Appendix I

CITY OF WADSWORTH

STORM MANAGEMENT REGULATIONS

MAY 1996

STORM MANAGEMENT REGULATIONS

PURPOSE

The purpose of these regulations are as follows:

1. To establish reasonable standards to be used as a basis for the design of all storm drainage systems within the City of Wadsworth.

2. To clarify portions of the existing Soil Sediment and Pollution Control Ordinance (Ord. 66-79)(Chapter 1391 of the Subdivision Regulations).

3. To specify detention/retention facility design standards.

4. To specify accepted materials and approved construction details.

SCOPE

These regulations shall apply to all residential, commercial and industrial development, including any construction, reconstruction, additions, excavation, embankment, etc., within the jurisdiction of the City of Wadsworth.

The regulations are intended to provide limits on the design of storm control systems so performance objectives can be achieved. Deviation from these regulations may be permitted, with the approval of the City Engineer, to allow flexibility in the actual design of the individual systems.

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I. Definitions

The following definitions are provided to familiarize the user of this text with some of the common terms used in the text.

Accelerated Runoff means increased runoff due to less permeable surface area primarily caused by urbanization.

Area of Special Flood Hazard means the land in the flood plain subject to a one percent or greater chance of flooding in any given year. This area is commonly referred to as the 100-year flood plain or area of secondary storms.

Backwater means the increased depth of water upstream from a dam, culvert pipe or obstruction in a stream channel due to the existence of such obstruction.

Backwater Curve means the term applied to the longitudinal profile of the water surface in a stream or open channel when flow is steady but non-uniform.

Base Flood means the flood having a one-percent chance of being equaled or exceeded in any given year. On the average, the flood occurs once in 100 years although it may occur in any given year. The term "base flood" has the same meaning as the 100-year flood, secondary storms, regional flood, or intermediate regional flood and may be defined in terms of elevations and discharges at various locations along a stream.

Bypass Channel means a man-made channel formed to carry excess stormwater runoff through a specific area.

Channel means a natural or artificial waterway which continuously or periodically contains moving water, or which forms a connecting link between two bodies of water. It has a definite bed and banks which confine the water.

Channelization means the straightening, dredging, or otherwise modifying of a stream and its overbank areas to permit the rapid passage of flood flows.

Channel Storage mean the control, retention, or detention of runoff.

Composite Hydrograph means a graph showing the sum of discharge values with respect to time from separate areas or sub-areas for a given point under consideration.

Conduit means an artificial or natural duct for conveying liquids.

Conveyance is a mathematical term applied to the measurement of the carrying capacities of channels and overbank areas. Conveyance is directly proportional to discharge.

Course means a natural or artificial channel for passage of water.

Critical Depth means that particular depth of flow in a channel or conduit with a given discharge at which the specific energy is at a minimum.

Critical Storm means that storm intensity for which it and more frequent storms will need peak runoff rates reduced to compensate for the increase in runoff volume caused by development.

Culvert means a closed conduit for the passage of surface drainage water under a highway, railroad, embankment, or other impediment.

Dam means a barrier constructed across a watercourse for the purpose of (a) creating a reservoir, and (b) diverting water into a conduit or channel.

Detention means the temporary delaying of stormwater runoff.

Development Area means any contiguous (abutting) area owned by one person, corporation, or operated as one development unit and used or being developed for non-farm commercial, industrial, residential, or other non-farm purposes upon which earth-disturbing activities are planned or underway.

Discharge means the rate of flow or volume of water flowing in a stream or conduit at a given place within a given period of time.

Discharge Control Structure means a structure designed to control the rate of stormwater discharge. Also called "Flow Control Structure".

District means the Medina County Soil and Water Conservation District.

Ditch means an excavation either dug or natural for the purpose of drainage or irrigation with intermittent flow.

Division means the Division of Soil and Water Districts, Department of Natural Resources.

Drainage means in general, the removal of surface or groundwater from a given area either by gravity or by pumping. The term is applied herein to surface water.

Drainage Area means (1) The contributing area to a single drainage basin, expressed in acres, square miles, or other unit or area. Also called Catchment Area, Watershed, and River Basin. (2) The area served by a drainage system receiving storm and surface water or by a watercourse.

Drainage System means the surface and sub-surface system for the removal of water from the land. This includes both the natural elements of streams, gullies, ravines, marshes, swales, and ponds whether of an intermittent or continuous nature and man made elements which include conduits and appurtenant features, culverts, ditches, channels, storage facilities, streets, and the storm sewer system.

Drainageway means a route or course along which water moves or may move to drain an area.

Drop Inlet Structure means a vertical structure in a drainageway for the purpose of dropping water to a lower level.

Earth Disturbing Activity means any grading, excavating, filling, or other alteration of the earth's surface where natural or man-made ground cover is destroyed and which may result in or contribute to erosion and sediment pollution.

Earth Material means soil, sediment, rock, sand, gravel, and organic material or residue associated with or attached to the soil.

Easement means a grant by the property owner of the use of a strip of land by the public or by one or more persons or corporations for a specific purpose or purposes.

Engineer or City Engineer means the City of Wadsworth Engineering Department and its designated representatives.

Erosion for this purpose only means:

(a) The wearing away of the land surface by running water, or ice.
(b) Detachment and movement of soil or rock fragments by water, or ice.

Excess Stormwater means that portion of stormwater runoff which exceeds the transportation capacity of natural drainage channels serving a specific watershed.

Flood means a general and temporary condition of partial or complete inundation of normally dry land areas from:

1. the overflow of inland or tidal waters, and/or

2. the unusual and rapid accumulation or runoff of surface waters from any source.

Flood Elevation means the maximum water surface elevation of a particular flood event at a given location along a stream. The elevations are usually referenced to mean seal level.

Flood Frequency means the average frequency, statistically determined, for which it is expected that a specific flood state or discharge may be equaled or exceeded. The frequency of a particular flood state or discharge is usually expressed as having a probability of occurring on the average of once within a specified number of years. See also "Recurrence Interval".

Flood Hazard Area means the land in the flood plain subject to a one percent or greater chance of flooding in any given year. This area is commonly referred to as the 100-year flood plain or area of secondary storm.

Flood Peak means the highest value of stage or discharge attained during a flood event, i.e., peak stage or peak discharge.

Flood Plain means the areas adjoining a watercourse which may be inundated during a flood.

Flood Plain Management means a full range of public policy and action for ensuring wise use of the flood plains. It includes collection and dissemination of flood information, acquisition of flood plain lands through outright purchase or easements, construction of flood control structures, and enactment and administration of codes, ordinances, resolutions, and statutes regarding flood plain land use.

Flood Plain Regulations means all codes, ordinances, resolutions, and other regulations relating to land use and construction within the limits of the regulatory flood plain.

Flood Profile means a graph or longitudinal plot of maximum water surface elevations of a flood event versus measured distance along a stream from a fixed point. The zero or beginning point is usually the mouth of the stream and elevations are most commonly expressed as feet above mean sea level.

Flood Proofing means any combination of structural and nonstructural additions, changes, or adjustments primarily for the reduction or elimination of flood damages to real property, water and sanitary facilities, structures, and contents of buildings in flood hazard areas.

Flood Protection Elevation means that elevation at any point along a watercourse corresponding to an increase of not less than 2 feet above the water surface profile associated with the base flood.

Flood Stage means the height of the water surface above some arbitrary datum where overflow of the natural banks of a stream results in flood damage. As commonly used by the U.S. Weather Bureau and others, flood stages are referenced to a particular stream gage which is a representative index of a specific reach of a stream.

Floodway means the channel of a river or other watercourse and the adjacent land areas that must be preserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designed height.

Floodway Encroachment Lines mean the physical lines marking the limits of the regulatory floodway on designated maps.

Floodway Fringe means that portion of the regulatory flood plain outside of the floodway.

Flow Routing means the derivation of an outflow hydrograph for a given stream reach from known values of upstream inflow.

Freeboard means the distance between the designed water surface elevation and the crest of the conveyance structure.

Frequency Curve means a graphical representation of the frequency of occurrence of specific events.

Gabion means a cage or wire basket filled with stones and deposited with others to protect against erosion.

Grade means (1) The slope of a channel, conduit, or natural ground surface, usually expressed in terms of the ratio or percentage of number of units of vertical rise or fall per unit of horizontal distance. (2) The elevation of the invert of the bottom of a pipeline, culvert, sewer, or similar conduit. (3) The finished surface of a road, top of embankment, or bottom of an excavation.

Grassed Waterway means a broad and shallow natural course of constructed channel covered with erosion resistant grasses or similar herbaceous cover and used to conduct surface water.

Head means the height of the free surface of water above a point of reference in the system.

Homogeneous Area means (1) A drainage area which has relative uniform runoff characteristics; i.e., land use, slope, soil treatment, etc. are relatively uniform. (2) Based on runoff curve numbers, a homogeneous area is one having curve numbers in the range of 65 to 80.

Hydraulics means a branch of science that deals with practical applications of the mechanics of water movement.

Hydraulic Grade Line means a hydraulic profile of the piezometric level of water at all points along a line.

Hydrograph means a graph showing the discharge stage, velocity, or other property of water with respect to time for a given point under consideration.

Hydrology means the applied science concerned with the water of the earth in all its states. It deals with the processes of governing the depletion and replenishment of the water resources of the land areas of the earth.

Improvements means the entire right-of-way grading and street surfacing, with or without curbs and gutters, sidewalks, crosswalks, water mains, sanitary and storm sewers, culverts, bridges, street trees, street lighting and other appropriate items.

Infiltration means (1) the entering of water through the pores of a soil or other porous medium. (2) The absorption of liquid by the soil, either as it falls as precipitation or from a stream flowing over the surface.

Initial Abstractions means all losses before runoff begins.

Inlet means (1) a surface connection to a drain pipe. (2) An opening into a storm sewer system for the entrance of surface or stormwater. (3) A structure at the diversion end of a conduit.

Inlet Control means control of the relationship between headwater elevation and discharge by the inlet or upstream end of any structure through which water may flow.

Lag means the increment of time from the center of mass of that portion of rainfall that runs off to the peak rate of runoff from the watershed. The lag of a watershed may be thought of as a weighted time of concentration.

Mean Velocity means that average velocity of water flowing in a channel or conduit at a given cross section or in a given reach. Also called average velocity. It is equal to the discharge divided by the cross-sectional area of the channel or conduit.

Non-Homogeneous Area means (1) a drainage area in which the runoff characteristics are dissimilar. (2) Based on runoff curve numbers, a non-homogeneous area is one having curve numbers outside the range of 65 to 80.

Orifice means an opening with closed perimeter and of regular form in a plate, wall or partition through which water may flow.

Open-Channel Flow means flow in any open or closed conduit where the water surface is free; that is, where the water surface is at atmospheric pressure.

Outfall means the location where storm runoff discharges from a sewer or conduit. Also applied to the outfall sewer or channel which carries the storm runoff to the point of outfall.

Outlet Control means control of the relationship between the headwater elevation and the discharge by the outlet or downstream end of any structure through which water may flow.

Overflow means the excess water that overflows the ordinary limits such as the stream banks, the spillway crest, or the ordinary level of a container.

Peak Rate of Runoff means the maximum rate of runoff for any storm.

Person means any individual, corporation, partnership, joint venture, agency, unincorporated association, municipal corporation, county or state agency, the Federal government, or any combination thereof.

Plat means a map of a tract or parcel of land.

Plan or Sediment control plan means a written description, acceptable to the approving agent, of methods for controlling sediment pollution from accelerated erosion on a development area and/or from erosion caused by accelerated runoff from a development area.

Precipitation means the total measurable supply of water received directly from clouds as rainfall, snow, hail, or sleet; usually expressed as depth in a day, month, or year.

Primary Drainage System means that part of the storm drainage system which is used regularly for collecting, transporting, and disposing of storm runoff, snow melt, and miscellaneous minor flows. The capacity of the primary drainage system should be equal to the maximum rate of runoff to be expected from a design storm which may have a frequency of occurrence of once in ten years. The primary system is also termed the minor system, or the storm sewer system and may include many features ranging from curbs and gutters to storm sewer pipes and open drainageways.

Post Development means the state of condition of the earth's surface after urbanization occurs. Other terms are developed, future and after development.

Pre-Development means the state of condition of the earth's surface prior to development.

Public Utilities means all persons, firms, corporations, co-partnerships or municipal authority providing gas, electricity, water, steam, telephone, sewer or other services of a similar nature.

Public Waters means that water within rivers, streams, ditches, and lakes, except private ponds and lakes wholly within single properties, or waters leaving property on which the surface water originates.

Rainfall Duration means the length of time of the rainfall event from beginning to end, usually in hours.

Rainfall Event means a fall of rain or precipitation in the form of water which occurs in a particular period of time.

Rainfall Intensity means amount of rainfall occurring in a unit of time, converted to its equivalent in inches per hours at the same rate.

Reach means a longitudinal segment of a stream or river within which flood heights are primarily controlled by man-made or natural obstructions or constrictions.

Recurrence Interval means the average interval of time within which a given event will be equaled or exceeded once.

Regulatory Area means that portion of the flood plain subject to inundation by the 100 year flood that has been designated as a portion of the major drainage system.

Regulatory Flood Plain means a watercourse and the area adjoining a watercourse which have been or hereafter may be covered by the base flood. The regulatory flood plain includes both the floodway and floodway fringe.

Regulatory Floodway means the channel of a river or other watercourse and the adjacent land areas that must be preserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designed height.

Return Period see "recurrence interval"..

Runoff means the portion of rainfall, melted snow, or irrigation water that flows across the ground surface and eventually is returned to streams.

Runoff, Total Direct means the total volume of flow from a drainage area for a definite period of time such as a day, month, or rainfall event which reached stream channels.

Runoff Volume means the total quantity or volume of runoff during a specified time period. It may be expressed in cubic feet per second, acre-feet, in inches depth of the drainage area, or in other units of volume.

Secondary Drainage System means that storm drainage system which carries the runoff from a storm having a frequency of occurrence of once in 100 years. The secondary system will function whether or not it has been planned and designed, and whether or not improvements are situated wisely in respect to it. The secondary system usually includes many features such as streets, ravines, and major drainage channels. Storm sewer systems may reduce the flow in many parts of this major system by storage and transporting water underground.

Sediment means solid material both mineral and organic, that is in suspension, is being transported, or has been moved from its site or origin by wind, water, gravity, or ice and has come to rest on the earth's surface above or below sea level.

Sediment Basin means a barrier, dam, or other suitable detention facility built across an area of flow to settle and retain sediment carried by the runoff waters.

Sediment Pollution means failure to use management or conservation practices to abate wind or water erosion of the soil or to abate the degradation of the waters or the state of soil sediment in conjunction with land grading, excavating, filling, or other soil disturbing activities on land used or being developed for non-farm commercial, industrial, residential, or other non-farm purposes.

Slope means the inclination or grade of a channel, conduit, or natural ground surface, usually expressed in terms of the percentage of units of vertical rise or fall per unit of horizontal distance.

Slope Protection means soil cover on a slope surface to minimize or eliminate erosion and/or to ensure stability of a soil slope steeper than the normal angle of repose of the soil. Examples are: low maintenance ground cover such as crown vetch and spreading juniper, dumped rock or rip-rap, stone filled gabions, bituminous or concrete paving, and concrete or timber cribbing.

Sloughing means a slip or downward movement of an extended layer of soil frequently resulting from the undermining action of water, waves, or the earth disturbing activity of man.

Soil Loss means soil moved from a given site by the forces of erosion and the redeposit of the soil at another site on land or in a body of water.

Spillway means a waterway in or about a hydraulic structure for the escape of excess stormwater.

Storage means the control, retention, or detention of runoff.

Channel Storage means storm runoff water present in a channel at any given time. Generally considered in the attenuation of the peak of a flood hydrograph moving downstream.

Depression Storage means that portion of the rainfall that is collected and held in small depressions and does not become part of the general runoff.

Detention Storage means storm runoff collected and stored for a short period of time and then released at a controlled rate (dry pond).

Downstream Storage means the storage of storm runoff water at some distance from the points of rainfall occurrence but before it reaches areas where it may endanger lives or property.

Off-stream Storage means the temporary storage of storm runoff water away from the main channel of flow

On-stream Storage means the temporary storage of storm runoff water behind embankments or dams located on the channel.

Retention Storage means storm runoff collected and stored for a short period of time and which is released at a controlled rate leaving in the facility a minimum pool of water. This facility is often associated with water related recreational or aesthetic uses (wet pond).
Upstream On-site Storage means the storage of storm runoff water near the points of rainfall occurrence, usually applicable to rooftop ponding, parking lot ponding, and small drainage basins.

Storm frequency means the average period of time which a storm of a give duration and intensity can be expected to be equaled or exceeded.

Storm, Primary Design means that storm used for design purposes, the runoff from which is used for sizing the primary storm drainage system. It usually is of such magnitude that it can be expected to occur only once every ten years.

Storm, Secondary Design means that storm used for design purposes, the runoff from which is used for sizing the secondary drainage works. It usually is a storm of such magnitude that it can be expected to occur once every 100 years.

Storm Drainage System means the surface and sub-surface system for the removal of water from the land, including both the natural elements of streams, gullies, ravines, marshes, swales, and ponds whether of an intermittent or continuous nature and man-man elements which include conduits and appurtenant features, culverts, ditches, channels, storage facilities, streets, and the storm sewer system.

Stormwater Management means the application of various techniques for mitigating the deleterious effects of land use on runoff.

Stream means a body of water running or flowing on the earth's surface or channel in which such flow occurs. Flow may be seasonally intermittent.

Street Classifications:

Collector Street means a street which is intended to carry traffic from minor streets to the major streets.

Major Street means a street used primarily for fast or heavy traffic between large or intensively developed districts.

Minor Street means a street intended primarily to provide pedestrian and vehicular access to the abutting properties.

Street Flow means the total flow of stormwater runoff in a street, usually the sum of gutter flow on each side of the street. Also, the total flow where there are no curbs and gutters.

Structure means a walled and roofed building, including a gas or liquid storage tank that is principally above ground. Mobile homes are also considered structures.

<u>Subdivision Regulations</u> mean regulations and standards established by the City Council of Wadsworth, Ohio and known by us as the City of Wadsworth Subdivision Regulations".

<u>Substantial Improvement</u> means any repair, reconstruction, or improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of a structure either, (a) before the improvement or repair is started, or (b) if the structure has been damaged and is being restored, before the damage occurred.

