CREW CENTRE OF EXPERTISE FOR WATERS

Retrofitting Sustainable Urban Drainage Systems to industrial estates

Summary report

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Retrofitting Sustainable Urban Drainage Systems to industrial estates: Summary report

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Hydro Nation International Centre

The James Hutton Institute

Scottish Government
Riaghaltas na h-Alba
gov.scot

CREW CENTRE OF EXPERTISE FOR WATERS

Published by CREW – Scotland's Centre of Expertise for Waters. CREW connects research and policy, delivering objective and robust research and expert opinion to support the development and implementation of water policy in Scotland. CREW is a partnership between the James Hutton Institute and all Scottish Higher Education Institutes supported by MASTS. The Centre is funded by the Scottish Government.

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Please reference this report as follows: Arthur, S., D'Arcy, B., Semple, C., Sevilla. A. and Krivtsov, V. (2020) Retrofitting Sustainable Urban Drainage Systems to industrial estates. Summary report. CRW2016_10. Available online at: crew.ac.uk/publications

ISBN: 978-0-902701-74-8

Dissemination status: Unrestricted

Acknowledgments: The team would like to thank all participants in the study, and SEPA, Scottish Government and Scottish Water for their contributions via the project steering group.

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Executive Summary

Research aim

Industrial estates are a well-recognised cause of pollution and Sustainable Urban Drainage Systems (SUDS) have been identified as an important option to address the pollution risk (Kim *et al* 2018, D'Arcy *et al* 2018). This study aimed to investigate the potential for retrofitting SUDS on industrial estates in order to try to reduce pollution of watercourses.

Background

As part of the Scottish Government strategy to manage diffuse pollution (WEWS Act 2003), Ministers directed Scottish Water to implement a capital programme of retrofits for some industrial estates where evidence suggested the surface water discharges had an impact on the quality of the receiving waters. Subsequent investigations by Scottish Water as part of their Quality & Standards investments, in collaboration with SEPA, found serious constraints in many situations for retrofitting adequate size end-of pipe solutions. Therefore, the project reported herein focused primarily on source control SUDS, or at least SUDS on an individual property basis, as well as conveyance types of SUDS[1].

Research undertaken

The principal research site was Houston Industrial Estate, Livingston, which has over 100 businesses (exact numbers and businesses change over time) and includes major, extensive factory premises, as well as intermediate-size factory premises and many small industrial units typically managed by a landlord or agent. In addition, one sector of the estate has been redeveloped since the statutory requirement to use SUDS technology was established in Scotland. That allowed the project to assess the maintenance of the SUDS installed at that time (largely permeable paving) as well as the SUDS awareness of those businesses (mainly commercial, but including one industrial site).

The research methods included:

1. An initial SUDS awareness survey conducted via in-person visits and a written survey.
2. Verification visits to investigate answers given by respondents concerning the presence of example SUDS features on their premises.
3. Detailed follow-up with several premises to explore barriers and opportunities to retrofitting SUDS in their specific circumstances.
4. A breakfast seminar and focus group at which participating businesses could focus on the project aims and offer input without the pressure of an official survey.

Key findings

Over 100 addresses were contacted at Houstoun Industrial Estate (HIE) and 65 responses were obtained. Of those, 13 claimed to have 3 or more different types of SUDS on their premises. Follow-up visits failed to verify those claims. The only common type of SUDS found in reality was permeable pavement, which has been extensively used for newer areas of car parking. Three examples of genuine filter drain features were also found (each on a redeveloped industrial site out with the commercial sector). It became very clear that there was extremely limited awareness of the various types of SUDS available to a business or a developer. That was not surprising given the nature of the businesses (not generally involved with drainage infrastructure or environment). The permeable pavement areas were often used to accept runoff from conventional sealed tarmac road surfaces; in almost all circumstances they seemed to be blocked.

On the more industrialised sites where gravel drains had been provided, they were only in reasonable condition at the site where the occupying business had been involved in specifying the drainage system (see Chapter 7, Case Study 2). One notable exception was the extensive industrial site described in Case Study 4, Chapter 8, where the surface water drainage from most of the site drains to a treatment pond. That pond is in effect a SUDS end-of-pipe facility treating the runoff from an extensive area which is essentially an industrial estate itself. Without it, the pollution load on the Caw Burn would be even greater and impacts more severe.

The very limited awareness of either the legislation or the technology surrounding SUDS suggests a retrofit programme or initiative without associated education and engagement would at best create features destined to be neglected subsequently. It also has implications for new build and general use of SUDS; there is a major need for a sustained engagement and education effort by all the organisations involved in driving SUDS into routine business.

Conclusions and recommendations

The study identified 3 broad classes of barriers to retrofits: Cost, time, and space. More detailed comments and views were identified in one-to-one dialogue during the initial

[1] Source control SUDS are not the responsibility of Scottish Water to maintain. Scottish Water is responsible for the operational maintenance of vested SUDS out with the curtilage of properties, draining more than one property and built to the standards outlined in Sewers for Scotland, currently the 4th Edition (Scottish Water, 2019).

survey and follow-up visits, in dialogue with the case study businesses, and at the breakfast seminar and focus group. They included:

1. Some of the smaller businesses felt that infrastructure was a matter for the head office and not their concern.
2. Businesses in rented property felt this was an issue for the landlord or agent.
3. Businesses were wary of possible extra costs when they already pay so much in business rates and water charges.

