YAVAPAI COUNTY

DRAINAGE CRITERIA MANUAL

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NOVEMBER, 1998
REVISED AUGUST, 2005

ACKNOWLEDGEMENTS

This Manual was prepared for Yavapai County by Arroyo Engineering, Inc. The contract was under the direction of Mr. Kenneth E. Spedding, Director, Yavapai County Flood Control District. The Manual was prepared by Mr. Robert Smolinsky, P.E., and Mr. Justin Turner, P.E. of Arroyo Engineering. Technical review was provided by Mr. Kenneth E. Spedding, District Director, as well as District Staff, Yavapai County Public Works, Yavapai County Planning and Zoning, and local engineering consultants.

Yavapai County and Arroyo Engineering Inc. would like to extend their appreciation to the City of Tucson, Department of Transportation and the City of Prescott Public Works Department for allowing portions of the Drainage Standards Manuals of these two municipalities to be adapted for use by Yavapai County and incorporated within this document.

CONDITIONS OF USE

The information presented within this Manual is to be used for the preparation of hydrologic, hydraulic and drainage related reports required by Yavapai County. Other appropriate procedures not presented within this Manual may also be used, provided approval for their use is first obtained from the Yavapai County Flood Control District.

The information contained within this Manual is based on what is believed to be the best procedures and techniques available at the time this document was prepared. Every attempt was made to define the applicability and the limits of the procedures presented herein. It is, however, the responsibility of the user of this Manual to exercise engineering judgment in the analysis and design of flood-control and stormwater improvements.

This manual is not intended to conflict with any other Yavapai County design standards or ordinances. If a conflict does arise, it is the intent of the County to require the more stringent or restrictive standard to apply.

As further progress is made in applied hydrology, hydraulics and fluvial geomorphology, appropriate modifications will be made to this Manual. The user should therefore contact Yavapai County, prior to the use of this Manual, to obtain any modifications and errata sheets which may apply.

August, 2005

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DEFINITIONS

ALL-WEATHER ACCESS is a safe vehicular route which either ordinary or emergency vehicles require for the purpose of unimpeded access during floods. This standard applies to public or private streets, or to a designated route connecting a street and the development or building in question. Stormwater runoff flowing either across or in the direction of an all-weather access route shall not exceed one (1) foot in depth during a 100-year flood.

AT-GRADE CROSSING is a depression or vertical sag in a roadway designed to allow drainage to cross a roadway without the use of a culvert.

BACKWATER is the effect that tailwater has upon upstream flow. Backwater can also refer to the calculations that are performed to compute subcritical water-surface profiles in an open channel.

BANK PROTECTION is a form of lining placed on the banks of a watercourse to protect against erosion and/or to decrease the flow resistance of the banks, thereby increasing hydraulic conveyance of the watercourse.

BASE FLOOD is a flood stage or height that statistically has a one (1) percent chance of being equaled or exceeded in any year. The Base Flood is often referred to as the one hundred year (100-year) flood.

CATCH BASIN is an appurtenance to a storm drain inlet used to capture runoff and to trap waterborne debris.

CHANNEL is a watercourse that has been constructed or extensively modified by man for the purpose of conveying stormwater.

CHANNEL LINING is an erosion-resistant material that is placed along the bottom and/or banks of a watercourse.

COLLECTOR CHANNELS are channels designed to capture dispersed surface flow (sheet flow) so that it can be concentrated for conveyance to a desired point using a conveyor channel.

CONVEYOR CHANNELS are channels which generally receive flow from upstream collector channel for conveyance to some downstream discharge point.

CRITICAL DEPTH is the depth of flow in an open channel which corresponds to minimum specific energy for that discharge.

CROSS-SLOPE is the transverse slope of the pavement of a street, usually measured at 90° to the direction of traffic flow.

CULVERT is a hydraulically short, closed conduit employed for the purpose of conveying stormwater through an embankment.

CURB INLET is a storm-drain inlet consisting of an opening in a vertical curb, in combination with a catch basin, which captures stormwater and delivers it into a storm-drain system.

DETENTION BASIN is a stormwater facility which uses a reservoir as a means of delaying the downstream progress of floodwaters in a controlled manner. This is generally accomplished through the combined use of temporary storage areas and a metered outlet device (such as a weir or culvert) which reduces downstream flood peaks, and thereby causes a lengthening of the duration of flow.

DEVELOPMENT means any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, drainage facilities, mining, dredging, filling, grading, paving, excavation or drilling operations, and storage of materials and equipment, located within the area of special flood hazard.

DRAINAGE BASIN is a watershed or runoff catchment area.

DRAINAGEWAY is a route or watercourse along which stormwater runoff moves, or may move, in order to drain a catchment area.

ENCROACHMENT is the advancement or infringement of uses, plant growth, fill, excavation, buildings, permanent structures or development into a floodplain which may impede or alter the flow capacity of a floodplain.

ENERGY GRADE LINE (EGL) is the elevation line which represents the total unit energy of flowing water. Points on the EGL are located above the water-surface elevation a distance equal to the velocity head plus the pressure head.

EROSION is the process of the wearing away of land masses.

FEMA is an abbreviation for Federal Emergency Management Agency

FLOOD OR FLOODING means a general and temporary condition of partial or complete inundation of normally dry land from (1) the overflow of flood waters, (2) the unusual and rapid accumulation or runoff of surfaces from any source, and/or (3) the collapse or subsidence of land along shore of a lake or other body or water as a result of erosion or the undermining caused by waves or currents of water exceeding anticipated cyclical levels or suddenly caused by an unusually high water level in a natural body of water, accompanied by a severe storm, or by an unanticipated force or nature, such as flash flood or an abnormal tidal surge, or by some similarly unusual and unforeseeable event which results in flooding as defined in this definition.

FLOOD INSURANCE RATE MAP (FIRM) means the official map on which the Federal Insurance Administration has delineated both the areas of special flood hazards and the risks premium zones applicable to the community.

FLOODPLAIN OR FLOOD-PRONE AREA means the areas adjoining the channel of a watercourse including areas where drainage is or may be restricted by man-made structures which have been or may be covered partially or wholly by floodwaters from the on hundred year flood.

FLOODWALL is an constructed wall which diverts floodwaters and prevents structures from being flooded.

FLOODWAY means the channel of a river or other watercourse and the adjacent land areas necessary in order to discharge the one hundred-year flood without cumulatively increasing the water surface elevation.

FLOODWAY FRINGE are areas that fall within the 1-percent-annual-chance floodplain, but are outside the floodway.

FREEBOARD is the extra vertical distance between the calculated maximum level of the design water surface in a conduit, culvert, reservoir, detention/retention basin, channel or canal and the top of the confining structure, which is provided as a safety factor for overtopping. The term is also used when referring to the vertical distance from the calculated, design water level in a detention/retention basin or channel, to the base of any man-made structure, such as the finished floor of a building.

FROUDE NUMBER is a dimensionless ratio used in hydraulic analyses which defines the relationship between inertial forces and gravitational forces of open-channel flow. A Froude Number greater than unity (i.e., 1) indicates supercritical flow conditions in which flow depths are controlled by upstream hydraulic conditions. Similarly, when the Froude Number is less than unity, the flow conditions are said to be subcritical, and are controlled by downstream hydraulic conditions.

GRATE INLET is a stormdrain inlet, normally consisting of a steel grate set flush with the pavement or gutter, in combination with a catchbasin which captures stormwater and delivers it to a stormdrain system.

GUTTER is the low area adjacent to the curb of a crowned street, and is used for conveying stormwater runoff.

HEADCUTS are vertical drops in the profile of earthen channels. Headcuts normally move in an upstream direction as a result of erosion.

HYDRAULIC GRADE LINE (HGL) is a line which represents the static head plus pressure head of flowing water.

HYDRAULIC JUMP is an abrupt rise in the water surface which occurs in an open channel when water flowing at a supercritical regime changes to a subcritical regime.

INVERT is the floor, bottom, or lowest portion of the internal cross section of a conduit or channel.

KEY-INS are the extensions of bank protection either (1) below the surface of the ground at the top of the bank; or, (2) at the upstream and downstream limits of the bank-protected reach.

LETTER OF MAP AMENDMENT (LOMA) is a document from FEMA that excludes an individual structure and/or a parcel of land that was inadvertently included in a Special Flood Hazard Area (SFHA) shown on an effective Flood Hazard Boundary Map (FHBM) or Flood Insurance Rate Map (FIRM).

LETTER OF MAP REVISION (LOMR) is a document from FEMA that changes an effective FHBM or FIRM. When a map revision is warranted, FEMA will either revise and republish the affected map panels or issue a LOMR that describes the changes and officially revises the effective map.

LEVEE is an embankment of compacted soil, often covered with an impermeable veneer, which is built to redirect or impede the flow of floodwaters.

LOCAL DETENTION/RETENTION BASIN is a relatively small-scale stormwater storage facility which is typically owned, built and maintained by a land owner, in conjunction with land development, in order to satisfy Yavapai County stormwater detention requirements.

MANHOLE is an opening into a storm-drain system from the ground surface through which access is obtained for the purpose of routine and/or emergency inspections and maintenance.

OBSTRUCTION is any alteration in, along, across, or projecting into any channel, watercourse, stream, lake or floodplain which may impede or divert floodwaters, either by itself or by catching or collecting debris carried by floodwaters, or that is placed where flow of water might carry the same downstream to damage of life or property.

ONE-HUNDRED-YEAR (100-YEAR) FLOOD is a flood having a one-percent chance of being equaled or exceeded in any given year (see BASE FLOOD).

OVERBANK FLOODING is floodwater which overtops the natural or constructed banks of a watercourse.

PRESSURE FLOW is the flow of water within a closed conduit without a free surface that is open to atmospheric pressure.

REGIONAL DETENTION/RETENTION BASIN collects runoff from a relatively large watershed and has been designed to use storage as a means of reducing downstream flood peaks, reducing possible flood damage, or reducing downstream channel construction costs. Regional facilities are usually multi-purpose, and normally are owned and operated by a public agency.

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REGULATORY FLOOD ELEVATION means an elevation one-foot above the base flood elevation.

REGULATORY FLOODWAY means the channel of a river or other watercourse and the adjacent land area that must be reserved in order to discharge the base flood.

REGULATORY FLOODPLAIN is any portion of a floodplain, as well as any areas which are subject to sheet flooding, that would be inundated by the base flood.

RETENTION BASIN is a facility which stores stormwater runoff, but is not provided with a significant positive outlet. Retention basins may be drained by infiltration, pumping or by a "bleeder" outlet into the downstream watercourse.

RILL EROSION is a pattern of narrow, near vertical troughs formed in relatively steep earthen embankments by stormwater cascading down the embankment.

SETBACK is the minimum horizontal distance between a structure and a watercourse. A setback is measured from the top edge of the highest channel bank or from the 100-year watersurface elevation whichever is closer to the channel centerline.

SHEET FLOW is shallow, diffuse stormwater runoff. It is characterized by approximately equal depths of runoff across a broad width of flow.

SOFFIT is the highest point within the cross section of a closed conduit.

STORM DRAIN is a combination of underground conduits and surface inlet structures constructed for the purpose of removing runoff from the ground surface, usually from streets and pavement, and conveying it to some downstream discharge point.

SUBCRITICAL FLOW is tranquil flow (i.e. the Froude Number is less than unity) in which gravitational forces are dominant over inertial forces. Subcritical flow is controlled by downstream conditions.

SUPERCRITICAL FLOW is rapid flow (i.e. the Froude Number is greater than unity) in which inertial forces are dominant over gravitational forces. Supercritical flow is controlled by upstream conditions.

TAILWATER is the flow condition existing at the downstream end of a hydraulic structure, or hydraulic condition, under investigation.

TOE-DOWN is the vertical extension of bank protection below the channel bed to prevent scour from undermining the protection on the channel banks.

TRANSITIONS are longitudinal sections of a channel within which the flow width is expanded or contracted.

WATERCOURSE means a lake, river, creek, stream, wash, arroyo, channel or other topographic feature on or over which waters flow at least periodically. Watercourses include specifically designated areas in which substantial flood damage may occur.

WEIR is an open-channel control section, with a horizontal crest above which fluid pressure may be considered hydrostatic.

CHAPTER 1. INTRODUCTION

1.1 Objectives

This Yavapai County Drainage Criteria Manual (Yavapai Manual) addresses engineering issues associated with drainage policies and criteria, drainage design practices and floodplain management within Yavapai County. It is the overall and primary objective of Yavapai County to provide drainage design criteria which serve to protect the health, safety, and general welfare of the citizens of the community, with regards to flooding and drainage issues.

This document provides general engineering guidelines and is not intended to be a substitute for sound engineering judgment when dealing with specific design problems. Specific engineering procedures and methodologies are not always dictated within this manual, but instead are often cited by reference to other widely accepted design manuals published by the U.S. Army Corps of Engineers, Arizona Department of Transportation, Federal Highway Administration and other regulatory agencies within Arizona. This approach is intended to provide the engineer with the flexibility to apply engineering methods most appropriate to an individual project. Other objectives of this manual include (1) minimizing the review time for drainage reports, (2) providing the design engineer with the County's drainage requirements prior to initiating a project; and, (3) providing for drainage infrastructure that is functional, durable and aesthetic.

1.2 Applicability

This manual is to be used by civil engineers in preparing drainage reports for stormwater planning, analysis and design within Yavapai County, Arizona. Many procedures that are presented or referenced within this manual have a limited range of applicability. An attempt has been made in this manual to specify these ranges whenever possible. However, it is the responsibility of the practicing engineer to utilize sound engineering judgment and experience when applying any engineering methodology to a particular project.

1.3 Floodplain Regulations and Drainage Policies

Yavapai County Flood Control District is mandated by the State, through Sections 48-3601 and 48-3627 of the Arizona Revised Statutes to adopt and enforce regulations designed to protect health, safety, and general welfare of the citizens within the jurisdiction area of Yavapai County and to minimize public and private losses due to flood conditions in specific areas.

The District is also mandated by the Federal Emergency Management Agency (FEMA) to regulate areas of special flood hazards. FEMA supplies the District with Floodway Maps and Flood Insurance Rate Maps which provide flood risk information and other technical data to be used in administering both floodplain management and insurance aspects of the National Flood Insurance Program (NFIP).

Requirements from both agencies have led to the adoption of the original Yavapai County Flood Control District Ordinance on December 14, 1981, and subsequent revision(s). The Ordinance requires that the Yavapai County Flood Control District regulate all activities within and along all watercourses within its jurisdiction.

Specific regulations have been adopted by the Yavapai County Flood Control District (District) for the purpose of enforcing the more general floodplain regulations contained within the Yavapai County Flood Control District Flood Damage Prevention Ordinance. Drainage Policies are enumerated within the "Policies" sub-heading of each major chapter contained in this manual. Since floodplain regulations and drainage policies are periodically modified or amended, the user of this manual should contact the Yavapai County Flood Control District prior to starting on a new project to obtain any new regulations, as well as design criteria and ordinance updates.

1.4 Compatibility with Arizona State Standards for Floodplain Management

The Arizona Department of Water Resources has developed a series of standards relating to hydrology, floodplain management, and drainage design criteria. These standards are intended for use statewide, especially in areas where more specific drainage standards and criteria have not been established by local agencies. These standards can be accessed at the following web site: http://www.water.az.gov/adwr/Content/Publications/default.htm This section provides a brief description of each of these state standards and how each relates to the Yavapai County Flood Control District drainage criteria presented within this document.

Requirement for Flood Study Technical Documentation (State Standard 1-97)

Description:

This document establishes documentation standards for flood studies submitted to Arizona Department of Water Resources (ADWR) or to FEMA). Flood studies for the purpose of delineating floodplains or revising floodplains in Arizona must meet the technical documentation standards outlined in this publication. This publication requires the study preparer to incorporate all essential technical data into one comprehensive data package that is known as the Technical Data Notebook (TDN).

Compatibility with YCFCD criteria:

All map amendments and revisions proposed within Yavapai County are required to be reviewed and approved by the Arizona Department of Water Resources (ADWR). The engineer engaged in the process of performing map revisions within Yavapai County should contact ADWR to obtain current standards and criteria for performing such flood studies. In addition, the user should review FEMA's "Guidelines and Specifications for Flood Hazard Mapping Partners" at http://www.FEMA.gov/fhm/dl_cgs.shtm, which is a document that is being updated continuously.

Requirement for Floodplain and Floodway Delineation in Riverine Environments (State Standard 2-96)

Description:

State Standard 2-96 uses a three-level approach to estimating 100-year peak discharges and for delineation of floodplain and floodway limits. The lower the procedure level the simpler the evaluation, and the more conservative the resulting design parameters. Following is a brief description of each of the three levels of analysis.

Level 1

This level is the simplest approach, requiring only the drainage area to determine peak discharge, floodplain width, and floodway width. 100-year peak discharge is estimated from a USGS data envelope curve. The floodplain depth and floodway width are estimated from regression equations developed from FEMA flood insurance studies in Arizona.

Level 2

This approach uses USGS regression equations to estimate 100-year peak discharges. The 100-year floodplain limits are established using normal depth assumptions.

Level 3

This approach involves a detailed hydrologic analysis using an approved local methodology or computer models such as HEC-1, TR-20, TR-55, etc. The floodplain and floodway analysis requires a water surface profile model, such as HEC-RAS or HEC-2, in conjunction with topographic data for the watercourse.

Compatibility with YCFCD criteria:

The Yavapai Manual provides specific criteria for conducting detailed hydrologic and hydraulic analysis of watercourses, which is consistent with the Level 3 approach presented within State Standard 2-96. In most cases the Level 1 and Level 2 approaches are generally not acceptable methods of determining floodplain/floodway limits within Yavapai County.

State Standard for Supercritical Flow (State Standard 3-94)

Description:

This document describes the concept of supercritical and near-critical open channel flow regimes and provides guidelines for associated hydraulic modeling. The guidelines are intended to be used on all detailed flood insurance studies and floodplain management applications on streams with supercritical flow in Arizona.

Compatibility with YCFCD criteria:

The Yavapai Manual does not specifically address modeling guidelines for supercritical or near-critical flow regimes. The user of this manual is encouraged to consult with this State Standard when performing hydraulic modeling on steep watercourses having supercritical or near-critical flow regimes.

State Standard for Identification of and Development Within Sheet Flow Area (State Standard 4-95)

Description:

This document is a combination of a tutorial, development standards within sheetflow areas, and a description of a three-level approach to sheet flow analysis. The tutorial portion provides a discussion of various classifications of sheet flow, including natural sheet flow, urban sheet flow, distributary flow, anastomosing flow, etc. The document discusses the characteristics of these various runoff patterns and provides photographs and sketches illustrating each type. A listing of the numerous hazards associated with sheet flow is also provided.

The development standards portion of the document provides recommendations related to the elevation of structures within sheetflow areas. In addition, recommended standards are listed which address such issues as walls and fences, site grading, alignment of structure with flow direction, and erosion protection.

The methodology portion of the document presents a three-level approach to analyzing sheet flow. Following is a brief description of each of the three levels of analysis.

Level 1

This level of analysis provides a recommended minimum finished floor elevation (FFE) based solely on the contributing drainage area at the building site. This approach is very simple, but yields conservative values for minimum FFE.

Level 2

A Level 2 analysis consists of determining the depth of flooding using normal depth assumptions and the Manning's Equation. This level of analysis requires the computation of a 100-year peak discharge and also requires topographic data at the building site.

Level 3

A Level 3 analysis consists of performing a detailed hydraulic analysis using either a two- or three-dimensional hydraulic model. This analysis is the most accurate representation of sheet flooding conditions, but also requires a much greater level of effort and cost.

Compatibility with YCFCD criteria:

The Yavapai Manual does not specifically address the subject of sheetflow. The user of this manual is encouraged to consult with this State Standard when performing hydrologic and hydraulic analysis within sheet flow areas.

State Standard for Watercourse System Sediment Balance (State Standard 5-96)

Description:

State Standard 5-96 addresses the following three issues: 1) Lateral migration setback allowances for riverine floodplains, 2) Channel degradation estimates for alluvial channels, and 3) Evaluation of river stability impacts associated with sand and gravel mining.

The lateral migration setback allowance standard is presented as a three-level approach. The Level 1 approach consists of two equations which define the setback as a function of 100-year peak discharge and channel curvature. These equations were originally developed for the City of Tucson Drainage Standards Manual. Additionally, the Level 1 approach is stated to be applicable to watershed areas of less than 30 square miles. The Level 2 approach involves using one or more of the following methodologies: 1) Allowable Velocity Analysis, 2) Tractive Stress Analysis, 3) Tractive Power Analysis, and 4) Bank Lining Adequacy Analysis. These methods consider erodibility based on velocity, tractive stress, long-term stability, and bank lining conditions, respectively. The Level 3 analysis involves modeling the hydraulic and sediment transport characteristics of the local watercourse in order to simulate the erosion/sedimentation and channel deformation processes which are expected to occur in the area of concern. References to other publications are made for the details associated with performing such an analysis, including ***Design Manual for Engineering Analysis of Fluvial Systems*** (ADWR, 1985) and ***Standards Manual for Drainage Design and Floodplain Management in Tucson, Arizona*** (City of Tucson, 1989).

The channel degradation estimates for alluvial channels is presented as a Level 1, Level 2 and Level 3 approach. The Level 1 approach consists of simple equations which estimate total scour and long term degradation as a function of 100-year peak discharge. This method is only recommended for channel reaches that are expected to be in general balance with the surrounding system (i.e., no nearby dams, bridges, encroachments, etc.). The Level 2 approach provides additional analysis techniques to justify a lesser scour value than determined under the Level 1 approach by considering natural resistance of the channel to degradation. These include erodibility evaluations, armor potential evaluation, channel profile history comparison and grade stabilization analysis. Again, reference is made to the two publications mentioned above for detailed descriptions of these analysis techniques. The Level 3 approach includes computer simulation of the erosion/sedimentation and channel deformation processes based on an understanding of historical trends, field evaluations, and Level 3 hydrologic modeling.

The evaluation of river stability impacts associated with gravel mining is presented as a Level 1, Level 2 and Level 3 approach. The Level 1 approach consists of applying criteria to establish a setback from the top of the pit to the channel bank. Level 2 consists of justifying a lesser setback by applying setback criteria of the Level 2 approach to lateral migration. Level 3 consists of mathematical modeling of the river channel to better determine the adequacy of the setback or to quantify the impacts associated with in-stream operation.

Compatibility with YCFCD criteria:

The procedures for setback and channel scour contained within the Yavapai Manual are in generally compatible with State Standard 5-96. Yavapai Manual does not specifically address issues related to sand and gravel mining. The user of this manual is encouraged to consult with this State Standard when sand and gravel mining within the riverine environment.

State Standard for Development of Individual Residential Lots Within Floodprone Areas (State Standard 6-05)

Description:

This standard presents a comprehensive site plan check list, sample site plan, and a typical cross-section of an elevated residential structure. The document is intended to standardize submittals of site plans for individual residential lots within floodprone areas.

Compatibility with YCFCD criteria:

The Yavapai Manual includes a building permit checklist for both residential lots and commercial sites that were based in part on the check list provided within the State Standard. The Yavapai County checklists, included within Appendix 2 of the Yavapai Manual, should be used for residential lot and commercial site development, as appropriate.

State Standard for Watercourse Bank Stabilization (State Standard 7-98)

Description:

State Standard 7-98 uses a three-level approach to watercourse bank stabilization. The lower the procedure level the simpler the evaluation, and the more conservative the resulting design parameters and the higher the construction cost. The Level 1 and Level 2 procedures are intended to be used where the bank protection project will be confined to a single property or group of properties under one ownership. Additionally, the Level 1 and Level 2 procedures only apply to rock riprap and wire-tied rock mattress designs. The Level 3 approach is intended for all but the simplest bank stabilization projects. This level of evaluation involves modeling of both the hydraulic and sediment transport characteristics of the watercourse. The Level 3 approach is applicable to all forms of bank stabilization, including rock riprap, gabions, wire-tied rock, concrete, grouted rock, vegetative linings, etc.

Compatibility with YCFCD criteria:

The Yavapai County bank stabilization standards are generally compatible with the State Standard 7-98 Level 3 approach. The Level 1 and Level 2 approaches may be acceptable under the conditions specified within the State Standard.

State Standard for Stormwater Detention/Retention (State Standard 8-99)

Description:

State Standard 8-99 uses a three-level approach to stormwater detention/retention. The lower the procedure level the simpler the evaluation, and the more conservative the resulting design parameters. Following is a brief description of each of the three levels of analysis:

Level 1

This level is the most conservative approach and consists of complete retention of the 1-hour, 100-year runoff volume from the project site. This approach results in zero runoff from the site for all flow events up to the 100-year event. The level of effort for this analysis is relatively small and the resulting retention volume is relatively large. The state standard lists this approach as acceptable for all levels of development.

Level 2

The Level 2 procedure is based on storage of a portion of the 1-hour, 100-year runoff volume from the project site. The procedure also includes an adjustment to the design basin outflow rate to account for the cumulative downstream effect of urbanization. An outflow structure is also established for 100-year peak outflow from the basin. The resulting basin is intended to provide a conservative measure of stormwater detention for most applications. However, this method does not explicitly address peak reduction of lesser flow events (e.g. 2-year and 10-year events). The state standard lists this approach as acceptable for single commercial lots, recommended for small subdivisions (< 160 acres), and not recommended for large subdivisions (> 160 acres).

Level 3

The Level 3 approach is identical to the approach provided within the Yavapai Manual. In fact, the state standard references the Yavapai Manual as a recommended publication for use in conducting a Level 3 analysis. The Level 3 analysis consists of performing a detailed analysis of existing and developed hydrology and designing a basin that insures that post-development peak discharges from the site do not exceed pre-development peak discharges for the 2, 10 and 100-year events. The state standard lists this approach as acceptable for single commercial lots and recommended for small subdivisions (< 160 acres) and large subdivisions (> 160 acres).

Compatibility with YCFCD criteria:

The Yavapai County stormwater detention requirements are compatible with the State Standard 8-99 Level 3 approach. The State Standard Level 1 and Level 2 approaches generally do not satisfy Yavapai County stormwater detention requirements.

