Department for Environment Food & Rural Affairs

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Environment Agency

delivering benefits through evidence

Cost estimation for control assets – summary of evidence

Report –SC080039/R5

Flood and Coastal Erosion Risk Management Research and Development Programme

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We operate at the place where environmental change has its greatest impact on people's lives. We reduce the risks to people and properties from flooding; make sure there is enough water for people and wildlife; protect and improve air, land and water quality and apply the environmental standards within which industry can operate.

Acting to reduce climate change and helping people and wildlife adapt to its consequences are at the heart of all that we do.

We cannot do this alone. We work closely with a wide range of partners including government, business, local authorities, other agencies, civil society groups and the communities we serve.

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Miranda Kavanagh

Director of Evidence

Executive summary

This summary of evidence provides indicative costs and guidance on a number of channel, flow and level control assets typical of those used by operating authorities for watercourses in England and Wales. Costs are typically site specific due to bespoke requirements and sizing and will generally increase with size and complexity of the asset.

Control assets	
Key cost components	Key cost components will be capital costs where new control assets are planned. Asset replacement/renewal is also a key issue to consider in whole life costing. Operation and maintenance (O&M) costs may also be significant and need to be considered for existing assets and new or planned assets. When assessing existing systems, appraisers should have detailed discussions with those managing assets to gain an understanding of existing costs, historical trends and likely future investment needs. Trends in system performance can be important, and linked to gradual changes in maintenance investment.
Key asset types	• Weirs and sluices (and drop structures) • Pumping stations • Outfalls • Flood defence gates • Tidal or flow regulation barriers • Bridges, culverts and screens (covered in a separate section) • Flumes and siphons • Locks
Data reviewed in specific guidance	Key reports and data sources include: • Environment Agency Unit Cost Database (capital costs) • Environment Agency Maintenance Standards (maintenance costs) • Environment Agency Thames Estuary 2100 reports • Internal Drainage Board costs for selected regions • Environment Agency MEICA asset costs
Other relevant data	Local or proxy records such as data from Environment Agency SAMPs and local authority information

Relative cost importance	Enabling costs	Variable costs
	Capital costs	Variable costs depending on type of asset, length and size
	Maintenance costs	Variable but can be high: operation and maintenance costs may be significant for control assets as these may include annual, intermittent and post-flood operation, running and maintenance costs
	Other cost considerations	May include environmental costs, disruption costs, decommissioning costs.
Cost estimation methodology	Initial concept/national appraisal	Approximate capital and O&M rates for some asset types available.
	Strategic, regional, or conceptual design	Approximate rates for some asset types available. Asset types without sufficient information would require information from local or proxy records.
	Preliminary feasibility/design	Specialist advice likely to be required. Advice from MEICA specialists may also be required.
Design life information	Vast amount of general and specific guidance on various asset types and their components.	
Quality of data	Limited coordinated cost information has been identified as currently available. As such the level of information is not sufficient to provide cost curves for all asset types. Coordinated recording of actual out-turn costs for these assets is limited, but some case studies and very generic costs from literature are provided to assist appraisers on the scale of costs for broad scale, early cost estimates. Indicative unit rates and example costs provided should not be used for anything other than very early or national level assessments due to the assumptions involved.	
Additional guidance	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 Case studies of recent schemes	

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Contents

1 Control assets

The Environment Agency and operating authorities with a supervisory role for watercourses in England and Wales have a requirement to build and maintain a wide and varied collection of assets including gates, pumping stations, outfalls and water level maintenance weirs.

To ensure the continuing safe and reliable operation of these assets, the operating authorities require a programme to carry out regular maintenance and replacement of these assets as and when needed.

In other related industries such as the water and waste water industry, there have been numerous demonstrated benefits from a sustained programme of investment in research and development in terms of reduced labour costs and enhanced reliability and asset operability.

1.1 Control asset cost information and guidance

A large number of potential control assets could be included in this evidence summary including:

- weirs and sluices (and drop structures)
- pumping stations
- outfalls
- flood defence gates
- tidal or flow regulation barriers
- bridges, culverts and screens (covered in a separate evidence summary)
- flumes and siphons
- locks

Information to support and provide guidance on the costs associated with these assets is presented below. Further general guidance and example photographs on these asset types are given in the Environment Agency's online *Fluvial Design Guide*.[1]

1.2 Data requirements

A number of standard cost parameters are required for control asset management. These include:

- capital costs
- operational costs – regular inspection, clearance and repair
- maintenance costs – de-silting, structural repairs, maintenance by the Environment Agency's Mechanical, Electrical, Instrumentation, Control and Automation (MEICA) team

[1] http://evidence.environment-agency.gov.uk/FCERM/en/FluvialDesignGuide.aspx

- intermittent repair and replacement costs
- decommissioning costs

1.3 Weirs and sluices

1.3.1 Capital costs

Estimated capital costs for fixed and movable weirs are available within the Environment Agency's Unit Cost Database (Environment Agency 2007). Indicative costs are based on out-turn costs from a total of 15 fixed and moveable weirs of varying widths. The costs include direct construction costs as well as contractors' overheads, temporary works and all associated works.

Average costs per structure are as shown in Table 1.1. Full details of the case studies for the four different types of weir summarised are available in the Unit Cost Database. These summary costs are applicable for indicative cost estimates for early assessments or high level cost appraisals. More detailed estimates require additional specialist assessment in terms of design and cost estimation.

