

## Highway filter drain waste arisings: a challenge for urban source control management?

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**Abstract** Essential maintenance activities on highway BMP drainage controls involve refurbishment of filter (French) drains which can generate substantial amounts of “controlled waste”. An innovative procedure for their re-instatement is described which offers a more sustainable option for filter drain/trench management. The quality classification of these waste arisings is problematical and it is difficult to reliably identify the risks posed by such materials and the most effective forms of management and disposal options.

**Keywords** Classification; disposal; highway filter (french) drains; in-situ renovation; waste arisings

### Introduction

The 7,500 km strategic road network in England (trunk roads and motorways) is the largest publicly owned asset in the UK and valued at £72 Billion (€102B), with drainage comprising about 9% of this total value. However, operational maintenance expenditure on this asset is confined to in-year discretionary spend (Revitt and Ellis, 2001). Highway runoff has been identified as a potentially significant source of receiving water pollution and one estimate suggests that such drainage could contribute as much as 50% of the total suspended solids, 16% of total hydrocarbons and between 35% and 75% of the total pollutant inputs to urban receiving waters in the UK (Ellis *et al.*, 1987). Whilst recent long term studies on UK motorways have generally confirmed these key determinands as frequently exceeding maximum and annual average concentrations for EU Drinking Water and Freshwater Environmental Quality Standards, little if any evidence was found of impact on downstream river quality and ecology (Moy *et al.*, 2003). Nevertheless, the range of observed event mean flow weighted pollutant concentrations was higher than quoted in the UK Highways Agency (1999) “*Design Manual for Roads and Bridges*” (DMRB).

The principal function of highway drainage is to remove surface water as rapidly and efficiently as possible from impermeable surfaces in order to minimise risks to vehicular traffic and to provide for adequate drainage of the road foundation and construction layers. Such runoff collection and conveyance is normally provided by conventional kerb-gully systems, slot drains, surface water channels/ditches, filter (and fin) drains and infiltration trenches, all of which also provide a pollutant treatment function. These drainage systems essentially only remove solid-associated pollutants through sedimentation and physical separation or adsorptive filtration mechanisms from the runoff water. Both filter (or French) drains and infiltration trenches collect surface water and control the groundwater level below the road with the latter allowing further infiltration into the underlying subsurface. Both systems have been shown to be effective in retaining solids and solid-associated pollutants (Colwill *et al.*, 1985; CIRIA, 1996) with as much as 80% TSS, 75% metals and 70% of oils being retained (Perry and McIntyre, 1986).

Inevitably such systems will eventually become clogged with contaminated sediment and accumulated litter, with the voids at the base of the drain/trench and around the drainage pipe becoming full of captured material. Estimates of the effective operational lifetime of filter drains are in the region of 10 years, and following substantial reduction in the conveyance and treatment efficiency, the removal and replacement of the granular infill material would be deemed necessary (DoT, 1992). The cost of the filter material replacement and softening of the pavement foundation and structure following clogging of the drain together with the need for regular maintenance, problems of stone scatter and potential for groundwater pollution were cited as reasons for a decline in the use of highway filter drains in the original 1991 DMRB published by the UK Department of Transport. The current Volume 4, Section 2 DMRB (Highways Agency, 1999) guidance is that filter drains are not generally suitable for urban applications although feasible in verge and embankment cuttings in rural highway situations, especially where groundwater problems may occur. However, this advice ignores existing drain filter assets and assumes that a costly full off-site removal and replacement of the granular drain backfill material will always be required. Despite such official advice, the use of filter drains on new roads and car parks continues and does not appear to have substantially affected its popularity. This paper is essentially concerned with maintenance issues associated with filter drains and the classification of waste arisings as controlled waste.

#### Highway filter drain design and maintenance

Traditional drainage practice has used filter (and fin) drains to intercept and convey highway runoff from contributing areas of less than 5ha, with such drains running alongside 50% of the English motorway and trunk road network. Such drains normally take the form of a 1m × 1m trench taken below road formation level which is filled with uniformly graded stone in the range 20-40 mm with a perforated (or porous) underdrain. The drain also provides runoff storage capacity (up to 10 mm rainfall depth for a 1:30 year event) during storm events that can help to delay and attenuate flood peaks within the receiving stream. A geotextile membrane is sometimes used to prevent fine material entering the filter drain while permitting ingress of water and also inhibits plant root growth and has some limited oil retention capability.