State Standard for Floodplain Hydraulic Modeling (State Standard 9-02)

Description:

This document is more of a tutorial on hydraulic modeling, rather than a standard. The document provides a description of numerous hydraulic models. The capabilities and limitations of the various types of hydraulic models are discussed. Hydraulic modeling guidelines, techniques, and good modeling practices are presented. A section is also included which describes how floodways are to be determined for submittal to FEMA.

Compatibility with YCFCD criteria:

This document presents considerably more detail on hydraulic modeling theory and practice than the Yavapai Manual and is a good source of additional information related to hydraulic modeling techniques and practices.

CHAPTER 2. DRAINAGE REPORT FORMAT AND SUBMITTAL REQUIREMENTS

2.1 Policies

The County has established a drainage report format that follows the submittal requirements outlined in the Yavapai County Subdivision Regulations, effective July 1, 2004. The format is titled, "Drainage Planning Submittal Requirements", and outlines the requirements necessary for preparing a Phase I, Phase II, and Phase III Drainage Report. These requirements must be adhered to for all submittals related to the subdivisions of land, as outlined in the Yavapai County Subdivision Regulations. The subdivision regulations should always be consulted when preparing a drainage report.

Subdivision drainage studies shall analyze all drainage basins with a tributary area of 10 acres or more, at the point that they enter the subdivision. Internal basins shall be analyzed when the drainage basin exceeds 10 acres in size, as well as smaller basins where drainage improvements are proposed.

NOTE: It may also be necessary to determine areas where floodplain delineations may be appropriate and to justify the method used to calculate and identify the hazard areas (detailed study, approximate study, drainage path). Floodplain or drainage path delineations shall conform to the following normal size limitations:

DETAILED STUDY:	Drainage basin greater than 160 acres in size.
APPROXIMATE STUDY:	Drainage basin between 40 and 160 acres.
DRAINAGE PATH:	Drainage basin between 10 and 40 acres.

The size limitation for the various types of delineations may be adjusted up or down depending on the conditions of the specific subdivision with the approval of the District. If channelization of a natural floodplain is proposed, both a pre-development and post-development floodplain delineation may be necessary to illustrate the effects of the proposed improvements.

When preparing a drainage report for purposes other than the subdivision of land, the Phase I, II and III submittal process may not be necessary. Typically, the information required in the Phase II and Phase III Drainage Reports can be combined into one report.

NOTE: The County recommends discussing all proposed drainage submittals with District staff prior to being prepared and submitted.

2.2 Review Process

All subdivisions, resubdivisions, rezonings, and use permits, as well as commercial and industrial developments and all other developments, that are within the jurisdiction of the County may be required to submit drainage reports, construction drawings/specifications, and as-built information in accordance with the requirements of this section. Five copies of the drainage reports shall be submitted to the County Planning Department or as otherwise specified by the County. Upon receipt of the drainage reports, the County will distribute the reports to the appropriate referral agencies for review and comment. Additional copies shall be submitted as requested by the County. All submitted reports should be cleanly reproduced. Photostatic copies of charts, tables, nomographs, calculations, or other referenced materials should be legible. Washed-out, blurred, or unreadable portions of the report are unacceptable and could warrant resubmittal of the report.

A pre-application consultation is suggested of all applicants for the processing steps of the subdivision regulations. The applicant shall consult with the Yavapai County Flood Control District for the general information regarding drainage criteria, required procedures, possible drainage problems, and specific submittal requirements.

The following sections outline the requirements necessary for preparation of Phase I, Phase II, and Phase III Drainage Reports. Drainage reports are to be prepared and sealed by a registered Arizona professional engineer. Figure 2.2 provides a general outline indicating the Phase Drainage Report necessary to satisfy the submittal requirements for a specific planning stage (i.e. rezoning, platting, site plan, etc).

2.3 Phase I Drainage Report

The applicant is referred to Figure 2.2 for general submittal requirements for a Phase I Drainage Report. The Phase I Report will review, at a conceptual level, the feasibility and design characteristics of the proposed subdivision. The Phase I Drainage Report shall be typed on 8½″ x 11″ paper and properly bound. The report shall be in accordance with the following outline and contain the applicable information listed.

2.3.1 Report Contents

I. GENERAL LOCATION AND DESCRIPTION

A. Location

1. Owner/Developer Name
2. Assessors Parcel Number(s)
3. City, County, State Highway and local streets within ¼ mile of the subdivision, or the area to be served by the drainage improvements.
4. Township, range, section, ¼ section.
5. Major drainageways and facilities.
6. Names of surrounding developments.
7. General project description

B. Description of Property

1. Area in acres.
2. Ground cover (type of ground cover and vegetation)
3. Major drainageways, floodplains
4. Existing irrigation facilities, such as ditches and canals
5. Existing and proposed land use.

II. DRAINAGE BASINS AND SUB-BASINS

A. Major Basin Description

1. Reference to all drainageway planning studies such as flood hazard delineation reports, drainageway planning reports, and flood insurance rate maps (FIRMs)
2. Basin drainage characteristics, existing and planned land uses within the basin, as defined by the Planning Department.
3. Identification of all nearby irrigation facilities within ½ mile of the property boundary, which will influence or be influenced by the local drainage.

4. Soils Classification Map.
5. Identification of all detention facilities.

B. Sub-Basin Description

1. Discussion of historic drainage patterns of the property in question.
2. Discussion of off-site drainage patterns and impact on development under existing and fully developed basin conditions, as defined by the Planning Department.
3. Discussion of proposed methods for managing stormwater quality during the construction phase.

III. DRAINAGE FACILITY DESIGN

A. General Concept

1. Discussion of existing drainage patterns.
2. Discussion of off-site runoff considerations.
3. Discussion of anticipated and proposed drainage patterns and improvements.
4. Discussions of the content of tables, charts, figures, maps or drawings presented in the report.
5. Discussion of hydrologic, hydraulic and other analysis methodologies used in the report.

B. Specific Details

1. Discussion of drainage problems encountered and solutions at specific design points.
2. Discussion of detention storage and outlet design.

IV. REFERENCES

Reference all criteria, master plans, and technical information used in support of drainage concept.

2.3.2 Drawing Contents

All drawings shall be 24″ x 36″ in size.

(a) General Location Map: A map shall be provided in sufficient detail to identify drainage patterns entering and leaving the development and general drainage patterns. The map should be at a scale of 1″ = 1000′ or 1″ = 2000′ and show the path of all drainage from the upper end of any off-site basins to the defined major drainageways. The map shall identify any major facilities from the property (i.e. development, irrigation ditches, existing detention facilities, culverts, storm sewers, etc.) along the flow path, to the nearest drainageway. Basins and divides are to be identified and topographic contours are to be included.

(b) Floodplain Information: The location of the parcel shall be plotted on the appropriate FEMA FIRM or Floodway Map, if available, and a copy provided in the report.

(c) Drainage Plan: Map(s) of the proposed development at a scale of 1″ = 20′ to 1″ = 200′ on a 24″ x 36″ drawing shall be included. The plan shall show the following:

1. Existing topographic contours at 5-foot maximum intervals. In terrain where the slope exceeds 15%, the maximum interval is 20 feet. The contours shall extend a minimum of 100 feet beyond the property lines. Depending on the proposed use and site conditions, USGS Topographic Quadrangle maps may be acceptable upon approval of the District.

2. All existing drainage facilities, both onsite and offsite, that significantly impact the site.

3. Approximate flooding limits, based on available information.

4. Conceptual major drainage facilities, including detention basins, storm drains, swales, riprap, and outlet structures in the detail consistent with the proposed development plan.

5. Major drainage boundaries and sub-boundaries, both off-site and on-site.

6. Any off-site features influencing development.

7. Proposed flow directions and, if available, proposed contours.

8. Legend to define map symbols (See Figure 2.1 for symbol criteria).

9. Title block in lower right corner.

2.4 Phase II Drainage Report

The purpose of the Phase II Drainage Report is to identify and define solutions to the problems which may occur on-site and off-site, as a result of the development. In addition, those problems that exist on site prior to development must be addressed during the preliminary phase. The Phase II Drainage Report shall be submitted during the subdivision process, with the application for a Preliminary Plan, or as outlined in Figure 2.2. All reports shall be typed on 8½″ x 11″ paper and properly bound in report format. The drawings, computer disks, figures, plates and tables shall be bound with the report. The report shall include a cover letter presenting the preliminary design for review and shall be prepared by or supervised by an Arizona Registered Civil Engineer. The report shall contain a signed certification sheet as follows:

"This report and drainage plan for the Phase II drainage design of (Name of Development) was prepared by me (or under my direct supervision) in accordance with the provisions of the "Drainage Planning Submittal Requirements" of Yavapai County and other regulations of the Yavapai County Flood Control District. I understand that Yavapai County does not, and will not, assume liability for the drainage facilities designed by others."

SIGNATURE:
Registered Professional Engineer

State of __________________ No.
(Affix Seal)

2.4.1 Report Contents

The Phase II Drainage Report shall be in accordance with the following outline and contain the applicable information listed:

I. GENERAL LOCATION AND DESCRIPTION

A. Location

1. Owner/Developer Name
2. Assessors Parcel Number(s)
3. Township, range, section, ¼ section.
4. Local streets within and adjacent to the subdivision with ROW width shown.
5. Major drainageways, facilities and easements.

6. Names of surrounding development, land uses, and identification of present zoning.

C. Description of Property

1. Area in acres.
2. Ground cover (type of trees, shrubs, vegetation, general soil conditions, topography, and slope).
3. All drainageways and floodplains.
4. Project description.
5. Irrigation facilities.
6. Proposed land use.

II. DRAINAGE BASINS AND SUB-BASINS

A. Major Basin Description

1. References to all drainageway planning studies, such as flood hazard delineation reports, drainageway planning reports, and flood insurance rate maps.
2. Major basin drainage characteristics, existing and planned land uses.
3. Identification of all irrigation facilities within the basin, which will influence or be influenced by the local drainage.
4. Soils Classification Map.
5. Identification of all detention facilities.

B. Sub-Basin Description

1. Discussion of historic drainage patterns of the property in question.
2. Discussion of off-site drainage flow patterns and the impact on development under existing and fully developed basin conditions, as defined by the Planning Department.

III. DRAINAGE DESIGN CRITERIA

A. Regulations: Discussion of the optional provisions selected or the deviation from this manual, if any, and its justification

B. Development Criteria and Constraints

1. Discussion of previous drainage studies (i.e. project master plans) for the site in question that influence or are influenced by the drainage design and how the plan will affect drainage design for the site.
2. Discussion of existing drainage studies prepared for adjacent projects.
3. Discussion of the drainage impact of site constraints, such as streets, utilities, light rail rapid transit, existing structures and developments.

C. Hydrologic Criteria and Results

1. Identify design rainfall.
2. Identify runoff calculation method.
3. Identify detention discharge/volumes and storage calculation method.
4. Identify design storm recurrence intervals.
5. Discussion and justification of other criteria or calculation methods used that are not presented in or referenced by this manual.
6. Summary table of pre and post-development watershed areas and peak discharges for the 2, 10, 25 and 100-year return periods (Refer to Figure 2.1).

D. Hydraulic Criteria

1. Identify references/methodologies used in performing hydraulic analysis.
2. Discussion of other drainage facility design criteria used that are not presented within this manual.

E. Variances from this manual

1. Identify provisions by section number for which a variance is requested.
2. Provide justification for each variance requested.

IV. DRAINAGE FACILITY DESIGN

A. General Concept

1. Discussion of existing drainage patterns.
2. Discussion of off-site runoff considerations and compliance with applicable criteria.
3. Discussion of the content of tables, charts, figures, plates or drawings presented in the report.
4. Discussion of anticipated and proposed drainage patterns and/or improvements.

5. Discussion of the stormwater runoff quality aspects of the drainage design including those activities necessary to control erosion and sedimentation during construction.

B. Specific Details

1. Discussion of drainage problems encountered and solutions at specific design points.
2. Discussion of detention storage and outlet design.
3. Discussion of maintenance access and aspects of the design.
4. Discussion of easements and tracts for drainage purposes.

V. CONCLUSIONS

A. Compliance with Standards

1. Discussion of compliance with Yavapai County drainage criteria.

B. Drainage Plan

1. Discussion of influence of proposed development on existing drainage conditions.
2. Discussion of effectiveness of the drainage design to control damage from storm runoff.

VI. REFERENCES

Reference all criteria and technical information used.

VII. APPENDICES

A. Hydrologic Computations

1. Land-use assumptions regarding adjacent properties.
2. Initial and major storm runoff at specific design points.
3. Historic and fully developed (pre/post) runoff computations at specific design points.
4. Hydrographs at critical design points.
5. Time of concentration and runoff coefficients.

B. Hydraulic Computations

1. Culvert capacities.

2. Storm drain capacities.
3. Gutter capacities.
4. Storm inlet capacity, including inlet control rating at connection to storm drain.
5. Open channel design.
6. Roadside ditch capacities.
7. Check dam and/or channel drop design.
8. Detention area/volume capacity and outlet design, details, and all supporting calculations. Depths of detention basins.
9. Downstream/outfall system capacity to the major drainageway system.

2.4.2 Drawing Contents

All drawings shall be 24″ x 36″ in size.

(a) General Location Map: A map shall be provided in sufficient detail to identify drainage flows entering and leaving the development and general drainage patterns. The map should be at a scale of 1″ = 1000′ to 1″ = 2000′ and show the path of all drainage from the upper end of any off-site basin to the defined major drainageways. The map shall identify any major construction (e.g. development, irrigation ditches, existing detention facilities, storm drains) along the entire path of drainage. Basins and divides are to be identified and topographic contours are to be included. USGS Quadrangle maps (7.5-minute) are acceptable.

(b) Floodplain Information: The location of the parcel shall be plotted on the appropriate FEMA FIRM and Floodway Map, if available, and a copy provided in the report.

(c) Drainage Plan: Map(s) of the proposed development at a scale of 1″ = 20′ to 1″ = 200′ on a 24″ x 36″ drawing(s) shall be included. The plan(s) shall show the following:

1. Existing (dashed lines) and, **if available, proposed (solid line) contours at 2-foot maximum intervals. In terrain where the slope exceeds 15%, the maximum interval is 10-feet. The contours shall extend a minimum of 100 feet beyond the property lines. Topography shall relate to the USGS survey datum or other local floodplain survey datum if applicable, include bench mark used. ***NOTE: USGS quadrangle maps are not acceptable, this includes enlargements***.

2. Property lines and easements (note the type of easement).

3. ** Streets, if available, indicating ROW width, flow-line width, sidewalk, etc.

4. Existing and proposed drainage facilities and structures, including irrigation ditches, roadside ditches, drainageways, gutter flow directions and culverts. All pertinent information, such as material, size, shape, slope and location shall also be included.

5. Overall drainage area boundary and drainage sub-area boundaries, both off-site and on-site.

6. ** Proposed type of street flow (i.e. vertical curb or combination curb and gutter), roadside ditch, gutter slope and flow direction, and valley gutters, if available.

7. ** Proposed storm drains and open drainageways, if available, including inlets, outlets, manholes, culverts, other appurtenances, and channel protection.

8. Proposed outfall point for runoff from the developed area and drainage facilities to convey flows to the final outfall point without damage to downstream properties.

9. Routing and accumulation of flows at various critical points for the initial storm runoff listed on the drawing using the format shown in Figure 2.1.

10. Routing and accumulation of flows at various critical points for the major storm runoff listed on the drawing using the format shown in Figure 2.1.

11. Volumes, release rates and locations for detention storage facilities and information on outlet works. This shall include design drawings, consisting of plan views, cross-sections and details of the basin, as well as the outlet/inlet works.

12. Identify all flood hazard areas (pre and post development, if applicable); detailed delineations (drainage basins greater than 160 acres), approximate delineations (drainage basins between 40 and 160 acres), and drainage paths (drainage basins between 10 and 40 acres).

13. Location and elevation of all floodplains affecting the property (detailed delineations).

14. ** Location and (if known) elevations of all existing and proposed utilities affected by or affecting the drainage design.

15. Identification of drainage patterns through the development.

16. Definition of flow path leaving the development through the downstream properties ending at a major drainageway.

17. Legend to define map symbols (see Figure 2.1 for symbol criteria).

18. Title block in lower right hand corner.

19. ** Location of stormwater pollution prevention activities and identify methods of controlling erosion and sedimentation during grading and construction phase(s).

** NOTE: Items 1, 3, 5, 7, 14 and 19 listed above (Section 2.4.2(c) - "Drainage Plan") will be required for the Phase II Drainage Report if the information is available. Availability of information will be determined by Yavapai County based upon the level of detail contained in the application submitted to the Planning Department and the current planning stage at which the application is being processed (i.e., rezoning, preliminary plan, etc.). Regardless of present availability, the information indicated above will be required in the Phase III Drainage Report.

2.5 Phase III Drainage Report

Refer to Figure 2.2 for general submittal requirements for a Phase III Drainage Report. The purpose of the Phase III Drainage Report is to update the design, to provide all information as outlined in Section 2.4 not previously provided, and to finalize the design details for the drainage facilities illustrated in the Phase II Drainage Report. Also, any change to the preliminary concept must be presented.

NOTE:	**The report shall be a "stand-alone" document containing all previously requested items.**

All reports shall be typed on 8½″ x 11″ paper and properly bound in report format. The drawings, computer disks, figures, charts, plates and/or tables shall be bound with the report or included in a folder/pocket attached at the back of the report.

The report shall include a cover letter presenting the final design for review and shall be prepared by of under the direction of Arizona Registered Civil Engineer. The report shall contain a signed certification sheet as follows:

"This report and drainage plan for the Phase III drainage design of (Name of Development) was prepared by me (or under my direct supervision) in accordance with the provisions of the "Drainage Planning Submittal Requirements" of Yavapai County and other regulations of Yavapai County . I understand that Yavapai County does not, and will not, assume liability for the drainage facilities designed by others."

SIGNATURE:
Registered Professional Engineer

State of __________________ No.
(Affix Seal)

The report shall also contain a developer certification sheet as follows:

"(Name of Developer) hereby certifies that the drainage facilities for (Name of Development) shall be constructed according to the design presented in this report. I understand that Yavapai County does not, and will not, assume liability for the drainage facilities designed and/or certified by my engineer, and that Yavapai County reviews drainage plans pursuant to the Arizona Revised Statutes, Chapter 21, Article 1, §48-3601 to §48-3628; but cannot, on behalf of (Name of

Development), guarantee that final drainage design review will absolve (Name of Developer) and/or their successors and/or assigns of future liability for improper design. I further understand that approval of the Final Plat does not imply approval of my engineer's drainage design."

2.5.1 Report Contents

The Phase III Drainage Report shall be prepared in accordance with the outline shown in Section 2.4.1 of this manual. The report shall follow the requirements presented in Section 2.4.2 of this manual.

2.6 Construction Plans

Where drainage improvements are to be constructed, the preliminary construction plans shall be submitted on 24″ x 36″ drawings, along with the Phase III Drainage Report. Final construction plans must be submitted prior to issuance of a Development Permit for the public and private improvements covered by the plans. Acceptance of the final construction plans by the Yavapai County Flood Control District is a condition of issuing the Development Permit. The plans and specifications for the drainage improvements will include, but is not limited to:

1. Storm drain inlets, outlets and manholes with pertinent elevations, dimensions, type, and horizontal control indicated.
2. Culverts, end-sections, and inlet/outlet protection, with dimensions, type, elevations, and horizontal control indicated.
3. Channels, ditches, and swales (including side/rear yard swales) with lengths, widths, cross-sections, and erosion control (i.e. riprap, concrete, grout) indicated.
4. Check dams, channel drops, erosion-control facilities.
5. Detention pond grading, trickle channels, outlets, inlets, safety barriers, cross-sections and landscaping.
6. Other drainage related structures and facilities (including underdrains and sump pump lines).
7. Maintenance access considerations.
8. Grading plans, and erosion and sedimentation control plans.
9. Riprap gradation chart
10. Cross-section and detail sheets for all drainage facilities included in the development

The information required for the plans shall be in accordance with sound engineering principles, the drainage criteria included in this manual, and the County requirements for subdivision design. Construction documents shall include geometric, dimensional, structural, foundation, bedding, hydraulic, landscaping, and other details as needed to construct the stormwater drainage facility. The accepted Phase III Drainage Plan shall be included as part of the construction documents for all facilities affected by the drainage plan. Construction plans shall be sealed by an Arizona Registered Civil Engineer as being in accordance with the County accepted drainage report/drawings.

2.7 Record Drawings

Record drawings for all improvements are to be submitted to and accepted by the County, prior to final acceptance of the improvements. Certification of the record drawings is required as follows:

1. Registered Land Surveyor: A registered land surveyor in the State of Arizona shall certify the as-built detention pond volumes and the surface areas at the design depths, outlet structure sizes and elevations, storm drain sizes and invert elevations at inlets, manholes, and discharge location, and representative open channel cross-sections, and dimensions of all drainage structures.

2. Registered Professional Civil Engineer: The responsible design engineer shall state that "based on site visitations and to the best of my knowledge, belief, and opinion, the drainage facilities were constructed in accordance with the design intent of the accepted drainage report and construction drawings."

Yavapai County will compare the "certified record drawing" information with the construction drawings. A "certified record drawing" will be accepted only if:

1. The "record drawing" information demonstrates that the construction is in compliance with the design intent.

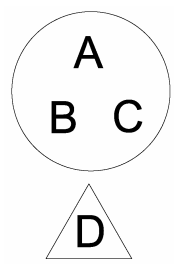
2. The "record drawings" are certified by both a registered land surveyor and the responsible design engineer.

A summary of the required certificates and approvals is presented as follows:

Item	Certification Required	Acceptance Required*
Phase I Drainage Report	None	Yes
Phase II Drainage Report	Engineer	Yes
Phase III Drainage Report	Engineer Developer	Yes
Construction Drawings	Engineer	Yes
Record Drawings	Engineer Land Surveyor	Yes Yes
Stormwater Pollution Prevention Plan	Engineer	Yes

* By Yavapai County Flood Control District

DRAWING SYMBOL CRITERIA AND HYDROLOGY REVIEW TABLE



A = BASIN DESIGNATION

B = AREA IN ACRES

C = COMPOSITE RUNOFF COEFFICIENTS

D = DESIGN POINT DESIGNATION

SUMMARY RUNOFF TABLE
(to be placed on drainage plan)

	PRE-DEVELOPMENT					POST-DEVELOPMENT				
DESIGN POINT	D.A.	PEAK FLOW (cfs)				D.A.	PEAK FLOW (cfs)			
		2-yr	10-yr	25-yr	100-yr		2-yr	10-yr	25-yr	100-yr
XX	XX.XX	XX.X	XX.X	XX.X	XX.X	XX.XX	XX.X	XX.X	XX.X	XX.X

FIGURE 2.1
DRAWING SYMBOL CRITERIA AND HYDROLOGY REVIEW TABLE

YAVAPAI COUNTY PLANNING PROCESS AS RELATED TO DRAINAGE SUBMITTAL REQUIREMENTS

REZONING AND PLATTING APPLICATIONS

Case I: Site being considered for rezoning will be platted in one filing

Planning Stage	**Required Drainage Submittal**
Sketch Plan and/or Master Plan	Phase I
Preliminary Plan	Phase II
Final Plan	Phase III

Case II: Site being considered for rezoning will be platted in more than one filing

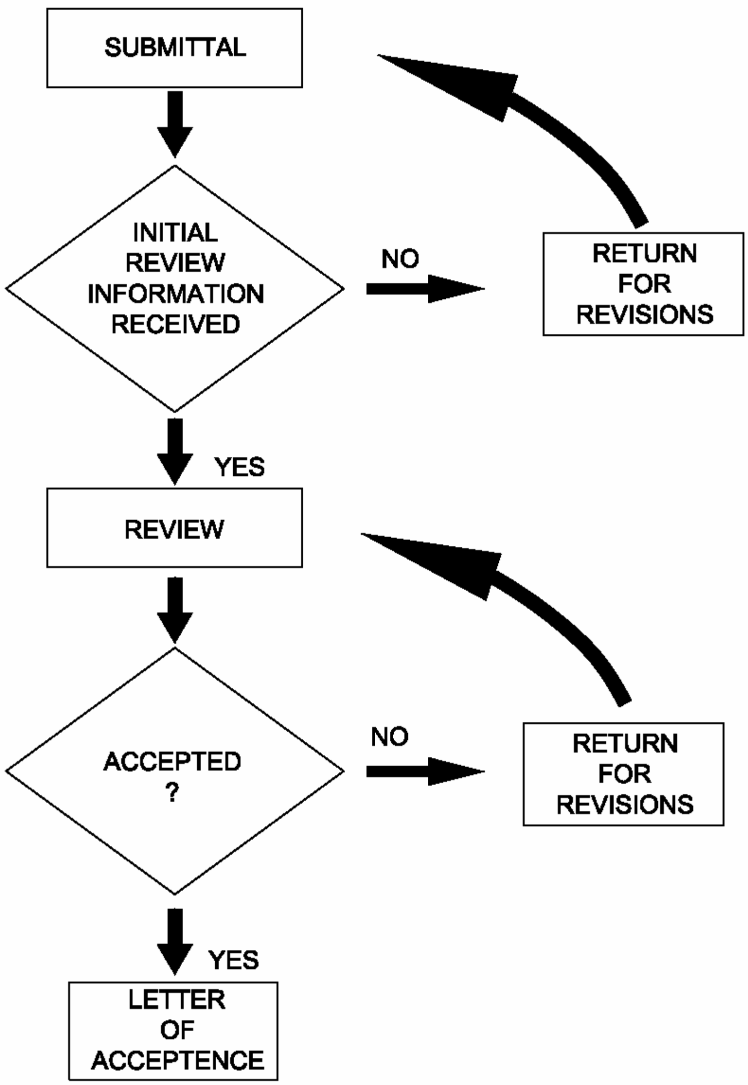
Planning Stage	**Required Drainage Submittal**
Sketch Plan and/or Master Plan.	Phase I to serve as total Site or Basin Master Plan in order to centralize drainage improvements (i.e., detention facilities, channels, storm drain, etc.) To the greatest extent possible.
Prior to approval of Preliminary Plans.	Phase II of total rezoned Site or Basin to further define and expand Master Study prepared at rezoning.
Preliminary Plan	Narrative evaluation compliance with the Phase II Report as related to the specific filing in question. Major modifications, discrepancies or over-sights identified in the Plan as compared to the Rezoning application may require the Phase II Drainage Report to be amended.
Final Plan	Phase III for specific filing

USE BY SPECIAL REVIEW AND SITE PLAN — A Phase III Drainage Report with final construction plans is required.

