The Operation and Maintenance of Sustainable Drainage Systems (and Associated Costs)

Report SR 626
February 2004

HR Wallingford

Robert Bray Associates

dti
Department of Trade and Industry

The Operation and Maintenance of Sustainable Drainage Systems (and Associated Costs)

Report SR 626
February 2004

HR Wallingford

Address and Registered Office: HR Wallingford Ltd. **Howbery Park, Wallingford, OXON OX10 8BA**
Tel: +44 (0) 1491 835381 Fax: +44 (0) 1491 832233

Registered in England No. 2562099. HR Wallingford is a wholly owned subsidiary of HR Wallingford Group Ltd.

Robert Bray Associates (Sustainable Drainage Consultants)
Fairfield, Coronation Road, Stroud, GL5 3SB
Tel: +44 (0) 1453 764885 Fax: +44 (0) 1453 765545

Contract - Research

This report describes work funded by the Department of Industry, Partners in Innovation Scheme, under Research Contract 39/5/137 cc2143, for which the DTI nominated officer was Richard Mellish, and the HR Wallingford nominated officer was Bridget Woods-Ballard.

Contributions to the project were also received from the project steering group:

- Babtie Group
- Binnie Black & Veatch
- Buchanan Consulting Engineers
- CIRIA
- English Partnerships
- Environment Agency
- Formpave Limited
- M C O'Sullivan & Co Ltd
- Marshalls Mono Ltd
- Montgomery Watson Harza Ltd
- Mott MacDonald Ltd
- Ponds Conservation Trust
- Robert Bray Associates
- SEPA
- Severn Trent Water
- T A Millard
- University of Bradford
- University of Abertay
- Welcome Break Group Ltd
- Westbury Homes
- White Young Green

DTI's management consultants for the project were WS Atkins Ltd., whose project officer was Mr J Leat. The report author was Bob Bray of Robert Bray Associates, and the work was undertaken as a sub-contract to HR Wallingford, who acted as project managers and report editors.

The HR job number was MCS 0430. The report is published on behalf of the DTI, but any opinions expressed in the report are not necessarily those of the funding department.

Contract - Research *continued*

Prepared by .....

(name)

.....

(Title)

Approved by .....

(name)

.....

(Title)

Authorised by .....

(name)

.....

(Title)

Date .....

This report is a contribution to research generally and it would be imprudent for third parties to rely on it in specific applications without first checking its suitability.

Various sections of this report rely on data supplied by or drawn from third party sources. HR Wallingford accepts no liability for loss or damage suffered by the client or third parties as a result of errors or inaccuracies in such third party data.

HR Wallingford will only accept responsibility for the use of its material in specific projects where it has been engaged to advise upon a specific commission and given the opportunity to express a view on the reliability of the material for the particular applications.

Executive Summary

The Operation and Maintenance of Sustainable Drainage Systems (and Associated Costs)

Report SR 626
February 2004

Sustainable Drainage Systems or SUDS, are gradually gaining acceptance as the preferred way of managing stormwater runoff from development areas.

This report describes a management strategy for the day to day care of SUDS, and applies current landscape maintenance practice to the problems of looking after a predominantly surface drainage infrastructure.

Guidance is provided on what maintenance techniques are appropriate for SUDS features and how drainage design, which takes landscape care into account, can significantly reduce management costs and improve performance.

Finally, two 'demonstration sites' are reviewed to try and gain an understanding of current cost implications associated with the operation and maintenance of SUDS features. It must be recognised that such management procedures are new for most contractors and there will be a period of time before the landscape management of SUDS is commonplace, and costs can be predicted with confidence.

Contents

Contents continued

Tables

Figures

Appendices

1. INTRODUCTION

Many people associated with the drainage of new developments now recognise that conventional drainage techniques can cause environmental damage, and that continuing to drain built-up areas as rapidly as possible with little regard for the environmental impacts is not a sustainable long term option. Sustainable Drainage Systems (SUDS) comprise an approach to managing runoff from urban areas that collect, clean, store and release water slowly to the environment in as natural a manner as possible. The benefits of SUDS (quantity, quality and amenity) may be summarised as follows:

- SUDS attenuate runoff to reduce flooding and environmental damage downstream from the site;
- SUDS manage pollution by trapping silts and treating runoff;
- SUDS provide amenity benefits to the local and wider community.

However, there are concerns about their operation and maintenance in both the short and long term. SUDS ideally comprise an integrated group of techniques that manage runoff from part or all of a catchment. Each component should add to the performance of the system, rather than operating as one of a series of isolated drainage devices. The management and maintenance of such systems should therefore be inclusive of all components of the design, from the point at which rainfall reaches the development surface to the point at which water is discharged to natural drainage paths, or storm sewers.

Conventional drainage is traditionally maintained by contractors using specialist machinery to clear gullies, pipework, and storage zones of trash and sediment accumulation. The frequency of maintenance is generally determined by routine rather than need, because most conventional drainage infrastructure is out of sight. Irregular maintenance activities are likely to be triggered by performance failure leading to surcharging of the upstream network and associated flooding.

Sustainable drainage systems make use of natural drainage processes, and the techniques used can be grouped into four general methods of control:

- Filter strips and swales;
- Filter drains and permeable surfaces;
- Infiltration devices;
- Basins and ponds.

Although the definitions are not rigorous and systems may operate in a variety of different ways, the techniques have in common simple concepts, which mirror natural drainage and are therefore easier to look after using recognised landscape maintenance practices.

The features used in SUDS should be highly visible and their function should, therefore, be easily appreciated by those charged with their maintenance. When problems occur, they are generally obvious and can be remedied simply using standard landscaping practice. The deterioration of SUDS will therefore tend to be gradual and, if the systems are properly maintained, can be managed out.

The design of SUDS therefore needs to take account of likely maintenance needs, in order to facilitate effective management and thus ensure long term performance over the lifetime of the systems.

2. MAINTENANCE AND WHOLE LIFE DESIGN

2.1 SUDS Whole Life Design Principles

One of the advantages of SUDS is that they are robust and easy to maintain. However, the effectiveness and ease of their long-term management will be dependent to a certain extent on their initial design characteristics.

Considerations that affect the design of SUDS structures, methods and components include:

- the drainage and water quality functions they are required to perform;
- the maintenance required to ensure they continue to work as intended;
- an assessment of the future repair or replacement requirements.

Although SUDS techniques are not new, application of the philosophy of sustainable drainage comprises a new approach to managing rainfall and therefore many clients, consultants and contractors are unfamiliar with implementing the basic objectives. Unlike conventional drainage, where water is collected in gullies and channels and conveyed underground to pipes and discharge points, SUDS design generally seeks to keep water on the surface in drainage pathways that are visible. It is important that the visibility of SUDS communicates how the system works and what care is required to ensure they continue to function at their expected performance levels.

The CIRIA design manuals recommend the concept of the surface water management train as the most appropriate technique for maximising sustainable drainage performance. This approach mimics natural catchment processes using drainage techniques in series to manage the flow and quality characteristics of the runoff. The surface water management train starts with prevention, or good housekeeping measures, for individual premises; and progresses through local source controls to larger downstream site and regional controls.

2.2 Relationships between SUDS Whole Life Design Criteria, and Operation and Maintenance Requirements

2.2.1 General

Management of SUDS should address the quantity, quality and amenity benefits of SUDS for the complete management train from where runoff begins to be collected to where it infiltrates into the ground, or is discharged to a watercourse or conventional pipe system.

'Prevention of runoff for individual premises' and 'local source controls' will normally be managed within the curtilage of individual developments. This reflects the responsibility of the landowner for drainage within the property boundary and applies to most industrial, commercial and other developments including housing where the site is managed as a whole, e.g. housing association property.

Larger downstream site and regional controls may be managed as part of a large development e.g. business parks, or else maintenance may be undertaken on behalf of the development by local authorities or other management organisations. This process sometimes involves the "adoption" process which is currently an issue for the management of SUDS, particularly in the private housing sector, and is generally implemented via the payment of commuted sums or through the assignment of responsibility to another party e.g. the local drainage authority.

2.2.2 Quantity drivers

The use of open attenuation structures such as basins, ponds and wetlands are often the most cost effective way of storing runoff, providing land is available for creating these features.

Design and management of attenuation structures needs to address all of the following issues to ensure that risks to performance are minimised:

- take into account the full design objectives of SUDS;
- allow effective maintenance;
- manage silt and vegetation accumulation;
- offer amenity benefits;
- exploit wildlife opportunities;
- use safe and effective inlet and outlet structures that are easy to maintain.

The use of the 'management train' with open silt interceptors and discreet forebays for regular silt removal should be employed, together with early interception of inorganic silt.

2.2.3 Quality drivers

A common criticism of conventional drainage is that gullies, silt traps and petrol interceptors are not maintained to an acceptable standard, and as a result contribute to pollution off-site that others are then required to manage. This situation arises in part because the structures are out of sight, but also because the consequence of failure does not have an impact on the site generating the runoff. When oil, silt and other pollutants are re-suspended following heavy rain, particularly in summer, the resulting effluent bypasses trapping mechanisms and discharges directly to the environment.

The integration of SUDS within the development area means that water quality problems can have a rapid and significant impact on public perception and amenity functions. Appropriate silt collection and pollution control mechanisms in SUDS design can minimise these pollution risks, providing they function effectively at all times. However, regular maintenance is required to ensure that risks to water quality can be spotted early, and acted on, avoiding system failure.

2.2.4 Amenity drivers

Unlike conventional drainage, SUDS are surface features generally charged with providing amenity benefits. This requirement drives the need for a level of operation and maintenance that ensures public acceptability in terms of visual aesthetics, as well as retaining the required technical performance standards.

2.3 Whole Life Design Criteria – Different SUDS Components

The following tables highlight design issues that are likely to influence the long-term performance of SUDS components, and that may impact on the feasibility of important operation and maintenance activities. They should not be considered as a comprehensive list of design criteria and objectives.

2.3.1 Filter Strips and Swales

Table 1 Design issues affecting long term performance of filter strips and swales

Component	Function	Design Criteria	Comments
Filter Strips	To transport runoff via vegetated surfaces that trap silt and pollutants. Usually located upstream of storage or infiltration area.	• Well-maintained grass or other vegetation able to trap pollutants. • A gently sloping site to ensure an even distribution of overland flow. • An even fall across the filter strip to minimise the possibility of erosion and gullying occurring. • A flush edge to the impervious hard surface collector.	Use of a gravel strip along the edge of the pavement surface is recommended to arrest and distribute flow evenly across the length of the filter strip.
Swales	To store and convey surface water via linear grassed areas (allow infiltration).	• Infiltration areas to retain runoff. • Stilling areas to arrest or redirect flows. • Inlet / inflow structures that ensure sheet flow in the swale. • Check dams and erosion control to maintain falls below 1 in 50 and prevent gullying. • Outlet / outfall structures that facilitate long-term maintenance and are resistant to blockage.	The use of coir blanket should be specified to ensure erosion does not take place during the early stages of grass growth. If the swale is likely to be water logged for several months in the year, this may prevent regular mowing, particularly during the winter, and may encourage a wetland flora to develop.

2.3.2 Filter drains and permeable surfaces

Table 2 Design issues affecting long term performance of filter drains and permeable surfaces

Component	Function	Design Criteria	Comments
Filter Drains	To transport and filter runoff via perforated or porous pipe in trench filled with filter material (granular material or lightweight aggregate fill). Removes silts and pollutants. Allows infiltration.	• Often designed to catch "first flush" volume of runoff, which carries most pollution. • Designs should ensure that silt is effectively intercepted prior to entry to filter drain.	The fill may be exposed at the ground surface or covered with turf, topsoil or other suitable capping. A variation on this theme is the 'treatment trench', which should be lined and discharges from a perforated or porous pipe to a storage structure, or to another SUDS feature in the 'management train'.
Permeable Surfaces	Load bearing constructions which allow surface water to enter underlying granular layers which store, clean and convey runoff to a discharge point.	• Designs should ensure that all runoff from hard surfaces enters the granular fill through the surface, rather than introducing water into the fill via gullies and piped systems. Roof water can be introduced into the granular layers via a filter device. This will ensure optimum performance, and maximum design life.	Permeable surfaces can accumulate silts, which can reduce the performance of both the infiltration surface and filler material. The use of geotextiles as an isolating layer prevents silt moving through the permeable fill and permanently affecting the structure. Geotextiles and the material above them can be removed and replaced, or rehabilitated to extend the design life of the system.

2.3.3 Infiltration Devices

Table 3 Design issues affecting long-term performance of infiltration devices

Component	Function	Design Criteria	Comments
Soakaways	To provide subsurface storage, allowing attenuation of flow and gradual infiltration of water into the surrounding soil.	• Designs should ensure that silt is effectively intercepted prior to entry to soakaway. • Critical design parameters are: 1. System storage capacity. 2. Rate of infiltration into surrounding soil.	The conventional 'chamber soakaway' should include inspection tubes to allow access for the removal of debris from the floor of the inspection tube or chamber. Sediment traps can be installed upstream to protect infiltration surface inside the chamber from clogging.
Infiltration basins	To provide storage and allow runoff to infiltrate into surrounding soil. May be used at source, or runoff can be conveyed in a pipe or swale to the infiltration area.	• Infiltration performance can be affected by compaction or by fine silt sealing the surface. • Silt impacts can be minimised by careful location in a 'management train' with silt collectors such as filter strips and swales upstream of the basin. • Site design and construction should ensure ripping of subsoil and careful soiling, cultivation and seeding together with siting away from direct sources of silt and compaction activity.	Compaction can be avoided by preventing vehicular access during construction and siting the basin so that it is not easily accessible to vehicles once operational.
Infiltration trenches	To provide pollution control, attenuation and infiltration via gravel-filled, linear sub-surface trenches.	• Designs should ensure that silt is effectively intercepted prior to entry to infiltration trench. • Critical design parameters are: 1. System storage capacity. 2. Rate of infiltration into surrounding soil.	The use of geotextiles as an isolating layer prevents silt moving through the permeable fill and permanently affecting the structure. Geotextiles and the material above them can be removed and replaced, or rehabilitated to extend the design life of the system.

2.3.4 Basins and ponds

Table 4 Design issues affecting long-term performance of basins and ponds

Component	Function	Design Criteria	Comments
Detention basins, extended detention basins	To provide wet weather storage in vegetated depressions (free from water in dry weather).	• Designs must ensure runoff can enter basins unimpeded, occupy the design volume and discharge at the agreed rate, whilst meeting appropriate amenity objectives. • There should be adequate vehicular access to the main basin, inlet and outlet structures, for inspection, and to allow for maintenance.	
Retention ponds	Permanently wet ponds provide storage and water quality improvement.	• Contain rooted wetland and aquatic vegetation – mainly around the edge. • Should ensure that runoff can enter basins/ponds at a rate, which will prevent erosion and allow full utilisation of the design volume during extreme events. • Should ensure that runoff remains within the structure for a sufficient length of time to trap silt and allow bioremediation before discharge at the agreed rate, whilst providing amenity objectives	Application of weedkiller to areas upstream or adjacent to these systems should be avoided in order to allow efficient biological action.
Wetlands	Wetlands use a combination of standing water and vegetation to reduce flow velocity and encourage silt deposition. Provide water quality treatment.	There should be adequate vehicular access to the main basin, inlet and outlet structures, settling ponds and any dry weather channels to allow for: • The regular cutting of grass; • Clearance of bankside vegetation; • Inspection and monitoring; • Sediment removal.	Planting of bank side trees to create shade will inhibit the future growth of aquatic vegetation but should only be used for 10% of wetland areas to ensure full bioremediation and silt trapping functions. Compaction of wetland areas during construction should be avoided to allow healthy plant growth and infiltration.