Although problems with filter drains have resulted in a policy of non-recommendation by the Highways Agency (Advice Note 39/38), it is generally considered that most problems are caused by use of inappropriate designs and/or poor construction practice at the build stage, with subsequent lack of maintenance over many years (Rowlands, 2007). Where filter drains are not functioning correctly there is the potential for spillages to infiltrate directly into underlying fissured strata, leading to rapid groundwater pollution, as demonstrated in the UK by Price (1994) and Ellis (2006).

Other identified issues relate to the relatively short 10 year life time of filter drains which can be significantly shorter on motorways or dual carriageways due to compaction by vehicular over-run. The usual 3m wide hard shoulder does not give sufficient clearance, particularly for heavy goods vehicles, when pulling over from the inside running lane. Following such over-run and compaction, the hydraulic efficiency of the system decreases, allowing little or no runoff water to permeate to the drainpipe in the affected area, as well as causing substantial stone scatter. Despite these operational deficiencies, filter drains have been retained in respect of reconstruction works dealing with large groundwater flows from highway cuttings and on long road lengths with relatively flat gradients. In addition, filter drains are advocated as a feasible urban source control BMP in the UK Sustainable Urban Drainage Systems (SUDS) Design Manual (CIRIA, 2000).

### In-situ maintenance and renewal of filter drains

It is undoubtedly the case that the major problem encountered in this type of drainage system is lack of adequate and regular maintenance, despite the UK Highways Agency estimate that filter drain maintenance has an annualised cost of between £20 M – £100 M (€27.2–€136 M) at 1995 figures. It is highly unlikely that this level of expenditure is actually incurred. Normal operation and management (O&M) practice to date has been to “dig out and replace” (at a rate of about 1 tonne per metre length), with the excavated contaminated material being taken off site and sent to landfill if the waste cannot be stored locally and the stone recovered. Hence there is clearly a need for an efficient, safe, and environmentally sustainable process together with a programme of filter maintenance and renovation for the proper management of the nation’s vital road infrastructure.

There is now available an on-site method for removing contaminated sediment that accumulates close to the surface and/or within a stone-filled filter drain/trench located at the edge of a highway pavement. The process utilises a dry separation technique and is sustainable in that it re-cycles in-situ the existing stone present in the drain trench (Rowlands, 2007). It also minimises the volume of additional new stone that may have to be transported to site, thus significantly reducing the number of vehicle movements to and from the site. The StoneMaster® system is capable of operating within a single lane closure, including a motorway hard shoulder and the process is self-contained within a specifically designed mobile vehicle that also allows the operation to meet all site safety requirements.

To date, the system has been used to re-cycle in-situ some 450 km of filter drain over the last 4 years since developing the process. Hence around 450,000 tonnes of silted stone have been processed in that period. If this material had been excavated and replaced or re-cycled off-site, it would have required an additional 45,000 HGV journeys to remove silted stone and subsequently import new or cleaned stone. The cleaning process applied to the clogged aggregate allows in-situ “as good as new” replacement. A single night shift can produce about 60 tonnes of waste arisings per 300m length of filter drain, i.e. around 10 tonnes per hour. This waste is predominantly material under 10 mm, the aim of the Stonemaster® system being to ensure recycling of 95% of material above 10 mm. The waste arisings comprise a mixture of contaminated silt, together with organic detritus originating from grass cutting and leaves, soil that may have been washed or placed over the drain, construction waste, and fines from poorly specified stone used in the initial construction. The Stonemaster® recycling system achieves over 80% less than 10 mm in the arisings with a greater than 95% retention of the fraction less than 63 µm, which is known to contain the majority of micro-pollutants (Revitt and Ellis, 2001).

