FLOOD PLAIN MANAGEMENT
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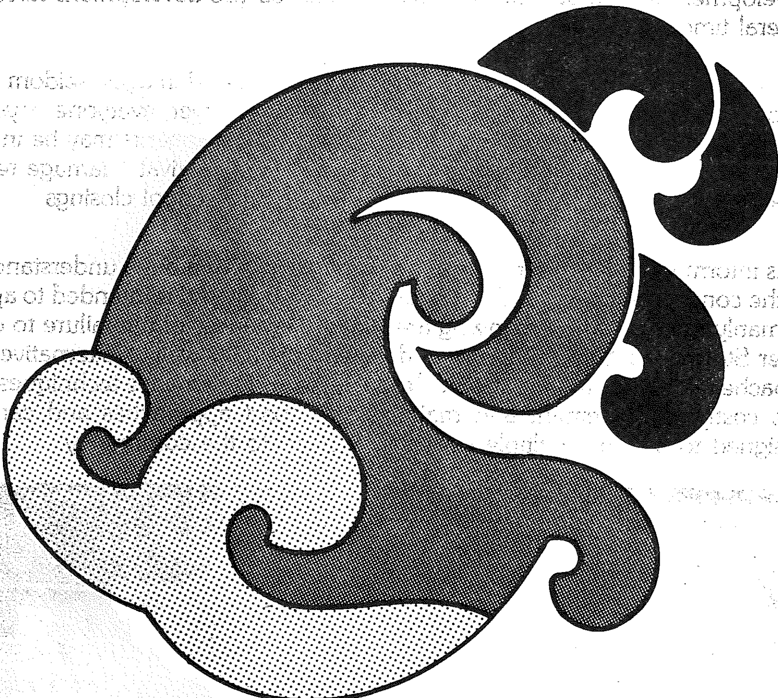
URBAN STORMWATER MANAGEMENT:



Another Alternative for Reducing Flood Damages

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Division of Waters
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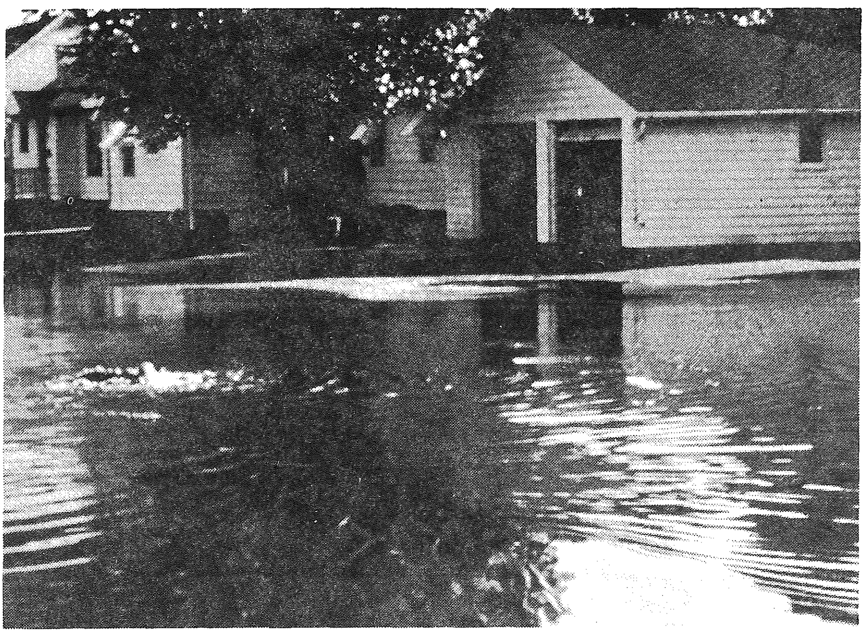
I. Introduction

Flood-prone areas are usually thought of as the low-lying land adjacent to streams, rivers and lakes. However, serious flood problems can exist many miles from any identifiable water body. Radical changes occur to runoff patterns in a watershed resulting from urbanization. Native vegetation, forests, meadows, croplands and wetlands are replaced by parking lots, sidewalks and buildings and natural drainageways are replaced by storm sewers and culverts. If actions are not taken to mitigate these modifications to the watershed, post-development stormwater runoff rates can exceed pre-development rates by several times.

