3.4 DRAINAGE AND FLOOD CONTROL DESIGN. This sub-section sets forth the criteria for engineering design of drainage and flood control systems.

3.4.1 GENERAL REQUIREMENTS. All development in the City that requires a grading permit or exceeds one acre in area, and all commercial development, shall submit a Drainage Control Plan and Report.

Design of drainage systems associated with development cannot cause increases in the flood peak discharges downstream from the development for 10-year and 100-year flood events.

All drainage plans shall conform to the requirements of the General Drainage Manual and be approved by the City Engineer or his designee.

Drainage and flood control plans shall be designed to conform to the City Flood Control Master Plan.

Drainage facilities shall be designed using currently accepted civil engineering standards of practice, applicable safety standards, and City or other approved design specifications.

In general, each development should handle its storm water runoff in such a manner that no increase in the 10 or 100-year peak storm runoff above the pre-development and/or natural state will occur on downstream properties.

In general, development changes the characteristic (quantity) of drainage from sheet flow to point discharge flow. While the amount of water may be controlled, the effects of all point discharges must be handled to insure no detrimental effects downstream of development.

Drainage facilities should be analysed, designed, and constructed to protect the development from the 100-year peak storm runoff. Most drainage collection system capacities for new development will be sized for the 10-year flood event, but no significant damage or risk of personal injury may occur from the 100-year flood. Major hydraulic structures (including bridges, large culverts, and open channels) will be designed for the 100-year flood.

For analysis purposes of the drainage system of a drainage basin area, all of the drainage basin upstream of the proposed development should be analysed for the conditions of new and/or planned development in conformance with the City's current Land Use Master Plan. Effects on downstream property owners and downstream flood control system shall be considered in the design and any negative impacts mitigated or design changes presented to mitigate problems to

[r, a.1, 05/01]

the satisfaction of the City Engineer or his designee. This may include acquisition of easements or agreements and/or construction or modification of existing improvements where needed both within the development and/or downstream.

All storm drainage and flood control systems shall be separate and independent from the sanitary sewer system.

New development should not cause a natural drainage channel to be filled in, obstructed, or diverted. When modifications to a natural drainage channel is proposed within the development, such changes will be addressed in the Drainage Control Plan and Report and shown on the improvement plans, and must be approved by the City Engineer prior to proceeding. In the event that modifications to natural drainage channels are approved, necessary easements and rights-of-way for structures and improvements shall be provided to the City.

The point at where the natural drainage channel enters and leaves the property will not be changed without approval of the City Engineer.

Improvements designed to protect a development shall be considered permanent and shall be designed and constructed accordingly. Such improvements shall be easily maintained by the maintaining agency.

New development shall provide the necessary means to insure drainage within the property being developed makes use of existing facilities and/or natural washes and shall be required to construct master planned improvements.

Streets are a significant and important component in urban drainage and shall be made use of in storm runoff within reasonable limits. The primary purpose of streets is for traffic. Reasonable limits for the use of streets for runoff shall be set by the City Engineer.

When drainage encroachments beyond that allowed for in the streets or point discharges are exceeded, an independent storm water system shall be designed and constructed by new development.

3.4.2 DESIGN CRITERIA - STREETS. Streets are a significant and important component in urban drainage and may be made use of in storm runoff within reasonable limits. The primary purpose of streets is for traffic. Reasonable limits for the use of streets for runoff shall be set by the City Engineer. Design criteria for gutter capacity and associated lane encroachment will depend on the roadway type as shown in Table 3.3. Street designs must include surface drainage relief points (inlets). This is especially important for flat gradient areas, local sumps or depressions and cul-de-sacs. For pedestrian safety, street flows must be limited such that the product of the depth (ft.) and velocity (ft./sec.) does

not exceed six (6) for the 10 year flow and eight (8) for the 100-year flow. Curb overtopping is not permitted in the 10 year event. When street encroachment limits are met, an underground storm sewer system shall be required. Where this underground conveyance is required to limit street flows, it will be designed for the 10-year design storm or greater.