Table 1.1 Environment Agency Unit Cost Database weir capital costs

Type	Average cost	Average width	Count
Narrow fixed weir (<5 m)	£29,100	3.6	1
Fixed weir (width 5–20 m)	£6,900	12.4	8
Fixed weir (width 20–40 m)	£2,800	30.5	2
Moveable weir	£61,100	15.1	4

1.3.2 Operation and maintenance costs

Weirs are not expected to require significant annual maintenance costs. High risk or deteriorated weirs may require annual inspection and maintenance for the following aspects:

- operational inspection costs associated with removal of accumulated trash on weir crests
- visual and condition asset inspections
- public safety inspections

For most design situations, annual operation and maintenance works should be minimal and specific risks that may increase the operational expenditure should be designed out.

The Environment Agency does not anticipate annual costs for weirs and these are not provided in its Maintenance Standards document (Environment Agency 2010). For other organisations, or cases where known issues require a higher frequency of inspection and maintenance, it is recommended that the costs associated with these aspects are accounted for through an assessment of the time required as well as the cost of undertaking the inspection.

Intermittent maintenance costs are more likely with remedial or repair works associated with foundation failure, excessive scour, undermining and security fence repairs. These costs are difficult to define or anticipate during design and appraisal studies, and so practitioners should generally assume that these are not required. For particular cases where the risks are likely or cannot be designed out, remedial costs should be identified and allowed for at future intervals.

1.4 Pumping stations

There are two main types of pumping station. The first discharges excess fluvial/surface/sewer water over or through fixed defences into the main river, highland carriers, tributaries or estuaries. The second lifts fluvial/surface water to a higher level from subsided catchments into an adjacent catchment, main river or highland carrier where gravity discharge cannot be achieved.

Pumping stations are typically maintained, operated and/or owned by water companies, Environment Agency, Internal Drainage Boards (IDBs), local authorities and other private companies.

1.4.1 Capital costs

Associated capital costs may include:

- ground investigation
- structural works
- earthworks
- pump installation
- weedscreen cleaner installation
- engineers' fees
- environmental fees

Cost differences will depend on the pumping station capacity, ground conditions, proximity of the outlet to the inlet, existing access routes and the location of an electricity supply.

Very few examples and typical costs suitable for broad scale or early stage appraisal processes are currently available.

The Thames Estuary 2100 (TE2100) study (Environment Agency 2006a) estimated costs for specific High Level Option (HLO) intervention measures that included pumping stations on the Thames. This work, carried out by consultancy Atkins, included estimated capital costs for four pumping station capacities as summarised in Table 1.2. Unfortunately costs for pumping station capacities between 0.2 m^3/s and 10 m^3/s were not assessed.

Due to the non-standard design, arrangement, duties and equipment used in pumping stations, these indicative costs will be misleading for anything other than very early stage feasibility or national level assessments. Detailed estimation should be determined by specialists.

Table 1.2 TE2100 study estimated capital costs for pumping stations

Size	Capital costs
Small (<50 l/s)	£195,000
Medium (50–200 l/s)	£277,000
Large(>200 l/s)	£410,000
Extra large (10 m^3/s)	£5,800,000

Source: Environment Agency (2006a)

1.4.2 Operation and maintenance costs

Periodic inspection of pumping station assets is typically carried out according to a maintenance schedule, with frequency based on the importance and risk of failure of the asset. Many pumping station assets will be, or need to be, equipped with telemetry to allow remote monitoring of many aspects of their operation.

The TE2100 study (Environment Agency 2006a) included generic estimated costs associated with annual maintenance and periodic costs for three standardised pumping station capacities as summarised in Table 1.3.

Table 1.3 TE2100 study estimated operation and maintenance costs for pumping stations

Size	Annual costs		Periodic refurbishment costs			
	Main-tenance	Running	12.5 years	25 years	50 years	Annualised
Small (<50 l/s)	£6,000	£3,000	£18,000	£35,000	£142,000	£6,000
Medium (50–200 l/s)	£7,000	£4,000	£42,000	£44,000	£166,000	£8,000
Large (>200 l/s)	£8,000	£5,000	£65,000	£63,000	£249,000	£13,000
Extra large (10 m^3/s)	£94,000	£80,000				N/A

Source: Environment Agency (2006a)

As part of this study, data from some of the 131 pumping stations managed for the Shire Group of IDBs were reviewed. Expenditure from 2007 to 2010 was assessed for 39 pumped catchments relating to both types of pumping station. Annual electricity and maintenance costs are presented in Table 1.4, Figure 1.1 and Figure 1.2. Average costs are provided but these may vary as a result of different operational requirements, periodic replacement costs and increased costs associated with post-flood inspections.