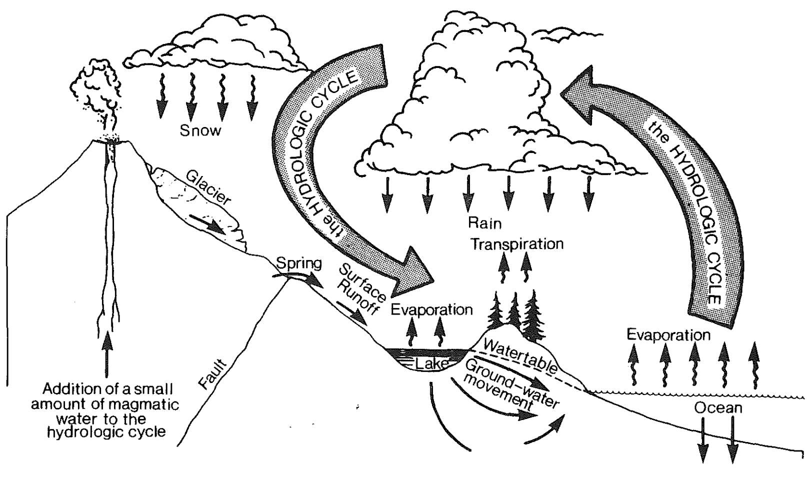
Those individuals or businesses which suffer flood damages seldom are responsible for the increased stormwater runoff. However, everyone pays for the unwise development practices of others. These payments may be in the form of expensive storm sewer upgrading, public and private damage relief, clean up, and inconveniences such as business and school closings.

This informational brochure has been prepared to give a basic understanding of the concepts involved in Stormwater Management and is intended to apply primarily to urban and urbanizing areas. Consequences of the failure to consider Stormwater Management are detailed herein, as well as alternative approaches to stormwater control. Often times, these alternative techniques are less costly to implement and maintain than past approaches and can be designed to provide multiple uses and benefits to the community.



II. Hydrologic Cycle

Pre-Development



The "HYDROLOGIC CYCLE"

The hydrologic cycle has no beginning or end; water continually evaporates into the atmosphere, eventually returning to the earth's surface as precipitation. However, it is helpful in the understanding of stormwater management concepts to consider precipitation as the beginning of the cycle. A single drop of rain has many possible courses of action: rain may be stored in shallow depressions, intercepted by vegetation, or percolate into the soil and groundwater. Any water remaining after the above general loss requirements are satisfied becomes runoff. This water will flow overland until it reaches a stream or channel. The streams will enter lakes or rivers which eventually enter the ocean. Throughout the process, water returns to the atmosphere via evaporation.

Post-Development

Urbanization changes the watershed, significantly affecting the hydrologic cycle. Elements of the natural system which prevent, or at least temporarily detain, runoff are eliminated in a high density development. Both the volume and rate of runoff can be significantly increased following development.

The volume of runoff is governed primarily by infiltration characteristics, ground slope, soil type and vegetative cover, as well as available storage. Development of a site greatly reduces the infiltration capacity of the ground by the introduction of impervious surfaces such as streets, sidewalks and buildings. Vegetation, which intercepts water, to a large degree is removed. Finally, small depressions, wetlands and other temporary stormwater holding areas are often filled to accommodate development. An increase in the overall runoff volume results in decreased groundwater recharge and the subsequent reduction in normal or low flow of streams.

Urbanization typically reduces the time it takes runoff to flow from its point of impact on the watershed to the watershed outlet. Street curbs and storm sewers are much more efficient at removing water than a natural channel. As the time required for a given amount of water to run off decreases, the peak rate of runoff increases. As development in the watershed increases, so too will the peak runoff rate increase. Storm sewers designed and built many years ago may now be unable to safely convey the increased runoff resulting from upstream development.

III. Resultant Damages

As urbanization proceeds and land values increase, the effects of uncontrolled runoff become an economic burden and a serious threat to the health, safety and well-being of a community.

The problems resulting from inadequate considerations given to stormwater management are many: flooding, stream bank erosion, sedimentation and adverse water quality impacts. These problems occur naturally, however, due to man-made changes to the watershed, including the habitation of the flood plain and the resultant harmful effects, can increase several fold. In addition to loss of personal property, adverse impacts associated with stormwater runoff include: health hazards, the closing of industry and commerce centers and the resultant loss of wages and income, delay of emergency vehicles and subsequent clean up costs.

Increased stormwater runoff will produce larger and more frequent floods. An area which may flood on the average of once every ten years may flood several times during a ten-year period following development of the upstream watershed. Storm sewers, adequately sized at the time of construction, may no longer be able to safely remove excess runoff.

In some urban areas, erosion of soil by stormwater runoff, and the resultant sedimentation, results in serious negative impacts. Stream channels erode in order to accommodate the increased volume and rate of runoff. Land areas under construction oftentimes are stripped of protective vegetation, creating the opportunity for huge soil losses.

All runoff carries a certain amount of pollutants. As the volume of runoff increases due to urbanization, the pollutant loading on receiving streams and lakes also increases. Pollution of stormwater runoff is the result of many things: contact with municipal and industrial wastes in combined sewer system; silt, resulting from soil erosion; litter, debris, gasoline, oil and other chemicals commonly found on streets and parking lots; and pesticides and fertilizers washed off of vegetation. The obvious impact is the general degradation of water quality of the receiving lakes and streams.