Opportunities identified were:

1. Recovering value from surface water drainage (rainwater harvesting but including end-of-pipe capture in treatment ponds as well as close-to-source roof or yard capture systems).
2. Public sector support for provision of SUDS on individual premises, for example by discounts on water charges or businesses rates, or green business support schemes analogous to energy innovation programmes. This may be complemented by the Scottish Government asking the water industry to undertake an assessment of the alternatives to the current use of rateable value as the basis of charging business premises for drainage.
3. Third party partnership support/funding for retrofits in return for adoption in perpetuity by the businesses including all necessary maintenance and refurbishment.
4. Planning SUDS retrofits as part of scheduled refurbishment work (e.g. road, yard or roof).
5. Retrofits wholly at the expense of the business as part of sustaining a green and progressive image to customers and suppliers.
6. A major inescapable need is for education and engagement with businesses, including support to grasp opportunities as well as understand requirements. There is clearly scope for reviews of public sector charging schemes and scope for cost-effective achievement of retrofits perhaps in partnership initiatives. That applies to the private roads on an estate too (within the larger sites), and also the connecting road networks in the ownership of the private landlords and managed by their agents. For public roads there is already the scope for Section 7 agreements between the local council and Scottish Water.

1 Introduction

Industrial estates are a well-recognised cause of pollution and Sustainable Urban Drainage Systems (SUDS) have been identified as an important option to address the pollution risk (Kim *et al* 2018, D'Arcy *et al* 2018). This study aimed to investigate the potential for retrofitting SUDS on industrial estates in order to try and reduce pollution of watercourses.

As part of the Scottish Government strategy to manage diffuse pollution (WEWS Act 2003), Ministers directed Scottish Water to implement a capital programme of retrofits for some industrial estates where evidence suggested the surface water discharges had an impact on the quality of the receiving waters. Subsequent investigations by Scottish Water as part of their Quality & Standards investments, in collaboration with SEPA, found serious constraints in many situations for retrofitting adequate size end-of pipe solutions. This project therefore investigated the potential for the retrofit of source control and conveyance SUDS for individual industrial premises at Houston Industrial Estate - a substantial area which represents the range of industrial estate types found in Scotland and elsewhere. Within that context, the objectives of the project were to:

1. Work with key stakeholders to identify the typical barriers to SUDS retrofit (e.g. financial, space, land ownership, education);
2. Work with business/land owners to understand what types of SUDS would be suitable given the risks and any constraints presented at the site;
3. Assess the businesses' willingness to install and evaluate the role incentives can play;
4. Produce case studies for Houstoun Industrial Estate which allow the project findings to be easily transferred to other sites.

2 Background

Industrial areas result in two forms of stormwater pollution, acute and diffuse (Chiew *et al.*, 1997). Acute pollution occurs as a result of an incident or accident, for example a major spill, malfunction or overflow. Diffuse pollution is the weather-driven mobilisation of contaminants from the landscape into the water environment (Campbell *et al.*, 2004). It is often chronic, and its characteristics are a function of the drainage catchment (e.g. land use, topography, soil). Industrial estates are not homogenous, and pollution risks are a function of the industrial land use. This form of pollution occurs continuously and requires ongoing management to protect receiving watercourse water quality and is linked to poor stormwater management.

Diffuse pollution from industrial estates has been identified to be a major cause of low river quality (EU WFD classification), in one instance contributing approximately 12% of the degrading pollutants in watercourses (SEPA, 1996).

In response to this, the Scottish Water Quality and Standards Investment programme implemented from 2006 (SR06 [2]) is one of the most significant water investment projects in Scotland to date. As part of this programme, Scottish Water funded a SUDS retrofit scheme for industrial development areas, such as the Houstoun Industrial Estate near Livingston, with the aim of improving discharge water quality and thus the ecosystem services and quality of the receiving urban watercourses. The research conducted within that project focused on implementing wetlands and ponds to improve existing industrial estate runoff. The retrofitted SUDS comprised of end-of-pipe systems, in accordance with the remit of Scottish Water, although these were constrained in many cases by land availability. Several risks and appropriate actions were identified through this work which were applicable to future industrial estate water quality management.
The work reaffirmed the lessons learned at the earlier (1996) retrofit of a small wetland created to improve to treat flow from the industrial estate and thereby protect quality of the Caw Burn. Although the retrofit wetland has had significant success in improving water quality, restoration of the Caw Burn to satisfactory condition has been held back by intermittent pollution episodes, as well as overloading on a routine basis, which has highlighted the need for SUDS retrofit measures at source. The programme identified a constraint in land availability within developed and active industrial sites. To address this, the Surface Water Action Plan (SWAP)[3] initiative was implemented, designed to identify site-specific best management practices (e.g. bunding of toxic material storage, appropriate maintenance of oil separators) which, while not providing water quality benefits to the extent of a retrofitted SUDS asset, do help limit the acute pollution risk to stormwater and the downstream watercourse. This initiative has been supported by legislative requirements governing industrial site discharges since 2005 (Controlled Activities Regulations, 2011).

[2] In 2006-2010 investment period (SR06) the approach was to retrofit SUDS where feasible. Where this was not possible Surface Water Action Plans (SWAPs) were prepared. In 2010-2015 (SR10) and 2015-2021 (SR15) investment periods the approach has been to undertake studies and prepare SWAPs.

[3] A Surface Water Action Plan (SWAP) identifies the impacted area, causes of downgrade and sets out recommended actions, timescales and responsible parties for delivery. These are agreed with SEPA. The SWAP approach focuses on source control rather than end of pipe.

2.1 Survey of business/land owners

A questionnaire was designed to gauge awareness of SUDS technology and relevant pollution regulations. The questionnaire had a 'Yes/No' format and contained a checklist of 10 types of SUDS features and asked for a response to whether or not the company is familiar with the technique, and whether or not there is an example of it on their premises. Colour images were used to aid recognition of specific features. This questionnaire was posted or emailed to the majority of premises on the estate and delivered by hand when that was not possible, or when no response to the original letter was received.