Table 1.4 IDB study estimated pumping stations running costs

Type	Capacity	Average annual cost	Count
Annual electricity costs	<500 l/s	£1,100	20
	500–1,500 l/s	£5,000	16
	>1,500 l/s	£13,300	3
Annual maintenance costs	<500 l/s	£4,400	20
	500–1,500 l/s	£5,200	16
	>1,500 l/s	£5,800	3

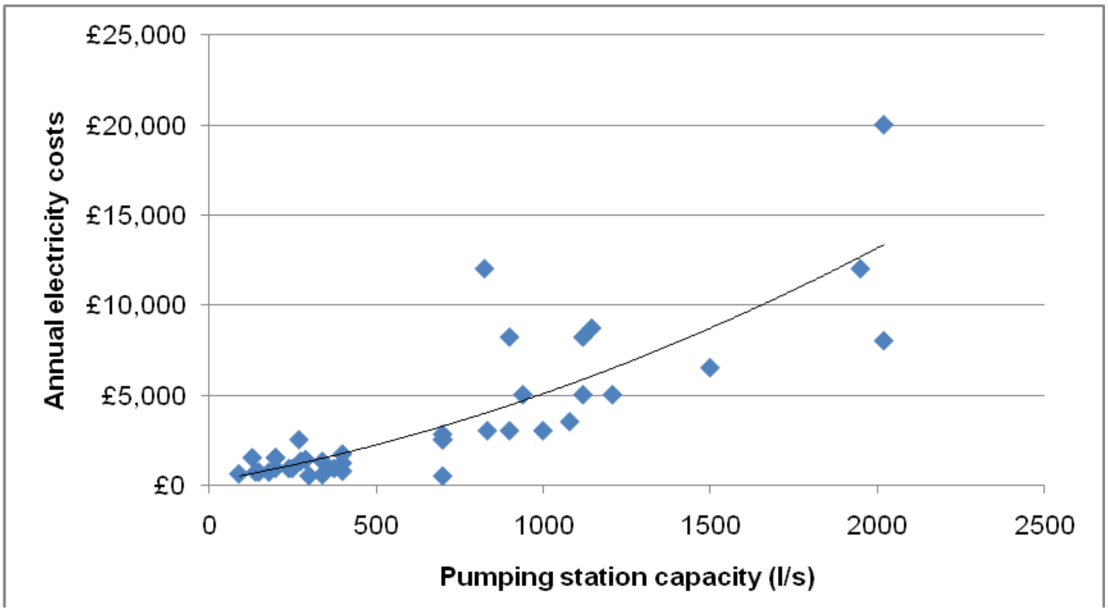

Figure 1.1 Annual electricity costs per pumping station capacity

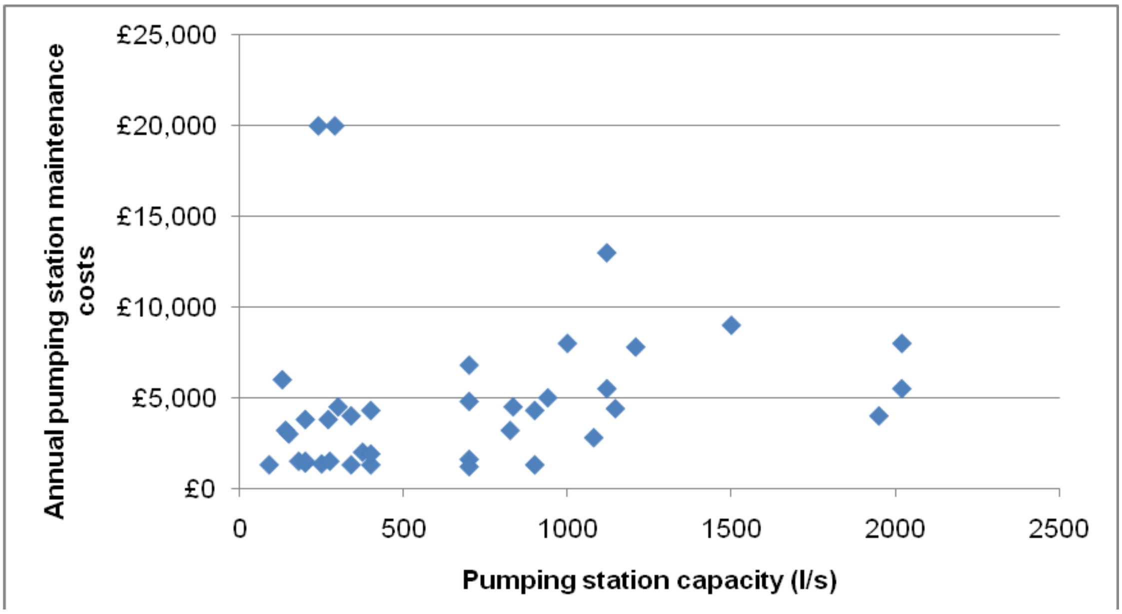

Figure 1.2 Annual maintenance costs per pumping station capacity

1.5 Flood defence gates

Flood defence gates are pre-installed gates used as a continuation of the line of defence while allowing access to river, foreshore or wharves, but are closed during flood events. They are typically attached to an adjacent structure/defence, but may also be laid into a recess on the ground and raised into position where space is limited. Closure mechanisms can be manual or automatically controlled by sensors and powered drive systems. Stop log type flood defence gates are rarely operated and typically require heavy lifting equipment.

1.5.1 Capital costs

Costs will vary depending on the size of structure required and requirement for automation. Automated options are useful where floodwaters rise rapidly and allow gate deployment without operative attendance (although confirmation of gate closure and safety aspects may require on-site attendance anyway), but can increase initial costs associated with telemetry and warning notices.

Costs are typically site-specific due to bespoke requirements and sizing of flood gates, and will increase with the size and complexity of the gate. Some estimated generic costs for representative gates sizes are provided in Table 1.5.

