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Environment Agency

delivering benefits through evidence

Cost estimation for managed realignment – summary of evidence

Report –SC080039/R8

Flood and Coastal Erosion Risk Management Research and Development Programme

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Miranda Kavanagh

Director of Evidence

Executive summary

This detailed summary of evidence on cost estimation provides indicative costs and guidance for managed realignment measures. The level of cost information is highly variable due to the range and scale of options available within this broad category. It is therefore not possible to provide suitable cost curves for different approaches to managed realignment, although guidance and collated indicative costs are provided for very high level appraisal.

Managed realignment		
Key cost components	Key cost components are likely to be the enabling costs (procurement, planning and design), capital construction costs and, depending on the success of the design and site objectives, post-construction monitoring and maintenance costs.	
Key asset types	• Managed realignment – bank realignment • Managed realignment – breach • Controlled abandonment • Regulated tidal exchange	
Data reviewed in specific guidance	Key reports and data sources include: • Defra and Environment Agency report, *National Evaluation of the Costs of Meeting Coastal Environmental Requirements* • report to the Coastal Futures Project on the economics of managed realignment by Robert Tinch and Laure Ledoux • ABPmer Online Managed Realignment Guide (UK and Europe)	
Other relevant data	Local or proxy records such as data from Environment Agency SAMPs and local authority information	
Relative cost importance	Enabling costs	Managed realignment options can take longer to implement than traditional options owing to the complexity of the planning process, including consultation, land acquisition and environmental assessment.
	Capital costs	Variable costs depending on type of method used, shape and size of site, and complexity of environment.
	Maintenance costs	Variable depending on the method used, success of the design, site objectives and so on. Costs anticipated to decrease over time as site stabilises.
	Other cost considerations	May include environmental costs, habitat creation, monitoring costs and land purchase costs.
Cost estimation methodology	Initial concept/ national appraisal	Approximate completed scheme capital costs available for a range of managed realignment

		methods.
	Strategic, regional, or conceptual design	No specific cost information provided. Guidance on data availability and procedures provided.
	Preliminary feasibility/design	No specific cost information provided. Guidance on data availability and procedures provided.
Design life information	Not normally relevant	
Quality of data	A range of limited data sources have been collated and data are provided suitable for strategic, early or national level appraisals. Three key reports provide indicative costs information for managed realignment schemes. The availability in costs information between different managed realignment schemes is not sufficient to provide cost curves for each method. Guidance and indicative cost information from case studies and examples is therefore provided to provide appraisers with the necessary information to support and assist with cost estimation.	
Additional guidance	Checklist of factors likely to influence capital and maintenance costs, and key factors to consider for detailed costs estimation List of R&D and general design guidance	

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1 Flood mitigation measures – managed realignment

Managed realignment consists of altering the existing coastal or estuarine defences to allow a previously protected area of land to be flooded by the tide. Defences can be removed, set back landward, decreased in height, or strategically breached.

While there are many drivers for managed realignment, the most important one is to provide sustainable and effective flood and coastal defence by the landward migration and creation of intertidal habitats (saltmarsh and mudflats) to decrease flood risk and to reduce the level of defence maintenance. Managed realignment is typically seen as part of a long-term strategy to address sea level rise.

Managed realignment is most likely to be beneficial in areas of low value agricultural land, sites where the topography allows short inland defences or no additional defences, and sites where only minor works are necessary to ensure natural succession to the desired habitat. Both forms of managed retreat (see below) produce a wider intertidal profile that is better able to respond to coastal processes and to reduce the effect of coastal squeeze.

1.1 Types of projects

1.1.1 Managed realignment – bank realignment

Bank realignment involves the deliberate removal of existing seawalls or embankments to allow the waters of adjacent coasts or estuaries to inundate the land behind. This approach involves:

- constructing a new flood defence line inland of the original
- promoting the creation of new areas of habitat on the land between the old and new lines
- removing the front sea wall either partially or wholly

This results in the development of a new area of habitat, which may act as a protective buffer to the new sea wall and the higher ground behind. Although the majority of managed realignment schemes are in estuarial conditions where saltmarsh or mudflats are the primary beneficiary, it is not exclusively carried out in these environments with some defences removed from open coast locations such as Dinas Dinlle near Caernarfon in north Wales.

Implementing managed realignment using the bank realignment technique is well suited to schemes where the primary purpose of the works is the creation of lower lying intertidal habitat for ecological benefit.

In most situations the land between the defences will have been reclaimed and may be at a lower elevation than the habitat in front of the defence. Infilling may therefore be necessary to help generate the required conditions for the new habitat. Such schemes can involve the use of dredged material, pumped onto the site to build up the level of the sediment to an appropriate height for habitat development.

1.1.2 Managed realignment – breach

Breach realignment involves deliberately breaching sections of existing seawalls or embankments to allow the waters of adjacent coasts or estuaries to inundate the land behind through a defined gap (the 'breach').

Implementing the mitigation measure of managed realignment using the technique of breach creation is well suited to schemes where the primary purpose of the works is the rapid creation of a definable new intertidal habitat, particularly saltmarsh habitat, for ecological benefit.

It is a most suitable technique on schemes where a measure of wave protection is needed for the site so that sedimentation can occur more rapidly. Retaining large sections of the original sea wall or embankment provides this shelter and hence encourages settlement of suspended sediments.

1.1.3 Controlled abandonment

Controlled abandonment is more suitable in locations where there is a natural rise to higher ground and no new defence line is necessary. Initial active management is likely to be required to create new areas of habitat behind the present defence line. In this instance, once the new habitat becomes established, maintenance of the coastal defence is discontinued and, with eventual failure of the defence, full tidal inundation of the new intertidal area occurs.

