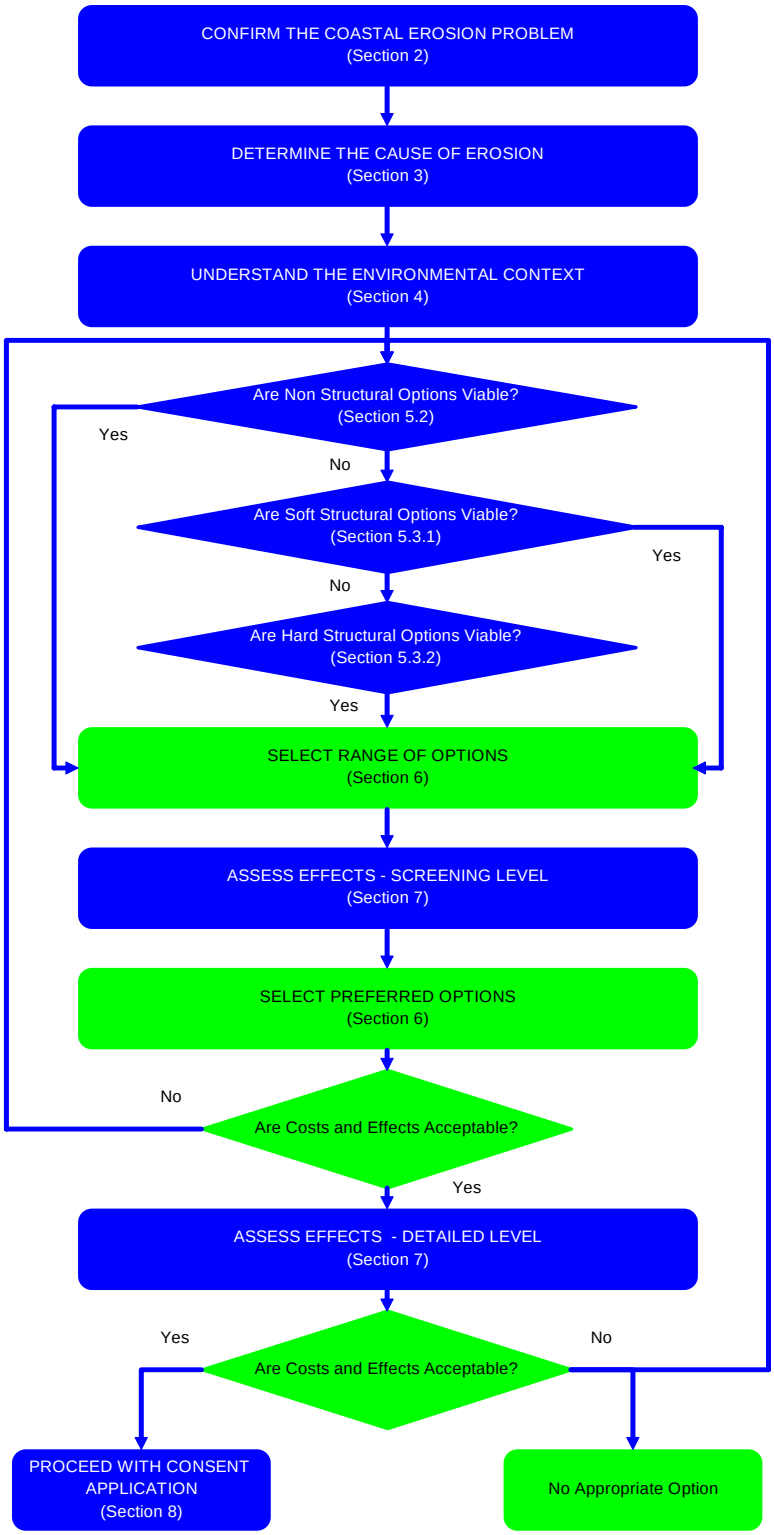
# COASTAL EROSION MANAGEMENT MANUAL




## SECTION 6 - SELECT AN OPTION(S)

### EXPECTED OUTCOME OF THIS SECTION:

To assess a range of coastal erosion management options and select an appropriate one to address your problem.

