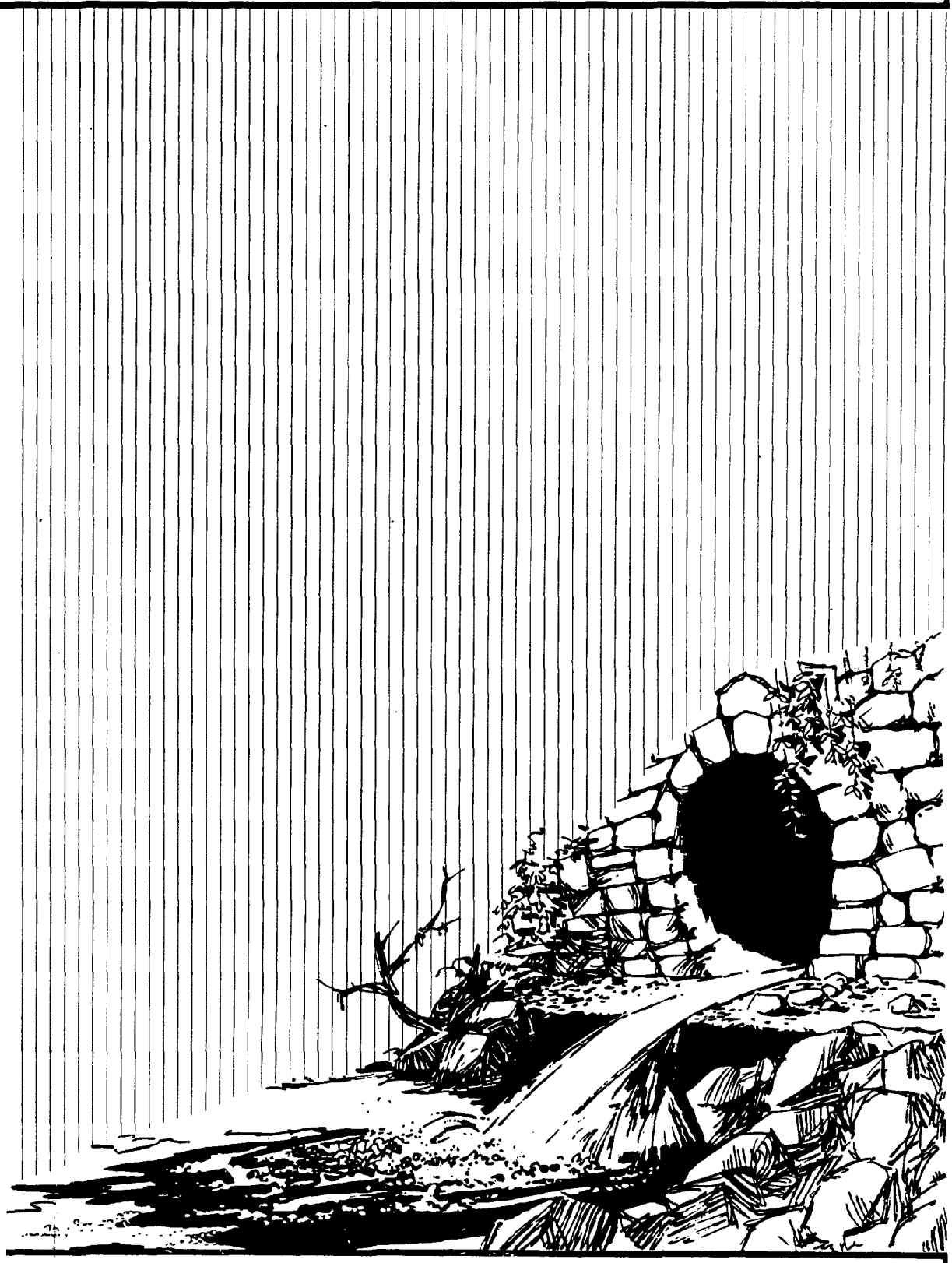
New Jersey Stormwater Program



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New Jersey Department of Environmental Protection

NEW JERSEY STORMWATER MANAGEMENT PROGRAM

TABLE OF CONTENTS

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INTRODUCTION

In New Jersey, stormwater management is a dual purpose program, which provides for removal of particulate pollutants as well as controlling floods. This is in accordance with the New Jersey Stormwater Management Act (1), which called for a program to improve the quality of stormwater runoff, and to restrain erosion damages downstream, as well as to control the extra flooding caused by development. A pilot program of this nature was initiated in four counties of the state early in 1980. More recently, a sophisticated planning exercise in stormwater management was conducted in Hunterdon County with funds contributed by the U. S. Soil Conservation Service, the state, and the county itself. The report on this demonstration project is available (2). Whereas, nationally, stormwater management is still generally designed for flood control only, our New Jersey regulations established in 1983 (3) that water quality aspects would be provided for as well, in the form of retention and of settlement particulate pollution. Although the statewide application of the new standards is not yet mandatory, funds are now being made available to counties and municipalities to plan on this basis. Details are given later in this paper.