2.3.5 SUDS Support (Ancillary) Structures

The four general methods of control are serviced by a series of details and structures, which contribute to SUDS design. These additional features can be categorised by function:

- Inlets;
- Outlets;
- Storage structures;
- Silt traps;
- Flow control devices;
- Headwalls;
- Low flow channels;
- Overland flood routes.

Inlets (convey water into a structure or system)
Inlets deliver water into a drainage feature and can include open structures like cross kerbs and riprap (stone piles to prevent erosion) or closed elements such as pipes. It is important that where inlets receive water directly from hard surfaces they remain unimpeded to flows and facilitate rapid drainage of areas that need to be free of standing water.

Grilles are sometimes used on large pipes or culverts to prevent access by children. However, wherever possible, these should be designed out, via careful management of storage, low flows and the use of overland occasional flood routes. There is usually the need for a pad or equivalent device to prevent local erosion where water leaves the inlet.

The failure of the structure and its consequence should be considered at design stage.

Outlets (convey water out of a structure or system)
Outlets from drainage features often act as control mechanisms and include pipes, weirs, storage structures etc. A common feature of outlet devices is the incorporation of a grille or other device to prevent blockage in a pipe or channel leading to the next component of the drainage system 'management train' or outfall. Appropriate design and effective maintenance must be employed in these circumstances, as it is vital that the outlet structure does not block. Outlets may also be combined with a headwall, which can introduce additional problems of health and safety and maintenance operations (see headwalls).

The failure of the structure and its consequence should be considered at design stage.

Storage Structures
Storage of runoff to meet regulatory requirements can be accommodated in semi-natural basins, ponds and wetlands or in a variety of engineering structures that range from 'collector trenches', innovative 'cellular boxes', sub-base void storage to conventional pipes and tanks. Although the storage function is essentially passive, as the structures fill and empty at each rainfall event, they usually require silt traps at the inlet point and inspection devices. To function effectively water has to enter storage structures quickly and exit slowly. This demands a control mechanism at the outlet. Wherever possible, silt collection and inspection devices should be visible or indicate their function independently of complicated instruction manuals. The experience of conventional drainage is that hidden features are easily forgotten or are ignored until they fail.

Below ground storage structures therefore require simple and visible inspection points where effectiveness can be monitored, blockage prevented and silt removed.

The failure of the structure and its consequence should be considered at design stage.

Silt Traps
Silt trap design ranges from simple open basins, filter strips and swales to small in-line chambers that protect drainage features in urban or other restricted sites.

Regular removal of silt is imperative for small silt traps but is most practical and effective in larger open structures. Regular silt removal allows planning of maintenance, prevents the build up of toxic silt and minimises damage to wildlife.

The ineffectiveness of silt traps and pollution control devices in conventional drainage is a major criticism of the traditional approach to managing runoff from development. Where possible silt should be managed in open traps where build up can be monitored, bioremediation takes place naturally and maintenance can be undertaken by landscape contractors. Maintenance should entail monthly inspection and planned removal of silt.

Flow Control Devices
Where possible the control of flows through a drainage system should be passive and avoid intervention through complicated control mechanisms. The design of low flow channels for day to day management of flows and open or overland floodways for extreme events is easily understood and maintained. Complicated shut-off valves, penstocks etc are subject to failure due to neglect or loss of keys required to activate them. Simple orifice plates, slot weirs, sluice controls etc offer robust solutions to flow management that can be managed easily using readily available materials. Flow control devices should be accessible to maintenance personnel, free from unnecessary risk and easily maintained by unskilled personnel.

It is important that the function of the control features should be visible and obvious to those who maintain the structure. Maintenance should entail regular (monthly) inspection, removal of impeding debris and removal of silt as necessary.

Headwalls
Historically, these structures have often been designed with relatively complicated control devices, vertical surfaces and inaccessible silt / trash collection features. If SUDS techniques have been implemented appropriately, silt control measures should have been introduced earlier in the management train and therefore the headwall should perform predominantly a flow control function. The headwall must be simple, safe, and easy to manage.

Low Flow Channels
Day to day drainage of sites is easily managed through open low-flow channels, which are visible and can contribute to the amenity of development. It will be necessary to route low flows through 'treatment stages' to ensure good quality of water and attenuate quantity of runoff. Where possible 'source control' features should clean and control water flow before it enters the low flow channel. Low flow channels can either be hard landscape details like rills and dished channels or natural features which replicate ditch and stream systems. The flow control mechanisms in SUDS should ensure that high rainfall events do not erode or flood the channels.

Overland Flood Routes
Wherever possible, a predicted route for high design flows or unforeseen flood conditions should be incorporated into the SUDS design. The route might be simple grass weirs and bypass swales or the use of other landscape features such as roadways and public open space to offer pathways for floodwater in extreme conditions.

All emergency overland flood routes should be identified and indicated to site managers. The routes need to be kept unobstructed at all times.

3. MANAGEMENT OF SUSTAINABLE DRAINAGE – PRINCIPLES AND PRACTICE OF LANDSCAPE MAINTENANCE

3.1 Introduction

In contrast to conventional drainage, which mainly comprises subsurface pipework and associated infrastructure, SUDS are predominantly surface systems and can employ a wide range of techniques from rainwater collection devices to grass channels or storage ponds. A key feature of SUDS is their integration within the local landscape and their amenity contribution, and it is appropriate therefore that landscape maintenance practice is applied to their management.

An advantage of using site managers and landscape contractors to maintain SUDS is that they are likely to have an intimate knowledge of the development and visit site on a regular basis to undertake routine care such as grass cutting, sweeping and litter picking. This attendance should ensure regular monitoring of the drainage system, a rapid response to maintenance needs, and a feeling of ownership of the SUDS features.

The principles of landscape maintenance have been established for some time and designers of SUDS have an opportunity to use existing management techniques to develop management plans and maintenance contracts. It is therefore necessary for SUDS designers to understand how landscape contractors function and the limitations of their expertise, as well as the opportunities they offer for the efficient and cost-effective maintenance of schemes.

3.2 Principles and Practice of Landscape Maintenance

For large complex sites, the following landscape maintenance procedures are usually applied. These can be simplified for smaller development areas:

(1) A Management Plan - describing the management objectives for a site over time, and the management strategies that will be employed to realise these objectives and reconcile any potential conflicts that may arise.

(2) A Specification - detailing the conditions under which the work will be done, the materials to be used and the standard of work required.

(3) A Schedule of Work – itemising the tasks to be undertaken and the frequency at which they will be performed.

3.3 The Management Plan

Management Plans are most appropriate for application in major parks and open spaces, wherever there are alternative choices for future action, and potential conflicts of purpose and priorities that need to be determined.

The following extract from 'A Guide to Management Plans for Parks and Open Spaces' sets out the types of Management Plans that can be prepared:

(a) A Management Plan

This predicts a degree of physical change, and therefore must present design proposals in its recommendations - it may become a Master Plan. This puts the emphasis on the presentation of proposed physical change with much of the documentation being in support.

(b) An Outline Plan

This is generally accepted as a more appropriate title for a management plan that wishes to establish the guiding principles, without providing detailed proposals which might constrain future options for achieving the outline objectives.

(c) A Maintenance Plan

This is appropriate if the principle interest is in establishing the best way of maintaining an area, or where there is a need to match maintenance aspirations to a secure financial base. Planned maintenance programmes over longer timescales can be made more secure by the more public exposure of the need and the commitment that the Maintenance Plan can guarantee. A Maintenance Plan can also establish changes in maintenance regimes that may be required to match a change in objectives e.g. the need to adapt operation and maintenance practices to accommodate specific wildlife habitats that may develop.

In terms of SUDS, the Maintenance Plan will generally be the most appropriate type of Management Plan to use. The document should include an explanation of the function of the SUD system and why it is being used on the site.

Where the drainage system has an impact on the wildlife value or public use of a site, it would be prudent to develop this simple explanation further to explain habitat enhancement goals, health and safety issues, and long term management implications. Sites with special wildlife or amenity interest may require detailed management plans, which monitor habitat development, infrastructure changes or damage to sites and ensure rapid responses to such changes, should they occur.

It is common for smaller commercial, industrial and housing sites to have a simple Maintenance Statement. In this case, a single page explaining the site management (including the sustainable drainage system) would be useful for all parties involved in the care of the development.

3.4 The Specification

A specification, usually preceded by Preliminaries, details how work is to be carried out and contains clauses that give general instructions to the contractor. Specific SUDS maintenance clauses may be included in a general specification or as a separate "Sustainable Drainage Maintenance Specification" section. Generic examples of sustainable drainage maintenance specifications are included as Appendix A, with clauses to support maintenance specification and schedule of works as Appendix B.

3.5 The Schedule of Work

The tasks required to maintain the site and the frequency necessary to achieve an acceptable standard should be set out in the Schedule of Work. An example is given in Appendix C.

Small commercial sites will usually have simple specification notes given to a contractor as a basis for maintenance on a performance basis. Examples of performance criteria are items such as:

- Length of grass;
- Tidiness;
- Extent of weed growth, etc.

This document will often form the basis of a pricing mechanism, and can also act as a checklist to ensure the work has been carried out satisfactorily.

3.6 Frequency of Maintenance Tasks

Landscape maintenance contract periods are usually 1 or 3 years duration. The 3-year period is increasingly common to ensure continuity and commitment to long-term landscape care. The frequency of regular landscape maintenance tasks in a contract period can theoretically range from daily to once in the contract period. In practice most site tasks are based on monthly or fortnightly site visits, except where grass or weed growth requires a higher frequency of work. In many cases a performance specification is used with terms such as "beds will be maintained weed-free" or "grass will be cut at 50mm with a minimum height of 25mm and a maximum height of 100mm" to obtain the required standards.

Frequency can be specified within the schedule to include irregular items such as "'meadow grass' - cut 2 times annually in July and September at 50mm, all arisings raked off and removed to wildlife features compost facility or to tip", which provides flexibility for work that is not critical to the management of the site.

Maintenance tasks which suit a performance approach commonly include plant growth, grass cutting, pruning and tree maintenance. However work tasks such as sweeping paths, regular litter collection and cleaning road surfaces will require work at an agreed frequency with a more specific timing such as weekly, monthly or annually. Where the frequency and timing of tasks is critical then a mixture of performance and frequency specification is necessary to ensure effective maintenance. This type of specification is useful where SUDS features require regular attention.

SUDS maintenance tends towards a frequency requirement to ensure a predicable standard of care which can be recorded on site and which provides a reasonable basis for pricing work. A convenient frequency for many tasks is at a monthly inspection as this is the usual minimum site attendance required in a Landscape Specification. The monthly frequency provides for an inspection of all SUDS features and checking all inlets and outlets.

Certain SUDS maintenance tasks however fall outside this monthly cycle and need to be accommodated in the contract period. The two most obvious are:

- wetland vegetation maintenance;
- silt management.

There are other tasks associated with ensuring the long-term performance of the systems that may be more difficult to predict, and may even fall outside any contract period. It may therefore be more appropriate to review requirements for e.g. system rehabilitation at interim periods, when contracts are falling due for renewal.

3.7 A Commercial Case Study

The Greenbelt Group is a commercial organisation providing services to those with an interest in land both in and around urban areas. The principal service offered by the company is the provision of a solution to the long-term management of non-developable land, which can include sustainable drainage systems. Detail of their management and maintenance approach is provided in Appendix F.

4. MAINTENANCE REQUIREMENTS OF SUSTAINABLE DRAINAGE COMPONENTS

The maintenance requirements associated with the four groups of SUDS are summarised in the tables below. Full maintenance specifications for use in designing and implementing a SUD scheme management plan are provided as Appendix A, with supporting clauses suggested in Appendix B.

4.1 Filter Strips and Swales

Table 5 Maintenance requirements of filter strips and swales

Component	Regular Maintenance	Occasional (Infrequent) Maintenance	Remedial Maintenance	Monitoring
Filter strips and Swales	• Regular grass cutting. • Litter removal. • Inlet and outlet cleaning (if present).	• Periodic removal of excess silt (due to slow accumulation). • In the event of reduced permeability (for swales used for infiltration), there are a number of landscape techniques, which can be used to open the surface to encourage infiltration: a) Scarifying to remove 'thatch' b) Aerating equipment to encourage water percolation c) Chisel or slitting tines d) Solid tines (spikes) e) Hollow tines f) Vibratory tines. g) As a last resort, it may be necessary to remove and replace the grass and topsoil (see below). • If silt accumulation is a problem: 1. Remove (reuse or compost) turf. 2. Remove accumulated silt (subject to toxicity test) and land apply or dispose of to tip. 3. Cultivate remaining topsoil to levels. 4. Reuse or re-turf area to agreed levels.	The following items can often be managed out through good design. Where they are found to be necessary, this is likely to be due to site-specific characteristics or unforeseen events, and as such their frequency is difficult to predict: • Reinstatement of edgings to hard surfaces. • Repair or relocation of damaged barriers. • Reinstatement of levels and turf due to erosion by rills or gullies. • Realignment of riprap or other erosion controls. • Repair/rehabilitation of inlets, outlets and overflows. • System rehabilitation following high silt loads discharged during a single event (see procedure in occasional maintenance).	Regular inspections should be undertaken, particularly during the vegetation establishment period and after significant storm events, to: • Identify areas of erosion, scour or gullies. • Identify locations of silt deposits. • Determine the health of the vegetation and the soil. • Identify areas of excessive waterlogging or other damage. Filter strips and swales accumulate silt naturally due to their primary position in the SUDS 'management train' sequence. The accumulation of silt occurs slowly, unless there is an unforeseen incident or badly managed construction event. In the event that swales develop a 'wet' swale character, then manage as wetland vegetation.

4.2 Filter Drains and Permeable Surfaces

Table 6 Maintenance requirements of filter drains and permeable surfaces

Component	Regular Maintenance	Occasional (Infrequent) Maintenance	Remedial Maintenance	Monitoring
Filter Drains	• Litter removal.	• Weed control (if required). The control of weeds will have to be managed carefully as weed killers may disrupt the biological action in the sub-base. Manual control or non-toxic and biodegradable weed killers should be used. • Surface silt removal (due to slow accumulation).	Good design practice should ensure that silt loads are intercepted upstream of a filter drain. However, if the permeability of the system does appear to be reducing with time due to silt accumulation, then consideration should be given to system rehabilitation, including: • Removal of stone above geotextile (if present). • Clean stone. • Removal of geotextile and safe disposal. • Replacement of geotextile. • Replacement of clean stone top layer.	Regular inspections should be undertaken, particularly after significant storm events, to: • Identify areas of erosion, scour or gullies around the outfall infrastructure. • Identify locations of silt/vegetation accumulation on the surface of the filter drain. • Identify any areas where damage (either vehicular or from vegetation growth) is evident.
Permeable Surfaces	• Manual brushing and litter removal • The surface should be kept clear of silt and cleaned at least twice a year to keep the voids clear, using regular brush and vacuum suction cleaning. This should be undertaken at the start of spring, when general landscape tidying of winter damage is carried out, and in the autumn after leaf fall.	• Weed control (if required). The control of weeds will have to be managed carefully as weed killers may disrupt the biological action in the sub-base. Manual control or non-toxic and biodegradable weed killers should be used.	If infiltration capacity of the surface appears t be decreasing due to silt accumulation, then consideration should be given to system rehabilitation, including: • Removal of permeable blocks and cleaning. • Removal of bedding grit and geotextile and safe disposal. • Replacement of geotextile and grit bedding layer, and replacement with clean permeable blocks. • Removal of accumulated silt from site (subject to toxicity test) and safe disposal.	• Any inlet / outlet infrastructure should be monitored regularly, to check for blockages or silt build-up. • Surface infiltration should be monitored following heavy rain for ponding. Where areas of the pavement show decreased infiltration (even after surface cleaning), they may require remedial maintenance.