1.1.4 Regulated tidal exchange

Regulated tidal exchange encompasses a range of techniques for intertidal habitat creation other than full breaching of the existing defence line. These include the use of sluice gates, weirs or pipes to control regular tidal inundation. It is distinct from managed realignment because a high degree of control is retained, the tidal range is restricted and the old defence line tends to require continued maintenance.

The main advantages of regulated tidal exchange over managed realignment are that it can enable habitat creation on a wider range of sites and that it can allow more accurate control of the flood regime.

1.2 Key cost requirements

Cost requirements for managed realignment practices for appraisal studies are:

- initial design, management and community liaison costs
- land acquisition
- capital costs for breaching or removal of existing defences
- capital costs for new defence alignment if higher ground is not available
- measures to implement and prepare land for suitable habitat restoration
- operation and maintenance (O&M) costs
- monitoring costs

Each of these aspects is discussed further in the sections below.

1.3 Initial design, management and administration costs

There is still considerable uncertainty regarding the benefits and costs of managed realignment. Results from case studies indicate that costs can be higher than expected, as it can be difficult to predict the success of habitat recreation and whether further works might be necessary to improve or accelerate habitat succession. Managed realignment options can take longer to implement than traditional options owing to the complexity of the planning process.

The assessment of whether managed realignment is an appropriate option will depend on a number of aspects requiring expertise from coastal managers, geomorphologists, environmental advisors and consenting authorities. This may require additional studies to ensure the desired outcomes are achievable and acceptable before such a scheme should be progressed. Therefore specialist ecological, topographical, hydrological and archaeological surveys may be required. It is suggested that the selection and design of sites should consider all aspects including:

- physical nature of the site
- engineering considerations
- environmental and nature conservation considerations
- social and cultural impacts
- economic and human resource considerations

The process of this assessment will therefore require:

- project planning
- partnership development
- baseline modelling, geomorphic and hydrodynamic surveys
- baseline engineering surveys (geotechnical, condition assessments, contaminated land investigations, economic appraisals, access and health and safety)
- environmental assessments/surveys (EIA, Appropriate Assessments)
- consent, permissions and licence applications and procedures
- methodology feasibility and screening studies to identify issues and select preferred options (may include detailed studies such as modelling of the effects of the realignment)
- evaluation of options and scheme design (breach design and secondary defences).
- consultation and communication of options to stakeholders and all interested parties

Depending on the objectives of a scheme, multiple partners may be involved These are split broadly into two groups:

- funding partners
- affected stakeholders

Funding partners are those defined as partners contributing resources either as 'in-kind' or cash to the scheme. These could include statutory bodies such as Natural England, landowners such as farmers, conservation organisations such as Wildlife Trusts, the National Trust and so on where a benefit is derived from the scheme to these partners and/or to the scheme itself. It should be recognised, however, that multiple objective, partner and funded schemes can be time-consuming and costly to develop. Specific partnership development activities may include:

- objective setting – project scope negotiation
- development of funding arrangements and payment of contributions – partner contributions, public funding, alternative mechanisms
- project governance – defining roles and responsibilities
- obtaining agreements and approvals – contractual, alignment of organisations

Effective engagement of local communities and other stakeholders is crucial to successful implementation. This may require the formation of a steering group including representatives of local communities, interest groups and statutory consultees. While the costs for this aspect can be high, designing with stakeholders in mind can win over support and reduce costs in the long run.

Consultees may be as follows:

- statutory consultees – for licences, permissions and consents
- local landowners and communities – to build understanding and allow concerns to be addressed
- political consultees – elected national and local government members (to build understanding)
- grant awarding bodies – as a condition for receiving grant aid
- wider consultees – non-governmental organisations (NGOs), research institutions and universities

Ideally the aim should be to generate positive publicity and to raise public awareness of the project in such a way that the interested population has a deeper understanding of the objectives and process. The ultimate goal of this is to ensure that elected decision-makers are empowered to make the difficult decisions that such a project typically involves without needing to be overly concerned about public backlash.

Lessons learnt from previous cases suggest that information for visitors to a realignment site is important to raise public awareness of the issues involved. Interpretation boards and literature may be required and funding secured for this early in the project lifetime.

Other aspects that may be relevant include:

- any legal and planning considerations such as consent or licence applications
- statutory designations
- the disposal or sale of spoil or materials associated with the works

Given the potentially wide range of additional costs, it is wise to include a high level of contingencies in budgeting for such projects.

The costs associated with this aspect can be high and are often difficult to define for any scheme. Costs will vary by the size of the site, and the drivers and complexity of the works. An example cost estimate for these aspects was carried out as part of a study by Defra and the Environment Agency (2006) based on a typical managed realignment site. Table 1.1 shows estimated pre-construction costs.

Table 1.1 Example enabling costs for managed realignment

Pre-construction costs	Cost
Topographic survey	£5,000
Water level data	£5,000
Niche modelling	£20,000
Other design costs (outline design, detailed design and so on)	£50,000
Environmental Impact Assessment	£50,000
Total	**£130,000**

Source: Defra and the Environment Agency (2006)

As part of this study, data collated by ABPmer's Online Managed Realignment Guide (OMReG; http://www.abpmer.net/omreg/) were provided and reviewed. Although the costs collated for this database are highly variable, the average pre-implementation costs associated with design, surveys, modelling and consultation are 17% of the total cost. Factors or risks that are likely to influence these costs are set out in Table 1.2.