In total 65 responses were received. The analysis of the results revealed that 90% of the companies claimed familiarity with at least one SUDS technology. However, whist the majority of the companies appeared to be familiar with specific SUDS features illustrated on the checklist, most (75%) were unfamiliar with the term 'SUDS'. The majority of these companies (77%) were familiar with more than one feature (Figure 1). However, many of the potential techniques were unfamiliar to most companies. Observations and analysis of the questionnaire results also revealed that some of the newer premises already appear to have SUDS. These are predominantly areas of permeable paving and, to a lesser extent, gravel filter drains. A number of companies also claimed ownership of other SUDS features (e.g. detention basins). It was also found that less than a quarter of all companies were aware of general binding rules (GBR) regulating pollution prevention at industrial sites, and ownership of the premises did not appear to be a decisive factor influencing that knowledge.

3 Verification of the Survey Responses

To further understand awareness, respondents to the survey were visited to verify their claims about the presence of SUDS on site. In general, as shown in Table 1, it was found that the vast majority of the claims could not be substantiated.

Whilst the primary purpose was to validate or 'ground-truth' the claims, the secondary aim was to assess the condition and maintenance of any existing on-site SUDS features. Permeable pavements were found to be the most common SUDS technique for the premises built since use of SUDS became a policy and statutory requirement in Scotland. The way it has been used in Houstoun Industrial Estate is undesirable (with hindsight): permeable block car-park spaces served by conventional tarmac road surfaces. In several such roads there is a significant slope and the car park spaces at the uphill side of the access road were often clean and probably still permeable (if water remains long enough to infiltrate before running off downslope), whilst the downslope bays were typically blocked and not functional.

Gravel filter drains were also identified in a number of locations and were generally found to be performing adequately. Contrary to claims on the simple questionnaire, the only other types of SUDS found on individual were retention ponds. Although not originally identified as ponds by one owner, surface water drainage

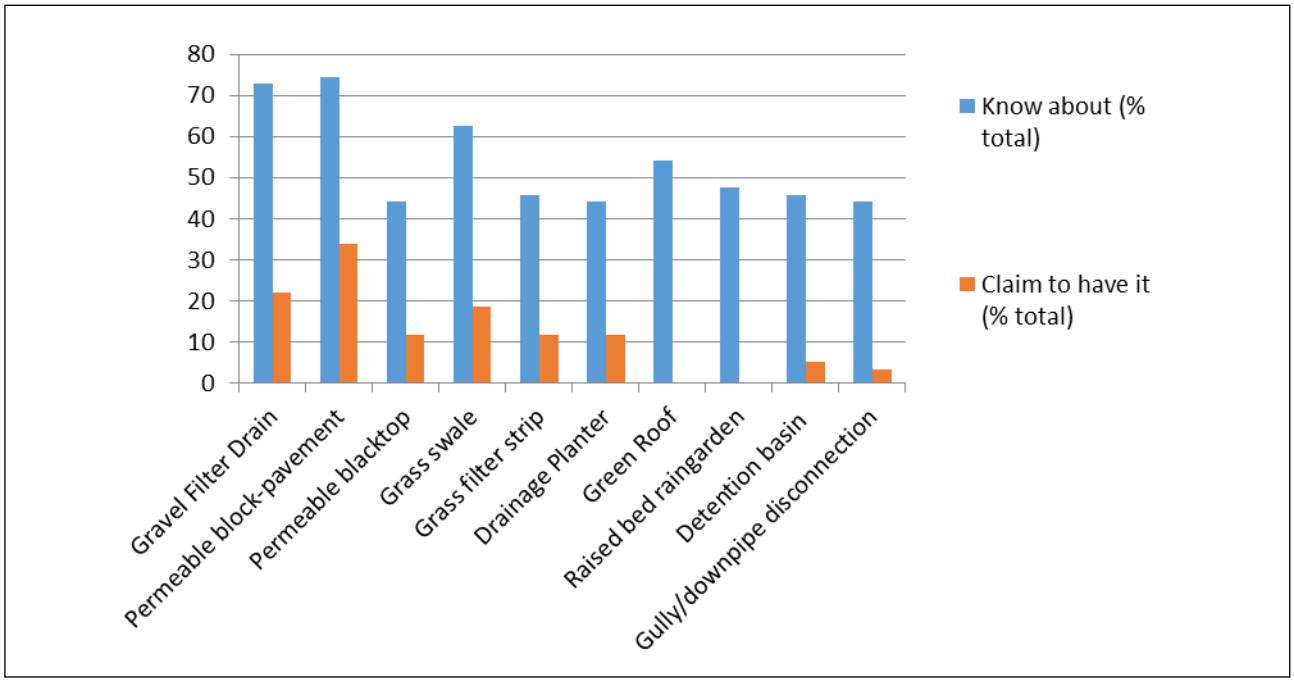

Figure 1. Claimed familiarity (%) with and ownership of specific SUDS features.