4.3 Infiltration Devices

Table 7 Maintenance requirements of infiltration devices

Component	Regular Maintenance	Occasional (Infrequent) Maintenance	Remedial Maintenance	Monitoring
Infiltration Basins	• Regular grass cutting. • Litter removal.	• Clearance of leaves, silt and other debris from grassed surface.	The two main problems to avoid are compaction, and silt accumulation on the infiltration surface. Such processes can often be managed out through good design. Where they are found to cause problems, this is likely to be due to site-specific characteristics, and as such the frequency of remedial maintenance is difficult to predict. Areas draining to infiltration basins should always be kept clear of silt as it may get washed into the device, reducing the permeability of the surface. In the event of reduced permeability, there are a number of landscape techniques, which can be used to open the surface to encourage infiltration: • Scarifying to remove 'thatch' • Aerating equipment to encourage water percolation • Chisel or slitting tines • Solid tines (spikes) • Hollow tines • Vibratory tines. As a last resort, it may be necessary to remove and replace the grass and topsoil (see Filter Strips & Swales).	Regular inspections should be undertaken, particularly during the vegetation establishment period and after significant storm events, to: • Identify areas of erosion, scour or gullies; • Identify locations of silt deposits; • Determine the health of the vegetation and the soil condition; • Identify areas of excessive waterlogging or other damage.
Infiltration Trenches	• Litter removal	• Weed control (if required). The control of weeds will have to be managed carefully as weed killers may disrupt the biological action in the sub-base. Manual control or non-toxic and biodegradable weed killers should be used. • Surface silt removal (due to slow accumulation).	Good design practice should ensure that silt loads are intercepted upstream of these components. However, if the permeability of the system does appear to be reducing with time due to silt accumulation, then consideration should be given to system rehabilitation, including: • Removal of stone above geotextile (if present). • Clean stone. • Removal of geotextile and safe disposal. • Replacement of geotextile. • Replacement of clean stone top layer.	Regular inspections should be undertaken, particularly after significant storm events, to: • Identify areas of erosion, scour or gullies around the outfall infrastructure. • Identify locations of silt/vegetation accumulation on the surface of the infiltration trench. • Identify any areas where damage (either vehicular or from vegetation growth) is evident.

4.4 Basins, Ponds and Wetlands

Table 8 Maintenance requirements of basins, ponds and wetlands

Component	Regular Maintenance	Occasional (Infrequent) Maintenance	Remedial Maintenance	Monitoring
Detention basins	• Regular grass cutting. • Litter removal. • Inlet and outlet cleaning.		The following items can often be managed out through good design. Where they are found to be necessary, this is likely to be due to site-specific characteristics or unforeseen events, and as such their frequency is difficult to predict: • Removal of silt accumulations when necessary, taking all the necessary measures to ensure the extracted material is disposed of properly and safely. • Repair of erosion or other damage. • Realignment of rip-rap or other erosion controls. • Repair/rehabilitation of inlets, outlets and overflows.	• Inlet and outlet structures should be inspected monthly and after large storms, for debris and erosion. • The basin surface should be inspected for areas of damage or erosion. • Silt accumulation should be monitored.
Ponds and Wetlands	• Regular grass cutting. • Litter removal. • Inlet and outlet cleaning.	• Clearance of bankside vegetation. • Control and removal of aquatic plants (quarterly in the first two years to control nuisance plants) Maintenance depends on the type of wetland effect desired. Different effects may include open ponds with wetland fringes, closed wetlands with a 75% - 100% cover, a wetland habitat mosaic or a dynamic wetland community subject to constant change. Basins, ponds and wetlands accumulate organic and inorganic silts depending on the type of design. The management of wetland silts depends primarily on the control of inorganic silt 'at source' and regular management of organic silt accumulation together with vegetation maintenance. Excavation of silt allows the wetland to function effectively by retaining runoff storage and treatment volumes. • Clearance of vegetation reduces the build up of organic	The following items can often be managed out through good design. Where they are found to be necessary, this is likely to be due to site-specific characteristics or unforeseen events, and as such their frequency is difficult to predict: • Repair of erosion or other damage. • Realignment of rip-rap or other erosion controls. • Repair/rehabilitation of inlets, outlets and overflows.	• Inlet and outlet structures should be inspected monthly and after large storms, for debris and erosion. • Silt accumulation should be monitored to establish appropriate removal frequencies.

Component	Regular Maintenance	Occasional (Infrequent) Maintenance	Remedial Maintenance	Monitoring
		silt. • Regular partial silt removal reduces the impact of maintenance on wildlife and ensures continuing filtering and bio-remediation of pollutants • Establish how the structure is lined and avoid damage to clay puddle layers or waterproof membranes. The frequency of need for these activities is difficult to predict. It is more practical to view this operation as a regular activity annually or at least once in any maintenance cycle e.g. every 3 years.		

Note: Further information on the maintenance of wetlands and ponds are included in Appendix D.

4.5 SUDS Support (Ancillary) Structures

Table 9 Maintenance requirements of SUDS support (ancillary) structures

Component	Regular Maintenance	Occasional (Infrequent) Maintenance	Remedial Maintenance	Monitoring
• Inlets • Outlets • Storage structures • Silt traps • Flow control devices • Headwalls • Low flow channels • Overland flood routes	• Litter removal. • Regular (monthly) strimming of grass adjacent to the structure. • Monthly cleaning of infrastructure, removal of impeding debris / silts etc. • SUDS should not ideally include working parts. However, where these are present, their free movement should be confirmed bi-annually, and greasing undertaken if necessary.		Erosion / damage repair to structure or surrounding bank-works.	Monthly inspection for evidence of erosion, damage, or potential blockage risks.

5. MAINTENANCE COSTS & INFLUENCING FACTORS

5.1 Introduction

Maintenance is an inevitable requirement of all drainage elements, and is vital to ensure long term performance. It is therefore essential that the cost of implementing long-term management agreements is accounted for during the planning stages. As SUDS techniques are new for most contractors, it will take time before the landscape management of SUDS is commonplace, and costs can be predicted with confidence.

However, in order to give an idea of the likely costs of maintenance of SUDS components, case studies are presented containing cost reviews of SUDS maintenance activities at two motorway service areas (MSAs). These contain a range of SUDS for surface drainage. Further information received from tenders for ongoing maintenance activities at the sites is presented and supplemented with additional information in Appendix E.

5.2 Cost Review of Recent SUDS Maintenance at Oxford Motorway Service Area

5.2.1 Oxford Motorway Service Area (MSA) M40 - Site Description

The site is a Motorway Service Area and comprises an Amenity Building, a Lodge and Fuel Filling Area with associated circulation routes, car parking and HGV lorry park. The site area is 10 hectares of which 6.5 hectares is developed as MSA with 4.5 hectares of impermeable surfaces. The development is enclosed by planted mounds with easement for a gas pipeline which crosses the north western boundary. A ditch flows along the western boundary and eventually into the River Thame.

5.2.2 SUDS Design at Oxford MSA, M40

The design approach taken for the site was 'to maintain the natural drainage pattern' with a boundary ditch being the principal route for discharge of rainfall runoff.

- Mean annual flood runoff was estimated at 19.21 L/sec from the 6.5 hectare undeveloped site;
- Using the 'natural' runoff requirement as the design norm for the site the requirement for a 50 L/sec requisitioned storm sewer, discharging directly to the River Thame with an estimated cost of £100,000, became redundant;
- Attenuation measures throughout the site limit flows entering the watercourse with a controlled outlet from the Balancing Pond;
- The first 10mm of runoff from impermeable surfaces is collected in an Interceptor Pond to prevent rapid runoff and reduce pollution after small rainfall events.

The 'key elements' of the drainage design approach agreed with the Environment Agency were:

- Amenity Building and Lodge roofwater drains to water features around the buildings;
- Porous paving system in the car park, stores and cleans runoff before discharging to wetland areas lower down the site;
- Impervious blacktop for the HGV parking area drains through lined 'french drains' to the wetland areas;
- A 'first flush' storage volume is controlled by an interceptor pond with shut-off facility to contain spillages;
- A sub-surface wetland provides further treatment for pollutants and delivers cleaned runoff to the balancing pond;
- The balancing pond accommodates shortfall attenuation storage and acts as an emergency environmental 'buffer';
- A floodway swale conveys clean storm runoff round the western boundary to the balancing pond;

- The wastewater treatment system is independent of the surface drainage but flows into the balancing pond and the outfall.

A plan of the development is shown in Figure 1.

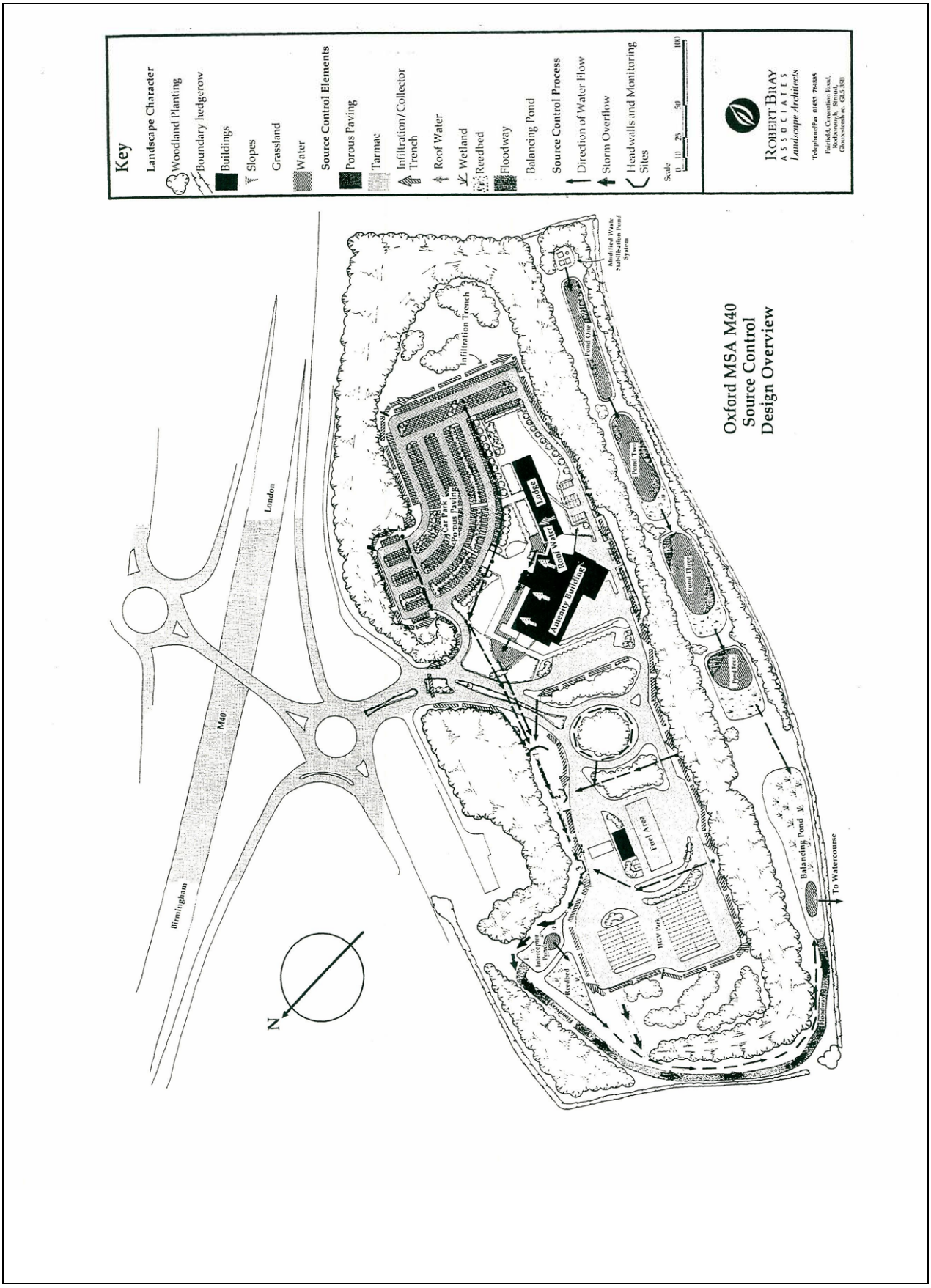

Figure 1 Plan of Oxford Motorway Service Area M40

5.2.3 Oxford MSA Maintenance Schedule of Work Summary

Maintenance Period: 1st October 2000 - 30th September 2001.
All maintenance items to be priced.
All Works to Specification.

Maintenance will be for 3 years (36 months) initially, to be reviewed at each 12 months. Defects liability will apply for 3 years to all plants which die through natural causes (i.e. not through malicious damage) and all such plants will be replaced by the contractor and at the contractors expense at the end of each 12 months.

All prices below for 12 months period.

	Annual frequency	**Unit Rate**	**Total Cost (£)**
PERIPHERAL PLANTING			
All grass verges 1.2 - 3M wide or as drawings.	15 cuts	200.00	3,000.00
All grass around source control areas.	15 cuts	85.00	1,275.00
All cuttings collected and removed from site, at first and last cut annually. Cuts at 35-50mm with 75mm max.			
All swale source control areas. Cuts at 100mm with 150mm max (in response to the development of wetland vegetation).	3 cuts	85.00	255.00
All edges trimmed (as Specification)	12 visits	75.00	900.00
Allow 2 cuts to meadow grass to all mounds & native planting areas at 50mm, all arisings to be raked off & stacked in piles on site, to form a wildlife resource, as instructed by the landscape architect & as this schedule & specification	2 cuts	1800.00	3,600.00
All native planting to be checked at grass maintenance visits & stakes and guards kept in good order at all times. All losses will be made good Oct-Dec each year			
Allowance to pick up all litter lodged in planting at monthly site visits.	12 visits	120.00	1,440.00
		SUB TOTAL	**10,470.00**
SCREEN PLANTING AND CAR PARK AREAS			
All grass verges and grass areas as drawings. All cuttings collected and removed from site. Cuts at 35-50mm. 75mm max.	15 cuts	200.00	3,000.00
All edges trimmed as Specification	12 Visits	60.00	720.00
Shrub beds as Specification and to include extra visits as required particularly during April, May, June and July. Allow a minimum of –	16 visits	250.00	4,000.00
Allowance to pick up all litter lodged in planting at monthly site visits.	12 visits	120.00	1,440.00

Sweeping hard paved areas (excluding roadways)	12 visits	150.00	1,800.00
Sweeping porous paving areas	2 visits	350.00	700.00
Herbicide to hard areas	4 Visits	200.00	800.00
Annual plant clear	1 Visit	480.00	480.00
Annual pump and electric check	1 Visit	250.00	250.00
ORNAMENTAL POND FEATURES MAINTENANCE			
Pond maintenance	4 Visits	240.00	960.00
Pond pumps, lights and associated fittings	12 Visits	150.00	1,800.00
NATURAL PONDS AND WETLANDS			
Pond and wetland maintenance	2 Visits	350.00	700.00
Check pipe inlet and outlet to and from horizontal reed-bed monthly	12 Visits	30.00	360.00
Check catchpit chambers, swales and rip-rap flow control areas	12 Visits	75.00	900.00
		SUB TOTAL	**17,180.00**
		TOTAL	**27,650.00**

5.3 Cost Review of Recent SUDS Maintenance at Hopwood Motorway Service Area

5.3.1 Hopwood Park MSA M42 - Site Description

The Hopwood Park Motorway Service Area MSA, Junction 2, near Bromsgrove in Worcestershire is situated on a north facing slope between the A441, the M42 and a new wildlife Reserve implemented as a planning requirement for the development. The site comprises 34 hectares, of which 9 hectares is developed as Motorway Service Area and 25 hectares as Wildlife Reserve. The site slopes down to Hopwood Stream which is a tributary of the River Arrow.