Table 1.2 Key factors influencing enabling costs

Factor influencing pre-construction costs	Impact on cost estimation
Complexity of modelling to assess the impacts	Complex environmental and morphological studies and advice may be required from hydro and coastal experts.
Degree of land negotiations	Local opposition from landowners and common right holders can increase the costs associated with planning and reaching agreement.
Management time required to obtain consents	Obtaining all relevant consents and approvals can take a long time.
Legislative changes	Project planning can extend over a long period and can be influenced and need to respond to legislative changes that can delay projects.
Consultation requirements	Consultation can be a major cost especially when dealing with multiple land owners. Costs associated with the provision of clear graphics/visuals as part of the communication process are known to be beneficial.
Strategic/planning support	Skills and dedicated support may increase costs.
Complexity of land ownership	A bigger scheme may have more landowners and more complex negotiations, so the transactions costs could increase nonlinearly.

The potential variation in administration and procurement costs is illustrated in the two examples below.

Example 1 – Treraven Meadows regulated tidal exchange
The Treraven Meadows regulated tidal exchange project took seven years to plan including the cost of £60,000 for a feasibility study. Total construction costs were £160,000 (excluding land purchase) (OMReG).

Example 2 – Nigg Bay
The Nigg Bay design and impact study was started in December 2001 and completed in August 2002 at a cost of £22,400. Total costs amounted to approximately £47,480, although staff time was on top of this – estimated to be 75% of a full-time employee (Chisholm et al. 2004).

1.4 Land acquisition

Managed realignment often faces particular problems with regard to stakeholder involvement where presentation of the change in flood management practices and substantial changes in land use for key stakeholders may require some form of compensation or land purchase.

In some cases managed realignment may be developed in agreement with landowners; where this is not the case land purchase may be required. Land purchase can therefore represent a high proportion of the total cost.

Land purchase and financial compensation for managed realignment of river or coastal flood defences can be funded from the Defra flood management budgets under current legislation. Defra have produced a guidance note[1] following consultation on this aspect to explain the circumstances in which this is appropriate and identifies alternative funding for such payments.

Land prices will vary by site and depend on the existing land use and any revenue generated from it. Prices may also vary depending on the willingness of a landowner to sell the land, although it is hoped that necessary liaison and public awareness of the project will have been carried out to ensure that landowners understand the objectives and process and are willing to cooperate.

Indicative land valuations for a particular land use and grade of land are available which are suitable to provide approximate costs for inclusion into broad scale cost estimations. Land acquisition costs will also need to incorporate legal and professional fees and any personnel costs associated with any additional liaison not covered elsewhere.

Detailed studies may require the services of an agricultural surveyor to determine an appropriate land value. Land values for unequipped bare land in each UK from the region Valuation Office Agency July 2009 update are given in Table 1.3.

1 http://webarchive.nationalarchives.gov.uk/20130123162956/http:/www.defra.gov.uk/environment/flooding/policy/guidance/realign.htm

Table 1.3 Value of unequipped land with vacant possession as at 1 July 2009

Region	Arable (£/ha)	Dairy (£/ha)	Mixed (£/ha)
North East	10,498	–	7,410
North West	12,350	12,587	11,572
Yorkshire and Humberside	12,555	10,703	10,910
East Midlands	12,506	11,115	11,115
West Midlands	13,674	13,380	13,232
Eastern	12,145	–	12,061
South East	12,738	–	12,488
South West	13,415	12,817	12,817
Wales	–	13,689	12,525
England and Wales	12,750	12,335	12,036
Scotland	9,680	9,221	6,437

Notes: Where there is no entry the land type is not typical within the area.
Values from Valuation Office Agency Property Market Report July 2009

1.5 Capital costs considerations

1.5.1 Realigned defence

Newly aligned defences may be required as part of a scheme or counterwalls required to protect surrounding development or sensitive areas. Newly aligned defences should be designed in accordance with tidal or coastal defence guidelines and will need to consider both present and future requirements. Defences should be designed to allow for consequent erosion and/or deposition in front of the defences together with sea level rise. As with any other defence, both capital and defence maintenance costs should be considered.

An important aspect in terms of costs of new aligned defences will be whether material can be won from the new intertidal area or local borrow pit to minimise transportation/import costs. This will depend on the suitability of materials and a ground investigation is generally required to test this.

Indicative costs for realigned defences can be obtained from the coastal or fluvial linear defence asset types provided elsewhere in this guidance, although detailed estimates will require specialist cost estimates that take into consideration local and site-specific influences.

1.5.2 Breach

Most situations design and undertake a controlled breach rather than leaving the breach to take place through erosion of the existing defence over time. In these cases the costs of removing a section of the existing defence alignment need to be included.

Breaches will typically be positioned at the location of existing channels or previous drainage channels to provide a preferential route for flows onto and off the site. They are typically not open to the predominant wave direction to avoid scour and erosion.

Costs will depend on the number of breaches. Breach width will need to be determined during the design phase. Breaches need to be wide enough to allow the tide to exit on the ebb tide without causing negative consequences from increased flows in part of the tidal cycle. The breach ends of earth embankments will need armouring if widening of the breaches is not desired.

The bed level of the breach should be considered, for cases where the foreshore level is higher than the intertidal area, to determine if the breach should be extended across the foreshore.