<u>Surface Flow</u> or Sheet Flow means the surface flow from rainfall on ground surfaces, pavements, or other exposed surfaces until such flow reaches a gutter, ditch, swale, inlet, or other point of concentration.

<u>Swale</u> means a drainage channel, normally grass lined, with relatively flat side sloped (5:1 or less).

<u>Technical Release 55</u> means the Soil Conservation Service (SCS) organized procedure for the analysis of stormwater.

<u>Time of Concentration</u> means the time required for stormwater runoff to travel from the most hydrologically remote section of the drainage area to the point under consideration.

<u>Time of Flow</u> means the time required for water to flow in a storm sewer or channel from the point where it enters to a particular point.

<u>Time of Inlet</u> means the time of concentration for the inlet, usually includes ground surface flow time and gutter flow time.

<u>Topsoil</u> means surface and upper surface soils which presumably are darker colored, fertile soil materials, ordinarily rich in organic matter or humus debris.

<u>Unit Hydrograph</u> means a graph of runoff vs. time produced by a unit rainfall over a given duration.

<u>Velocity of Approach</u> means the mean velocity immediately upstream from a weir, dam, or other hydraulic structure.

<u>Watercourse</u> means a channel in which a flow of water occurs either continuously or intermittently in a definite direction. The term applies to either natural or artificially constructed channels.

<u>Water Level:</u>

> <u>Design High Water Level</u> means calculated water level in storage facilities associated with the primary design storm and volume requirements criteria. Also, predicted water level in ditches and swales under primary design storm.
>
> <u>Maximum Water Level</u> means the predicted water level in storage facilities or drainage system in overflow condition used in conjunction with flood flow routing of the secondary design storm.

II. Storm Control Criteria

Storm runoff control addresses both peak rate and total volume of runoff.

The peak rate of runoff from an area after development shall not exceed the peak rate of runoff from the same area before development for all storms up to a 100-year frequency, 24 hour storm. In addition, if it is found a proposed development will increase the volume of runoff from an area, the peak rate of runoff from certain more frequent storms must be controlled further.

There are two reasons why increases in volume of runoff require a control standard more restrictive than controlling just the pre-development conditions. First, increases in volume means runoff will be flowing for a longer period of time. When routed through a watershed, these longer flows may join at some point downstream; thereby creating peak flows and the problems associated with peak flows (flooding). This is known as the "Routing Problem." Second, longer flow periods of large runoff quantities place a highly erosive stress on natural channels. This stress can be minimized by reducing the rate of discharge.

Critical Storm

The increase in the rate of runoff is dependent on the type and amount of development that occurs on a site. The change from pervious to impervious land uses causes an increase in runoff. In keeping with the storm control criteria, the developed runoff must be controlled and/or detained to reflect pre-developed conditions..

1. To determine the allowable peak rate of runoff that can be discharged from the development, a critical storm frequency shall be determined as follows:

   a. Determine the volume of runoff from a 1-year frequency, 24-hour storm occurring over the area before and after development.

   b. Determine the percent of increase volume due to development and using this percentage, pick the critical storm from the following table:

If the percentage of increase in volume of runoff is		The critical storm for discharge limitation will be
Equal to or greater than	and less than	
0	10	1 Year
10	20	2 Years
20	50	5 Years
50	100	10 Years
100	250	25 Years
250	500	50 Years
500	----	100 Years

2. The peak rate of discharge from any storm having a frequency greater than or equal to the critical storm, occurring over the development, shall not exceed the peak rate of runoff from a 1-year frequency storm, occurring over the same area, under pre-development conditions. Storms of less frequent occurrence (longer return period) than the critical storm, shall control the peak rate of discharge from the development to be no greater than the peak rate of runoff for the same frequency storm under pre-development conditions.

   As an example, if the total volume is shown to be increased by 35%, the critical storm is a 5 year storm. The peak rate of runoff (allowable discharge) for all storms up to the intensity of the critical storm shall be controlled so as not to exceed the peak rate of runoff from the 1-year frequency storm under pre-development conditions. The peak rate of runoff (allowable discharge) from a more intense storm need only be controlled so as not to exceed the pre-development peak rate of runoff from the same frequency of storm.

3. The storm control structure shall be designed to only release the allowable discharge for each given storm frequency through the 100 year storm occurrence. The system will require a storage area where storm can be detained until it is released through the control structure. The difference between the actual peak rate of runoff from the developed site and the allowable peak rate of discharge will determine the required storage volume.

   Storage volume does not have to be provided for off-site upstream areas. Runoff from off-site areas will be routed through the drainage system in the proposed development at the same frequency that was used for the on-site system.

III. Uniform Design Standards

The Engineering department of the City of Wadsworth have established these uniform design standards for all drainage systems, public or private, which affect more than one owner, so that any individual drainage system will be compatible with any adjacent drainage system. By having all drainage systems compatible, the chance of sedimentation caused by a drainage system failure is greatly reduced.

Conditions

No improvements shall be made unless and until all necessary plans, profiles, and specifications therefore, and the preliminary plat, have been submitted to and approved by the City and also the County Engineer, in the case of lands outside the City. The improvements shall be of such sizes, capacities and amounts as are required for the development of the proposed subdivision and of extra sizes as may be necessary to serve nearby land which is an integral part of the neighborhood service drainage areas.

The subdivider shall be required to extend, or petition for the extension of, the improvements to serve adjoining unsubdivided land. If streets or utilities are not available at the boundary of a proposed subdivision, the Planning Commission may require the subdivider to construct, or petition for the construction of, off-site extensions of the improvements. Procedures for providing any necessary public lands, extra-size and off-site improvements and general standards for prorating costs are set forth in Section 1383.05 of the Subdivision Regulations. (ord. 3-80. Passed 3/18/80)

Design Storm Criteria

Meeting the following standards and criteria does not relieve any person from liability from storm damage to another person's property.

Design Storms

The primary drainage system is that part of the storm drainage system which is used regularly for collecting, transporting, and disposing of storm-water runoff, snow melt, and other miscellaneous minor flows. The capacity of the primary drainage system should be equal to a maximum rate of runoff expected from a design storm of established frequency or given intensity. For design by the Rational Method or the SCS TR-55 Method, the following return frequency storms will be used. When designing by the Wadsworth Modified Rational Method, use the given intensities.

Structure Type	Primary Design Storm Rational or Tr-55 Methods	Wadsworth Modified Rational intensity (i)
Culverts	10 Year	4
Drive Culverts	10 Year	4
Open Drainage Swales	10 Year	4
Roadside Ditches	10 Year	4
Storm Sewers	10 Year	4
Bridges	100 Year	7
Flood plain Structures	100 Year	7

The secondary drainage system is that part of the storm drainage system which carries the runoff which exceeds the capacity of the primary drainage system. The secondary drainage system should have the capacity to carry runoff from a storm with a return period of 100 years without posing significant threat to public safety or property.

Primary Storm Design Criteria

1. Conduits shall be designed on the basis of flowing full with surcharge to the gutter line. Backwater effects shall be considered..

2. Depth of flow in natural channels shall not exceed full stage, backwater effects considered.

3. Depth of flow in roadside ditches shall be of such depth that the flow will not exceed the ditch capacity and flow onto private property except at designated discharge points. Proposed water surface elevation shall not exceed 1' below the proposed edge of pavement elevation.

4. Depth of flow in streets with curb and gutter shall not exceed the curb height. Velocity of flow in the gutter at design depth shall not exceed ten feet per second. In addition to the above, the following are maximum encroachments of the primary design storm onto the pavement:

   a. For Minor and Collector Streets, the spread may not exceed 8 feet.

   b. For Major Streets, one lane of the traffic in each direction shall be free from water.

5. Depth of flow in artificial channels shall not exceed 0.8 bank full stage. Velocity of flow shall be determined in accordance with the design criteria for open channels as outlined under Section IX. See Exhibit III-1.

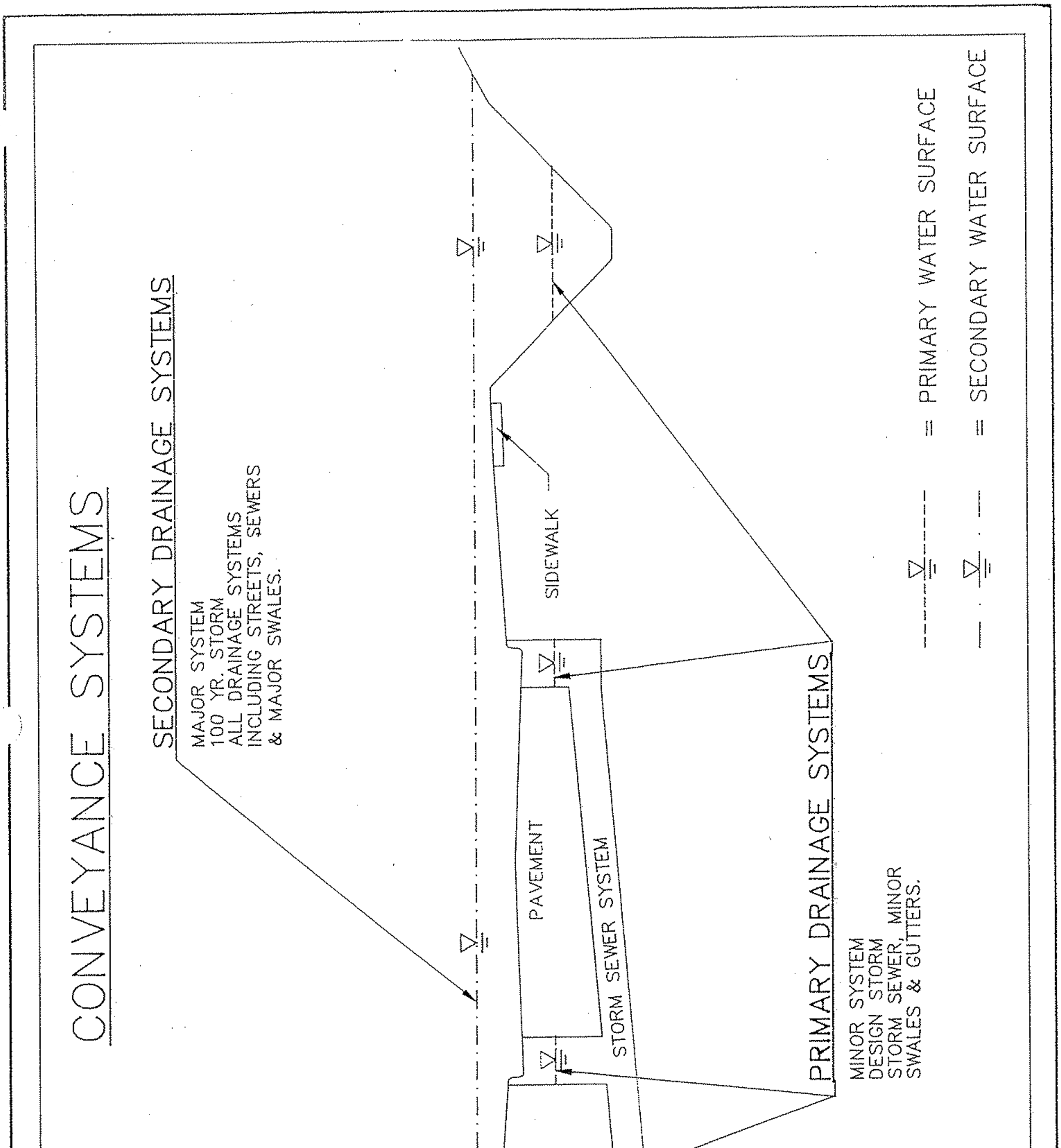
Secondary Storm Design Criteria

The secondary storm floodway and floodway fringe for natural streams shall be as defined by the U.S. Army Corps of Engineers, the U.S. Department of Housing and Urban Development, or the Ohio Department of Natural Resources, where such determinations have been made.

Many of the drainageways associated with the secondary storm systems are in areas beyond those designated as floodway or floodway fringe areas. For these areas, the secondary storm flood limits shall be determined by accepted methods of determining water profiles using the secondary design storm runoff. One foot elevation shall be added to the flood profile as freeboard for protection in the event of future encroachments into the floodway fringe of the secondary drainageway.

When a street is designated as the secondary drainageway, the depth of flow shall not exceed 9" at the gutter line for local and collector streets and shall not exceed 3" depth at the crown for arterial and freeways. The same maximum depth criteria will apply where a secondary drainageway crosses the street. Where a secondary drainageway is located outside a street right-of-way, easements shall be provided as necessary to accommodate the storm event.

In determining the required capacity of surface channels and other drainageways used for secondary storm runoff, the street storm inlets and conduits provided for the primary design storm shall be assumed to be carrying their design capacity. See Exhibit III-1.


CONVEYANCE SYSTEMS
SECONDARY DRAINAGE SYSTEMS
MAJOR SYSTEM
100 YR. STORM
ALL DRAINAGE SYSTEMS
INCLUDING STREETS, SEWERS
& MAJOR SWALES.
SIDEWALK
PAVEMENT
STORM SEWER SYSTEM
SIDEWALK
PRIMARY DRAINAGE SYSTEMS
MINOR SYSTEM
DESIGN STORM
STORM SEWER, MINOR
SWALES & GUTTERS.
= PRIMARY WATER SURFACE
= SECONDARY WATER SURFACE

Erosion Control

Any work within the City shall comply with the Soil Sediment Pollution Control Ordinance (Ord. 66-79, Section 1391 of the Subdivision Regulations). An erosion control plan shall be submitted to the Soil Conservation Service for review and approval for all sites greater than 5 total acres. An NPDES permits shall be obtained from the OEPA when required.

Contractor shall follow the best management practices for the control of sediment on the site. Necessary erosion control devices shall be installed prior to earthwork activities.

Extra-Size and Off-Site Improvements

Extra size and off-site improvement costs are subject to Subdivision Regulations Section 1383.05.

Flood Plain

If any portion of the land within the subdivision is subject to inundation or flood hazard by storm water, such fact and portion shall be clearly indicated on the preliminary and final plats by a prominent note on each sheet of such map whereon any such portion shall be shown. Natural watercourses shall be indicated on the preliminary and final plats in like manner.

Land subject to flooding, and land deemed by the Planning Commission to be otherwise uninhabitable, shall not be platted for residential occupancy or for such other uses as may increase danger to health, life or property, or aggravate the flood hazard. (Ord 2917. Passed 7/21/64. Ord. 33-88)

Footer Drains

Any new footer drains shall be routed to a sump where the water will be pumped to an unobstructed gravity drain. The storm drains shall be connected to the public storm sewer if possible. No footer drain will be permitted to tie directly into the public storm sewer unless it can clearly be shown that the proposed footer drain will not surcharge in any storm.

Maintenance of Drainage Systems

Any portion of the drainage system, including on-site and off-site storage facilities, that is constructed by the developer will be continuously maintained by the owner or owners subsequent in title of the affected lands unless it is officially accepted by the City for maintenance. The developer shall cause the maintenance obligation to be inserted in the chain of title to the affected lands as a covenant running with the land in favor of the City.

Easements

Access to flood control or storm drainage facilities for emergency, inspection, maintenance and improvement purposes, shall be provided as follows:

A. Access to flood control or storm drainage ditches, channels and storage facilities, shall be by means of easements. Such easements shall be not less than sixteen feet in width.

B. Access along flood control or storm drainage ditches and channels, shall be by means of easements. Such easements shall be not less than sixteen feet in width, exclusive of the ditch, channel or other facility it is to serve. An easement of this type shall be provided on one side of the flood control or storm drainage ditch, channel or similar facility.

C. Access around storage facilities shall be a minimum ten feet easement in the case of detention or dry basins and a minimum twenty-five feet easement in the case of retention or wet basins. The width shall be measured from the design high water level and shall include the storage facility itself. The approving agency may require easements in excess of the minimums.

D. Easements for emergency flow ways shall be a minimum fifteen feet in width.

E. Flood control or storm drainage easements containing underground facilities shall have a minimum width of sixteen feet.

Natural Channels

Where a subdivision is traversed by a drainageway, channel or stream, a stormwater easement or drainage right-of-way, conforming substantially with the lines of such watercourse, shall be provided. The easement shall be a minimum twenty feet wide or of such further width as adequate for the purpose and generally parallel with the rear or side lot lines.

Natural Features

Due consideration shall be given to preserving outstanding natural features such as scenic spots, water bodies or exceptionally fine groves of trees. Dedication to and acceptance by a public agency are usually the best means of assuring their preservation. (Ord. 2917. Passed 7/21/64)

Pipe Removal Policy

The following should be used by the designer as a guideline for determining whether an existing pipe that is taken out of service, regardless of type, should be abandoned or removed:

A. Pipes 8 inches in diameter or less, regardless of depth or height of fill, may be abandoned in place.

B. Pipes 10 inches through 24 inches in diameter or rise with less than 3 feet of final cover should be removed or filled; with more than 3 feet of final cover they may be abandoned in place. (The designer should use discretion in removing small pipes under existing rigid pavement or base which is to remain in place.)

C. Pipes over 24 inches in diameter or rise should generally be removed. (The designer should use discretion in removing any pipe with more than 10 feet of cover)

D. Where it is necessary to maintain service of small unrecorded storm drain connections to a storm sewer being taken out of service, but this cannot be assured without removal of that sewer; the storm sewer shall be removed.

Storm Sewer Policy

For projects located within the dedicated right-of-way.

To the extent funds are available in the annual appropriations to the storm drain capital improvement fund (60-S-02), the City shall pay at least fifty percent (50%) of the cost or at the City's option, provide the required labor and equipment to install the storm sewer piping and appurtenances in the following.

The Safety Director determines that the improvement will significantly improve public safety, or;

The City Engineer determines that the improvement is needed to prevent extensive deterioration or structural damage to the roadway, or;

Curbs and gutters are proposed as part of the improvement.

In cases where the instances outlined in A. above are not met and the property owner desires to have storm pipe installed along the abutting frontage and is willing to pay 100% of the cost thereof, the City will provide the following (at no cost):

Pipe size requirements, pipe grade requirements, set minimum off-site transition ditching requirements and establish the location of any needed catch basins or inlets.

Labor and material needed to install catch basins and/or inlets.

For projects located outside of dedicated right-of-way on private property within existing developed areas of the City. .

