San Francisco Bay Area

WATER QUALITY PLANNING PROGRAM

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WATER QUALITY MANAGEMENT PROGRAM

THE USE OF GREENBELTS TO CONTROL OIL AND GREASE IN URBAN STORMWATER RUNOFF

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Introduction

The Association of Bay Area Governments (ABAG) identified parking lots as an important source of oil and grease in an urban watershed (1981a). Oil and grease in runoff from parking lots examined in the ABAG study (1981a) in Richmond, Contra Costa County, California comprised 18.5% of the total oil and grease loading to the watershed. However, parking lots comprised only 5.8% of the total land area, indicating that a disproportionate quantity of oil and grease eminated from parking lots. ABAG (1981b) also reported that a 90% and 60% reduction in oil and grease loading from parking lots would result in a 25% and 17% reduction, respectively, in the total oil and grease load of the watershed. Thus, the control of parking lots appears highly favorable as an effective approach to limit oil and grease from a watershed.

Greenbelts may be well suited to remove pollutants from the runoff of parking lots and other areas of high hydrocarbon concentration. Greenbelts can be designed as an intermediary structure between paved areas and storm sewers or can eliminate the need for some storm sewers. Runoff can be directed from the pavement onto a greenbelt, from which it can percolate through the soil. As the water percolates, hydrocarbons should be filtered and adsorbed, allowing opportunity for biological, chemical and physical degradation. Unfortunately, no data are available assessing the efficiency of greenbelts in removing hydrocarbons, since existing greenbelt systems were primarily designed to reduce the physical size requirements of storm sewer systems.

Greenbelt Design

A preliminary method has been presented by ABAG (1981c) for the design of a greenbelt to treat stormwater from parking lots for oil and grease. That system is reproduced here, with the design then expanded to allow an evaluation of system effectiveness.

A diagram showing the hypothetical application of a greenbelt in a parking lot is shown in Figure 1. The lot is graded so that all runoff waters are channeled into one or more greenbelts. The entrance to the

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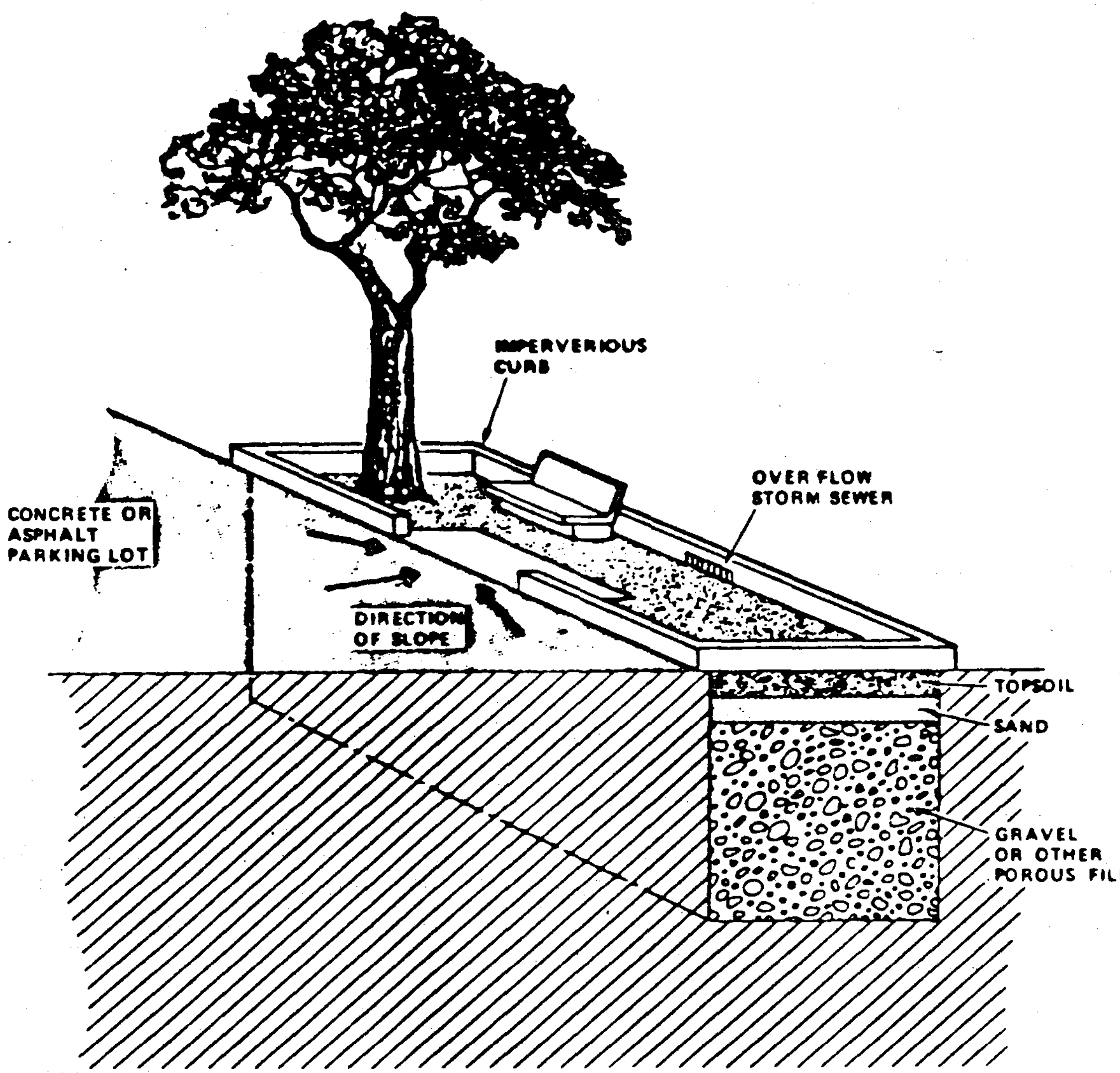