Wave breaks can be used at sites vulnerable to wave action to decrease the erosion of sediment recently deposited in the intertidal area, or to decrease the erosion of the old defence. Wave breaks may also be required in the intertidal area to avoid wave penetration. This approach can also remove or reduce the need for scour protection on any new realigned defences landward.

1.5.3 New intertidal area

Raised/lowered land levels may be needed prior to decommissioning of existing defence alignment and subsequent tidal inundation. Land levels can be altered by the redistribution of onsite material or importing material to site. Material can be gained from borrow pits or newly created creek networks.

Construction of new drainage channels may be required along the landward side of any new realigned defence. In addition, land drainage sluices may be required, along with pumping stations where the land is lower, to enable water to be expelled during tidal locking. If creation of replacement habitat is required by the Habitats Regulations then it is an integral part of the scheme, and its costs and benefits must be included in the analysis.

The site may require existing land drains to be decommissioned as well as the creation of new artificial creek system or the reinstatement of relic creeks. Creek networks can be left to develop naturally or can be artificially created matching old creeks identified from aerial photographs. The latter has the advantage of aiding the drainage of water from the site and may be cheaper depending on the length of time since the land was originally reclaimed.

Existing buildings or structures will require demolition and removal if present within the intertidal area. Recreation and habitat creation opportunities may also be required such as improved (or moved) public access to site, bird hides, access and wildlife nesting raised islands.

1.5.4 Vegetation establishment

Costs for habitat creation aspects are covered in a separate section of the guidance and include costs associated with saltmarsh and mudflat restoration/creation aspects that are relevant to high level cost estimation for managed realignment schemes. Natural re-colonisation is preferable to planting or seeding. However, habitat creation will be required in certain circumstances where regeneration is not anticipated to occur quickly enough. In these circumstances design and engineering costs for creating new habitats will need to be considered and may also include planting or seeding.

Dealing with existing vegetation is required and may require removal or pre-treatment such as very short cropping prior to inundation. The intertidal area may also require ploughing or harrowing of compacted sediment prior to inundation.

1.5.5 Tidal exchange design

These systems allow inundation to be controlled and can be used on their own or as a precursor to bank breaching. The system will usually require the lowering of an embankment crest and spillway creation or the installation of culverts/pipes through the defence – designed to control the flow via the pipe sizing or associated flow control structures (penstock, flap valves). A number of different controls may be needed to account for variable tidal ranges.

1.5.6 Other considerations

Diversion of existing services in the intertidal area may be required or scour protection measures provided where the cost of diversion is prohibitive.

Decommissioning costs may be relevant to the existing defence once the realigned defence is established. The expense of removing or maintaining the old defence must be considered as it could prove a hazard if it is left to erode naturally. The re-use of materials from the embankment should be investigated.

1.6 Indicative capital costs

It is clear that the specific details of the geography of the site and coastal/fluvial processes, together with the pattern and state of existing defences, are critical to the determination of costs for managed realignment schemes. While the above factors should be taken into account for those undertaking detailed appraisal studies for strategic, catchment and national appraisals, indicative values of managed realignment are available from a number of sources to inform broad scale cost estimates.

Very generic assessments of the costs associated with managed realignment that may be useful for very high level strategic cost exercises include the costs associated with breaching (£1,500–500,000 per breach), embankment removal (£15–20 per m^3) and the removal of hard engineering (£70,000–120,000 per km taken from a SNIFFER project report (SNIFFER 2005).

A number of studies have reviewed the costs of existing schemes and tried to determine indicative costs from broad estimates based on experience and engineering judgement. These are presented and reviewed here as a collation of current best estimates for the indicative costs that may be appropriate for strategic or early assessments of the costs associated with managed realignment schemes. The key documents examined include:

- *National Evaluation of the Costs of Meeting Coastal Environmental Requirements* (Defra and Environment Agency 2006)
- *Economics of Managed Realignment in the UK* (Tinch and Ledoux 2006)
- *Managed Realignment and Regulated Tidal Exchange in Northern Europe – Lessons Learned and More* (Rupp-Armstrong et al. 2008)

1.6.1 National Evaluation of the Costs of Meeting Coastal Environmental Requirements

This study under the Joint Defra/Environment Agency Flood and Coastal Erosion Risk Management R&D Programme made some basic assumptions with regard to the costs of recreating saltmarsh for an assumed 60 ha managed realignment site in different regions of England. Costs were defined using a number of assumptions, indicative costs and unit rates and provide an example of the sorts of cost inclusions required at a very high level assessment. Costs were built up based on the following assumptions:

- land purchase costs – variable depending on location from £9,675 to £15,173 per hectare
- pre-construction costs
- topographic survey £5,000
- water level data £5,000
- niche modelling £20,000
- other design costs (outline design, detailed design and so on) £50,000
- construction costs
- construction of earth bank, including breach and mobilisation/demobilisation, £3,000 per metre

These assumptions result in different costs per (60 ha) managed realignment site, across England. Costs were converted to a per hectare level for comparison and are summarised in Table 1.4 depending on the shape of the site.

Table 1.4 Assumed costs for managed realignment schemes (per 60 ha site)

Region	Long thin site with no rising ground	Long thin site with rising ground	Square site with rising ground	Square site with no rising ground
East of England	£122,000	£62,000	£90,000	£128,000
South East	£127,000	£67,000	£95,000	£133,000
South West	£127,000	£67,000	£93,000	£132,000

Notes: No rising ground options includes the cost of providing additional set bank flood defences behind the existing defence line.
Source: Defra and Environment Agency (2006)

1.6.2 Economics of Managed Realignment in the UK

This report to the Coastal Futures Project indicated that, even though only a small number of cases were reviewed, the costs per hectare of habitat created vary over two orders of magnitude from just £1,500 per ha at Nigg Bay in Scotland to £90,000 per ha at Brancaster in Norfolk (Table 1.5). The average cost is £33,000 per ha (2004-2005 prices).

