# BEACH NOURISHMENT AND ITS IMPACT ON HOLIDAY BEACHES

By

Ir. Nor Hisham Mohd. Ghazali

Senior Asst. Director, Coastal Eng. Div.,

Dept. of Irrigation & Drainage Malaysia

## *Introduction*

Recreational beaches depend on wide space and good water quality as well as amenities in order for them to be popular with the public. When such beaches lose popularity, it is often related to the loss of beach space, erosion or degradation of the surrounding environment. In the case of erosion or loss of beach space, beach nourishment is now accepted as the best solution. It provides the sand and profile that is required to reduce wave energy but also provides economic returns as additional area for social and economic activities are created.

This paper discusses the conceptual design of beach nourishment for erosion protection of sandy beaches and the impacts and issues arising from the implementation of beach nourishment projects on holiday beaches. The cases featured in the discussions are drawn from the experiences and records of the Department of Irrigation and Drainage Malaysia, Coastal Engineering Division in undertaking coastal protection work throughout the country.

## *Beach Nourishment in Malaysia*

There are several types of erosion control methods that can be used for sandy beaches. Among these are hard protections such as revetments and groynes which are structures made of armour rocks. Revetments are shore-parallel structures that dissipate the energy of waves while groynes are shore-normal structures which trap sand. Both hard protection methods cause changes to the shoreline; revetments can cause high wave reflection that often cause the beach immediately in front of it to lower. Protecting a beach using hard structures may also cause erosion of its neighbours because the protected beach will no longer contribute sediment to the local shoreline system.

Beach nourishment is a method of coastal protection which places imported sand onto the beach to create a wider beach berm and longer slope in order to dissipate wave energy. It is sometimes called a "soft engineering" approach due to the fact that affected beach is not hardened with structures and it encourages a regeneration of marine life. This method is also not an entirely 'permanent' solution since the renourishment sand is free to move within the coastal system. Beach nourishment strategy also calls for a continual re-nourishment schedule based on the shoreline's erosion trends. Local beach nourishment works are usually designed to last for at least 5 years before the next re-nourishment exercise is conducted.

Beach nourishment projects implemented by the Government of Malaysia are normally targeted at traditionally popular beaches on both the west and east coast of Peninsular Malaysia. These include Taman Robina in Seberang Perai Utara, Pulau Pinang; Batu 4 in Port Dickson in Negeri Sembilan; Pantai Sabak in Kelantan; and Kuala Terengganu to Kuala Ibai in Terengganu. These areas were classified as 'critical' under the National Coastal Erosion Study (1986) and beach nourishment was chosen with the intention of restoring the beach and its recreational value. Since the year 2000, Pantai Layangan-layangan in Labuan, and Teluk Cempedak in Kuantan, Pahang have also benefited from beach nourishment works. The Teluk Cempedak beach nourishment is done in combination with another system called the Pressure Equalisation Module. At the time of writing, an approximately 4 km-long beach nourishment project is underway at Port Dickson from Bagan Pinang to Pantai Saujana which includes the stretch at Batu 4.

Apart from Pantai Sabak, all the earlier projects were reasonably successful in reducing the erosion effect but these shorelines have, as expected, gradually degraded since their construction in the 1990's. In Pulau Pinang, it is speculated that major port developments and encroachment of development activities into the dynamic zone of the shoreline may have contributed to this. The Kuala Terengganu project succeeded in stabilising the shoreline at Pantai Batu Buruk where at one point, the Hotel Primula was merely 20 meters from the high water mark. However, the project could not provide a safe beach for swimming due to steep nearshore slopes. In the case of Pantai Sabak, Kelantan, the volume of nourishment was not sufficient to reduce the erosion problem caused by the interruption of longshore sediment supply by the breakwaters at Pengkalan Datu.

The mix success gained from these beach nourishment projects revealed gaps in the local understanding of beach nourishment. Nevertheless, when properly executed as in the case of Port Dickson and Teluk Cempedak, it draws more visitors and improves the economic activity of the immediate area. The beach nourishment projects that have been conducted over the years may not have been entirely successful in restoring the beaches to their past glory. However, every project has contributed to further the local understanding of beach changes. The benefits of beach nourishment has been acknowledged by the Ministry of Tourism which has allocated RM20 million for beach improvement by renourishment in the Eighth Malaysia Plan.