Figure 1. Application of a greenbelt in a parking lot.

belt is a concrete spreading apron to facilitate equal distribution of the waters over the belt, and lessen the chances of erosion. The greenbelt itself consists of a layer of topsoil supporting plant life, underlain by a layer of sand, which rests on a thick bed of gravel. Runoff waters percolate down through the top layers which decrease hydrocarbon concentration through adsorption and filtration. According to Rich (1980), such percolation removes essentially all suspended solids which should also reduce hydrocarbon concentration.

The gravel layer acts both as a drain, keeping the upper layers from saturation, and as a reservoir where stormwater is stored while it percolates into the surrounding soils at depth. Since the soil underlying the parking lot will be isolated from surface infiltration, percolation out of the gravel bed should be quite rapid. For large or very intense storms beyond the design capacity of the greenbelt, a storm drain inlet is constructed on the far side of the belt. In this manner the waters in excess of the greenbelt's treatment capacity are removed, preventing erosion or damage to the plant cover. Note that for all storms the greenbelt will absorb the first-flush waters, in which hydrocarbon levels may be relatively high.

Greenbelts also can be used in parking lots as median strips, with runoff directed from the pavement onto the strips. Underdrains may be required if underlying soils are relatively impervious. Miles Laboratories, Inc, has developed parking lots using this type of median strip, with their design shown in Figure 2 and Figure 3 (Poertner, 1974). While this system was designed to reduce storm sewer requirements, it may also prove effective in reducing oil and grease from runoff.