NOTE: The drainage submittal requirements as outlined in this Table are general guidelines and do not represent all circumstances under which specific drainage submittals may be required. Prior to submittal, the applicant shall consult with the Yavapai County Flood Control District for submittal requirements regarding applications or processes not addressed in this Table.

FIGURE 2.2
DRAINAGE SUBMITTAL REQUIREMENTS

SUBMITTAL/REVIEW PROCESS



NOTE: Review time increases if any “NO” is received and the submittal is returned for revisions

FIGURE 2.3
SUBMITTAL/REVIEW PROCESS

2.8 Drainage Easement Basic Language

The basic language to be used in granting drainage easements on Subdivision Plats is classified and stated as follows:

Class I Easements are hereby granted to the property owner(s) of this subdivision for drainage purposes as shown on this plat in the areas marked Drainage Easement Class I. The property owner(s) of the particular lot or parcel which includes a drainage easement is responsible for maintaining the drainage easements condition as it was when the subdivision was approved. Drainage easements conform to the natural or man-made watercourses and shall not be moved from the location existing at the time of the approval of the subdivision (unless approved by the Yavapai County Flood Control District).

These watercourses may require periodic maintenance to convey on-site or off-site discharges. Periodic maintenance may consist of the removal of earth and/or vegetative material that has built up since the original approval of the final plat for this subdivision.

Class II Easements are hereby granted to the Yavapai County Flood Control District and the property owner(s)of this subdivision for drainage purposes as shown on this plat in the areas marked Drainage Easement Class II. The property owner(s) of the particular lot or parcel which includes a drainage easement is responsible for maintaining the drainage easements condition as it was when the subdivision was approved. Drainage easements conform to the natural or man-made watercourses and shall not be moved from the location existing at the time of the approval of the subdivision (unless approved by the Yavapai County Flood Control District).

These watercourses may require periodic maintenance to convey on-site or off-site discharges. Periodic maintenance may consist of the removal of earth and/or vegetative material that has built up since the original approval of the final plat for this subdivision.

If the drainage easements are not adequately maintained, the Yavapai County Flood Control District will not be responsible or liable for any damage. However, it has the authority to enter onto the site and maintain the drainage easements. If the District has to do the maintenance, the property owner(s) will be billed. Should court action be necessary to collect these bills, the property owner(s) shall be responsible for attorney’s fees and court costs.

Class III Easements are hereby granted to the Yavapai County Flood Control District for drainage purposes as shown on this plat in the areas marked Drainage Easement Class III.

The Yavapai County Flood Control District is responsible for maintaining the drainage easements condition as it was when the subdivision was approved. Drainage easements conform to natural or man-made watercourses and shall not be moved from the location existing at the time of the approval of the subdivision (unless approved by the Yavapai County Flood Control District).

These watercourses may require periodic maintenance to convey on-site or off-site discharges. Periodic maintenance may consist of the removal of earth and/or vegetative material that has built up since the original approval of the final plat for this subdivision.

2.9 Final Plat NOTE Language

The following basic Final Plat NOTE language shall be included on Final Plats, as applicable:

> A detailed 100-year floodplain has been delineated on this plat in accordance with the criteria established by State Standard (SS 2-92) under the authority of the Director of the Arizona Department of Water Resources.
>
> The area hereon, within the 100-year floodplain limits represents an area subject to flooding from the regulatory flood event. All development and uses within this area is subject to the requirements of the Yavapai County Flood Control District Ordinance.
>
> A floodway and minimum finished floor elevations for lots _______ through ____ have been established and presented on this plat. Additionally, restrictive building envelopes have been established and provided for those lots and those affected by other drainage related facilities, placing them outside the 100-year floodplain. Floodplain limits, base flood elevations and regulatory elevations may be modified by subsequent studies approved by the Yavapai County Flood Control District.
>
> No chain link, woven wire or block wall fences are to be placed within the 100-year flood areas (or those areas necessary to convey storm runoff from the subdivision).
>
> Prior to any work being conducted within these watercourses, the property owner(s) shall verify that such maintenance activities complies with all applicable Federal, State and local requirements including, but not limited to, the Corps of Engineers 404 Permit requirements.

The following basic Final Plat NOTE language shall be included on all Final Plats:

> Natural ground conditions may convey flows through individual lots. Caution should be exercised in selecting a building site. Property owners may wish to contact the Yavapai County Flood Control District for additional direction.

CHAPTER 3. HYDROLOGY

3.1 Purpose

The purpose of this chapter is to present methodologies, acceptable to Yavapai County for estimating peak discharges and developing synthetic hydrographs for use in the analysis and design of drainage facilities. Yavapai County will normally accept the Rational Method and the U.S. Army Corps of Engineers HEC-1 Flood Hydrograph Package for the estimation of design discharges: The most current Arizona Department of Transportation (ADOT) Highway Drainage Manual should be used for guidance when utilizing the following two methods.

3.2 Policies

- Peak runoff calculations shall be performed, at a minimum, for the 2-year, 10-year, 25-year and 100-year return periods, in conjunction with all drainage reports for private developments and public works projects.

3.3 Rational Method

The Rational Method may be utilized for computing peak runoff from small watersheds for the purpose of designing drainage conveyance facilities and stormwater detention/retention basins. The Rational Method should be applied within the following limitations:

- The drainage area should not exceed 160 acres.
- The time of concentration (T_c) should not exceed 60 minutes.
- The watershed should be fairly homogenous (i.e., the watershed should not consist of two or more land-uses of significantly different character), since this can lead to errors in estimates of T_c and runoff coefficient "C".
- The watershed should not contain stormwater facilities that require routing of flow, such as detention/retention basins.

Watersheds that do not meet the above criteria should be modeled using an appropriate rainfall runoff methodology such as Corps of Engineers HEC-1 computer program.

A number of variations of the Rational Method are currently in use by communities throughout the Southwestern United States. These methods vary mostly in the method used to compute the time of concentration, T_c. It is recommended that the Rational Method presented within Chapter 2 of the "Highway Drainage Design Manual, Hydrology", Arizona Department of Transportation, March 1993 (or as updated), be utilized for hydrologic analysis within Yavapai

County. This methodology was developed for use within Arizona, and the manual is readily available. Other Rational Methods may also be acceptable, but must approved by the Yavapai County Flood Control District prior to use.

3.4 HEC-1 Flood Hydrograph Package

This method is the U.S. Army Corps of Engineers rainfall runoff model. It should be used for modeling larger, more complex watersheds, or drainage networks. It is suggested that the options to be used in the HEC-1 model be thoroughly reviewed with the County prior to utilizing this method. The SCS Type II 24-hour storm distributions with antecedent moisture condition II is generally acceptable. The HEC-1 methodology presented within the Arizona Department of Transportation (ADOT) ***Highway Drainage Design Manual - Hydrology*** (latest revision) is acceptable for use on projects reviewed by Yavapai County. Application of the HEC-1 model, as well as other complex rainfall/runoff computer models requires calibration and verification of the reasonablness of the of the results as described within the ADOT manual.

3.5 Flood Hydrographs

The procedure described within this section should be used in conjunction with the Rational Method for developing hydrographs from small watersheds, for the design of stormwater detention/retention basins, and for other stormwater routing analyses. As with the Rational Method, the hydrograph synthesis presented within this section should not be utilized for watershed areas greater that 160 acres. The procedure presented herein was taken from Hickok, et al., 1959, which presented a method of hydrograph synthesis for small watersheds within the Southwest.

A flood hydrograph is developed based on the curvilinear, dimensionless hydrograph shown in tabular form within Table 3.2. The symbols used in Table 3.2 are defined as follows:

t = Cumulative time from beginning of runoff, in minutes.

T_r = Rise time of the hydrograph, in minutes, calculated from the following equations:

$$T_r = 545 * V / Q_p$$

and

$$V = C * A * P_1 / 12$$

Where:

P_1	=	One hour rainfall value for the return period storm under investigation, in inches.
A	=	Watershed area in acres.
C	=	Runoff coefficient.
V	=	Runoff volume, in acre-feet.
Q_p	=	Peak discharge, in cfs.

Q	=	Discharge at time t/T_r, in cfs.
Q_p	=	Peak discharge, in cfs.
v	=	Accumulated runoff volume at time t, in acre-feet.
V	=	Total runoff volume of storm event, in acre-feet.

TABLE 3.2
CURVILINEAR, DIMENSIONLESS HYDROGRAPH

t/T_r	Q/Q_p	v/V	t/T_r	Q/Q_p	v/V
0	0	0	1.6	0.545	0.671
0.1	0.025	0.002	1.7	0.482	0.707
0.2	0.087	0.007	1.8	0.424	0.742
0.3	0.160	0.020	1.9	0.372	0.773
0.4	0.243	0.036	2.0	0.323	0.799
0.5	0.346	0.063	2.2	0.241	0.841
0.6	0.451	0.096	2.4	0.179	0.875
0.7	0.576	0.136	2.6	0.136	0.900
0.8	0.738	0.180	2.8	0.102	0.917
0.9	0.887	0.253	3.0	0.078	0.932
1.0	1.000	0.325	3.4	0.049	0.953
1.1	0.924	0.400	3.8	0.030	0.965
1.2	0.839	0.464	4.2	0.020	0.973
1.3	0.756	0.523	4.6	0.012	0.979
1.4	0.678	0.578	5.0	0.008	0.983
1.5	0.604	0.627	7.0	0	1.000

CHAPTER 4. FLOODPLAIN ANALYSIS

4.1 Purpose

This chapter presents policies, criteria and methodologies for delineating floodplain limits and water-surface elevations to be shown on Subdivision Plats and Development Plans as well as policies for approving developments located within the boundaries of regulatory 100-year floodplains, and other floodplain encroachments. In addition, general guidelines and references are provided for revising Flood Insurance Rate Maps.

4.2 Policies

The following policies relate to floodplain information required to be provided with subdivision drainage studies submitted to the County for approval:

a. Floodplain or drainage path delineations shall conform to the following normal size limitations:

   Detailed Delineations: Drainage basin greater than 160 acres in size.

   Approximate Delineations: Drainage basins between 40 and 160 acres.

   Drainage Path: Drainage basins between 10 and 40 acres.

b. For those developments that will be located within a regulatory floodplain, a note on the Final Plat shall be included stating the minimum finished floor elevations and that the owner/developer will have an Arizona Registered Civil Engineer or Land Surveyor certify the finished-floor elevations of all new structures located within the floodplain. In the case of manufactured homes, all elevations are related to the bottom of the structural frame. (Refer to Section 2.9 of this manual)

c. Floodplain delineations shall be shown on Subdivision Plats.

The following policies relate to proposed encroachments into a regulatory floodplain.

d. Encroachments into the floodplain shall not cause the water surface elevation to rise more than one (1) foot in elevation. This allowable rise in water surface will only be permitted if existing development will not adversely be affected by the rise in water surface elevation.

e. Encroachments into the regulatory floodway are discussed in detail in Section 4.5 of this manual.

4.3 Methods for Determining Water Surface Profiles

4.3.1 Normal Depth

If the depth and direction of flow in an open channel are nearly constant with respect to time and space (i.e. steady, uniform flow conditions), the flow regime is said to be "normal". Under such conditions, the hydraulic characteristics of a channel can be evaluated by using the well-known Manning's equation, which is described in such hydraulic texts as *Open-Channel Hydraulics*, by V.T. Chow (1959) and the *Handbook of Hydraulics*, by E.F. Brater and H.W. King (1982).

When delineating natural floodplains using "normal depth" calculations, it is important to check that the energy grade line slopes continuously in the downhill direction. The energy grade line is defined as a line connecting points of known total head or total specific energy, H, as computed by:

$$H = Y + V^2/2g \qquad \text{(Eqn. 4.1)}$$

Where:

H	=	Total specific energy, in feet.
Y	=	Depth of flow, in feet.
V	=	Average flow velocity, in feet per second.
g	=	Gravitational constant = 32.2 ft/sec^2.

In those cases where the slope of the energy grade line does not closely approximate the channel-bed slope, the assumption of uniform flow is not valid. In such instances, backwater calculations must be performed, rather than the much simpler analysis based on "normal depth" assumptions.

4.3.2 Backwater Modeling

If the assumptions of uniform-flow cannot be satisfied, then a water-surface profile will need to be developed using the Standard Step Backwater Method. This is especially true if the channel cross-section geometry changes significantly along the reach being analyzed or there are hydraulic structures or controls such as culverts, bridges, weirs, and/or flow contractions/expansions which affect hydraulic conditions.

The basic procedure for performing Standard Step Backwater calculations is presented in a number of readily available references including *Open-Channel Hydraulics*, by V.T. Chow (1959) and *Applied Hydraulics in Engineering*, by H. M. Morris and J. M. Wiggert (1972). However, due to the extensive calculations associated with performing Standard Step Backwater method, computer programs are usually employed for this purpose. The U.S. Army Corps of Engineers *HEC-2 - Water Surface Profiles* or the *HEC-RAS - River Analysis System* programs are the most widely used and accepted computer program in use for this type of analysis. The most current version of the U.S. Army Corps of Engineers software shall be utilized for computer backwater modeling on projects that are to be reviewed by Yavapai County. Submittals of HEC-2 or HEC-RAS shall include detailed output files and computer disks containing input/output files, in conjunction with summary tables that present pertinent hydraulic parameters. In addition, cross-section plots for representative cross-sections and cross-sections at critical locations shall be included within hydraulic reports.

One advantage of using the Standard Step Method is that if the computation is started at an assumed elevation that is inaccurate for a given discharge, the resulting flow profile will converge to the correct flow depths with each succeeding cross-section evaluated along the reach. Therefore, if a starting water-surface elevation cannot be established at the beginning of the reach, an assumed elevation may be established far enough away from the "starting" cross-section to correct for any initial error.

The step computations should proceed in an upstream direction for subcritical profiles and in the downstream direction for supercritical profiles. For flow regimes that contain both subcritical and supercritical flows, the computations should be performed both in the upstream direction and in the downstream direction and the appropriate water-surface elevations determined.

4.4 Revising Flood Insurance Rate Maps

Federal Flood Insurance Rate Maps

In 1968 the U.S. Congress established the National Flood Insurance Program (NFIP) which enables property owners within participating communities to purchase flood insurance at reasonable rates. The flood-hazard areas identified as Special Flood Hazard Areas (SFHA) have been delineated on Flood Insurance Rate Maps (FIRMs) which are available from the Yavapai County Flood Control District. These maps depict 100-year flood boundaries, flood insurance rate zones, and regulatory flood elevations, most of which are the result of detailed engineering analyses performed as part of a Flood Insurance Study (FIS).

FIRMs are used for establishing flood-insurance rates for affected structures, and for floodplain management by the Yavapai County Flood Control District. All new development within regulatory floodplains must be reviewed and approved by the Yavapai County Flood Control District. During the review process the Yavapai County Flood Control District staff may require a more detailed analysis than was presented in the FIS. For smaller developments the FIRM's may be used to establish minimum finished floor elevations, or other site grade elevations.

Map Amendments and Revisions

Occasionally, because of limitations of the scale at which a NFIP map was prepared, the floodplain boundaries are not delineated in sufficient detail to reflect individual structures that are elevated on relatively high ground, or show small parcels of land that have been filled. Similarly, floodplain information is subject to change, such as after the construction of drainage improvements or development of more accurate hydrology methods. Since FIRMs are subject to change because of a variety of reasons, FEMA has developed a map modification process designed to keep maps updated with current information.

Information depicted on effective NFIP maps may be changed by a physical revision of the map, by a Letter of Map Revision (LOMR), or by a Letter of Map Amendment (LOMA). New map panels may be printed; or, if the revisions are relatively small, a LOMR/LOMA may be issued that describes the modifications. Changes to effective FIRMs resulting from the exclusion of individual structures and undeveloped parcels are described in a LOMA; whereas, communities having updated data, or having constructed new flood-control improvements may request a LOMR.

The general requirements for technical and scientific data needed to substantiate a LOMR or LOMA are similar. However, there are procedural differences that determine the amount of data required, and how the data are to be submitted. General descriptions of the FIRM modification process are presented within the FEMA publication entitled *Appeals, Revisions, and Amendments to Flood Insurance Rate Maps: A Guide For Community Officials*. More technical information is included within the FEMA publication entitled *Flood Insurance Study Guidelines and Specifications for Study Contractors*, as well as FEMA's "Guidelines and Specifications for Flood Hazard Mapping Partners" at http://www.FEMA.gov/fhm/gs_main.shtm, which is a document that is being updated continuously. FEMA also publishes standard forms for presenting technical data for LOMAs and LOMR's. In addition, all map amendments and revisions proposed within Yavapai County are required to be reviewed and approved by the Arizona Department of Water Resources (ADWR). The engineer engaged in the process of performing map revisions within Yavapai County should contact ADWR to obtain current standards and criteria for performing such flood studies.

If construction is proposed on land within a SFHA, a *Conditional* LOMA or LOMR can be obtained, provided that the proposed structural information meets the established criteria for a standard LOMA or LOMR. After construction is completed, certified "as-built" information must be provided to FEMA for the purpose of obtaining a LOMA or LOMR. The information required for a *Conditional* LOMA or LOMR is basically the same information that is required for either a LOMA or LOMR. Property owners and developers should note that a *Conditional* LOMA or LOMR only provides a comment on the proposed plan, and does not amend the map or waive requirements to purchase flood insurance.

FEMA typically charges fees for the review of requests for the various types of map amendments and revisions. These fees can range from a few hundred to a few thousand dollars, depending on the complexity of the request. Since these fees are modified periodically, those engaged in preparing such requests should contact FEMA to obtain a current fee schedule.

4.5 Construction Within a Designated Floodway

The following criteria are intended to provide guidance to qualified professional engineers when analyzing and certifying proposed encroachments within an adopted regulatory floodway.

The Yavapai County Flood Control District Ordinance and the requirements of the National Flood Insurance Program (NFIP) prohibit encroachments within a regulatory floodway, including fill, new construction, substantial improvements and other development, unless certification by a registered professional engineer is provided demonstrating that the encroachment does not result in any increase in flood levels. This requirement is outlined in Section 5.6 of the District Ordinance and is included in paragraph 60.3(d)(3) of the NFIP regulations.

Because floodway development is contradictory to the tenets of sound floodplain management, such development is discouraged by the Federal Emergency Management Agency (FEMA). Therefore, these certification requirements assume that all practical alternatives to floodway development have been investigated thoroughly and have been deemed not feasible.

This section does not address cases and situations requiring the actual revision of the floodway via redelineation of the floodway boundary. To accomplish an encroachment within a regulatory floodway, a revision of the floodway may be necessary.

4.5.1 Elevation of Structure

The lowest floor, including basement, of any site built structure, or the bottom of the structural frame or the lowest point of any attached appliances of any manufactured housing, whichever is lower, shall be at least 1-foot above the base flood elevation, as published by FEMA or other approved floodway study. It is stressed that 1-foot is the minimum allowable and that more clearance may be appropriate due to velocity of flow, probability of debris collection on the structure or other factors that should be evaluated by the engineer. All foundations shall be designed as flow-through structures.

4.5.2 Definition of "NO-RISE"

If an adopted regulatory floodway has been computed and is displayed on the effective NFIP map, all areas within the floodway are considered to be effective in conveying the 100-year discharge. Therefore, no obstructions, regardless of size, can be placed within the floodway without obstructing flow and causing some increase in the base flood elevation (BFE). Although the backwater computer model may show little change in the BFE, it may reveal changes in other variables (e.g. top width, flow area, velocity). The changes can be translated into increases in the BFE that may not be considered significant by themselves. However, the long term cumulative effects of such increases will eventually result in significant changes. Therefore, no development in the floodway should occur without proper compensation for the lost conveyance.

It is FEMA's position that this regulation is to be interpreted exactly as written; that is, "no" rise above the BFE. Therefore, nothing that offers any resistance to flow of floodwaters should be placed within a regulatory floodway, unless compensatory action is taken to restore the lost conveyance.

4.5.3 Loss of Conveyance

In the case of ***a simple floodway encroachment***, a "no-rise" determination can usually be made based on consideration of conveyance only. In such a situation, it is the difference in the conveyance before and after encroachment, or the aforementioned loss of conveyance that must be addressed if the effects of development are to be compared against the "no-rise" criterion. The computation of loss of conveyance is most appropriately accomplished by isolating a portion of a cross section, separate from the backwater computer model, and performing hand computations. Examples of typical hand computations for proposed fill and bridge pier construction are included at the end of this section for reference. However, it is appropriate to incorporate three or more new field surveyed cross-sections at the site of the proposed construction that reflect existing conditions into the un-encroached and encroached backwater computer models. This is done to establish the base flood conditions at that location, which are to be used in the hand computations. The formula used to determine conveyance (K) is given in equation 4.2.

$$K = 1.49/nAR^{2/3} \qquad \text{(Eqn. 4.2)}$$

Where:

n = Manning's roughness coefficient.
A = Flow area, in square feet.
R = Hydraulic radius, in feet.

The loss of conveyance is computed using the "n" value and hydraulic radius at the site of the encroachment as applied in the computer model.

4.5.4 Compensation

Once a determination has been made as to the amount of conveyance lost as a result of the proposed encroachment, the engineer is required to adequately compensate for this loss. This compensation is accomplished by including some means or measures within the proposed floodway development for providing an increase in effective conveyance, at some point on the cross section, equal to or greater than that lost. Equal area exchanges are only valid if the “n” value and hydraulic radius remain unchanged between the encroachment site and the compensation site. It is also important that the flow area provided is truly effective; that is, open to inflow and outflow and not just an isolated low spot or depression. This increased effective conveyance could be computed by hand in a manner similar to that used to compute the loss of conveyance.

The means or measures used to provide this effective conveyance (e.g., excavation, roughness coefficient reduction) would be at the discretion of the engineer but must be approved by the District. .

4.5.5 Submittal Requirements

Prior to any development occurring in a floodway area, it must be demonstrated that an encroachment within the floodway area will not result in ***any*** increase in the BFE. The items identified below are deemed necessary (at a minimum) to document and demonstrate compliance with the “no-rise” criterion for simple floodway encroachments. The analysis must be submitted to the District for review and approval. Once approved, the District will issue a Development Permit.

1. The Corps of Engineers HEC-2 or HEC-RAS hydraulic backwater models for the 100-year flood and floodway water-surface profiles for the following:

   a. A calibration or test run, duplicating the effective Flood Insurance Study (FIS) model. The calibration run shall include both the natural cross-sections and the floodway encroachment analysis. The calibration run shall extend sufficiently upstream and downstream to fully evaluate the impact of the proposed development.

   b. Existing conditions (effective FIS) model modified to include a minimum of three (3) additional field surveyed cross-sections through the proposed project site. Cross-sections must reflect existing site conditions prior to construction of the project. The model shall include both the natural cross-sections and the floodway encroachment analysis.

   c. Post-project conditions model. This model must include surveyed cross-sections through the proposed project site reflecting floodplain conditions after construction of the proposed project. The 100-year flood (without floodway) and floodway elevations for this model must not be greater than those in the existing conditions model described in item “b” above. This hydraulic backwater model is necessary to ensure that any changes in transition losses, which are based on velocity heads rather than on conveyance, do not cause increases in water surface elevations. Also, a hydraulic backwater model provides a means of evaluating effective flow areas upstream and downstream of the encroachment and compensation sites.

2. The following information, to be obtained by hand computation, using the cross sections and 100-year encroached hydraulic data in the modified existing conditions computer model output provided under item 1b:

   a. Calculation of the reduction in conveyance (K) caused by the proposed obstruction, assuming no change in floodway water surface elevation, and using the "n" value appropriate for the site of the proposed obstruction.

   b. Calculation of the increase in conveyance (K) obtained by the proposed offsetting measure, using the "n" value appropriate for the site of this measure.

   c. Comparison showing that the conveyance increase computed in 2b equals or exceeds the loss computed in 2a.

3. A copy of the appropriate NFIP map showing the existing floodway and indicating the project area.

4. Topographic mapping tied to the appropriate floodplain circuit reference mark (elevation) of the entire project area indicating the location of all cross sections used in the modified hydraulic model and a plan view of all project elements. The floodplain circuit reference mark (RM) can be found on the corresponding Flood Insurance Rate Mape (FIRM). The plan shall be to scale of no less than 1″ = 100′, and shall contain contours with a contour interval of 2-feet or less.

5. Construction and foundation plans, certified by a registered professional engineer, for all project elements, including those measures employed to provide additional effective conveyance.

6. Elevated foundations must be designed to withstand both hydrodynamic forces caused by velocity of waters and hydrostatic forces caused by standing water. They must also meet the requirements of the Building Department.

7. Scour Analysis; the scour analysis should consider debris accumulation on piers as required for the HEC-2/HEC-RAS computer modeling. Soil tests shall be presented to verify the nature of the in-place soils to the full depth of the projected scour. The method of scour analysis shall be at the engineer's discretion, but shall be appropriate for the type of encroachment (piers, stem walls, solid foundation or fill).

Acceptable methods for scour analysis can be found within the References section of this manual for Chapter 7 - Erosion and Sedimentation. Foundation shall be located at least 3 feet below the maximum estimated scour elevation.

8. Lateral Loading Analysis; the lateral loading on the structures shall allow for at least the following amounts of debris accumulation:

Piers or stem walls - 1 foot either side of pier or stem wall.
Lowest structural member - The following minimal lateral load shall be considered:

Elevation of Lowest Structural Member Above Floodway Elevation	Equivalent Depth of Penetration into Water Surface
Less than 1′	Actual penetration plus 2′
1′ to 1.99′	1′
2.0′ to 2.99′	0.5′
Over 3.00′	0

The flow velocities used for the loading analysis shall be obtained from the HEC-2/HEC-RAS run with the encroachment in place. A flow distribution showing velocities for each increment between "GR" points at the location of the structure shall be included with the analysis. If applicable, it may be necessary to run the HEC-2/HEC-RAS model as "supercritical" to obtain the appropriate design data.