## *Influence of Beach Characteristics on Recreation*

### Shapes, slopes and space

The definition of a good beach for picnics and recreation may differ between people and places. Climate, natural environment and social factors influence the perception of what is a good recreational beach. For instance, in temperate countries, the dry beach berm is fully utilised in the summer for sun-bathing. Hence, wide open beaches have much appeal. However, in hot climates like Malaysia, the local population generally prefers the shade, hence growing trees such as the casuarinas on the upper shore is highly appreciated and is a common feature of the shoreline in the north of Penang Island, Pahang and Port Dickson.

A beach can be considered good if there is ample space even at high tide. Beach space is a function of slope and tidal range. The profile of a typical beach is as shown in **Figure 1**. It comprises a backshore and the intertidal foreshore. The area beyond the low water mark to the offshore sandbars is known as the nearshore area.

Over the years, the quality of some stretches of the Port Dickson shoreline has reduced due to a lack of sand in the backshore area. As a result, some beaches are entirely submerged during high tide but provide over 100 meters of beach during the low tide. As illustrated in **Figure 2**, a very flat nearshore will mean there will be plenty of beach space during low tide but very little space at high tide. A longer walking distance to the water during low tide may deter locals from wanting to spend a long time in the water, especially during the late morning till mid-afternoon hours.

## Water depths and water quality

With regards to the safety aspect, water depth is a major factor. Areas with large tidal ranges and steep slopes may be dangerous to children since deeper foreshores allow larger waves to penetrate onto the beach. Gentle beach profiles provide a wider area of shallow water which is safer for children.

Poor water quality, especially qualities that are apparent to the naked eye, can deter beach users. Hence, local authorities should conduct daily beach clean-up maintenance works. The discharge of waste water into the nearshore via short outfalls is still an existing problem in Malaysia. The *Guidelines JPS 1/97: Erosion Control as a result of Development in the Coastal Zone* indicate that outfalls should be extended to beyond the Low Water Mark in order to minimise the recirculation of wastewater into the beach area. The best alternative is nonetheless the proper treatment of all wastewater before discharging into marine waters.

## Amenities

Local authorities can contribute to the quality of recreational beaches by providing good access and ample space for parking. Amenities such as public toilets and changing facilities and food courts collectively enhance the usability of a beach. Unfortunately, these facilities are currently also the major polluters of the beach. In most places, sullage (wastewater other than that from the toilet such as cooking oil and grease, kitchen waste, dishwater) is directly discharged into the drains and eventually onto the beach. The Department of Irrigation and Drainage is currently promoting the use of control-at-source devices at waterfront food outlets to trap grease and kitchen waste. Wastewater from public toilets should be properly treated before discharging into the sea.

## *Typical Design of Beach Nourishment*

Beach nourishment provides sediment to an eroding shoreline but allows natural coastal processes to continue. Theoretically, all beaches have an equilibrium profile and a newly renourished beach will adjust over time to achieve this equilibrium. When a beach is artificially nourished, the stability of the placed material is related to the equilibrium profile which in turn is related to grain size and the wave conditions (Dean, 1977). Figure 3 illustrates the shape of a typical nourished beach and the equilibrium profile which it will eventually achieve under the predominant wave and tidal conditions.

The design of beach nourishment is based on grain size, wave climate, tidal elevations and the depth of closure. These are briefly discussed in the following paragraphs.

### Erosion History

Beach profile records from periodical surveys and shoreline maps are the only means by which engineers can determine the rate of erosion of a shoreline. By identifying correctly the rate of retreat of shoreline, one can better design the length of additional berm width and ultimately the volume of nourishment required. However, it is not uncommon that beach nourishment projects are designed without a rigorous analysis of the shoreline history.

### Wave Climate

Different shorelines have different wave climates. The waves on the west coast of Peninsular Malaysia is predominantly wind-driven and fetch lengths or the distance over which wind can travel determines the height of waves that can generated. Being protected by Sumatera, the fetch length on the west coast is limited hence, a typical offshore wave on the west coast is usually around 2 to 3 m in height.

