Article 2

Feature article from Watershed Protection Techniques. 1(1): 3-5

Hydrocarbon Hotspots in the Urban Landscape

Two central paradigms emerged from the EPA's Nationwide Urban Runoff Study in the early 1980s. One was that pollutant concentrations in urban runoff were more or less the same regardless of the contributing land use. The second was that urban runoff carried relatively few priority pollutants, most of which were metals.

Subsequent monitoring has generally reinforced both paradigms, particularly for conventional pollutants such as sediments, nutrients, and organic carbon. However, two recent research studies suggest that there may be major exceptions to these paradigms. The studies point to the existence of *hotspots* in the urban landscape that produce significantly greater loadings of hydrocarbons and trace metals than other areas.

Hotspots are often linked to places where vehicles are fueled and serviced, such as gas stations, bus depots, and vehicle maintenance areas. Others occur where many vehicles are parked for brief periods during the day (convenience stores and fast food outlets), or where large numbers of vehicles are parked for a long time (commuter parking lots).

Hotspots are evident in the data of Schueler and Shepp (1992). Their survey of oil and grit separators in suburban Maryland show the differences in the quality of pool water and trapped sediments in separators draining five different paved areas (Table 1). Gas stations and convenience stores had much higher levels of hydrocarbons and metals both in the water column and the sediments. Streets and residential parking lots, on the other hand, had much lower hydrocarbon and metal concentrations.

Gas stations were found to be an extremely significant hotspot for hydrocarbons. Composite priority pollutant scans at the gas station sites revealed the presence of 37 potentially toxic compounds in the sediment and 19 in the water column. Many compounds were polycyclic aromatic hydrocarbons (PAHs) that are thought to be harmful to both humans and aquatic organisms (Table 2). Non-gas station sites, on the other hand, recorded far fewer priority pollutants that had much lower concentrations.

Pitt and Field (1991) monitored metal and PAH levels in runoff from a number of sites in Mobile,

Table 1: Sediment and Pool Water Quality Found in Oil Grit Separators at Various Urban Locations (Schueler and Shepp, 1992)

Parameter	Gas Stations	Convenience Stores	All-Day Parking Lots	Streets	Residential Parking
Comparative Sediment Quality (reported in mg/kg of sediment)					
Total P	1,056	1,020	466	365	267
TOC	98,071	55,167	37,915	33,025	32,392
Hydrocarbons	18,155	7,003	7,114	3,482	892
Cadmium	35.6	17.0	13.2	13.6	13.5
Chromium	350	233	258	291	323
Copper	788	326	186	173	162
Lead	1,183	677	309	544	180
Zinc	6,785	4,025	1,580	1,800	878
Comparative Pool Water Quality (reported in µg/l)					
Total P*	0.53	0.50	0.30	0.06	0.19
TOC*	95.51	26.8	20.6	9.9	15.8
HC*	22.0	10.9	15.4	2.9	2.4
Cadmium	15.3	7.9	6.5	ND	ND
Chromium	17.6	13.9	5.4	5.5	ND
Copper	112.6	22.1	11.6	9.5	3.6
Lead	162.4	28.8	13.0	8.2	ND
Zinc	554	201	190	92	ND

ND = Not Detected   * in units of mg/l

Table 2: Some Priority Pollutants Detected in Gas Station Oil Grit Separator Sediments or Pool Water (Schueler and Shepp, 1992)

Napthalene	Di-n-octyl pthalate
2-Methylnapthalene	Benzo(b) flouranthene
Acenapthene	Indeno (123-cd) pyrene
Flourene	Di-n-butyl pthalate
Phenathrene	Toulene
Flouranthrene	Ethyl benzene
Pyrene	Total xylenes
Butylbenzylpthalate	Methylene chloride
Chrysene	Benzene
	Acetone phenols

Alabama, including vehicle service areas, parking lots, salvage yards, landscaped areas, and loading docks. They employed the rapid Microtox procedure to assess the possible toxicity of several hundred runoff samples.

Although their monitoring data was variable, they reported that many of the maximum PAH and metals concentrations in runoff samples were found at vehicle service areas and parking lots, as opposed to street surfaces. Of greater concern, nearly 60% of the hotspot runoff samples were classified as moderately to most toxic, according to their relative toxicity screening procedure.

Are Hotspots Environmentally Significant?

The mere presence of high pollutant concentrations at hydrocarbon hotspots does not always imply actual toxicity. Indeed, acute toxicity to aquatic organisms exposed to hotspot runoff is probably a rare event. This is due to relatively brief exposures during storm events, large dilution factors in urban creeks, and the fact that many pollutants are strongly bound to sediments and thus are not readily available to aquatic life. Pitt and Field (1992) reviewed a series of studies that provide convincing evidence of longer-term chronic toxicity to aquatic organisms when exposed to urban runoff.

The greatest environmental risk appears to occur when metal and hydrocarbon-laden sediments are deposited in downstream lakes and estuaries. The bottom sediments of many small, highly urbanized estuaries are heavily contaminated with metals and PAHs. Runoff from urban hotspots appears to be a major contributing factor to sediment contamination in these cases, as witnessed in both the Anacostia and Delaware estuaries (Schueler and Shepp, 1992; McKenzie and Hunter, 1979). The consequences of sediment contamination often include greatly reduced benthic diversity and transfer of pollutants into fish tissue. Techniques to remedy bottom sediment contamination are in their infancy, and have yet to be proven effective.