### Filter drain waste arisings, classification and disposal

#### Waste arising quality

In general, as shown in Figure 1, the waste arisings have been found to be normally below 500 ppm for Total Petroleum Hydrocarbons (TPH), with very low concentrations of Class 2 carcinogens (C<sub>5</sub> – C<sub>10</sub>) and no samples breaching the 10,000 ppm level for Class 3 carcinogens (C<sub>10</sub> – C<sub>30</sub>). PAH levels are normally well below the 100 mg/kg Waste Acceptance Criteria (WAC) value for inert landfill waste.

Heavy metals are typically in the 400 – 500 ppm range although some waste arisings can be as high as 1000 ppm (Figure 2) which would be considered to be the limit (0.1%) for non-hazardous landfilling for lead. Thus in terms of heavy metal distributions, Figure 2 implies that filter drain arisings essentially comprise non-hazardous material that should be generally acceptable for inert landfill disposal.

The EU Framework Directive on Waste (75/442/EEC) defines waste as “any substance... which the holder discards... or is required to discard” and represents the first major piece of

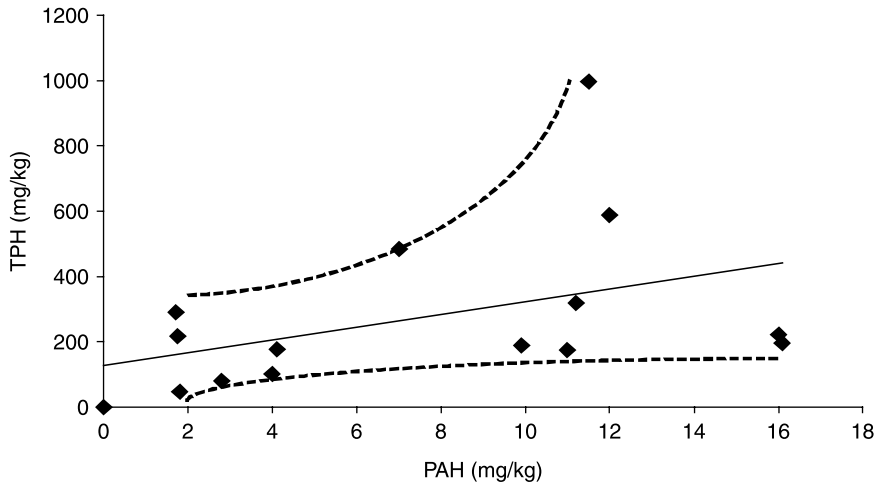


Figure 1 Hydrocarbon distributions in filter drain waste arisings

EU legislation relating to waste management. The European Waste Catalogue (EWC; 2001/118/EC) provides a standard classification and definition of generic waste types which was brought into English law with the 2002 Landfill regulations. Filter drain arisings as well as the majority of wastes associated with other urban source control facilities, carry a waste code of 17 05 04 under the EWC, “Soil and Stones other than those mentioned in Code 17 05 03”; the latter code covering “Soil and Stones containing dangerous substances”. Whilst there is an increasing awareness and documentation concerning O&M procedures for BMP drainage controls (filter drains, soakaways, pond/wetlands etc.), there is much less appreciation of waste disposal issues associated with the contaminated arisings generated during maintenance and cleaning operations. These arisings only become “controlled wastes” following maintenance activities. When the filter drain, soakaway or infiltration trench is “dug-out”, all of the material remains waste until the stone and gravel content is recovered and put to use.

The main contaminants of concern in the waste classification are heavy metals and hydrocarbons. However, their quantities and exact nature in filter drain arisings are subject to inherent variability in source composition, degradation products and timing of the maintenance schedule. For example, it is normally not possible to say if the site has