# 6. SELECT AN OPTION(S)

The selection of an erosion management option for any site requires careful consideration of the specific site characteristics and values, the range of erosion management options available, the potential environmental effects associated with these options, and the design, cost, construction and maintenance issues. Selection is therefore by necessity an iterative process.

This section presents a process for selecting a coastal erosion management option that:

- is capable of managing the identified cause of erosion;
- has acceptable environmental effects associated with it; and
- has reasonable and practicable costs associated with it.

In the latter part of the section an example is provided to further illustrate the process.

## 6.1 MATTERS TO CONSIDER

### 6.1.1 CAUSE OF THE EROSION

*Refer Section E, Design Information.*

The first fundamental consideration in managing coastal erosion is the cause of erosion. The option selected must be able to manage the erosion that is taking place. Figure 6.1, Figure 6.2 and Figure 6.3 identify the cause of coastal erosion which each option presented in this manual is able to manage. While there are usually several options which could be utilised in the management of the erosion, the most effective and appropriate option will often be the option which addresses the cause of erosion. For example, where the construction of a seawall on a beach is exacerbating erosion the further construction of a seawall(s) will protect the coastline, however the removal of the existing wall in conjunction with beach nourishment addresses the cause of the erosion.

### 6.1.2 ALTERNATIVES

Often where there is a coastal erosion problem somebody will have a preconceived idea of the solution. That solution is usually developed independently of a full understanding of the cause of erosion, e.g. it is common for seawalls to be identified as the solution to a coastal erosion problem. Considering alternatives helps to ensure that any option proposed for erosion management is the best practicable option for the site. In many cases a more appropriate solution than the originally conceived idea is identified. In-addition, the consideration of alternatives is often required where a resource consent is required to allow the implementation of the proposed solution.

***Figure 6.1***
*Suitability of Options to Hard Coast Erosion*

| CAUSE OF EROSION / OPTION | Land Use Strategy | Buffer Mechanisms | Remedial Planning Techniques | Good Practices | Beach Nourishment | Revegetation | Dune Reconstruction | Other * | Seawalls | Groynes | Offshore Breakwaters |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Natural Processes** | | | | | | | | | | | |
| Weathering (wetting and drying) | ✓ | ✓ | ✓ | | | | | | ✓ | | |
| Bioerosion (biological weakening of rock). | ✓ | ✓ | ✓ | | | | | | ✓ | | |
| Undermining due to wave action (hydraulic, mechanical) | ✓ | ✓ | ✓ | | | | | | ✓ | | ✓ |
| Increased groundwater levels after storm events. | ✓ | ✓ | ✓ | | | | | ✓ | ✓ | | |
| Overloading by added fill mass or large trees. | ✓ | ✓ | ✓ | | | | | ✓ | | | |
| Block failure due to seaward dipping bedding layers. | ✓ | ✓ | ✓ | | | | | ✓ | ✓ | | |
| Slumping of upper soil layers | ✓ | ✓ | ✓ | | | | | ✓ | | | |
| Loss of vegetation which was serving a retaining/stabilising role. | ✓ | ✓ | ✓ | | | ✓ | | | ✓ | | |
| **Human Activity** | | | | | | | | | | | |
| Attrition by stormwater discharged down cliff face (accelerated by increase in development and runoff) | ✓ | ✓ | ✓ | ✓ | | | | | | | |
| Increased groundwater levels from irrigation, discharge of stormwater | ✓ | ✓ | ✓ | ✓ | | | | | ✓ | | |
| Loading of cliff top by development. | ✓ | ✓ | ✓ | ✓ | | | | | ✓ | | |

** See Section 5.3.1.4*

### 6.1.3 HIERARCHY OF OPTIONS

The hierarchy of options presented in Figure 1.1 should be considered at all times during the selection process. Wherever possible non-structural options are preferable to structural options and likewise soft structural options are preferable to hard structural options. The important aspect is to be able to justify the selection of a particular solution.