Table 1.5 Selected flood gate capital costs

Dimension	Automatic/manual	Capital cost	Source
8 m × 1 m	Not specified	£21,000	Environment Agency (2009)
12 m × 1 m	Not specified	£50,000	Environment Agency (2009)
5 m × 0.6 m	Manual	£5,500	Environment Agency (2009)
5 m × 0.6 m	Automatic	£17,000	Environment Agency (2009)
3 m × 1.25 m	Not specified	£24,000	FLOODsite (2008)
7 m × 2.1 m	Not specified	£71,000	FLOODsite (2008)
12 m × 2.5 m	Not specified	£169,000	FLOODsite (2008)

Costs relating to the type of gate were derived as part of the TE2100 study to assess HLO intervention measures that included frontage gates on the River Thames. The report included costed options to increase the flood gate Standard of Protection.

The options for different gate types are provided in Table 1.6. The costs relate to gate modification to increase the height of flood defences (up to 0.3 m) or replacement of the gates where possible (for increases above 0.3 m). Estimated costs were derived from industry price information and the consultants' and Environment Agency's previous experience. They do not include preliminaries, VAT, professional fees (including design fees), contingencies and land take costs. For the purposes of this TE2100 study, an additional 82% of the base cost was used to account for preliminaries, general items and design fees for the construction of new gates and the modification of existing gates.

Table 1.6 TE2100 study estimated flood gate raising and gate replacement costs

Gate type	Size	Gate raising (0.3 m) (£)	Gate replacement (0.3–1 m) (£)
Single leaf side hinged gate	Small (<2 m wide)	5,620	10,470
	Medium (2–4 m wide)	9,080	16,580
	Large (4–10 m wide)	17,120	37,120
Single leaf sliding gates	Medium (2–6 m wide)	84,600	145,400
	Large (6–15 m wide)	209,200	290,800
Double leaf side hinged gate	Small (<2 m wide)	11,240	N/A
Double leaf side hinged mitre gate	Medium (2–8m wide)	11,055	N/A
	Large (8–16 m wide)	16,860	N/A
Double leaf sliding gates	Large (8–16 m wide)	149,951	281,464

Source: Environment Agency (2006a)

1.5.2 Operation and maintenance costs

Ownership of gates can vary from the Environment Agency and local authorities to IDBs and, in some instances, commercial or private ownership. It is typically the responsibility of riparian owners to ensure gate closure during flood events following instruction from the Environment Agency. Although the Environment Agency owns and manages many flood gates, in some circumstances, riparian owners may also be responsible for the maintenance of the gates.

Maintenance costs are likely to include the following:

- annual inspections
- flood event mobilisation, inspection and closure verification
- training and exercises to ensure readiness for gate closure
- intermittent maintenance to gate, repair and replacement of damaged or expired parts
- electricity costs for automated gates and any telemetry/CCTV

The TE2100 study (Environment Agency 2006a) estimated Thames-specific cost estimates for specific HLO intervention measures that included frontage gates on the Thames. This work included the estimated annual maintenance costs and periodic costs for a range of flood gates as summarised in Table 1.7.

Table 1.7 TE2100 study estimated flood gate operation and maintenance costs

Size	Annual maintenance costs	Annual running costs	Annualised periodic refurbishment costs[1]
Small	£500	£750	£280
Medium	£800	£750	£600
Large	£2,500	£750	£1,320

Notes: [1] Refurbishment costs are irregular but are identified as an annual cost for the purposes of this report.
Source: Environment Agency (2006a)

1.6 Gravity outfalls

Outfalls are the structure at the point of discharge into a river. Outfalls provide an outlet for urban and rural land drainage, and combined sewer overflows (CSOs), but may also function to prevent tidal flooding behind fixed defences. In addition, these structures may provide a water level management function to control flow and water levels in tributaries behind the fixed defence. They typically consist of pipework penetrating the line of the fixed defence. Non-return valves (such as flap valves), isolating penstocks, complex sluice gates or gated weir structures are used to control backflow.

1.6.1 Capital costs

Costs of outfalls are dependent on the location, type, size, number of barrels, and requirement for non-return valves or penstocks. Very few examples and typical costs suitable for broad scale or early stage appraisal processes are currently available.

The TE2100 study Environment Agency (2006a) estimated costs for approximately 20 types of outfall and provides indicative costs suitable for use in national or regional estimates (see Table 1.8). Site-specific assessments are essential at an asset level.

Table 1.8 TE2100 estimated outfall capital costs

Outfall size	Cost (2006 base date)
Small (1,000 mm diameter)	£59,000
Medium (2,000 mm diameter)	£80,000
Large (2 × 1,500 diameter)	£108,000

Source: Environment Agency (2006a)

1.6.2 Operation and maintenance costs

Operation and maintenance costs for outfalls will include a number of annual and intermittent costs including:

- operational inspections

- repairs/ replacement of non-return valves
- other intermittent maintenance activities
  - wall repairs
  - replacement of sealing
  - scour protection
  - obstruction removal
  - de-silting

Operation and maintenance costs for an outfall with a headwall and an outlet with a non-return valve are covered by the Environment Agency's Maintenance Standard guidance (Environment Agency 2010). Costs are available for three target condition grades based on the Condition Assessment Manual (Environment Agency 2006b) (Table 1.9). These costs are indicative costs and represent a broad range of costs per year per outfall categorised by two outfall sizes and target condition grades.