9. Impact Loading Analysis; normal impact loads are those which relate to isolated occurrences of typically sized ice blocks, logs, or floating objects striking the structure. For design purposes, this can be considered as a concentrated load acting horizontally at the maximum water elevation, or any point below it, equal to the impact force created by a 1000 pound mass traveling at the velocity of the flood water, acting on a one-square-foot surface of the structure.

Special impact loads are those which relate to large conglomerates of floating debris, either striking or resting against a structure or its parts. In an area where special impact loads may occur, the load considered for design purposes is the impact created by a 100 pound load times the width of the building, acting horizontally over a one foot wide horizontal strip at the maximum water elevation or at any level below it. Where natural or artificial barriers exist which would effectively prevent these special impact loads from occurring, these loads may be ignored in the design. The equivalent depth of penetration into the water surface given for the lateral loading analysis shall be applied to the special impact loading.

10. Engineering Evaluation; the engineer shall evaluate the amount and nature of debris available in the drainage basin to determine if a greater debris accumulation allowance is justified for any or all calculations.

11. An executed copy of a certification statement signed and sealed by a registered professional engineer. A blank copy of the certification statement is included at the end of this section.

12. Additional analysis may be appropriate and/or required by the District on a case by case basis.

NOTE: It is recommended that all proposed encroachments be discussed with District staff prior to submitting the analysis

CERTIFICATION OF A "NO-RISE" DETERMINATION FOR A PROPOSED FLOODWAY ENCROACHMENT

____
Community Name

Development Name

Lot/Property Designation/Parcel Number

Property Owner

I hereby certify that the proposed measures, in combination with the property development designation above, will result in no loss of flow conveyance and/or will not result in any increase in flood levels during the occurrence of the 1 percent annual chance of exceeding the (100 year flood) discharge.

I further certify that the data submitted herewith in support of this request are accurate to the best of my knowledge, that the analyses have been performed correctly and in accordance with sound engineering practices, and that the proposed structural works are designed in accordance with sound engineering practice.

____
Date

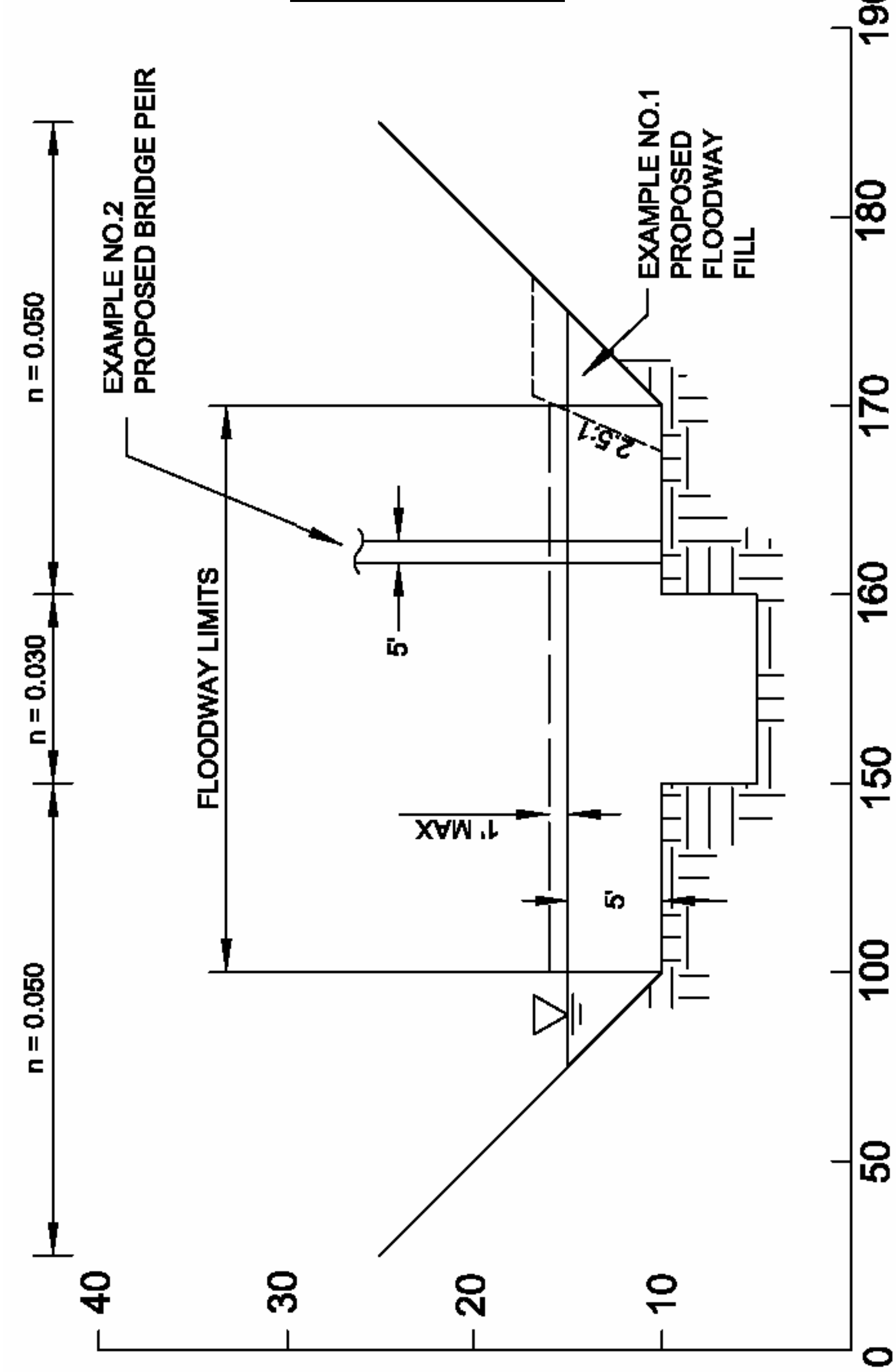
Registered Professional Engineer

Seal

EXAMPLE CONVEYANCE CALCULATIONS

NO-RISE FLOODWAY

TYPICAL SECTION



Example 1

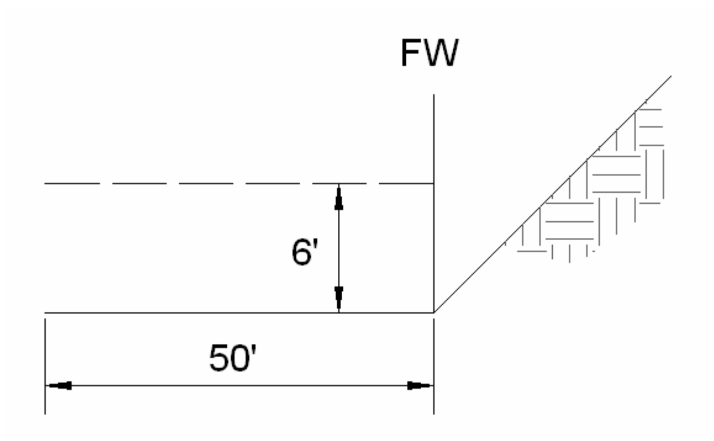
CONVEYANCE CALCULATION

RIGHT OVERBANK CONVEYANCE (PRE-DEVELOPMENT)

Assumptions:

1. Portion of fill in floodway fringe is allowable and is accounted for in floodway surcharge.
2. Pre-development conveyance should assume existence of wetted perimeter along floodway boundary
3. Maximum conveyance loss will occur in conjunction with floodway depth, therefore, use floodway water surface elevation in computation.
4. Conveyance losses computed with floodway water surface elevation and properly compensated for will not increase 100-year (base flood) elevation.

Therefore:



$K_{pre} = (1.49/n) \times A \times R^{2/3}$

$A = 50 \times 6 = 300\ ft^2$

$WP = 50 + 6 = 56$ ft

$R = 300 / 56 = 5.36$

$R^{2/3} = 3.06$

$K_{pre} = (1.49 / 0.050) \times (300) \times (3.06) =$ 27,356.40 cfs

Example 1 (cont.)

CONVEYANCE CALCULATION

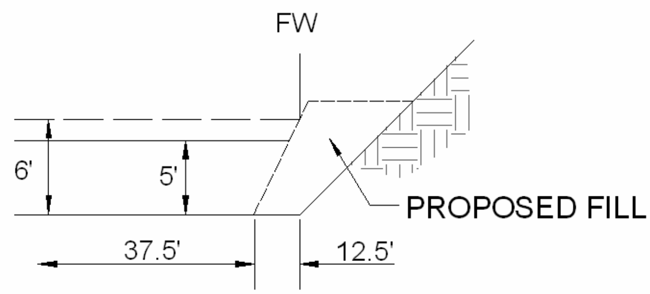
RIGHT OVERBANK CONVEYANCE (POST-DEVELOPMENT)

Assumptions:
1. All previous assumptions still hold
2. Proposed fill slopes above floodway water surface elevation and outside floodway limit do not contribute to wetted perimeter.

Therefore:

$K_{post} = (1.49 / n) \times A \times R^{2/3}$

$A = (1 \times 50) + (½ \times 5 \times (50 + 37.5))$
$= 268.75$ ft



$WP = 37.5 + (12.5^2 + 5^2)^{½} + 0 = 50.96$

$R = 268.75 / 50.96 = 5.27$

$R^{2/3} = 3.03$

$K_{post} = (1.49 / 0.05) \times 268.75 \times 3.03 = 24,266.51$ cfs

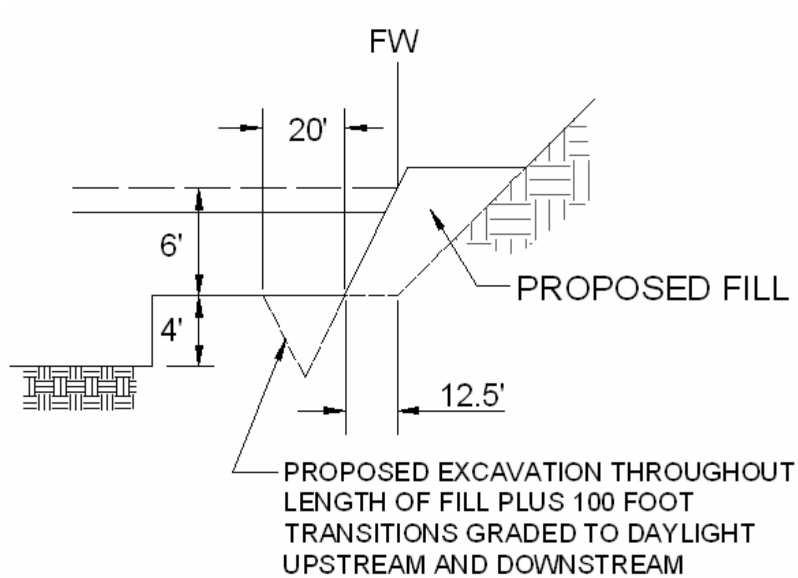
TOTAL CONVEYANCE LOSS IN FLOODWAY

$K_{pre} - K_{post} = 27,356.40 - 24,266.51 =$ 3089.89 cfs

Example 1 (cont.)

CONVEYANCE CALCULATION

DESIGN OF CONVEYANCE COMPENSATION MEASURE



$K_{prop} = (1.49 / n) \times A \times R^{2/3}$

$A = 268.75 + (½ \times 20 \times 4)$
$= 308.75\ ft^2 > 300\ ft^2$ (PRE)

$WP = 50.96 - 20 + (2 \times (10^2 + 4^2)^{½}) = 52.5$

$R = 308.75 / 52.50 = 5.88; \quad R^{2/3} = 3.26$

$K_{prop} = (1.49 / 0.05) \times 308.75 \times 3.26 = 29{,}994.45$ cfs

Since K_{prop} (29,9945.45) > K_{pre} (27,356.40), the proposed compensation measure is adequate

NOTE: Fill slope would require adequate protection against erosion and check structures for stability.

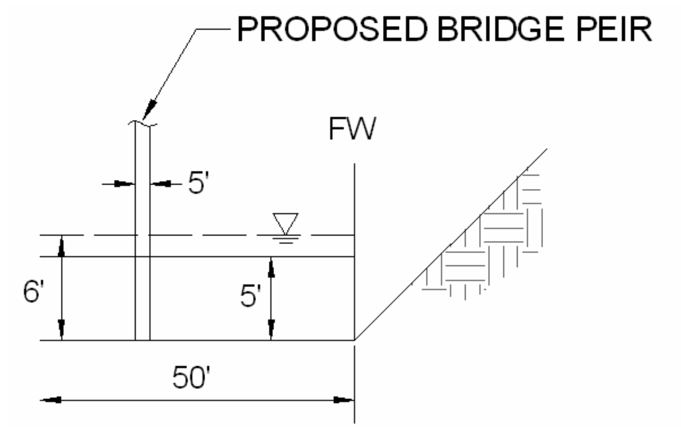
Example 2

CONVEYANCE CALCULATION

RIGHT OVERBANK CONVEYANCE (PRE-DEVELOPMENT)

Same as Example No. 1 = 27,356.40 cfs

RIGHT OVERBANK CONVEYANCE (POST-DEVELOPMENT)



A = $(6 \times 50) - (6 \times 5) = 270\ ft^2$

WP = $(50 - 5) + (2 \times 6) + 6 = 63$ ft

R = $270 / 63 = 4.29$; $R^{2/3} = 2.64$ ft

Weighted "n" value:

"n" ROB (0.050) : $(50 - 5) + 6 = 51$ ft

"n" CONC. (0.013): $2 \times 6 = 12$ ft

WP = $51 + 12 = 63$ ft

"n_w"= $(51 / 63) \times 0.050 + (12 / 63) \times 0.013 = 0.043$

$K_{post} = (1.49 / 0.043) \times 270 \times 2.64 =$ 24,699.35 cfs

TOTAL CONVEYANCE LOSS IN FLOODWAY

$K_{pre} - K_{post} = 27{,}356.40 - 24{,}699.35 =$ 2657.05 cfs

Example 2 (cont.)

CONVEYANCE CALCULATION

DESIGN OF CONVEYANCE COMPENSATION MEASURE

Trial No. 1

Placement of dumped rock rip-rap across entire right overbank * beneath bridge, “n” = 0.035.
* Excavated and prepared

Weighted “n” value

“n_w” = $(51 / 63) \times 0.035 + (12 / 63) \times 0.013 = 0.031$

$K_{prop} = (1.49 / 0.031) \times 270 \times 2.64 = 34{,}260.39$ cfs

Since K_{prop} (34,260.39) > K_{pre} (27,356.40), the proposed compensation measure is adequate

4.6 Sealed Septic Systems in Floodplains

This section contains the general requirements that Environmental Services utilizes in cases where a sealed septic system is required, due to location in a flood prone area. Some variation may apply in cases where information indicates that erosion or scour depths may be deeper than the proposed depth of the leach lines.

a. Each site will be individually evaluated during the routine on-site evaluation (percolation test). Specific recommendations will be made at that time by an Environmental Services representative.

b. In general, the leach area will be installed deeper than usual (3-feet below natural grade) to minimize the chance of a small erosional flow breaching the integrity of the leach system. For a temporal flow (1 day or less) this will minimize the downward saturation from the flood flow.

c. Tanks can be installed at standard depth of over 6-inches. Sealed septic systems utilizing caulk or other adhesive-type substances will not be required, as the caulks have a tendency to permanently seal the tank closed, preventing routine maintenance. Instead, rubber collars or grommets should be used.

d. Septic systems are prohibited within regulatory floodways, unless a variance is granted by the District.

CHAPTER 5. STORMWATER STORAGE (DETENTION/RETENTION)

5.1 Purpose

The following section describes the criteria and policies which are to be followed for the analysis and design of stormwater storage facilities associated with developments located within Yavapai County. The purpose of implementing stormwater storage is to mitigate the impacts of increased flow peaks that occur as a result of watershed urbanization. The intent of stormwater storage requirements is to hold runoff to historic peak levels for the full range of storm events, from the 2-year through the 100-year event. Regardless of the calculation method utilized to analyze detention facilities, it is necessary to demonstrate that runoff peaks are maintained at "undeveloped" levels for the 2-year, 10-year and 100-year storm events. The reason for this requirement is that the impact of development is normally far more pronounced for the frequent storms than it is for major storms, such as the 100-year event. For example, while the developed peak runoff for a 100-year event may be only 20% higher than the historic runoff, it is common that the 2-year peak runoff, under developed conditions, may be as much as two to six times larger than the natural runoff. A facility designed to detain only the 100-year storm event may be practically ineffectual when functioning under the more frequent storm events. As a result, facilities most often will need to be designed with multi-frequency outlet structures in order to perform as intended.

5.2 Policies

General Policies

a. Stormwater detention/retention shall be incorporated within subdivisions, commercial and industrial developments of one (1) acre or larger. Stormwater detention may be required on developments smaller than one (1) acre in size, if downstream flooding hazards may be increased as a result of development. The detention/retention system shall have the effect of ensuring that, at a minimum, post-development 2, 10 and 100-year peak discharges from the development will not exceed the pre-development values.

b. On-line detention facilities shall not be permitted on natural watercourses or watercourses that drain more that 100 acres upstream of the detention-basin outlet structure, unless approval to do so is obtained from the Yavapai County Flood Control District.

c. The use of rooftops as storage areas for runoff is **not** an acceptable method of meeting the detention/retention criteria of Yavapai County.

d. Individual lot-storage systems within single-family residential developments are **not** acceptable for meeting the detention/retention criteria of Yavapai County.

e. Finished floors of structures shall be a minimum of one foot above the 100-year water-surface elevation of any adjacent detention basin(s).

e. No part of any stormwater detention/retention facility shall be constructed within any public right-of-way.

f. The maximum depth of ponded water within any parking area shall not exceed one (1) foot for the 100-year storm. Planning of areas within a parking lot, which will accept ponding, should be such that pedestrians are inconvenienced as little as possible. Deeper areas should be confined to remote areas of parking lots, whenever possible.

g. The minimum longitudinal slope permitted within parking-lot storage facilities is 0.005, unless concrete valley gutters are provided. With concrete valley gutters, a minimum longitudinal slope of 0.002 may be permitted

h. Detention/retention must be based on pre minus post development conditions for the on-site area only. Detention/retention requirements may only be waived if the on-site area is being directly discharged to a watercourse with a drainage area greater than 80 square miles. In some instances, Yavapai County Flood Control District may determine that discharges may be increased for select watercourse reaches downstream by the use of detention. In this case Yavapai County will accept retention for the site or a slower discharge rate to minimize the downstream impacts of the detention system.

i. In instances where the Yavapai County Flood Control District has waived the requirements of detention/retention for industrial or commercial sites, a first flush retention (See Figure 5.1), which is defined as the first 0.5 inches of runoff across the entire property, must be retained to reduce stormwater pollutants from being discharged off-site. An alternative system for reducing stormwater pollutants must be approved by the Yavapai County Flood Control District.

j. For industrial and commercial sites, the bottom 12 inches of the detention facility must retain the first flush (See Figure 5.1), which is defined as the first 0.5 inches of runoff across the entire property. Basin depth must be limited to 12 inches to minimize percolation time. An alternative system for reducing stormwater pollutants must be approved by the Yavapai County Flood Control District.

Maintenance Policies

l. A maintenance plan shall be prepared in conjunction with the detention/retention basin design that includes both scheduled and unscheduled maintenance activities. SCHEDULED MAINTENANCE includes such items as mowing, pruning, and trash removal that are performed on a regular basis. UNSCHEDULED MAINTENANCE includes repairs, usually made necessary by storms and floods, which are discovered either during regularly scheduled inspections, or during inspections made after flooding. Unscheduled maintenance shall also include removal of sediment buildup.

m. Maintenance ramps or other access shall be provided into detention/retention facilities in order to facilitate scheduled and unscheduled maintenance activities. Access easements from public right-of-way shall be provided to all detention/retention facilities.

n. Maintenance of local detention/retention facilities, provided in conjunction with new developments, shall be the responsibility of the private property owner or neighborhood association. The District shall reserve the authority to periodically inspect privately-owned detention/retention basins to ensure satisfactory maintenance is being provided.

o. Final Plats, Development Plans and CC&R's shall have a note stating (a) that the owner(s) shall be solely responsible for the operation, maintenance, and liability for detention/retention systems; and, (b) that District staff may periodically inspect the detention/retention facilities to verify that scheduled and unscheduled maintenance activities are being performed adequately.

Retention Policies

p. Stormwater retention basins are generally not permitted within Yavapai County, because of concerns related to water rights and the potential problems associated with long-term ponding of stormwater. However, retention basins may be permitted to meet stormwater detention criteria when a more conventional stormwater detention basin is impractical (e.g. if adequate grade is not available for draining the basin).

q. Maximum disposal times for stormwater runoff for retention facilities are as follows:

q.1 12 hours for basins that intercept runoff from an upstream watershed area that is ten acres in size, or smaller.

q.2 24 hours for basins that intercept runoff from an upstream watershed area that is greater than ten acres and less than 30 acres in size.

q.3 36 hours for basins that intercept runoff from and upstream watershed area that is 30 acres in size, or greater.

r. Retention systems that utilize subsurface disposal of stormwater shall incorporate some form of infiltration enhancement system such as gravel-filled engineered basin floors or trenches to minimize sealing of the basin bottom. A soils report, including an infiltration test, shall be required in such instances that demonstrate that the basin will drain within the maximum disposal times.

s. If a pump is to be used to drain a retention basin it should be provided with an automatic control switch with a vertical float mechanism, or an equivalent device. A pump inlet box should be provided, and the inlet should be screened.

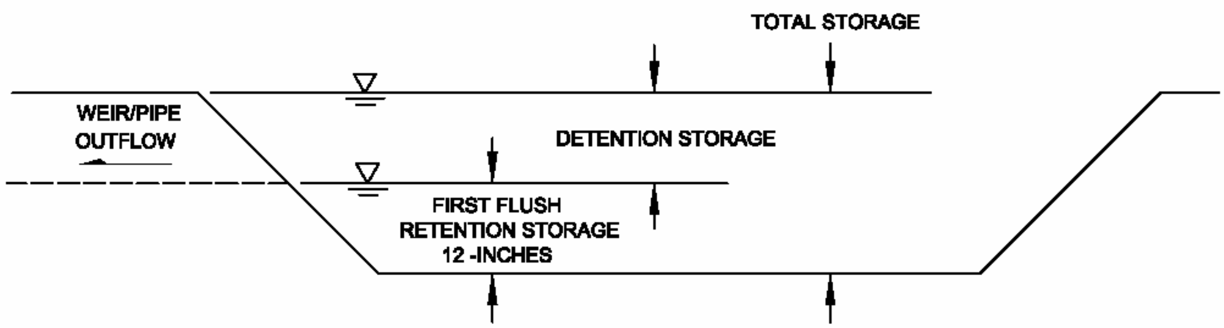


FIGURE 5.1
EXAMPLE OF FIRST FLUSH RETENTION CONFIGURATION

5.3 Design Procedures

5.3.1 Hydrology

Peak flow values and inflow hydrographs used for the analysis and design of detention basins shall be determined using the methodology specified within Chapter 3. "HYDROLOGY" of this manual. For purposes of detention basin analysis and design, inflow/outflow peak flow values and hydrographs shall be evaluated for the 2, 10 and 100-year return periods. The design of the majority of small on-site detention basins will be based on peak discharges using a modified Rational approach, and a synthetic hydrograph developed from the procedure provided within Section 3.4 of this manual. It is suggested that a more thorough analysis, such as the HEC-1 or TR-20 method be utilized whenever more complex basins are involved.

When preparing plans utilizing on-site detention, the engineer should consider the impact of the retarded peak flow rates on flows from upper portions of larger drainage basins. That is, the analysis should evaluate how the detained runoff will impact the overall basin discharge rate. Cases may be encountered where on-site detention facilities would actually increase the discharge in the receiving stream or would have no beneficial affect. When such cases are encountered, the hydrological analysis should be included together with a request that the on-site detention be waived due to its potential detrimental affect on the receiving stream.

5.3.2 Reservoir Routing and Sizing

On-Line Detention Basins

An on-line detention basin intercepts all runoff from the upstream watershed and routes it through an outlet structure in a reduced or metered manner. This is a common type of basin that is typically used to regulate flows from on-site watersheds associated with new development. On-line basins are not recommended on natural alluvial watercourses that convey significant amounts of sediment.

The outflow hydrograph and the basin volume requirements associated with an on-line detention shall be determined using a reservoir routing technique such as the "Storage-Indication Method" or the "Modified Puls Method". Commercially available software packages which perform basin routing, such as HEC-1 and Pond Pack, are also acceptable for use in Yavapai County. Figure 5.1 provides an illustration of the typical hydrograph performance of an on-line basin. Detailed, step-by-step descriptions for these procedures are presented in a number of readily available publications including (1) *Handbook of Applied Hydrology* by V. T. Chow, (2) *Soil Conservation Service, National Engineering Handbook, Section 4-Hydrology*, (3) *Pima County/City of Tucson Stormwater Detention/Retention Manual*, and (4) *Hydrologic and Hydraulic Training Session Manual* by the Arizona Department of Transportation.

These methods of flood routing assume invariable discharge-storage relationships and level water-surface elevations within the storage reservoir. While these assumptions are adequate for most detention basin routing, these methods should generally not be used for most channel routing applications.

Off-Line Detention/Retention Basins

An off-line detention basin only captures a portion of runoff, allowing a certain portion to flow past the basin. After the flow event has passed, the stored stormwater is generally disposed of by a "bleeder drain", infiltration or a pump. Off-line basins generally require significantly less storage volume than on-line basins and therefore are more effective in reducing peak flows. However, off-line basins are generally more costly to construct because of the structural appurtenances necessary to control the quantities of "capture flow" and "bypass flow".

Reservoir routing is generally not required for an off-line basin. The basin size is typically determined by the volume of stormwater contained within the hydrograph located above the design "bypass flow" (Figure 5.2).

On-Line Retention Basins

An on-line retention basin intercepts all flow from the upstream watershed but is not provided with a gravity outlet structure. Typically the basin is designed to permit overflow at the point on the receding limb of the hydrograph that corresponds with the design outflow. The retained flow is then disposed of through infiltration or pumping. Use of this type of basin is typically limited to those situations where a conventional detention basin outlet structure will not function due to lack of grade.