### 6.1.4 EXISTING WORKS

Existing works at adjacent sites and their effectiveness should be considered during the selection process. If existing works are considered to be effective and appropriate, then it maybe that extending them is preferable to introducing new works. This is because extending existing effective works can result in lesser adverse environmental effects (e.g. visual impact, land use effects).

***Figure 6.2***
*Suitability of Options to Semi-hard Coast Erosion*

| CAUSE OF EROSION / OPTION | Land Use Strategy | Buffer Mechanisms | Remedial Planning Techniques | Good Practices | Beach Nourishment ** | Revegetation | Dune Reconstruction | Other * | Seawalls | Groynes | Offshore Breakwaters |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Natural Processes** | | | | | | | | | | | |
| Weathering (wetting and drying) | ✓ | ✓ | ✓ | | | | | | ✓ | | |
| Bioerosion (biological weakening of soil) | ✓ | ✓ | ✓ | | | | | | ✓ | | |
| Undermining due to wave action (hydraulic, mechanical) | ✓ | ✓ | ✓ | | ✓ | | | | ✓ | | ✓ |
| Current action | ✓ | ✓ | ✓ | | ✓ | | | | ✓ | | |
| Loss of vegetation (in front of or on banks) | ✓ | ✓ | ✓ | | | ✓ | | | ✓ | | |
| Increased groundwater levels after storm events | ✓ | ✓ | ✓ | | ✓ | | | | ✓ | | |
| Overloading by added fill mass or large trees | ✓ | ✓ | ✓ | | | | | | | | |
| Bank slumping | ✓ | ✓ | ✓ | | ✓ | | | | | | |
| **Human Activity** | | | | | | | | | | | |
| Attrition by stormwater discharged over bank face (accelerated by increase in development and runoff) | ✓ | ✓ | ✓ | ✓ | | | | | | | |
| Loss of vegetation | ✓ | ✓ | ✓ | ✓ | | ✓ | | | ✓ | | |
| Loss of beach in front of bank | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | |
| Wearing through human use | ✓ | ✓ | ✓ | ✓ | | | | | | | |
| Increased groundwater levels from irrigation, discharge of stormwater | ✓ | ✓ | ✓ | ✓ | | | | | | | |
| Loading of upper levels by development | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | |

** See Section 5.3.1.4*

*** Will only apply for these causes if there is or has been a beach in front of the bank.*

Where there are existing, ineffective works at the site being considered, then it may be beneficial to include removal of them in the design of the option as a means of remediation. An alternative is repairing or reconstructing the existing works to a suitable standard.

In some cases, existing works represent an ad hoc approach to coastal erosion management (e.g. several sections of seawall along the coast of different style and not continuous). In these situations 'tying' the works together or replacing them entirely is desirable, so as to provide an integrated approach.