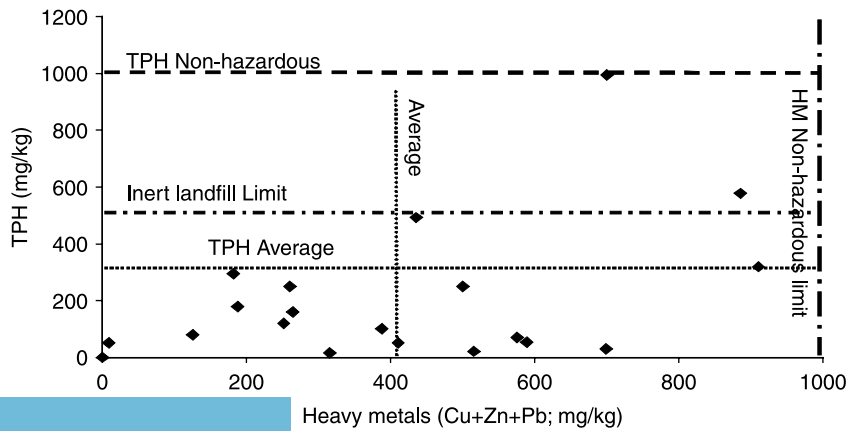


Figure 2 Filter drain pollutants and landfill waste code classification

been subject to spillage at some time in the past or to excessive verge-side herbicide applications. Nevertheless, the UK Environment Agency (EA) has agreed that the overall waste arisings can be classified as being inert for landfill purposes, if the appropriate leaching tests or waste acceptance criteria (WAC) can be met. Otherwise, disposal at non-hazardous landfill sites should be acceptable, bearing in mind that the location of landfill sites has a major impact on transport costs and hence it is operationally preferable that either type of landfill can be used. Without speciation, the limits on TPH for non-hazardous landfill classification are 1,000 ppm, and 500 ppm for disposal at an inert landfill site as indicated in Figure 2.

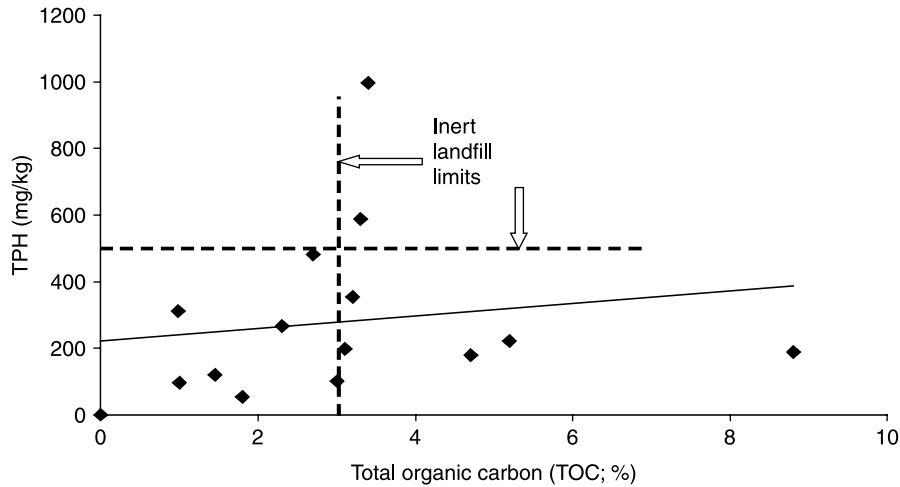
However, it is far from clear why TPH should be limited to 500 ppm when it is the PAH fraction which is of most environmental concern. For oily wastes (EWC Code 16 07 08 \*), the EU Directive allows an upper TPH limit value of 10,000 ppm for non-hazardous waste providing the PAH are low. On this basis, the 500 ppm limit imposed for inert landfilling of filter drain arisings under Code 17 05 04 appears to be highly conservative. The 10,000 mg/kg (1% w/w) variation on the generic threshold for oily waste is allowed on the basis of the specific nature of contaminating oil being known or identified. If unknown, then 8 chemical marker thresholds including benzo-a-pyrene (50 mg/kg; 0.005%) must be used to determine the carcinogenicity and which in total must not exceed 1% of the total TPH.