> To the extent funds are available in the annual appropriation to the storm drain capital improvement fund (60-S-02), the City shall pay fifty percent (50%) of the cost or at the City's option, provide the required labor and equipment to install the storm sewer piping and appurtenances in the following instances:
>
> > The pipe size needed to serve the drainage area is 12" diameter or greater, and;
> >
> > More than fifty percent (50%) of the drainage area is located off-site, and;
> >
> > The property owners are willing to grant such temporary and permanent easements as required at no cost to the City.

In those instances where the pipe size needed to serve the drainage area is less than 12" in diameter and more than fifty percent (50%) of the drainage area is located off-site, the City Engineering Division will provide engineering assistance to the project to the extent time constraints of the division permit.

IV. Rainfall in the City of Wadsworth

Introduction

Rainfall information is basic to the design of all storm facilities. Rainfall is a natural event and precise projections of its frequency and intensity cannot be made. However, useful information can be obtained by analysis of past storms. Reasonable predictions of the frequency of occurrence (recurrence interval), the duration, the amount, the distribution of the amount with respect to area, the distribution of the intensity with respect to time, and the seasonal probability of an occurrence can be made.

Rainfall Intensity - Duration - Frequency

The most familiar presentation of rainfall data is a set of curves representing different frequencies of occurrence of rainfall events with the intensity of the rainfall plotted against its duration. A series of intensity - duration - frequency curves for rainfall in Wadsworth, Ohio had been derived from the data published in USDA Technical Paper No. 40 and Technical Paper 35. The data was re-evaluated by the Illinois State Water Survey in 1992 and results were published in Bulletin 71.

Intensity-duration-frequency curves have been developed using these values and are shown in Exhibit IV-1. These curves shall be used in conjunction with the Rational Method for calculating runoff.

The equations for the intensity-duration-frequency curves were developed in accordance with FHWA HEC-12, March 1984. The base equation is as follows.

$$i = \frac{a}{(t+b)^m}$$

i = intensity in inches per hour

t = time of concentration

a, b, and m are constants given in the following table for each frequency storm:

Design Year	a	b	m
1	33.102	13.49	0.820
2	40.256	13.18	0.819
5	50.354	13.33	0.821
10	57.723	13.12	0.819
25	69.809	12.92	0.817
50	82.104	13.21	0.819
100	94.153	12.99	0.818

Rainfall Distribution by Time

Rainfall intensity - duration - frequency curves give a value of the intensity of rainfall during a particular time interval but do not necessarily present the sequence of events during a storm. The rainfall event causing storm runoff from a watershed for which this text is intended will most probably be in the nature of a thunderstorm or frontal storm. These storms are characterized by a period of rainfall of gradually increasing intensity with a comparatively short intense mid-storm followed by additional rainfall of gradually decreasing intensity. Each storm is a separate distinct event, however, with enough of a common pattern that an intensity distribution with time can be developed for use where such information is required to estimate storm runoff, such as in development of hydrographs.

The Soil Conservation Service has developed several typical storm distributions. Their Type II Storm is most suitable for rainfall of the summer thunderstorm type as occurs in Ohio. This distribution is based on the 24 hour rainfall for a given recurrence interval with the accumulation to a given hour shown as a ratio of the total 24 hour rainfall amount.

The City of Wadsworth have adopted the 24 hour rainfall values from Bulletin 71 as shown in table below. These values shall be used in conjunction with the TR-55 Tabular and Graphical Peak methods for calculating runoff and sizing detention basins.

The 24 hour total rainfall for the City of Wadsworth is as follows:

Recurrence Interval Years	24 Hour Rainfall Total Inches
1	2.04
2	2.50
5	3.10
10	3.60
25	4.39
50	5.11
100	5.89

Table IV-1

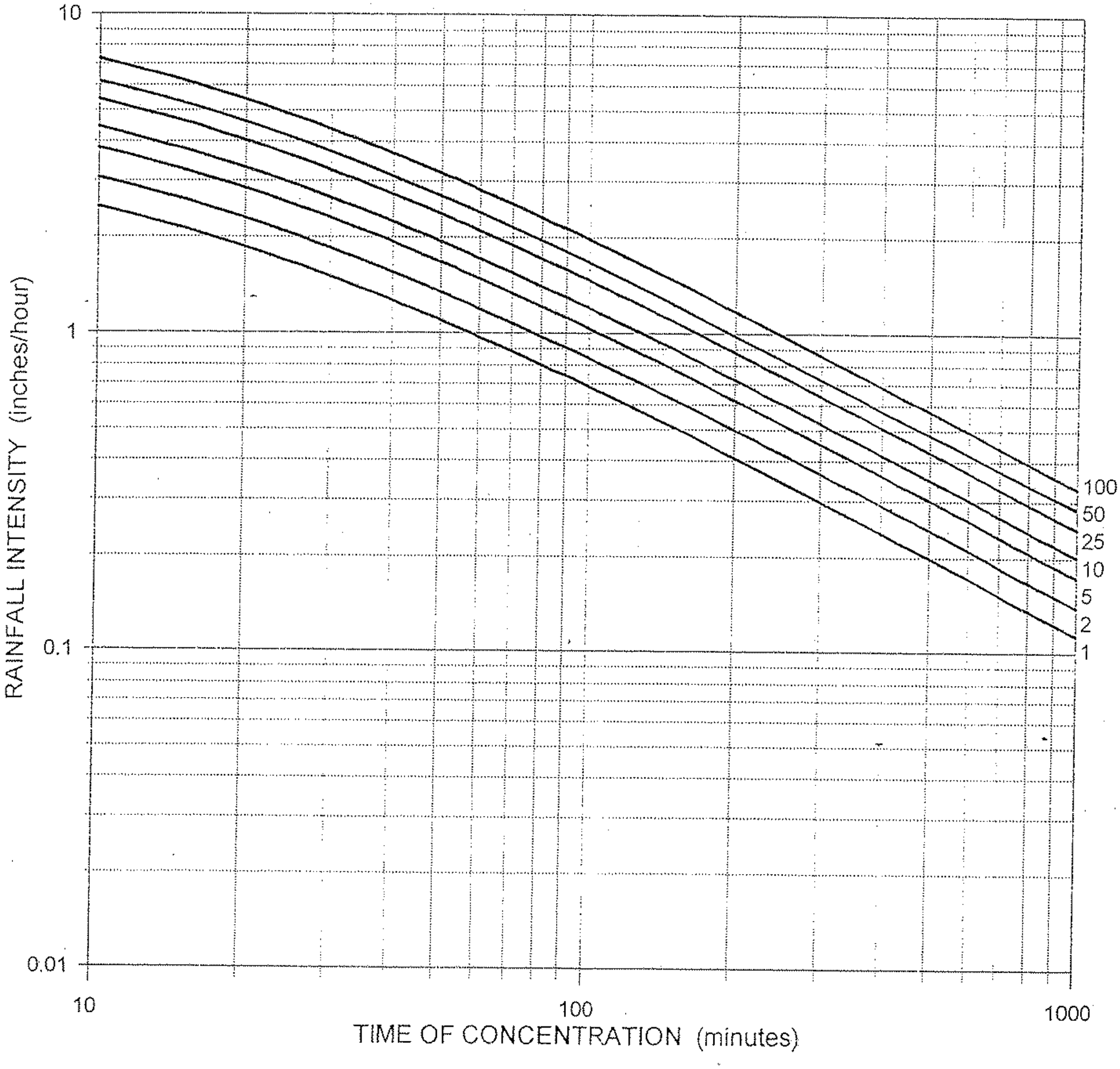
Although this distribution is based on 24 hour duration of storm, almost 64% of the rainfall occurs in the 4 hour period between the 10th and 14th hours and 27.6% in the 15 minute interval proceeding the 12th hour.

Rainfall Distribution by Area

The data given in the tables and exhibits is for point rainfalls but should be valid for areas up to 10 square miles. Other methods such as U.S.G.S Water Resources Investigations Report 93-4080, and U.S.G.S. Open-File Report 93-135 will be considered. For larger watersheds, U.S.G.S Water Resources Investigations Report 89-4126 or S.C.S TR-20 may be used.

EXHIBIT IV-1

CITY OF WADSWORTH RAINFALL
INTENSITY - DURATION - FREQUENCY



V. Storm Runoff Calculation Methods

The following methods are currently accepted by the City. All storm calculations must be performed by a Registered Professional Engineer in the State of Ohio, and submitted with improvement plans for review.

Rational Method

The Rational Method may be used to determine peak rate of runoff from areas generally not larger than 200 acres. The other methods discussed later in this chapter may also be used to obtain peak rate of runoff.

The basic formula for the Rational Method is **Q = C*I*A** in which:

Q = Peak rate of runoff in cubic feet per second.

C = Runoff coefficient, an empirical coefficient representing a relationship between rainfall and runoff.

I = Average intensity of rainfall in inches per hour for the time of concentration (Tc) for a selected frequency of occurrence or return period.

Tc = Time of concentration, the estimated time required for runoff to flow from the most remote part of the area under consideration to the point under consideration. It consists of the total of time for overland sheet flow, open channel flow, and pipe flow.

A = Area drained in acres.

The Rational Method procedures for calculating peak rates of runoff are as follows.

1. Drainage areas must be determined using existing topographic maps or actual field surveys. A drainage map should be developed showing the sub-areas draining to the outlet. These sub-areas should be planimetered to determine the acreage under consideration.

2. Runoff coefficients are dependent upon the land use and the soil classification. Land use of the drainage area shall be determined from aerial photography or field survey. Soil classifications can be determined from the Soil Conservation Service Soil Survey Maps, available from the Medina County SCS Office. The soil classifications must be delineated in the site plans. The soil classifications are divided into four Soil Groups. Common soils found in Wadsworth and their respective Soil Groups are given in Exhibit V-1.

3. Once the land use and the soil groups are determined, values for runoff coefficient 'C' can be obtained from Exhibit V-2. If the land use and soil group varies over the drainage area, a composite runoff coefficient can be calculated as an average of the sub-area coefficients, weighted by area.

4. The intensity is dependent upon the time of concentration 'Tc' which must be calculated first. The conveyance system used to determine Tc must be shown on the drainage map including slope and distance of each flow segment. Tc can be obtained from Exhibit V-3 for short distances. For larger drainage areas, other methods as explained in Chapter 3 of TR-55, may be used. Once, Tc is determined, an intensity can be obtained for any design frequency storm.

5. The rainfall intensity is obtained from Exhibit IV-1.

6. Peak runoff can be calculated by substituting these values into the formula.

Wadsworth Modified Rational Method

For small drainage areas and/or ease in calculations, the City has developed an optional method for calculating storm runoff. The Rational Method formula, **Q=C*i*A**, is still used. However, values for **C** and **i** are given as follows.

Runoff coefficient C for:	**Impervious**	**0.96**
	Residential	**0.45**
	Open Space	**0.30**

Commercial Areas - can be prorated based upon these values.

****Time of concentration is disregarded.**

The rainfall intensity **i** for all bridges, flood plain structures, and secondary drainageways shall be 7.0 inches/hour.

The rainfall intensity **i** for all other storm drainage systems will be 4.0 inches/hour.

Hydrograph Methods

For areas larger than 200 acres or where it is necessary to know the volume of water discharged in addition to the peak rate of discharge, the Rational Method is not adequate. There are numerous adoptions of the hydrograph method available which present a reasonable compromise considering data required, complexity of computations, and information obtained.

Of various unit hydrograph methods, the one especially appropriate in addressing problems relating to changes in storm runoff due to changes in land use is outlined in "Urban Hydrology for Small Watersheds," Technical Release No. 55 (TR-55), Engineering Division, Soil Conservation Service (SCS), U.S. Department of Agriculture, 1986. This publication can be obtained by contacting the local S.C.S. office. A brief description of this method is presented for use with this design manual.

The methodology of the S.C.S. explained in Technical Release No. 55 can be used to provide peak rates of runoff, tabular values of rate of runoff versus time from which a hydrograph can be plotted, estimated total volume of runoff or estimated volume of storage required to reduce rate of runoff to a desired value. The basic information required is:

1. Area of the watershed.
2. Soil type
3. Land use
4. Time of concentration
5. Travel time - Time of flow from the point of collection of the water in the design watershed to a point of evaluation or design. This is required when combining hydrographs from more than one watershed or where channel routing is considered.
6. Watershed factors: Slope, Flow length, Natural ponding.
7. Design Storm based on 24-hour duration rainfall for design recurrence interval.

Graphical Peak Discharge Method

Where peak rate of flow and total volume of runoff are needed, the Graphical Peak Discharge Method of Chapter 4 of S.C.S. TR-55 may be used.

The general procedure for determining peak discharge and total runoff volume from an area is as follows:

1. Determine the total acreage in the study area.
2. Determine average slope of the study area.
3. Delineate the different soil types according to hydrologic soil groups using soil survey maps and Exhibit V-1. (These maps are available in the Medina County Soil Conservation Service District Office.)
4. Delineate the various land use areas according to Exhibit V-4. (** See Note)
5. Subdivide the total area into sub-areas according to hydrologic soil groups and land use and assign the runoff curve numbers from Exhibit V-4.
6. Calculate the weighted runoff curve number i.e., Weighted CN = sum(CN of sub-area x sub-area) / sum(sub-areas).
7. Determine the precipitation (P) or total rainfall depth for the design storm of chosen frequency and 24 hour duration. See Table IV-1 for 24 hour rainfall data.

8. Calculate the potential maximum retention after runoff begins in inches (S), using the formula:

$$S = \frac{1000}{CN} - 10$$

9. Determine direct runoff in inches (Qro) using equation:

$$Qro = \frac{(p - 0.2\,s)^2}{(p + 0.8\,s)}$$

10. Determine the time of concentration (Tc) and travel time (Tt) for the drainage area.

11. Determine the Unit peak discharge (Qu) in csm/in using Exhibit V-5.

12. Determine the Peak discharge in cfs (Qp) using the equation:

$$Qp = \frac{A^{*}\,Qro^{*}\,Qu}{640}$$

13. Determine the total volume of runoff in cf using the equation:

$$Vr = \frac{Qro^{*}\,A^{*}\,43560}{12}$$

*** Note: Curve Numbers for pre-developed on-site land uses for undeveloped parcels shall not exceed values given for Open Space - fair condition.

Tabular Method

If the rate of runoff, with respect to time, is needed in addition to the peak discharge rate and total runoff volume, the Tabular Method as outlined in Chapter 5 of SCS, Technical Release No. 55, 1986 should be used. The information required is the same as for the peak discharge method. The tabular hydrograph method may be used to determine the effects of structures and combinations of structures including channel modifications, at different locations in the watershed. This method produces a runoff hydrograph which is useful in defining outflow characteristics for given control structures.

Exhibit V-1

MEDINA CO. SOILS - Hydrologic Groups From SCS-EPM Ohio Supp.

Exh. OH2-2, 9/78 and Soil Survey of Medina County.

SOIL	MAP SYMBOLS FOUND IN SOIL SURVEY	HYDROLOGIC SOIL GROUP
Bennington	BnA, BnB	C
Berks	BrF	C
Bogart	BtA, BtB	B
Canadice	Ca	D
Caneadea	CcA, CcB	D
Canfield	CdA, CdB, CdB2, CdC2	C
Cardington	CfB, CgB, CgC2, CgE2	C
Carlisle	Ch	A/D*
Chagrin	Cm	B
Chile	CnA, CnB, CnC, CoC2, CoE2, CoF2, CpA, CpB,	B
Condit	Cy	D
Ellsworth	ElB, ElB2, ElC, ElC2, ElE2, ElF, EsB, EsC2	C
Fitchville	FcA, FcB, FlA	C
Geeburg	GbC	C
Glenford	GfA, GfB, GfC2	C
Haskins	HsA, HsB	C
Holly	Hy	D
Jimtown	JtA, Jtb	C
Linwood	Ld	A/D*
Lobdell	Le	B
Lorain	Ln	C/D*
Luray	Ly	C/D*
Mahoning	MgA, MgB, MlA, MlB	D
Miner	Mr	D
Olmstead	Od	B/D*
Orrville	Or, Os	C
Oshtemo	Ot	B
Ravenna	ReA, Reb	C
Rawson	Ro	B
Rittman	RsB, RsB2, RsC, RsC2, RsD2, RsF	C
Schaffenaker	ScF	A
Sebring	Sg, St	D
Wadsworth	WaA, WaB	C
Wallkill	Wc	C/D*
Willette	Wt	A/D*
Wooster	WuB, Wub2, Wuc2, WuD2, WuE2, Wuf	C

Note: Two Hydrologic Soil Groups such as A/D, B/D or C/D indicates the drained/undrained condition.