New Jersey established a program of this nature because of the great concern with nonpoint source pollution and the environmental degradation which has been observed in New Jersey streams in urban and urbanizing areas. Within the past year, the state has become particularly concerned with pollution of coastal area waterways. For this reason, the stormwater management program is now being extended to coastal areas, even where no riverine floods are involved. In such areas, only limited retention storage is to be provided, sufficient to provide for settlement of particulate pollutants, without going to the extreme of providing extra storage for the major flood flows.

The New Jersey stormwater management regulations make it clear that various alternative types of detention facilities can be used. The EPA has researched a wide variety of types of retention facility, in various states and various conditions nationwide. In New Jersey, the municipalities, counties and land developers have in most cases used detention basins, or infiltration basins.

To put the stormwater management program in proper context, particularly in coastal areas, it must be remembered that its contribution to improving water quality conditions relates almost entirely to runoff from new facilities. The institutional arrangements for stormwater management are effected through the land-use laws, applied to developers. Therefore, if existing

towns and developments are to have runoff pollution completely controlled, this must be done by some entirely different program.

For coastal areas, the stormwater management program may not be sufficient, even for controlling polluting runoff from new development. Some pollutants are found dissolved in stormwater, or remain in colloidal form, which settles only slowly. Therefore, complete control of urban runoff pollution, even in newly developed areas, may require measures other than new stormwater management.

NONPOINT SOURCE POLLUTION OCCURRENCE AND HYDROCARBONS

It is difficult to relate the characteristic biological degradation of urban streams to the pollution concentrations actually observed. In some cases, planned or unplanned releases of industrial waste may be responsible; but widespread similar degradation in non-industrial areas may be attributable largely to hydrocarbons. Hydrocarbons usually occur in concentrations of from 2 to 4 mg/l in urban runoff, mainly in particulate form, the remainder being dissolved (4). Although runoff from streets and parking lots has perceptible oil sheens on the surface, which are in liquid form, petroleum hydrocarbons are quickly sorbed on the particulates in runoff; so that storm sewers rarely contain

hydrocarbons in liquid form unless substantial quantities have been spilled or deliberately released in the catchment area.

Relatively little attention has been given by government agencies to petroleum hydrocarbons in urban runoff, because this pollutant is not a scientifically definable substance but rather a complex and variable mixture, not included in U.S. EPA's listing of priority pollutants, and not among the parameters measured and reported routinely by the U. S. Geological Survey.

The potential for biological damage by hydrocarbons has been given little attention; but a study of petroleum impacts in the Delaware Estuary showed that concentrations of 1 mg/l of petroleum in water, when sorbed on particulates, had serious adverse effects upon filter-feeding biota (5). In view of this finding, the regular presence of several times these concentrations of hydrocarbons in urban runoff is highly suspect, as a cause of biological damage. Also, in water which is ultimately to be chlorinated, the presence of hydrocarbons is obviously undesirable, because of the trihalomethane problem.

Pollution in stormwater runoff, like the flood peaks in small streams, originates widely throughout the drainage area. Whether the runoff is conveyed to the stream by a storm sewer or by an open channel is immaterial to the fate of the pollutants. However sheet flow at moderate slope over grass not only slows

down the velocity, but also removes most of the particulates. Unfortunately for the quality of our small streams, most developers (other than in single-family large-lot subdivisions) collect storm drainage systematically and route it through curbs, gutters and storm drains, which deliver a full load of runoff pollution to the streams.

It is not too much to say that the pollution in storm runoff from urban and urbanizing areas is a major environmental problem, which is more important to the quality of most of our small streams than point source pollution from the effluent of wastewater treatment facilities.