Land Use Requirements

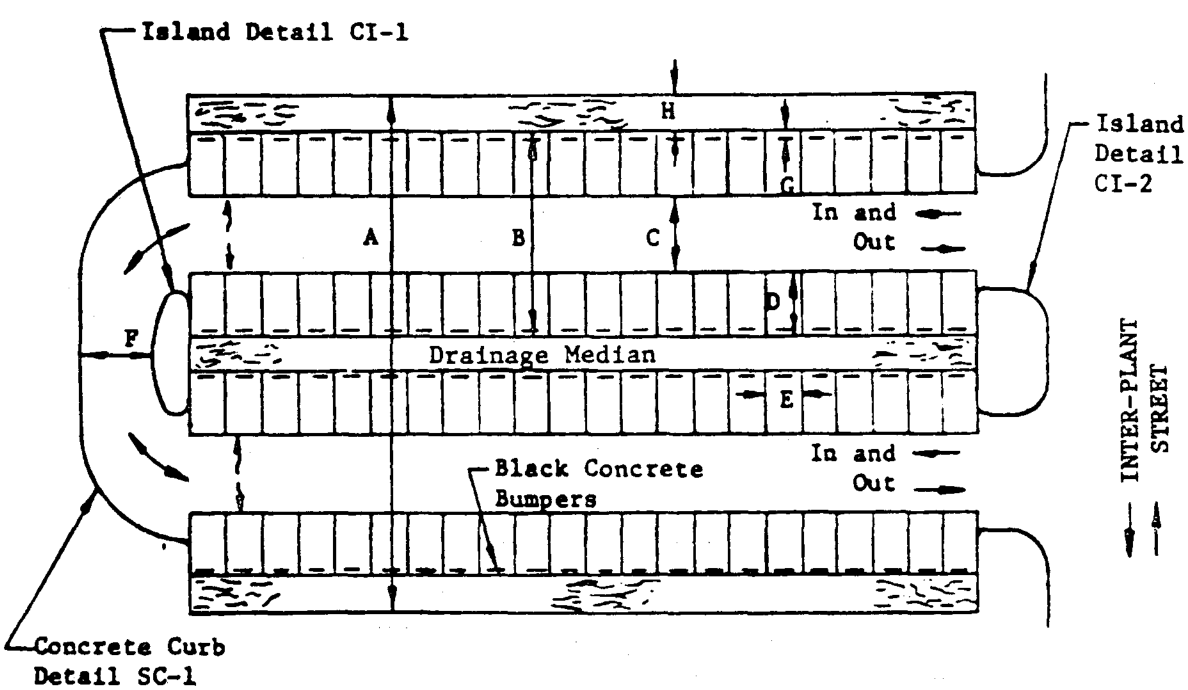
The design of a greenbelt needed for a particular application can be quite flexible. Waters can be routed to one large belt or to several small ones. The shape of the belt is arbitrary within the limits imposed by the necessity of providing proper flow patterns. The percolation rate can be controlled by the choice of soil for the top layers. The design storm, or rainfall value beyond which excess water will not be treated, can be varied. The depth of the gravel bed and the thickness of the upper layers can be varied. A simplified calculation of the area needed for a greenbelt is presented here to point out variables that must be considered. Any actual design would require more rigorous calculations based upon site-specific information.

The total rain absorbable in a day (R_A) is the total time in a day (D) divided by the percolation rate (P).