Table 1: The number of premises reporting they have each type of SUDS identified in the initial questionnaire			
SUDS Types	**No. premises CLAIMED**	**No.premises VERIFIED**	**NOTES**
Green roof	0	-	Correct: none seen on visits
Raised bed raingarden	0	-	Correct: none seen on visits
Gully or downpipe Disconnection	2	0	Two gullies diverted into a man-hole in the road [not into greenspace!]
Detention basin	3	0	None seen on visits
Drainage planters	7	0	None seen on visits
Permeable blacktop	7	0	None seen on visits
Grass filter strip	9	0	None seen on visits
Grass swale	11	0	None seen on visits
Gravel filter drain	14	4	Only 4 real examples found. Others refer to gravel surrounding the base of buildings.
Permeable block pavement	20		Ubiquitous on new & redevelopments (but not always recognised by occupiers).

from almost their entire site drains into a broad open channel served by an oil boom at the outlet end, where it passes into an initial smaller pond which serves as a sediment forebay. The outlet from that pond passes flow into the larger pond, from which water is abstracted for use on the plant. Excess flow discharges into a drain (presumably the culverted Caw Burn) via an outflow on the opposite side and diagonally across from the inflow at the far end of the rectangular pond. Pond water quality appeared good.

There appear to be no shared SUDS features around the estate visible from the access roads. Given the large-scale verification efforts for this project, it is possible (although unlikely) that there are a small number of additional SUDS which may exist within the small number of individual premises not visited for various reasons during the study.

4 Case Study Development

Based on the survey and verification work, it was concluded that general awareness of SUDS approaches was not good, and that to promote them it was desirable to work with business/land owners to generate four case studies to highlight how SUDS could be retrofitted.

4.1 Case Study 1 – Transcal

The building construction consisted of three sides of corrugated metal with the fourth side, facing approximately north-north-west, mostly comprised of glass (Figure 2). The roof is angled with a central peak, falling to the east and west, and is constructed of cladding. A basic assessment of the structure contours from the provided borehole data have led to the conclusion that a clay layer will cause any infiltrated runoff to travel in an approximate east-south-east direction. Transcal manufactures seats and interiors for the automotive and aerospace sector. There is no treating of hides on site as the leather and faux leather used is treated elsewhere and transported to the site. Because of this, there is not likely to be any hazardous chemicals or processes involved in the day-to-day operation of the manufacturing line.The current system of drainage uses the traditional method, i.e. impermeable surfaces channelling runoff to a surface water drain, the latter going to the Caw Burn. During the site visit, it was found that there have been no problems with flooding.

In addition to the main car park (48 spaces), the delivery yard is also used for parking vehicles, private and company owned. During the site visit, there was only one marked company vehicle present. It was noted that there is a significant amount of debris and clutter in the delivery yard which has the potential to contaminate runoff if not managed properly. This debris consists of an open skip, a pallet of gritting salt, two large storage containers, various sizes and lengths of rusted metal parts and other material. There are large areas of green space within the Transcal boundary around two sides of the building that are currently not being used but it does provide natural drainage.

The possibility of creating a retention pond was immediately discarded as Transcal was concerned about the health and safety implications of having a body of water beside the path. It would be possible to provide a fence but the visual impact on the surrounds may be considered too intrusive and an additional expense. The alternative of a detention basin was much more acceptable as the detention basin will be in a drained state

Figure 2. Overview of the Transcal Case Study Site.

except during storm events. After discussing the issue further with the Transcal, there are two approaches which were considered to provide permeability of the surface of the Transcal site - permeable asphalt (PA) and permeable block paving (PBP). Depending on the configuration chosen, three options were available:

1. Option 1: Yard and roof discharges to the basin, PA across all other surfaces
2. Option 2: Yard and roof discharges to the basin, PA on road surfaces, PBP on car park spaces
3. Option 3: Yard, roof and road discharges to the basin, PBP on car park spaces only

In addition to the above, the premises would also benefit from the installation of swales, flow attenuation tanks, and raised bed planters. Further details can be found in a recent conference paper (Krivtsov et al 2019).

4.2 Case Study 2 – Unnamed Company

The building consists of four sides of corrugated metal with a small glass reception area facing approximately west-south-west. The roof is angled with a central peak, falling to the north and south, and is constructed of cladding. As well as the building, the site comprises a large storage yard, a car park, a depot and some rough ground.

The owner supplies vehicles for hire to the construction industry. The foreman on site stated that the plant equipment is cleaned by the contractors before being returned. The vehicles are then moved down to the vehicle wash on the site for a thorough clean before being moved for servicing and rehire.

Onsite there is a small strip of grass of approximately 20 metres long and 2 metres wide, this runs alongside the delivery yard. There is a fence running down this strip with another 1 metre of grass on the other side and it is unclear who owns the land between the two companies. A second area of green space is present on the western side of the site but is possibly too small to be used effectively. The section 'Rough ground' to the north has a small rundown office on it with various other debris. It has been allowed to grow wild as it is not currently being used.

The yard is fitted with a silt trap which discharges to a filter drain. The vehicle wash comprises a concrete slab that falls towards a drain in the centre, thereby preventing contaminated water running onto the surrounding ground. This drain leads to an oil separator where any detergents are contained allowing the water to discharge to the foul sewer that is shared by Speedy Services.

Part of road surface within the site could be replaced with permeable paving or porous asphalt, but this may restrict the movement of heavier vehicles. Nonetheless, the use of permeable block paving can be used on the car parking spaces.

The delivery yard was measured, and basic tests suggested water flowed from the north area to the green space while the remainder moved east or south to the gullies. This simple test showed that it would be of use to create a swale on the green space there if the kerb along its length was removed/modified in such a way to provide entry points for the water.

It would also be prudent to create a filter strip along the east and south side of the delivery yard to contain contaminants before water enters the drainage network. The total length of the filter strip would be approximately 36 m. It was recognised, however, that one of the drawbacks of the filter strip is that it would reduce the amount of space available to keep vehicles and material before they can be moved to the storage yard.

The roof has been split into two halves that have three downpipes leading from each side. As such, the use of attenuation tanks and raised rain gardens would provide a method of attenuation. In this case, using raised bed gardens on the south side of the building could provide an aesthetic feature with attenuation tanks recommended on the north side of the building.