Exhibit V-2

RUNOFF COEFFICIENTS

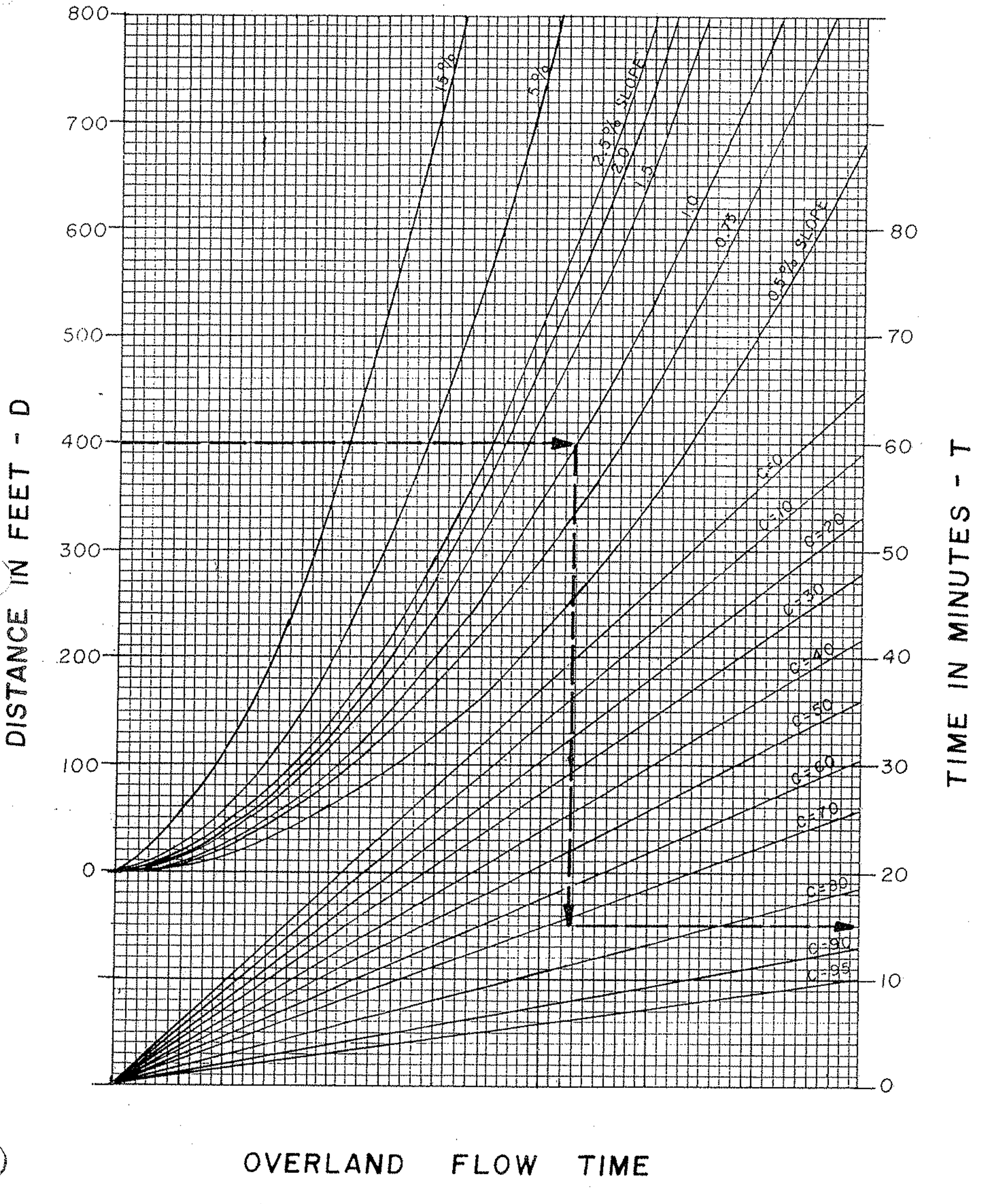
RATIONAL METHOD

LAND USE DESCRIPTION		HYDROLOGIC SOIL GROUPS A	B	C	D
Cultivated land:	without conservation treatment	0.32	0.50	0.66	0.74
	with conservation treatment	0.17	0.30	0.43	0.50
Pasture or range la	poor condition	0.26	0.45	0.61	0.69
	good condition	0.05	0.16	0.36	0.47
Meadow:	good condition	0.05	0.13	0.30	0.43
Wood or Forest lan	thin stand, poor cover, no mulch	0.05	0.23	0.41	0.54
	good cover	0.05	0.10	0.29	0.41
Open Spaces, lawns, parks, golf courses, cemeteries, etc.					
good condition:	grass cover on 75% or more of the area	0.05	0.16	0.36	0.47
fair condition:	grass cover on 50% to 75% of the area	0.05	0.28	0.45	0.57
Commercial and business areas (85% impervious)		0.69	0.77	0.83	0.86
Industrial districts (72% impervious)		0.50	0.66	0.74	0.80
Residential:					
Average lot size	Average % Impervious				
1/8 acre or less	65	0.41	0.59	0.72	0.77
1/4 acre	38	0.16	0.37	0.54	0.64
1/3 acre	30	0.12	0.32	0.50	0.61
1/2 acre	25	0.09	0.29	0.47	0.59
1 acre	20	0.06	0.26	0.45	0.57
2 acres		0.05	0.23	0.41	0.50
Paved parking lots, roofs, driveways, etc.		0.96	0.96	0.96	0.96

The coefficients are applicable for a ten year storm frequency.

For recurrence intervals longer than ten years, the indicated runoff coefficients should be in assuming that nearly all of the rainfall will become runoff and should be accommodated by creased runoff coefficient.

EXHIBIT V-3 TIME OF CONCENTRATION CHART-RATIONAL METHOD



SOURCE: "AIRPORT DRAINAGE" FAA 1965

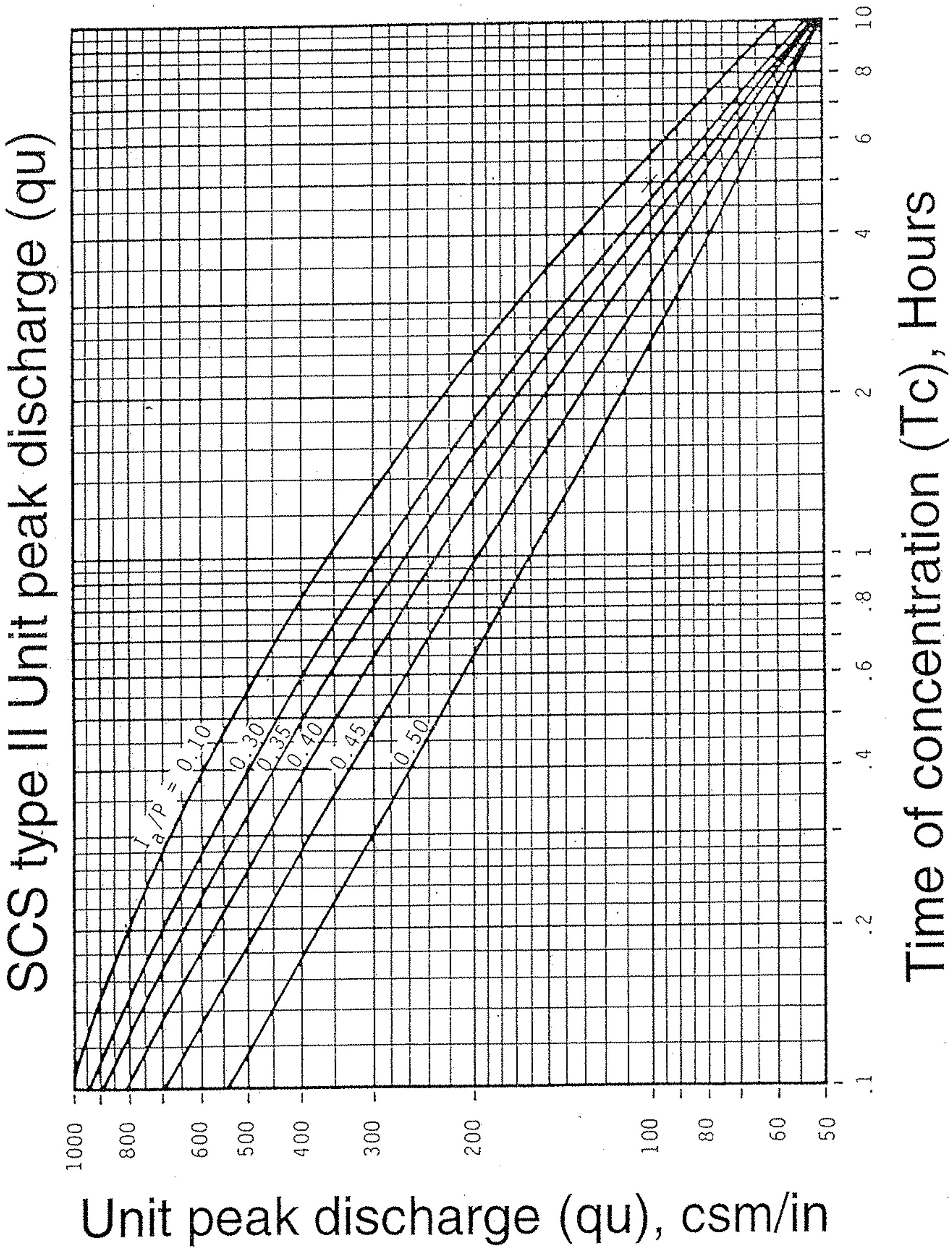
RUNOFF CURVE NUMBERS
(ANTECEDENT MOISTURE CONDITION II)

LAND USE DESCRIPTION			HYDROLOGIC SOIL GROUPS			
			A	B	C	D
Cultivated land:	without conservation treatment		72	81	88	91
	with conservation treatment		62	71	78	81
Pasture or range land:	poor condition		68	79	86	89
	good condition		39	61	74	80
Meadow:	good condition		30	58	71	78
Wood or Forest land:	thin stand, poor cover, no mulch		45	66	77	83
	good cover		25	55	70	77
Open Spaces, lawns, parks, golf courses, cemeteries, etc.						
good condition:	grass cover on 75% or more of the area		39	61	74	80
fair condition:	grass cover on 50% to 75% of the area		49	69	79	84
Commercial and business areas (85% impervious)			89	92	94	95
Industrial districts (72% impervious)			81	88	91	93
Residential:						
	Average lot size	Average % Impervious				
	1/8 acre or less	65	77	85	90	92
	1/4 acre	38	61	75	83	87
	1/3 acre	30	57	72	81	86
	1/2 acre	25	54	70	80	85
	1 acre	20	51	68	79	84
	2 acres		47	66	77	81
Paved parking lots, roofs, driveways, etc.			98	98	98	98
Streets and roads:						
	paved with curb and storm sewers		98	98	98	98
	gravel		76	85	89	91
	dirt		72	82	87	89

For a more detailed description of agricultural land use curve numbers, refer to S.C.S. National Engineering Handbook, Section 4, Hydrology, Chapter 9, August 1972.

The remaining pervious areas (lawn) are considered to be in fair condition for these curve numbers.
SOURCE: S.C.S. Urban Hydrology For Small Watersheds. T.R. No. 55

EXHIBIT V-5 TIME OF CONCENTRATION CHART-TR55 METHOD



VI. Runoff Control Methods

Introduction

The runoff control criteria stated previously necessitates the use of storm runoff control facilities in most developments. If designed properly, these facilities can be incorporated into the design and offer an added amenity to the urban environment. If designed poorly, these facilities have the potential for adding to neighborhood blight or a threat to public health and safety.

Storm storage facilities can be functional and wholly unobtrusive. This positive impact can be achieved by adherence to four basic steps in the implementation of storm storage facilities.

These are:

1. Proper selection of runoff control mechanism.

2. Proper design of facility.

3. Construction of facility in strict adherence to design.

4. Regular maintenance program and designated responsibility for maintenance.

This section discusses these steps which result in a rewarding and often cost-saving approach to storm management.

Detention/Retention Structures

Structures for detention or retention of storm may be considered together since the major control structures function the same for each. The principal difference is that while the control mechanism for detention or (dry basins) may be entirely passive, there should be some manner of movable gate provided in a retention or (wet basin) so that it can be drained for occasional maintenance.

The results of applying detention or retention storage methods for peak discharge control are illustrated by the typical hydrographs shown in Exhibit VI-1. The objective of both methods is to reduce the peak rate of discharge by storing the storm runoff and controlling the release rate. The difference in discharge rates shown is a function of the control devices rather than the type of detention/ retention basin.

Infiltration of the stored storm will occur to some degree depending on underlying soil characteristics. However, in most cases, the amount of infiltration is minimal and is not considered as a part of the structural design. Thus, the total area under the hydrographs representing total volume of runoff will be substantially the same for all three cases.

Land requirements are associated with any storage facilities. The demand for land is a major economic factor. For this reason, consideration of the multi-use concept for either wet or dry detention structures is strongly encouraged.

Detention and retention structures can be categorized as: dry basins, permanent (wet) ponds, storage tanks, and multi-use storage areas such as parking lots, roof tops, underground storage, roadway embankments and other shallow holding areas. Design criteria of the various types are discussed in the following section.

Design Criteria for Detention/Retention Structures

The following criteria are recommended as standards of design. The criteria is intended to provide limits on the design of structures so performance objectives can be achieved, but allow flexibility in the actual design of the individual basins. Drawings of typical structures are included. Again, these drawings are not to be taken as the actual design configuration for all applications, but are included only as a guide for design.

Dry Basins

Dry basins are surface storage areas created by constructing an embankment or excavating a basin. These basins include an outlet structure which is designed to control the rate of discharge from the basin. As storm surcharges the outlet structure, the excess flow temporarily backs up into the basin, and is metered out at a controlled rate after the rainfall ceases. The discharge control structure for most dry detention basins is usually a multi-stage device.

Design Criteria

1. Maximum release rate shall be determined as stated in Section II. The allowable peak discharge for all storms up to and including the critical storm shall be the 1 year pre-developed peak discharge. Once the critical storage volume is reached, the allowable discharge is increased to the pre-developed peak discharge for each successive storm occurrence.

2. The required storage volume shall be determined by the Graphical Storage Method or the Storage-Indication Method, discussed in Section VII.

3. The side slopes of the detention/retention basin, unless paved or rip-rapped, shall not exceed 4:1 to insure safety and maintenance capability. The bottom of the basin shall be sloped at a minimum 1% grade to the outlet control device. The 1 year pre-developed flow shall be carried by pipe through the basin.

4. Any constructed embankments for permanent or temporary impoundment of water are subject to jurisdiction under the Ohio Dam Safety Laws (ORC 1521, 1987) as administered by the Ohio Department Of Natural Resources (ODNR). Exemptions are allowed, depending upon the relationship of the height of the dam, the volume of storage and the drainage area.

5. Maximum water depths in dry basins should be held to a minimum, with an absolute maximum of 10 feet.

6. The minimum top width of any embankment used for detention should be five feet.

7. The outlet control devices may be either single-stage or multi-stage structures. They shall be designed such that the permissible release rates are not exceeded at the calculated head for the design storage volume. The discharge control structure will normally be located at the bottom of the basin near the downstream end. The control outlet device shall be at the absolute lowest point of the basin.

8. All storm frequencies up to and including the 100 year storm shall be controlled through the primary and/or a secondary control structure. All earthen embankments shall have a minimum freeboard of three inches (3") above the maximum calculated water surface elevation to the top of dam.

9. Flow control structures should preferably be constructed of reinforced concrete (pre-fabricated or cast in place). The control structures shall be designed and constructed such that the public health, safety and welfare is fully protected. Any exposed face greater than 4' in height shall have adequate handrails. Standard aluminum or plastic coated manhole steps shall be provided for any outlet structure over 36" in depth.

10. A 50-percent increase in the net area of grates for inlets is recommended to allow for possible blocking of the inlets by debris. A typical grated inlet is shown in <u>Exhibit XIII-8</u>. Trash screen shall be installed between the inlet pipe and the outlet control orifice.

11. The outlet channel shall include adequate provision for energy dissipation and erosion protection.

12. No storage volume will be required for off-site upstream areas. Flows from off-site areas in excess of the allowable discharge from the on-site area may be routed either around or through the detention/retention basin. Provision for excess flow routed through the storage facility shall be included in the design of the emergency spillway. The emergency spillway shall be designed for overflow rates based on the runoff predicted from the 100 year design storm.

13. Fencing around the storage facility in a manner which attempts to prevent access is generally undesirable. However, barriers to access may be desirable to limit the area reserved for storm control. When required, these barriers should be designed with consideration given to the aesthetics of the site and nearby area. Landscaping and grading or natural wood fencing can offer suitable barriers.

14. Provisions for erosion and sediment control during construction should be included in the design of the storage facility. The four major design considerations of erosion and sediment control during construction are:

    a. Disturb as little of the site as possible.
    b. Cover the soil as soon as possible.
    c. Control the rate of runoff by using temporary energy dissipaters and control structures where necessary.
    d. Allow sediment to settle out of the stormwater before leaving the site.

15. A storage facility is an integral part of the adjacent environment and, therefore,

should serve an aesthetic improvement of the area. The use of landscape principles is encouraged and, in some cases, may be required for certain sites. In any event, the planting and preservation of the desirable trees and other vegetation should be a part of the storage facility design.

16. Typical design configuration of the on-site detention basins are included in Exhibit XIII-12.

17. Easements shall be required per Section III - Easements.

18. An emergency spillway shall be included which shall have a capacity for the runoff from a 100 year storm with three inches (3") of freeboard.

19. The calculated water surface elevations of the storage facility shall be indicated on the detailed plans for the critical design storm and the 100 year frequency storm.

Wet Ponds

Wet ponds are permanent ponds where additional storage capacity is provided above the normal water level and special features for controlled release are included. Historically, wet ponds have proven extremely effective in abating increased runoff and channel erosion from urbanized areas. They are a major Soil Conservation Service land treatment practice.

Some problems often encountered with wet ponds are: site reservation (land requirements), permanent easements, complexity of design and construction, safety hazards and maintenance problems. Because of large land requirements and the necessity of maintaining a permanent pool of water, wet ponds have a broader application for instream control where large watershed areas are involved compared to their use as on-site facilities for small urban areas. However, the recreational and aesthetic benefits of permanent wet ponds are very often considerable and may be justifiable in certain on-site applications.

Design criteria for dry basin design shall also apply to wet ponds except as modified herein.

1. The maximum permanent pool area shall not exceed 10 percent of the upstream watershed area.

2. The minimum depth from normal pool water level to bottom of side slope should be three feet. It is recommended the shallow perimeter of the pond extend from the bottom of the side slope for a distance of ten feet into the pond area. This is a safety factor in the event of accidental or intentional encroachment into the pond.

3. At least 25 percent of the pond area should be a minimum of 10 feet deep.

4. A suitable means should be utilized to prevent water from becoming stagnant. Natural springs and aeration devices such as fountains are appropriate. Ponds constructed in permeable soils shall be sealed by a suitable method.

5. The top of the embankment width shall be a minimum five feet for non-vehicular traffic and ten feet for vehicular traffic. The retaining structure shall be designed in accordance with the best acceptable design practices and comply with ODNR requirements.

6. A provision shall be included for completely draining the pond to allow periodic cleaning, inspection, and other maintenance. Drain facilities may be an integral part of the flow control structure or a separate structure.

7. The detained volume shall be that amount of stored runoff above the normal pool water surface elevation.

8. Probable quantities of sediment from the drainage area should be estimated for the expected life of the pond, and provisions for occasional sediment removal should be included in the design. Wet ponds may be over-excavated to accommodate siltation from construction activities during development.

9. When a permanent maintenance easement is required, the developer shall provide a minimum 25 feet in width around the perimeter of the wet pond to act as a buffer zone to adjacent properties. The easement is measured from the water's edge for the maximum storage elevation or the outside toe of slope of any embankment.

10. Shoreline protection shall be provided where necessary to prevent wave action erosion. Embankment protection shall also be provided to prevent erosion.

Parking Lot Storage

Parking lot storage is surface storage where shallow ponding is designed to flood specifically graded areas of the parking lot. Controlled release features are incorporated into the surface drainage system of the parking lot. This method can easily be incorporated into a site development at approximately the same cost as that of a conventional parking lot.