Table 3.3

Street and Gutter Capacity for the *10-year* Event	
Street Classification	Maximum encroachment
Local (residential)	No curb overtopping.* Flow may spread to crown of street.
Minor collector (residential); Commercial	No curb overtopping.* Flow spread must leave one lane free of water.
Major Collector	No curb overtopping. * Flow must leave at least two lanes of travel free. (One lane in each direction)
Arterial	No Curb overtopping.* All travel lanes to remain open.
Major Arterial	No Curb overtopping.* No encroachment is allowed on any traffic lane.

* Where no curb exists, encroachment shall not extend over property lines.

Streets must also provide for routing of the 100-year design storm to adequate downstream conveyance facilities. The 100-year flood flows in streets should be contained within street right-of-way and adjacent drainage easements.

3.4.3 DESIGN CRITERIA - STORM DRAINS. Storm drain design conveyance capacity will be sized for a minimum of the ten year, three hour flood. The one hundred year, three hour design flood will be used for evaluation and prevention of significant damage to street overflow. Inlets must have sufficient capacity to prevent local ponding during the ten year event, with fifty percent (50%) blockage of inlets by debris. Analysis of combined street and storm drain capacity for the one hundred year flood must determine maximum ponding depths and water levels and show that these depths are non-damaging. In instances where sufficient combined capacity does not exist the storm drain size may have to be increased beyond that of the 10 year design.

In areas where underground water is anticipated to be added to the drainage system, the pipe size should be increased accordingly. In general, ground water will not be allowed to flow in streets and gutters and in other overland flow situations.

Design considerations will be given for differences in interception capacity of inlets on a gradient as compared to interception capacity of inlets in sag locations. Inlet spacing and locations will be for continuous grade or sag situations as appropriate. Inlets will be spaced so as to keep the street encroachment of flood waters to the minimum. Sag points may be required to have additional inlets spaced to control the maximum level of ponding.

All storm drains will be designed by application of the Mannings equation. Minimum design velocity shall be two ft./sec. flowing one-half full. The mannings "n" value shall represent that value that will be seen during the useful life of pipe which may differ from that of a new pipe. The hydraulic grade line will be shown for all pipe systems. The minimum storm drain diameter shall be 12" for smooth wall (insides) and 15" otherwise.

Storm drains shall not be designed for surcharged (pressure) pipe conditions unless otherwise approved by the City Engineer. When storm drains are designed for full pipe flow, or surcharged pipe conditions, the designer shall establish the hydraulic grade line considering head losses caused by flow resistance in the pipe, and changes of momentum and interferences at junctions, bends and structures. The water surface elevation profile and hydraulic grade line will be shown for the ten year and the one-hundred year design flood as required in the Drainage Control Plan and Report.

3.4.4 DESIGN CRITERIA - CULVERTS. In general, culverts are used to carry runoff from an open channel or ditch under a roadway to a receiving open channel or ditch. The minimum culvert diameter shall be 24". All culvert crossings under a roadway shall be designed to handle the 100 year storm (see bridges). All culvert crossings under arterial roads shall not have any road overtopping. Any other road overtopping shall be limited by the velocity/depth product and as detailed in Section 3.4.2.

A culvert entrance blockage factor of up to fifty percent (50%) shall be used for small diameter culverts and culverts placed in drainages with upstream debris as determined by the city. The one hundred year design storm water backwater surface upstream will be determined using an approved method (generally a HEC-2 or HEC-RAS) unless otherwise not required by the city. The back water must be shown to be non-damaging and be approved by the affected property owner. Potential paths of embankment overtopping flows will be determined and redirected, if necessary, so that no significant flood damage occurs. Entrance and exit structures must be installed to minimize erosion and maintenance. The minimum culvert slope shall be one percent (1%) unless otherwise approved.

3.4.5 DESIGN CRITERIA - BRIDGES. Bridges consist of major structures

carrying major washes or drainages. The roadway facility handled can be any classification of roadway. Low water crossings are generally not permitted Bridges can consist of free span structures, box culvert, multiple box culverts, multiple precast bridges and others.