Waves are influenced by the bathymetry and are limited by depth. Hence, deeper nearshore areas experience higher waves. The sand banks and mudflats off the west coast limit nearshore waves to about 1.5 m. Wave climates on the east coast are naturally higher since the fetch lengths over the South China Sea may extend to over 1500 km. Nearshore waves in the east coast may reach 3 m .

## Grain Size

The sand for the nourishment should be typically coarser than the original or native sand for stability. The typical grain size of sediment from local beaches is about 0.3 mm. The coarser the grain size, the more difficult it is to be moved by nearshore currents and waves. Grain size also influences the slope of the nearshore and gentler slopes are associated with finer grain sizes. Sand for beach nourishment is usually from an offshore location.

## Tidal Elevations

Tidal elevations and nearshore slopes determine to what extent a beach will be submerged during the various times of the day. The associated water depths also influence the size of the waves that can penetrate the shore and the distance of the wave run-up as it breaks on the shore. Tidal elevations determine how high the new beach berm should be built.

## Depth of Closure

The depth of closure (Nichols et al, 1998) is an important concept in the design of beach nourishment. It is the seaward limit where no major change in bed level is expected to occur under an extreme wave condition. Any changes to the beach profile shape will occur in areas along the profile shallower than this depth. The depth of closure can be determined by statistical analysis of a series of beach profiles or by using empirical formula.

## Profile Shape

The profile of beach nourishment is a geometric shape with a flat dry beach berm and foreshore slope. Cost constraints commonly influence the steepness of the design slope and the length of the dry berm. In local designs, a slope angle of 15 to 20 degrees and a dry beach berm of 60 meters are commonly used. The length of the design berm is governed by the expected rate of reduction, costs and the expected time for renourishment. The local practise of allowing about 20 meters of the new beach berm to be ‘sacrificed’ in the process of achieving equilibrium has appeared to be sufficient in most cases. On the east coast, beaches commonly erode over the North-east monsoon period and rebuild during the milder South-west monsoon.

Ideally, a new beach should be designed as similar as possible to the original profile as a lateral projection of the original beach profile. This would however require a large volume of sand. As illustrated in Figure 3, the new beach is designed with a simple horizontal berm and foreshore slope. The nourished profile tends to become a concave shape at equilibrium. Efforts are now being made to study the evolution of nourished beach profiles in Malaysian conditions.

### Local Drainage

Although local drainage outfalls are not an intrinsic part of the renourishment design, it would be unwise to have a beach nicely restored but only to allow for surface drainage to create natural channels over it. Thus, current practise is to provide for proper channelling of existing drainage outfalls. Efforts are also being undertaken to implement control-at-source methods to improve discharge water quality especially at nearby food outlets.

## *Project Preparation*

A beach nourishment project attracts much attention to the local population as it is costly and affects many parties. A lack of information can create resistance and apprehension especially amongst beach users and the business community. The experience from local projects tells us that many potential problems can be solved through consultation prior to project commencement. Project implementation meetings nowadays commonly include all stakeholders of the shoreline including, government agencies, hotel operators and the Fishermen’s Association. A high level of integration is required in order to anticipate and resolve potential stumbling blocks in project implementation. The smooth progress of beach nourishment projects is very much dependent on good sea and weather conditions and contractors normally fully exploit favourable climate conditions. The haulage distance between the source of sand and the project site is a major influence over the contract sum and the contractor is normally responsible in determining where his source is and what necessary approvals are required to extract and transport the sand. It is therefore imperative that the government, as the client, pre-empt or avoid administrative delays. As far as possible, an especially for long stretches of nourishment works, implementation should be made in stages so as not to disrupt too much of beach activities. The local diary for beach and marine recreational events such as regattas, sports meets and festivals must be accommodated in the project planning.

It is now becoming a common practice that a public relations campaign be launched before works start so as to advise the public on the purpose of the project and the activity on site and to assure their safety and that of the project itself. Beach nourishment works cause temporary loss of use and income to local businessmen hence it is important that they be pre-warned. Hotel operators, although aware that beach nourishment will ultimately improve their beaches, are typically initially resistant to any form of works that may disrupt beach use but can accommodate the situation. The management of a major beach resort in Pahang, convinced of the benefits of a beach nourishment project fronting their hotel, used the details of the project scheduling provided to them so as to advise their tour agents and regular guests of how long the beach would be unusable and how better their hotel would be after the project was completed.