The major disadvantage is the inconvenience to users during storms requiring storage. This inconvenience can be minimized with proper design consideration. Parking lot design and construction grades are critical factors. This method is intended to control the runoff directly from the parking area, and is usually not appropriate for storing large runoff volumes.

Design criteria for dry basin design shall also apply to parking lot storage except as modified herein.

1. The water depth in the storage area shall not exceed twelve inches and/or nine inches within parking spaces.

2. The maximum surface slope of the storage area shall be 4 per cent and the recommended minimum slope is 0.5 percent.

3. Off-site drainage shall be directed around parking lot storage.

4. The parking lot shall be completely drained in the minimum time permissible within the constraints of the runoff control standards.

5. The storage area should be located in the more remote, least used, portion of the parking facility, if possible.

6. Provisions shall be included for overflow of runoff above the design storm, such as uncontrolled drainage structures near the ponding area or secondary overland swales.

7. Parking lots being used for storm detention shall be constructed of concrete pavement with sealed joints. Asphalt pavement may be used if the required storage volume is increased by 1/3 to accommodate future resurfacing.

Rooftop Storage

Rooftop storage is surface storage provided on flat rooftops designed with provisions for temporary ponding and with special roof-drain-controlled release features. Rooftop storage utilizes the built-in structural capability of rooftops to store certain amounts of rainfall.

Existing and/or proposed structures shall conform to all local building codes to meet the requirement of being able to support a specified storage volume. It usually performs a retention function since the method is to hold the stored water for a relatively long time while draining gradually. For this reason, directing the drained water to lawn areas and infiltration trenches where it can percolate is possible.

The main disadvantages of rooftop storage are the inspection and maintenance requirements. Routine inspections are difficult when the installations are not readily accessible. Clogging of the roof drains make routine inspections a necessity. This method is discouraged by the City.

Minimum design criteria for rooftop storage shall be as follows:

1. The rooftop shall be completely drained within the minimum time permitted under the runoff control standards.

2. A minimum roof pitch of 0.25 inch per foot to the outlet device shall be provided to assure complete drainage.

3. Overflow drains shall be provided to accommodate major storms, and shall be located above the maximum water depth. Roof scuppers are to be provided in parapet walls.

4. The building structure shall be designed to provide a watertight roof. Additional layers of roofing membrane or coating are recommended to provide a watertight seal.

5. It is recommended the flow control device be in compliance with the local building code and the National Plumbing Code. Several types of fixed and variable capacity flow control devices (roof drains) are available commercially.

6. The design of other storage control methods in combination with rooftop storage, such as infiltration or storage trenches, is appropriate.

Underground Storage Tanks

Underground storage tanks may be constructed in lieu of surface storage facilities. Storage tanks may be constructed of reinforced concrete either pre-fabricated or poured-in-place, corrugated aluminum or approved equal. Construction and maintenance costs make this method relatively expensive. Therefore, this method is most applicable where land area is very valuable, such as in industrial and commercial areas.

Design criteria for dry basin design shall also apply to underground storage tanks except as modified herein.

1. The structural design shall be in accordance with current design practice. Any underground storage facilities under pavement shall be designed to withstand traffic bearing loads.

2. The minimum size drainpipe shall be eight inches.

3. An access hatch or manhole shall be provided for inspection and maintenance. All openings shall be properly secured to minimize safety hazards.

4. The required storage volume, discharge release rate, and detention period shall be as determined for surface storage facilities. A flow control device, such as a simple weir or orifice shall be included.

5. Overflow provisions shall be included to accommodate the less frequent storms up to and including the 100 year storm runoff.

6. The storage tank shall include provisions for completely draining the tank.

7. When conduits are used for storage, special consideration shall be given to the structural strength and load-carrying capacity of the conduit as well as the bearing capacity of the soil. Perforated pipe may be used where soil conditions are favorable for infiltration methods.

Infiltration for Runoff Control

Infiltration methods seek to restore the naturally occurring process of the hydrologic system by permitting stormwater to percolate into the ground. The degree to which infiltration of storm can be utilized depends on the physical characteristics of the soil or soils and the groundwater system of the area. Obviously, infiltration of storm lessens the amount of rainfall that becomes runoff. Hydrologically, infiltration reduces the total volume of direct runoff and decreases the peak discharge rate. The infiltration process also enhances groundwater recharge.

Current emphasis appears to be toward the use of the infiltration methods only where soil suitability and site conditions are favorable. Soils having slow permeability and shallow depths to bedrock are, understandably, poor locations for infiltration methods.

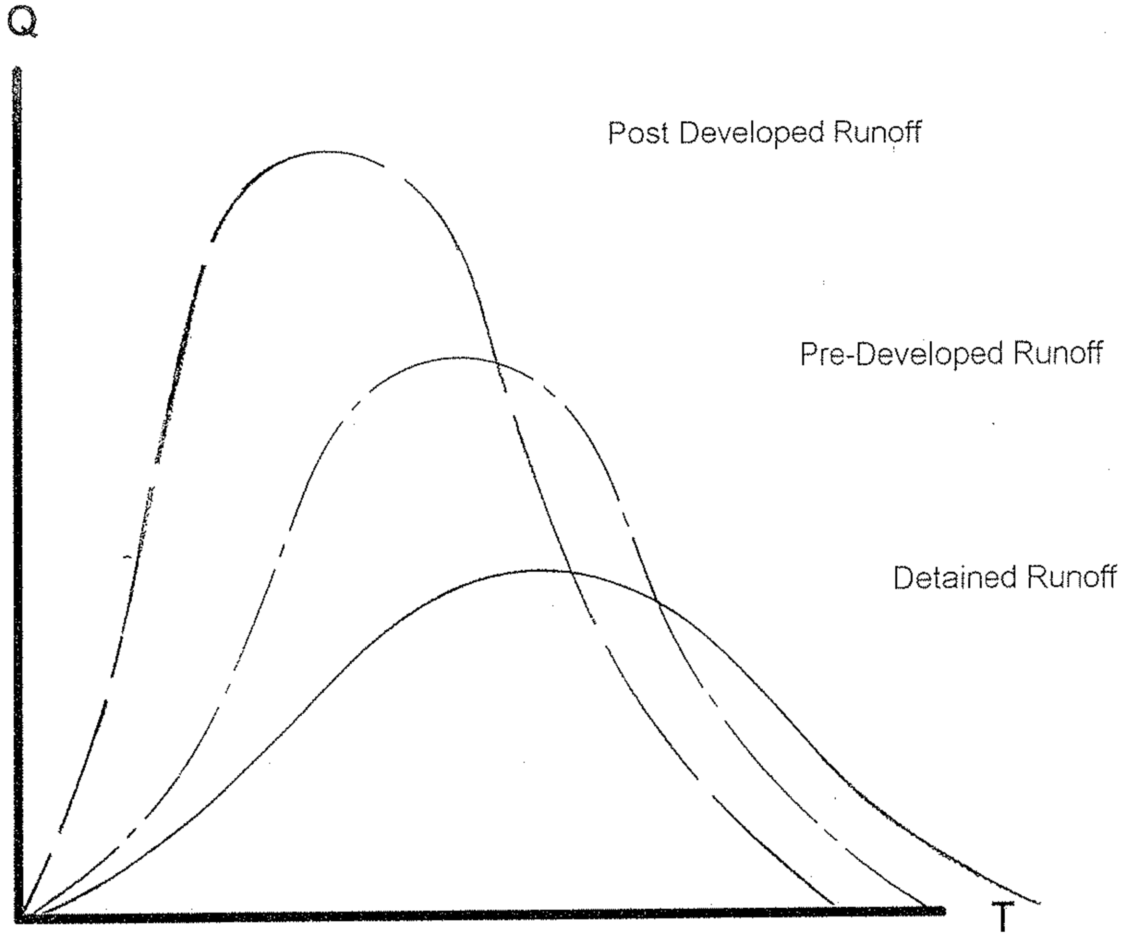
Sediments, oils and other debris can cause problems by clogging the soil surface resulting in loss of storage capacity. Therefore, installation of infiltration structures near areas where these products are present is discouraged. Infiltration structures usually have a short term life expectancy and maintenance is expensive. thus, unless adequate inspection and maintenance can be provided, the use of structural infiltration methods is discouraged.

In most instance, infiltration methods are not capable of handling large amounts of runoff due to limits of the soil infiltration capacity. Infiltration control methods, therefore, are usually limited to handling relatively small sources of runoff such as roof drains, small parking lots, tennis courts and the like. Infiltration methods may also be incorporated as one part of a large runoff control system utilizing several different techniques. Some specific infiltration structures are dry wells, infiltration trenches and storage trenches.

Dry Wells

Dry wells should be filled with crushed stone or washed gravel of two inch size. Storage volume may be computed by assuming one-third of the storage volume is within the voids between the stones. Therefore, the dry well excavated volume must be three times the required storage volume. Dry wells are most applicable for storing runoff from rooftops and other areas free of sediment and debris. An outlet control structure can be provided but may not be required. They may discharge directly into unsaturated soils or the groundwater. Dry wells discharging into an aquifer are subject to regulation and approval by the Ohio Department of Natural Resources.

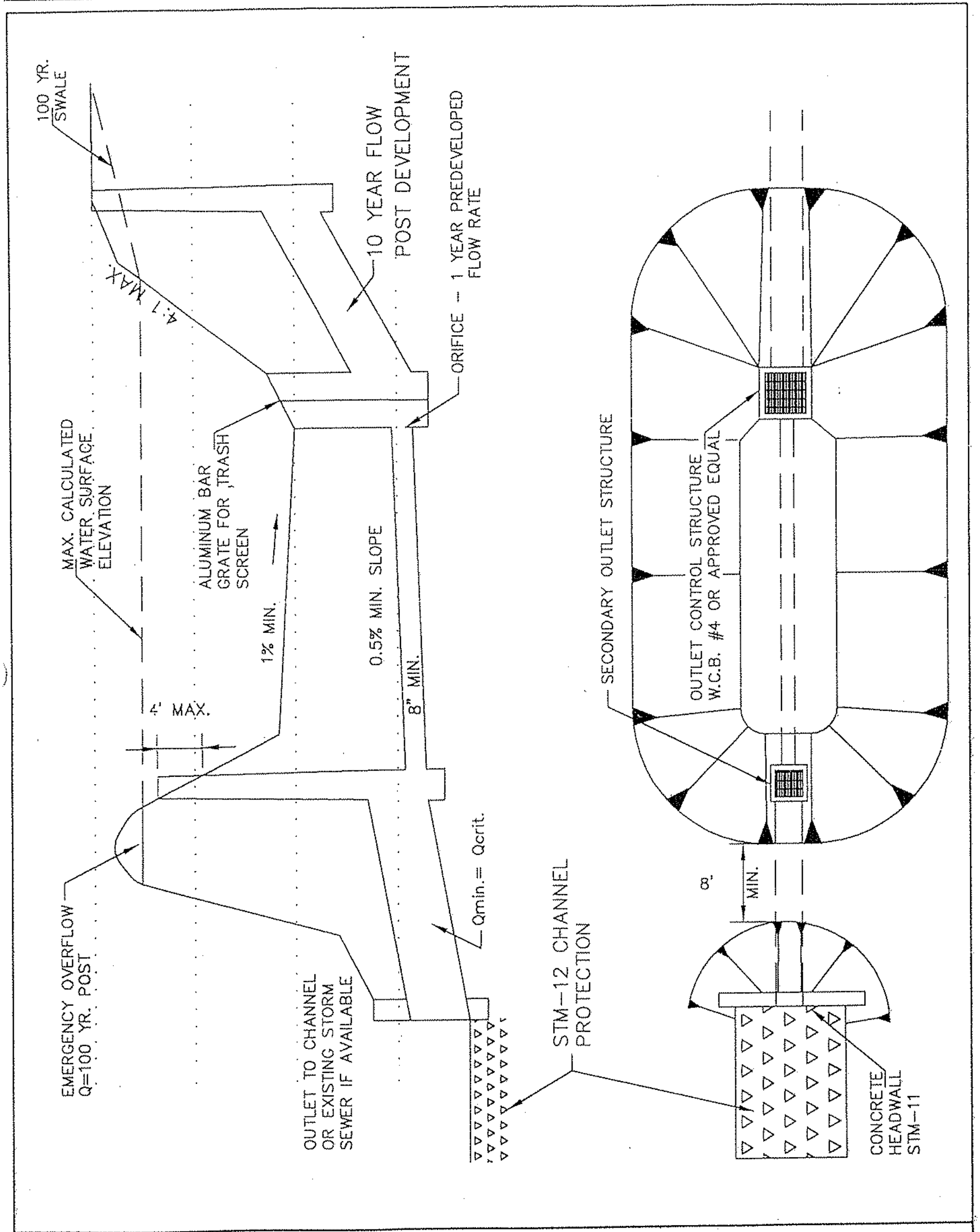
EXHIBIT VI-1 Typical Hydrographs



DISCHARGE (Q) - VS - TIME (T)

TYPICAL HYDROGRAPHS

EXHIBIT VI-2 TYPICAL DETENTION BASIN



TYPICAL DRY DETENTION BASIN

VII. Storage Volume

Methods for Determining Required Storage Volume

This section examines several methods for estimating the volume requirements of different types of storm storage facilities. The criteria used to choose the appropriate runoff prediction method may also be used to determine the method of estimating storage requirements. Generally, if the Graphical Peak Discharge Method of runoff calculation is appropriate for a given situation, it may be assumed that the Graphical Detention Basin Storage Method are similarly applicable. If the Tabular Method of Unit Hydrograph Method are used for estimating runoff then the Storage Indication Flow Routing Method is most accurate for determining storage capacity.

Graphical Storage Method

The graphical method presented herein is developed by the Soil Conservation Service, presented in Chapter 6 of the "Urban Hydrology for Small Watersheds" Technical Release No. 55. It is based on average storage and routing effects using the storage-indication method of routing. The graphs relate inflow (**Qi**) and release rate (**Qo**) to storage requirements for single stage weir or pipe outlet structures.

Divide the peak allowable outflow (Qo = Q 1 year pre-developed) by the peak inflow (Qi = Q critical year developed). Enter the graph at this ratio, move up to the Type II rainfall curve, then move left to the Vs/Vr values. Multiply this obtained value by the volume of runoff (Vr = critical year developed) to obtain the required volume of storage (**Vs**). **Vs** should also be calculated for lesser frequency storms to determine if any additional storage is necessary.

For any application where the graphical method is not appropriate, a more accurate flow routing method, such as the storage-indication method, is required to determine storage requirements. Even when flow routing is performed, the volume of storage determined using the Graphical Method will be helpful.

Storage-Indication Flow Routing Method

Flow routing problems are solved by using the continuity equation. The continuity equation is based on the concept of conservation of mass. For a given time interval the volume of inflow minus the volume of out-flow equals the change in volume of storage.

The continuity equation expressed in this simplest form is:

$$dT\,(I - O) = S$$

dT = a time interval

I = Average rate of inflow during the time interval

O = Average rate of outflow during the time interval

S = change in volume of storage during the time interval

The rate of inflow is determined by the inflow hydrograph produced from TR-55 Tabular or other approved methods. The rate of outflow (discharge) is determined by the water surface elevation versus discharge characteristics of the outlet control structure. The change in storage volume is determined by the elevation versus storage volume of the reservoir.

For routing studies, the inflow hydrograph is determined once the design storm and watershed-parameters have been established. Also, the elevation-storage curve is determined by the geometric configuration of the detention basin or reservoir. The elevation-discharge curve is dependent on the hydraulic characteristics of the outlet control structure.

All three graphs must be developed independently prior to performing the Storage-Indication Method of flow routing. Operation Tables are provided in Exhibits VII-3 & 4.

Design of the Outlet Control Structure

For purposes of storm management, an orifice, a simple weir, or a combination of the two are the most reliable flow control devices. The theoretical flow characteristics for these devices are as follows:

Circular orifice (submerged discharge)

$$Q = C^* A^* \sqrt{2gh}$$

Q = orifice discharge in cfs

C = coefficient of discharge

A = orifice cross-sectional area in ft^2.

g = gravitational acceleration constant = 32.2 ft/sec^2

h = height of water surface over center of orifice

Note: When the storage water surface falls below the top of the orifice opening, the flow characteristics are approximately equivalent to those of a weir.

Weir Discharge

$$Q = C^* L^* H^{3/2}$$

Q = weir discharge in cfs

C = weir coefficient of discharge

L = length of weir in feet

H = hydraulic head above weir crest in feet

Values for the constants to be used in the above equations for different configurations of weir may be found in Exhibit VII-2.

Other types of flow control devices will require variations of the above equations.

Multistage outlet control structures are possible by including both the orifice and weir in one structure. A common configuration used in detention structures is a pipe orifice as a primary discharge near the bottom of a reservoir with another orifice or simple weir located a few feet above the orifice or near the top of the structure as a secondary discharge. When both control devices are used together, the resulting discharge is the sum of the individual discharges for a given storage elevation.

Elevation - Storage Curve

The elevation-storage curve is the amount of storage in a proposed detention basin at any given elevation. Therefore, before this curve can be developed, a preliminary detention basin must be designed. A rough grading plan showing the basin is helpful. As the design of the basin is changed and finalized, the grading plan should be completed, and this curve must be modified to reflect the final design.

Elevation - Discharge Curve

The elevation discharge curve is the amount of calculated discharge from the proposed basin, through the proposed outlet structure, at any given elevation. Therefore, before this curve can be developed, a preliminary outlet control structure must be designed. As the design of the outlet structure is modified, this curve must be modified. The following section will provide criteria for the design of the outlet control structure.

Storage-Indication Calculations

For sufficiently small time intervals, (dT) the continuity equation can be expressed:

$$\frac{I_1+I_2}{2}-\frac{O_1+O_2}{2}=\frac{S_2-S_1}{dT} \qquad \text{(A)}$$

Subscripts "1" and "2" represent the beginning and end of the time interval. Usually, the complete inflow hydrograph is known or can be determined, as well as the initial storage and outflow values. Therefore, the remaining unknown values are the outflow at the end of the time interval (O_2) and the storage volume (S_2). The above equation is rearranged as follows:

$$\frac{I_1+I_2}{2}+\frac{S_1}{dT}-\frac{O_1}{2}=\frac{S_2}{dT}+\frac{O_2}{2} \qquad \text{(B)}$$

The left side of this equation can be determined for successive increments of time, and therefore, the right side of the equation can be quantified. Storage-indication curves are developed to determine outflow (O_2) for know values of ($S_2/dT + O_2/2$).