Table 1.9 Environment Agency outfall maintenance cost unit range (£/year/outfall)

Span/diameter (m)	Outfall diameter (mm)	
	<600	**>600**
Target condition grade 2	595–3,285	830–11,365
Target condition grade 3	325–1,620	455–5,640
Target condition grade 4	75–865	115–2,940

Source: Environment Agency (2006b)

As the range of costs for outfall maintenance is very wide, Environment Agency (2006b) recommended that a weighting and scoring methodology is used to determine an appropriate point within the range, based on the three main factors that influence operation and maintenance costs as described in Table 1.10.

Table 1.10 Weighting of factors influencing maintenance costs

Factor that influences maintenance costs	Weight
Difficult access (distance to work site, protected sites/species, invasive species, overhead power cables, confined space)	2
Factors related to the properties of the outfall that increase the maintenance needs (for example, under-designed or incorrectly orientated)	2
Maintenance of the asset is undertaken as a standalone maintenance activity.	1

Notes: A score between 0 and 2 is given to each factor. Scores are multiplied by the weight to give a score between 0 and 10. A value of 0 corresponds to the lower end of the cost range and a value of 10 corresponds to the higher end of the unit cost range.
Source: Environment Agency (2006b)

The TE2100 study (Environment Agency 2006a) estimated costs for specific HLO intervention measures that included outfalls on the Thames. This work included the estimated annual maintenance and periodic costs for a range of outfall types and sizes as shown in Table 1.11.

Table 1.11 TE2100 estimated outfall annual operation and maintenance costs

Size	Annual maintenance costs	Annual running costs	Annualised periodic refurbishment costs
Small (1,000 mm diameter)	£500	£100	£1,680
Medium (2,000 mm diameter)	£500	£100	£2,240
Large (2 × 1,500 mm diameter)	£1,000	£100	£2,900

Notes: Refurbishment costs are irregular but are identified as an annual cost for the purposes of this report.
Source: Environment Agency (2006a)

Operational inspection costs may be estimated by multiplying the frequency and cost per inspection (operative hours required multiplied by operator rates). Guidance on inspection frequencies for outfalls from the Environment Agency Maintenance Standards document (Environment Agency 2010) are provided in Table 1.12.

Table 1.12 Environment Agency outfall inspection frequencies

Maintenance activities	Target condition grade	Frequency
General inspections	Grade 2 (good)	1–5 years
	Grade 3 (average)	3–10 years
	Grade 4 (poor)	10+ years

Source: Environment Agency (2010)

1.7 Tidal or flow regulation barriers

Tidal and flow regulation barriers, controls and impounding structures are, by their very nature, likely to vary enormously in function, size and impact on the ecological and physical characteristics of an estuary or river upstream and downstream of the structure.

Further aspects to consider are environmental and socio-economic impact studies (including consultation) to ensure that the structures will not have an adverse impact on the movement of wildlife and the composition of habitat types, nor influence navigation and commercial interests in the river or estuary.

Costs of impounding structures will depend heavily on the size and type of gate. The gate types listed in may be relevant to flood defence applications:

Table 1.13 Gate types used in flood defences

Type	Description
Mitre	A double-leaf gate, the closure of which forms an angle pointing upstream typically used in canals and entrances to marina basins
Vertical sector	Typically a pair of curved gates widely used at the entrance to marinas where passage through the lock is required under the widest possible tidal range
Delta	Similar in principle to vertical sector gates but the gate leaf is flat
Fishbelly flap	Variable weir gates designed as a torsionally rigid structure operation over long spans and controlled by hydraulic cylinder from one side
Tilting	Normally flat structures, hinged along their lower edge
Horizontal sector/radial	Either vertical lift or radial gates typically used for the control of flows and levels in rivers and estuaries
Self-regulating tideway (SRT)	Tidal flaps hinged on the top of the culvert so that it floats on the surface of the water until the specified desired water level has been reached, at which point the SRT will close and stay closed.

Considerations as to the type of gate to employ and the costs associated will depend on a number of criteria including:

- tidal/flow and reverse loading, hydrodynamic, and other loading mechanisms
- speed of operation
- consequences of failure
- requirement to operate at varying downstream/tidal levels
- control (and resilience) requirements
- future maintenance considerations

Additional information, photographs and diagrams on gate types and the advantages and disadvantages of each, along with the construction and operational requirements of each can be found on the KGAL website[2] and in a paper presented to the Institution of Civil Engineers (ICE) in 2001 (Grubb 2001).

1.7.1 Capital costs

Due to the highly varied nature of these types of control structures it is not possible to provide accurate or consistent unit rates or comparisons of the relative costs associated with impounding structures. Furthermore, typical costs per tonne unit rates have not been found to provide a good guide to project costing due to the highly site-

[2] http://www.kgal.co.uk/flood_defence_overview.html

specific and individual nature of these structures, as well as design savings as a result of familiarity and occurrence of particular designs.

Very few examples and typical costs suitable for broad scale or early stage appraisal processes are currently available.

The ICE paper on flood gates written by Kenneth Grubb (Grubb 2001) provides some typical costs for a range of gate designs based on a theoretical 10 m wide gate entrance and an assumed average level of control equipment (Table 1.14). These estimates should not be used for anything other than very early or national level assessments due to the assumptions involved.