Free-span bridges must pass the one hundred year event with a minimum of two feet of freeboard. No significant increases are allowed in upstream water levels. An approved method (generally a HEC-2 or HEC-RAS) of potential upstream water surface may be required by the City. Local and regional scour analysis are required on the structure, upstream and downstream and embankments. All potential scour will be mitigated. Appropriate references for this are Stream Stability at Highway Structures, Hydraulic Engineering Circular No. 20, Federal Highway Administration and computer programs such as USCOE HEC-6 or FHWA FESWMS.

For structures crossing FEMA designated flood plains and drainages, other requirements will be used, consult the City Engineering Dept.

3.4.6 DESIGN CRITERIA - CHANNELS

3.4.6.1. OPEN CHANNELS. Generally, there are two types of channels, they are man made and natural. Natural channels can be further subdivided into several sub-categories such as un-encroached, encroached, partially encroached, bank lined and others. The one-hundred year recurrence flood will be used for design for all channels unless otherwise approved by the city. All open channels must be designed as permanent in nature and have a minimum freeboard of one (1) foot. They must be designed as generally low maintenance facilities and must have adequate access for the entire length.

3.4.6.2. MAN-MADE CHANNELS. Man-made channel side slopes will generally be limited to a maximum slope of 2H:1V. Flatter slopes are generally recommended for maintenance and safety reasons. Safety is a primary concern. A channel should be designed such that a person falling into it could climb out within a reasonable length. A channel that is shallow in depth or in remote areas, or in areas of restricted right of way may, upon approval, have a steeper slope. Maximum velocities will depend on the type of material used for the channel lining. Supercritical velocities are not permitted for any material used. Drop structures and other energy dissipating design may be required to limit velocities to control erosion and head cutting.

Maximum velocities for grass lined channels depend on the type(s) of grass mixtures. The designers should consult appropriate design

literature for details. It is assumed that grass lined channels will be mowed at least annually. The minimum bottom width of a grass lined channel will be 6 feet unless otherwise approved by the maintenance agency. The minimum bottom width of all man-made channels shall be designed to facilitate access and maintenance.

3.4.6.3 NATURAL CHANNEL. The use and preservation of natural drainage ways shall be encouraged. Natural channels for drainage conveyance can reduce long term maintenance costs, can reduce initial costs associated with drainage, and can enhance passive recreation, and open space uses. When natural channels are incorporated into the drainage control plan, consideration shall be given to the impact of increased flows due to improvements to upstream drainage basins and areas, adequate access for maintenance and debris removal, long term degradation and erosion potential, and the need for additional set-backs for structures.

3.4.7 DESIGN CRITERIA - STORAGE FACILITIES. Generally, there are two types of storage: retention and detention. Retention ponds which are normally intended for infiltration of stored water may require extensive subsoil and groundwater studies as well as extensive maintenance requirements and safety concerns and are generally not allowed.

Detention facilities (basins) are used to temporarily store runoff and reduce the peak discharge by allowing flow to be discharged at a controlled rate. The controlled discharge rate is based on either limited down stream capacity, as in regional basins, or on a limit on the increase in flows over pre-development conditions, as in local facilities, and in some instances both.

Regional detention facilities are those identified by the City and will be identified in the Master Storm Drain Study and other regional studies. Generally, these facilities control flow on major washes or drainage basins, are of major proportion, and are built as part of major development or mitigation plans.

Local detention facilities are usually designed by and financed by developers or local property owners desiring to improve their property. These facilities are intended to allow development of property by protecting a site from existing flooding and/or to protect downstream property from increased runoff caused by development. In small facilities, detention storage volume may be provided in small landscaped or turfed basins, parking lots, underground vaults, excess open space, or a suitable combination. In larger facilities, dual functions may be served. These larger facilities are required

to reduce existing flooding to allow a development and/or control increased runoff caused by the development itself. These larger facilities may store significant flood volumes and may handle both off-site and on-site flows.

3.4.7.1 Design criteria - Detention facilities will generally be used to prevent local increases in the ten year, seventy two hour and the one-hundred year, seventy-two hour peak flows, or the one-hundred year three hour storm, whichever case requires the largest volume. Post-development discharges must not exceed pre-development discharges. If downstream facilities lack adequate capacity to handle the flow, other release rates must be used.