CONVENTIONAL STORMWATER MANAGEMENT

Conventional stormwater management differs from flood control in that it is preventive in nature rather than remedial. Instead of remedying existing conditions, it is required to be carried out as a condition of new development, by the developer himself, or on his behalf. The basic rationale for stormwater management is that new development, whether for housing, commercial, industrial or highway facilities, greatly increases the rate and the volume of storm runoff from given precipitation. This results in creased flood damages downstream. More recently it has also been noted that the increased rate and volume of runoff from

development also contributes to increasing stream erosion downstream. New development also generally results in increased pollution downstream, as has already been referred to. In the past, reduction of this runoff pollution and stream erosion have not been among the objects of conventional stormwater management.

Stormwater management is sometimes carried out by means of roof top storage, underground pits or tunnels, porous pavement, or grassy swales, designed to prevent the desired retention, retardation or infiltration of flow. However, in New Jersey, the approach usually relies on detention basins or infiltration basins.

The main hydraulic criterion for conventional stormwater detention is that a specified design storm occurring after development should produce no higher peak rate of runoff than the peak rate which would occur from the same storm prior to development, measured at the site itself. Obviously, if the volume of runoff from the site is increased by the development, peak flood flows further downstream will generally be increased by the development, even though peak flows at the site may not be increased. In many of the older stormwater management systems, a single design storm was specified, frequently the 100 year frequency storm. Control of 100 year storms or any other single design storm on a small drainage area requires relatively little detention storage; but is very ineffective in controlling the

peaks of smaller floods, and in reducing erosion damage. Moreover, it has been shown that the effect of such programs in controlling floods disappears rapidly downstream (6,7). It is now clear that stormwater management detention programs are only effective in controlling flood and erosion damage downstream when the post-development peaks of any of several design floods can be held to their pre-development level. To meet New Jersey standards, control of flood hydrographs of 2 year, 10 year and 100 year floods to pre-development levels at site is required. Even so, when the flood flows of many contributing drainage areas are to be aggregated into a river, the stormwater detention programs will seldom reduce resulting peak flood flows as much as the increased volume of stormwater runoff will increase them.

Planning and Institutional Aspects

The conventional stormwater management plan is simple in concept. The municipality passes an ordinance requiring developers to submit a stormwater detention plan for each proposed new development. These plans must be reviewed and approved by the municipal engineer or other appropriate local authority; and the developer or owner must then construct the necessary retention facility on his own property. Except in the case of large developments, where master detention basins (or regional basins) may be built for control of relatively large areas, such a program usually results in a small detention basins on each of

many lots, in what has been referred to scornfully as the "chicken pox" pattern. The disadvantages of a multitude of small detention basins at-site, such as usually results from conventional stormwater management, include the excessive amount of land required, the difficulty of maintenance, and the planning and regulatory burden entailed by such a large number of facilities.

Although simple in principle, implementation of stormwater management programs presents some difficulties. In their desire to encourage economic development, municipalities are under pressure to waive any requirements adding to developers costs. Most municipal engineers are structure-oriented; and the hydraulic and hydrologic analysis of stormwater management plans may be beyond their personal competence. Therefore, hiring of additional staff or retention of consultants is generally required. Difficult maintenance problems arise; which are covered in a later section.

WATER QUALITY CONTROL IN STORMWATER MANAGEMENT

Background

In stormwater management, water quality control is usually obtained through dual purpose detention basins designed, first,

to reduce flood damages downstream and, second, to reduce nonpoint source pollution from storm runoff. Although somewhat similar in concept to the much earlier sediment control and flood retention programs of the U. S. Soil Conservation Service, the idea of using stormwater detention basins to reduce environmental pollution in streams of urbanizing areas first gained currency through the Section 208 water quality planning studies started in 1975, under Federal authority (8). Section 208 studies in several states, including New Jersey and Virginia, reported favorably upon this concept. However, definitive action could only be taken later; as needs for such a program were recognized more generally; and as plans were implemented under various local and state authorities.

Concept

The underlying principle of dual purpose detention is that the detention of flood flows, for reduction of damages downstream, and the retardation of flood flows, for settlement of particulates, can advantageously be combined in the same structure, with little loss in effectiveness of either program. Flood damages are almost entirely due to floods of magnitude greater than two year frequency, with most of the damages due to a few very large floods; whereas the harmful pollution occurs mainly as the cumulative effect of a large number of small storms, most of which are not larger than one year frequency. It

is also true that the prolonged retention of a given amount of retention storage, even though it does not contribute to reduce peak flows from large storms at site, does contribute to reduce peak flows further downstream, since, for the larger streams, total volume of water released over a 24 hour period is more important to flooding conditions than the peak flow at various development sites. Therefore, in order to be fully effective, a dual purpose detention basin must hold runoff from the frequent small storms over a prolonged period of time; but it must operate effectively for flood control when a larger storm occurs.