Table 1.14 Indicative capital costs for various gate types

Gate type	Arrangement	Assumed gate size	Typical costs
Mitre	Single set	10 m wide × 8 m high	£500,000
Vertical sector	Single pair	10 m wide × 8 m high	£650,000
Horizontal rising sector	Single gate	10 m wide × 3 m high	£350,000
Delta	Single pair	10 m wide × 8 m high	£550,000
Tilting	Single gate	10 m wide × 3 m high	£250,000

Notes: Costs based on 2001 prices
Source: Grubb (2001)

Capital and intermittent costs for various Thames barriers were determined as part of the TE2100 study and provide specific capital replacement, annual maintenance, annual running costs and periodic refurbishment costs as summarised in FLOODsite (2008).

Examples of SRT gates are provided in a presentation by Greg Armstrong to an Institute of Fisheries Management event (Armstrong 2010). The costs for three case studies carried out between 2005 and 2008 varied from £25,000 to £125,000.

It is recommended that specialist design and build contractors are used for anything other than national or feasibility stage cost estimates.

1.7.2 Operation and maintenance costs

Operation and maintenance costs for large impounding structures will include a number of annual and intermittent costs for the gate structure, control building and monitoring equipment including:

- routine inspection, servicing and consumable part replacement
- intermittent repair/replacement of gate seals
- 10–12 year gate removal to replace wheel bearings, hoists and so on
- 20–25 year dis-assemble and refurbishment of gearboxes
- 20–25 year installation of stop-logs to de-water and repaint gates and frames
- 50 year replacement of drive system, gate structure and generator

1.8 Mechanical, Electrical, Instrumentation, Control and Automation (MEICA) assets

Many control assets are classed as MEICA assets as they are a single identifiable asset or a collection of assets on a site with complex mechanical and electrical operating equipment that operate automatically and/or have a power source. Most MEICA assets in the Environment Agency are classified as 'Major Assets' with a total estimated operating cost exceeding £5,000 per year.

Mechanical and electrical assets are most likely to be associated with the following applications:

- gated flow control structures
- gated flood control barriers
- pumping stations
- demountable barriers
- canal locks or water level management structures

1.8.1 MEICA asset types

MEICA assets may have a single or number of sub-categories that are defined and based on item types, sub-types and sizes. The Environment Agency has a classification document[3] that defines these asset types and includes the following MEICA asset types:

- actuation
- building services
- motor control centres (to operate equipment onsite)
- pressure systems
- engines
- power supplies
- gates
- high voltage equipment
- instrumentation
- lifting appliances
- motors
- pumps
- miscellaneous
- power transmission
- special Items

[3] Identification and Inventory of FRM MEICA Operational Assets

- automation
- weedscreens and cleaners
- hydraulic systems

Guidance on mechanical and electrical elements, power supplies, control panels and instrumentation, controls and automation is given in the Fluvial Design Guide.[4]

1.8.2 MEICA cost elements

Costs associated with MIECA assets can be broken down into the following elements:

Table 1.15 Costs associated with MEICA assets

Element	Description
Operation costs	Routine costs associated with operator attendance. Works may include water level control, weed clearing, operator maintenance, lubrication, site cleaning, general ground maintenance, security and general allowance for access control for contractors and others.
MEICA maintenance	All planned activities involved in maintaining items within the asset inventory. These can be split between: • Frequent maintenance activities – classified by the Environment Agency as those carried out at up to a five year frequency. These activities generally don't require disassembly of assets. • Intermittent maintenance activities – classified by the Environment Agency as those carried out every six or more years.
Energy costs	Sub-cost that includes the cost of electricity, oil and gas used for operations and heating.
Structure and grounds maintenance	The cost of maintaining the infrastructure of the site including buildings, storage areas, access tracks, perimeter and security fencing, external hand railing and fencing, public safety provision. This may include items such as interceptors, septic tanks and site drainage facilities as well as vegetation management and on-site signage. This element may also include civil elements including foundation support for the operating equipment including any concrete, brick or masonry channels, or any embedded structural steel work that is not part of a building.

Although individual MEICA assets will have different design lives and rates of deterioration, with some components replaced at regular intervals, the design life standard of most MEICA assets is 25 years. However, with complex MEICA operating equipment, intermittent maintenance and component replacement periods will be dictated by component obsolescence. These deterioration rates will depend on a number of factors such as:

[4] http://evidence.environment-agency.gov.uk/FCERM/en/FluvialDesignGuide.aspx

- type of equipment – obsolescence is a major factor in complex electronic equipment (some equipment types are less complex and more robust than others)
- the way it is used – generally, the lower the operating hours the less general wear is experienced and the longer the component life, although inactivity can be as damaging as over use in some instances
- environmental conditions – corrosion is a major deterioration factor in asset equipment
- quality of maintenance – the quality and quantity of maintenance will influence the continuing safe and reliable operation of these assets and in the long term may reduce costs and enhance reliability and asset operability.

1.8.3 Environment Agency MEICA costing

The Environment Agency's MEICA teams have developed good guidance on design life estimates of asset types, capital replacement estimates and component costs. The Environment Agency has a workload calculator that provides generic costs associated with standard asset unit types and assists with estimating ongoing maintenance aspects. Unit costs are associated against each asset for annual maintenance costs. This allows annual budgets to be determined by totalling the annual costs.

The unit costs are based on historical rates for maintenance activities. Each of these cost estimates is associated with different asset types, sub types and asset sizes (300 asset categories).

