications for developments on the coast at this and other affected sites, ensuring that a buffer development setback zone is allowed for.

CONCLUSIONS

The Coastal Management Section of Dubai Municipality attempts to quantify the dynamic coastal response to extensive major development projects by both monitoring and coastal modeling, with the latter providing predictions of future evolution of the coast. This understanding is brought to bear when implementing the provisions of coastal management legislation, in particular project municipal permitting requirements.

LITERATURE CITED

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