The general procedure for flow routing by the Storage Indication Method is as follows:

1. Develop the inflow hydrograph. Hydrographs can be developed using the TR-55 Tabular Hydrograph Method or other approved method.

2. Estimate storage requirements, make a preliminary design of a storage facility and develop an elevation-storage curve for the storage site. Data may be obtained from field survey and topographic maps. The graphical flow routing method is helpful in preliminary design of the storage facility.

3. Develop an elevation-discharge curve for the outlet control structure. This is based on the hydraulic characteristics of the flow control device. The size of the flow control device is based on the design discharge rate and the design high water level.

4. Select the time interval (dT). The value of (dT) may need to be decreased if the storage-indication curve developed in the following step exceeds the equal value line represented by

$$O_2 = \frac{S_2}{dT} + \frac{O_2}{2} \qquad (C)$$

5. Develop the storage-indication curve by plotting O_2 versus ($S_2/dT + O_2/2$).

   Check the choice of (dT) as explained in the preceding step. The suggested format for storage-indication computation and operation tables is included to facilitate calculations of this and subsequent steps.

6. Tabulate inflow values for each routing interval (dT) from the design inflow hydrograph, and calculate the average inflow (I_{avg}) by averaging successive values.

$$I_{avg} = \frac{I_1 + I_2}{2} \qquad (D)$$

7. Perform the routing by using the operations table and the storage indication curve.

$$\frac{S_1}{dT} - \frac{O_1}{2} = \frac{S_1}{dT} + \frac{O_1}{2} - O_1 \qquad (E)$$

The sum of the values from equations (D) and (E) above for each time interval (dT) quantifies the right side of equation (B).

When inflow equals zero, all values across the operations table are zero. From this point on, average inflow I is determined from Step 6, and values for $S_1/dT + O_1/2$ and O_1 are taken from preceding values of $S_2/dT + O_2/2$ and O_2 of the preceding routing interval.

Referring to the operations table, the value of $S_2/dT + O_2/2$ is obtained summing columns five and six and subtracting column seven. The outflow value (O_2) is determined using the developed storage-indication curve (Step 5)

8. Develop the outflow hydrograph by plotting O_2 versus time from the operations table.

VII-1 TYPE II RAINFALL FOR BASIN ROUTING

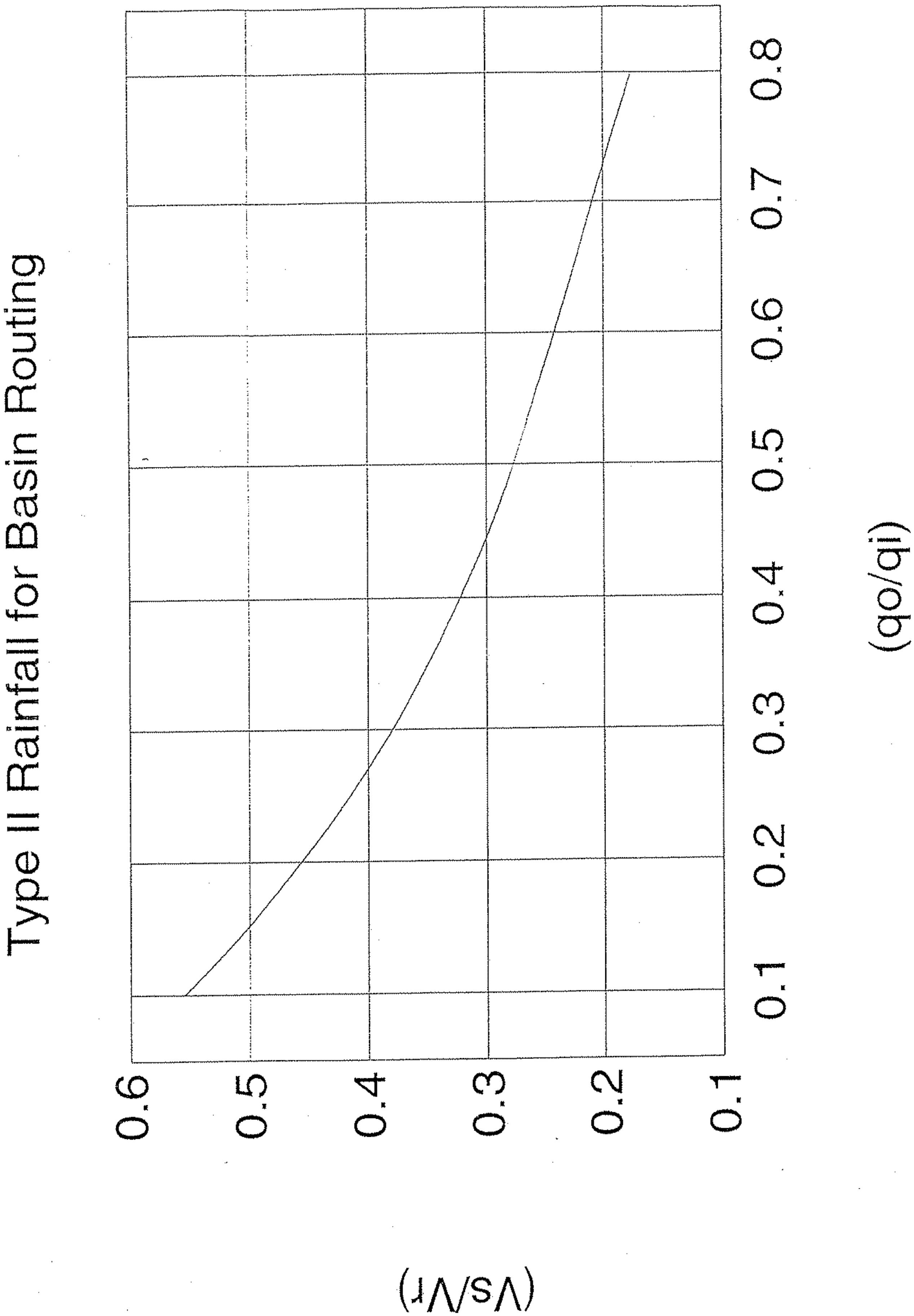


Exhibit VII-2 TABLE OF C VALUES FOR WEIRS AND ORIFICES

Values of C in Q=CLH^1.5 for Broad-Crested Weirs											
Head H, ft	Breadth of crest of weir, ft.										
	0.50	0.75	1.00	1.50	2.00	2.50	3.0	4.0	5.0	10.0	15.0
0.2	2.80	2.75	2.69	2.62	2.54	2.48	2.44	2.38	2.34	2.49	2.68
0.4	2.92	2.80	2.72	2.64	2.61	2.60	2.58	2.54	2.50	2.56	2.70
0.6	3.08	2.89	2.75	2.64	2.61	2.60	2.68	2.69	2.70	2.70	2.70
0.8	3.30	3.04	2.85	2.68	2.60	2.60	2.67	2.68	2.68	2.69	2.64
1.0	3.32	3.14	2.98	2.75	2.66	2.64	2.65	2.67	2.68	2.68	2.63
1.2	3.32	3.20	3.08	2.86	2.70	2.65	2.64	2.67	2.66	2.69	2.64
1.4	3.32	3.26	3.20	2.92	2.77	2.68	2.64	2.65	2.65	2.67	2.64
1.6	3.32	3.29	3.28	3.07	2.89	2.75	2.68	2.66	2.65	2.64	2.63
1.8	3.32	3.32	3.31	3.07	2.88	2.74	2.68	2.66	2.65	2.64	2.63
2.0	3.32	3.31	3.30	3.03	2.85	2.76	2.72	2.68	2.65	2.64	2.63
2.5	3.32	3.32	3.31	3.28	3.07	2.89	2.81	2.72	2.67	2.64	2.63
3.0	3.32	3.32	3.32	3.32	3.20	3.05	2.92	2.73	2.66	2.64	2.63
3.5	3.32	3.32	3.32	3.32	3.32	3.19	2.97	2.76	2.68	2.64	2.63
4.0	3.32	3.32	3.32	3.32	3.32	3.32	3.07	2.79	2.70	2.64	2.63
4.5	3.32	3.32	3.32	3.32	3.32	3.32	3.32	1.88	2.74	2.64	2.63
5.0	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.07	2.79	2.64	2.63
5.5	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.32	2.88	2.64	2.63

Hamilton Smith, Jr., "Hydraulics," 1886

Smith's Coefficients of Discharge for Circular and Square Orifices with Full Contraction								
Diameter of Circular Orifices (feet)				Head (feet)	Side of Square Orifices (feet)			
0.02	0.04	0.10	1.00		0.02	0.04	0.10	1.00
	0.64	0.62		**0.4**		0.64	0.62	
0.66	0.63	0.61		**0.6**	0.66	0.64	0.62	
0.65	0.63	0.61	0.59	**0.8**	0.65	0.63	0.62	0.60
0.64	0.62	0.61	0.59	**1.0**	0.65	0.63	0.61	0.60
0.64	0.62	0.61	0.59	**1.5**	0.64	0.62	0.61	0.60
0.63	0.61	0.60	0.60	**2.0**	0.64	0.62	0.61	0.60
0.63	0.61	0.60	0.60	**2.5**	0.63	0.62	0.61	0.60
0.63	0.61	0.60	0.60	**3.0**	0.63	0.62	0.61	0.60
0.62	0.61	0.60	0.60	**4.0**	0.63	0.61	0.61	0.60
0.62	0.61	0.60	0.60	**6.0**	0.62	0.61	0.61	0.60
0.61	0.61	0.60	0.60	**8.0**	0.62	0.61	0.61	0.60
0.61	0.60	0.60	0.60	**10**	0.62	0.61	0.60	0.60
0.60	0.60	0.60	0.59	**20**	0.61	0.60	0.60	0.60
0.60	0.60	0.59	0.59	**50**	0.60	0.60	0.60	0.60
0.59	0.59	0.59	0.59	**100**	0.60	0.60	0.60	0.60

STORAGE - INDICATION COMPUTATION TABLE

				dT= minutes	
(1) Elevation (ft)	(2) Discharge O2 (cfs)	(3) Storage S2 (cfs-min)	(4) O2 / 2 (cfs)	(5) S2 / dT (cfs)	(6) S2 / dT + O2 / 2 (cfs)

STORAGE - INDICATION OPERATIONS TABLE

(1) Routing Interval (ea)	(2) Hydrograph Time T (hours)	(3) Time Interval dT T2 - T1 (min)	(4) Inflow I (cfs)	(5) Average Inflow (I1 + I2) / 2 (cfs)	(6) Previous (8) S1 / dT + O1 / 2 (cfs)	(7) Previous (9) O1 (cfs)	(8) (5)+(6)-(7) S2 / dT + O2 / 2 (cfs)	(9) (2) From S-I Curve O2 (cfs)
1		0.0	0.0	0.0	0.0	0.0	0.0	0.0
2					0.0	0.0		
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								

VIII. Storm Sewers

Introduction

Storm sewer systems are designed to collect and convey storm runoff from street inlets, from runoff control structures, and from other locations where the accumulation of storm water is undesirable. Storm sewers are closed conduits which convey storm runoff from a drainage area to an outlet. Although the storm sewer is the basic part of the primary storm drainage system, it also serves to carry a significant portion of the runoff during the infrequent major storms.

The objective of a storm sewer system is to remove runoff from an area fast enough to avoid unacceptable amounts of ponding damage and inconvenience. Therefore, design criteria and general design procedures are presented herein to meet these objectives.

Design Criteria

Storm sewers shall be designed to meet the physical requirements stated in the Design Storm Criteria of Section III, and in section 1383.04 of the Subdivision regulations. In addition, the following specific design criteria are presented to guide the engineering design of storm sewers.

Design Criteria

1. Depth - the depth of the storm sewer shall be sufficient to receive water from street inlets and other drainage structures. The minimum cover for storm sewers crossing streets with curb and gutter shall be one foot (clearance) from the bottom of the curb or underdrain to the top of conduit. A minimum cover of two feet from finished ground surface is recommended at all other locations.

2. Velocity - A minimum velocity of two feet per second (fps) is recommended to insure self-cleaning. The maximum allowable velocity shall be 12 fps unless special materials are included for protection against scouring.

3. Design Discharge Method - The Rational, the Wadsworth Modified Rational, SCS TR-55 Peak Discharge, or other acceptable methods may be used to determine peak discharge.

4. Hydraulic Design - The hydraulic design of storm sewers shall be based on the Manning Equation; The hydraulic grade line for both the primary and major design storms shall be considered.

5. Roughness Coefficients - Exhibit VIII-2 lists the range of Manning roughness coefficients (n) to be used for different conduit materials.

6. Manhole Spacing - Manholes should be located at junctions of conduits, at changes in conduit direction, and at changes in slope. Maximum spacing in storm sewers is 350 feet to facilitate maintenance activities.

7. Hydraulics at Structures - Conduits at structures should be aligned crown to crown when

possible. A maximum vertical separation of 24 inches may be allowed if deemed applicable. Invert elevations shall be given to the center of the structure.

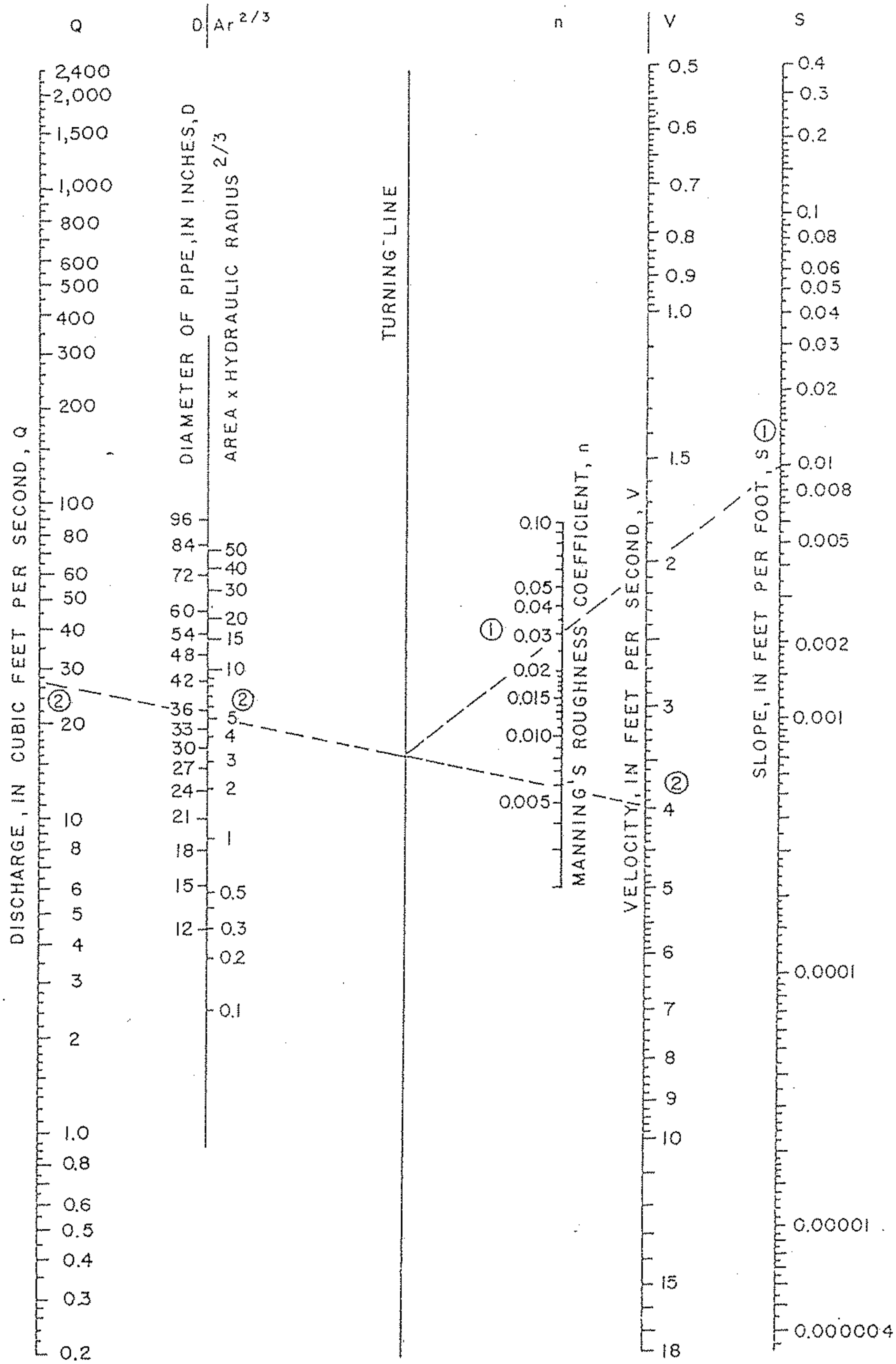
The maximum turn for storm shall be 90 degrees. The invert of the structure shall be filled with concrete to the spring line of the conduit to form a smooth radius. The structure shall be sized such that a radius of 2 x DIA of the smaller conduit can be formed within the structure. The minimum interior dimension for any structure shall be two feet.

Where pipe diameters and/or the angle of entry inhibit the structural integrity of square or rectangular structures (i.e. entry at the corner), a circular manhole shall be specified. Box-outs in precast structures shall be properly sized to compensate for the slope of the pipe, wall thickness, and/or angle of entry.

8. Inlet Spacing - Curb inlets shall be placed immediately upstream of intersections They shall be placed in the tangent sections as much as possible. Multiple inlets may be required at sags in the pavement and at the end of downhill cul-de-sacs. The maximum spacing of curb inlets along both sides of the pavement shall be 250 feet and they shall be located at a 4 feet skew to align with pavement joints. Additional inlets shall be located where necessary to meet encroachment criteria stated in Section III.

9. Drainageways - Storm in drainageways being diverted to the streets shall be intercepted by catch basins or other inlet structures before reaching the right of way. Additional catch basins or inlet structures shall be located as necessary to drain possible ponding areas between or behind adjacent lots.