Outlet Design

Dual purpose, long-time retention is accomplished by a small outlet called a retention outlet, at the low point of the detention storage, sized for slow release of the runoff from the designated small storm. See Figure 1. This designated small storm is referred to as the settleability design storm.

Above the level of the detention storage needed to control the settleability design storm will be the main outlet, or the lowest of two or more main outlets. The main outlets are designed so as to provide the necessary degree of control of specified design storms (for flood control). Although stormwater management ordinances usually specify requirements in terms of flow effects at site only, effective control downstream requires that designs

are adequate to control any of several different frequency design storms. For example, when a series of 400 detention basins were modeled, covering an 8000 acre main watershed, with each basin designed to control peak flow from 100 year post-development floods at site to the level of the 100 year pre-development peak at that site, the 100 year watershed, post-development peak flow at the outlet of the main was reduced by only 2%, and the two year and ten year peaks were reduced not at all. By contrast, a similar series of detention basins each designed to control particulate pollution from small floods, and to hold either a two, ten, or hundred year flood at site to its pre-development peak, reduced the post-development peak of hundred year floods of the main watershed by 20%, and the peaks of ten and two year floods by 24% and 44% respectively (4). It is apparent that a stormwater management detention criterion only designed to control a hundred year frequency storm at site to pre-development levels, would be of only minor effect downstream. Whereas a detention basin designed to control any of three design storms would be quite effective.

Control of Particulate Pollution

In New Jersey, the settleability design storm is 1 1/4 inches in 2 hours or the one year 24 hour storm. The South Florida Flood Control District uses a settleability design storm of 1.0 inch of runoff or the runoff from a three year frequency storm, whichever

is greater. The New Jersey standard requires slow emptying of the retained settleability detention over a 36 hour period, except for residential area, where evacuation of an 18 hour period is acceptable. It has been estimated that this degree of retention will remove about 60% of the total suspended sediments in urban runoff, a similar proportion of the petroleum hydrocarbons, and lead, and perhaps 45% of the BOD, copper and phosphates. Of course, dissolved pollutants such as nitrates should be unaffected by retention. Such special retention provisions are referred to as the water quality storage provisions of stormwater management.

Summary

Although water quality storage provisions of stormwater management are not sufficient to eliminate entirely the increase in particulate pollution caused by various forms of econmic development, they are capable of greatly reducing it, thereby correspondingly reducing the unfavorable environmental effects. The water quality storage provisions have the incidental effect of extending the flood control effects of the detention basins further downstream. As previously mentioned, even greater effects in removing particulate pollutants from urban runoff can be obtained by passing the runoff in sheet flow over lawns or other thick vegetation; and virtually complete elimination of

particulate pollution can be obtained through infiltration basins.

THE NEW JERSEY PROGRAM

The New Jersey Stormwater Management Act (1) required all municipalities to prepare and implement a stormwater management plan and ordinance within one year from the date of promulgation of comprehensive stormwater management regulations by the New Jersey Department of Environmental Protection, or by the next reexamination of the municipal master plan as required by the Municipal Land Use Law (9). However, the mandatory provisions of the law were made contingent upon the State providing to municipalities 90% of the cost of preparing stormwater management plans.

For implementation of the law, Stormwater Management Regulations (3) were adopted by the Department of Environmental Protection in 1983. These regulations define Phase I planning for municipalities, which involves the adoption of a stormwater management ordinance after only administrative planning. Phase II planning for counties or municipalities consists of detailed watershed studies to encourage a broader approach to stormwater management. For both phases of planning, design standards require the construction of dual purpose detention basins rather than the conventional type, described above.

Because the funding required by the law to be made available to municipalities to offset the cost of developing a Phase I plan was not appropriated initially, there has been a delay in implementing the regulations. In the interim, the stormwater management regulations have been enforced only where adopted voluntarily by sub-state agencies, or, within the flood hazard area, by special provisions in the Flood Hazard Area regulations (10).