***Figure 6.3***
*Suitability of Options to Soft Coast Erosion*

| CAUSE OF EROSION / OPTION | Land Use Strategy | Buffer Mechanisms | Remedial Planning Techniques | Good Practices | Beach Nourishment | Revegetation | Dune Reconstruction | Other * | Seawalls** | Groynes | Offshore Breakwaters |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Natural Processes** | | | | | | | | | | | |
| Long term sea level change | ✓ | ✓ | ✓ | | ✓ | | ✓ | | ✓ | | |
| Decrease in onshore sediment transport due to decrease in swell conditions | ✓ | ✓ | ✓ | | ✓ | | | | ✓ | | ✓ |
| Reduced sediment loads from river and stream sources | ✓ | ✓ | ✓ | | ✓ | | | | ✓ | | |
| Formation of updrift littoral barriers (e.g. through rockfall) | ✓ | ✓ | ✓ | | ✓ | | | | ✓ | | |
| Increased longshore drift due to change in medium term wave climate | ✓ | ✓ | ✓ | | ✓ | | | | ✓ | ✓ | ✓ |
| Loss of downdrift headland | ✓ | ✓ | ✓ | | ✓ | | | | ✓ | ✓ | ✓ |
| Increased windborne sediment transport to backdune areas due to change in wind climate or loss of vegetation | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | | | | |
| Increase in offshore sediment transport due to increase in sea conditions | ✓ | ✓ | ✓ | | ✓ | ✓ | | | ✓ | | ✓ |
| Saturation of beach | ✓ | ✓ | ✓ | | ✓ | | | ✓ | ✓ | | |
| **Human Activity** | | | | | | | | | | | |
| Focusing of wave energy by diffraction/refraction (e.g. at offshore breakwaters) | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ | | |
| Sand extraction or dredging | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | |
| Reduced sediment loads from stormwater discharge sources | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | |
| Containment of updrift sediment sources (e.g. by seawalls) | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | |
| Formation of updrift littoral barriers (e.g. groynes) | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | |
| Scouring of beach due to stormwater discharge | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | |
| Reshaping dunes | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | | | |
| Structures in dune areas altering wind regime | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | |
| Increased windborne sediment transport to backdune area due to loss of vegetation | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | | |
| Use of exotic plant species | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | |
| Saturation of beach by stormwater discharge | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ | | |

** See Section 5.3.1.4*

*** Seawalls are primarily suitable to protect land, not the beach system.*

### 6.1.5 FATAL FLAWS

Options which are suitable to manage the identified cause of erosion may still be

impractical in some cases. Factors which may make the option impractical include design issues (e.g. an incompatibility between the structure being considered and the site conditions) or the option not achieving the desired outcome (e.g. non-structural options may require removal of development which is the sole reason for managing the erosion in the first place). Factors such as these are known as 'fatal flaws' and usually justify the removal of the option from the selection process. Fatal flaws may become apparent at any stage in the selection and design process.

## 6.2 SELECTION PROCESS

The selection process presented here is based primarily on environmental effects but also considers life cycle costs and existing works.

### 6.2.1 SELECT A RANGE OF OPTIONS

*Refer Section E, Design Information.*

The first step is to identify the range of options which might be used to manage the identified cause of erosion. Figure 6.1,Figure 6.2 and Figure 6.3 provide a useful reference for this purpose. Within each type of option there may be several alternatives, e.g. seawalls may be vertical or sloped, rock rubble or concrete etc. The range of options should be screened so as to identify the preferable option.

### 6.2.2 SCREENING LEVEL AEE

*Refer Section F, Assessment of Effects on the Environment.*

The next step is to undertake an assessment of potential environmental effects. This will initially be at a screening level, with a detailed assessment required for the preferred option. The level of detail in either the screening or detailed level assessment will be dependent on the scale of the project and the significance of the environmental effects. In either case, the assessment of effects should identify both adverse and beneficial effects and possible means of mitigation for all options under consideration.

### 6.2.3 SELECT THE PREFERRED OPTIONS

*Refer Section 7, Assessment of Environmental Effects.*

There any many screening methods which may be used to select the preferred option. A matrix type approach is often the most suitable, as it shows the organisation of ideas and is relatively easy to follow. This approach involves presenting the relative scale of environmental effects associated with each option in a table format. It is suggested that in every case the 'Do Nothing' option be included in the matrix to identify the likely effect of taking no action. The categories considered should be the same as those used to prepare an AEE.

The key factor is to ensure all relevant effects are considered. In some cases a weighting process may also be appropriate to reflect values of particular significance.