VIII-1 NOMOGRAPH FOR SOLUTION OF THE MANNING FORMULA



STORM SEWER DESIGN CHART

CITY OF WADSWORTH

PROJECT NAME: **TYPE OF PIPE:**

DESIGN FREQUENCY- YEAR N- DATE DESIGNER

FROM	TO	DRAINAGE AREA		TIME (MIN.)		INTENSITY	RUNOFF	CHANGE	SUM	DISCHARGE	LENGTH	CALC.	SIZE OF	SLOPE	FULL	FULL	REMARKS
MH	MH	dA	SUM A	dT	SUM T	"I"	COEF.	CA	CA	"Q"	OF PIPE	DIA.	PIPE	OF PIPE	"V"	"Q"	

$I = a / (t + b)^m$

Coef.	Years						
	1	2	5	10	25	50	100
a	33.102	40.256	50.354	57.72	69.809	82.104	94.153
b	13.490	13.180	13.330	13.120	12.920	13.210	12.990
m	0.820	0.819	0.821	0.819	0.817	0.819	0.818

TR-55/Rational Frequency		WRM
Structures	**Design Yr.**	I
Storm Sewers	10 Yr.	4
Culverts	10 Yr.	4
Bridges	50 Yr.	7
Floodplain	100 Yr.	7

Manning's "N" Values		
Type	**Existing**	**Proposed**
SMOOTH INSIDE PLASTIC	0.012	0.011
R.C.P.	0.015	0.013
C.M.P.	0.024	N/A
V.C.P.	0.015	0.013

IX. Culverts & Open Channels

Highways and railroads traversing the land cut across individual watersheds. To allow the flow from each watershed across the embankment culverts are built at the lowest points of the valleys. The hydraulic operation of culverts under various possible discharge conditions cannot be classified either as pressure flow or an open channel flow. The actual conditions involve both of these basic concepts.

The fundamental objective of hydraulic design of culverts is to determine the most economical diameter at which the design discharge is passed without exceeding the allowable headwater elevation. The major components of a culvert are its inlet, the barrel and the outlet (Exhibit IX-1). Each of these components has a definite discharge delivery capacity that will control the hydraulic performance of the whole structure.

A culvert may be inlet or outlet controlled. In inlet control, the discharge is dependent only on the headwater above the invert at the entrance, the diameter of the pipe and the geometry of the entrance. The slope, length and the roughness of the pipe do not influence the discharge. Outlet control occurs when the discharge is dependent on all the hydraulic factors Exhibit IX-1, such as the slope S, length of the barrel L, diameter D, roughness n, headwater depth HW, and tailwater depth TW.

Under various discharge conditions, the hydraulic operation of culverts may be classified into four categories (Exhibit IX-2):

A. submerged inlet and outlet: $HW/D > 1.2$

B. submerged inlet with full flow but free discharge at the outlet; $HW/D > 1.2$

C. submerged inlet with partially full pipe; $HW/D > 1.2$

D. unsubmerged inlet; $HW/D < 1.2$

The hydraulic conditions of these categories are discussed next.

A. Submergence of the culvert outlet may be the result of inadequate drainage downstream. In this case, the culvert discharge is primarily determined by the tailwater elevation TW and the head loss of the culvert, regardless of the culvert slope. The culvert flow can be treated as a pressure flow. The total head loss, Hl, is the sum of head loss at the entrance he, head loss due to friction, hf, and the head loss at the exit which is $V^2/2g$. Hence,

$$Hl = he + hf + \frac{V^2}{2g} \qquad (1)$$

The head loss at the entrance is given by:

$$he = Ke^* \frac{V^2}{2g} \qquad (2)$$

where Ke is a head loss coefficient which depends on the conditions at the entrance as shown in Exhibit IX-1. Some typical conditions at the entrance are shown in Exhibit IX-2.

The head loss due to friction may be calculated either by the Darcy-Weisbach equation or by the Manning's equation. From Darcy-Weisbach equation

$$hf = f^* \frac{L}{D} * \frac{V^2}{2g} \qquad (3)$$

and from Manning's equation

$$hf = \frac{(n^2 * V^2 * L)}{(C_m{}^2 * R^{4/3})} \qquad (4)$$

Common values used for the Manning's roughness coefficient are n = 0.015 for concrete pipe and n = 0.024 for corrugated metal pipe. For a pipe flowing full the hydraulic radius is R = D / 4. Manning's equation is easier to apply but is less accurate compared with the Darcy-Weisbach equation.

B. If the discharge carried in a culvert has a normal depth that is larger than the barrel height, the culvert will flow full even if the tail water level drops below that of the outlet. In this case, the discharge is controlled by the head loss and the level of the head water (HW). The hydraulics are the same as discussed before.

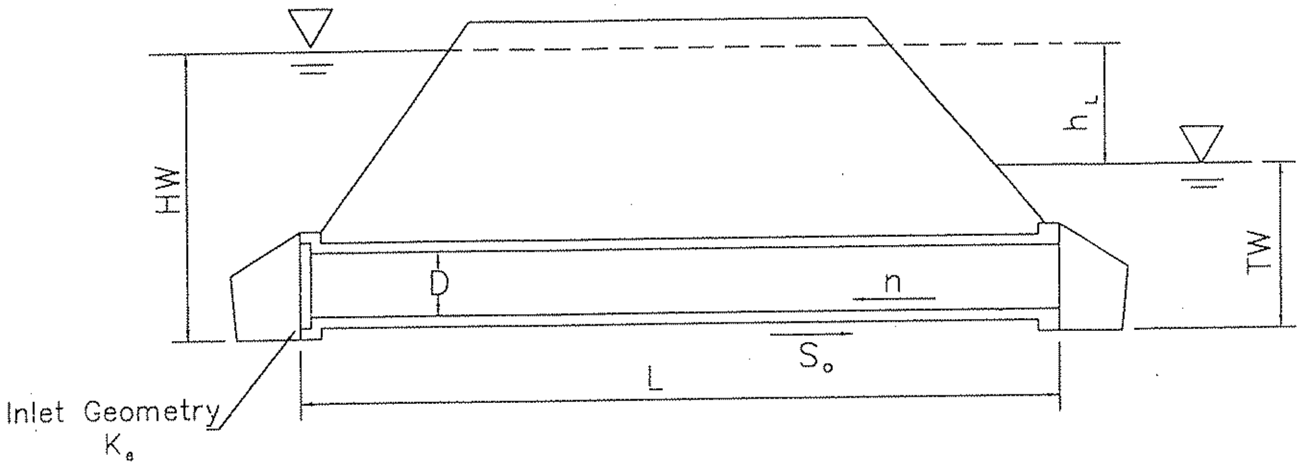
C. If the normal depth of discharge is less than the barrel height, with the inlet submerged and free discharge at the outlet, a partially full pipe flow condition will normally result, as illustrated in Exhibit IX-2. The culvert discharge is controlled by the entrance condition, and the flow is said to be under entrance control. The discharge can be calculated by

$$Q = C_d A \sqrt{2gh}$$

where h is the hydrostatic head above the center of the orifice, A is the cross-sectional area of the pipe, and Cd is the coefficient of discharge. The values of Cd for various entrance conditions are given in Exhibit VII-2.

D. When the hydrostatic head at the entrance is less than 1.2D, air will break into the barrel and the culvert will flow under no pressure. In this case, the culvert slope and the barrel wall friction determine the flow condition in the culvert for open channel flow. Due to a sudden reduction of the water area at the entrance, the flow usually enters the culvert in a supercritical condition. The critical depth takes place at the entrance of the barrel. The friction of the barrel wall gradually dissipates the energy. If the rate of dissipation is higher than the flow could gain from the barrel slope, the depth of the flowing water will increase in the downstream direction. Depending on the tail water level, the supercritical flow may convert to sub-critical flow through a hydraulic jump. The flow conditions can be computed by applying the water surface profiles developed for open channels.

HYDRAULIC FACTORS AFFECTING CULVERT DISCHARGE



- D = Height of culvert, in feet
- HW = Headwater depth at culvert entrance
- L = length of culvert
- n = Surface roughness coefficient
- S_o = Slope of the culvert conduit
- TW = Tailwater depth at culvert outlet
- K_e = Entrance loss coefficient
- h_L = Head loss through culvert

COEFFICIENTS FOR HYDRAULIC DESIGN OF INLETS

ENTRANCE SHAPE		Head loss Coefficient K_e	Discharge Coefficient C_d
With Headwall			
	Groove edge	0.19	0.734
	Round (0.15 D Radius)	0.15	0.775
	Round (0.25 D Radius)	0.10	0.860
	Square edge	0.43	0.625
Headwall & 45° wingwalls			
	Groove edge	0.20	0.731
	Square edge	0.35	0.651
Headwall & Parallel Wingwall			
	Groove edge	0.30	0.691
	Square edge	0.40	0.634
Miter	2:1 embankment slope	0.62	0.580
Projecting entrance			
	Groove edge	0.25	0.70
	square edge (Thick wall)	0.46	0.614
	Thin wall	0.92	0.525

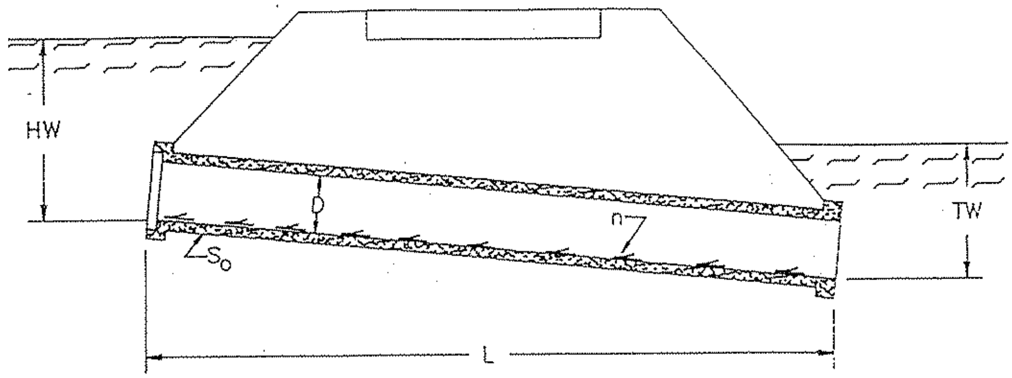


Figure 1. Notations for culvert analysis.

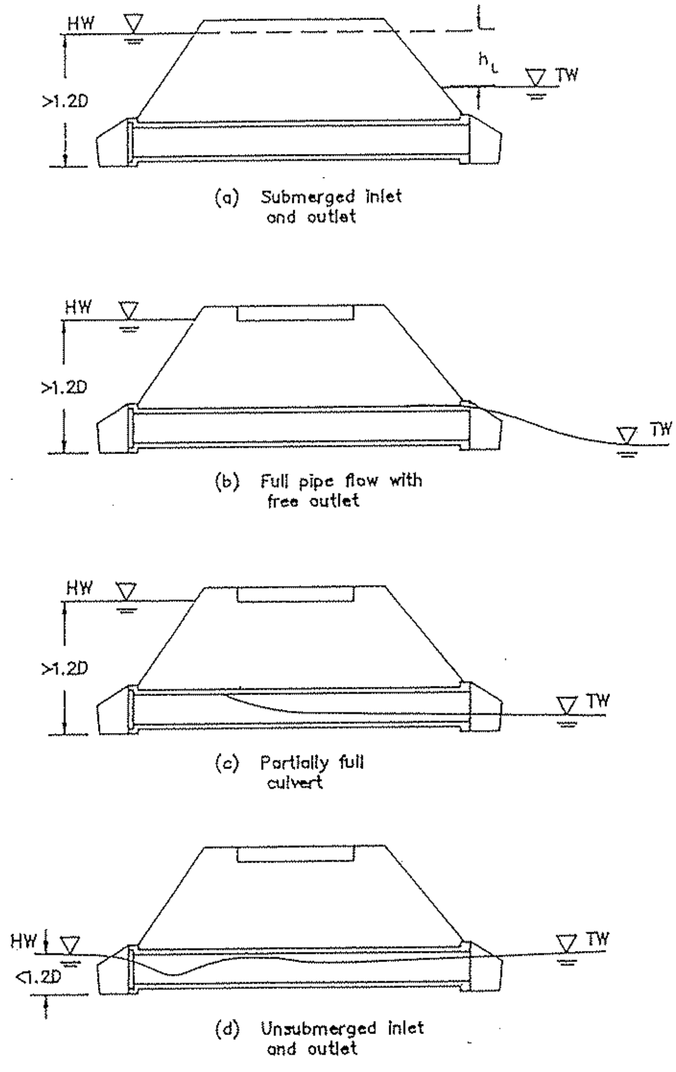


Figure 2. Hydraulic operation of culverts.

CULVERT ANALYSIS

CULVERT SIZE DESIGN

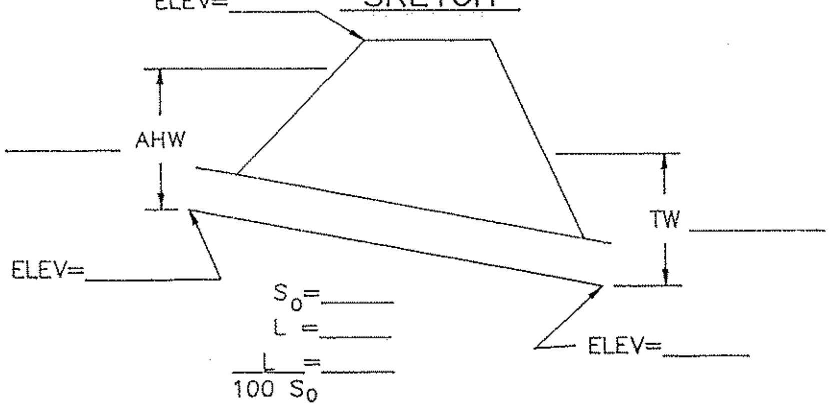
PROJECT:

DESIGNER ____________

DATE: ____________

CULVERT DESCRIPTION (ENTRANCE TYPE)	SIZE	Q	HEADWATER COMPUTATIONS: INLET CONT.		OUTLET CONTROL $HW = H + h_o - LS_o$								Controlling HW	OUTLET CONT. Size OK if HW>		OUTLET VELOCITY	COMMENTS
			$\frac{HW}{D}$	HW	Ke	H	d_c	$\frac{d_c+D}{2}$	TW	h_o	LS_o	HW		$D+\frac{(1+Ke)V^2}{2g}$	.75D		