On-line retention basins are generally provided with storage volume equal to the total volume under the hydrograph that corresponds to the point on the receding limb of the hydrograph that corresponds to the design outflow (Figure 5.2).

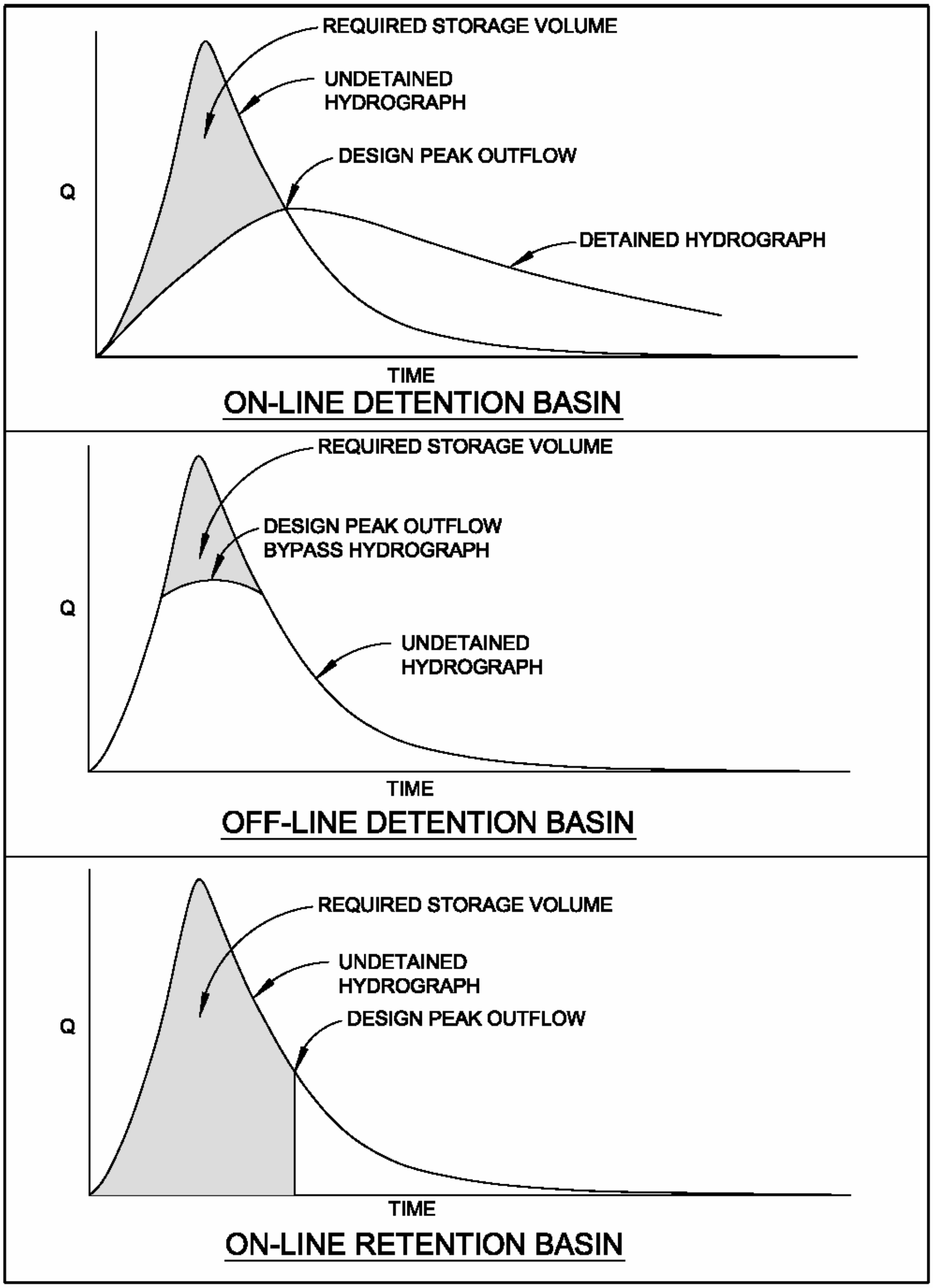


FIGURE 5.2
HYDROGRAPH PERFORMANCE FOR VARIOUS BASINS

5.3.3 Outlet Structures

Because Yavapai County requires attenuation of the 2, 10 and 100-year peak flows, multi-frequency outlet structures may be necessary in the design of many on-line stormwater detention facilities. There are no standardized procedures for the design of optimum multi-frequency outlet structure. The potential combinations of suitable outlets for any particular basin are numerous, and limited only by the creativity and experience of the engineer. Figure 5.3 provides some conceptual examples of typical multi-frequency outlet structures. Additionally, the engineer is referred to a publication entitled *Stormwater Detention Outlet Control Structures*, by the American Society of Civil Engineers. This publication provides other information related to the design and construction of multi-frequency detention basin outlet structures.

The minimum allowable pipe size for outlet structures is 6 inches in diameter. However, orifice plates with smaller openings may be attached at the pipe inlet to further reduce the flow capacity of a pipe. *Trash racks* may be required for pipe and orifice outlets which are 24 inches or less in diameter and for pipe outlets where water borne debris is expected to be present. Trash racks shall be designed to be removable, and have a surface area of at least 10 square feet. Openings in the trash rack should not exceed one-half the area of the outlet pipe for mesh screens, or one-third the diameter of the outlet for bar screens. Design of the trash rack should consider the likelihood that unclogging may be necessary when the basin is filled with water. Additionally, a concrete pad is recommended around the inlet to the outlet structure in order to facilitate maintenance of the trash rack.

5.4 Safety Consideration

Basin Side-Slopes and Depths

The following slope/depth ratios are required for multi-use basins and basins that have unrestricted access:

a. A maximum of 2:1 for protected side-slopes and 3:1 for unprotected side-slopes where depths of ponding are less than three feet.

b. A maximum of 4:1 for side-slopes where depths of ponding are three feet or greater.

A benched configuration is required for basins in excess of six feet deep. Benches within basins shall be proportioned so the bench width is at least three times the height of the slope above it, measured from the lowest point on the top of the slope above the bench. The minimum width of a bench shall be six feet. The maximum depth to the first bench shall conform to the previous slope/depth ratios.

Security Barriers

Basins designed in accordance with the previously listed requirements should preclude the need for security barriers. However, detention basin design should always consider safety aspects of the facility. In the following instances security barriers are required. These barriers may consist of vegetation, masonry, wood, or chain-link. Vegetation, or a combination of vegetation and structural materials, is preferred.

Security barriers shall be provided to prevent access for all basins where depths of ponding exceed three feet and where slopes are steeper than 4:1.

Vegetative barriers must be of a width equal to or greater than overall height, with a density sufficient to restrict access. If vegetative screening is to be used, plant materials must be in place and established at the time the occupancy permit is requested.

A minimum 42-inch barrier height is required.

Detailed sections of proposed fences, if required, are to be shown on paving and grading plans or development plans, as appropriate.

Security barriers, if required, shall not restrict the hydraulic capacity of structures.

State Dam Safety Requirements

The Arizona Department of Water Resources (ADWR), Division of Safety of Dams, has legal jurisdiction over all dams (embankments) which exceed certain height and storage limits. A "jurisdictional dam" as defined by ADWR, is "...either 25 feet or more in height or stores more than 50 acre-feet. If it is less than six feet in height, regardless of storage capacity or does not store more than 15 acre feet regardless of height, it is not jurisdictional." The ADWR should be contacted regarding specific dam-safety requirements in conjunction with the design of any embankment which might come under their jurisdiction.

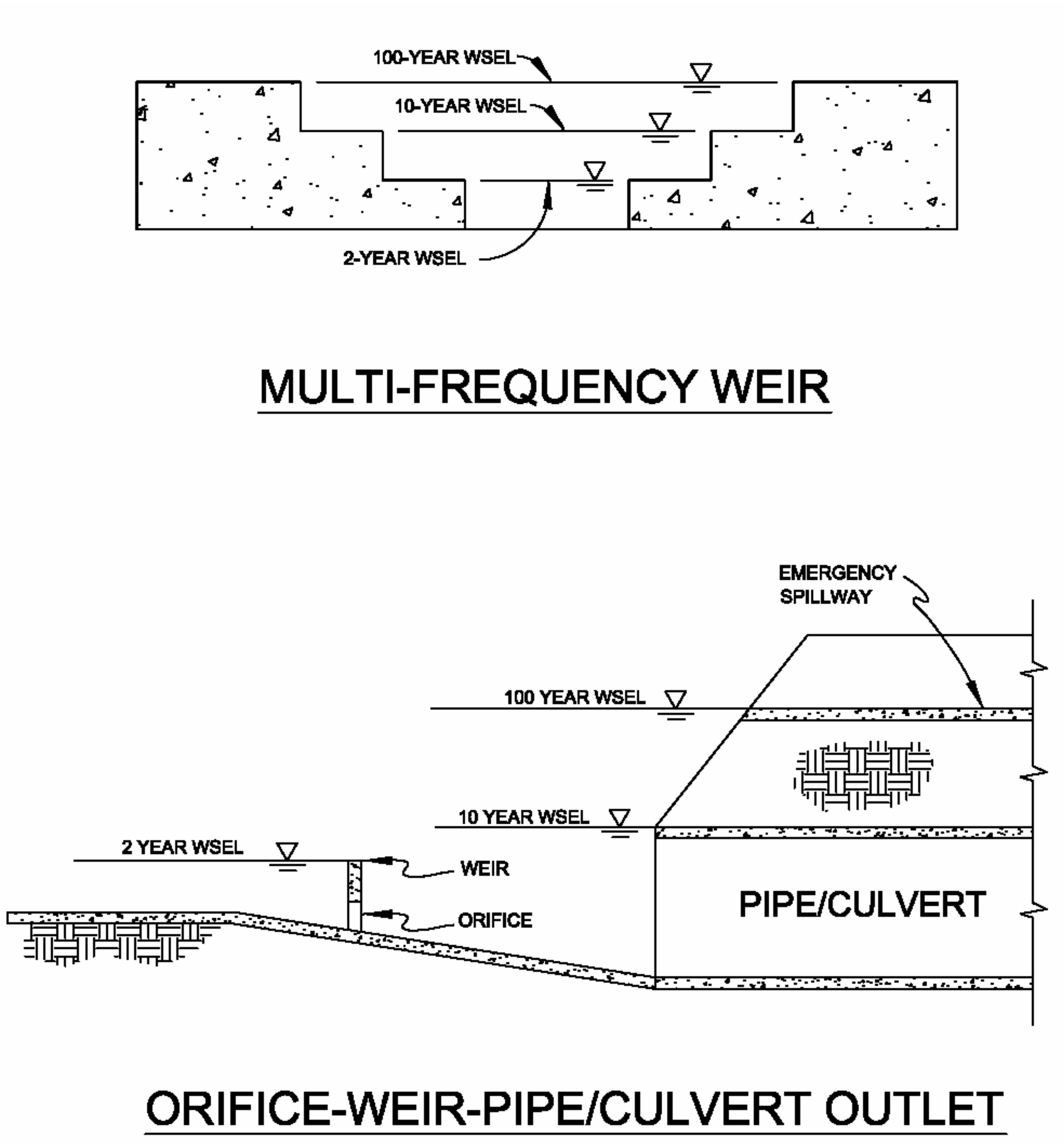


FIGURE 5.3
EXAMPLES OF MULTI-FREQUENCY OUTLET STRUCTURES

CHAPTER 6. OPEN CHANNEL DESIGN

6.1 Purpose

The purpose of this chapter is to (1) provide minimum requirements for the analysis and design of constructed open channels, (2) discuss several optional method of providing stabilization for channel banks and, (3) provide technical design considerations and criteria for the analysis and design of open channels.

6.2 Policies

a. Under most circumstances, channels designed and constructed in conjunction with new developments, will be owned and maintained by the developer, homeowners association or individual property owner.

b. In instances when channel improvements will be dedicated to Yavapai County for operation and maintenance, channel design and construction must conform to County design specification.

c. For constructed channels, it is recommended that the 100-year peak discharge shall be contained in a defined channel cross-section which includes adequate freeboard. However, other designs may be acceptable, as approved by the District.

d. Drainage channels may not be constructed adjacent to roadways without prior written permission from the County Engineer.

e. Unless flow leaving a site is entering a constructed drainageway, the flow must be returned, as nearly as feasible, to the pre-existing condition (i.e., depth, velocity and width).

f. Constructed channels shall follow the existing watercourse alignment as closely as is feasible.

g. Where the expected velocity, depth of flow, or channel geometry would result in scour in an earthen channel, an appropriate type of channel stabilization shall be necessary.

h. No valves, closures, transformers, standpipes, poles or other obstructions will be permitted in any surface drainage channel or roadside ditch.

6.3 Channel Stabilization

Channel stabilization is used to control the horizontal and/or vertical alignment of a watercourse, whether natural or constructed. The purpose of channel stabilization is to reduce flood hazards, erosion hazards and maintenance costs associated with the drainage of natural or urban runoff. Channel stabilization is generally required when flow velocities and soils conditions result in the potential for bank erosion. Some form of channel stabilization will generally be required in conjunction with new channel construction unless an analysis is performed, as described in Chapter 7 of this manual, that demonstrates an erosion hazard does not exist along the subject reach. A variety of stabilization methods are acceptable within their range of applicability. Stabilization methods which have been found to be acceptable include those described within the following sections:

6.3.1 Rock Riprap

Rock riprap stabilization consists of either dumped rock, or rock held in place with wire mesh and rail piles. Rock may be placed on the banks only, or on both the bed and banks as the channel conditions dictate. Rock riprap is acceptable for use within Yavapai County if designed in accordance with the procedures presented within this manual. Methods of riprap design other than the one presented herein may also be used, provided they are first approved by Yavapai County.

Riprap Sizing

The chart provided on Figure 6.1 of this manual provides the median size of riprap, D_{50} for the average flow velocity with the riprap in place. A family of curves on Figure 6.1 is provided for channels with various curvatures. The angle of curvature specified on Figure 6.1 is defined as the angle made by the intersection of the centerline of the straight channel with a tangent to the outside bend (Figure 6.2). The chart provided on Figure 6.1 was developed under the assumption that the specific weight of the rock is 165 pounds per cubic foot. If rock of a substantially different specific weight is to be used, the D_{50} should be adjusted by use of Equation 6.1:

$$k_r = 102.96k/(w_r - 62.4) \quad \text{(Eqn. 6.1)}$$

Where:

k	=	D_{50} from Figure 6.1, in feet.
k_r	=	D_{50} for rock to be used, in feet.
w_r	=	Unit weight of rock to be used, in pounds per cubic foot.

Figure 6.1 also assumes that riprap will be placed on channel banks having side-slopes no steeper than 3:1. Dumped rock rip rap is not permitted as a method of bank protection on side-slopes steeper than 3:1 unless an approved engineering analysis is performed which demonstrates the

stability of the steeper slope. Generally, if side-slopes steeper than 3:1 are required for rock bank protection, then the rock must be held in place with wire mesh, gabion baskets or grout.

Riprap Gradation, Thickness, and Rock Shape

The gradation of rock riprap should follow a smooth curve. The ratio of the largest size rock to D_{50} should be about two (2), and the ratio of D_{20} to D_{50} should be about one-half. The riprap blanket shall have a minimum thickness of $2.0D_{50}$. Table 6.1 provides a recommended design gradation for riprap.

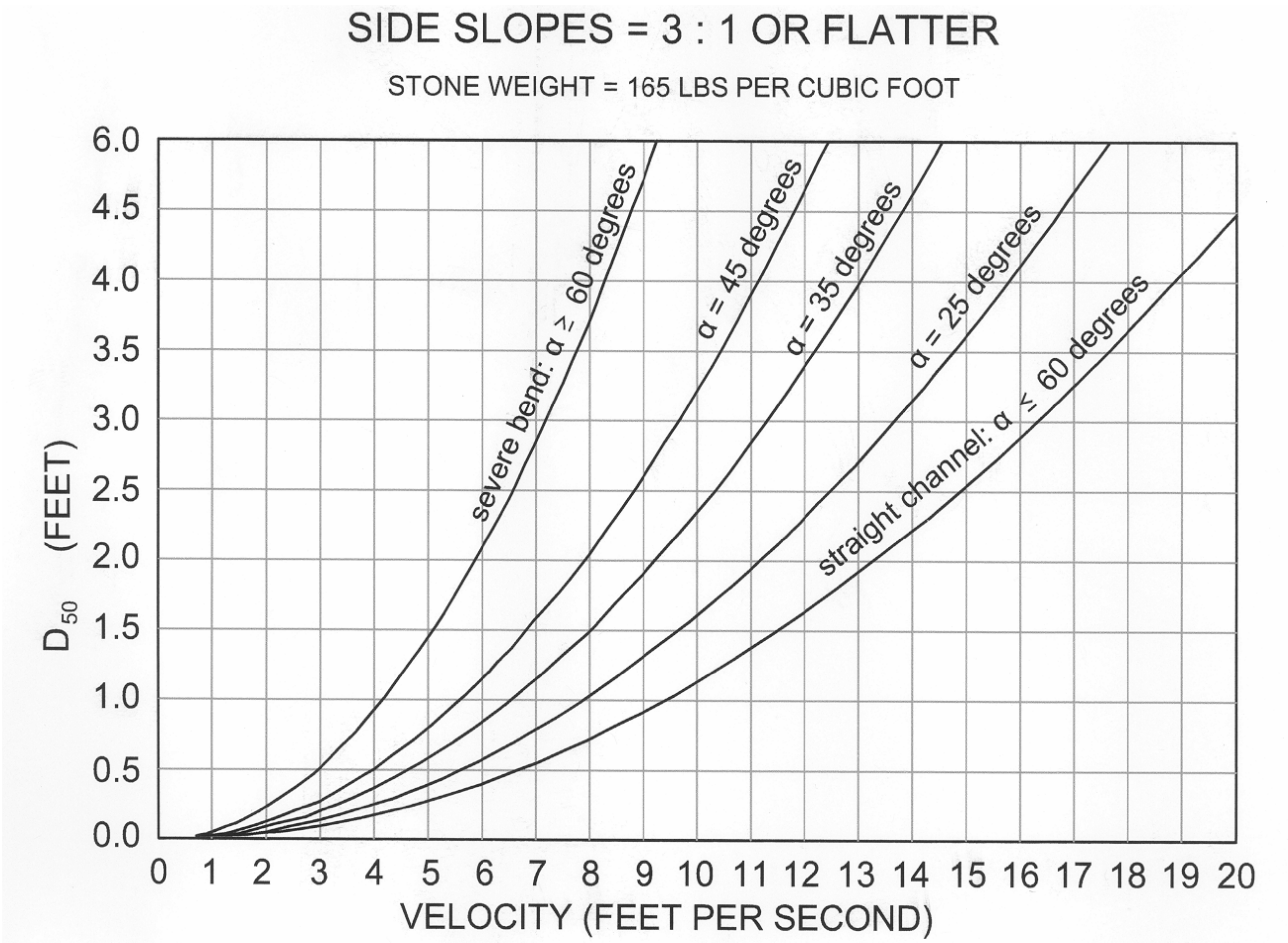
The shape of the riprap rock should be "blocky" rather than elongated. More nearly cubical rocks "nest" together, and are more resistant to movement. Also rocks with clean, sharp edges and relatively flat faces will form a riprap mass having an angle of internal friction greater than round stones, and will be less susceptible to slope failure.

TABLE 6.1
RIPRAP GRADATION CHART
(USDOT, FHWA, HEC-11)

Stone Size Range	Stone Weight Range	Percent of Gradation
1.5 d_{50} to 1.7 d_{50}	3.0 W_{50} to 5.0 W_{50}	100
1.2 d_{50} to 1.4 d_{50}	2.0 W_{50} to 2.75 W_{50}	85
1.0 d_{50} to 1.15 d_{50}	1.0 W_{50} to 1.5 W_{50}	50
0.4 d_{50} to 0.6 d_{50}	0.1 W_{50} to 0.2 W_{50}	15

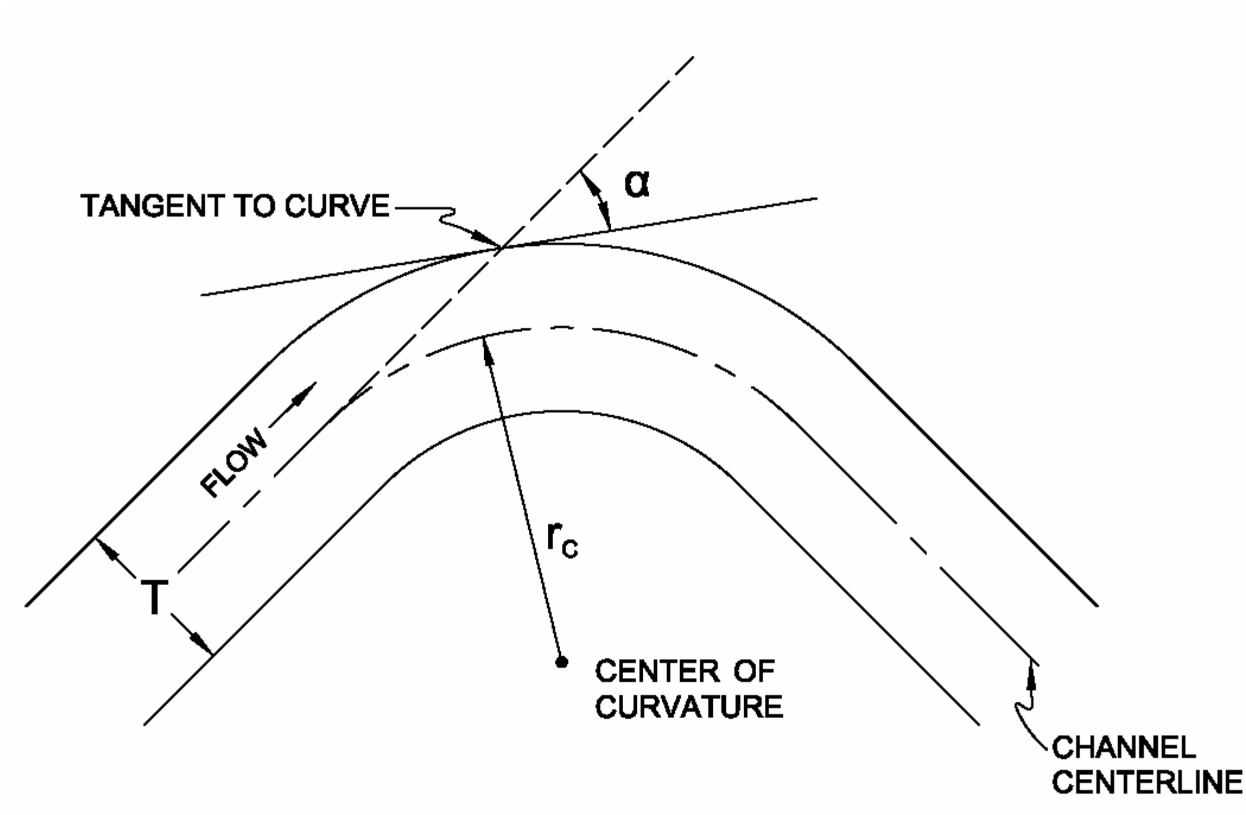
Riprap Filters

Filters are generally required underneath rock riprap to prevent fine material from being leached out through the riprap. Two types of filter materials are commonly used: gravel filters and fabric filters. Gravel filters consist of a layer of well-graded sands and gravels. Generally the thickness of a gravel filter should not be less than nine inches. Fabric filters are more commonly used, generally are very effective and easier to install than gravel filters, although care must be exercised in placing large rocks on the fabrics to prevent damage to the fabric.



SOURCE: City of Tucson Drainage Standards Manual (1989)

FIGURE 6.1
RIPRAP SIZING CHART



Relationship between α and r_c/T

$$r_c/T = \cos\alpha / (4 \times \sin^2(\alpha/2))$$

FIGURE 6.2
DEFINITION SKETCH FOR CHANNEL CURVATURE

6.3.2 Concrete

Concrete lined channels, reinforced with rebar or wire mesh, are often used when flow velocities are high, or when there is limited width for the construction of a channel. Concrete lining of the entire channel (i.e. banks and bottom) is usually required for very high flow velocity and steep channel gradients. However, an earthen bottom and concrete-lined banks, with bank toe-downs and, in some instances, periodic grade-control structures are also practical in certain locations. Concrete or "shotcrete" channel lining without some form of rebar or mesh reinforcement is *not* permitted by Yavapai County. The minimum thickness for concrete lined channels is six (6) inches, measured perpendicular to the face of the lining.

6.3.3 Gabion Baskets and Mattresses

Gabion baskets and mattresses are specially designed wire mesh containers for rock riprap stabilization. Gabions are generally used when adequate rock size or gradation is unavailable for ordinary dumped riprap. Additionally, gabion structures can be constructed on much steeper slopes than dumped riprap, and will therefore require less right-of-way. In general, the minimum thickness of a gabion basket should equal two-thirds of the D_{50} rock size determined from Figure 6.1. Additionally, an adequate gravel or fabric filter should always be installed with gabions.

6.3.4 Grouted Rock

Grouted rock provides another bank stabilization option when adequate rock size or gradation is unavailable for dumped riprap. Grouted rock may also be placed on slopes as steep as 1:1 provided the underlying soils have adequate strength. During construction of grouted rock bank protection, it is important that the grout is applied in a manner that ensures grout penetration to the bottom of the riprap blanket. The minimum thickness of grouted-rock bank stabilization should equal two-thirds of the D_{50} rock size determined from Figure 6.1. The rock shall be free of fines which prevent full penetration of grout.

6.3.5 Articulated Revetment Units

Articulated revetment units (ARUs) are a stabilization material which is composed of a system of interlocking concrete blocks which may be used to line drainageways. ARUs have limited application in this area, and are used primarily on small watercourses which have very flat side-slopes and very low velocities of flow. Certain manufacturers are producing ARUs that are suitable for larger watercourses. These particular products have the advantage of allowing vegetation to grow through the ARU mat. However, in many cases, cost is a limiting factor in utilizing these products. The design engineer should consult the manufacturer's design specifications in order to evaluate the suitability of using a particular ARU on a project.