IV. Stormwater Management Philosophy

Development within this country has usually sought to maximize the use of land and the convenience in using that land. Virtually no emphasis was placed on retaining the beneficial aspects of natural systems. Stormwater conveyance systems were designed to remove rain water from a site as quickly as possible. The effect of this type of action on a community-wide basis resulted in the adverse impacts mentioned in the previous section.

Man-made stormwater conveyance systems rarely can be economically built to safely remove runoff from infrequent, severe storms. Typically, storm sewers are designed for a 5 or 10-year frequency storm. Consequences to the surrounding area resulting from 25 or 100-year rainfall must also be considered. Additionally, demands on the storm sewer system increase as the upstream watershed becomes developed.

The primary goal of most stormwater management agencies in urban areas is to reduce existing runoff control problems and prevent new problems from developing. The basic philosophy of how best to achieve this goal is currently undergoing change throughout the country. A new emphasis is now being placed on non-structural control measures, including land treatment and land use controls which limit the peak runoff rate from a development site. This is accomplished by controlling stormwater where it falls, on-site, through the use of site grading, vegetation areas, temporary stormwater storage and other measures.

By maintaining pre-development drainage patterns and runoff rates, the negative impacts of urbanization associated with stormwater runoff can be reduced. Accelerated channel erosion and subsequent sediment problems would be reduced with the "on-site" control of runoff, as would the amount of pollutants entering a lake or stream.

Obviously, it is easier and more cost-effective to apply these measures to areas currently undergoing development, as opposed to already established communities. At best, these stormwater management concepts may only prevent runoff problems from becoming worse in an established area. Alternate approaches may be required by existing communities with existing problems such as flood proofing of buildings, acquisition of flood-prone property, flood plain zoning and traditional structural flood control measures such as channelization.

V. Control Measures

Stormwater control measures should be designed to maintain or reduce peak runoff rates and volumes from a developed area to pre-development rates. The actual method or methods used will vary from site to site. Suburban residential areas where lot sizes are relatively large will require fewer, if any, control measures compared to a commercial/industrial development, where most of the site is covered by impervious surfaces.

In general, on-site control measures either preserve the natural drainage system or mitigate the effects of human intervention. The alternative measures discussed on the following pages are intended to illustrate concepts, not detailed engineering design criteria. Local initiative in the planning, design and implementation of stormwater management measures suitable to the unique needs of each community is encouraged.

A. Vegetative Cover

Soil types and vegetative cover play an influential role in determining the amount of runoff from a particular site. The infiltration and percolation rate of soils indicate their ability to absorb rainfall and thereby reduce the amount of direct runoff. Sandy soils tend to have higher infiltration rates than fine-grained soils, such as silt or clay, due to the larger spaces between particles. Likewise, good topsoil containing a sufficient amount of organic matter also has the ability to absorb a significant amount of rainfall. During site construction, it is a good practice to retain as much topsoil as possible to be used in areas to be re-vegetated. This not only maintains conducive soil conditions for water absorption, but also provides a proper plant growth medium.

Vegetative cover also plays an important role in stormwater runoff control. All things being equal, the infiltration rate of soil with a vegetative cover is greater than an identical soil with no cover. Vegetation also significantly reduces soil erosion, absorbing the energy of falling rain, and serving as friction control by slowing the velocity of runoff. In any development area, vegetation areas should be incorporated in the site plan wherever possible. This may take the form of grassed waterways or swales, open spaces such as lawns or parks, or the retention of "natural areas".

It should be pointed out that proper landscape design should significantly reduce runoff and resultant inconveniences from frequent, less severe rainstorms. Runoff will still occur at times when there is sufficient rainfall to saturate the soil. Such saturation may result from a long period of continuous rain. At such a point, the ability of the soil and vegetation to absorb additional moisture is severly restricted. Additional heavy rainfall of short duration would probably result in substantial runoff from a site, requiring other control measures to prevent downstream flooding.

Stormwater Storage

The temporary storage of excess runoff to be slowly released following the storm peak is one of the primary means of reducing the adverse stormwater related impacts resulting from urbanization. While the temporary storage of stormwater runoff does not significantly decrease the volume of runoff, storage can modify the time-distribution of runoff. The major financial benefits derived from properly designed storage facilities include the reduction of flooding occurrences and reduced downstream drainage facilities. Secondary benefits include the reduction of pollutant loading of receiving bodies of water, downstream erosion reduction and increased groundwater recharge.