Priorities

Each of the 567 municipalities in New Jersey has been assigned a priority classification based on its need for stormwater management planning. Areas relatively undeveloped but experiencing development pressures have been identified as high priority. Also classified as high priority are the Passaic River basin communities (a high flood risk area) as well as those communities whose uncontrolled runoff is impacting the water quality in reservoirs, shellfishery beds and beaches. Urban communities, rural areas that are not experiencing development and areas that would not benefit from stormwater management have been assigned low priority status. The remaining municipalities are in the medium priority category. The significance of the priority is that funds will not be offered nor will application

of the regulations be made mandatory in low or medium priority areas.

Grant Programs

Two grant programs have been established to administer the stormwater management program. High priority municipalities were invited in 1986 to apply for grants of $5000 each to cover 90% of the cost of preparing and adopting a stormwater management ordinance (Phase I). Sixty applications were received and the Department of Environmental Protection is preparing for a second round of applications. Cost sharing grants were also made available to counties for the development of a comprehensive county stormwater management plan and/or a detailed watershed planning study (Phase II). Six grants have been approved and these studies are scheduled to be completed within the next two years. Limited funds remain; and, through a cooperative effort with the U.S. Soil Conservation Service, the cost of two additional watershed studies will be shared by the Department of Environmental Protection and the U.S. Soil Conservation Service. The main purpose of the Phase II grants is to allow for an engineered watershed plan to be developed to replace the ubiquitous small basins, one for each building site, which usually develop from a Phase I ordinance.

Watershed Planning Study

It is widely acknowledged that planning of stormwater management at the watershed level will produce more effective control of runoff than the conventional site-by-site approach.

However, such planning, which usually results in decisions to build master detention basins, is not often utilized, because of the cost of planning, requiring use of complex models such as the U.S. Soil Conservation Service Hydrologic Model TR-20, and because of the institutional problems involved.

In order to encourage watershed level stormwater management planning, the New Jersey Department of Environmental Protection co-sponsored a demonstration study with the U.S. Soil Conservation Service and Hunterdon County, on the South Branch Rockaway Creek. Close cooperation was obtained from the municipalities and other agencies involved, both in conducting the study and in preparing the final report.

The recommended plan developed by this study (2) requires each new development to provide on-site water quality controls, and to contribute a fee towards two regional detention basins designed to provide flood control for the watershed. The water quality controls must provide retention storage sufficient to comply with the State's Stormwater Management regulations.

The fee is to be levied in lieu of the on-site control of the 10 year and 100 year storms, as otherwise required by state regulation. In each case, the fee is to be levied is proportionate to the increased runoff volume in the 100 year storm which is contributed by that development. The fee, per unit volume of increased runoff, is to be determined by dividing the total estimated costs of the two regional basins by the total increase in runoff volume from the 100 year storm with the watershed fully developed. A detailed description of the financial aspects of the plan can be found in the study report.

The recommended stormwater management plan, with its combination of on-site and regional controls, was found to be far more effective than any other strategy in attenuating downstream flood peaks for all storm frequencies investigated. When on site controls were used exclusively, downstream peaks could not be effectively reduced. This was true whether the on-site basins were designed for single or multiple frequency peak control (i.e. 2-year, 10-year, and 100-year). The exclusive use of master detention basins also failed to match the effectiveness of the recommended plan, in addition to leaving the stream upstream of the master detention basins exposed to the added floods, erosion and pollution caused by development.

When quality controls at site are used in conjunction with master detention basins designed to control the larger floods, the

system meets fully the runoff pollution control objectives of the regulations throughout the watershed. As regards the flood control effects, the recommended plan sacrifices a good deal of control in the reaches between the development sites and the regional basins, but has a much greater control than the regulation's standard further downstream, as well as being more economical to construct and to maintain. All participating agencies ended in concurrence.

TECHNICAL INTERFACE PROBLEMS

Among the various kinds of water programs, stormwater management is unusually beset with interfaces, which include both well-defined programs and certain emerging problems which may be poorly defined but cannot be disregarded. The four major interfaces involve, respectively, freshwater wetlands, groundwater recharge, shellfish and estuary preservation, and nonpoint source pollution generally.