6.3.6 Soil Cement

Soil cement, also termed Cement Stabilized Alluvium (CSA), is primarily used as channel bank stabilization on large alluvial watercourses in Arizona and elsewhere. It may also be used to line channel bottoms, as well as for use in the construction of larger scale grade-control structures, collector dikes, and spillways. Soil-cement bank stabilization is normally placed on 1:1 slopes, and consists of six to eight-inch vertical lifts, eight to ten feet in width, placed horizontally in a stair-step manner in order to attain the desired height of channel bank. Soil cement can also be placed on 3:1 (or flatter) slopes, at a minimum thickness of eight to twelve inches where a lesser level of protection is acceptable. This latter technique is often termed soil-cement "slope paving". Soil cement design applications shall consider the effects of freeze-thaw cycles.

6.4 Design Considerations

The design of drainage channels can involve highly complex hydraulic analysis techniques and considerations. The existence of transitions, culverts, channel curves, changes in flow regime, etc., can produce hydraulic conditions significantly different from those determined from steady, uniform-flow analyses. This section provides certain considerations that are commonly encountered in open channel analysis and design. However the design engineer is referred to the following publications for detailed presentation of these and other procedures and considerations associated with the design of open channel facilities: 1) *Hydraulic Design of Flood Control Channel*, U.S Army Corps of Engineers, 2) *Hydraulic Design Manual*, Los Angeles Flood Control District, and 3) *Design of Small Canal Structures*, U.S. Department of the Interior, Bureau of Reclamation.

6.4.1 Channel Geometry

Open drainage channels shall be designed using either trapezoidal, rectangular, or compound cross sections, unless prior approval of an alternate design is provided from the Yavapai County Flood Control District.

Side slopes for constructed earthen or dumped riprap channels shall be no steeper than 3:1, unless an approved soils analysis demonstrates that steeper side slopes are stable. Side slopes for lined channels may be steeper, depending upon the structural stability of the lining and the underlying soils. Reinforced concrete linings may have vertical side slopes, provided that the design is adequate to prevent failure from hydrostatic or earth pressures. Shotcrete may be placed on side slopes as steep as 1:1, provided this slope is not significantly steeper than the natural angle of repose of the soil. Soil cement lining may be placed on 1:1 side slopes, provided it is of sufficient thickness to be structurally stable. The minimum thickness of soil cement on a 1:1 side slope should be four feet, measured normal to its face. Where soil cement is used as slope paving, with a maximum thickness of one foot, the maximum allowable side slope should be 3:1.

In the case where a channel will be accepted for maintenance by the County, a minimum bottom width of 10-feet is required, and an access road, along at least one side of the channel bank, having a minimum width of 12 feet. Exceptions to the minimum requirements for public drainageways may be permitted if deemed appropriate by Yavapai County. Privately maintained channels have no minimum bottom width, except as dictated by hydraulic considerations.

6.4.2 Flow Regime

Flow regime in an open channel can be either subcritical (tranquil) or supercritical (rapid). The Froude number for subcritical flow is less than 1.0 and the Froude number for supercritical flow is greater than 1.0. Critical flow is defined as having a Froude number of 1.0. Flow that is in the proximity of critical depth is generally unstable and excessive wave action or undulations of the water surface may occur. For this reason channel designs should avoid flow regimes that have Froude numbers in the range of 0.86 to 1.13.

6.4.3 Freeboard

Freeboard is the additional depth required in a channel beyond the depth calculated for conveyance of the design discharge. The purpose of freeboard is to protect against hydraulic disturbances such as waves, unforeseen obstructions to flow, debris and inherent inaccuracies in assumptions and analyses techniques. Following are the minimum freeboard requirements for open channels, with a minimum freeboard of one foot for design depths of flow of three feet or more:

Subcritical Flow (i.e. Froude number < 0.86)

Minimum Freeboard = 1.0 feet

Supercritical Flow (i.e. Froude number > 0.86)

Minimum Freeboard Calculated From Equation 6.2. If the calculated minimum freeboard is less than one-foot and the flow depth is three (3) feet or greater the minimum freeboard shall be one (1) foot

$$FB = 1/6(y + v^2/2g) \qquad \text{(Eqn. 6.2)}$$

Where:

FB	=	Freeboard, in feet
y	=	Maximum depth of flow, in feet
v	=	Average velocity of flow, in feet per second
g	=	Gravitational constant = 32.2 ft./sec

The freeboard requirements described above are for uniform channel reaches where no unusual flow disturbances are anticipated. Additional freeboard is required at channel bends and junctions, where backwater effects or superelevation may occur, or where hydraulic jumps may occur. The engineer should consult the references provided at the beginning of this section for computing hydraulic conditions at such locations.

The lining of protected channels shall extend to a height necessary to include the freeboard requirement, unless approval to the contrary is granted from the Yavapai County Flood Control District.

6.4.4 Hydraulic Jump

A hydraulic jump occurs when flow changes from supercritical flow to subcritical flow. Hydraulic jumps can occur (1) when the slope of the channel changes from steep to mild; (2) at sudden expansions or contractions in the channel section; (3) at culverts or bridges in steep channels; (4) at the downstream side of dip crossings; (5) at channel junctions; and, (6) sharp bends.

Hydraulic jumps are useful in dissipating energy, and consequently they are often purposely forced to occur at drainageway outlet structures in order to minimize hydraulic forces and erosion. However, because of the large amount of energy dissipated in hydraulic jumps, it is not advisable to allow them to occur except under controlled circumstances. Therefore, if during the design of a channel, it appears that a hydraulic jump might occur at an undesirable location, computations should be made to determine the height, length and other characteristics of the jump. In addition, steps should be taken to either eliminate the jump or contain it, in order to prevent damage to the channel or surrounding property.

Procedures for analyzing the hydraulic jump are well documented in the references cited at the beginning of this section as well as in numerous other easily available hydraulic texts and manuals.

6.4.5 Curved Channels

Flow in a curved channel will create centrifugal forces which will cause a rise in the water surface along the outside of a bend. At the same time, a corresponding depression will be created in the water surface along the inside of the bend. In addition, spiral secondary currents tend to form within the bends. These currents can cause scour to occur along the outside of a bend, and deposition along the inside of a bend. Cross waves that propagate downstream will also form, if the flow in the channel is supercritical.

Although curves are inevitable in the design of most open channels, they should be minimized in order to avoid the special problems associated with their design. The design of channel bends must include considerations for superelevation, limiting curvature, bend scour, and special design curves.

6.4.6 Transitions

Transition sections designed to collect and/or discharge flow between the natural floodplain and constructed channels can be located at either the upstream or downstream ends of constructed channels. They can also be located along a segment or segments of a constructed channel itself. In either case, it is necessary to design the flow transition to minimize the disturbance of flow. In the case where flow in a constructed channel is being transitioned back to the natural floodplain, sufficient distance must be allowed for the flow to adequately expand to the original width of the natural floodplain.

Procedures for analyzing curved channels and transitions are well documented in the references cited at the beginning of this section as well as in other easily available hydraulic texts and manuals.

CHAPTER 7. EROSION AND SEDIMENTATION

7.1 Purpose

This chapter provides certain criteria and considerations that apply to alluvial watercourses (i.e. watercourses formed within unconsolidated sediments). This chapter does not apply to watercourses within Yavapai County that are formed within bedrock or highly stabilized geologic formations. The engineer should investigate the specific watercourse characteristics and discuss the matter with District staff, to determine whether erosion and sedimentation concerns need to be addressed for a particular project.

7.2 Policies

a. Assessment of erosion hazards shall be performed for all proposed development adjacent to alluvial (i.e., sand-bed) watercourses within Yavapai County.

b. Adequate building set-backs shall be established or bank stabilization measures shall provide for all development along alluvial watercourses.

c. A minimum building setback of 20 feet, or as established under the guidelines presented within Section 7.3.4 of this manual, applies to all channel banks and floodways.

7.3 Applicability and Procedures

7.3.1 Bank Protection Requirements

Bank protection measures to be designed along alluvial (i.e., sand-bed) watercourses will require scour analyses to determine bank protection toe-downs, unless the entire channel bottom will be lined. Toe-downs refer to the vertical distance that the bank protection extends below the invert of the channel. The design scour depth, to which the bank protection toe-downs must extend are determined by adding various scour components, as appropriate, and applying a safety factor to the result. The scour components which must be addressed include the following:

- *General scour*
- *Anti-dune trough depth*
- *Local scour*
- *Bend scour*
- *Low-flow thalweg*

Each of these scour components must be determined and summed in order to determine the *Total Scour*. A safety factor of 1.3 is typically applied to the *Total Scour* to determine the depth of toe-down for the bank protection. Detailed procedures and equations for estimating each of the above scour components is provided within the publication entitled *Design Manual for Engineering Analysis of Fluvial Systems* (ADWR, 1985). Engineers engaged in the analysis and design of flood-control and erosion-control facilities on sand-bed watercourses within Yavapai County should become familiar with this manual and utilize the procedures contained therein. In addition, a manual prepared for the City of Tucson presents a more simplified approach to the determination of the scour components necessary for design of bank protection toe-downs. The complete title of this manual is the *Standards Manual for Drainage Design and Floodplain Management in Tucson, Arizona*, (1989). Chapter 6 of this manual addresses scour and bank protection toe-downs. The manual is available from the City of Tucson Department of Transportation, Engineering Division. The procedures presented within either of these manuals are acceptable for designing bank protection toe-downs within Yavapai County.

7.3.2 Grade-Control Structures

When channelization of a natural watercourse occurs, the top width is usually narrowed, and channel roughness is normally decreased. The result usually is an increase in flow velocity and possibly flow depth, with a corresponding increase in sediment-transport capacity. Sediment transport capacity then exceeds sediment supply; then if the channel is composed of transportable sediments, the channel bed will begin to degrade. Another factor that contributes to this degradation is the upstream urbanization of the watershed. Urbanization increases runoff and decreases sediment yield, which further increases sediment transport. The result of all these factors is that channel bed degradation will occur until the channel slope is flat enough to result in the sediment transport rate becoming equal to the incoming sediment supply. Streambed degradation can become extreme over time and can threaten underground utilities, bank protection, culverts and other structures that are within or near the watercourse. Under these conditions, grade-control structures, or lining of the channel bed are usually required in order to prevent damage by stream-bed degradation.

An analysis to assess the potential need for grade-control structures will be required for all proposed channelization projects on alluvial or sand-bed watercourses within Yavapai County. Analysis procedures to perform this assessment are provided within the two previously referenced manuals (i.e., Arizona Department of Water Resources and City of Tucson).

7.3.3 Bridge Scour

In addition to standard hydraulic analyses associated with bridge design, a scour analysis is also required for proposed bridges located within alluvial or sand-bed watercourses. These analyses require assessment of the scour components listed previously within this section, with special attention given to local scour at bridge piers and abutments.

In addition to the two previously cited references relating to scour analysis, the following publication provides additional analysis procedures specific to scour analyses of bridge structures: *Highways in the River Environment*, U.S. Department of the Interior, Federal Highway Administration.

7.3.4 Building Setbacks

Prudent building set-backs shall be established for all proposed development adjacent to alluvial watercourses within Yavapai County. Channel bank erodibility may be assessed, and erosion setbacks may be established by using procedures developed by the Natural Resource Conservation District. These procedures are presented in detail in the previously referenced City of Tucson Standards Manual and consist of the *Allowable-Velocity Approach, Tractive-Stress Approach*, and the *Tractive-Power Approach*. In lieu of performing a detailed erosion study, the following equations may be used to establish setbacks to guard against lateral migration of unstabilized channel banks associated with alluvial watercourses which have drainage areas of less than 30 square miles (City of Tucson, 1989):

$$SB \geq 1.0\,(Q_{p100})^{0.5}, \text{ for } r_c/T_w \geq 10 \qquad \text{(Eqn. 7.1a)}$$

$$SB \geq 1.7\,(Q_{p100})^{0.5}, \text{ for } 5 < r_c/T_w < 10 \qquad \text{(Eqn. 7.1b)}$$

$$SB \geq 2.5\,(Q_{p100})^{0.5}, \text{ for } r_c/T_w \leq 5 \qquad \text{(Eqn. 7.1c)}$$

Where:

SB = Minimum setback, in feet, measured from the top edge of the highest channel bank or from the edge of the 100-year floodplain limit, whichever is closer to the channel centerline.

Q_{p100} = Peak discharge of 100-year flood, in cubic feet per second.

r_c = Radius of curvature of channel centerline, in feet.

T_w = Top width of channel, in feet.

Notes: 1. Equations 7.1b and 7.1c apply only to setbacks on the outside of the channel bend. Equation 7.1a may be used for setbacks on the inside of a channel bend.

2. See Figure 6.2 of this Manual for a determining r_c and T_w.

Lesser setbacks than those determined from Equations 7.1 may be allowed provided they can be justified by use of the following methods, which would indicate that a lesser setback is appropriate:

1. A detailed sediment transport analysis, prepared by an Arizona Registered Professional Civil Engineer.

2. The Allowable-Velocity Approach, Tractive-Stress Approach, or Tractive-Power Approach (City of Tucson, 1989), any or all of which must indicate that the channel banks are *not* erosive for the flow conditions associated with runoff events up to and including a 100-year flood on the affected watercourse.

Additional considerations which should be addressed when evaluating reduced erosion setbacks are as follows:

1. Determination of historical migration of the channel by viewing historical series of aerial photography.

2. Evaluate vegetation growth in the vicinity for bank stabilization and age of vegetation (certain vegetation species do not typically grow in floodplain areas).

3. Conduct a geotechnical evaluation to determine age of soils and erodibility.

4. Use alternative methods to determine age of soils in the area (e.g., archaeological review)

CHAPTER 8. CULVERTS AND STORM DRAINS

8.1 Purpose

This chapter provides policies and criteria for the analysis and design of culverts and stormdrain systems. Analysis methodologies are provided mainly by reference to widely accepted and available design manuals that have been prepared by the Federal Highway Administration and other government agencies.

8.2 Policies

a. All natural drainages crossing roadways will be culverted, unless otherwise approved by the County Engineer.

b. Street crossings shall be designed to convey the 25-year peak discharge under the road. Regardless of the size of the culvert, street crossings are to be designed to convey the 100-year peak discharge under and/or over the road to an area downstream of the crossing to which the flow would have gone in the absence of the crossing. 100-year flow depths over the roadway shall not exceed 1-foot in depth. Flows up to or including the 100-year frequency shall not cause increased flooding of private land, developable lands or buildings, unless a drainage easement is obtained for those areas. The ponded headwater elevation shall be delineated on a contour map or using other surveying methods, as required.

c. The minimum size for culverts draining roadways is 18-inches in diameter or arch equivalent, and for driveways is 15 inches in diameter.

d. Culverts with a diameter less than or equal to 48 inches shall have a concrete headwall or other approved inlet/outlet protection.

e. Outlet protection shall be evaluated for all culverts as described in this Chapter.

f. All culverts shall be placed in the natural flow line and channel whenever possible. A detail showing the proposed culvert(s) will be required. The detail will include but shall not be limited to, invert elevations, top of road elevations, headwalls, inflow and outflow channel geometry, erosion protection, etc.

g. Minimum cover of fill over culverts must be provided to maintain the structural integrity of the pipe under anticipated loading conditions. Culvert manufacturers provide minimum cover requirements for prefabricated pipe. All culverts shall have a minimum of one-foot (1) of cover from the top of subgrade. The top of culverts shall not extend into the roadway subgrade. Minimum cover shall be measured from the top of subgrade, which is the bottom of the pavement structural section.

h. Storm drains shall be designed such that at least one lane of traffic is free from runoff, during a 10-year flow, on arterial streets. Storm drains shall be designed such that flow will be contained between the curbs, during a 10-year flow, on local and collector streets.

i. The minimum pipe diameter allowable for public storm-drain systems is 18 inches, unless otherwise approved by Yavapai County . In general main-line stormdrains should be at least 24 inches in diameter.

j. Public storm-drain systems should be designed for pressure flow whenever possible.

k. The minimum flow velocity in a storm drain is 3 feet-per-second, for purposes of self-cleaning.

l. The minimum allowable storm-drain slope for concrete or smooth metal pipe shall be 0.1 percent. However a minimum slope of 0.3 percent is desirable, whenever possible.

m. Manholes should be located at stormdrain junctions, changes in pipe size, sharp curves, angle points in excess of ten degrees and at abrupt changes in grade. Manholes shall also be located at regular intervals as follows:

300 feet:	Pipe diameter $\leq$ 30 "
400 feet:	30" $<$ Pipe diameter $\leq$ 45 "
500 feet	Pipe Diameter $>$ 45"

8.3 Culvert Design Procedures

8.3.1 Culvert Hydraulics

Culvert hydraulics should be evaluated using the procedures established by the Federal Highway Administration (FHWA) as presented within the readily available publication entitled *Hydraulic Design of Highway Culverts* (1985), often referred to as "HDS-5". Culverts should be evaluated for **both** inlet control and outlet control, to ensure that the correct headwater elevation is determined. Use of the computer programs, such as the FHWA "HY-8" program or equivalents, are also acceptable for culvert analysis and selection.

In order to expedite review and approval of the hydraulic design of culverts by County staff, the Culvert Design Form within "HDS-5" should be used. This form is also provided as Figure 8.1 of this manual. The computer reports produced by the "HY-8" or equivalent programs are also acceptable for presenting culvert analysis results.

8.3.2 Debris Grates

As part of the culvert design process, the engineer should consider whether or not the upstream watershed will yield sufficient naturally-produced or man-made debris to pose a potential blockage problem. If debris is considered a problem, then an appropriate grate should be considered, or the culvert should be enlarged to account for blockage. Because of the large number of combinations of culverts and types of debris possible, there is no single standard grate design. Rather, the engineer is advised to review the Federal Highway Administration manual entitled *Debris-Control Structures* (1971) to help aid in selecting an appropriate debris grate.

It is the policy of Yavapai County that debris grates on culverts be used only where necessary. The recommended method of accounting for expected debris problems is to increase the size of the culvert, whenever possible.

8.3.3 Outlet Protection

Outlet protection shall be evaluated for all culverts. The following guidelines, adapted from the Arizona Highway Department, are suggested for determining what type of outlet protection is required. For culvert outlets located within the right-of-way, grouted riprap shall be provided at all inlets/outlets as well as on fill slopes, unless otherwise approved by the County Engineer. For culverts not located within the right-of-way the following outlet protection shall be utilized:

CULVERT OUTLET VELOCITY

Less than 4 fps	No protection required
More than 4 fps and less than 10 fps	Dumped rock riprap (See section 6.3.1 for riprap sizing)
More than 10 fps and less than 15 fps	Wire tied or grouted rock riprap
Greater than 15 fps	Energy dissipater

For culverts with outlet velocities greater than 15 fps, an energy dissipator should be considered. The objective of an energy dissipater is to return the flow to a condition which approximates the existing flow width, depth and velocity. The engineer designing energy dissipators should refer to the FHWA publication entitled *Hydraulic Design of Energy Dissipater for Culverts and Channels, HEC No. 14,* (1983).

8.4 Storm Drain Design Procedures

8.4.1 Storm Drain Hydraulics

The hydraulic design of storm drain systems includes the determination of flow peaks, the evaluation of street and gutter flow, capacity and spacing of inlets and hydraulic grade line computations for the underground conduits. The procedures provided within Chapter 3 of this manual shall be used for determining flow peaks for the design of stormdrain systems. A number of widely distributed manuals are available which provide hydraulic design procedures for evaluation of street and gutter flow, inlet design and hydraulic grade line calculations. Some of these manuals include 1) *Urban Storm Drainage Criteria Manual*, Denver Regional Council of Governments (1969), 2) *Drainage of Highway Pavements (HEC No. 12)*, Federal Highway Administration (1984), 3) *Design of Urban Highway Drainage - The State of the Art*, Federal Highway Administration (1979), and 4) *Drainage Design Manual for Maricopa County, Arizona, Volume II - Hydraulics*. Several additional publications are provided in the References section of this manual.

A number of computer programs are available for performing hydraulic grade line (HGL) calculations. The use of appropriate computer programs are acceptable, however in order to facilitate review and approval by Yavapai County, the results of any HGL computation should be compiled on a standard Hydraulic Grade Line Calculation Sheet such as is provided on Figure 8.2 of this manual. In addition, a profile plot of the hydraulic grade line shall be provided which, at a minimum, provides pipe invert elevation, hydraulic grade line, energy grade line, ground surface, pipe sizes, junctions, curves, angle points, man-holes, laterals and the downstream controlling tailwater.

8.4.2 Inlet Clogging

The following guidelines should be followed to provide an appropriate factor of safety against clogging of pavement inlets:

GRATES:

Sump Conditions:

- Orifice Flow: required area = 2 x calculated area.
- Weir Flow: required perimeter = 2 x calculated perimeter.

Continuous-grade conditions:

- Required length of opening = 2 x calculated length.

CURB OPENING INLETS:

Sump Conditions:

- Required length of opening = 1.5 x calculated length.

Continuous-grade conditions:

- Required length of opening = 1.25 x calculated length.

COMBINATION GRATE AND CURB OPENING:

Sump Conditions:

- Orifice Flow: required area = 2 x calculated area for grate; required length = 1.25 x calculated length for curb inlet.
- Weir Flow: required perimeter = 2.0 x calculated perimeter for grate; required length = 1.25 calculated length for curb inlet.

Continuous-grade conditions:

- Required length of opening = 1.5 x calculated length for grate; required length = 1.25 x calculated length for curb inlet.

SLOTTED DRAINS

Sump Conditions:

- Required length = 2 x calculated length.

Continuous-grade conditions:

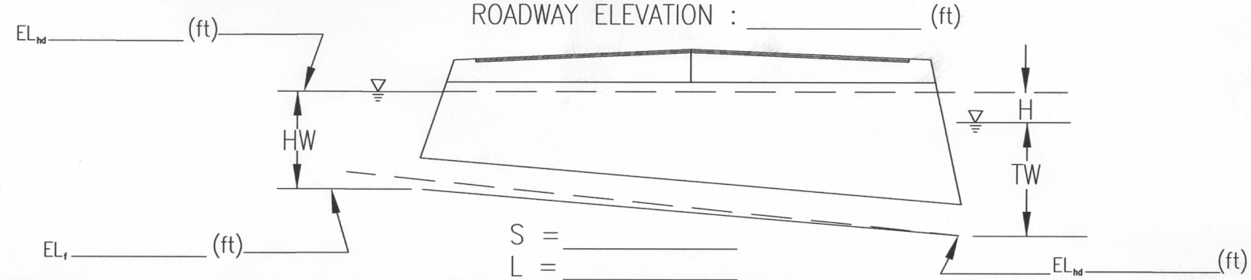
- Parallel to flow: required length = 1.5 x calculated length.
- Perpendicular to flow: Do not use.

These general guidelines should be used unless more detailed information related to clogging for a specific grate type is available from the manufacturer.

NOTE: All stormdrain inlet grates shall be designed to prevent bicycle tire penetration (i.e. "bicycle-safe" grates).

PROJECT: ______________________	STATION : ______________	**CULVERT DESIGN FORM**
______________________	SHEET ______ OF ______	DESIGNER/ DATE : __________ / __________ REVIEWER/ DATE : __________ / __________

ROADWAY ELEVATION : ____________ (ft)



CULVERT DESCRIPTION (MATERIAL - SHAPE - SIZE - ENTRANCE)	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS: INLET CONTROL				OUTLET CONTROL							CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
			HW/D (2)	HW	FALL (3)	EL_{hi} (4)	TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)			

TECHNICAL FOOTNOTES

(1) USE Q/NB FOR BOX CULVERTS

(2) HW_i / D FROM DESIGN CHARTS

(3) FALL = $HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = [(1 + k_e + (29n^2L))/R^{1.33}]V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS

a. APPROXIMATE
f. CULVERT FACE
hd. DESIGN HEADWATER
hi. HEADWATER IN INLET CONTROL
ho. HEADWATER IN OUTLET CONTROL
i. INLET CONTROL SECTION
o. OUTLET
sf. STREAMBED AT CULVERT FACE
tw. TAILWATER

COMMENTS / DISCUSSION:

CULVERT BARREL SELECTED

SIZE : ______________
SHAPE : ______________
MATERIAL : __________ n : ______
ENTRANCE : ______________

FIGURE 8.1
CULVERT DESIGN FORM

HYDRAULIC GRADE LINE CALCULATION SHEET SHEET ________ OF ________

PROJECT: ______________________________

LINE: ______________________________ CALCULATED BY: ______________________________

DATE: ______________________________

STATION	INVERT	D	H.G.L.	SHAPE	d_{gh}	A	Q	V	$V^2/2g$	Sf	Ave. Sf	L	h_f	h_b	h_j	h_{mh}	E.G.L.

FIGURE 8.2
HYDRAULIC GRADE LINE CALCULATION SHEET

CHAPTER 9. STREET AND PARKING LOT DRAINAGE

9.1 Purpose

The purpose of this chapter is to provide County policies related to stormwater flow within street sections and allowable ponding depths within parking areas.