### 6.2.4 ARE COSTS AND EFFECTS ACCEPTABLE?

*Refer Section E.6.1, Costing Methodology and Section F, Assessment of Effects on the Environment.*

The costs and effects associated with the preferred option then need to be considered in more detail. While the preferred option is 'better' than the others considered, the effects associated with it may still be unacceptable or it's cost too high. If that is the situation changes might be able to be made (e.g. mitigative measures to reduce effects, change in materials to reduce costs) so that the costs and effects become acceptable. These changes may significantly change the option, in which case it may be beneficial to repeat or reconsider the screening process to ensure that it remains the preferred option.

If the costs and effects of the preferred option (amended or not) are unacceptable, then either the second preferred option should be assessed or the process of selecting a range of options and screening them repeated.

## 6.3 WHERE TO NEXT?

*Refer Section E, Design Information and Section F, Assessment of Effects on the Environment.*

A preliminary design and more detailed assessment of effects will be required once a preferred option makes it through the screening level process. Where more than one preferred option is identified, a preliminary design and more detailed assessment of effects will also be required to justify the choice of preferred option. The level of preliminary design and detailed assessment of effects will be dependent on the project, particularly its scale. Once the preliminary design and detailed assessment of effects are completed, the acceptability of costs and effects need to be reconsidered.

Having completed the selection process, there are two possible outcomes:

1. That a coastal erosion management option is identified that will manage the coastal erosion problem and has acceptable costs and effects associated with it. This option may or may not require a resource consent, building consent etc.
2. That there is no acceptable coastal erosion management option at this stage (i.e. the only appropriate option is do nothing). This may be because costs are too high or that the effects are unacceptable. In such circumstances it may be useful to reconsider the range of options that were identified, with a view to identifying further alternative options and/or approaches.

## 6.4 EXAMPLE

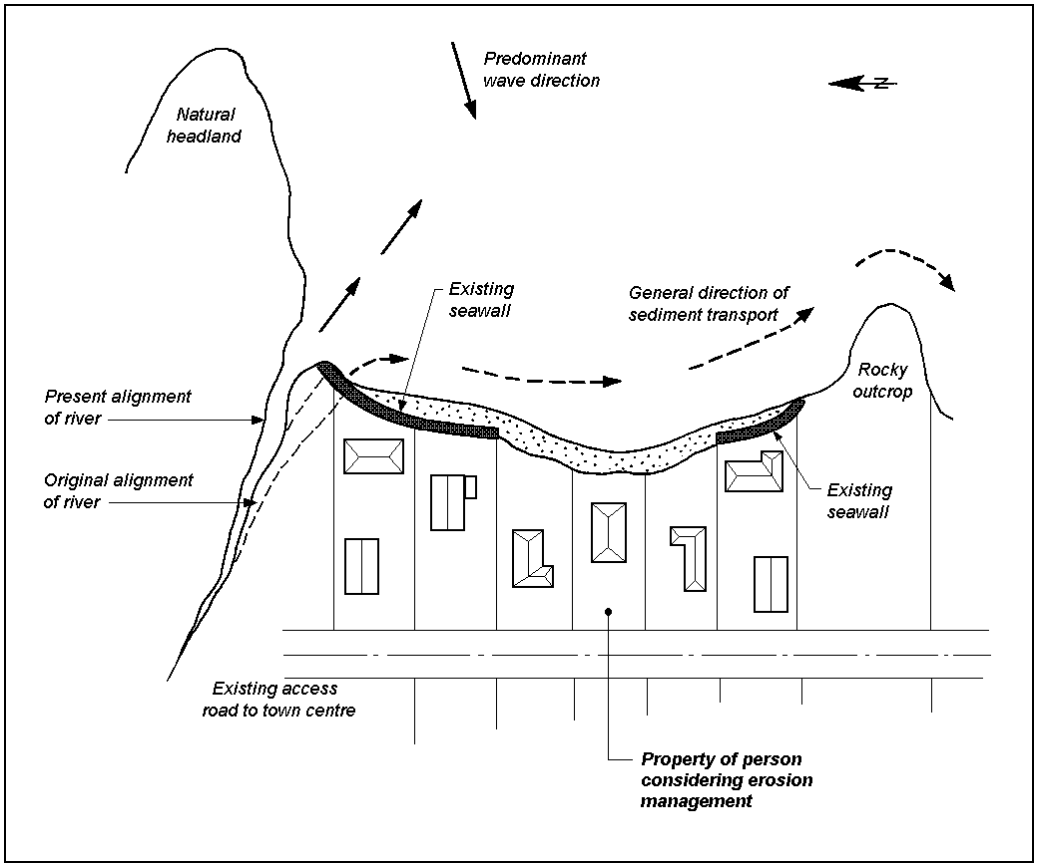
The following example is provided to illustrate the selection process. For a real problem more detail than what is presented would be required to accompany a resource consent application.