5.3.2 SUDS Design at Hopwood Park MSA M42

The drainage design approach at Hopwood included the following considerations:

The 'greenfield runoff rate' for the site was set at a maximum of 5 L/sec/ha up to a 1 in 25 year return (36mm of rain in 2 hours) and a maximum discharge for the whole site of 48.3 L/sec.

Runoff from the HGV area (1.72ha) was required to discharge into a tributary brook which joins Hopwood Stream, and thereby enhances base flows in the stream, which are particularly important when watercourses are vulnerable to damage in summer.

The 10mm 'first flush' volume, which contains most of the pollutants on hard surfaces is treated by stone trench filtering or wetland treatment and discharged to the Wildlife Reserve Wetland or Hopwood Stream over a minimum 48 hour period.

Storm events in excess of the 10mm 'first flush' can by-pass 'primary treatment' but must pass through a balancing pond which is designed to have a wetland treatment zone to 'polish' water passing through the system.

Separate spillage containment is provided to areas at risk from severe pollution and includes the HGV Area with $36m^3$ containment, the main access road, Fuel Filling Area and Coach Park with $36m^3$ and the Amenity Building Service Yard with $5m^3$. The design figure of $36m^3$ allows for a standard tanker spillage.

The site is divided by a stormwater ditch draining the adjacent A441. Although the ditch was considered independent of the SUDS proposals for the Hopwood Park site it divided the catchment into 2 parts and the site is therefore considered as 2 sub-catchments, the HGV Park and the remainder of the MSA, both eventually draining to Hopwood Stream.

The HGV Lorry Park

- Water is collected across a grass filter strip to trap silt;
- 10mm 'first flush' runoff enters a stone collector trench which treats oils and other pollutants naturally;
- A spillage basin with wetland 'treatment zone' and outlet valve to isolate any spillage event;
- Heavy rain passes across the trench into a grass swale;
- Balancing pond 1 with marginal wetland 'treatment zone' receives all water before release to the wildlife reserve wetland.

Main Access Road, Fuel Filling Area and Coach Park

- A proprietary silt and oil interceptor begins treatment to runoff which has been collected by conventional gully and pipe drainage;
- 2 spillage basins with wetland 'treatment zones' and outlet valves isolate any spillage event;
- A 'constructed wetland' cleans 10mm 'first flush' runoff with an additional outlet valve to isolate any spillage event;
- A wetland ditch, receiving water at a controlled rate to prevent erosion, conveys treated 'first flush' runoff to the balancing pond with marginal wetland 'treatment zone';
- A bypass swale collects storm overflow and conveys it parallel to the ditch over the riprap cascade into the pond;
- Balancing pond 2 and treatment wetland receive all water as the last link in the 'management train' before release to the 'stilling area' and Hopwood Stream.

Car Park

- A sub-surface collector trench treats 10mm 'first flush' runoff;
- A bypass channel conveys stormwater directly to the pond;
- A pipe outlet delivers all runoff to balancing pond 3 and marginal wetland 'treatment zone' before release to the 'stilling area' and Hopwood Stream.

Amenity Building

- Clean water is piped directly from the roof to a 'feature' balancing pond with marginal wetland planting;
- A cascade, controlled by a slot weir, falls to the 'stilling area' before it flows to Hopwood Stream.

A plan of the development is shown in Figure 2.

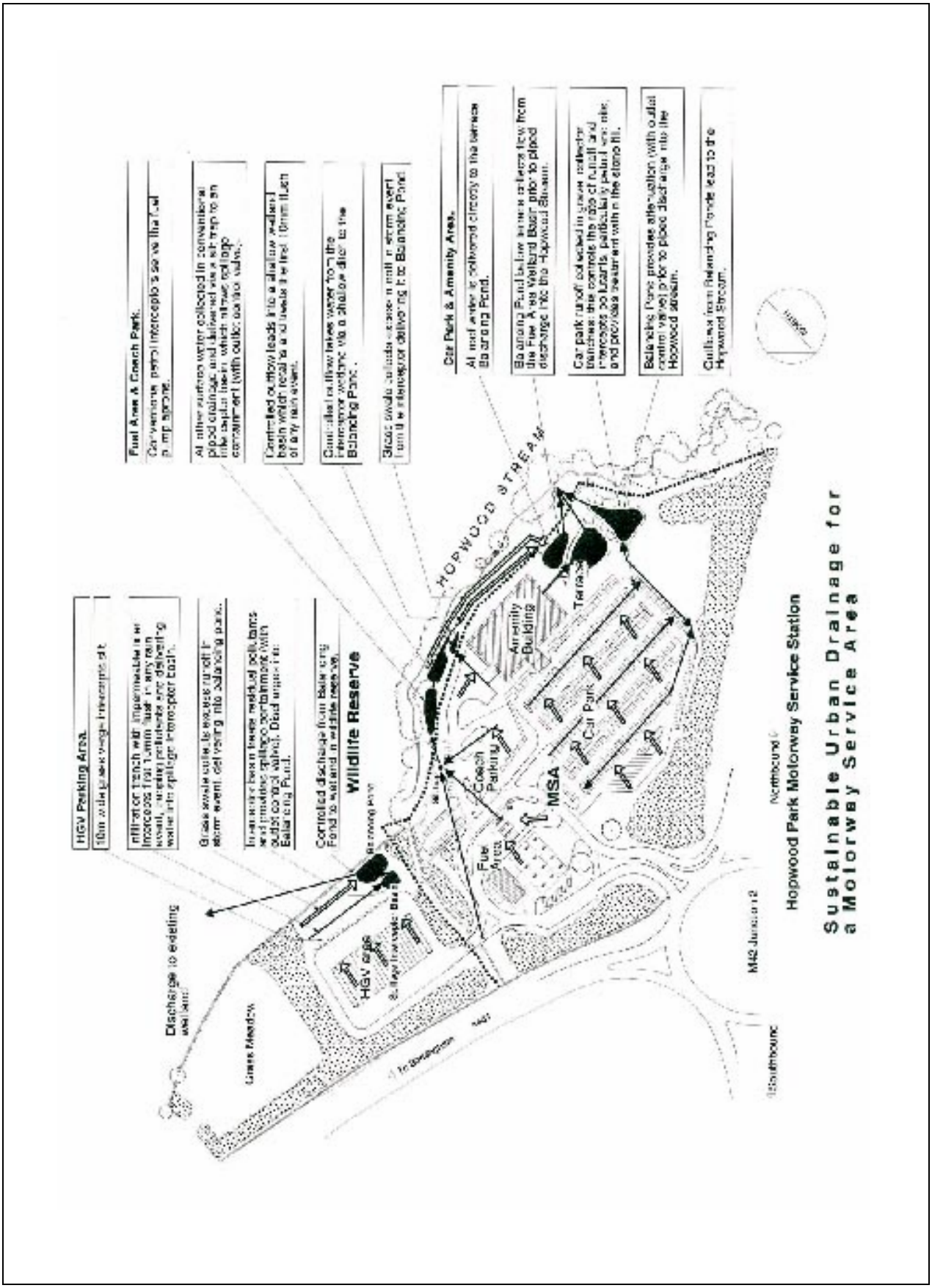

Figure 2 Plan of Hopwood Park Motorway Service Area M42

5.3.3 Hopwood MSA Maintenance Schedule of Work Summary

Maintenance Period: 1st October 2000 - 30th September 2001.
All maintenance items to be priced.
All Works to Specification.

Maintenance will be for 3 years (36 months) initially, to be reviewed at each 12 months.

Defects liability will apply for 3 years to all plants which die through natural causes (i.e. not through malicious damage) and all such plants will be replaced by the contractor and at the contractors expense at the end of each 12 months.

All prices below for 12 months period.

PERIPHERAL PLANTING	**Annual frequency**	**Unit Rate**	**Total Cost (£)**
All grass verges 1.2 - 3M wide or as drawings. All grass around source control areas. All cuttings collected and removed from site, at first and last cut annually. Cuts at 35-50mm with 75mm max.	12 cuts	150.00	1800.00
Meadow grass to all mounds and native planting areas will require 2 no cuts at 75mm at an agreed frequency, probably July and October. All raisings to be raked off and stacked in wildlife piles on site	2 cuts	400.00	800.00
Woodland grass to woodland edge and along the stream corridor on the MSA side of the Hopwood Stream 1 cut at 75mm, all arisings to be raked off and stacked in wildlife piles on site	1 cut	250.00	250.00
All native planting pits will receive Roundup weed treatment to keep a 1M weed free circle round plants at all times. Using a 1M diameter template as agreed through 2001 and 2002.	3 visits	200.00	600.00
All native planting to be checked at grass maintenance visits and stakes and guards kept in good order at all times.	3 visits	60.00	180.00
All losses to be made good Oct-Dec each year.			
Allowance to pick up all litter in planting at monthly site visits.	10 visits	30.00	300.00
HGV, FUEL AREA AND COACH PARK AND CAR PARK PLANTING AREAS			
Shrub beds to be maintained weedfree as Specification Visits to be notified and to include extra visits as required particularly during April, May, June & July.	12 visits	200.00	2400.00
Litter: pick up all litter in planting at monthly site visits.	12 visits	20.00	240.00
Herbicide to Hard Areas as required.	12 visits	10.00	120.00
Weed treat gravel areas round buildings as required and raked monthly	12 visits	25.00	300.00

BALANCING POND FEATURE TO AMENITY AREA			
End of season tidy of all dead growth All arisings removed to wildlife piles on site.	1 visit	60.00	60.00
Spring tidy of all dead growth surviving the winter All arisings removed to wildlife piles on site.	1 visit	60.00	60.00
2 summer clearances of up to 25% of all pond growth All arisings removed to wildlife piles on site.	2 visits	80.00	160.00
Allow to maintain Aerator Fountain as directed by the supplier	2 visits	40.00	80.00
SUSTAINABLE DRAINAGE FEATURES			
Litter: pick up all litter in planting at monthly site visits	12 Visits	20.00	240.00
Grass generally as required 35 - 50mm not to exceed 75mm Fortnightly or as required April 1 to Oct 30 plus 2 additional visits Nov and March as specification	16 visits	25.00	400.00
Swale grass as required 100mm minimum - 150mm maximum as required	8 visits	25.00	200.00
Wetland and ditch. Autumn and spring if necessary	2 Visits	40.00	80.00
Inlets and Outlets			
1. Inlets and Outlets 22 no.	12 Visits	50.00	600.00
2. Valves	2 Visits	10.00	20.00
Weed treatment to hard surfaces as necessary	4 Visits	40.00	160.00
Rip-rap inspection	12 Visits	10.00	120.00
Grass weir inspection	12 Visits	10.00	120.00
Pontoon inspection	12 Visits	10.00	120.00
Drop manhole inspection	12 Visits	10.00	120.00
Stilling area inspection	12 Visits	10.00	120.00
Undertake monthly visual monitoring of the site			
		TOTAL	**£9,650.00**

5.4 Competitive Tender Rates for Oxford and Hopwood Service Station Sites

The information gained from the case studies at Oxford and Hopwood MSA has been supplemented with additional competitive tenders gained at the two sites for ongoing maintainence of the landscape including SUDS features.

A number of contractors were approached to provide a rigorous accreditation of the likely costs associated with operation and maintenance activities. However, the selection of contractors familiar with the management of Sustainable Drainage proved difficult, as few landscape contractors have undertaken long term maintenance of developments with a complete suite of SUDS techniques.

The following tables show the prices that were received.

Table 10 Oxford MSA, M40 (2002 - 2003) Tender Costs

	Total Contract Sum (£)	Natural Areas Grass & Swale (£)	Swale (£)	Litter in native planting (£)	Ornamental pond (£)	Natural ponds (£)	Inlet / Outlet (£)	Catchpits and Controls (£)
Contractor 1	39124	5693	2080	360	1248	1248	2496	2496
Contractor 2	24699	4650		960	1280	1920	480	720
Contractor 3	20648	5748	2135	240	240	675	120	364

Table 11 Hopwood MSA, M40 (2001 – 2002) Tender Costs

	Total Contract Sum (£)	Natural Areas & Swale (£)	Swale (£)	Litter in native planting (£)	Litter in Swale (£)	Feature Pond (£)	Wetland & Ditch (£)	Inlet / Outlet (£)
Contractor 1	37320	15760	960	1200	1200	1100	480	3500
Contractor 2	28286	11421	-	425	240	1400	750	1700
Contractor 3	9650	3630	200	300	240	280	80	1380

The range of quotations given was considerable. For maintenance of Oxford MSA the quotations ranged from £20k to nearly £40k, and for Hopwood MSA from under £10k to £37k. This indicates the enormous range of costs that might currently be expected for landscape maintenance including SUDS components, even when a clear specification and schedule is provided for pricing purposes.

5.5 Further Cost Information

Further details of these quotations and additional notes on maintenance activities and costs are given in Appendix E, with example maintenance notes included in Appendix F.

6. CONCLUSIONS

The effective management of SUDS requires a change in the way maintenance of drainage components is undertaken. Instead of being considered as conventional drainage infrastructure, they should be viewed as landscape features to be managed using established landscape management techniques which are commonly used and well understood in the care of development sites.

Recent experience at Hopwood Park MSA, M42 and other SUDS sites in England, together with discussions regarding the management of SUDS in Scotland, indicates that early recommendations for maintenance may have been too intensive and prescriptive.

Swales, ponds, wetlands and surrounding areas can be encouraged to develop more natural vegetation with less intensive maintenance and therefore reduced costs. Filter drains and treatment trenches, particularly where protected from siltation, can require minimal attention. A more relaxed approach to the intensity of site care should not, however, compromise the frequency of site attendance and the inspection and maintenance of inlets, outlets and control structures.

The benefits of less intensive maintenance can be summarised as follows:

- Reduced cost;
- Reduced green waste;
- More resilient vegetation;
- More effective filtering and treatment;
- Wildlife enhancement;
- An attractive, natural appearance;
- Greater institutional acceptance of SUDS.

A recent silt evaluation and management project at Hopwood Park MSA, M42 has demonstrated that where inorganic silt is intercepted 'at source', before entering a wetland component of the management train, then the volume of organic silt is small. Where on-site disposal of silt can be undertaken then this process is simple, quick and cost-effective. In the case of the 7 wetland / pond features de-silted at Hopwood Park, the total cost of silt management for a 5 year period has proved to be less than £500.

Knowledge and experience of SUDS management is being refined constantly, and as existing SUDS schemes are re-evaluated, a more realistic view of maintenance will emerge. In the meantime, the guidance in this report will provide a baseline from which to develop a robust SUDS maintenance strategy.

Appendices

Contents

Appendix A

Sustainable Drainage Maintenance Specifications

Appendix A Sustainable Drainage Maintenance Specifications

Filter Strips and Swales

Activity	Frequency (per annum)	Quantity
Litter		
Collect and remove from site all extraneous rubbish not arising from the contract work and detrimental to the appearance of the site, including paper, packaging materials, bottles, cans and similar debris.	Monthly	
Grass Mowing		
Maintain height of grass between 100mm and 150mm. Cut when necessary and remove arisings to wildlife piles if grass exceeds 150mm.	As required	
Generally to surroundings and banks of swale, keep grass at 35mm-50mm minimum and 75mm maximum.		
Grass in the base of the channels should be longer to trap debris and oils. Keep between 100mm -150mm		
First and last cut in season, or if grass longer than 150mm, disposal of arisings on wildlife piles, composting areas, or off-site as required by Schedule of Works		
Where marsh or wetland develops due to wet conditions, review frequency with Client representative		
Scarifying and Removal of 'Thatch'		
Scarify with tractor-drawn or self-propelled equipment to a depth of 50mm to relieve thatch conditions and remove dead grass and other organic matter.	As required following inspection	
Spiking		
Spike with tractor-drawn or self-propelled spiker to aerate the soil to a depth of 100mm, at 100mm centres.	As required following inspection	
Hollow Tining		
Hollow tine with tractor-drawn or self-propelled equipment to a depth of 100mm, at 100mm centres, removing the cores from the surface.	As required following inspection	

Filter Strips and Swales (cont.)