When beach nourishment projects displace the traditional berthing space of nearshore fishermen and affect their livelihood, potentially difficult situations may arise leading to project delays. Hence, their participation in the relevant project implementation meetings is necessary so as to discuss displacement issues and means of compensation.

## *Impacts*

Beach nourishment projects have several impacts upon the project area. These are mostly during the construction period and include deterioration of water quality and temporary loss of economic use of the beach area due to construction activity. These issues are discussed below.

## During Construction

Beach nourishment projects involve the transporting of sand from a source and depositing it onto the project beach. *Guidelines JPS 1/97: Erosion Control as a Result of Development in the Coastal Zone* state that sand sources must be at a distance of at least 1.5 km (measured from Mean High Water Spring) or where the depths are at least 10 meters (measured from Lowest Astronomical Tide) whichever is the greater. This guideline takes into account the influence of depths on wave penetration and avoids situations where sudden depressions are created which can affect sediment transport and create imbalance in the coastal processes.

Sand is dredged at the sand source using dredgers and transported by dredgers and barges to the project locality. Typically, the dredged material is first placed in a sandpit created on the seabed at an offshore location and then pumped onshore where construction vehicles complete the work by spreading and levelling the sand. In order to pump onshore, a floating pipeline is usually installed. During the beach construction activity, the marine water quality of the immediate works area degrades due to increased suspended sediments in the water column. However, the water quality usually improves after construction work ceases as suspended sediments naturally settle. Care must be taken to isolate the suspended sediments from neighbouring beaches.

During construction activity, the project beach is closed to the public hence depriving them recreational space. It is therefore understandable that hoteliers fear that, due to the construction works, current guests may move and future guests may cancel resulting in a loss of reputation. Construction activity may result in increased noise levels and pollution due to the vessels and machinery on site. To counter this, government projects now include environmental management plans that monitor the environment quality whilst construction is ongoing. Contractors must ensure that noise levels do not exceed ambient levels particularly when working within the vicinity of hotels. Normally, working hours on the beach are restricted to daylight hours.

Nearshore fishermen are often the first to be affected by beach nourishment project activity in the form of the following:

1) The transport path of dredgers and sand barges from the sand source to the project site may intrude traditional fishing grounds and cause damage to nets and fish traps;
2) Increased sea traffic in the project vicinity may pose a navigational hazard to smaller boats;
3) Increased suspended sediment in the water column may damage cage culture;
4) Loss of space for boat parking and forced migration to other beaches as their beach is being rebuilt causes disruption in fishing activity and loss of income.

Some form of compensation is usually provided for the affected parties by the contractor either in cash or in kind.

## After Construction

The initial impact on any recently nourished beach is usually positive in the form of an increase in visitors. Construction vehicles and installations must be totally removed from the site before a beach can be re-opened to the public. However, on beaches where drastic changes have been introduced, the public must be forewarned. Changes in beach width and profile do have an effect on boaters and fishermen as the extended beach distances the water from dry berm where boats are often stored.

The newly extended beaches may even lead to unsustainable backshore development as local governments are often eager to exploit the new space without considering the dynamic nature of the new beach. In general, construction of permanent structures should adhere to the *Guidelines JPS 1/97: Erosion Control as a result of Development in the Coastal Zone* (DID, 1997) which requires permanent structures to be at least 60 meters from the high water mark. This setback distance for sandy shores has been widely found to be safe for local use with certain exceptions allowed for islands. However, permanent structures should not be built on newly constructed beach berms. Although temporary or low-cost structures may be tolerated, care should be taken to ensure that these have allowed for natural beach adjustment. It is perhaps wiser to first initiate planting of shore-stabilising flora. As an example, the residents of Pantai Layang-layangan in Labuan commendably initiated a tree planting exercise immediately after the completion of a beach nourishment project in 2002 (Nishad, M., 2003)

It is inevitable that some marine organisms suffer as a result of the re-nourishment works. Re-colonisation usually takes some time to occur and in the meantime a barren beach may exist.