### 6.4.1 BASIS OF EXAMPLE

A person who owns a property at the centre of a beach is faced with a coastal erosion management problem. Observations and investigations have shown that the property has lost 10m from its seaward boundary over the past 12 years and that long term erosion is occurring at the site. At this rate of loss it is anticipated that the structural integrity of the house on the property will be compromised within 5 to 10 years.

The site layout is shown in Figure 6.4. Seawalls exist over the northern and southern reach of the beach. These walls were built some 50 to 60 years ago as a sloping basalt block and mortar structure. Inspection of the structure has shown it to be in good condition and effective at protecting the landward properties. So much so that intense development behind the wall has occurred within the last 10 years. Because of the form of the walls local residents believe that it has landscape value.

***Figure 6.4***
*Site Layout for Example*




Passive erosion is occurring at the unprotected properties. Past investigations have shown that the major supply of sediment to the beach was the river at the northern end. However, the orientation and hydraulic efficiency of the river discharge channel has altered with urbanisation of the area and sediment is now deposited off-shore at a depth where it is not easily mobilised and transported onshore.

Furthermore development in the catchment has resulted in a finer sediment characteristic which is easily removed from the moderately energetic beach. The loss of sediment supply and the continued moderate wave energy from the east-nor-east direction has resulted in a loss of sediment from the beach system. The rocky outcrop at the southern end of the beach allows for some bypassing and sustains another beach to the south. The continued erosion of the beach has resulted in the existing walls being outflanked and insufficient sediment within the beach system to provide a recreational beach. Therefore the amenity value of the beach is reducing.

### 6.4.2 RANGE OF OPTIONS

Based on Figure 6.1 the range of options that could be applicable to manage this coastal erosion problem are as shown in Figure 6.5:

***Figure 6.5***
*Range of Options for Example*

| OPTION No. | |
|---|---|
| | NON-STRUCTURAL |
| 1 | Planned Retreat |
| 2 | Re-diversion of stream |
| 3 | Removal of existing seawalls |
| | |
| | SOFT STRUCTURAL |
| 4 | Beach Nourishment |
| | |
| | HARD STRUCTURAL |
| 5 | Seawalls - extend existing sloping rock/mortar wall |
| 6 | Seawalls - rock rubble (new wall) |
| 7 | Groyne |
| 8 | Headland |
| | |
| | COMBINATION OF OPTIONS |
| 9 | Planned Retreat, re-diversion of stream and removal of existing seawalls |
| 10 | Beach Nourishment & southern headland |

Removal of the existing seawalls would expose existing areas of development to coastal erosion.

Because sand bypassing occurs at the southern end of the beach, installation of a groyne or groyne fields or a headland at the southern location will either temporally or permanently reduce the supply of sediment to the beach system to the south. This will have an adverse effect on that beach system.

The combination of options including either, rediversion of the stream, removal of existing seawalls, or the installation of a headland would not be appropriate for the reasons discussed above.

Investigation of the offshore sediments has shown a build up of sandy material but that the more recent sediment is of a fine grain nature and unsuitable as beach material. Therefore, rediversion of the stream to its original location would not maintain a suitable supply of sediment.