The costs were based on feasibility study costs and may not represent actual costs. However, the figures can be instructive if considered as a means of demonstrating the possible range of costs.

Table 1.5 Example managed realignment costs

Scheme	Area (ha)	Length of defence (km)	Capital cost (£)	Maintenance cost (£)	Total cost (£)	£/ha
Orplands	40	2	131,000		131,000	3,300
Freiston	66	1.75	2,221,000	556	2,777,000	42,000
Abbotts	84	3	244,000		244,000	2,900
Paull Holme	75	2.5	4,188,000	162	4350,000	58,000
Brancaster	7.5	0.25	668,000	7	675,000	90,000
Nigg Bay	25	0.8	39,000		39,000	1,500

Notes: The figures need be treated with great caution given the inconsistencies across the different project appraisals. Note that some of the costs reported are real costs and others are estimated costs, and there can be problems comparing these.
The costs include capital and maintenance costs, but exclude the costs of land purchase or opportunity costs for land.
Source: Tinch and Ledoux (2006)

1.6.3 Managed Realignment and Regulated Tidal Exchange in Northern Europe – Lessons Learned and More

This study, an ABPmer paper presented at a Defra Flood and Coastal Management Conference, reviewed the costs available for 37 managed realignment and regulated tidal exchange schemes implemented in the UK and held within ABPmer's OMReG. Costs per hectare were derived from the available data and adjusted to account for land purchase and converted to 2007 prices. The analysis indicated that, in general, earlier schemes were less expensive than later schemes.

Schemes undertaken since 2000 have been much more sophisticated involving multiple organisations, with multiple benefits, requiring additional licensing and modelling, and consequent mitigation requirements. These have been meticulously planned, consulted and monitored as a result. A further factor that affected the post-2000 schemes was the increase in agricultural land prices over recent years.

For the purposes of this project, the data available from the OMReG was reviewed after costs were provided and updated to 2010 values. Where a new counterwall of significant length is required the data show that such a scheme will always be substantially more expensive. Post-2000 schemes have averaged at £15,000/ha for schemes without major defence construction, rising to £69,000/ha for schemes where major new retreated defences were built. This compares with equivalent figures pre-2000 of £10,000 and £27,000/ha, respectively (Table 1.6).

Table 1.6 Example managed realignment costs, with and without new defence construction

Type of realignment	Pre-2000		Post-2000	
	Number of examples	Average cost per ha	Number of examples	Average cost per ha
With major new defence construction	3	£27,000	9	£69,000
Without major new defence construction	6	£10,000	18	£15,000

Source: OMReG

The costs per hectare were analysed to determine the variation between the type of realignment methodology. The results are presented in Table 1.7.

Table 1.7 Example managed realignment costs by managed realignment method

Type of realignment	Pre-2000		Post-2000	
	Number of examples	Average cost per ha	Number of examples	Average cost per ha
Managed breach	6	£18,000	18	£36,000
Regulated tidal exchange	3	£10,000	7	£24,000
Defence removal*	N/A	N/A	1	£48,000

Notes: * A further defence removal example is available but due to a very small area of realigned protected area, the cost per ha is not representative.
Source: OMReG

Other costs and the proportion of costs associated with new defences and land costs are available for each of the case studies, but due to the highly variable nature of these costs between schemes and the inconsistent recording of this information this information is not presented here.

1.7 Detailed capital cost estimates

Detailed capital cost estimates should be derived using site-specific costs built up from estimates or experience of undertaking previous studies. Additional local or proxy records may also be available from the Environment Agency – for example, System Asset Management Plans (SAMPs) information – or local authorities.

Unit costs for new coastal defence embankments/walls may be used to estimate costs for new counter or set back flood defences. Costs for breaching and any necessary land raising/lowering or drainage works will need to be determined using standard rates or worked up using unit rates for these aspects.

More detailed analysis will require costs to be determined using standard bills of quantities and costs/methods from price estimating books such as SPONS (Davis

Langdon 2011) and CESMM (ICE 2012), previous experience, or from tender returns at the design stage of an analysis.

1.7.1 Risks/data confidence and uncertainties

When assessing the detailed costs associated with managed realignment schemes, there will be many factors that can affect the whole life costs. Table 1.8 provides a summary of some of the key factors that will affect these costs and which should be considered by appraisers when undertaking all levels of cost estimates associated with these schemes.

Table 1.8 Key factors affecting appraisal costs for managed realignment

Factor influencing appraisal costs	Impact on cost estimation
Unforeseen planning delays	Delays can be costly and may be due to the complexities and number of organisations and stakeholders involved.
Requirement for compulsory purchase or public inquiry	Compulsory purchase or public inquiry can increase costs substantially.
Shape of the managed realignment site and the presence of rising ground	Strongly influence costs of each site because they affect the length of new embankment required.
Size of intertidal area	Land purchase costs will increase the further back the defensive line is moved.
Aggressive wave climate	Increased costs for scour protection and more substantial structures.
Economies of scale	Large scale or grouped options may have economies of scale that reduce costs.
Area of intertidal areas	If a new line of defence is to be constructed, it may make little difference to costs whether it is set back 50 or 500 m, so the same engineering cost can be spread over a greater or lesser area. Thus a larger set back may give cheaper costs per cubic metre of flood storage potential, or per hectare of habitat created.
Level of land raising/lowering in intertidal area	More extensive land raising/lowering or drainage reconnection works will increase costs.
Ground conditions	Estuarine and coastal locations are often associated with poor ground conditions and poor foundation materials. Specialist geotechnical input will be required to ensure stability of realigned embankments.
Risk of altered wave attack	Uncertainties in the long-term development of the foreshore and the ability of the foreshore to withstand wave attack can increase upfront studies and long-term maintenance costs.