Wetlands

The site chosen for a detention basin often includes land classified as wetlands; and the preservation of freshwater wetlands is a matter of prime environmental interest. Such preservation has achieved legal sanction nationally through the permit processes of the Corps of Engineers, which is backed in

this endeavor by the Fish and Wildlife Service and the Environmental Protection Agency. State laws to preserve wetlands are pending in various states, including New Jersey. A high proportion of major land developments involve wetlands, either in the area to be developed economically or at the site of a proposed detention basin. In evaluating stormwater management interfaces with a wetlands program, it is usually not clear what the specific wetlands attributes are which are being protected, or whether the need for protection is absolute or can be traded off for other values. In some cases, as where endangered species are involved, the attribute protected may be clearly identified and the degree of protection afforded may be virtually absolute. However, in most cases the wetland is identified only by the presence of swamp-tolerant vegetation or by hydric soils. In such cases, it may usually be assumed that, as regards wetlands values, the intermittent impoundment characterizing a detention basin constitutes a non-significant variation from the less frequent flooding which already exists.

Groundwater

The control of groundwater is an extremely complex and rapidly evolving field, with which most stormwater management programs need have little to do. However, in areas of aquifer recharge, in order to sustain the aquifer, it is usually considered desirable to use infiltration basins for stormwater management,

rather than the more usual dry detention basins. In various areas, including Nassau County (New York) and parts of New Jersey and Florida, it has sometimes been found that the desired infiltration of surface runoff has served to contaminate the aquifer with nutrients, pesticides, or other undesirables. This is a problem difficult to handle, on account of the large number of structures involved, the wide variation in pollutant concentrations, both temporarily and from one drainage basin to another, and the practical difficulty of evaluating the degree of runoff pollution at any site and its subsequent fate in groundwater. In general terms, infiltration basins to handle the less polluted runoff are desirable, while the more polluted runoff should be handled otherwise.

Shellfish and Estuary Preservation

This potentially important interface with stormwater management is reduced in incidence by the fact that most small streams draining directly to vital waters in coastal zones suffer little damage due to floods. In such areas, rainfall from even rather severe storms usually infiltrates directly into the ground. Bays, estuaries and the ocean seacoast itself usually have important shellfish and finfish and recreational resources, and require a high degree of protection, which is different in kind as well as in degree from that of normal upland streams. Infectious bacteria, virus and fungi are of primary importance to

both bathing beaches and the maintenance of shellfish beds; and pesticides are also of great importance. The protection afforded to normal inland streams by well-planned stormwater management programs cannot be assumed to be equally effective in coastal areas. Normal type stormwater retention of particulates is a desirable step for protection of shellfish and estuaries, but not necessarily a sufficient one. For more adequate protection, control of pollution from existing facilities will usually be required.

Conclusion

The water quality stormwater control program provides only a partial answer to the nonpoint source control problems; but it has the great advantage that it can be readily implemented. All it takes is the passage of a local ordinance, under authority of the Stormwater Management Act and the State's regulations. to require local developers to incorporate such stormwater retention provisions in the plans which they submit for municipal site plan and subdivision approval. This is not an unfair burden upon developers; because the program only requires them to take action to reduce the environmental damage which their developments would otherwise create. Where river floods are involved developers have to provide dual purpose detention basins; but in other coastal areas only the water quality detention provision are necessary.

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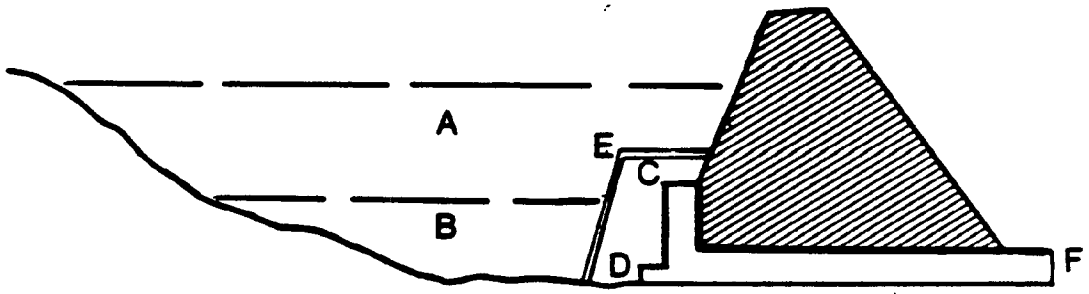
DUAL PURPOSE DETENTION BASIN OUTLETS



LEGEND

A - Volume to Control 100 Year Storm

B - Volume to Control Settleability Storm

C - Flood Control Outlet

D - Retention Outlet

E - Trash Racks

F - Downstream Outlet