Planned retreat would be one way of addressing the issue. However, the areas behind the existing seawalls are intensely developed and will in the long-term be subject to adjacent erosion. A non-structural option such as a planned retreat will have similar effects to the do nothing option.

Beach nourishment could be used to increase the beach berm width, resulting in minimal adverse environmental effects and increased amenity value of the beach. A seawall would protect the existing areas of development effectively and could be designed to be incorporated within the existing structures, maintaining the landscape value of the area, but continued erosion of the remnant beach would further reduce the amenity value of the area. Another option for the seawall could include a rock rubble structure as this has less wave reflection but would tend to contain a larger area of the beach.

For the purpose of this example, the final range of options for evaluation are as given in Figure 6.6:

***Figure 6.6***
*Final Range of Options for Evaluation*

| OPTION No. | |
|---|---|
| 1 | Planned Retreat |
| 4 | Beach Nourishment |
| 5 | Seawall - extending existing sloping wall |
| 6 | Seawall - rock rubble structure |

### 6.4.3 SELECTING THE PREFERRED OPTION

A numerical screening process is used in this example (See Figure 6.7). This process involves assigning a value to each option for categories considered in the assessment of environmental effects (as discussed in Section 7). The totals for these values can be used for ranking a number of options. The values assigned are based on the effects of each option relative to other options for consideration, and use the existing situation as a benchmark. The result of the detailed screening process is that beach nourishment is the preferred option, followed by extending the existing sloping seawall.

### 6.4.4 ACCEPTABILITY OF COSTS AND EFFECTS

From the assessment of environmental effects beach nourishment is the preferred option. To renourish the beach some 12,000 cubic metres of sediment is required which can be obtained immediately offshore in 15m of water. Investigations have shown that this material is not vital to any other coastal processes and could be used for beach nourishment. Costs to establish on site, address existing stormwater outfall locations, and nourish the beach (in order to create a full recreational beach) would be in the order of $300,000. The alternative of providing a seawall, consistent with the existing seawall, would comprise 75m of wall at an estimated cost of $150,000.

***Figure 6.7***
*Numerical Screening Process*

| Option No. | Natural Character | Physical Processes | Heritage | Visual & Landscape | Landuse | Social & Economic | Construction Effects | TOTAL | Commentary |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | -2 | 1 | 1 | -2 | -4 | 0 | -5 | Only slightly beneficial effect on natural character as seawalls to remain. Main beach will continue to erode and downdrift supply will reduce. Amenity value will reduce. Loss of existing development. |
| 4 | 3 | 1 | -2 | 2 | 2 | 1 | -3 | 4 | Smothering of ecosystem will occur, although only temporarily. Amenity value of the beach will increase. Sand to be initially obtained from offshore. |
| 5 | -1 | -3 | 1 | 1 | 2 | 2 | -2 | 0 | Will provide continuous walkway for public use. Will blend into existing structures. May increase rate of erosion. Amenity value will reduce. |
| 6 | -2 | -2 | 0 | -3 | 2 | 2 | -2 | -5 | Won't interfere with landuse. Rubble will look out of place. Potential for habitat. Will tie up sediment in new structure. Amenity value will reduce. |
| Do Nothing | 1 | -2 | 1 | 1 | -5 | -4 | 0 | -8 | Similar to planned retreat, except no transition of land use or allowance for land use strategy. |

*0 = No effect, 5 = Significant beneficial effect, -5 = Significant adverse effect.*
*No differential weighting is given for categories.*

Both options are expensive for one landowner to fund. However, it needs to be recognised that beach replenishment would immediately benefit at least three properties, and be of greater amenity for the community. Moreover with continued beach renourishment sediment will also be available to the downdrift beach and maintain the amenity value in that area.

It is considered that the costs associated with beach replenishment are too high for the individual to pay. The affected person should look to gain community support (and possibly TLA support) for the scheme which would benefit a wider range of individuals. Overall it is considered that the environmental effects of beach nourishment will be beneficial.