9.2 Policies

9.2.1 Streets and Roadways

a. Cross-drainage structures shall be provided to pass flow under streets without diversion to adjacent properties. Street crossings shall be designed to convey the 25-year peak discharge under the road. Regardless of the size of the culvert, street crossings are to be designed to convey the 100-year peak discharge under and/or over the road, at a maximum depth of one (1) foot, to an area downstream of the crossing to which the flow would have gone in the absence of the crossing. Flows up to and including the 100-year frequency shall not cause increased flooding of private land, developable lands or buildings, unless a drainage easement is obtained for those areas. The ponded headwater elevation shall be delineated on a contour map or using other surveying methods, as required.

b. If drainage is to be carried in streets, minimum pavement widths may be increased to handle flows or as required by the County Engineer.

c. Roadside drainage channels shall be in accordance with the drainage analysis and the drainage plan as approved by the County Engineer.

d. Inverted crown streets will not be acceptable without approval of a variance from the County Engineer.

e. For new developments and subdivisions within three (3) miles of the corporate limits of a city or town, the roads and roadways shall be designed to the adopted drainage criteria of that city or town or the county criteria, whichever criteria is more restrictive. The drainage design criteria selected shall consider the city or town supporting and/or supplying services and the potential for annexation.

f. In general, "at-grade" or "dip" crossings are not permitted. However, for flows crossing broad shallow washes, where the construction of a culvert is not practical or desirable, the road may be dipped to allow the entire flow to cross the road. Use of dip crossings must be approved by the County Engineer. The pavement through the dip shall have a one-way slope parallel to flow and curbing and medians must not be raised. Upstream and downstream cutoff walls and aprons shall be provided to mitigate headcutting and erosion.

g. Depth of flow in the roadside drainage channels for the design storm shall be limited to preclude saturation of the adjacent roadway base course.

h. Local soil conditions, flow depths, and velocities within the channel are usually the primary hydraulic considerations in channel geometric design; however, terrain and safety considerations have considerable influence. Steeper side slopes of rigid, lined channels may be more economical and will improve the hydraulic flow characteristics. The use of steeper slopes is normally limited to areas with limited roadway where the hazard to traffic can be minimized through the use of guardrails or parapets.

i. Whenever possible, storm water shall be conveyed separately from the street system and defined drainageways shall follow existing alignment.

j. In the event nuisance water is conveyed in the street, curb and gutter will be required. Runoff shall be limited to the 10-year storm event or a maximum centerline crown depth of "zero", whichever is less, and must be contained within the curbed sections.

k. If curbs and gutters are to be installed, a detailed cross-section of the proposed curb and gutter shall be specified on the Project Plans for approval before construction. Construction and design shall be to ADOT or M.A.G. Standard Specifications and approved by the County Engineer.

l. In the event the street is used for nuisance drainage, an engineered outlet structure will be required with calculations, by an approved method, supporting outlet capacity.

m. Drainage ditches behind curbs are neither required nor encouraged.

9.2.2 Parking Lots

a. Parking shall be permitted in the floodplains of watercourses provided that the maximum depth of flow does not exceed two feet during a 100-year flood. Overnight parking will be limited to floodplains where the flooding does not exceed one foot in depth during the 100-year flood, unless otherwise approved by Yavapai County.

b. Any parking lot that is located within a 100-year floodplain shall have a prominent sign posted at the entrance to the parking area that contains the information that the parking lot is subject to periodic flooding of depths up to "x" feet, and that overnight parking is not advised.

c. Parking areas may be used as detention/retention facilities provided that maximum depths of ponding do not exceed one foot. The areas which have the maximum depth of ponding should be located in the more remote areas of the parking lot, whenever feasible.

d. Any portion of a parking lot that is located within a detention/retention facility shall have a prominent sign posted at the entrance to the parking area that contains the information that the parking lot is subject to periodic flooding of depths up to "x" feet, and that overnight parking is not advised.

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<u>APPENDIX 1</u>

YAVAPAI COUNTY STORMWATER GUIDANCE MANUAL
FOR CONSTRUCTION SITES

(BOUND UNDER SEPARATE COVER)

YAVAPAI COUNTY STORMWATER GUIDANCE MANUAL FOR CONSTRUCTION SITES

Prepared for:

Yavapai County, Arizona

Prepared by:

WestLand Resources, Inc.
Engineering and Environmental Consultants

TABLE OF CONTENTS

1. INTRODUCTION

This guidance document has been developed by Yavapai County in order to help operators of construction sites in the County understand and comply with the stormwater management requirements of the Arizona Department of Environmental Quality. Arizona Department of Environmental Quality regulates discharges of stormwater from construction sites under the Arizona Pollutant Discharge Elimination System Construction General Permit.

The operator could be the owner, the developer, the general contractor, or individual contractor. When responsibility for operational control is shared, all operators must apply. Thus, a single construction site may have a number of operators who may operate under a common or separate Stormwater Pollution Prevention Plan.

The Arizona Department of Environmental Quality promulgated administrative rules in 2001 (Title 49, Chapter 2, Article 3.1, the Arizona Administrative Code; Title 18, Chapter 9, Articles 9 and 10; and the Clean Water Act as amended [33 U.S.C. 1251 et seq.]) establishing the Arizona Pollutant Discharge Elimination System Program that governs stormwater discharge from construction sites into waters of the United States.

Stormwater discharges generated during construction activities can cause an array of physical, chemical and biological water quality impacts. Specifically, the biological, chemical and physical integrity of the waters may become severely compromised. Water quality impairment results, in part, because a number of pollutants are preferentially absorbed onto mineral or organic particles found in fine sediment. The interconnected process of erosion (detachment of the soil particles), sediment transport and delivery is the primary pathway for introducing key pollutants such as nutrients (particularly phosphorus), metals and organic compounds into aquatic systems.

Stormwater runoff from construction sites can include pollutants other than sediment such as phosphorous and nitrogen, pesticides, petroleum derivatives, construction chemicals and solid wastes that may become mobilized when land surfaces are disturbed. Generally, properly implemented and enforced construction site ordinances effectively reduce these pollutants.

These rules apply to discharges that are within Arizona, but not within Indian Nations as defined by 18 U.S.C. §1151. Issued for a five-year period beginning February 25, 2003, the Arizona Pollutant Discharge Elimination System General Stormwater Permit for Construction Activities (the “Permit”) replaces the previous construction general permit that was issued for a five-year term by Environmental Protection Agency Region 9 in February 1998 (63 FR 7858) and July 1998 (63 FR 36490). A Permit is required for all construction sites that disturb an area greater than one acre. The Permit contains requirements such as submittal of the Notice of Intent at least two days prior to commencement of construction and development of a Stormwater Pollution Prevention Plan specific to each construction site. Permit coverage for each construction site greater than one acre is required from commencement of construction until the site has been stabilized as defined in the Permit. Details of the Arizona Pollutant Discharge Elimination System Program can be found on Arizona Department of Environmental Quality’s website at:

http://www.azdeq.gov/environ/water/permits/stormwater.html#const.

This document provides an overview of the general Permit requirements and instructions that will help you determine if you need to seek Permit coverage for your site, and guide you through the Permitting process, including how to obtain Permit coverage, basic requirements and example of a typical Stormwater Pollution Prevention Plan outline, and how to implement the Stormwater Pollution Prevention Plan during construction, including inspection and maintenance. The five sections in this guidance include: 1) Introduction; 2) Before Construction; 3) During Construction; 4) Following Construction; and 5) Stormwater Compliance at a Glance.

2. BEFORE CONSTRUCTION – "PLAN THE WORK"

DOES MY CONSTRUCTION PROJECT NEED PERMIT COVERAGE?

Yes, if any of the following are true:

- My project disturbs more than one acre.
- My project disturbs less than one acre but is part of a larger plan of development.

In addition to a stormwater permit, you may need other permits from local, state, or federal agencies. For example, you may need:

- County Grading Permit
- Air Quality Permit
- US Army Corps of Engineers 404 Permit
- Aquifer Protection Permit
- Others

Contact Development Services for assistance, at:

Yavapai County Development Services
(www.co.yavapai.az.us)

ARE THERE ANY WAIVERS FROM PERMIT COVERAGE?

Yes. Two, in fact:

- Where the rainfall erosivity factor (R) in the revised universal soil loss equation (RUSLE) is less than five (5). This can be determined through either: 1) Arizona Department of Environmental Quality's web-based SMART system (http://az.gov/adeq/noi), or 2) a manual calculation (http://www.epa.gov/npdes/pubs/fact3-1.pdf).
- Where the operator certifies that stormwater controls are not needed based upon a total maximum daily load (TMDL). Currently, Arizona TMDLs do not address this issue; however, the permit includes the TMDL waiver as a future option.

HOW DO I OBTAIN PERMIT COVERAGE?

The operator for the project must submit a Notice of Intent (http://www.azdeq.gov/environ/water/permits/download/constnoi.pdf), the official form for notifying Arizona Department of Environmental Quality of the operator's intention to discharge stormwater under the Construction General Permit. When the operator signs the Notice of Intent, he or she certifies that a Stormwater Pollution Prevention Plan for the project has been completed and is in place, and that the operator will comply with the terms and conditions of the Construction General Permit. Arizona Department of Environmental Quality now has an online SMART Notice of Intent system (http://az.gov/adeq/noi), which allows the operator to complete and submit a Notice of Intent electronically.

The Notice of Intent, Stormwater Pollution Prevention Plan, and the authorization letter received from the Arizona Department of Environmental Quality must be submitted to the Yavapai County Development Services/Flood Control District for review.

HOW DO I KNOW IF I'M AN OPERATOR?

An operator is defined in the Construction General Permit as any person associated with a construction project that meets either of the following two criteria:

1. The person has operational control over construction plans and specifications, including the ability to make modifications to those plans and specifications; or
2. The person has day-to-day operational control of those activities at a project necessary to ensure compliance with a Stormwater Pollution Prevention Plan for the site or other permit conditions (e.g., authorized to direct workers at a site to carry out activities required by the Stormwater Pollution Prevention Plan or comply with other permit conditions).

What information do I need to include in my Notice of Intent?

Information that needs to be provided with the Notice of Intent includes:

- Operator name and contact information
- Project information (project name, location, size, estimated construction dates, etc.)
- Receiving waters
- Location of Stormwater Pollution Prevention Plan

The information in the Notice of Intent must be complete and accurate for discharges to be authorized by the Construction General Permit.

When Should I Submit My Notice of Intent?

Typically, permit coverage is available within two business days of Arizona Department of Environmental Quality's receipt of the Notice of Intent. However, there are two circumstances in which permit coverage may be delayed:

- If the project is within an area that the Arizona Department of Environmental Quality and the U.S. Fish and Wildlife Service have determined may support animals or plants protected under the Endangered Species Act, or

- If the project is within ¼ mile of a unique (http://www.azdeq.gov/environ/water/permits/images/uw.jpg) or impaired (http://www.azdeq.gov/environ/water/assessment/download/305-02/att3.pdf) water.

In either case, Arizona Department of Environmental Quality will issue a letter to the applicant noting that permit coverage is being delayed *32 business days* while Arizona Department of Environmental Quality reviews the potential impacts of the project. In the case of unique or impaired waters, Arizona Department of Environmental Quality requires that the Stormwater Pollution Prevention Plan be submitted along with the Notice of Intent.

HOW MANY NOTICES OF INTENT DO I NEED FOR A PROJECT?

Anyone who qualifies as an operator must submit a Notice of Intent for the project. Any given project, therefore, may have multiple Notices of Intent with different operators working under a shared Stormwater Pollution Prevention Plan or separate Stormwater Pollution Prevention Plans.

Another consideration is whether or not parts of the construction project will be sold off prior to stabilization of the entire site. For instance, in residential development projects, it is not uncommon for a developer to sell blocks of the development to a variety of homebuilders after land development has occurred. However, even though the sites have been sold, the developer still has a stormwater obligation under the Stormwater Pollution Prevention Plan until he can submit a Notice of Termination for the entire property. Therefore, it has become common practice for a land developer to submit separate Notices of Intent for each anticipated block, allowing him to submit Notices of Termination as responsibility for the stormwater management is transferred to the homebuilder.

WHAT'S IN A STORMWATER POLLUTION PREVENTION PLAN?

The Stormwater Pollution Prevention Plan is a public document that:

- Identifies potential sources of pollution in discharges from a construction site,
- Identifies Best Management Practices that will be used to reduce pollutants in stormwater,
- Assures compliance with the terms and conditions of the Construction General Permit, and
- Identifies the responsible parties for onsite activities

The Stormwater Pollution Prevention Plan must be signed and certified by an Operator with policy-making authority or a duly authorized representative of the Operator.
A sample Table of Contents for a Stormwater Pollution Prevention Plan is provided on the following page.

The Arizona Department of Environmental Quality Construction Stormwater Pollution Prevention Plan checklist (http://www.azdeq.gov/environ/water/permits/download/cswppp.pdf) is a useful tool to ensure your plan meets all of the necessary requirements.

SWPPP TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

WHAT TYPE OF BEST MANAGEMENT PRACTICES DO I NEED?

Best Management Practices can be both structural and non-structural. Non-structural Best Management Practices, such as good housekeeping and proper maintenance of onsite vehicles and equipment, are often as important as structural Best Management Practices in improving the quality of stormwater discharges from a construction site.

Structural Best Management Practices should be designed to reduce or prevent sediment loss from disturbed areas on your construction site. There are three general types of structural Best Management Practices that should be used on the site:

- Runoff control – diversions, check dams, grade control structures, velocity dissipaters
- Erosion control – surface roughening, soil stabilizers, straw mats
- Sediment control – silt fences, filter socks, earthen berms, sediment basins and traps

Naturally, proper installation of structural Best Management Practices according to manufacturers' and/or engineers' recommendations is essential to an effective stormwater management program.

EXAMPLES OF COMMON BEST MANAGEMENT PRACTICES

The most common Best Management Practices are:

- Temporary Diversion Dike,
- Stabilized Construction Entrance,
- Check Dams,
- Straw Bale Barriers, and
- Silt Fence.

Construction techniques for these Best Management Practices are provided as Appendix A.

TYPICAL CONSTRUCTION SITE PROBLEMS AND ASSOCIATED BEST MANAGEMENT PRACTICES

Concrete washout with no containment or sign

Designated concrete wash out area

Silt Fence - Bad

Silt Fence - Good

Petroleum Product Storage - Bad

NOI Posting – Needs to be complete NOI (both pages) and have AZPDES Permit number

Bad

Good

Storm Basin Inlet Protection

Bad

Good

Slopes

Bad

Good

Construction Entrances

Bad

Good

SOME USEFUL LINKS

Maintain your Best Management Practices - Environmental Protection Agency construction industry poster (http://www.epa.gov/npdes/pubs/posterside1.pdf)

Best Management Practice Fact Sheets
(http://www.epa.gov/npdes/pubs/app_b_conguide.pdf)

3. DURING CONSTRUCTION – "WORK THE PLAN"

INSTALLING BEST MANAGEMENT PRACTICES

- Follow your Stormwater Pollution Prevention Plan
- Install the Best Management Practices in the order specified in the Stormwater Pollution Prevention Plan's sequence of major activities
- Follow the engineers or manufacturers' specifications when installing the Best Management Practices

WHAT TO KEEP ON SITE

- Notices of Intent for all Operators associated with the project
- The Stormwater Pollution Prevention Plan itself
- A sign must be posted near the main entrance to the project with the following information:

  - Arizona Pollutant Discharge Elimination System Authorization Number
  - Name and telephone number of a local office or project contact person
  - Brief description of project
  - Location of the Stormwater Pollution Prevention Plan if not on site and name of a contact person for the Stormwater Pollution Prevention Plan

CONDUCTING INSPECTIONS ENVIRONMENTAL PROTECTION AGENCY GUIDANCE ON MAINTENANCE AND INSPECTION (HTTP://WWW.EPA.GOV/NPDES/PUBS/CHAP05_CONGUIDE.PDF)

- Inspections must be conducted by "qualified personnel".
- Include inspection frequency in the site Stormwater Pollution Prevention Plan.

Construction General Permit Requirements for Inspection Frequency are as follows:

- Once every seven calendar days, or
- Once every 14 calendar days, and also within 24 hours of the end of each storm event of 0.5 inches or greater,

OR

- Once a month, and anytime rain is predicted, and within 24 hours of the end of each storm event of 0.5 inches or greater where any of the following conditions exist:

  - The site has been temporarily stabilized
  - Runoff is unlikely due to winter conditions
  - Construction is during a seasonally dry period in an area that receives less than 20 inches of rainfall per year

- Document findings of the inspection on a Compliance Evaluation Report, which must be maintained with the Stormwater Pollution Prevention Plan.
- Once deficiencies are corrected, note the corrective action taken and the date and time of implementation on the inspection report.

Best Management Practice Maintenance

- All Best Management Practices must be maintained in effective operating condition.
- If a Best Management Practice needs to be modified or additional Best Management Practices are needed based on the results of an inspection, implementation must be completed before the next anticipated storm event or as soon as practicable.
- Sediment must be removed from traps or ponds when capacity has been reduced by 50%.

STORMWATER POLLUTION PREVENTION PLAN MAINTENANCE

- The Stormwater Pollution Prevention Plan is a "living document" and must be updated as site conditions and Best Management Practices change.
- The Operator must amend the Stormwater Pollution Prevention Plan within 15 business days whenever:
  - There is a change in design, construction, operation, or maintenance at the construction site that has a significant effect on the discharge of pollutants to the waters of the United States that has not been previously addressed in the Stormwater Pollution Prevention Plan; or
  - During inspections, monitoring if required, or investigations by the Operator or by local, state, MS4, or federal officials, it is determined the discharges are causing or contributing to water quality exceedances or the Stormwater Pollution Prevention Plan is ineffective in eliminating or significantly minimizing pollutants in stormwater discharges from the construction site.
- If the Stormwater Pollution Prevention Plan needs to be revised based on results of an inspection, revise the Stormwater Pollution Prevention Plan within seven calendar days of the inspection.
- Keep records of maintenance activities and any Stormwater Pollution Prevention Plan modifications.
  - Note day, month and year of change on Stormwater Pollution Prevention Plan site map.
  - Keep records of when major grading activities begin or end, when Best Management Practices are installed or removed, and when stabilization occurs.
  - Records must be maintained for three (3) years following final stabilization of the site.

4. FOLLOWING CONSTRUCTION

SUBMIT NOTICE OF TERMINATION FORM (HTTP://WWW.AZDEQ.GOV/ENVIRON/WATER/PERMITS/DOWNLOAD/CONSTNOT.PDF)

The Notice of Termination is the official form to notify Arizona Department of Environmental Quality that you want to terminate Construction General Permit coverage. The Notice of Termination should be submitted when one of the following two criteria is met:

- Another Operator has assumed operational control, or
- Final stabilization is achieved.

Final stabilization **means that all soil-disturbing activities have been completed and either of the two following criteria have been met:**

- A uniform vegetative cover with a density of 70% of the native background vegetative cover is established on all areas not paved or covered by permanent structures.
- Equivalent permanent stabilization measures (e.g. pavement, rip-rap geotextiles, gabions) have been employed.

OR

- Temporary stabilization (including perimeter controls) has been achieved on residential lots prior to occupation by the homeowner, and the homeowner has been made aware of final stabilization requirements.

POST-CONSTRUCTION RESPONSIBILITIES

- The operator must install structural measures during construction for control of pollutants after construction is complete.
- Post-construction stormwater measures must be noted in the Stormwater Pollution Prevention Plan.
- Examples of Post-construction Best Management Practices (http://cfpub.epa.gov/npdes/stormwater/menuofbmps/post.cfm)
- The operator is only responsible for the installation and maintenance of stormwater management measures prior to final stabilization of the site, and is not responsible for maintenance after stormwater discharges associated with construction activity have been eliminated from the site.

5. STORMWATER COMPLIANCE AT A GLANCE

1. Prepare a Stormwater Pollution Prevention Plan
2. Certify the Stormwater Pollution Prevention Plan
3. Submit a Notice of Intent
4. Retain the Notice of Intent and the Stormwater Pollution Prevention Plan at the project site
5. Implement the Stormwater Pollution Prevention Plan
6. Inspect and maintain pollution controls, improving as necessary
7. Submit Notice of Termination
8. Retain records after the project is complete for a minimum of three years

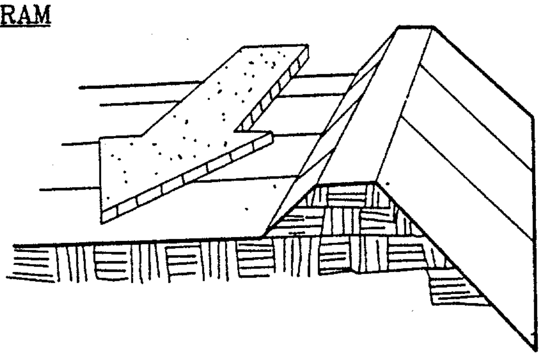
APPENDIX A

BEST MANAGEMENT PRACTICES

CONSTRUCTION TECHNIQUES

SYMBOL	**TEMPORARY DIVERSION DIKE**
D.D.	

DIAGRAM



CONDITIONS WHERE PRACTICE APPLIES

_*_ PERIMETER CONTROL
_*_ SLOPE PROTECTION
___ SEDIMENT TRAPPING
___ DRAINAGEWAY & STREAM PROTECTION
___ TEMPORARY STABILIZATION
___ PERMANENT STABILIZATION & EXPOSURE LIMITS
___ NON-SEDIMENT POLLUTION CONTROL

DEFINITION

A temporary berm or ridge of compacted soil, located in such a manner as to channel water to a desired location.

PURPOSE

The purpose of an earth dike is to direct runoff to a sediment trapping device or stabilized outlet, to reduce the potential for erosion. Earth dikes can also be used for diverting clean water away and sheet flows away from disturbed areas and unprotected slopes.

APPROPRIATE APPLICATIONS

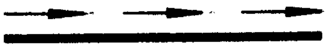
Earth dikes are often constructed upstream of disturbed areas and around construction sites. The dikes should remain in place until the disturbed areas are permanently stabilized. The dikes must be on-site and maintain the inflow and outflow conditions at the site to the historic drainage pattern.

LIMITATIONS

Limit to upstream drainage areas of 10 acres or less and for slopes less than 5 percent. For larger areas more permanent structures should be built. All structures shall be in compliance with local municipality's or Flood Control District's hydraulic design standards.

- Often times earth dikes create more disturbed area on site and become barriers to construction equipment.
- Earth dikes must be stabilized immediately which adds cost and maintenance concerns.
- Diverted stormwater flow may cause flood damage to adjacent areas.

SYMBOL	TEMPORARY DIVERSION DIKE
D.D.	



PLANNING CONSIDERATIONS

An earth dike itself does not control erosion or remove sediment from runoff, rather it directs runoff to an erosion control device such as a sediment trap or directs runoff away from an erodible area. Temporary diversion dikes should not adversely impact adjacent properties and must conform to local floodplain management regulations.

- Advantages:
  - Earth dikes can handle flows from large drainage areas and are easy to install.
  - Also, once stabilized, earth dikes require little maintenance.
  - Uses on-site materials.

DESIGN & SIZING CRITERIA

Temporary Diversion Dikes

1. All dikes shall be compacted by earth-moving equipment.

2. All dikes shall have positive drainage to an outlet.

3. Top width may be wider and side slopes may be flatter if desired to facilitate crossing by construction traffic.

4. Location should be adjusted as needed to utilize a stabilized safe outlet.

5. Earth dikes shall have an outlet that functions with a minimum of erosion. Runoff shall be conveyed to a sediment trapping device such as a sediment trap or sediment basin when either the dike channel or the drainage area above the dike are not adequately stabilized.

SYMBOL	**TEMPORARY DIVERSION DIKE**
D.D.	

6. Temporary stabilization, when necessary, shall be as scheduled below:

FLOW CHANNEL STABILIZATION

TYPE OF TREATMENT	CHANNEL GRADE	ROCK (D50) STABILIZATION
1	0.5-1.0%	4" Rock
2	1.1-2.0%	6" Rock
3	2.1-4.0%	8" Rock
4	4.1-5%	Rip-Rap 8-12"

A. Stone or recycled concrete equivalent, in a layer at least 8 inches in thickness and be pressed into the soil with construction equipment.

B. Rip-Rap to be in a layer at least two times the D50 and pressed into the soil.

C. Approved equivalents can be substituted for any of the above materials.

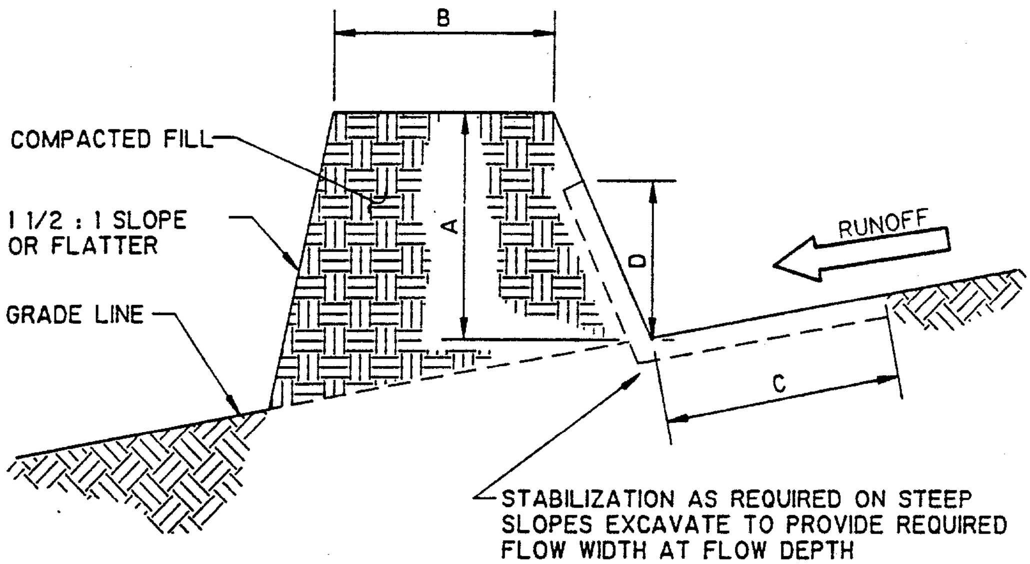
7. Filter cloth may be used for dikes in use for long periods.

MAINTENANCE REQUIREMENTS

Inspection and required maintenance must be provided after each rain event.

References (1,10,11,23)

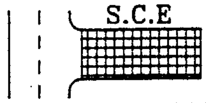
SYMBOL	TEMPORARY DIVERSION DIKE
D.D.	