Activity	Frequency (per annum)	Quantity
Monitoring Inspect infiltration areas following heavy rain and record areas that are 'ponding' and where water is lying for more than 48 hours. Report to Client.	As required, monthly and in response to advice from site personnel.	
Remedial Work to Grass Areas Subject to Silt Accumulation Remove damaged or silt-covered turf to a depth 50mm below original design level and cultivate to a fine tilth. *Either:* Re-turf using turf of a quality and appearance to match existing using additional fine sieved topsoil to BS3882 to achieve final design levels; *Or:* Reseed to BS7370: Part 3, Clause 12.6 using seed to match existing turf in appearance and quality. Supply and fix fully biodegradable coir blanket as suppliers instructions to protect seeded soil. Top-dress with fine sieved topsoil to BS3882 to achieve final design levels. Provide protection and watering to promote successful germination and/or establishment. When there is a build up of silt in the channel bottom, i.e. 50mm above the general area, then this should be removed in autumn or early spring when the ground is damp, and grass turves transplanted to original levels. Lift turf for no more than 20% of length or area of base to ensure filter function continues, and remove depth of accumulated sediment. Replace or renew turves. Spread excavated material on site or to make up levels where required (providing the silt is not considered contaminated. This should be checked with Environment Agency).	As required in response to advice from site personnel or landscape contractor	

Filter Drains / Infiltration Trenches

Activity	Frequency (per annum)	Quantity
Litter		
Collect and remove from site all extraneous rubbish not arising from the contract work and detrimental to the appearance of the site, including paper, packaging materials, bottles, cans and similar debris.	Monthly	
Grass Mowing		
Generally, to surroundings of filter drain, keep grass at 35mm-50mm minimum and 75mm maximum. Ensure that grass cuttings are collected and disposed off well away from the system, to ensure they do not contribute to future surface clogging.	As required	
Disposal of arisings on wildlife piles, composting areas, or off-site as required by Schedule of Works		
Weed control		
Hand pull or spot treat weed growth in filter drains / infiltration trenches using an approved herbicide.	As required	
Monitoring		
Monitor accumulation of silt at inlet / outlet infrastructure. Advise Client if silt build-up is significant and take action to prevent blocking of drain.	Monthly	
Monitor effectiveness of filter drain / infiltration trench surface, and when water does not infiltrate immediately, advise Client of possible need to rehabilitate surface layers.		
Rehabilitation Works		
Remove 150 – 300 mm of the 20mm – 40mm single size clean round stone and set aside on a clean, hard surface or polythene sheet. Jet wash to remove any silt for reuse.	As required	
Fold in vertical geotextile sides and roll up horizontal geotextile including accumulated silt, taking care not to contaminate clean stone layer beneath.		
Remove silted geotextile and dispose of safely to tip.		
Supply and install replacement geotextile to match previous installation, fixing to edge boards as detail.		
Replace clean 20mm – 40mm round stone making up volume with stone to match to surrounding ground level.		

Permeable Pavement

Activity	Frequency (per annum)	Quantity
Litter		
Collect and remove from site all extraneous rubbish not arising from the contract work and detrimental to the appearance of the site, including paper, packaging materials, bottles, cans and similar debris.	Monthly	
Grass Mowing		
Generally, to surroundings of permeable pavement, keep grass at 35mm-50mm minimum and 75mm maximum. Ensure that grass cuttings are collected and disposed off well away from the system, to ensure they do not contribute to future surface clogging. Disposal of arisings on wildlife piles, composting areas, or off-site as required by Schedule of Works	As required	
Weed Control		
Hand pull or spot treat weed growth in permeable pavement surface using an approved herbicide.	As required	
Cleaning of Permeable Pavement		
Light brushing and removal of sweepings	Monthly general site care and as required	
Special brush and suction clean	Twice a year, firstly in Spring and secondly in Autumn after leaf fall.	
Monitoring		
Monitor accumulation of silt, and advise Client if additional action is required to prevent pavement surface clogging	Monthly	
Monitor effectiveness of pavement and when water does not infiltrate, advise Client of possible need for rehabilitation of surface layers	Monthly	

Permeable Pavement (cont.)

Activity	Frequency (per annum)	Quantity
Rehabilitation Works		
Lift, jet wash and stack slotted blocks for re-use.	As required	
Fold in vertical geotextile sides and roll up horizontal geotextile including accumulated silt taking care not to contaminate clean stone layer beneath.		
Remove silted 5mm grit and geotextile and dispose of safely to tip.		
Ensure existing sub-base is protected and free of contamination.		
Supply and install replacement geotextile to match previous installation fixing to edge. Restraint as necessary.		
Supply, lay and loose screed to level approximately 50mm depth of 5mm SS crushed stone to BS882 on geotextile as Spec block manufacturer's specification.		
Relay cleaned blocks ensuring tight butt joints and as manufacturer's specification. Vibrate with a vibrating plate Type DVP75/22'' or similar and finish as manufacturer's specification.		

Infiltration Basins

Activity	Frequency (per annum)	Quantity
Litter		
Collect and remove from site all extraneous rubbish not arising from the contract work and detrimental to the appearance of the site, including paper, packaging materials, bottles, cans and similar debris.	Monthly	
Grass Mowing		
Generally keep grass at 35mm-50mm minimum and 75mm maximum although some infiltration basins may be natural or semi- natural vegetation and be maintained as landscape schedule.	As required	
Disposal of arisings on wildlife piles, composting areas, or off-site as required by Schedule of Works		
Sweeping		
Sweeping of areas draining to infiltration device and removal of sweepings to minimise risk of clogging.	Monthly	
Scarifying and Removal of 'Thatch'		
Scarify with tractor-drawn or self-propelled equipment to a depth of 50mm to relieve thatch conditions and remove dead grass and other organic matter.	As required following inspection	
Spiking		
Spike with tractor-drawn or self-propelled spiker to aerate the soil to a depth of 100mm, at 100mm centres.	As required following inspection	
Hollow Tining		
Hollow tine with tractor-drawn or self-propelled equipment to a depth of 100mm, at 100mm centres, removing the cores from the surface.	As required following inspection	
Monitor		
Monitor accumulation of silt and advise Client if action is required to prevent fine silt affecting infiltration basin		
Monitor accumulation of silt at inlet / outlet infrastructure. Advise Client if silt build-up is significant and take action to prevent blockages.		
Monitor effectiveness of infiltration basin surface, and when water does not infiltrate 48 hours after heavy rain, advise Client of possible need to rehabilitate surface layers.		

Infiltration Basins (cont.)

Activity	Frequency (per annum)	Quantity
Remedial Work to Grass Areas Subject to Silt Accumulation		
Remove damaged or silt-covered turf to a depth 50mm below original design level and cultivate to a fine tilth. *Either:* Re-turf using turf of a quality and appearance to match existing using additional fine sieved topsoil to BS3882 to achieve final design levels; *Or:* Reseed to BS7370: Part 3, Clause 12.6 using seed to match existing turf in appearance and quality. Supply and fix fully biodegradable coir blanket as suppliers instructions to protect seeded soil. Top-dress with fine sieved topsoil to BS3882 to achieve final design levels. Provide protection and watering to promote successful germination and/or establishment. When there is a build up of silt in the basin bottom, i.e. 50mm above the general area, then this should be removed in autumn or early spring when the ground is damp, and grass turves transplanted to original levels. Lift turf for no more than 20% of area of base to ensure filter function continues, and remove depth of accumulated sediment. Replace or renew turves. Spread excavated material on site or to make up levels where required (providing the silt is not considered contaminated. This should be checked with Environment Agency).	As required in response to advice from site personnel or landscape contractor	

Detention Basins

Activity	Frequency (per annum)	Quantity
Litter		
Collect and remove from site all extraneous rubbish not arising from the contract work and detrimental to the appearance of the site, including paper, packaging materials, bottles, cans and similar debris.	Monthly	
Grass Mowing		
Maintain height of grass between 100mm and 150mm.	As required	
Cut when necessary and remove arisings if grass exceeds 150mm		
Generally to surroundings to allow access keep grass at 35mm-50mm minimum and 75mm maximum.		
Meadow Management		
Areas not required for access may be managed for wildlife interest only.	1 or 2 cuts annually	
Disposal of arisings on wildlife piles, composting areas, or off-site as required by Schedule of Works		
Monitoring		
Monitor build up of silt and growth of vegetation likely to cause a reduction in the storage volume of the basin and advise Client or Supervising Agent.	Monthly	
Inspect inlet and outlet infrastructure to ensure all are unobstructed and show no signs of physical damage.		
Inlets and Outlet Infrastructure Maintenance		
Remove all litter and debris from inlet and outlet structure surroundings.	Monthly	
Strim 1m radius to all inlets and outlets, collecting all arisings and remove to wildlife piles, compost facility or dispose from site.		
Remove all accumulated silt from inlet and outlet aprons and use to make up design levels or top enclosing banks or berms on site, or dispose of to an approved tip.		
Ensure free movement of any moving parts, and grease if required.		

Detention Basins (cont.)

Activity	Frequency (per annum)	Quantity
Silt Accumulation Management		
Remove up to 25% of accumulated inorganic and organic silt using suitable tracked machinery and buckets without teeth (to prevent damage to liners), to the following guidelines: • Operate at a minimum distance of 1m from the bank • Undertake work between September and November inclusive to protect breeding or hibernating wildlife • Stack silt within 1m of bank edge for 48 hours to drain • Spread silt maximum 300mm deep as directed on site and outside line of drainage to de-water and oxidise (subject to consultation and agreement from Environment Agency) • Relocate after 1 month to make up design levels or top enclosing banks and berms or dispose of safely to authorised tip • Remove vegetation to wildlife piles, compost, or dispose off site after 48 hours	Three yearly, or as required	
Spillage		
In the event of a serious spillage close / block off inlet and or outlet infrastructure and contact the Environment Agency immediately.	If required	
Overflow Weirs		
Grass Check for erosion of grass surface and make good as necessary. Replacement turves will require pegging using wood or mild steel pegs, and monitoring monthly	Monthly	
Rip-Rap / Stone Check that stone remains in position and that erosion does not occur. Replace stones if required to ensure integrity of overflow surface.		

Ponds and Wetlands

Activity	Frequency (per annum)	Quantity
Litter		
Collect and remove from site all extraneous rubbish not arising from the contract work and detrimental to the appearance of the site, including paper, packaging materials, bottles, cans and similar debris.	Monthly	
Grass Mowing		
Generally, to surroundings of ponds / wetlands, keep grass at 35mm-50mm minimum and 75mm maximum for access. Ensure that grass cuttings are collected and disposed off well away from the system, to ensure they do not contribute to pond quality deterioration and/or inlet / outlet infrastructure blockages.	As required	
Meadow Management		
Areas not required for access may be managed for wildlife interest only. Disposal of arisings on wildlife piles, composting areas, or off-site as required by Schedule of Works	1 or 2 cuts annually	
Manage Aquatic Planting		
Inspect vegetation to pond edge and remove nuisance plants during first one to three years.	Monthly initially, and then as required	
Hand cut submerged and emergent aquatic plants a minimum of 100mm above wetland base, to include no more than 25% of pond / wetland surface. (Machine cutting to be a method approved by the Client or Supervising Agent).	Monitor monthly and manage annually or every 3 years	
Determine whether a pond liner has been used to waterproof the pond/wetland and protect accordingly. Damage to any pond liner will be made good at the Contractors expense.	Between September and November inclusive.	
Remove all arisings including floating weed and spread on bank to de-water for 48 hours.		
Undertake an end of season clearance of up to 25% of all pond and wetland growth during September, minimising damage to wildlife and on instruction from the Client Representative/LA.	Annually	
Retain seed heads which contribute to winter appearance, keeping the maximum diversity of existing plants.		

Ponds and Wetlands (cont.)

Activity	Frequency (per annum)	Quantity
Undertake a spring tidy of all dead growth surviving the winter in February or March using shears and not a strimmer, ensuring that all new growth is retained. Disposal of arisings on wildlife piles, composting areas, or off-site as required by Schedule of Works		
Bank Clearance		.
Remove bank vegetation by cutting to ground level, using an approved technique and as directed on site, up to 25% of all vegetation from waters edge to a minimum of 1m above water level taking care not to damage banks and potential water vole habitat. The work to be undertaken between September and November inclusive in any one year. Disposal of arisings on wildlife piles, composting areas, or off-site as required by Schedule of Works	Annually, if required, or every 3 years between September and November	
Monitoring		
When silt accumulates to within 150mm of inlet or outlet inform and recommend remedial work to Client.	Monthly	
Management of Silt Accumulation		
Following a site inspection by Client Representative/LA programme a phased removal of silt should be agreed, depending on the rate of build up and risk assessment. Confirm that silt is not considered toxic by the Environment Agency Remove silt as instructed - not more than 300mm depth and not more than 25% of pond or wetland area at any one time. Spread excavated material adjacent to wetland to allow de-watering of silt and then on site to make up levels or off site if the silt is considered special waste. Retain as much of existing vegetation as possible to ensure rapid re-colonisation of open areas. Remove up to 25% of accumulated inorganic and organic silt using suitable tracked machinery and buckets without teeth (to prevent damage to liners), to the following guidelines: • Operate at a minimum distance of 1m from the bank • Undertake work between September and November inclusive to protect breeding or hibernating wildlife	Annually if required, or every 3 years. Undertake during mid-summer.	

Ponds and Wetlands (cont.)

Activity	Frequency (per annum)	Quantity
• Stack silt within 1m of bank edge for 48 hours to drain • Spread silt maximum 300mm deep as directed on site and outside line of drainage to de-water and oxidise (subject to consultation and agreement from Environment Agency) • Relocate after 1 month to make up design levels or top enclosing banks and berms or dispose of safely to authorised tip • Remove vegetation to wildlife piles, compost, or dispose off site after 48 hours		
Inlets and Outlet Infrastructure Maintenance		
Remove all litter and debris from inlet and outlet structure surroundings.	Monthly	
Strim 1m radius to all inlets and outlets, collecting all arisings and remove to wildlife piles, compost facility or dispose from site.		
Remove all accumulated silt from inlet and outlet aprons and use to make up design levels or top enclosing banks or berms on site, or dispose of to an approved tip.		
Ensure free movement of any moving parts, and grease if required.		
Spillage		
In the event of a serious spillage close / block off inlet and or outlet infrastructure and contact the Environment Agency immediately.	If required	
Overflow Weirs		
Grass Check for erosion of grass surface and make good as necessary. Replacement turves will require pegging using wood or mild steel pegs, and monitoring monthly	Monthly	
Rip-Rap / Stone Check that stone remains in position and that erosion does not occur. Replace stones if required to ensure integrity of overflow surface.		

Appendix B

SUDS Regular Maintenance Documentation

Clauses to support landscape maintenance specification and schedule of works

Appendix B Suds Regular Maintenance Documentation

Clauses to support landscape maintenance specification and schedule of works

Introduction

Where appropriate, the specification clauses given in this section follow the style of the NBS Landscape (National Building Specification) Q35 Landscape Maintenance section.

SUDS clauses should be considered with standard Landscape Maintenance Preliminaries, General Conditions, Specification and Schedules of Work.

General SUDS Management Clauses

Provision of notice
The Contractor will provide 7 days notice of the following operations, to give the Supervising Agent the opportunity of being present.

- Filter Strips and Swales: Removal of silt
- Filter Drains and Permeable Paving: Remedial work to infiltration surfaces or collector structures
- Infiltration Basin: Spiking, scarifying, removal of accumulated 'thatch' and silt
- Basins, Ponds and Wetlands: Removal of silt and /or vegetation
- All repair and reinstatement works generally
- All silt removal and disposal generally.