4.3 Case Study 3 – Whyman Gordon

The Wyman Gordon (WG) site is in the eastern part of Houstoun Industrial Estate. The business operations in WG at this location are forging metal components for the petrochemical and aeronautical industries. The range of products produced onsite includes jet engine shafts, valves able to function under pressure for oil and gas industries, seamless extruded metal pipes, and other high specification products.

The site is drained by a separate sewer system, with surface pipes draining most of the site into a stormwater pond, and foul sewers draining into the Scottish Water sewer network (Figure 3). There is an effluent treatment facility which takes trade effluent and pre-treats it prior to discharge into the foul sewer, under licence from Scottish Water. The treatment comprises oil interception and pH adjustment.

The case for retrofits at Wyman Gordon is to protect the pond, which represents a valuable water resource for the company, as well as the environment from an excess of

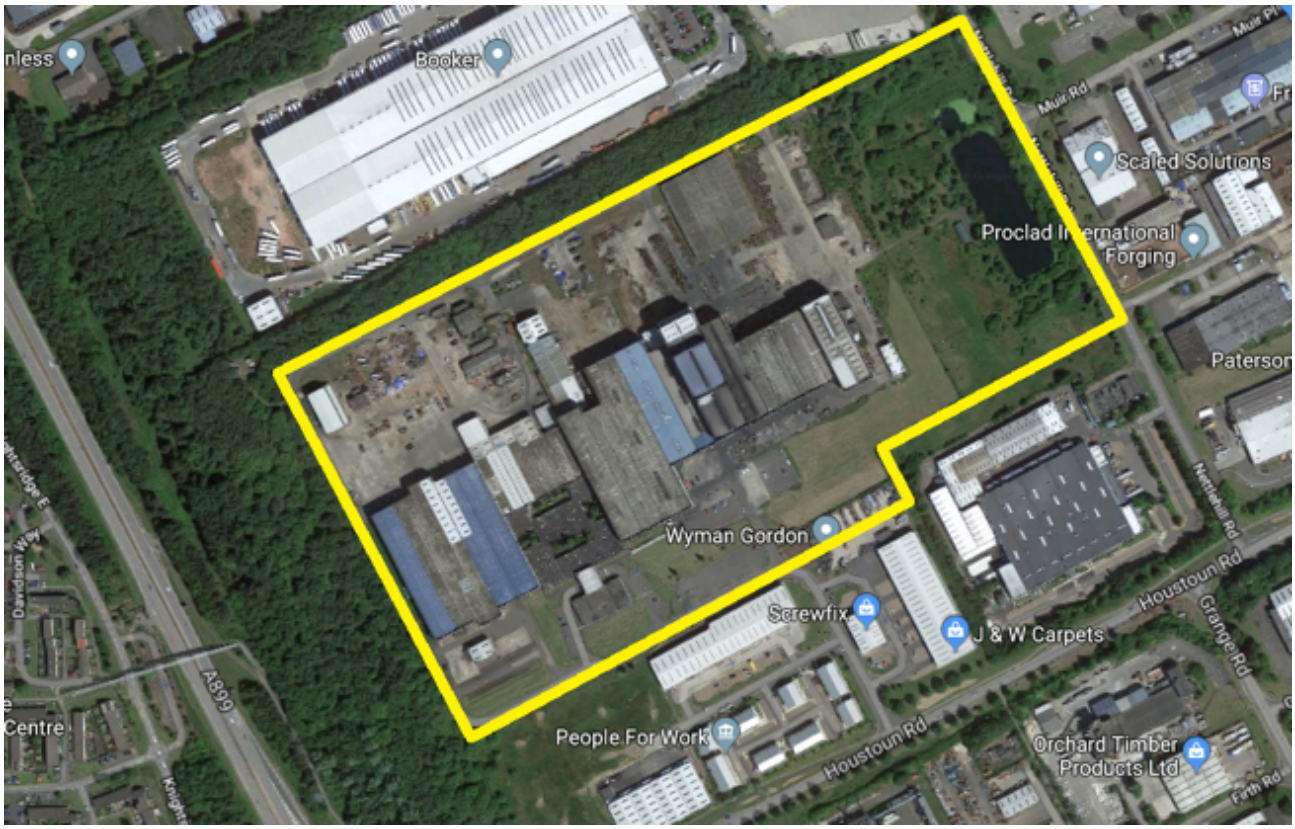

Figure 3. Overview of the Wyman Gordon Case Study Site.

contamination from activities around the site. In particular, retrofit SUDS features would provide two categories of benefits:

a) Contingency planning - to allow localisation of dangerously polluting materials in case of accidents, spills or leaks.

b) Day-to-day first level of clean-up, close to sources of contaminated runoff around the site.

In respect of purpose (a) above, there is an important approach road (typically only modestly contaminated, but potential hazard nonetheless) which does not drain to the ponds; that would therefore be the environmental priority for a retrofit. Surface water drainage from it (and the adjacent extensive visitor car park) discharges via a limited number of road gullies into a different branch of the drainage network serving the estate. However, there flows could be managed using a length of grass verge in the ownership of the company if it was converted into a swale.

The potential swale to help manage pollution risks at the road and oil/chemicals handling areas would assist in protecting the valuable water resource of the ponds at the factory by achieving capture and treatment at source. It may also help improve day-to-day practices and care in handling the potential pollutants.

The visitor car park, which is out with the main factory boundary fence, is served by three road gullies located in the tarmac at the downhill part of the car park. They are close to some crash barriers which demarcate the car park from the road. It should be possible to excavate some biofiltration planters (in-ground raingardens – potentially proprietary units) to receive the flows from the gullies instead of their current connection to the drainage system.