Factor influencing appraisal costs	Impact on cost estimation
Impact on wider estuary	The impact of changes to critical navigation channels will increase analysis costs.
Initial scour and wave attack	Scour to existing and new embankments may need enhanced wave protection in short term prior to intertidal vegetation establishment.

1.8 Operation and maintenance costs

It is difficult to obtain figures for the annual cost of embankment operation and maintenance actions for managed realignment schemes as the cost is often included within different general maintenance budgets or is not separately identified.

Maintenance is needed to ensure that the defences remain in the condition required for sustainable use of the intertidal area created and that no unexpected changes occur that would destabilise the works. Maintenance costs of the secondary line are usually lower, resulting in net benefits in terms of direct defence costs.

Operation and maintenance costs for newly created lines of defence will depend on the type of defence, the costs of which can be determined from linear coastal defence maintenance unit costs.

Costs associated with operation and maintenance aspects for newly created habitat areas can be obtained from the habitat creation evidence summary. A UK Biodiversity Action Plan (UKBAP) report (Defra and partners 2006) suggests annual maintenance costs for saltmarsh areas of £51 per hectare. The costs associated with saline lagoons, which may be more relevant to managed realignment schemes, are £170 per hectare. This higher cost accounts for the additional requirements for wardens, water level management aspects and vegetation management.

1.9 Monitoring costs

Realignment is not just a single event – it is a process that continues into the future. It requires further monitoring and presents responsibilities for all involved. Monitoring is required for a number of reasons prior to construction, during construction and inundation and post-works.

A standard monitoring plan should incorporate the following processes required for monitoring a managed realignment scheme:

1. Carry out pre-monitoring (to identify a baseline)
2. Define the scheme aims (including ecosystem functions and habitat structure)
3. Design approach to achieve aims
4. Define measurable criteria
5. Perform managed realignment works
6. Conduct post-construction monitoring
7. Undertake a periodic review and assessment of whether further engineering is required

Pre-scheme monitoring may be required for two years to gather data for modelling and geomorphological assessments, and to establish a baseline against which to judge post-monitoring data. Monitoring may also be required as part of consent or licence specifications to ensure objectives and mitigation measures are sufficient under licence agreements.

Monitoring is an important role in the post-project stage to assess the impacts of the project and to determine if the design is operating as intended, and if any re-design, intervention or compensation is required. Monitoring is essential to assess if there has been an increase or decrease in tidal currents, erosion or accretion within a site. Longer term monitoring will also be required to determine the type and progress of plant colonisation that has occurred following breaching and tidal inundation.

It may be crucial to have experts on hand after the initial breach event to ensure that everything continues appropriately and as expected. The monitoring process provides an early warning of trends or changes. Without monitoring how the system is performing it is impossible to know what effects it is having on the environment. Such knowledge is a critical part of evaluating the success of a project and should be factored in.

Costs associated with monitoring should be determined in conjunction with specialists.

Typical monitoring techniques which may be required for a managed realignment project include:

- topographical survey (may include laser scanning)
- monitoring intertidal accretion rates
- monitoring intertidal erodability
- flow monitoring
- monitoring scour and counter wall erosion
- ecological monitoring

The CIRIA report, Coastal and Estuarine Managed Realignment – Design Issues (Leggett et al. 2004) document suggests the monitoring schedule set out in Table 1.9.

Table 1.9 Suggested monitoring schedule

Time after completion	Reason
6 months	Monitor large-scale changes as a result of works (for example, the formation of creeks)
1 year	To confirm that large-scale changes are diminishing as expected and objectives are being met. Any unexpected changes will require remedial works.
Year 3, 6 and 10	To confirm site is stable and objectives have been met. To confirm desired species have colonised and habitat is developing. Species monitoring can be reduced or stopped after 10 years if objectives have been met.
Year 20	Monitor overall changes over last 10 years.

Source: Leggett et al. (2004)

A number of indicative costs for topographical, ecological and habitat monitoring assessments are provided in the *Practical River Restoration Appraisal Guidance for Monitoring Options* (PRAGMO) (RRC 2011).

1.9.1 Whether to include monitoring as part of flood defence appraisal

Monitoring may be required to demonstrating compliance with the Habitats Regulations or the Water Framework Directive. It is necessary to consider the costs of monitoring when appraising schemes against these requirements as these costs may be essential expenditure to comply with project conditions.

However, it has been questioned whether these costs should be considered for coastal defence projects. It is typical of managed realignment projects that these costs are attributable to habitat creation/protection policy and often undertaken by organisations not directly responsible for coastal and flood defence planning and construction. So for the purposes of comparing different options for coastal and flood defence, it would seem reasonable to omit these costs (Tinch and Ledoux 2006).

The view preferred by Tinch and Ledoux (2006) is that the most economically efficient approach is to ignore any monitoring costs associated with habitats policy when appraising flood defence options – in effect to treat these as costs of habitat policy, not costs of flood defence. Similarly the Defra and Environment Agency (2006) report assumed no costs for monitoring were included as it was assumed that these costs were already paid for by nature conservation agencies as part of the statutory monitoring of designated sites and that this existing monitoring would be transferred to the new managed retreat sites.