Litter collection
Purpose: to retain amenity benefit and to reduce risk of blockage of SUDS function and risk of failure.

- Collect and remove from site all extraneous rubbish not arising from the contract work and detrimental to the appearance of the site, including paper, packaging materials, bottles, cans and similar debris.

Frequency: Monthly or as detailed in Schedule of Works

Sweeping
Purpose: Areas draining to an infiltration device should be kept clear of silt as it may get washed into the device, reducing the permeability of the soil and filling up space that should be used for storage of runoff.

- Sweeping of areas draining to infiltration device and removal of sweepings to minimise risk of clogging.

Frequency: Monthly, or as detailed in Schedule of Works

Disposal of arisings
Purpose: To remove / dispose of material collated during operation and management tasks.

- Disposal of arisings from site should be undertaken as follows:

(1) All litter and extraneous rubbish to be removed from site.
(2) All topsoil to be stacked for reuse or spread as directed on site.
(3) All subsoil to be stacked for reuse or spread as directed on site.
(4) All other inorganic arisings to be removed from site.

(5) All organic arisings to include grass cuttings, prunings, aquatic plant dredgings, organic silt etc to be disposed of
   - to wildlife piles (if available); or
   - to compost heap (if available); or
   - removed from site to authorised tip.

(6) All organic silt to be disposed of to:
   - to wildlife piles (if available); or
   - to compost heap (if available); or
   - removed from site to authorised tip.

(7) All inorganic silt from closed silt traps to authorised tip, classified as 'special waste'

(8) All inorganic silt from open basins and wetlands should be:
   - stacked, dewatered on site and spread on banks and berms to design levels (if possible); or
   - disposed of to authorised tip, where classified as 'special waste'.

Frequency: As required

Cleanliness
Purpose: To retain the site in a clean, tidy state.

- Ensure that no silts etc are stored on hard or permeable surfaces. Soil and arisings should be removed from hard surfaces. The Works should be left in a clean, tidy condition after maintenance operations.

Frequency: As required, and after all maintenance operations.

Protect Existing Grass
Purpose: To ensure that grassed areas are protected at all times.

- During maintenance operations, protect existing grass where necessary by laying boards or tarpaulins during the work. Do not place excavated material directly on the grass. All grass surfaces damaged during maintenance operations will be reinstated by turf to design levels at the contractor's expense.

Frequency: As required, and during all maintenance operations.

Clauses for Grassed Areas

General clauses
Carry out operations as necessary in order to:

- Maintain grass height within the specified range
- Ensure that soil and grass does not become compacted
- Repair grassed areas damaged by trampling, abrasion or scalping during mowing
  Maintain turf in a manner appropriate to the intended use.

Grass cutting
- Remove litter, rubbish and debris from grassed areas before mowing
- Cut to a near even finish, without rutting or compaction of the surface, especially when ground conditions are soft
- Leave edges neat and well defined
- Neatly trim all grass edges round the base of lighting columns, manholes, and the like
  Sweep adjoining hard areas clear of arisings and remove
- Do not cut during periods of drought or when ground conditions or grass are wet, without prior agreement of Supervising Agent.

Trees in grass
- Do not allow mowing machinery closer than 100mm to any tree stem
- Avoid damage to tree stems by nylon filaments, rotary cutters, or other mechanical tools.

Grass cutting machines
- All grass cutting machines must be appropriate to the grass cutting operation required, taking due regard to grass type, mowing specification, ground contour and condition. Machinery is to be well maintained and correctly adjusted to give a clean even cut, without damaging the grass.

Mowing general areas
- Maintain height of grass between 35mm and 50mm removing first and last cut in season (or as specified in Schedule of Works).

Mowing grass for pollution control
Purpose: To retain a grass sward that will trap sediments and pollution but resist collapse (lodging) of the grass stems:

- Maintain grass between 100mm -150mm in length.

Frequency: As required.

Remedial Work to Grass Areas Subject to Silt Accumulation
Purpose: To reinstate design levels, restore or improve infiltration and remove silt.

- Remove existing or damaged turf, and reinstate grass surface to design levels.

Frequency: As required.

Clauses for Infiltration Surfaces

Scarifying and removal of 'thatch'
Purpose - To improve infiltration performance, break up silt deposits and prevent compaction of the soil surface.

- Scarify with tractor-drawn or self-propelled equipment to a depth of 50mm to relieve thatch conditions and remove dead grass and other organic matter.

Frequency: As required.

Spiking
Purpose - To improve infiltration performance, break up silt deposits and prevent compaction of the soil surface.

The perforation of the surface by spikes will penetrate panned layers and allow water to percolate to more open soil below, particularly if the operation is followed by top dressing with a medium to fine sand. Spiking is particularly effective when the soil is moist.

- Spike with tractor-drawn or self-propelled spiker to aerate the soil to a depth of 100mm, at 100mm centres.

Frequency: As required.

Hollow tining
Purpose - To improve infiltration performance, break up silt deposits and prevent compaction of the soil surface.

The perforation of turf and removal of cores with a hollow-tined implement to relieve compaction or to reduce the amount of undesirable material, e.g.: heavy clay or thatch, and to allow the entry of air, water, nutrients or top dressing materials.

- Hollow tine with tractor-drawn or self-propelled equipment to a depth of 100mm, at 100mm centres, removing the cores from the surface.

Frequency: As required.

Clauses for Permeable Pavements

Cleaning of permeable pavement surfaces
Purpose – To remove silt that may accumulate and impair the function of the pavement and ensure a neat appearance.

- Regular manual brushing and removal of sweepings
- The block surface should be brushed a minimum of twice a year with a mechanical suction brush as recommended by the manufacturer.

Frequency: As required, or as recommended by the manufacturer

Clauses for Water Bodies

Aquatic Vegetation Management

Purpose: Aquatic plant control is undertaken to:

a) Encourage the establishment of desirable plants
b) Maintain flood attenuation volumes
c) Optimise water quality treatment performance
d) Prevent organic silt accumulation
e) Maintain open water for conservation
f) Allow access for de-silting.

- Emergent vegetation (up to 25% of vegetation area) should be managed by cutting at 100 mm above soil level using shearing action machinery and disposal of arisings. Ideally some emergent remains should be left to provide cover and food for wildlife
- Up to 25 % of submerged vegetation should be cut and raked out at any one time, using approved rakes, grabs or other techniques, depending on whether clay or waterproof membranes are present
- Mechanical cutting of aquatic vegetation from the bank must be undertaken using the principles outlined under silt removal (dredging)
- Raking of non-rooted vegetation and dredging can also be used to control vegetation
- Aquatic vegetation, whether cut by hand or machine, must be removed from pond or wetland
- Arisings should be stacked close to the pond / wetland for 48 hours to de-water and allow wildlife to return to the SUDS feature
- Aquatic plants can then be removed to wildlife piles, compost or for disposal from site after 48 hours and before decomposition, rotting or damage to existing vegetation can occur.

To maximise wildlife potential, the following clauses should also be considered:

- All wetland edges should have an uncut fringe at the margin of the lower bank and the water during normal maintenance
- Particular constraints for specific species are given below:

1. *Birds*
   - Care must be used to avoid damage to nesting birds during the breeding season (mid March to mid July).
   - Where unavoidable, work within the breeding season must be undertaken with hand-held tools to minimise disturbance and prevent accidental damage.
   - No work should be undertaken without first checking for the presence of nests which if found to be occupied should not be disturbed and the Client informed.

2. *Water voles*

   Legal protection makes it an offence to intentionally:
   - Damage or destroy or obstruct access to any structure or place which water voles use for shelter or protection.
   - Disturb water voles while they are using such a place.

   Detailed information on Management of this protected animal can be found in the 'Water Vole Conservation Handbook' published by English Nature, the Environment Agency and the Wildlife Conservation Research Unit 1998.

Maintenance work should be carried out at least 1m from wetland edges to protect banks and during September to November to avoid sensitive times for the breeding animal.

(See Appendix abstract from Managing SUDS Ponds and Wetlands containing rare species by Matt Jones)

3. *Great Crested Newt*
   Legal protection is also afforded to the Great Crested Newt under 'The Wildlife and Countryside Act 1981 (as amended).

Detailed information on Management of this protected animal can be found in the Great Crested Newt Conservation Handbook published by Froglife, Mansion House, 27-28 Market Place, Halesworth, Suffolk, IP19 8AY Tel 01986 873733

Newts visit ponds to breed in early spring and may remain through to July but young can be in the ponds until September. Work to ponds should not be undertaken between February and August inclusive. However the work required to keep SUDS ponds in optimum condition ie: occasional removal of limited quantities of silt and aquatic vegetation with only moderate shading is completely compatible with Great Crested Newt Conservation.

Maintenance of SUDS features should use appropriate methods at the least damaging time of the year.

Generally it will be practical to undertake maintenance work September – November for both protected species and as 'good practice' for conservation purposes.

Frequency - Annually or as required but at least once during the maintenance contract (e.g.: 3 years).

Bank Clearance
Purpose - Woody and non-woody vegetation control around SUDS features is necessary for a number of reasons:
a) To allow access
b) To retain water storage
c) To stimulate vegetation growth at ground level to protect banks from erosion
d) To control succession of vegetation to scrub and trees
e) To provide cover for wildlife
f) To maintain amenity value.

- Bank clearance should include cutting of all vegetation around SUDS features down to normal water level. Wherever possible only part of the banks to wetlands should be cut in any one year and some vegetation should be retained around each wetland feature at any one maintenance visit.

- Bank clearance waste can damage ground flora, affect water quality and also amenity if left in situ. Disposal options include:
  – wildlife piles on site
  – composting on site
  – removal from site.

Clauses for General System Management

Monitoring

Purpose - To identify risks to the system performance, and ensure effective long-term operation through the planning of effective operation and maintenance programmes, and rehabilitation works.

- Monitor site at each site visit.

Frequency: Monthly, or as required.

Weed control

Purpose – To prevent accumulation of silt and ensure a neat appearance. Weed growth on filter drains / infiltration trench / permeable pavement surfaces is often temporary due to lack of soil and drying of the trench will kill most weed growth during summer.

- Identify perennial weeds such as nettles, docks, thistle, ragwort etc which have established in the gravel surfaces and around inlet / outlet structures, and hand pull or spot treat with Glyphosate or similar approved herbicide. Avoid blanket spraying of weedkiller which may inhibit bioremediation of organic pollutants and contribute to pollution load.

Frequency: As required.

Inlets and Outlet Maintenance

Purpose: To ensure that inlets and outlets function as required, and do not cause system failure.

- Inspect at each site visit and ensure all are unobstructed and show no physical damage
- Strim 1M clear margins and keep hard aprons free from silt and debris.

Frequency: Monthly, or as required.

Construction of Wildlife Piles

Purpose: These features provide refuges, hibernation shelter, food and egg laying sites for a large number and animals. They also avoid the removal of 'green waste' from site. When rotted down at the end of 3-5 years they provide compost that can be used as a surface dressing to ornamental planting.

- Wildlife piles should be located in sunny or semi-shaded areas away from direct access by people
- Construct base using substantial prunings or other branch material laid in a criss-cross pattern
- Add seasonal shrub and other woody prunings through winter
- Add non-woody and grass cuttings through Summer
- Create tidy piles up to 1.2m high and with ground area to suit
- Construct new wildlife piles each year and use old wildlife pile as compost to plant beds if required after 3 – 5 years
- Wildlife piles should be located above normal flood level of watercourses or be protected by hedges or similar features.

Silt Accumulation Management

Purpose: Silt removal (dredging) includes removal of inorganic silt derived from runoff across hard surfaces and organic silt formed by accumulation of plant remains. Silt removal is necessary for a number of reasons:

a) to maintain storage capacity
b) to prevent blockage of inlets and outlets

c) to manage pollutants such as hydrocarbons.

- Where machinery is used to excavate silt then undertake the operation in dry weather when surrounding ground is firm and ideally operate from a hard surface
- Use machinery with an extending arm to avoid contact with edges, banks and other features to a minimum distance of 1m from the edge. Use a bucket without teeth to avoid puncturing clay layers or waterproof membranes
- Consider late summer and early autumn (september and october) as optimum time for remedial work to minimise damage to surrounding areas and ensure quick regrowth of aquatic vegetation
- Plan appropriate bankside working areas, and protect wetland and bankside habitats wherever possible
- Undertake preparatory tree and shrub management, if required.

Frequency: As required.

Appendix C

Example Schedule of Work

Appendix C Example Schedule of Work

A Schedule of Work (work programme) shows when work is to be done and the frequency of the operation. Elements of Specification can be included where necessary to explain operations as the Maintenance Plan is often used on site by contractors.

The schedule of work often forms the base sheet for pricing works in the form of a Maintenance Schedule Summary.

Note: No allowance for silt removal has been included in this Schedule.

MAINTENANCE SCHEDULE SUMMARY

All maintenance items to be priced.

Maintenance will be for 3 years (36 months) to be reviewed at each 12 months.

All prices below for 12 months period with prices for further 2 years at end of Schedule.

PERIPHERAL PLANTING		***Unit Rate Total***
All grass verges 1.2 - 3M wide or as drawings. *All grass around source control areas* *All cuttings collected and removed from site* *at first and last cut annually* *cuts at 35-50mm with 75mm max.*	*As required*	
All swale source control areas *cuts at 100mm with 150mm max.*	*As required*	
All edges trimmed as Specification	*12 visits*	
Allow 2 cuts to meadow grass to all mounds and native planting areas at 50mm, all arisings to be raked off and stacked in piles on site, to form a wildlife resource, as instructed by the LA. and as this schedule and specification	*2 cuts*	
All native planting to be checked at grass maintenance visits *and stakes and guards kept in good order at all times.* *All losses will be made good October-December each year..* *Allow to pick up all litter lodged in planting at monthly site visits.*	*12 visits*	
	Sub- Total _____	

SCREEN PLANTING AND CAR PARK AREAS		***Unit Rate Total***
All grass verges and grass areas as drawings. *All cuttings collected and removed from site* *cuts at 35-50mm. 75mm max.*	*As required*	
All edges trimmed as Specification	*12 visits*	

Shrub beds as Specification and to include extra visits as required particularly during April, May, June and July. Allow a minimum of -	*16 visits*
Litter lodged in planted areas	*12 visits*
Sweeping Hard Paved Areas (excluding roadways)	*12 visits*
Sweeping Porous Paving Areas	*2 visits*
Herbicide to Hard Areas	*4 visits*

ORNAMENTAL POND FEATURES MAINTENANCE

Pond maintenance.	*4 visits*
Pond pumps, lights and associated fittings	*12 visits*

NATURAL PONDS AND WETLANDS

Pond and wetland maintenance.	*2 visits*
Check pipe inlet and outlet to and from horizontal reed-bed monthly	*12visits.*
Check catchpit chambers, swales and rip-rap flow control areas	*12 visits*

Sub Total _____

TOTAL _____

Total	*Year 1.*	*2002-2002*	*(Jan 1 - Sept 30)*	_____
Total	*Year 2.*	*2002-2003*	*(Oct 1 - Sept 30)*	_____
Total	*Year 3.*	*2003-2004*	*(Oct 1 - Sept 30)*	_____

Grand Total for 3 years _____

This form of schedule has proved adequate at both Oxford and Hopwood but a further itemisation of tasks has been found to be useful particularly for 'Special Requirements' as shown at the end of the specimen specification and there is omission of regular silt removal from ponds.

Appendix D

Notes on Managing SUDS ponds and Wetlands

Appendix D Notes on Managing SUDS Ponds and Wetlands

Vegetation Management

A basic principle for wetland management is a 'little and often' approach, usually involving no more than 25% clearance at any one time. This has a number of advantages:

- the organic waste produced is manageable;
- the wetland retains its general character;
- phased removal fits with a 3 year contract period;
- damage to wildlife is minimised;
- costs are spread over the contract period;
- bioremediation continues to function;
- storage volumes are maintained.