Difficulty in Treating Hotspots

Few stormwater technologies are currently available to effectively control the runoff from hydrocarbon hotspots. Most hotspot source areas are less than an acre in size, exist in already developed areas, and are widely scattered across the urban landscape. Nichols (1993) notes that there are over 1,500 vehicle maintenance operations in the Washington, DC area alone.

The most common method to control hydrocarbon loadings from small sites has been the oil grit separator (OGS). It consists of a concrete structure linked to the storm drain system with two pools used to trap oil and grit (Figure 1). Recent research, however, indicates that oil grit separators are not effective in trapping pollutants (see article 119). For example, in field inspections of over 100 OGS systems, the average depth of trapped sediment was found to be a mere two inches.

Further, the mass of trapped sediments in OGS systems did not increase over a five year time frame. Monthly sampling revealed sharp reductions in the depth of trapped sediments of as much as 25 or 50% from one month to the next. Dye tests indicated that OGS systems had a residence time of less than 30 minutes during even minor storms. In contrast, Pitt *et al*. (1991) conclude that at least 24 hours of settling are needed to achieve any meaningful reduction in potential toxicity from hotspot areas.

The poor performance of oil grit separators can be attributed to three key flaws: (1) an on-line design that promotes frequent resuspension of previously deposited oil and sediments, (2) insufficient treatment volume, and (3) poor internal geometry.

Prospects for Improving On-Site Technology

Can the dismal performance of the current generation of oil grit separators be improved? New off-line designs have been developed in a number of communities to reduce resuspension (Shepp, 1992). Not much performance data are yet available to evaluate the performance of these new designs. However, it is reasonable to expect that they will be more retentive than current designs, but the question remains—by how much?

Ultimately, the effectiveness of any design is dependent on regular and frequent clean-out of trapped sediments. This, unfortunately, has been the "Achilles heel" of existing OGS technology. For example, in a recent Maryland study not a single OGS system out of over 100 inspected had ever been maintained.

Four factors explain this poor track record. First, a market does not yet exist to clean out and dispose of sediments. Few vendors are available to perform the task themselves. Second, many local governments have been slow in enforcing clean-out requirements on small business owners. Third, clean-outs are quite expensive, ranging from as much as $1,000 to $2,000

per site each year. Lastly, concerns about the actual or perceived toxicity of the trapped sediments have limited options for safe and economical disposal. Many landfill operators are loath to accept wet sediments with pollutant concentrations on the order of those reported in Table 1.

Sand filters may turn out to be a better alternative for treating runoff from hydrocarbon hotspots than OGS systems. As a filtering medium, sand is very effective in "straining" out hydrocarbons and metals. Also, most sand filters are designed to treat a much greater volume of runoff than OGS systems. Perhaps most importantly, clean-out of sand filters is easier and less frequent. On the downside, sand filters are more expensive to construct, and may still be subject to disposal problems at some hotspot sites.

Source control may hold the greatest promise to reduce the delivery of pollutants from hotspots. This pollution prevention approach stresses the importance of eliminating the spills, leaks, and emissions that create the hotspot in the first place. A series of better handling, recycling, storage and disposal practices can reduce the chance that automotive fluids and cleaning solvents come into contact with rainwater and run off the site. The Santa Clara Valley Nonpoint Source Program has published an excellent summary of pollution prevention practices for gas stations (see article 136).

Summary

Although small in size, pollution hotspots are prevalent in the urban landscape. More monitoring is needed to define the magnitude of the metal and PAH loads they deliver to downstream waters. Currently, few effective techniques are available to treat hydrocarbon hotspots. Further testing of new designs of oil grit separators and sand filters is warranted.

In the end, our capability to reduce hotspots may well depend on solving institutional problems—assuring regular and environmentally safe sediment clean-outs, and preventing pollutants from being exposed to stormwater runoff at hotspot areas. **See also articles 119 and 120.**

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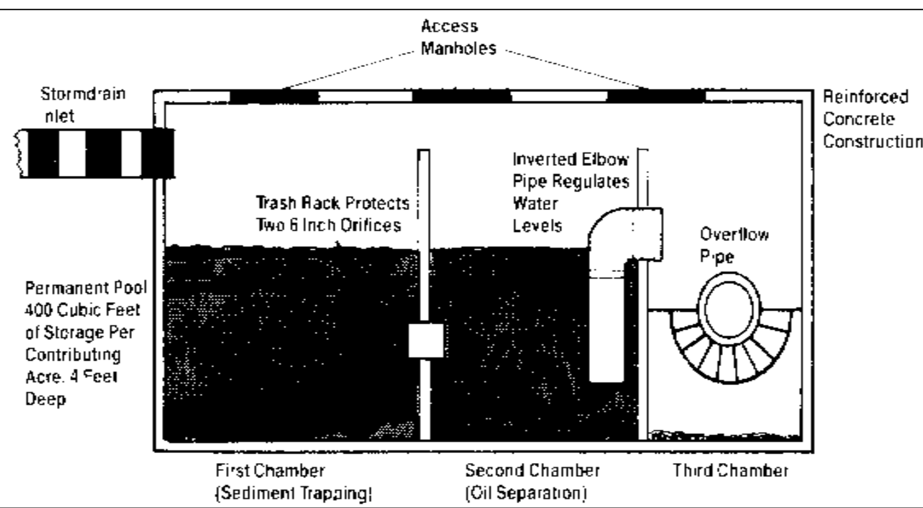

Figure 1: A Typical Oil and Grit Separator (Schueler, 1987)