$$R_A = \frac{D}{P} \qquad (1)$$

PERPENDICULAR PARKING

HEAD IN ONLY

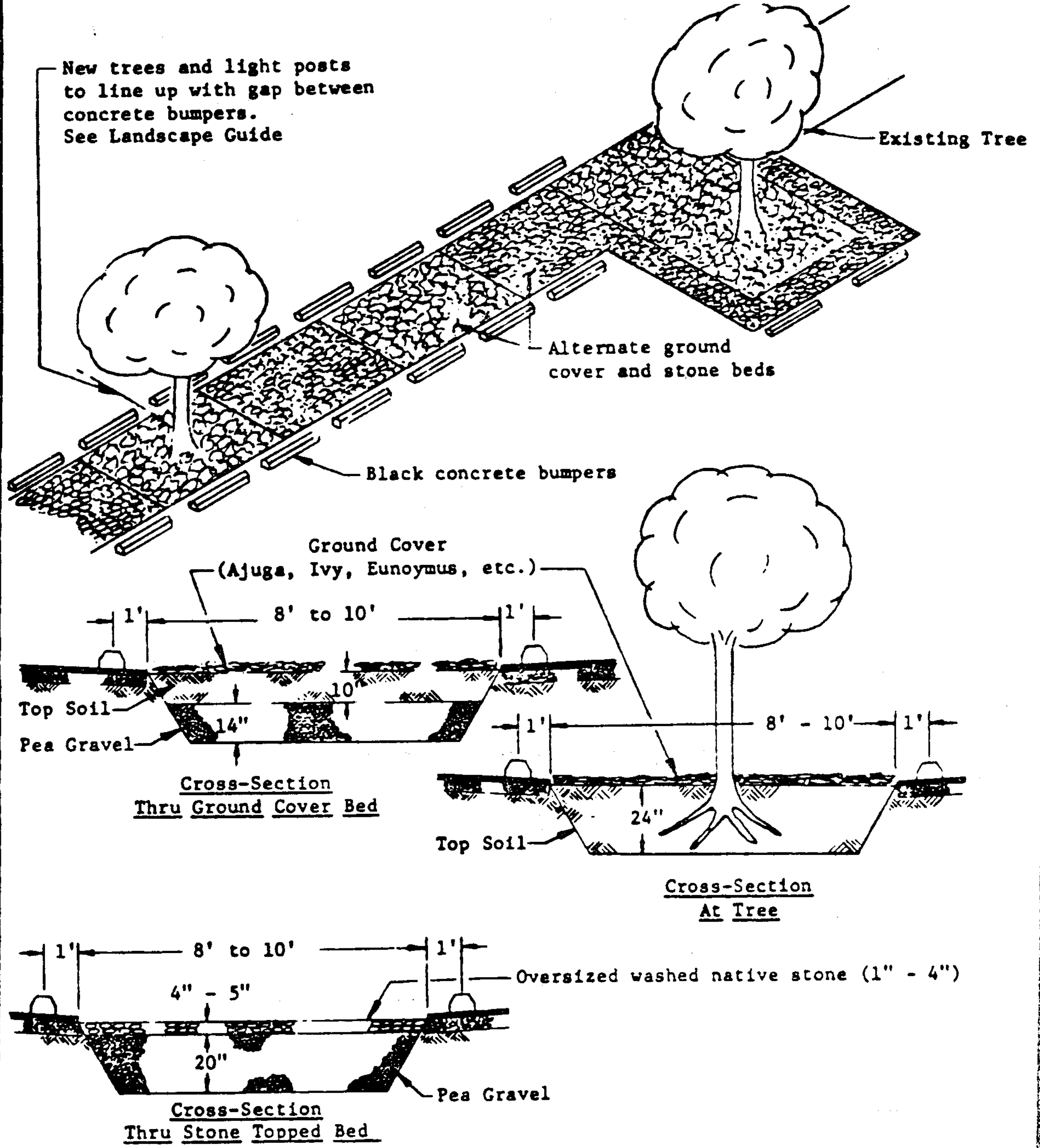


KEY	DESCRIPTION	MINIMUM	NORMAL	OPTIMUM
A	Overall lot width	136'	146'	158'
B	Parking bay width	56'	58'	64'
C	Drive width	20'	22'	26'
D	Parking space length	18'	18'	19'
E	Parking space width	9'	10'	10'
F	End drive width	12'	20'	20'
G	Pavement edge to bumper centerline	1'	1'	1'
H	Median width	8'	10'	10'

a. layout using pervious median strip

Source: Miles Laboratories, Inc.
Building Construction Standards

Figure 2. Parking lot details using greenbelts as median strips.
(taken from Poertner, 1974)



b. details of median strip for parking lot drainage

Source: Miles Laboratories, Inc.
Building Construction Standards

Figure 3. Specifications of a greenbelt used as a median strip. (taken from Poertner, 1974)

Note that this assumes that the gravel bed below is deep enough to prevent saturation. It also assumes that the rainfall rate is uniform throughout the day. If S is the daily rainfall of the largest storm the greenbelt is designed to treat, the total area that can be drained is:

$$A = \frac{R_A}{S} a \tag{2}$$

where A is the total area to be drained including the greenbelt, and (a) is the area of the greenbelt. To determine the area of the parking lot alone (A_2), excluding the greenbelt, use

$$A = A - a = \left(\frac{R_A}{S} - 1\right) a \tag{3}$$

Several examples are presented to demonstrate the use of these equations. The slowest percolation rate recommended for soils in which a seepage pit is to be dug is 30 minutes/inch (U.S. Department of Health, Education and Welfare, 1967). Suppose this type of soil is used for the top layer of a greenbelt which is to treat storms as large as 2 inches/day.

P = 38 minutes/inch
D = 1440 minutes/day
S = 2 inches/day

$$R_A = \frac{D}{P} = \frac{1440 \text{ min/day}}{30 \text{ min/day}} = 48 \text{ inches/day} \tag{4}$$

$$\frac{R_A}{S} = \frac{48}{2} = 24 \tag{5}$$

The fraction of the total area that would have to be devoted to greenbelts is:

$$\frac{a}{A} = \frac{S}{R_A} = \frac{1}{24} \tag{6}$$

If a more permeable soil were chosen, one for which P = 10 minutes/inch, and the design storm was only 1 inch/day, then:

$$R_A = \frac{E}{P} = \frac{1440}{10} = 144 \text{ inches/day} \tag{7}$$

$$\frac{R_A}{S} = 144 \tag{8}$$

$$\frac{a}{A} = \frac{1}{144} \tag{9}$$

For this example less than 1% of the area would have to be devoted to greenbelt. Notice however that in this case the gravel bed would have to handle a great deal of water, and would perhaps become the limiting factor depending on its size and the permeability of surrounding soils.

Costs and Benefits

It is impractical to quantify the costs and benefits of greenbelts. No data are available concerning the effectiveness of hydrocarbon removal. Capital costs will greatly depend upon local land values. However, a subjective evaluation has been performed to identify those factors which should be considered when deciding on the feasibility of a greenbelt system. Peripheral benefits of greenbelts excluding all oil and grease removal may in many cases be sufficient to justify greenbelt construction.