4.4 Case Study 4 – Public SUDS

Three different retrofit possibilities were considered to install SUDS in public / shared spaces:

1. Public sector roads with no additional drainage connections.
2. Private (unadopted) roads, maintained by landlords or their agents on behalf of owners or occupiers.
3. Public SUDS in the sense of the definition in the Water and water Environmental Act 2003 (shared drainage features within the remit of Scottish Water, subject to compliance with their Standards).

The Scottish SUDS for Roads manual (Pittner and Allerton, 2010) identifies 5 types of SUDS features or techniques which provide effective treatment for road runoff:

1. Grass filter strips
2. Pervious pavements
3. Grass swales
4. Filter drains/Infiltration trenches
5. Bioretention areas

The manual includes a section on the benefits of retrofits but does not offer any suggestions for additional ideas, modifications to existing infrastructure or discussion of methodology for retrofit assessments. For this study, in addition to the 5 SUDS techniques listed, the potential for gully diversion into greenspace was considered as an appropriate technique. This technique could be either a diversion into a length of swale or other feature (instead of total removal of kerbs) or it could be a feed into an in-ground raingarden, gravel filter, infiltration drain, or other feature (bioretention). For this project three considerations were important in identification of the potential for retrofitting SUDS to address road runoff:

a) The availability of potentially suitable green space immediately alongside the road edge (typically bounded by the road edge kerb);

b) Scope for build outs or gravel filter drains; and

c) The condition of the road and potential for major refurbishment.

A survey form was used in order to collect information on the roads around the estate and the possibilities for retrofit SUDS serving just road runoff.

Two roads were identified as possible candidates for retrofit SUDS (Houstoun Road and Firth Road). Firth Road was selected to be a case study for a virtual swale retrofit, because it could potentially drain into a possible detention feature in open grassland on the estate. Even without the detention feature, it could be retrofitted to simply take road runoff and become a road drainage swale.

For a public SUDS feature (WEWS Act 2003 definition, c/o Scottish Water) the method was to seek a large area of green space at a low level in relation to surrounding and up-hill areas of the estate, into which surface water could, in theory at least, be diverted.

Using these approaches 6 retrofit proposals were developed for public/shared space within the industrial estate, these were largely focussed on key arterial routes through the area.

4.5 Business Breakfast Workshop

Although the Case Studies were developed in partnership with the key stakeholders, it was considered appropriate to explore the barriers further in a workshop setting. Within that context, Specific invitations were emailed to 45 of the Industrial Estate businesses for whom names and addresses had been confirmed, spanning a spectrum of premises from rented SMEs to large, extensive and complex industrial sites. To encourage an atmosphere of business-led dialogue, one of the larger businesses on Houstoun Industrial Estate (DS Smith Packaging) agreed to

host the breakfast seminar.

It was hoped to have 6 - 10 different industrial/ commercial premises represented in the focus group; the optimal number. Larger numbers of participants would tend to split into small sub-groups with independent and unrecorded conversations which may be off-topic. Representatives from eight different companies attended, from small enterprises of <10 employees to larger businesses with 100-1,000 staff. In addition, a representative of Scottish Water (Trade effluent control) participated.

Three open questions were developed based on information gained during early stages of this project and discussions with the project steering group:

1. What opportunities are there for SUDS retrofit on your premises?
2. What barriers are there for SUDS retrofit on your premises?
3. What incentives may be useful?

In a preamble several useful points were made by the businesses present, blocked drains and sediment and litter were often mentioned and interlinked:

1. *"Drainage systems are old and have accumulated sediments"*
2. *"Drains are often blocked"*
3. *"At rush hour a lot of litter is discarded and may be part of the blocked drains problem"*

Flooding was suggested to be a function of the blocked drains and sediment.

The focus group discussion followed and ran for over an hour. In relation to barriers example points offered included:

1. *"…for small businesses it is very difficult to do things we [the project] are looking for"*
2. *"Who will pay? We are already paying too much"*
3. *"…could existing charges be reduced?"* [water charges, rates]
4. *"much of the drainage system is the responsibility of private landlords… the landlords need to be educated"*

Surprisingly, several opportunities and incentives were identified:

1. *"…if we can divert some of the contaminated water can we get a discount [from Scottish Water]?"*
2. *"…Are SUDS ECA compliant?"* [ECA relates to the Enhanced Capital Allowance (ECA) scheme which is concerned with energy; could something like that be introduced for drainage?]
3. *"…how many roads in HIE are owned by the council?"* [implication being that a significant proportion of the impervious area could be addressed by retrofits for the public road; match any efforts by the businesses for their property]
4. *"…employees care both about the company and the environment"* and *"an ethical business… will be valued both by the workforce and the clients"* [in relation to statement about having Green Apple awards]
5. *"…we have a VIBES award and it's important for workforce and customers/suppliers"*
6. *"…people who work in HIE also live locally as well, many are active in the community, and they do care about the environment"* [endorsed by the business from Fife for their situation too].
7. *"…there is scope for governmental help with water harvesting; that would decrease runoff and discharge and should therefore reduce the costs/charges".*

Habitat and amenity were also suggested by a business as a positive consideration, with one person commenting: *"…if scraping out a grass verge to make a swale, why not do a wild flower seeded turf, rather than just conventional grass?"*

The overall range of comments and observations may be summarised as follows:

1. There is a need for an association of businesses to provide a collective voice to address a broad variety of issues as well as provide a focus for help and dialogue on environmental issues.
2. There was genuine interest from the participating businesses in the drivers for SUDS technology and potential for retrofits on a plot-by-plot basis.
3. Costs are certainly a consideration and several businesses showed interest in reductions in water charges in return for disconnection or installation of SUDS units with return flow at slower rate to existing drains.
4. Similarly, there was interest in recovering value from rainfall on the premises (washing/flushing toilet etc); several businesses use a lot of metered water which is a significant cost.
5. There was little indication of hostility, in principle, to retrofits.
6. More innovation in charging schemes by public bodies should be encouraged by the Scottish Government to help businesses (on all issues) and especially in relation to being able to retrofit SUDS cost-effectively for all parties concerned.