## *Conclusion*

Beach nourishment projects are touted as the best coastal defence method for holiday beaches because they create wider beach space for recreational and economic use. However, this promise of better economic returns is accompanied by a period of temporary loss during the construction stage to the local business population which may force them towards temporary relocation. It is therefore important that the public be advised on the aims and objectives of a proposed beach nourishment project before they are implemented. Correspondingly, their participation in project implementation will facilitate the smooth running of the project. Impacts during construction can be minimised and out of concern for the public and the environment, all beach nourishment projects nowadays include environmental management plans. Newly nourished beaches often lead to hurried development in the backshore as local authorities try to optimise the additional space without considering its stability.

The design of beach nourishment projects takes into consideration the local rate of erosion, the natural beach slope, native and imported sediment grain sizes, wave climate and tidal levels. The definition of a quality beach also depends on local tastes, activities and amenities. As the understanding of the evolution of nourished profiles improve in the country, better designs will be produced in order to sustain the economic usage of holiday beaches. Due to the major contribution of beach tourism to the national economy, beaches must be well-preserved and protected against erosion. Beach nourishment can improve deteriorating holiday beaches and restore their revenue-earning potential. Yet, its effectiveness can only be fully realised if the public and stakeholders understand and contribute towards enhancing the quality and cleanliness of the beach environment.

## Acknowledgment:

The author would like to record his gratitude to the Director of Coastal Eng. Division and the Director-General of the Department of Irrigation and Drainage Malaysia for their support towards the preparation of this paper. Opinions presented within this paper remain that of the author and should not in anyway be construed as the official stand of the Department of Irrigation and Drainage Malaysia.

## References:

Dean, R., 1977: *Equilibrium Beach Profiles: U.S. Atlantic and Gulf Coasts. Ocean Engineering Report No.12; January 1977*

DID, 1997; *Guidelines JPS 1/97: Erosion Control as a result of Development in the Coastal Zone; published by the Department of Irrigation and Drainage Malaysia.*

Nicholls, R.J., Capobianco, M., Larson, M. & Birkemeier, W.A., 1998: *Depth of Closure: Improving understanding and prediction. Proceedings 26th International Conference on Coastal Engineering, Copenhagen, ASCE New York, pp. 2888-2901*

Nishad, M., 2003; *Pers. Comm*.