1.10 Other cost estimate requirements

In addition to the above cost estimates required, the following parameters are required to ensure whole life costs are correctly defined so as to incorporate them into an appraisal.

1.10.1 Appraisal period/design life

The design life is typically defined as the minimum length of time that a scheme is required to perform its intended function. The design life for appraisals is typically taken to be 100 years, although alternative periods can be used. The design life is also an important consideration in whole life costing as component assets of a design may have a shorter service life and not last as long as the overall scheme design life. This has implications for cost estimates to ensure that a whole life cost estimate correctly identifies all long-term maintenance and asset replacement costs over the intended appraisal period.

A key aspect of managed realignment projects is that they will almost certainly take longer to execute than would a simple ‘patch up’ of existing defences. This is partly due to the more complex planning and engineering likely to be needed, and partly due to the delays arising through the consultation and approval process.

If no maintenance or intervention is undertaken, embankments will deteriorate over time. This deterioration has been determined from the asset deterioration project (Environment Agency 2009) which provides the asset deterioration for both maintained and non-maintained scenarios for coastal embankments with permeable and impermeable revetments. However, these may not be relevant for new defences

located behind existing defences and not at risk of direct open coast erosion and wave attack. The use of fluvial defence deterioration rates may be more applicable and are also provided below.

Table 1.10 provides an indication of the likely deterioration rates from a new (grade 1) embankment to gradually poorer asset conditions for three different embankment types. It can be seen that a new and maintained embankment with permeable revetments would need replacement at year 50, although site specifics or the type of embankment constructed could vary this significantly.

Table 1.10 Asset deterioration rates (years)

		Grade				
		1	**2**	**3**	**4**	**5**
Wide embankment, permeable revetments, without maintenance	Best estimate	0	9	19	31	38
Wide embankment, permeable revetments, with maintenance	Best estimate	0	13	25	42	50
Wide embankment, impermeable revetments, without maintenance	Best estimate	0	9	19	31	38
Wide embankment, impermeable revetments, with maintenance	Best estimate	0	13	25	42	50
Wide fluvial turf embankment, without maintenance	Best estimate	0	3	6	25	40
Wide fluvial turf embankment, with maintenance	Best estimate	0	15	30	130	150

Notes: The deterioration is estimated in years from condition grade 1 (very good) to each consecutive grade (for example, for the first row it takes nine years for a grade 1 defence to deteriorate to a grade 2 (good) condition and 31 years to deteriorate to a grade 4 condition (poor).
Source: Environment Agency (2009)

1.11 Cost estimation methodology

Figure 1.1 shows the most important aspects required to generate a whole life cost estimate for managed realignment schemes.

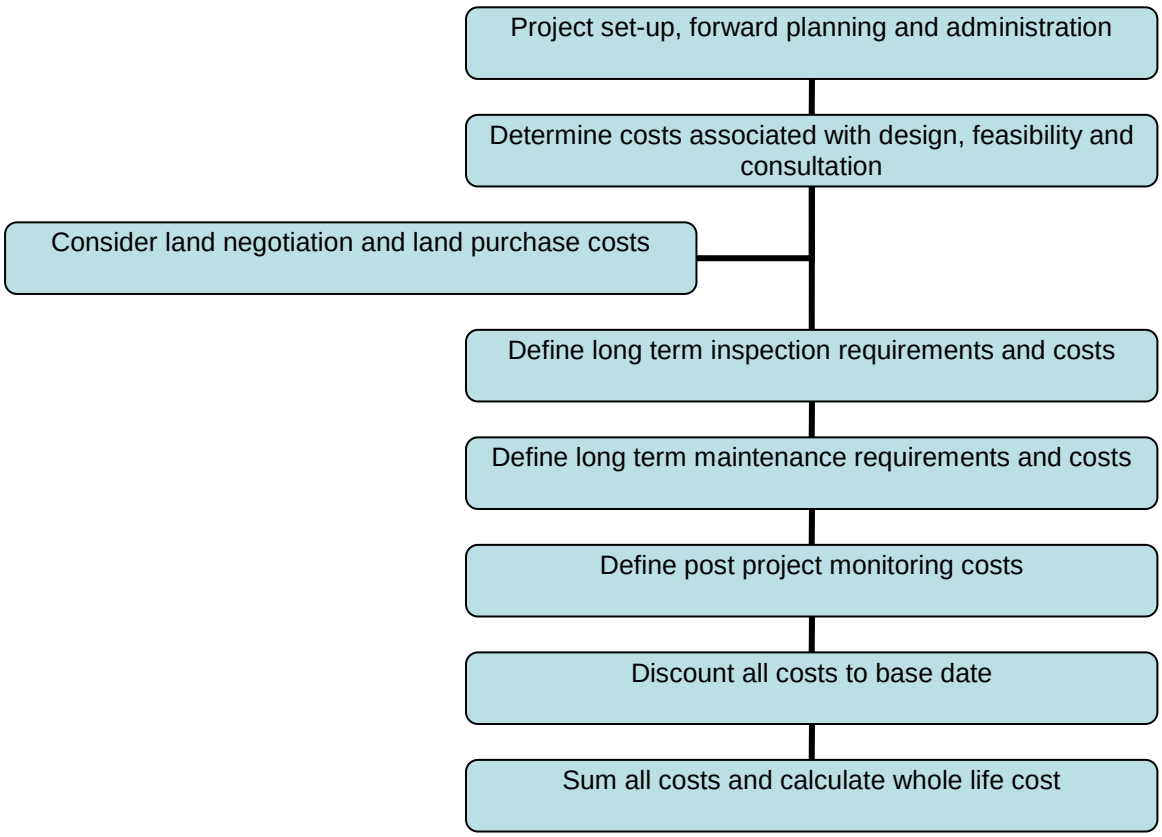

Figure 1.1 Flow diagram for managed realignment whole life costs

1.12 Case studies

A good source of data and information is the ABPmer Online Managed Realignment Guide (www.abpmer.net/omreg). This includes a number of downloadable case studies on specific sites in the UK and Europe. The online database includes summary information and summary cost information for many other managed realignment schemes in the UK.