In summary, in the terms of the focus group questions, the following points were noted:

1. What opportunities for SUDS retrofit on your premises?

1. Diverting flow from a gully into adjacent grass areas.
2. Downpipes when on outside of walls, especially if old and in need of repair/replacement.
3. Using the grass lawn areas.
4. Raised bed raingarden looks nice.
5. Enhancing the work place.

2. What barriers for retrofit SUDS on your premises?

1. Cost; but unaware of the options and what they might cost.
2. Space e.g. in general, but also specific examples such as a downpipe is close to a door or window.
3. Downpipes are sometimes inside the building, making diversion to an attenuation unit or feature more expensive.
4. Soils not thought to be good for infiltration in Houstoun Industrial Estate.
5. Maintenance?

3. What incentives may be useful?

1. Discount water charges.
2. Discount local business rates.
3. Government supported scheme equivalent to energy incentives.
4. Rainwater harvesting (replace and hence reduce some of mains water requirement).
5. Environmental awards.
6. Environmental accreditations.

In summary, for the 8 businesses who participated, principal barriers were, as anticipated, space, cost and time. Principal opportunities were financial incentives such as recovering value from rainwater harvesting, reductions in business rates, or reductions in water charges in return for provision of retrofit SUDS, but also positive factors such as business environment awards to show their customers and staff (e.g. VIBES, Green Apple) for example were cited by Diageo and DS Smith).

Technical measures (types of SUDS) were largely unfamiliar to the audience, but once explained, smaller premises found the diversion of road gully drainage into adjacent grass landscape areas to be very attractive. One very small business suggested that the gully to swale option would be enhanced if it was not just excavation to create a grass channel, but instead using the excavation and channel creation work to create a wildflower garden – increasing landscape interest and attractiveness for staff and customers. All the businesses requested more information about the SUDS aims and the techniques involved; all participants expressed interest in feedback; and several invited a follow-up visit to their premises.

Some businesses were forthright in expressing their concerns about business rates, water charges, and other issues, and were rightly conscious of demands on their time as well as money. However, there was a positive swell of suggestions/ideas/comments regarding the potential SUDS offered.

The other important finding was the lack of any collective voice for the businesses on the industrial estate, to help in dialogue with the local authority and Scottish Water. Such a forum or association would also help disseminate important information, such as legislation and technology (e.g. SUDS and rainwater harvesting). There are examples of this type of forum elsewhere.

5 Discussion

This study highlighted the need for more information about diffuse pollution to be disseminated effectively, including information about the infrastructure options which have been developed over recent decades to address it. The misunderstanding displayed by the mismatch between survey results and verification visits to premises, highlighted the need for far more effort by regulators and others to explain the problems and technical solutions to industry, commerce, and others.

Some premises are so large they are each like an industrial estate with a variety of buildings and activities on site and extensive areas of contaminated impervious surfaces. In one example the whole of the most contaminated part of the area of the premises was drained to a treatment pond which produces good quality drainage to the Caw Burn. Although there is no source control at those premises at present, it suggests the end-of-pipe option can be very effective. On the large, estate-scale premises, perhaps a retrofit solution to create retention ponds or extended detention basins, might be cost-effective.

At least one company does have space for such a retrofit wetland and may consider creating a large scale retrofit feature (on a former football pitch and surrounding land in its ownership). That action would greatly help protect the end-of-pipe wetland at the Caw Burn in this case study estate from pollution risks at those premises and manage peak flows.

Unsurprisingly, the possibility – in theory at present – of having discounts for retrofits was attractive to the businesses consulted during the study. A better idea of costs of retrofits in relation to size of any potential discount from Scottish Water, and hence calculating a

pay-back period for the outlay by a business, would be very useful.

If the retrofit actions would enhance the appearance of the industrial premises and hence the estate as a whole, there might also be a case for a discount of business rates for such businesses as an incentive. Other opportunities are more immediately feasible e.g. rainwater harvesting for use on site as is already done at one company (recirculated from the large ponds). Other companies may be interested, but more information on such options, especially the cost benefits, is needed.

Roads should be seen as a separate component of the drainage contamination alongside the individual businesses and retrofit measures should be sought there too. At this study site, that would involve both local council and private landlords. The local council perhaps in conjunction with Scottish Water, could take a lead by carrying out SUDS retrofits on public greenspace, and trying to stimulate a matching commitment from the other businesses. A 2025 raingardens by 2025 style initiative might be the way to try that (Wadsworth et al 2014).

6 Conclusion

In this Chapter the conclusions are presented in the context of industrial estate drainage, the survey findings and the outputs from the workshop.

6.1 The Status Quo

1. The literature, discussions with SEPA and site visits confirmed that industrial estates are a significant source of pollutants. Following best management practices within each industrial estate lot is always the first step in managing the issue, but the literature shows it may not be enough to protect the water environment. Very large areas of contaminated impervious surfaces, far too large for any housekeeping measures, were present at many premises at Houstoun Industrial Estate, exemplifying the need for SUDS.
2. Hotspots of pollution were also evident, and several would be best managed by containment not drainage.
3. All newer developments on the estate were equipped with SUDS (overwhelmingly with permeable paving parking areas), but almost invariably showed a need for better maintenance. The only other proper SUDS features found onsite and verified by inspection were 3 filter drains and a large SUDS pond serving one of the large factories.