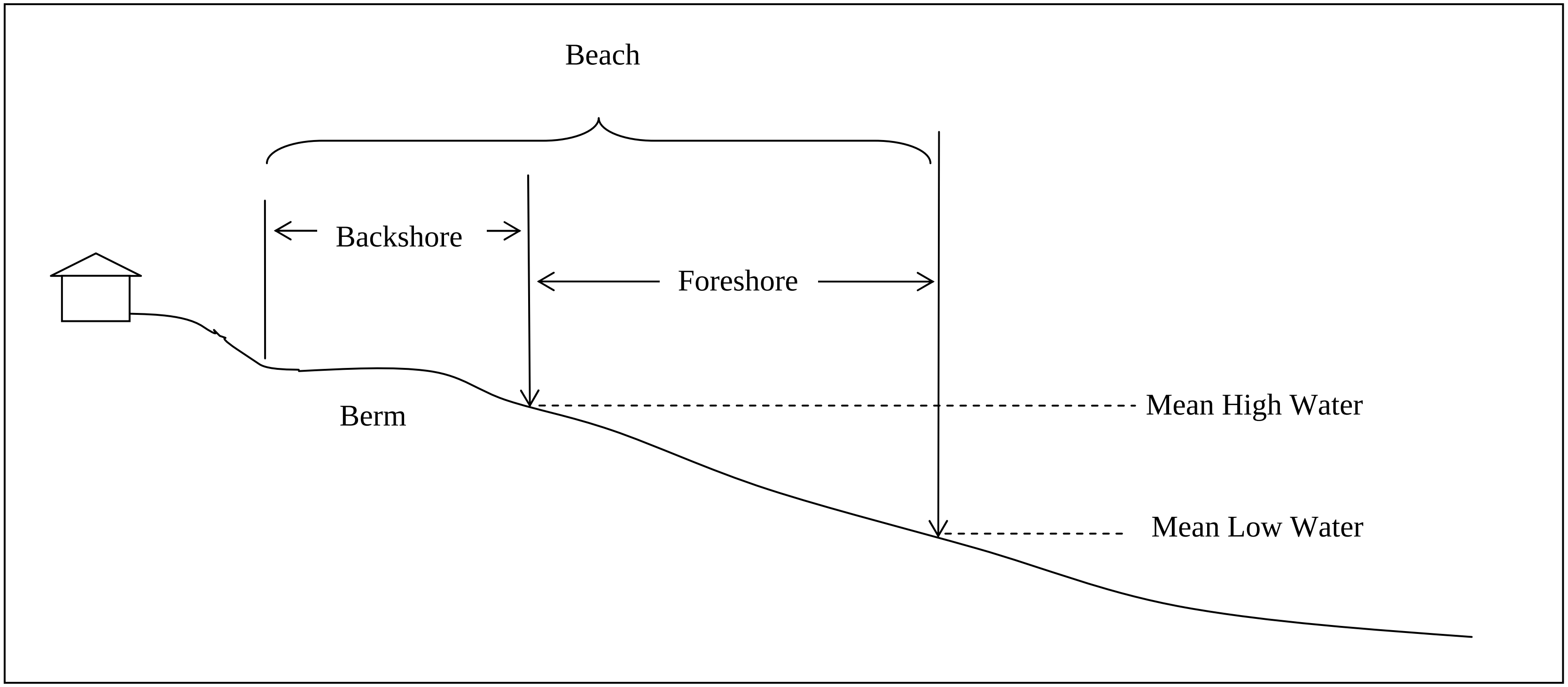


Figure 1: Typical beach profile

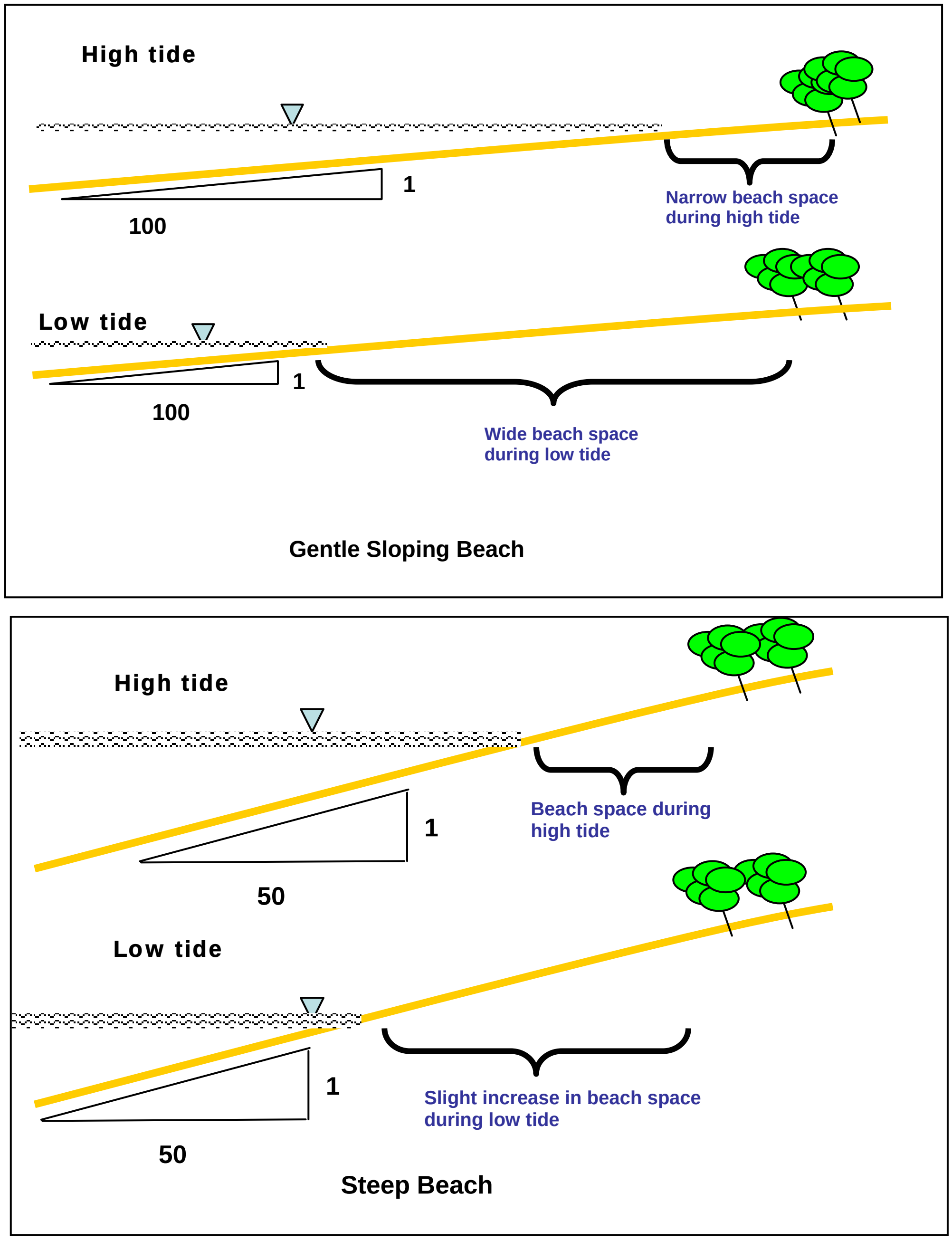


Figure 2: Changes in beach space for tidal range of 1 meter.