Standard engineering practice shall be used in determining the volume of the required facilities. A minimum of one (1) foot of freeboard is required above the maximum water surface elevation. Emergency spillways or overflows will be incorporated into all designs. Structures and facilities shall be designed so as not to be damaged in case of emergency overflow. Detention basins must empty within 24 hours. The maximum depth of a basin should be 3 feet unless otherwise approved. Below grade basins are preferred. Partially wet basins may be allowed for recreational or aesthetic purposes, but storage below permanent spillways or low-level outlets cannot be included in control calculations. Ground water should not be introduced into detention basins without approval of the City. Multi-use (e.g. recreation) should be considered for all detention basins.

Energy dissipation and erosion protection is required at all outlet structures where storm drainage is released into a natural or erodible channel, unless otherwise approved by the City. All basins are required to function properly under debris and sedimentation conditions. Adequate access must be provided to allow for cleaning and maintenance. All basins shall be designed as permanent facilities unless otherwise approved in writing by the City.

3.4.8 FLOODPLAINS. Flood plains are generally classified as FEMA (FEMA stands for Federal Emergency Management Agency) and non-FEMA. Any work in and around FEMA designated and mapped Flood plains should refer to the local ordinance governing their use. All work in the FEMA floodplain requires an appropriate permit.

3.4.8.1 FLOOD PLAINS (NON-FEMA)
In general, all building floor levels should be constructed two feet above the 100 year flood level. Encroachments into the 100 year floodplain for natural water courses will not be permitted unless

otherwise permitted by the City. All natural drainages, washes, and waterways that convey a developed 100-year flow of greater than 150 cfs will be left open unless otherwise approved. Developments located adjacent to or in Flood plains may be required to stabilize the continual degradation and erosion of the channel by installing grade control structures and/or by other effective means. Any alteration of the floodplain is not permitted unless the proposed use can be shown to have no significant negative influence on the flood conveyance, the floodplain, or the alteration itself.

In the layout and design of new developments, adequate access to Flood plains and erosion protection shall be provided. It is preferred that streets be positioned between Flood plains and structures. Where not possible or feasible, additional structural setbacks will be required.

Hydrologic, hydraulic, erosion, and geomorphologic studies will be required of developments adjacent to Flood plains.

3.4.9 EROSION CONTROL. Necessary measures shall be taken to prevent erosion due to drainage at all points in new developments. During grading and construction, the developer shall control all potential storm runoff so that eroded soil and debris cannot enter any downstream water course or adjoining property. All drainage that leaves a new development shall be adequately addressed to mitigate all erosion on adjacent properties. Erosion mitigation shall be permanent unless otherwise approved. A comprehensive reference on erosion control is Sedimentation Engineering by the ASCE.

3.4.10 IRRIGATION DITCHES. In general, irrigation ditches shall not be used as outfall points for drainage systems, unless such use is shown to be without unreasonable hazard substantiated by adequate hydraulic engineering analysis.

3.4.10.1 USE OF DITCHES - The irrigation ditches running through the area are laid out on very flat slopes and with limited carrying capacity. It is obvious, based on experience and hydraulic calculations, that irrigation ditches cannot, as a general rule, be used as an outfall point for storm drainage because of physical limitations. Exceptions to the rule are when the capacity of the irrigation ditch is adequate to carry the normal ditch flow plus the maximum storm runoff with adequate freeboard to obviate creating a hazard to those below and around the ditch. Ditches are almost always totally inadequate for use as drainage ways.

Irrigation ditches are sometimes abandoned in areas after the agricultural land is no longer farmed. Provisions must be made for ditch perpetuation prior to its being chosen and used as an outfall for drainage. Use of irrigation ditches for collection and transportation of storm runoff shall be made only when in accordance with the basin master plan.

3.4.10.2 Irrigation Company Approval. Any use of, alteration of, or relocation of structures on any irrigation ditch (or canal) shall have the written approval of the irrigation company who shall take the responsibility thereof.