SKETCH



DATA

Q_1 = ____ TAILWATER ELEV. ________ Q_1 = ____ YR. STORM

Q_2 = ____ TAILWATER ELEV. ________ Q_2 = ____ YR. STORM

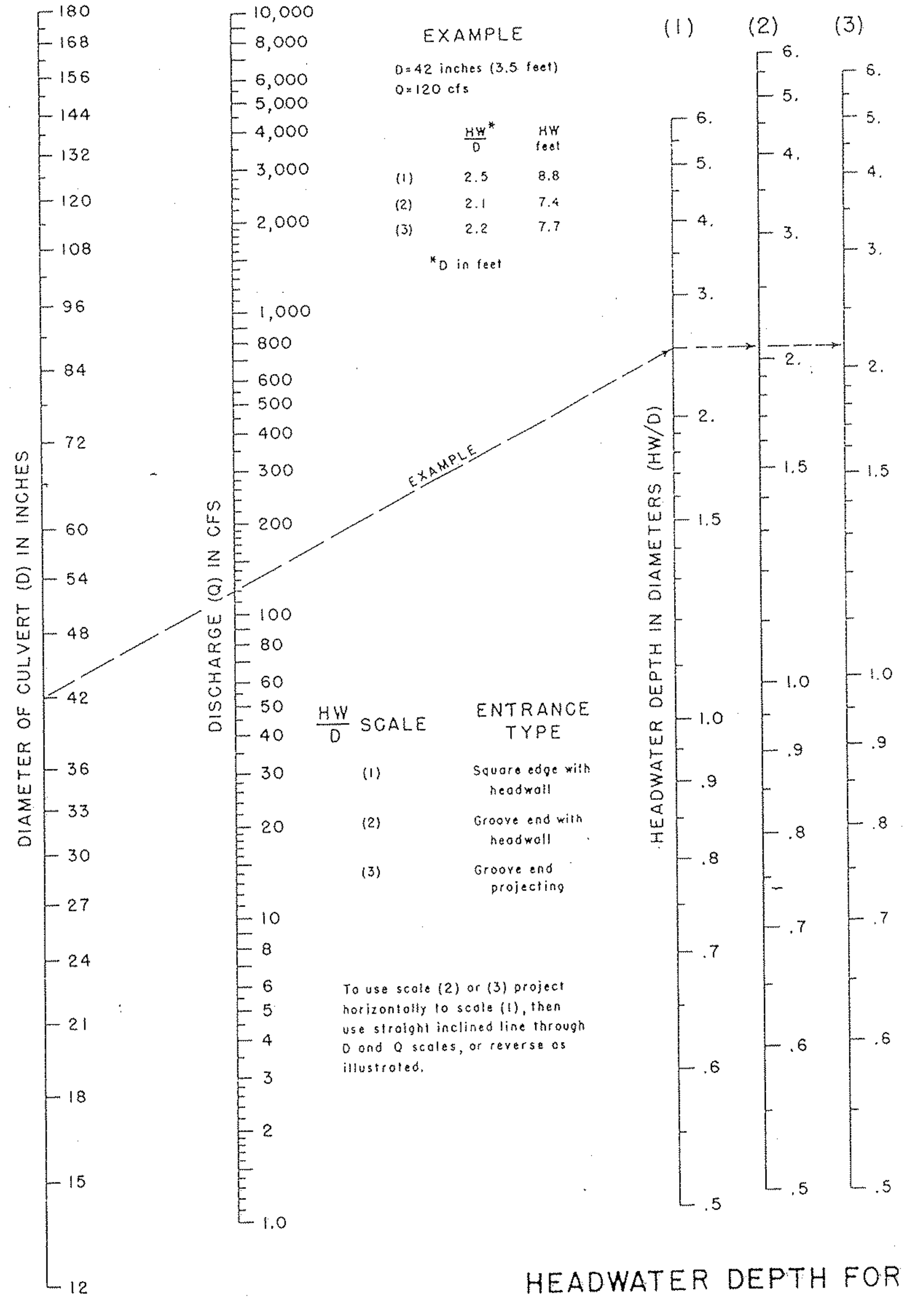
FINAL DESIGN

SIZE ______ INLET ELEV ______ SKEW ______ HEADWALL ______

COVER ______ OUTLET ELEV ______ LENGTH ______ SLOPE ______

VELOCITY ________ PROTECTION ____________

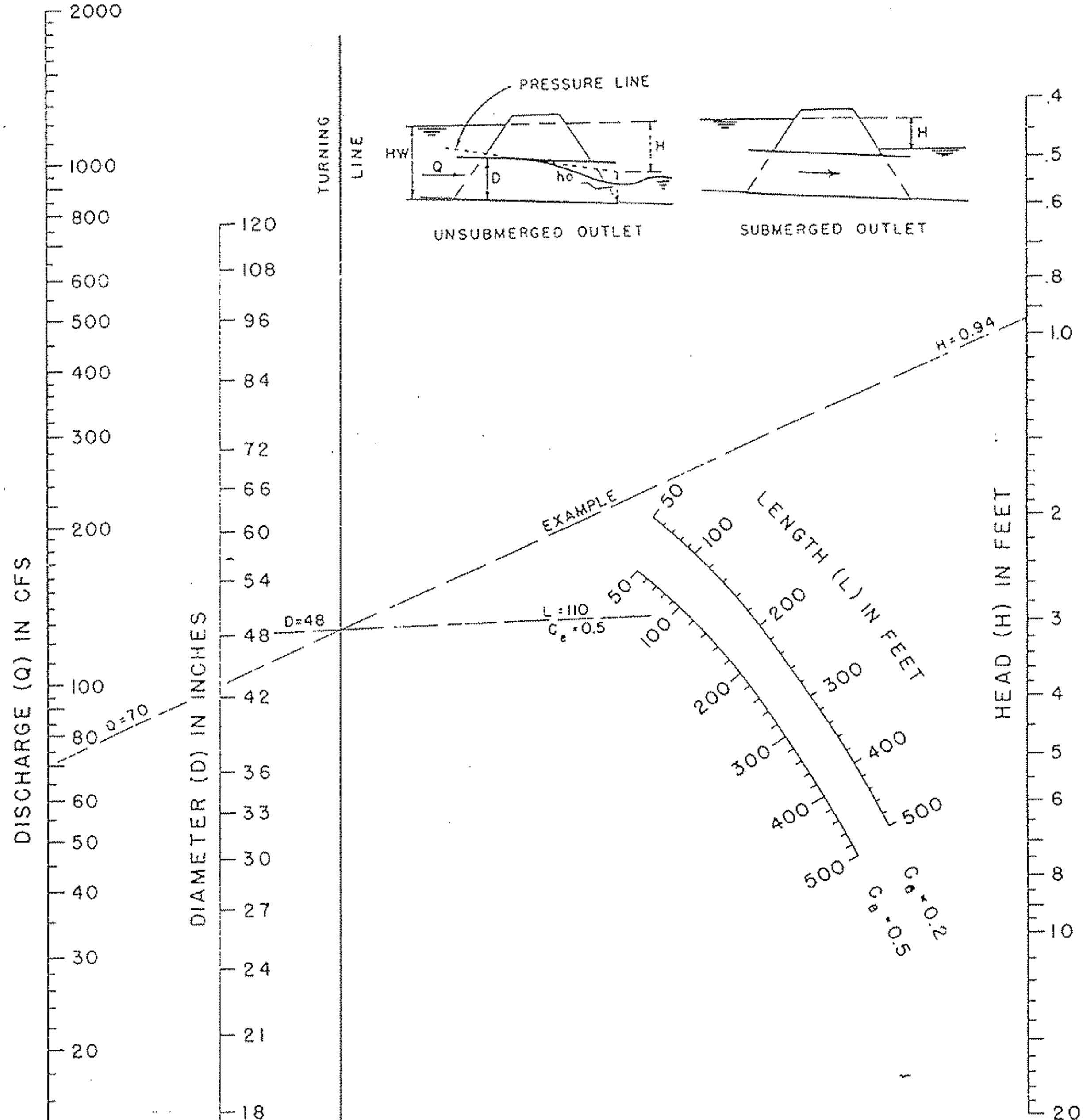
EXHIBIT IX-4 CONCRETE PIPE CULVERTS INLET CONTROL



HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS
OCTOBER 1960

EXHIBIT IX-5 CONCRETE PIPE CULVERT OUTLET CONTROL



EQUATION: $H = \left[\frac{2.5204\,(1+C_e)}{D^4} + \frac{466.18\,n^2\,L}{D^{16/3}}\right]\left(\frac{Q}{10}\right)^2$

H = Head in feet

C_e = Entrance loss coefficient

D = Diameter of pipe in feet

n = Manning's roughness coefficient

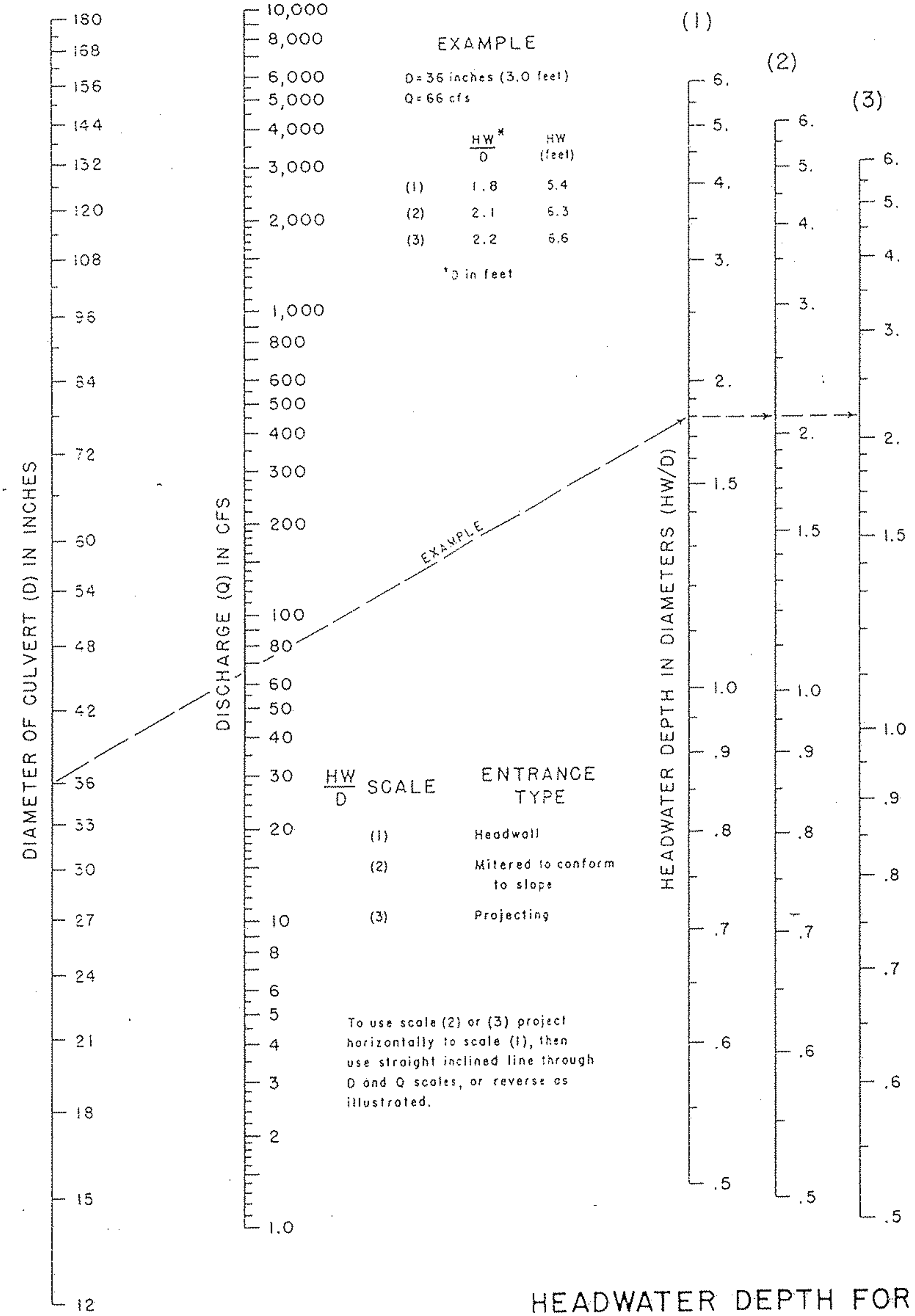
L = Length of culvert in feet

Q = Design discharge rate in cfs

HEAD FOR
CONCRETE PIPE CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS
OCTOBER 1960

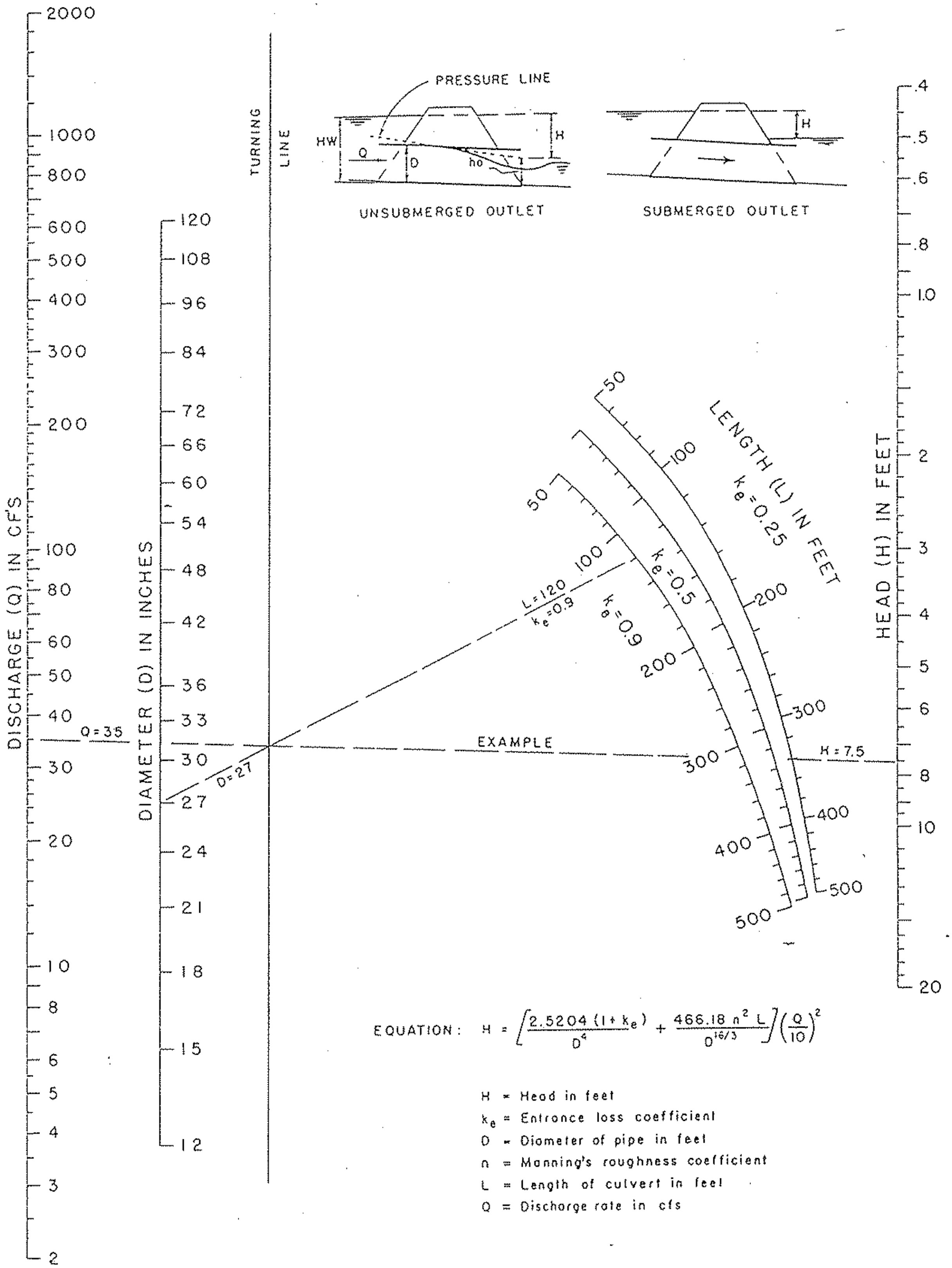
EXHIBIT IX-6 CORRUGATED METAL PIPE CULVERT INLET CONTROL



HEADWATER DEPTH FOR
C. M. PIPE CULVERTS
WITH INLET CONTROL

BUREAU OF PUBLIC ROADS
OCTOBER 1960

EXHIBIT IX-7 CORRUGATED METAL PIPE CULVERT OUTLET CONTROL



EQUATION: $H = \left[\frac{2.5204\,(1+k_e)}{D^4} + \frac{466.18\,n^2\,L}{D^{16/3}}\right]\left(\frac{Q}{10}\right)^2$

H = Head in feet
k_e = Entrance loss coefficient
D = Diameter of pipe in feet
n = Manning's roughness coefficient
L = Length of culvert in feet
Q = Discharge rate in cfs

HEAD FOR
C. M. PIPE CULVERTS
FLOWING FULL
n = 0.024

BUREAU OF PUBLIC ROADS
OCTOBER 1960

X. Bibliography

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2. Drainage of Highway Pavements, Hydraulic Engineering Circular No. 12, FHWA - TS - 202, Frank L. Johnson and Fred F.M. Chang, March 1984.

3. Handbook of Hydraulics, Fifth Edition, McGraw-Hill Book Company, King & Brater.

4. Hydraulics, Hamilton Smith Jr., 1886

5. Location and Design Manual, Volume Two, Drainage Design, Bureau of Location and Design, Ohio Department of Transportation, April 1992.

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7. Rainfall Frequency Atlas of the Midwest, Bulletin 71, Midwestern Climate Center and Illinois State Water Survey, Floyd A. Huff and James R. Angel, 1992.

8. Stormwater Design Manual, Mid-Ohio Regional Planning Commission, Burgess & Niple, Limited, June 1977.

9. Urban Hydrology for Small Watersheds, Technical Release No. 55, Soil Conservation Service, Engineering Division, U.S. Department of Agriculture, June 1986.

XI. Detention Maintenance Letter

Mr. William Lyren, Service Director
City of Wadsworth
120 Maple Street
Wadsworth, OH 44281

RE: **Commercial Basins**

Dear Mr. Lyren:

We, the owners of ______________________________, agree to the complete maintenance of the detention basin.

This maintenance work to include:

1. Cleaning of grating on outlet control structure and orifice.

2. Keeping the outlet pipe open.

3. Repair of earthen dike in case of erosion.

4. Removal of debris as they occur.

5. Surface of dike and detention basin shall be seeded or planted with

   A. Grass (which shall be mowed)

   B.____________________

Sincerely,

____
Owner(s)

State of Ohio
Medina County

Before me, a notary public in and for said county and state, personally appeared the above named ______________________________ who acknowledged the making of the foregoing instrument and the signing of this agreement to be his free act and deed. In testimony whereof I have hereunto set my hand and affixed by official seal at ______________, Ohio, this _____ day of ______, 1996.

____
Notary Public

____
My Commission Expires

Mr. William Lyren, Service Director
City of Wadsworth
120 Maple Street
Wadsworth, OH 44281

RE: **Residential Basins**

Dear Mr. Lyren:

We, the owners of ______________________________, agree to the complete maintenance of the detention basin.

This maintenance work to include:

1. Cleaning of grating on outlet control structure.

2. Repair of earthen dike in case of erosion.

3. Removal of debris as they occur.

4. Surface of dike and detention basin shall be seeded or planted with

   A. Grass (which shall be mowed)

   B.____________________

Sincerely,

______________________________ ______________________________
Owner(s) Owner(s)

State of Ohio
Medina County

Before me, a notary public in and for said county and state, personally appeared the above named ______________________________ who acknowledged the making of the foregoing instrument and the signing of this agreement to be his free act and deed. In testimony whereof I have hereunto set my hand and affixed by official seal at ______________, Ohio, this _____ day of ______, 1996.

____
Notary Public

____
My Commission Expires

XII. Site Plan Requirements

General Information Required

I. The plan shall be drawn to a scale of 1:20, show topographic features of the lot, building placement, and activity area, and shall include a circulation and parking plan, planting and landscape plan, with engineering and construction information.

II. A location map shall be provided with the following:

A. Title, name, and address of subdivider.

B. Site planner, surveyor and date.

III. The following existing and proposed data shall be provided:

A. Boundary lines and distances.

B. Easements - Location, width, and purpose.

C. Streets on and adjacent to the tract.

1. Name and right-of-way width and location.
2. Type, width, and elevation of surfacing.
3. Established centerline elevations.
4. Walks, curbs, gutters, etc.

D. Driveways and parking lots on and adjacent to the tract.

1. Type, width, elevation, and location.
2. Visual relief and traffic channelization shall be provided through the use of trees, planted and landscaped dividers, island and walkways.
3. Where applicable, screening of parking areas and service areas from surrounding properties shall be provided.
4. On-site traffic circulation shall be designed for fire and police protection.
5. The design and construction standards of all private roads, driveways, and parking areas shall conform to the standards and regulations established by the City Engineer.

E. In the case of commercial or industrial uses, adequate provision shall be made for the disposal of all wastes as directed by the Director of Public Service.

F. The architectural design of buildings shall be developed with consideration given to the relationship of adjacent developments.

G. Utilities

1. Size location, and invert elevation of sanitary and storm sewers.
2. Location and size of water mains.
3. Location and size of gas lines.
4. Location of fire hydrants.

5. Electric and telephone poles.
6. Street and parking lot lights.

H. Ground elevations - One foot contours and spot elevations are required.

I. Subsurface conditions - Conditions that are not typical, such as abandoned mines, gas wells, etc.

J. Other conditions on the adjacent land

1. Approximate direction and gradient of ground slope, including any embankments or retaining walls.
2. Character and location of buildings, railroads, power lines, and towers and other nearby non-residential land uses or adverse influences.

K. Proposed public improvements - Highways or other major improvements planned by public authorities for future construction on or near the tract.

L. North arrow and scale

M. Detention/retention basin shall include the following:

1. One foot contours and spot elevations are required.
2. All piping sizes, grades, inverts, locations, etc.
3. All catch basin types, sizes, details, orifices, grates, etc.
4. Critical Storm, volume required, high water elevation.
5. Type of ground cover.

N. Approved recorded agreement covering the maintenance of the detention/retention facility.

O. Approved letter or approved sediment control construction details and procedure as specified by the City.

P. A property survey with iron pins set may be required and a plat provided to establish and allow the checking of the location of said facilities.

Q. As-Built drawings prepared by a professional engineer or surveyor shall be submitted on mylar prior to final acceptance. The As-Built survey shall also verify the storage volume of detention/retention structures.