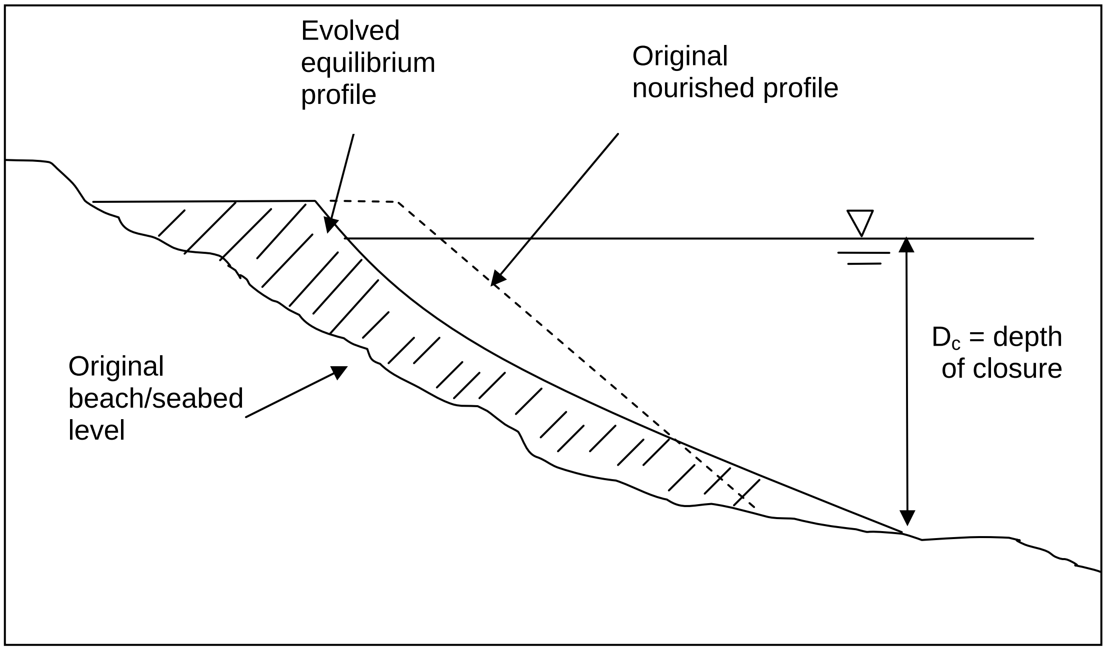


Figure 3: Typical artificially nourished beach profile and expected profile at equilibrium.