The primary benefit of oil and grease removal can not be quantified because of the lack of data. Little work has been done identifying hydrocarbon decomposition rates in systems other than soil cultivation. In Texas, oil decompositive rates of about 0.5 lbs/ft^3 of soil per month were observed for three different types of oily sludge cultivated in unfertilized soil. Decomposition rates increased to about 1.0 lbs/ft^3 of soil per month when the soil was fertilized (Kincannon, 1972). However, this application employed large doses of oily material applied on a batch basis, rather than the low levels of oil and grease contamination anticipated to be chronically applied to greenbelts. The success of degrading oily sludges through cultivation and biological degradation indicates the high potential of the greenbelt system in removing oil and grease from stormwater. Important bacteria responsible for oil and grease degradation include Pseudonomas Flavobacterium, Micrococcus, Acinetobactor, Nocardie, Corynebacterium and Arthsobactor (McKenna and Heath, 1976; Ward and Brock, 1975; and Kincannon 1972.)

Numerous other advantages are associated with the use of greenbelts. The treatment has minimal adverse environmental effects and is applicable to improvement of almost any area. The design is flexible and greenbelts are aesthetically pleasing. Greenbelts offer the opportunity of use in areas of particularly high levels of oil and grease deposition, in which treating relatively small land areas results in substantial reduction in the total watershed oil and grease load. Sewer system costs may be reduced substantially. Other pollutants, particularly those associated with suspended solids, should also be reduced. The treatment is not capital intensive, and the land used for greenbelts could be part of local landscaping.

A major cost in constructing greenbelts is the capital cost of the land. The analysis presented above shows that approximately 1/24 to 1/144 of the land area in parking lots would need to be devoted to

1/144 of the land area in parking lots would need to be devoted to greenbelts. In areas with relatively low land values, this cost may not be substantial. However, in areas with very high land values, the cost for additional lands to be devoted to greenbelts may be prohibitive.

Many problems which traditionally arise with the use of land application for wastewater treatment are not as important in this application (U.S. EPA. 1975). Stormwater runoff is by nature intermittent, so induced rest periods are not required to allow maintenance of the aerobic environment necessary to the action of soil microbes. Contamination of groundwater could be a problem in some cases, but in many instances problems will not occur. The hydrocarbons in urban stormwater are high molecular weight fractions since the low molecular weight fractions evaporate very quickly, these large molecules are not easily transported by groundwater. Similarly, the lead in urban runoff is mostly tetraethyl lead, which is not easily transportable and poses little threat to groundwater. Groundwater pollution might occur in cold areas when the streets are salted.

Some additional costs will be incurred in the use of greenbelts. Construction costs include the price of the land used and the cost of excavating and constructing the greenbelt. Plants for the belt must be chosen to survive intermittent heavy watering. Routine maintenance will include care for the plant cover and removal of trash. Care must be taken that creation of water channels to the storm drain does not occur, reducing the effectiveness of the greenbelt. It may also be necessary to irrigate the belt in the dry season, depending on the climate and on the plants chosen for use.

Some problems must be expected in the use of greenbelts, and early applications in particular must be well monitored. The soil may become clogged by colloidal hydrocarbons, through this is unlikely due to the low concentrations being treated. If it does occur, this would necessitate the removal, replacement, and disposal of the top layer of soil. This would involve extra cost, but the cost would be low since the soil to be removed is on the surface. Care must be taken that contamination of groundwater does not occur, and application in areas with high groundwater tables or special groundwater problems should be carefully evaluated. Large scale use of greenbelts will decrease the net runoff coefficient for an area, which may or may not be helpful. Limitations on use of greenbelts are possible due to the existence of other underground structures which would interfere with percolation.

Summary and Conclusions

The use of greenbelts to treat stormwaters from areas with locally high hydrocarbon concentration appears attractive. Reduction of the hydrocarbon pollutant contributions from parking lots can have a large effect on the quality of urban stormwater runoff. Numerous benefits besides oil and grease reduction are associated with greenbelts, enhancing the attractiveness of their construction. A primary consideration is the cost of the land, which will vary considerably depending on the specific site. The amount of land required as a greenbelt will vary dependent principally upon design storm magnitude and soil characteristics.

Future work should be directed toward examining the performance characteristics of greenbelts in removing oil and grease. Soil particle size, texture and percolation rate are important factors to be considered when assessing system removal capabilities. However, values associated with greenbelts excluding oil and grease removal are sufficiently high to encourage the further testing and development of greenbelts for runoff pollutant control.

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