The removal of wetland vegetation may not be required for some years after implementation, although nuisance weeds or vigorous colonisers should be removed at regular intervals. However, it is eventually necessary to ensure flood volumes are retained and that bioremediation continues effectively by controlling plant growth.

The removal of wetland vegetation helps prevent the build up of organic silt and can present a more tidy appearance where wetland features are close to amenity areas.

Wetland vegetation is unlikely to contain significant pollution loading unless used at the beginning of a 'management train' and can be disposed of in the normal way by removal to compost heaps or wildlife piles. Removal from site should be a last resort.

The cosmetic removal of dead growth may be required for reasons of appearance on prestigious sites but is usually unnecessary where a natural effect is acceptable.

Although the removal of a proportion of plant growth annually is usually included in the maintenance plan it will definitely be necessary once in every 3 years to ensure required care is undertaken within the normal contract period.

Sediment Management

The various types of basins, ponds and wetlands accumulate organic and inorganic silts depending on the type of design. The management of wetland silts depends primarily on the control of inorganic silt 'at source' and regular management of organic silt accumulation together with vegetation maintenance. Silt accumulates in these systems for two main reasons - stormwater runoff brings day to day debris and silt from hard surfaces, and wetlands generate organic silt due to accumulation of plant remains in wet conditions.

Wetland Organic Silt

Where vegetation growth occurs in wet conditions the dead remains of plants can accumulate and raise the level of the wetland floor. This can be managed in two ways:

- physical removal of plant remains
- oxidation of plant remains by reducing water levels.

The appropriate method will depend on design characteristics, visual requirements and wildlife concern. However it is important to consider the place of "temporary pools" in the SUDS vocabulary as these are

seen as important habitats by conservation bodies (Biodiversity Action Plans / BAPS and Habitat Action Plans) and can reduce maintenance obligations significantly.

Inorganic Silt

It is important that the majority of wetland areas are protected (forebay or silt-trap) from inorganic silt, which is more difficult to manage and is often associated with pollution as contaminants are usually physically linked to particles.

Sediment Management and Disposal

Sediment accumulations should be removed when necessary, taking all the necessary measures to ensure the extracted material is disposed of properly and safely.

Silt removal (dredging) includes removal of inorganic silt derived from runoff across hard surfaces and organic silt formed by accumulation of plant remains. Silt removal should remove only accumulated inorganic and organic silt but not wetland subsoil or topsoil layers with protection of clay or artificial waterproof membranes. It is 'best practice' to remove only up to 25% of silt on any one occasion to conserve habitat and ensure continuity of bioremediation processes

When plants and organic silt are removed from a wetland, the remains are usually spread locally to allow them to 'dewater' and theoretically to allow wetland creatures to return to their habitat. The organic matter reduces in bulk and weight as water is lost and oxidation occurs. The silt piles can be spread as a surface mulch after a month or so which offers a relatively cost effective way of managing large volumes of heavy organic waste.

A more elegant way of dealing with organic silt is to allow occasional drying of the wetland and oxidation of plant remains in situ. This technique is a management tool that mimics the natural drying of temporary pools in summer but may only be suitable for certain wetlands where permanent 'treatment volumes' are not required or where land owners understand the cycle of events likely to occur. A design variation of this technique is to artificially lower wetland levels over a relatively short period to replicate the 'temporary pool' phenomenon. It is important that this should be done at the appropriate time to synchronise with natural biological patterns (for example not in spring when many annual species are breeding and unable to resist artificial drying of the ponds).

Inorganic silt will need to be assessed in case it needs to be classified as special waste. If this is the case it will need to be disposed of to a licensed landfill. If the inorganic silt is not special waste it can be disposed of on-site in the same manner as organic silt.

The frequency of need for these activities is difficult to predict. It is more practical to view this operation as an occasional/ infrequent activity, which may be required once in any maintenance cycle e.g. every 3 years.

MANAGING SUDS PONDS AND WETLANDS CONTAINING RARE SPECIES

MATT JONES, RIVERS & WETLANDS OFFICER
Warwickshire Wildlife Trust, Brandon Marsh Nature Centre, Brandon Lane, Coventry, CV3 3GW

Extracts from a paper given at the Standing Conference on Stormwater Source Control, Coventry University, Friday 20 September 2002

INTRODUCTION

Whilst primarily an engineering solution to a drainage issue, one of the potential by-products of Sustainable Drainage Systems (SuDS) is the creation of wetland habitats. The fear for those responsible for the maintenance of such systems is that they will attract rare and/or legally protected species, which in turn will limit their ability to manage the SuDS scheme. The aim of this paper is to highlight the key protected species that may become associated with SuDS systems, and show that subsequent management need not compromise either the functioning of the SuDS scheme, or the survival of the protected species.

The main functions of SuDS will always relate to flood control and water quality. Any system that appropriately utilises a range of techniques should not require major management intervention. However inevitably some maintenance will be required in order to ensure the dual functions of the system continue to operate effectively.

With regard to the pond / wetland elements of SuDS, two periodic maintenance activities may be required :

- the removal of accumulated silts, and
- the control of vegetation.

Such activities will inevitably impact on habitats, and the species that they support.

CONSERVATION INTEREST OF SuDS …….

MANAGEMENT PRACTICES

It is important to appreciate that the presence of protected species within a SuDS system should not prevent the required management activities being undertaken. However, management must be carried out in such a way as to avoid contravention of the relevant legislation. Every effort must be made to minimise the impact on species, whether this is direct (i.e. the killing or injuring of individuals), or more indirect (i.e. the damaging or destroying of nests, burrows or other 'habitat') – failure to do so could result in prosecution. In order to avoid this, there are two key aspects of management that need to be considered :-

- the timing of the works, and
- the employment of appropriate methods.

Timing

By undertaking management works at particular times of the year, and thus avoiding key seasons, it is possible to minimise any potential impacts on protected species.

Starting with the great crested newt, it is important to realise that they only visit ponds in order to breed – the remainder of the year is spent living a terrestrial lifestyle. Adult great crested newts enter ponds from late February in order to commence breeding, with eggs being individually laid on the submerged leaves of marginal and aquatic plants. While most of the adults will have left the pond again by the end of July, the larvae continue their development, not leaving until the end of August. Thus any work on ponds containing great crested newts must avoid the period between February and August.

With reference to water voles, the situation is slightly more complicated, since the species remains resident throughout the year. Like the newt, the best time to undertake management is influenced by the breeding cycle. Water voles suffer high winter mortality, but breed very quickly each year in order to sustain a population. Water voles have a relatively long breeding season running from March to September. It is towards the end of this period that the population is at its most robust and mobile, and this is the time that should be targeted for work on ponds that support the species.

Finally, with all nesting birds protected, works that may impact on potential nesting sites (including open water, marginal vegetation and reedbeds) must not be carried out during the nesting season which runs from approximately March to August.

The relatively simple conclusion therefore is that works should only be carried out in the autumn or the winter. However, the management of wetland habitats during the winter months is notoriously problematic - this is the wettest part of the year, so ground conditions can be very difficult, and water levels relatively high. Consequently September to November is highlighted as the best time to undertake pond / wetland management work – the critical periods for protected species are avoided (breeding and the rearing of young will be completed), while weather and ground conditions should still be most suitable for such works. [Note that early within this three month window should be favoured where water voles are present – they will still be mobile in September, but by November will be relatively inactive underground.]

Methods

Having selected the most appropriate time of year to undertake any work, the adoption of appropriate management practices will further minimise the impact on protected species. Whether de-silting or controlling vegetation, any management should be undertaken in accordance with best practice guidelines for the management of ponds. Not only will this be of benefit to the protected species, but will benefit biodiversity generally. The key principles are outlined below:-

- Ensure that methods, and particularly machinery, are suitable both to the site and the scale of the works. With reference to the control of vegetation, hand removal may prove to be the most sensitive method.

- Minimise the disturbance caused by heavy machinery by restricting the number of access points. In particular highlight and tape off any 'no-go' areas. This is particularly important where great crested newts are present, ensuring that their terrestrial habitats are not damaged, particularly any hibernacula[1].

- Avoid damaging banks. This is particularly pertinent where water voles are present, which may have a network of burrows within the banks of the waterbody. Remain as far from the water's edge as possible, to minimise compaction of the bank and damage to water vole burrows.

- Ideally any vegetation removal should not be complete. As a minimum, a fringe of marginal / emergent plants should be retained around at least half of any pond. Such vegetation not only provides egg laying sites for newts, but also food and cover for water voles, plus an important habitat for birds and dragonflies etc. Providing it is not highly invasive, some submerged and floating plant species should also be retained.

- Ensure the sensitive disposal of silt and/or vegetation (guidelines on which are available from the Environment Agency). In particular avoid damage to other areas of conservation value such as great crested newt hibernacula, water vole burrows, or other habitats such as wetlands or species rich grasslands. Further, watercourses and waterbodies should be safeguarded from any potential run-off.

ACCEPTING THE CHALLENGES …….

CONSERVATIONISTS

There is a challenge to conservation organisations. It is necessary for the sector to take a flexible approach to the management of SuDS systems. It must remember that any ponds or other wetland habitats associated with SuDS schemes are the by-product of engineering, not habitat creation projects per se. The primary functions of SuDS schemes (i.e. flood control and pollution prevention) must be appreciated, and the importance of these not compromised – the consequences of failure of the system through a lack of necessary management could have serious implications over a much wider area.

SuDS DESIGNERS

There are arguably two challenges for the designers of SuDS schemes. The first is that systems should be designed such that wherever possible the need for maintenance is minimised - for example, ensuring the volume of silt entering a retention pond is controlled by incorporating appropriate traps 'upstream' within the system.

The second is a little more controversial. Given that the management of SuDS schemes need not be detrimental to protected species or biodiversity in general, there is an argument for designing in features of benefit to wildlife.

CONCLUSION

Where there is a wetland element to SuDS schemes, habitats will be created which will be colonised by a variety of species, potentially including the rare and protected. It has been shown that provided the right approach is taken, the survival of the protected species can be ensured, without compromising either the operation or management of the SuDS system. Indeed, subject to ensuring that the primary functions of flood control and pollution prevention are met, there is no reason why the design of the system should not also actively promote wildlife. Drainage systems in the 21st Century should be sustainable and biodiverse.

Appendix E

Additional Information on Maintenance Activities and Associated Costs

Appendix E Additional Information on Maintenance Activities and Associated Costs

Filter Strips and Swales

It can be difficult to isolate the maintenance of these grass surfaces from general grass cutting costs.

For example at Oxford MSA, it can be seen that contractors with little experience of managing SUDS put a high figure to swale grass management, although the overall cost of grass cutting is similar.

Experienced Contractor	
All verges and grass areas around source control areas	£5175.00
Swale	£255.00
Inexperienced Contractor 1	
All verges and grass areas around source control areas	£3613.84
Swale	£2080.00
Inexperienced Contractor 2	
All verges & grass areas around source control areas & swale	£4650.00
Inexperienced Contractor 3	
All verges and grass areas around source control areas	£3613.00
Swale	£2135.00

The approximate areas considered are:	
Verges and other amenity grass	60,000 m^2
Swale	21,000 m^2

It is important to note that the because the swale stays wet due to unforeseen high groundwater levels, and the experienced Contractor knew that only 3 visits, on average, were required to cut the grass in any one year the price for maintenance was low.

It seems that the additional length of 100 – 150mm grass length required in swales compared to 25 - 50mm for amenity grass areas can reduce the frequency of cut required to 3 – 10 per annum, depending on local conditions. This will reduce the cost of maintenance compared to normal amenity grass but may not be reflected in the tender price because the cost is based on site visit frequency, rather than detailed task analysis.

The Hopwood Park site has a different design configuration with a filter strip serving the HGV Park and overflow swales off-line from the main water flow routes, collecting only exceptional storm flows. The result of this design feature is that the filter strip grass grows very quickly due to regular water from a large hard surface catchment whilst the swales are dry during most of the summer and require less mowing than may be expected.

Two of the contractors who tendered show very high prices to cut all the verges and amenity grass, whereas the price from English Landscapes is very low, but this figure is only for amenity grass round the swales.

Experienced Contractor	
All verges and amenity grass areas	£3430.00
Swales	£200.00
Inexperienced Contractor 1	
All verges and amenity grass areas	£14800.00
Swales	£960.00
Inexperienced Contractor 2 – prices not separated	
Inexperienced Contractor 3	
Amenity grass areas around swales	£960.00
Swales	£280.00

The approximate areas considered are:

Areas of swale and filter strip

HGV Area Swale	160m^2
HGV Area Filter Strip	520m^2
Main Site Swale	240m^2
Total Area	920m^2

The filter strip at Hopwood is visually and practically part of the grass verge and would normally be included in verge maintenance. Similarly, the swales which are within the normal maintenance envelope of the site will be included in amenity grass maintenance.

It is significant that the prices for swale maintenance are small compared to general grass cutting and that the contractors have extracted a notional sum to put against the item in the Schedule of Work.

It is important when designing filter strips and swales that they should be considered part of general site maintenance and easily accessible, so the cost of mowing will be taken as part of a total site operation rather than as a separate task. The cost of SUDS maintenance should therefore be integral with normal site care.

Filter Drains and Permeable Surfaces

Although filter drains and permeable surfaces perform similar functions, the maintenance associated with each technique is different.

Filter drains, particularly where protected by filter strips or other silt interceptors, normally only require inspection and occasional weed control.

The normal day to day maintenance costs associated with these tasks can be derived from inspection charges for other features such as inlets and outlets, manholes, rip-rap etc. Unit costs can vary from £5.00 per inspection to £100.00 per inspection.

Permeable surfaces however require regular maintenance which is described below (taken from the 2002 Formpave brochure):

The surface blocks require routine maintenance and the surface should be brushed at least twice a year with a mechanical suction brush. It is recommended that this should be carried out in the spring and after leaf fall in autumn.

Ultimately, perhaps after 25 years or more, areas of the laying course may become filled with silts and toxins. If this occurs the surface blocks should be uplifted and the affected areas of laying course material and geotextile disposed of. The existing sub-base can be left in situ. Fresh geotextile and laying course stone should be installed and the existing surface blocks re-used.

In practice it has been very difficult to find any sites which receive regular maintenance as specified. Sites are usually swept when accumulated debris is visible, and maintenance is generally undertaken without understanding of the function of the pavement.

The following assessment is based on detailed discussions with two Sweeping Contractors at a site where maintenance has been undertaken to a high standard.

It is important to recognise that most Clients and most Sweeping Contractors do not currently understand the significance of permeable paving design and function.

Maintenance of Permeable Paving at MSA's by Sweeping Contractors

The two Sweeping Contractors contacted confirmed that the normal machine used for sweeping car parks on commercial sites provides both a brush and suction function.

Bicester Sweepers (Bicester Sweepers, Glebe Court, Nr Fringford, Bicester, Oxon) use a Johnson 600 lorry mounted machine or a precinct sweeper for cleaning block paving. They consider that it is normal to sweep 60-80 car spaces a day.

The cost per day is between £250 - £300. The contractor did not consider there would be a difference in maintaining permeable or normal block pacing.

Drain Brain (Drain Brain International Ltd, Meadow Lands Farm, Bibury, Glos, GL7 5LZ) were contracted by Welcome Break Group to provide a quotation to clean the paving and associated roads at Oxford MSA M40 during late Summer 2002.

The machine proposed to sweep the paving was again a Johnson 600 with jet wash facility and brush and suction function. The contractor considered that there was no difference between permeable paving and normal block paving until informed that the slots contained 3mm grit. This was perceived as a real limitation to the use of the sweeper (see comments by Gardenworld below). It was confirmed that normal concrete blocks are sometimes lifted from the surface using the suction function and therefore the suction facility is often turned off until the blocks are bedded down which is sometimes up to a year after construction.