Whilst the arisings are non-hazardous and may be suitable for inert landfill, existing UK regulations do not allow the waste to be disposed of and landscaped adjacent to the highway verge as an alternative disposal route. This is because suitable exemptions were not provided at the time the legislation was drawn up and the process of planning application is not feasible for drainage maintenance activities, where such activities may have to be undertaken at short notice anywhere around the network. Acceptance for inert landfill also requires that the Total Organic Content is below 3%. This is to avoid methane generation as part of the EC's aim to reduce greenhouse gases and to ensure that humic or fulvic acids are not generated leading to increased leaching rates of heavy metals. However, it is not possible to control TOC unless verge maintenance is carried out more frequently, and organic waste (such as grass cuttings and litter) is routinely removed. As indicated in Figure 3, for filter drain arisings going to landfill, the TOC levels can exceed the 3% limit. However under the current EWC Code 17 05 04 regulations, for soils going to landfill, TOC is allowed to exceed 3% if the Dissolved Organic Carbon (DOC) is low as established from the WAC tests. Under 10:1 WAC leaching tests, DOC levels of filter drain arisings are typically less than 1 mg/l in the eluate which is not unexpected given the prolonged leaching times prior to drain refurbishment. It can therefore be argued that the same dispensation as for EWC 17 05 03 soil wastes should be applicable to filter drain waste arisings which are essentially a mixture of silt and sand with minor amounts of fine gravel.

#### Maintenance challenges

From the above it can be seen that O&M of BMP facilities such as filter drains have some significant hurdles to deal with, and yet their main purpose is to facilitate storm-water disposal, itself a contaminated waste "material" in the context of highway operations. It is estimated that there are 140 million tonnes of contaminated stormwater to be removed every year from the English high speed road network. This therefore raises an important issue in the development of BMP source control facilities, where it needs to be recognised that such facilities will at best extract and store pollutants; they do not make them disappear.

The maintenance of filter drains also involves administrative overheads. Section 34 of the 1990 UK Environmental Protection Act (EPA) provides for a "duty of care" for all



**Figure 3** TOC and TPH limits for inert landfill

controlled waste and filter drain arisings, which must be continually assessed to confirm they are non-hazardous with a waste transfer note identifying and coding the waste when it is transferred to a carrier or to a disposal site. It also has to be recognised that the timing of maintenance activities has important consequences. Night-time O&M activities have become commonplace on UK highways, and it is generally the case that the waste arisings generated have to be temporarily stored until daytime opening of official landfill and/or waste transfer sites. Such temporary overnight storage must not exceed 50 m<sup>3</sup> of waste and must be securely and safely located. Waste transport companies may have planning permission to store waste in larger quantities but unless the waste can be left in a tipper overnight, the waste material has to be “double-handled” in order to free the tipper for other duties.

From the above it can be seen that current EU waste legislation has considerable management and cost implications for the operation of BMP drainage controls such as filter drains. As the arisings become more heavily contaminated, so the situation becomes more complex, particularly in the case of hazardous waste which cannot be co-disposed with non-hazardous waste under the 1999 EU Waste Directive. BMP urban drainage now has to recognise that stormwater drainage O&M activities need to be viewed as a waste management issue, both of the contaminated runoff itself and the pollutants carried with it as well as in the sedimented sludge or arisings. Climate change is only likely to lead to more severe storm events with less predictability and thus reinforce the waste arisings issue in the future, which in all probability will become a much higher priority for urban drainage BMPs. Initial BMP design needs to consider and anticipate this waste issue with some urgency as it is likely to become an increasing problem when it comes to disposal as part of either planned or unplanned maintenance operations.

### Conclusions

Whilst there is a legal requirement to ensure that stormwater waste arisings do not present risks to the environment or human health, there are undoubtedly problems and challenges related to understanding and identifying the risks posed by such “controlled waste” and to assess the most effective form of management and disposal routes. The innovative re-cycling filter drain StoneMaster® process helps to raise awareness of the value of properly maintained filter drains, and promotes planned drainage maintenance as a way of ensuring that drainage assets do not become liabilities when it comes to

compliance with environmental legislation, as well as making an important contribution to sustainable drainage. The process illustrates best practice in filter drain management, which is increasingly focussing on achieving the required water quality and control of water flow from highway outfalls, as well as minimising waste disposal requirements.

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