MEICA teams also use a Computerised Maintenance Management System (CMMS) to record and measure maintenance costs incurred against planned works. This is also a work management tool that records costs undertaken for activities and allows ongoing verification and revision to the maintenance unit rates. Each asset within the CMMS is assigned a planned preventative maintenance (PPM) schedule that provide life cycle costs and activities based on the residual life of assets for each asset to help with future asset management and budgeting.

Costs for MEICA assets for detailed studies should be obtained from either Environment Agency MEICA teams or specialist consultants with experience in the capital and maintenance aspects of MEICA assets. The Environment Agency can provide a range of information such as:

- the latest unit cost information from the MEICA workload calculator
- suggested replacement intervals for types of mechanical and electrical (M&E) and building assets
- inventory data on existing assets from the CMMS

Information from the Environment Agency's MEICA workload calculator was used to provide indicative costs associated with the capital and maintenance activities for typical MEICA assets. These costs will be improved as the Environment Agency's MEICA teams record the actual cost of works on the CMMS.

The estimates provided in the tables below are based on the experience of regional MEICA teams drawing on typical costs experienced for similar types of work. The possible range of actual costs is high and the costs provided should be only used to support engineering judgement for initial assessments and not as a replacement for local knowledge or specialist advice for design purposes. The costs provided are given in pounds per activity and exclude supervision, planning, mobilisation and demobilisation, other non-productive time, and travel and other sundry costs.

Costs for frequent maintenance activities are provided in Table 1.16 for small, medium and large assets as classified by the MEICA asset class reference system. These costs are representative of typical activities without adverse site access restrictions. Site-specific factors that could influence the maintenance activity should be considered before deciding if these costs are appropriate.

Table 1.16 Environment Agency MEICA estimated frequent maintenance costs

Frequent maintenance activity	Small (£)	Medium (£)	Large (£)
Annual actuator maintenance	80	150	300
Bi-annual common controls maintenance	150	150	250
Gate annual mechanical maintenance	250	500	1,500
Six-month hydrostatic instrument calibration	100	100	100
Six-month shaft encoder calibration	100	100	100
Six-month ultrasonic calibration	100	100	100
Annual gearbox maintenance	100	100	250
Automation programmable logic controller (PLC) annual maintenance	250	500	1250
General site safety and operational inspection	125	250	500
Annual hydraulic system maintenance	250	250	500
Five-year hydraulic system maintenance	2,000	5,000	12,000
Annual electric submersible pump	250	250	250
Three-year electric submersible pump	800	1,600	4,000
12-month building electrical	65	250	500
36-month building electrical	250	500	2,000
12-month heating system	200	200	400
12-month ventilation	65	65	250
12-month tidal flap	250	500	1,500
Motor control centre (MCC) – every 12 months	125	125	250
MCC – every 60 months	500	750	1,500
Motor – every 12 months	65	125	250
Motor – every 60 months	500	750	1,500

Estimated costs associated with a range of typical intermittent maintenance activities are given in Table 1.17. These costs assume that there are no adverse site access restrictions or complicated temporary works required. The values represent a general average cost and need to be adjusted for particular site circumstances. They therefore represent costs that are applicable for early assessment of MEICA assets, but should not be used to replace specialist advice for specific assets.

Table 1.17 Environment Agency MEICA estimated intermittent maintenance costs

Intermittent maintenance activity	Small (£)	Medium (£)	Large (£)
Seven-year gate major mechanical maintenance	2,800	6,000	15,000
12-year gate painting and mid-life refurbishment	12,000	35,000	90,000
Seven-year gearbox maintenance	1,000	2,000	5,000
15-year hydraulic system refurbishment	5,000	10,000	15,000
10-year heating system refurbishment	1,000	1,500	2,500
12-year tidal flap painting and mid-life refurbishment	10,000	30,000	75,000
MCC 12-year component replacement	5,000	7,500	10,000
Eight-year pump replacement	1,500	5,000	20,000

The MEICA workload calculator also provides estimated design life and replacement costs for a range of MEICA assets. The design life for appraisals is typically taken to be 100 years. The design life is especially important for MEICA assets due to the shorter life of components that will require replacement or refurbishment during the asset design life. This has implications for cost estimates to ensure that a whole life cost estimate identifies correctly all long-term maintenance and asset replacement costs over the intended appraisal period.

The Environment Agency MEICA team has provided estimated design life and replacement costs for a number of standard asset types as shown in Table 1.18. These are indicative and further advice will be required depending on the intended operation of an asset (at the design and costing stage) and during an asset life to determine the actual component replacement/refurbishment timing.

The replacement costs include the costs associated with replacement of the elements as well as an allowance to account for supervision, planning, mobilisation, asset removal and refurbishment.