1.12.1 Nigg Bay, Cromarty Firth

In 2003 the RSBP undertook a managed realignment scheme in Nigg Bay in the Cromarty Firth in the north of Scotland (Chisholm et al. 2004). RSPB purchased a 25 ha site behind a 1950s seawall that was unable to prevent tidal inundation to the reclaimed land. After land purchase, the site was allowed to flood at high tide through breaching of the sea wall in two locations.

Excluding staff costs and land purchase, the whole scheme cost £47,480 to complete. This was based on the following elements

- Design and impact study = £22,400
- Capital = £14,470 (£2,100 on strengthening existing landward defences; £1,470 on culvert blocking and breach digging; £1,100 on tree removal from the sea wall; £8,450 on fencing to retain stock on site; £1,350 on topping)
- Surveys and monitoring = £8,500

- Publicity = £2,000 (£1,400 on a video, £600 on the launch event; and £110 on an FEPA licence)
- Licence £110

In terms of staff cost, RSPB estimated that total staff time for the duration of the project (March 2001 to March 2003) was equivalent to 70–75% of one full-time employee.

Land purchase was an additional cost excluded from the total costs provided above, although this was funded by the Heritage Lottery Fund.

The low costs of this scheme are explained by several factors.

- The realigned defence was constructed along the line of an old seawall, reducing the construction costs. It was estimated that building a new wall from scratch would have cost a minimum of £9,000.
- The site had been reclaimed relatively recently (50 years ago), so that a minimal amount of work was necessary to recreate the conditions for intertidal habitat creation.

1.13 UK Biodiversity Action Plan costings report

The UK Biodiversity Action Plan costings report (Defra and partners 2006) provides a summary of the costs associated with the three managed realignment schemes undertaken by RSPB:

1.13.1 Uphill Sluice and Walborough, Somerset

This realignment scheme on the Severn Estuary created 5 ha of intertidal habitat. The land was owned by Avon Wildlife Trust and so no there were no land purchase costs. The capital costs of £140,000 included:

- land and legal issues and permits of £15,000
- design and consultation costs of £25,000
- earthwork costs of £70,000
- provision of footpath and gates of £15,000
- environmental and archaeological works of £15,000

1.13.2 Goosemoor, Exe Estuary

This scheme included the creation of 5.75 ha of saltmarsh, saline lagoon and mudflat habitat through a regulated tidal exchange project. The costs were estimated at £100,000 which included:

- capital costs of £70,000 for construction and installation of tidegate, works to floodbank and a new secondary bank)
- associated indirect costs of £30,000 for staff costs and allowance for the negative costs for the loss of land value to landowners).

1.13.3 Glasson, Lancashire

This managed realignment scheme created 6.4 ha of intertidal habitat, including a saline lagoon. The total estimated cost was £167,600 and represented an overall cost saving of £32,800 compared with the estimated cost of renewing the original line of defences. The total costs included:

- capital costs of £94,000 for a new landward bank
- net land purchase costs of £40,000

1.14 Checklist

Use the checklist to:

- identify the key cost elements required for watercourses
- ensure all relevant whole life costs are incorporated into the cost estimate

Managed realignment

Item	Description	Frequency	Comment
Management, liaison and consultation			
Management	Initial setting up management team and project planning. Determination of action plan/tasks and timetable. Seek funding for project.	Ongoing	
Stakeholder engagement	Early engagement with stakeholders	Ongoing	
Feasibility studies	Undertake feasibility study.	One-off	
Surveys	Undertake baseline surveys and all environmental/engineering surveys.	One-off	
Design	Evaluation of options and scheme design	One-off	
Land purchase			
Land negotiations	Consultation with landowners	One-off	Needs to be undertaken early in project life. May be complicated with large sites.
Land purchase	Purchase of land. May require land agents.	One-off	
Design and capital works			
New defence	Costs of new defence alignment	One-off	

Item	Description	Frequency	Comment
alignment	construction costs.		
Breach works	Costs associated with breach works and scour protection/wave breaks if required Costs of removing material	One-off	
New intertidal area	Costs associated with land raising/lowering, creek excavation.	One-off	
Habitat creation works	Costs of preparation, seeding, planting	One-off	
Tidal exchange works	Costs of any new flow control structures	One-off	
Other costs	Contractor's profit, mobilisation, running costs and site supervision costs	One-off	Typically 10% of total capital costs
Operation & maintenance			
Inspections	Cost of regular inspections.	Ongoing	
Maintenance	Costs of maintenance and intermittent works associated with new structures	Ongoing	
Monitoring			
Structural surveys	Post breach monitoring and scour assessments	Ongoing	
Morphological surveys	Erosion and accretion surveys Sediment monitoring	Ongoing	
Habitat surveys	Plant colonisation Bird surveys	Ongoing	

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