6.2 Survey Findings

1. Business operators typically did not know what "SUDS" were and had almost no awareness of individual types of features (even some of those respondents whose premises did have SUDS). The initial quick survey was an essential step to gather evidence that could be tested and make the case for the recommendations which follow.
2. Some business claimed the presence of SUDS onsite, when site inspection discovered there were none, others the converse - they stated there were none when they had permeable pavement.
3. The implications of the awareness survey and follow-up ground truth site visits are that for the great majority of respondents, they have very little understanding of SUDS techniques and they are unfamiliar with them. That has been demonstrated even for those newer parts of the Houstoun Industrial Estate which have been redeveloped since the statutory requirement to use SUDS came into effect.
4. The results highlight the need for engagement / education awareness efforts by SEPA and others; the chances of adequate maintenance of SUDS are very small if it is not understood.
5. Permeable pavement has been the dominant SUDS technique used by developers in the redeveloped parts of the industrial estate. The units involved were commercial, rather than industrial. Very little evidence of any maintenance was found, however there were plenty of examples of the consequences of this lack (blocked surfaces and ponding).
6. Only one proper gravel filter drain was found during this study. SUDS filter drains were also at some time functional at two other premises.
7. One large retention pond (with primary settlement pond) is the only other SUDS feature found during the survey. It was well-protected by multi-stage design and the water is harnessed for use in the production process at the site.
8. Some businesses, especially very small operations, did not respond well to cold-call visits to undertake surveys. Those businesses who responded to the invitation to participate in a breakfast seminar showed a far more open-minded willingness to engage in two-way dialogue with the researchers.
9. A number of businesses showed a willingness to be involved with the project and be considered as case studies for a theoretical retrofit. The main driver for this appeared to be because it was "green" and linked to a wider environmental strategy. Others felt that some retrofits should be a wider investment in the estate to improve its appearance.

6.3 Case Studies\Workshop

1. Although some businesses were forthright in expressing their concerns about business rates, water charges, and other issues, they were rightly conscious of demands on their time as well as money. The feedback from the same people at the focus group was positive as the focus group progressed.
2. That positive swell of comments was helped by leadership from the host company and from the guest speaker from Diageo; however, even the small local businesses responded with a number of positive suggestions.
3. In summary, for the 8 businesses who participated, principal barriers were, as anticipated, space, cost and time. There were three significant additional barriers to uptake by businesses:
    a. Where businesses rented the property there was a lack of interest in getting involved as it was felt that is was either an issue for the landlord or that the landlord would not be interested.
    b. Staff in the businesses were often wholly focused on running them and felt the management of the property was a matter for "head office".
    c. Businesses viewed it as an extra cost when considered alongside the existing rates and charges they pay. Hence incentives are particularly important and partial implementation of possible retrofit may be considered.
4. The principal opportunities were financial incentives such as recovering value from rainwater harvesting, reductions in business rates, or reductions in water charges in return for provision of retrofit SUDS, but also positive factors such as business environment awards to show their customers and staff.
5. Technical measures (types of SUDS) were largely unfamiliar, but when explained one of the more attractive options for smaller premises was diversion of road gully drainage into adjacent grass landscape areas. One very small business suggested that the gully to swale option would be enhanced if it was not just excavation to create a grass channel, but instead using the excavation and channel creation work to create a wildflower garden – increasing landscape interest and attractiveness for staff and customers. All the businesses requested more information about the SUDS aims and the techniques involved.
6. The other important finding was the lack of any collective voice for the businesses on the industrial estate, to help in dialogue with the local authority and Scottish Water. Such a forum or association would also help inflow of information.

6.4 Recommendations

1. SEPA, together with the local authority, Scottish Water and Scottish Government, need to review policy and practices to better develop adequate awareness of SUDS.
2. That needs to include a more creative and achievable way of delivering effective regulatory control, such as a sampling approach to check existing SUDS are being adequately designed, installed and maintained, and poor practice on site is addressed for example with administrative penalties with recourse to courts only on refusal to pay. The lack of any such approach could have been why some large businesses refused to participate (it's not seen as important) and why pollution continues despite measures available for simple enforcement and prevention.
3. In parallel, perhaps a positive campaign would help raise awareness; ideas floated in the focus group and in individual dialogue with some businesses included a raingardens campaign such as "2025 raingardens by 2025" for West Lothian, including retrofit SUDS on the industrial estates?
4. A better network for sharing environmental good practice would also help.
5. A review of charging schemes for industrial/ commercial premises would be useful to incentivise retrofits (in parallel with a modest regulatory initiative, and an enthusing campaign.
6. A follow-up project to model predicted benefits for flood risk management as well as water quality protection would be useful.
7. In places the road surface was in poor condition. There might be scope for adding new drainage features (SUDS) as part of planned programmes of road improvements?
8. Some novel techniques were identified as options worth following up (hedge planters, gully diversions into green space). Research projects are needed to properly evaluate such opportunities.
9. During the validation exercise, the condition of the permeable pavement areas was almost invariably poor; a research project to survey routine practices for that widespread SUDS technique would be very useful, including identification of good maintenance case study sites, as the problems of lack of maintenance are now casting doubt on the technique. The examples found here could feed into that.
10. Finally, some businesses might be willing to enter into a follow-up research project to implement on-site SUDS, perhaps in a partnership research venture part-funded by them.

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