Table 1.18 Environment Agency MEICA asset design life and estimated refurbishment costs

MEICA asset type	Design life (years)	Range of refurbishment cost
Building services		
Electrical systems	25	£2,000–41,000
Heating systems	15	£2,000–41,000
Ventilation	12	£2,000–62,000
Control		
Automation – PLC based	10	£10,000–41,000
Automation – relay based	20	£2,000–10,000
Common MCC controls	20	£10,000–41,000
Electrical		
Auto transformers	20	£3,000–25,000
Electronic power components (soft and variable starters)	15	£3,000–41,000
High voltage (HV) control equipment	15	£10,000–31,000
HV switchgear and power factor correction capacitors (PFCCs)	25	£8,000–14,000
Single-phase motors	20	£2,000–41,000
Three-phase motors	30	£113,000
Lifting and winching		
Cranes over 5 tonnes	30	£62,000
Cranes up to 5 tonnes	25	£10,000–21,000
Davits and winches over 5 tonnes	25	£21,000–31,000
Davits and winches up to 5 tonnes	15	£2,000–10,000
Mechanical		
Actuation	15	£6,000–31,000
Engines (30–250 hp)	15	£52,000
Engines (over 250 hp)	25	£206,000–227,000
Engines (up to 30 hp)	10	£8,000
Gates over 10 m^2	40	£155,000–309,000
Gates up to 10 m^2	30	£10,000–52,000
Gearbox up to 250 hp	25	£2,000–31,000
Gearbox over 250 hp	30	£103,000

MEICA asset type	Design life (years)	Range of refurbishment cost
Pumps		
Air compressors	15	£4,000–206,000
Electric and hydraulic submersible pumps	20	£4,000–144,000
Horizontal centrifugal pumps	25	£10,000–206,000
Positive displacement pumps (injection and vacuum)	15	£10,000–206,000
Screw pumps	35	£21,000–516,000
Vertical extended spindle pumps	35	£10,000–£206,000
Other		
Powered weed screen (rotating comb)	20	£62,000–£206,000
Powered weed screen (articulated arm and vertical grab)	15	£62,000–309,000
Hydraulic systems	20	£6,000–103,000
Pressure systems	20	£2,000–31,000

1.9 Case studies

The following case studies may help those producing cost estimates for control assets.

- Alrewas Weir fish pass. Case Study A in *River Weirs – Good Practice Guide. Guide – Section A*. Environment Agency R&D Publication W5B-023/HQP. Available from: http://evidence.environment-agency.gov.uk/FCERM/Libraries/FCERM_Project_Documents/SW5B-023-HQP-e-e_pdf.sflb.ashx [Accessed 16 January 2014].
- Crimpsall Sluice Replacement Scheme. Sluice decommissioning and rock weir. Case Study B in *River Weirs – Good Practice Guide. Guide – Section A*. Environment Agency R&D Publication W5B-023/HQP. Available from: http://evidence.environment-agency.gov.uk/FCERM/Libraries/FCERM_Project_Documents/SW5B-023-HQP-e-e_pdf.sflb.ashx [Accessed 16 January 2014].
- Bifurcation weir and sidespill. Case study 5.1 from *Manual of River Restoration Techniques,* River Restoration Centre. Available from: http://therrc.co.uk/MOT/Final_Versions_%28Secure%29/5.1_Cole.pdf [Accessed 16 January 2014].

1.10 R&D and general design guidance

1.10.1 General

- Environment Agency, 2010. *The Fluvial Design Guide* [online]. Available from: http://evidence.environment-agency.gov.uk/FCERM/en/FluvialDesignGuide.aspx [Accessed 16 January 2014]

1.10.2 Weirs and fish passes

- Ackers, P. and Thomas, A.R., 1976. *Design and operation of air-regulated siphons for reservoir and head-water control*. In Proceedings of a Symposium on Design and Operation of Siphons and Siphon Spillways (ed. S.K. Hemmings), 13–14 May 1975, London, organised by British Hydromechanics Research Association.
- Aisenbrey, A.J., Hayes, R.B., Warren, H.J., Winsett, D.L. and Young, R.B., 1978. *Design of small canal structures*. US Bureau of Reclamation. Available from: http://www.usbr.gov/pmts/hydraulics_lab/pubs/manuals/SmallCanals.pdf [Accessed 16 January 2014].
- Environment Agency, 2003. *River Weirs – Good Practice Guide. Guide – Section A*. R&D Publication W5B-023/HQP.
- Environment Agency, 2010. *Environment Agency Fish Pass Manual: Guidance notes on the legislation, selection and approval of fish passes in England and Wales*. Document GEHO 0910 BTBP-E-E.
- Grubb, K., 2001. *Impounding Gates for Marina and Harbour Navigation Use*. Paper written for the Institution of Civil Engineers. Available from: http://www.kgal.co.uk/c2/uploads/marina_gates_a.pdf [Accessed 16 January 2014].

1.10.3 Gates

- US Army Corps of Engineers, 1997. *Engineering and Design: Vertical Lift Gates.* Engineer Manual 1110-2-2701. Available from: http://140.194.76.129/publications/eng-manuals/index.html [Accessed 16 January 2014].
- US Army Corps of Engineers, 2000, *Engineering and Design: Design of Spillway Tainter Gates* [radial gates]*.* Engineer Manual 1110-2-2702. Available from: http://140.194.76.129/publications/eng-manuals/index.html [Accessed 16 January 2014].

1.10.4 Outfalls

- SEPA, 2008. *Engineering in the Water Environment Good Practice Guide: Intakes and Outfalls*. WAT-SG-28.

1.10.5 Pumping stations

- US Army Corps of Engineers, 1999, *Engineering and Design: Mechanical and Electrical Design of Pumping Stations.* Engineer Manual 1110-2-3105. Available from: http://140.194.76.129/publications/eng-manuals/index.html [Accessed 16 January 2014].
- Wharton, S.T., Martin, P. and Watson, T.J., 1998. *Pumping Stations – Design for Improved Buildability and Maintenance*. CIRIA R182.

1.11 References

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