The cost per hour was similar for both contractors at £28 - £30 per hour and the cost estimate for Oxford was £257.60 per month. The hourly rate does not include travel or tipping charges.

The contractors were unaware that there are no gullies, pipework, manholes or petrol interceptors to maintain in permeable pavements.

The anticipated number of gullies which would be required in a conventional drainage scheme at Oxford is a minimum of 100 with 2 petrol interceptors

The cost of maintaining gullies at Oxford is £6 / hour with some jetting allowed for and is estimated at 2 days @ £600 / day = £1200.00 + disposal of waste.

The waste generated by gullies and interceptors can be disposed of at £50 / tonne / m^3 if non-special category or between £100 - £200 per tonne / m^3 if considered special waste.

Maintenance of Permeable Paving at Sanders Gardenworld – Garden Centre, Bristol Road, Brent Knoll, Somerset, TA9 4HJ

The Sanders Gardenworld Garden Centre displays a combination of permeable and impermeable surfaces, where all surface water is directed to permeable block paving and then to underground storage for reuse or to adjacent ditches known locally as rhynes or rheins. There are no gullies or interceptors on the site.

The site maintenance manager, Mr Mervyn Rawlings, explained how the drainage system works and was interviewed about the maintenance of the permeable paving.

The permeable paving was laid under supervision by Formpave Ltd who supplied the blocks, rectangular blocks in the car park (Aquaflow 100 x 200 x 80mm) and Aquaflow ML interlocking blocks (heavy duty application) in the coach park and service areas. There are approximately 4000 m^2 Aquaflow and 4000 m^2 of Aquaflow ML on the site.

Sanders Gardenworld understand the requirement for maintenance particularly as garden centre products can contribute soil and silt to block permeable paving systems.

The maintenance regime comprises daily attention to keep the pavement clean using a hand guided machine with a hoover-suction action. The machine used is a Prisma 37 and is similar to the AL-KO 750B Leaf Sweeper / Garden Vacuum Machine which is commonly available (cost approximately £400.00). Although this type of machine is modest in its action it removes a significant proportion of day to day silt accumulation. The machine is very manoeuvrable and can reach tight corners common to commercial car parks.

The company appreciate the need to clean the blocks thoroughly and this is undertaken in autumn with the hire of a large cleaning machine with 2 brushes back and front with suction facility. The machine is hired for 2 days and costs approximately £400.00 without driver or £750.00 including labour.

All block areas are cleaned to re-establish full permeability.

Mr Rawlings confirmed that they had not experienced problems with grit being removed by the suction process due to the interlock achieved when the blocks are vibrated at installation.

The site has now been in operation for 2 years (since January – March 2000) and no remedial action has been required to the surface.

The blocks have not required gritting in cold weather and there has been no ponding on the permeable surface although it was observed on the tarmac surface during the site visit.

The experience gained at the Sanders Gardenworld site suggests that the maintenance required by permeable paving can be quite flexible but benefits from regular removal of day to day debris with an occasional robust clean using a heavy duty brush and suction machine (a machine recommended by Formpave is the Applied 414/RS manufactured by Applied Sweepers Ltd, Bankside, Falkirk, Scotland, FK2 7XE Tel: 01324 611666).

In general the maintenance required by permeable surfaces is similar to that for block paving or tarmac. It is important to ensure that the brush and suction care which is now a standard technique in the hard surface sweeping industry is provided to the permeable paving.

Any additional cost for special maintenance of permeable paving will be offset by the savings on cleaning required for gullies, pipes and interceptors in conventional drainage.

Infiltration Devices

Many infiltration surfaces are part of other SUDS techniques and are maintained as part of normal landscape management.

Infiltration trenches, which are similar in construction to filter drains have been used at both Oxford and Hopwood.

At Oxford, filter drains have been used round the peripheral road system to collect runoff directly and collect water in porous pipes within the trench. The water is routed to a collector manhole which then discharges to the interceptor pond. There has been no dedicated maintenance to these filter drains apart from weed treatment and site inspection. The maintenance would have been the same if the trenches were designed for infiltration function.

These structures have been designed with a geotextile protective layer below the top stone cover and will require attention at some time in the future as part of occasional management to deal with accumulation of silt.

At Hopwood Park, there is a 'treatment trench' which is designed in a similar way to an infiltration trench. The treatment trench is protected from silt by a filter strip and so should not require remedial work for a long time. Maintenance for this SUDS feature is also occasional weed treatment and regular inspection which can be accommodated as part of a normal landscape maintenance visit.

The cost element associated with these inspections may be priced between £10 - £100 per inspection, but once contractors are familiar with the work involved it is likely that the cost will be minimal or absorbed into an integrated monthly inspection charge.

Basins, Ponds and Wetlands

Detention basins are areas for storage of surface runoff and should be free from water under dry weather flow conditions. These areas can therefore be maintained either simply as grass, when they can be managed as multi-functional spaces, or as other vegetation types such as screen planting, wet grassland or habitat mosaic. Grass maintenance is the simplest maintenance to specify but the other vegetation types can be accommodated by specification.

Ponds and wetlands require special maintenance. However they often require very little care in the first years of establishment and regular maintenance can be programmed for a time convenient to the contractor.

The more natural a pond the design, the lower the management costs and the more resilient the feature is to damage.

Many of the tasks associated with ornamental ponds are cosmetic and are not required for native wetlands.

Oxford MSA M40

The initial water features at Oxford MSA comprise three ornamental ponds which collect and store water from the buildings and begin conveyance to the balancing pond. They require regular care to maintain an attractive appearance and keep encroaching vegetation in check.

They comprise:

Pond 1	-	Formal Pond	100 m^2 (approx.)
Pond 2	-	Canal	200 m^2 (approx.)
Pond 3	-	'Natural Pond'	300 m^2 (approx.)

The SUDS water features follow develop a more natural character and comprise:

Pond 4	-	Interceptor Pond	700 m^2 (approx)
Wetland 5	-	Reedbed	650 m^2 (approx)
Pond 6	-	Balancing Pond	3650 m^2(approx)

The unit costs for maintenance to the ornamental ponds (4 visits per year) and natural ponds (2 visits per year) are as follows:

	Ornamental Ponds *4 visits / year*		Natural Ponds *2 visits / year*	
Experienced Contractor	240.00	960.00	350.00	700.00
Contractor 1	312.00	1248.00	624.00	1248.00
Contractor 2	320.00	1280.00	960.00	1920.00
Contractor 3	60.00	240.00	337.50	675.00

Hopwood Park MSA M42

The water features at Hopwood comprise 2 ponds which serve the HGV Park, 4 ponds serving the Fuel Filling Area, Coach Park and Service Yard, 1 pond serving the Car Park and a "feature pond" that takes relatively clean water from the Amenity Building roof.

HGV Park

Pond 1	-	Spillage pond (permanent water)	50 m^2 (approx.)
Pond 2	-	Balancing pond (permanent water)	100 m^2 (approx.)

Fuel Filling Area, Coach Park and Service Yard

Pond 3	-	Spillage pond (permanent water)	60 m^2 (approx.)
Pond 4	-	Wetland (permanent water)	340 m^2 (approx.)
Pond 5	-	Spillage pond (permanent water)	20 m^2 (approx.)
Pond 6	-	Balancing pond (permanent water)	160 m^2 (approx.)

Car Park

Pond 7	-	Car Park pond (permanent water)	120 m^2 (approx.)

Amenity Building

Pond 8	-	Feature pond (permanent water)	600 m^2 (approx.)

The unit costs of maintenance for the 7 natural water features and one ornamental pond are as follows:

	Ornamental Ponds *4 visits / year*		Natural Ponds *2 visits / year*	
Experienced Contractor	£60/£80	£280.00	£40.00	£80.00
Contractor 1	£250/£300	£1100.00	£240.00	£480.00
Contractor 2	£200/£400	£1400.00	£375.00	£750.00

The difference in cost between maintaining ornamental and natural ponds is demonstrated in both comparisons.

In most cases, the cost of a site visit to maintain a pond whether ornamental or natural is less than the cost of emptying a petrol / oil interceptor (£600 + disposal of waste).

Silt Management

The maintenance costs listed above do not include the removal of silt from the ponds. The guidance in this report and from Wildlife Trust managers is that ponds should be de-silted frequently rather than in a single operation when full. The experienced contractor at each site was asked to price the removal of 25% of accumulated silt from each pond (excluding the large balancing pond at Oxford), using a long arm excavator and disposing of excavated silt adjacent to the pond (subject to analysis of silt quality). Both contractors considered that the work could be undertaken for the sum of £400.00.

Recent experience suggests that this work should only be necessary once every 3 years.

The removal and disposal of silt and pond plant growth has been cited as a major cost in the management of SUDS. The findings at Oxford and Hopwood confirm that if the ponds and wetlands are relatively small or have well defined forebays to collect silt, then regular removal of small quantities of silt is neither difficult nor expensive.

SUDS support (ancillary) structures

The cost of maintaining SUDS support structures including inlets and outlets, silt traps, storage structures, flow control devices, headwalls, low flow channels and overland routes depends on a number of factors, including:

- Visibility;
- Access;
- Simplicity;
- Robustness.

Where contractors have little understanding of the structures needing maintenance, then the tendency is to increase costs.

Oxford MSA M40

The design of control structures at Oxford was influenced largely by conventional engineering and wastewater treatment technology. This resulted in the use of pipe connections with a number of manholes between open SUDS features and consequently a relatively expensive maintenance cost for inlets / outlets and control devices.

The following are prices from the experienced contractor:

	Unit Rate	***Annual Cost***
Pipe inlet and outlet from reedbed	£30.00	£360.00
Catchpit chambers (with swales, rip-rap and flow control area)	£75.00	£900.00

These unit rates reflect the requirement to lift manhole covers, inspect and clean pipes where necessary and clear blockages.

Hopwood Park MSA M42

At Hopwood Park MSA, the control structures were designed to be easier to manage and without the need for specialist equipment. They are also visible with the exception of the cut-off valves which are housed within a manhole structure. In practice it is difficult to check if the cut-off valves have been maintained as the lifting keys and valve keys are housed in the main Amenity Building. This situation also inhibits a rapid response to spillages.

Despite careful design, some SUDS control details have still attracted relatively high unit rates for maintenance from some contractors.

The following are prices from the experienced contractor:

Inlets and Outlets 22 no.	12 visits @ £50.00	£600.00
Valves	2 visits @ £10.00	£120.00
Rip-rap inspection	12 visits @ £10.00	£120.00
Grass weir inspection	12 visits @ £10.00	£120.00
Pontoon inspection	12 visits @ £10.00	£120.00
Drop manhole inspection	12 visits @ £10.00	£120.00

These can be compared with prices from the most expensive of the inexperienced contractors:

Inlets and Outlets 22 no.	12 visits @ £80.00	£960.00
Valves	2 visits@£100.00	
Rip-rap inspection	12 visits @ £40.00	£480.00
Grass weir inspection	12 visits @ £30.00	£360.00
Pontoon inspection	12 visits @ £30.00	£360.00
Drop manhole inspection	12 visits @ £40.00	£480.00

However following detailed discussion with Neil Farmer of English Landscapes, who visited the site and saw how the control devices were working, a much lower set of prices were provided in the accreditation check.

Inlets and Outlets 22 no.	12 visits @ £10.00	£120.00
Valves	2 visits @ £10.00	£120.00
Rip-rap inspection	12 visits @ £5.00	£60.00
Grass weir inspection	12 visits @ £5.00	£60.00
Pontoon inspection	12 visits @ £5.00	£60.00
Drop manhole inspection	12 visits @ £5.00	£60.00

Inspection of these SUDS support structures and simple clearance of blockages when necessary should only take minutes to complete. The monitoring of the SUDS system at each monthly site visit should be undertaken as part of a multi-task operation and quickly become part of a simple checklist activity.

In order for the inspection costs to be kept low it is important that the structures are highly visible so that physical intervention is only required when a problem is evident. At other times the contractor can move quickly from inspection to inspection without incurring unproductive time in lifting covers or checking pipes.

Appendix F

Greenbelt Company – Landscape Specification Notes

Appendix F Greenbelt Company - Landscape Specification Notes

The Greenbelt Group of Companies Ltd have proposed innovative solutions to the management of sustainable drainage systems.

The following management objectives and maintenance notes have been taken from a recent draft (29.10.01) specification. Sustainable Urban Drainage Systems – A solution for their management and maintenance.

MANAGEMENT OBJECTIVES

Before, during and for 12 months (or other period agreed between the GBGC and the developer) after completion of the development, GBGC objective is to ensure that the features for which it will become responsible are designed, constructed and maintained to standard acceptable to the GBGC.

These required standards will be described in the Management Plan provided by the GBGC before development commences.

After handover, the GBGC will continue to operate the system as designed, maintain it as per the management plan and will ensure there are no health and safety risks beyond those identified and accepted in the management plan.

The key objectives to be addresses by the design and management of the system are:-

a) to ensure public safety
b) to ensure satisfactory maintenance and operation of the system according to all relevant consents and licences and provide the protection against flooding as per the design.
c) to protect water quality through the interception, retention and/or natural treatment of diffuse pollutants.
d) to maintain public liaison in order to explain the role of the system and features and the importance of maintaining clean discharges from the surface water system.
e) to manage and develop the visual amenity of the system by maintaining the soft landscape as per the maintenance programme including:-
    I grass and other vegetation cutting
    II litter picking
    III structure maintenance
    IV inspection and management of trees including coppicing
    V inspection and repair or perimeter fences, gates, penstocks and other features

MAINTENANCE

At the initial assessment stage, the developer will submit proposals for GBGC's approval for a future maintenance plan for the surface water system which is to be taken over by them.

At detailed design stage, it is likely that this plan will be revised with the GBGC's approval.

It is anticipated that the design will incorporate features to reduce future maintenance activities and costs. Inclusion of features which, by maintaining all parts of the system, can reduce the need for

large scale maintenance activities are to be encouraged. For example, regular street cleaning and gulley emptying together with the provision of silt traps on surface water systems will reduce the frequency of silt removal from ponds. The later can have significant effects on the ecology of any pond.

Typical maintenance access requirements are shown on the attached sketches. Larger machinery may be used in certain circumstances but specific agreement will be required from the GBGC.

In some cases, improvements on existing watercourses or ditches to be incorporated in the drainage system can be made to facilitate maintenance and environmentally enhance the system as shown on the attached sketches. Any amendments will be assessed by GBGC to ensure retention of design capacity and acceptable access for maintenance.

Maintenance of systems during construction and for the 12 months (or other period agreed between the GBGC and the developer) after the development is complete will be the responsibility of the developer. The developer should take all possible measures to prevent debris of any kind entering the surface water drainage system. This will require a strict system for disposal of waste especially plastic, expanded polystyrene and other wind blow substances.

The developer is generally advised to either install a temporary sacrificial system during the construction phase, or to construct temporary interceptor lagoons in order to trap suspended solids or pollutants prior to discharge into the system to be transferred.

The developer will keep records of maintenance activities, in particular silt removal operations. It is possible that this information can be used to make modifications to the on going maintenance plan which will be adopted by the GBGC on handover.

The GBGC will carry on maintaining the system according to the maintenance plan. They will also respond in the appropriate manner to reports or work required from property owners/occupiers and neighbouring land owners.

Maintenance of any surface attenuation feature will at times unavoidably have an effect on the ecology of the system. It is important that these types of maintenance operations are identified at an early stage especially where they are necessary to maintain storage or flow capacity. It may be desirable to time maintenance to take account of species habitats, so periodic surveys should be undertaken to assess this as part of maintenance planning.

Access for safe, mechanised maintenance is frequently overlooked in the understandable wish to maximise developable areas. Whilst small, localised restricted areas can be accommodated, designs which require extensive hand maintenance must be avoided.