Naturally occurring ponds, wetlands and shallow depressions provide valuable temporary storage of stormwater runoff. When natural storage areas are either insufficient or lost due to development, man-made facilities are required. Various alternatives include restrictive culverts, roof-top storage, parking lot ponding and retention/detention ponds.

The design of stormwater storage facilities require the careful consideration of their multiple impact, including personal safety, protection of real property, annual cost of the facility, possibilities for multiple use, and aesthetic enhancement of the surrounding area.

Parking Lot Storage

The large area characteristic of parking lots serving office complexes, shopping centers and industrial areas make these sites especially conducive for stormwater detention. Large volumes of rainfall can be stored on portions of the lot. The slow release of stored water can be accomplished by an undersized outlet drain or pipe. Induced infiltration, grassed areas or gravel filled seepage pits can be used in combination or in lieu of a restrictive outlet.

If possible, these parking lot storage areas should be located away from high-use areas, thereby minimizing inconvenience to building occupants. Ponding depths should typically be less than one foot, eliminating potential safety hazards and possible damage to parked vehicles.

Rooftop Storage

Temporary storage of rainfall on horizontal rooftops is utilized in several areas of the country. Rooftop detention facilities do not result in inconvenience to pedestrians or building occupants. However, design considerations are a critical factor for such facilities.

Structural integrity, leakage problems, maintenance requirements and provisions for possible overflow must be carefully considered by a qualified architect or engineer. These problems can be addressed, especially if designed into the original building plans. Structural design should not pose a significant problem in Minnesota since buildings are already required to accommodate heavy snow loadings. Maintenance is primarily limited to the removal of debris and ice, actions which would be required under any circumstances.

Surface Basins

When additional large amounts of runoff storage are required, some type of artificial detention or retention ponds are typically utilized. The major design considerations include the total volume of storage required and the permissible release rate. A local community or watershed district may require a developer to limit runoff to the safe carrying capacity of receiving stream(s) or the pre-development rate.

Retention ponds are storage facilities which remain partially filled with water at all times. The ponds are designed to store excess runoff to be slowly released following the rainfall. By maintaining a minimum water level, additional benefits can be achieved, including enhancement of the surrounding landscape, recreational opportunities and wildlife habitat.

Detention ponds differ from retention areas in that water is "detained" only for a short period of time following a severe storm. The majority of the time, these facilities remain dry and are suitable for other uses, such as park areas, playgrounds, ball fields or other open space uses.

The design of these facilities is the critical factor to their acceptance by the general public. If the facility is to also be used as a recreational area, its use as a ponding area should be restricted to severe storms, not every time it rains. Water should drain from detention ponds within 1-2 days following the storm so as to not only allow for additional protection from subsequent severe rainfall, but also to reduce any safety hazard and eliminate breeding grounds for mosquitos.

Maintenance

Continuing maintenance requirements of stormwater management facilities should be a major factor in their planning and design. Limited attention paid to operation and maintenance will often result in a facility becoming an eyesore, nuisance or health hazard, as well as reducing its effectiveness.

Maintenance considerations include algae and aquatic vegetation control, mosquito control, debris removal, sediment removal and the maintenance of hydraulic facilities. The responsibility for maintenance should be clearly established before a stormwater management plan is implemented.

Additional Information and Assistance

The intent of this brochure is to acquaint the general public with the concepts of stormwater management. The planning and implementation of effective stormwater management measures will require more detailed analysis than presented herein. The Minnesota Department of Natural Resources - Division of Waters is prepared to assist a community in the development of stormwater management measures.

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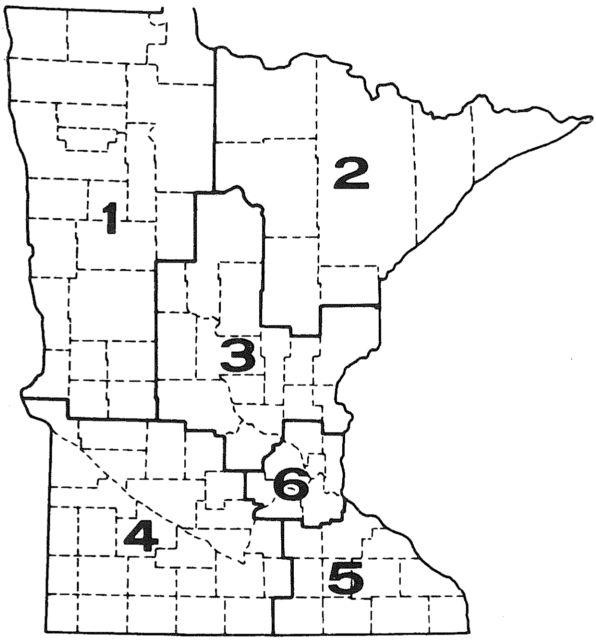

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