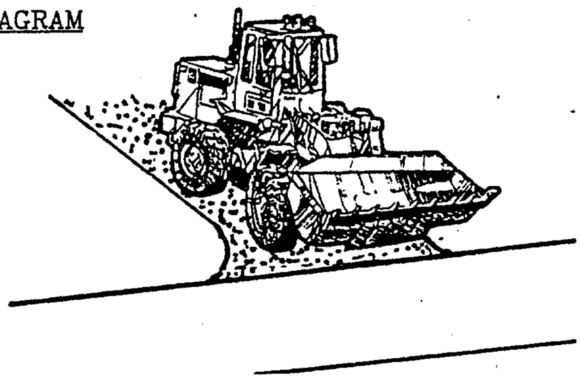
REQUIREMENTS BASED ON UPSTREAM DRAINAGE AREA

	DIKE 1 (5 ACRES OR LESS)	DIKE 2 (5-10 ACRES)
A-DIKE HEIGHT	18″	36″
B-DIKE WIDTH	24″	36″
C-FLOW WIDTH	4′	6′
D-FLOW DEPTH	8″	15″

TEMPORARY DIVERSION DIKE

SYMBOL	STABILIZED CONSTRUCTION ENTRANCE
	

DIAGRAM



CONDITIONS WHERE PRACTICE APPLIES

- ___ PERIMETER CONTROL
- ___ SLOPE PROTECTION
- _*_ SEDIMENT TRAPPING
- ___ DRAINAGEWAY & STREAM PROTECTION
- _*_ TEMPORARY STABILIZATION
- ___ PERMANENT STABILIZATION & EXPOSURE LIMITS
- _*_ NON-SEDIMENT POLLUTION CONTROL

DEFINITION

A stabilized pad of aggregate underlain with filter cloth located at any point where traffic will be entering or leaving a construction site to or from a public right-of-way, street, alley, sidewalk or parking area.

PURPOSE

The purpose of a stabilized construction entrance is to reduce or eliminate the tracking of sediment onto public rights-of-way or streets. Reducing trackout of sediments and other pollutants onto paved roads helps prevent deposition of sediments into local storm drains and production of airborne dust.

APPROPRIATE APPLICATIONS

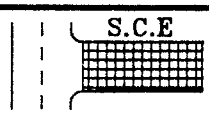
A stabilized construction entrance should be used at all points of construction ingress and egress. NPDES permits require that appropriate measures be implemented to prevent trackout of sediments onto paved roadways.

LIMITATIONS

The stabilized construction entrance plan should be reviewed as part of the project traffic control plan.

- Construct on level ground.
- Stabilized construction entrances are rather expensive to construct and when a wash rack is included, a sediment trap of some kind must also be provided to collect wash water runoff.

SYMBOL



STABILIZED CONSTRUCTION ENTRANCE

PLANNING CONSIDERATIONS

Stabilized construction entrances are not very effective in removing sediment from equipment leaving a construction site. Efficiency is greatly increased, though when a washing rack is included as part of a stabilized construction entrance. Build on level ground.

♦ Advantages:

- Does remove some sediment from equipment and serves to channel construction traffic in and out of the site.

DESIGN & SIZING CONSIDERATIONS

The aggregate for stabilized construction entrance aprons shall be 1 to 3 inches in size, washed, well-graded gravel or crushed rock. The apron dimensions recommended are 30 ft. x 50 ft. and 6 inches deep.

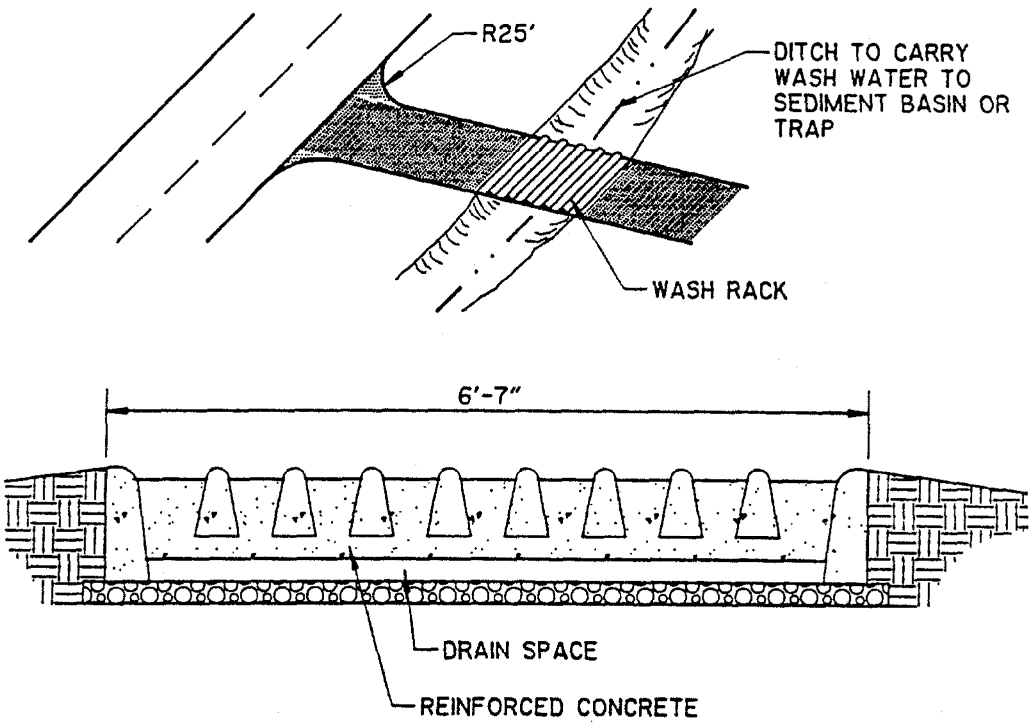
- Entrance must be properly graded to prevent runoff from leaving the construction site.
- When wash areas are provided, washing shall be done on an area stabilized with crushed stone which drains into a properly constructed sediment trap or basin (pond).

MAINTENANCE REQUIREMENTS

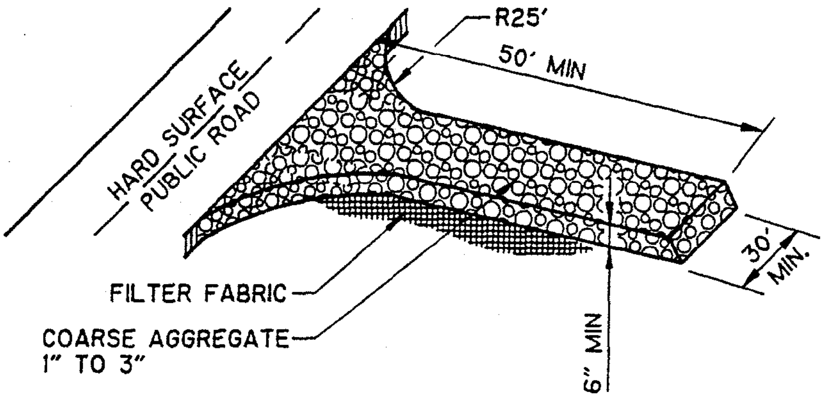
- Inspect monthly and after each rainfall.
- Replace gravel mat when surface voids are no longer visible. Periodic top dressing with additional stone will be required.
- All sediments deposited on paved roadways must be removed within 24 hours.
- Remove gravel and filter fabric upon completion of construction.

References (1,2)

SYMBOL	**STABILIZED CONSTRUCTION ENTRANCE**
	



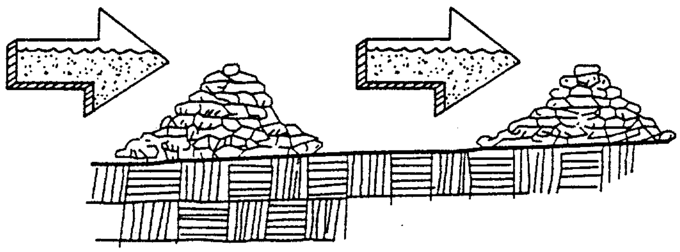
WASH RACK



STABILIZED CONSTRUCTION ENTRANCE

SYMBOL	CHECK DAMS
C.D. 	

DIAGRAM



CONDITIONS WHERE PRACTICE APPLIES

___ PERIMETER CONTROL
___ SLOPE PROTECTION
_*_ SEDIMENT TRAPPING
_*_ DRAINAGEWAY & STREAM PROTECTION
___ TEMPORARY STABILIZATION
___ PERMANENT STABILIZATION & EXPOSURE LIMITS
___ NON-SEDIMENT POLLUTION CONTROL

DEFINITION

Small temporary dams constructed across a swale or drainage ditch.

PURPOSE

Check dams reduce the velocity of concentrated stormwater flows, thereby reducing erosion of the swale or ditch, and slow water velocity to allow sediment capture.

APPROPRIATE APPLICATION

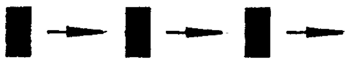
Check dams are used to reduce the velocity of channel flow in smaller channels and temporary swales. This practice is limited to use in small open channels which drain 10 acres or less.

LIMITATIONS

Check dams should not be used in live streams. Do not install in channels which have already been lined or vegetated.

PLANNING CONSIDERATIONS

Check dams only perform their function of reducing velocities of concentrated flows and energy if they have been sized and constructed correctly and are maintained properly.

SYMBOL	**CHECK DAMS**
C.D. 	

- Advantages:

    - Check dams reduce the need for more stringent erosion control practices in the swale due to the decreased velocity and energy of runoff.

DESIGN & SIZING CRITERIA

Check dams can be constructed of either rock or logs. Provide a deep sump immediately upstream.

The maximum spacing between the dams shall be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam.

Rock check dams shall be constructed of appropriately sized rock of D50 equal to 8"-12" minimum. The rock must be placed by hand or mechanical placement (no dumping of rock to form dam) to achieve complete coverage of the ditch or swale and to ensure that the center of the dam is lower than the edges. The rock used must be large enough to stay in place given the expected design flow through the channel.

Log check dams shall be constructed of 4 to 6-inch diameter logs. The logs shall be embedded into the soil at least 18 inches.

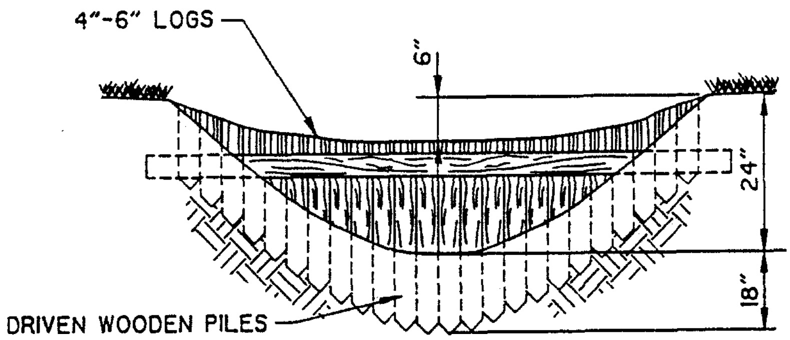
In the case of grass-lined ditches and swales, check dams shall be removed when the grass has matured sufficiently to protect the ditch or swale unless the slope of the swale is greater than 4 percent. The area beneath the check dams shall be seeded and mulched immediately after dam removal.

MAINTENANCE REQUIREMENTS

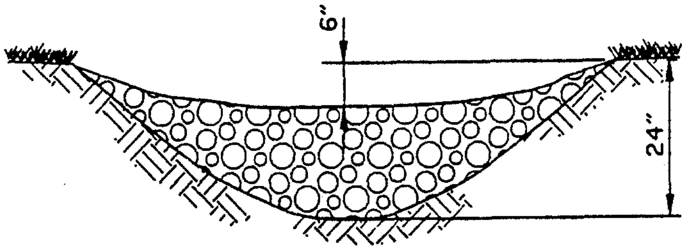
Check dams shall be monitored for performance and sediment accumulation during and after each runoff producing rainfall. Sediment shall be removed when it reaches on half the sump depth.

Reference (1,14)

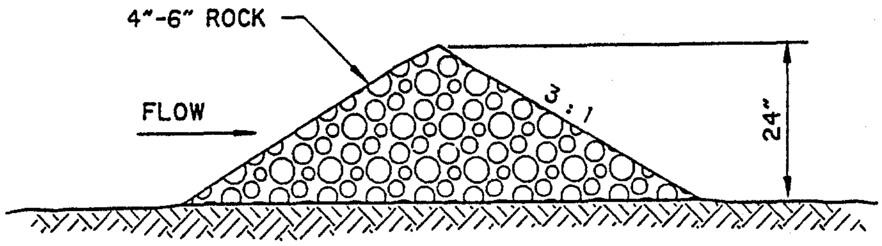
SYMBOL	CHECK DAMS
C.D.	



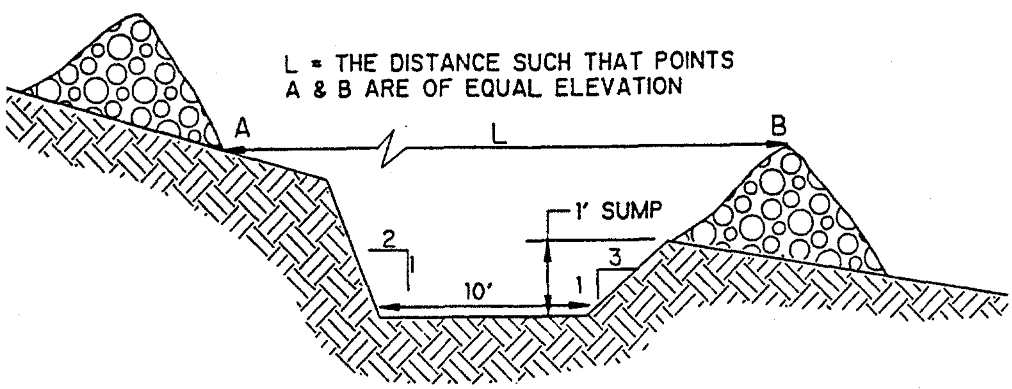
LOG CHECK DAM



ROCK CHECK DAM



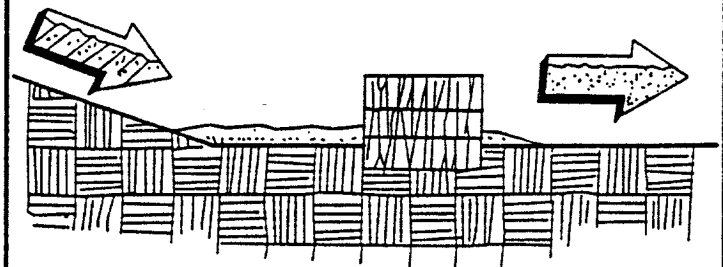
ROCK CHECK DAM CROSS-SECTION



SPACING BETWEEN CHECK DAMS

SYMBOL	STRAW BALE BARRIERS
S.B.B. ■ ■ ■ ■ ■ ■	

DIAGRAM



CONDITIONS WHERE PRACTICE APPLIES

- _*_ PERIMETER CONTROL
- ___ SLOPE PROTECTION
- _*_ SEDIMENT TRAPPING
- ___ DRAINAGEWAY & STREAM PROTECTION
- ___ TEMPORARY STABILIZATION
- ___ PERMANENT STABILIZATION & EXPOSURE LIMITS
- ___ NON-SEDIMENT POLLUTION CONTROL

DEFINITION

A temporary barrier of straw bales or similar material used to intercept sediment laden runoff from small drainage areas of disturbed soil.

PURPOSE

The purpose of a straw bale dike is to reduce runoff velocity and cause deposition of the transported sediment load.

APPROPRIATE APPLICATIONS

The straw bale dike is used where there are no concentrations of water in a channel or drainage way, and where erosion would occur from sheet flow. These barriers are typically constructed, below disturbed areas subject to sheet flow of runoff to intercept and detain sediment.

LIMITATIONS

- Straw bale dikes are not to be used for extended periods of time because they tend to rot and fall apart.
- Suitable only for sheet flow on slopes of 2% or flatter.
- Not appropriate for large drainage areas, limit to one acre or less.
- Straw bales lose their effectiveness rapidly due to rotting, thus constant maintenance is required.
- Not recommended for concentrated flow, channel flow, and live streams.
- Bale bindings of jute or cotton not recommended.

SYMBOL	STRAW BALE BARRIERS
S.B.B. ■ ■ ■ ■ ■ ■	

PLANNING CONSIDERATIONS

When installed and maintained properly, straw bale dikes remove approximately 67% of the sediment transported in construction site runoff. This optimum efficiency can only be achieved through careful maintenance with special attention to replacing rotted or broken bales. Barrier should be constructed on a level contour to prevent concentration of flow against a small portion of the barrier.

DESIGN & SIZING CRITERIA

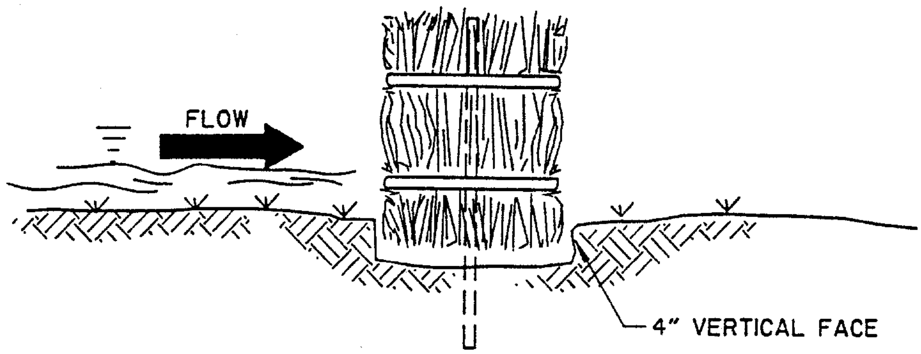
1. Bales shall be placed on the contour and in a row with ends tightly abutting the adjacent bales.
2. Maximize ponding by locating barrier away from the toe-of-slopes. This also provides access for maintenance.
3. Each bale shall be embedded in the soil a minimum of four inches and placed so the bindings are horizontal. Bindings placed on soil will soon disintegrate and cause the barrier to fail.
4. Bales shall be securely anchored in place by either two stakes or re-bars driven through the bale. The first stake in each bale shall be driven toward the previously laid bale at an angle to force the bales together. Stakes shall be driven flush with the bale.
5. Bales shall be removed when they have served their usefulness so as not to block or impede storm flow or drainage.

MAINTENANCE REQUIREMENTS

Inspect monthly and after each rain event. Remove and properly dispose of detained sediments when silt depth reaches 6".

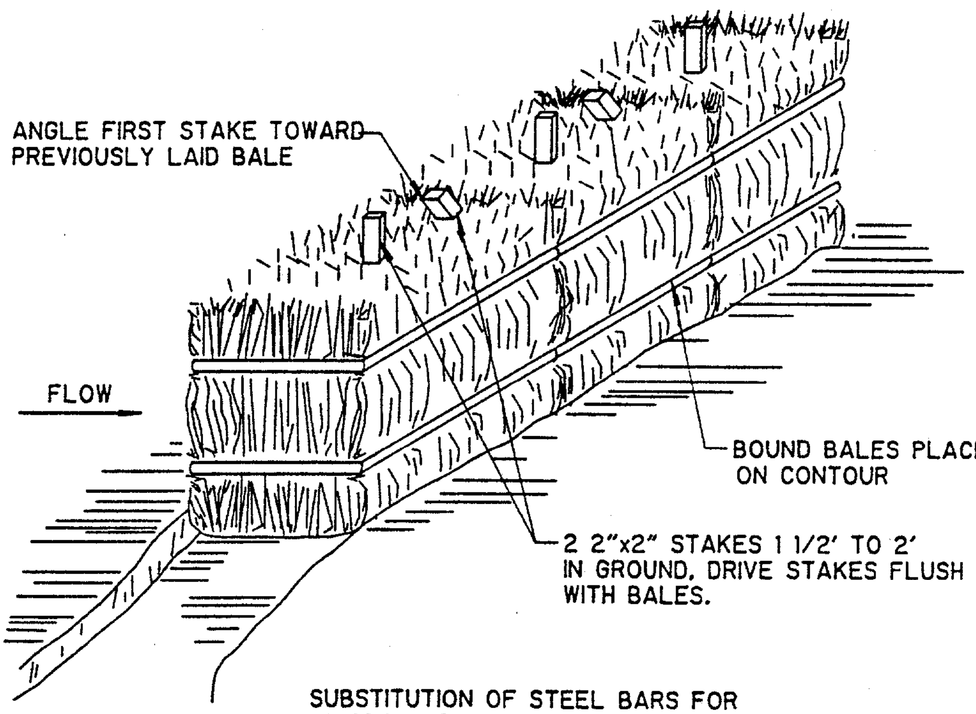
References (1,2,4,14)

SYMBOL	STRAW BALE BARRIERS
S.B.B. ■ ■ ■ ■ ■ ■	



* PROMOTES ON SITE SEDIMENTATION BY CREATING A TEMPORARY POND.

BEDDING DETAIL



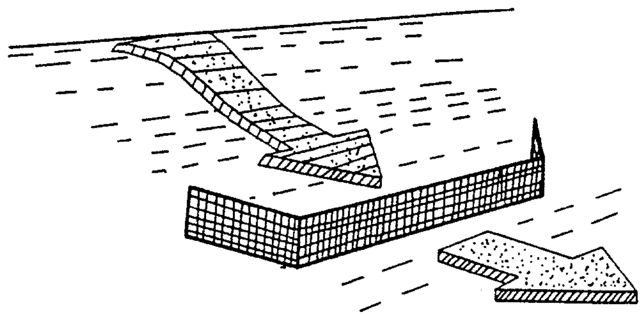
SUBSTITUTION OF STEEL BARS FOR WOODEN STAKES IS NOT RECOMMENDED DUE TO POTENTIAL FOR DAMAGING CONSTRUCTION EQUIPMENT

ANCHORING DETAIL

STRAW BALE BARRIERS

SYMBOL	SILT FENCE
S.F.	

DIAGRAM



CONDITIONS WHERE PRACTICE APPLIES

- * PERIMETER CONTROL
- __ SLOPE PROTECTION
- * SEDIMENT TRAPPING
- __ DRAINAGEWAY & STREAM PROTECTION
- __ TEMPORARY STABILIZATION
- __ PERMANENT STABILIZATION & EXPOSURE LIMITS
- __ NON-SEDIMENT POLLUTION CONTROL

DEFINITION

A temporary sediment barrier consisting of a filter fabric stretched across and attached to supporting posts, entrenched, and, depending upon the strength of the fabric used, with wire fence for support.

PURPOSE

1. To intercept and detain small amounts of sediment from disturbed areas during construction operations in order to prevent sediment from leaving the site.
2. To decrease the velocity of sheet flows and low-to-moderate level channel flows.

APPROPRIATE APPLICATIONS

Filter fences must be provided just upstream of the point(s) of discharge of runoff from a site, before the flow becomes concentrated. They may also be used:

1. Below disturbed areas where runoff may occur in the form of sheet and rill erosion; wherever runoff has the potential to impact downstream resources.
2. Perpendicular to minor swales or ditch lines for up to one acre contributing drainage areas.

Not intended for use in detaining concentrated flows.

Synthetic fabric filter fences are only applicable for sheet or overland flows and not the volumes of water in concentrated flows.

SYMBOL	SILT FENCE
S.F. —■—■—■—	

LIMITATIONS

- Filter fences will create a temporary sedimentation pond on the upstream side of the fence which may cause temporary flooding. Fences not constructed on a level contour will be overtopped by concentrated flow resulting in failure of the filter fence.
- Filter fences are not practical where large flows of water are involved, hence the need to restrict their use to drainage areas of one acre or less, and flow rates of less than 0.5 cfs.
- Problems may arise from incorrect selection of pore size and/or improper installation.
- Do not allow water depth to exceed 1.5 feet at any point.
- Improperly installed fences are subject to failure from undercutting, overtopping, or collapsing.

PLANNING CONSIDERATIONS

Laboratory work at the Virginia Highway and Transportation Research Council has shown that silt fences can trap a much higher percentage of suspended sediments that can straw bales. Silt fences are preferable to straw barriers in many cases. However while the failure rate of silt fences is lower than that of straw barriers, there are many instances locally in which silt fences have been improperly installed. The installation methods outlined here can improve performance.

- Construct along a level contour.
- Silt fences should remain in place until the disturbed area is permanently stabilized.
- Provide sufficient room for sediment removal equipment between the silt fence and toes of slopes or other obstructions.
- The ends of the filter fence should be turned uphill to prevent stormwater from flowing around the fence.
- Provide an undisturbed or stabilized outlet suitable for sheet flow.
- Do not construct in live streams or intermittently flowing channels.

SYMBOL	SILT FENCE
S.F. 	

DESIGN & SIZING CRITERIA

- Upstream drainage area limited to 1 acre or less when used alone or in combination with sediment basin in a larger site.
- Maximum slope steepness perpendicular to fence line, 1:1.
- Maximum sheet or overland flow path length to the fence ≤ 100 feet.
- No concentrated flows greater than 0.5 cfs.

Selection of a filter fabric is based on soil conditions at the construction site (which affect the equivalent opening size (EOS) fabric specification) and characteristics of the support fence (which affect the choice of tensile strength). The designer shall specify a filter fabric that retains the soil found on the construction site yet will have openings large enough to permit drainage and prevent clogging. The following criteria is recommended for selection of the equivalent opening size:

1. If 50 percent or less of the soil, by weight, will pass the U.S. standard sieve No. 200, select the EOS to retain 85 percent of the soil. The EOS should not be finer than EOS 70.

2. For all other soil types, the EOS should be no larger than the openings in the U.S. Standard Sieve No. 70 [0.0083 in. (0.21 mm.)] except where direct discharge to a stream, lake, or wetland will occur, then the EOS shall be no larger than Standard Sieve No. 100.

To reduce the chance of clogging, it is preferable to specify a fabric with openings as large as allowed by the criteria. No fabric should be specified with an EOS smaller than U.S. Standard Sieve No. 100 [0.0059 in. (0.15 mm.)]. If 85 percent or more of a soil, by weight, passes through the openings in a No. 200 sieve [0.0029 in. (0.074 mm.)], filter fabric shall not be used. Most of the particles in such a soil would not be retained if the EOS was too large, and they would clog the fabric quickly if the EOS was small enough to capture the soil.

SYMBOL	SILT FENCE
S.F. —■—■—■—	

Selection of fabric tensile strength and bursting strength characteristics shall be supported with wire mesh in and as recommended by the fabric manufacturer. Filter fabric material shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable life at a temperature range of 0° F. to 120° F.

- Typical Installation:

  Filter fences are to be constructed on a level contour to maximize the available ponding area and prevent concentration of flow against the fence.

  a. Posts shall be spaced a maximum of 6 feet apart and driven securely into the ground a minimum of 30 inches.

  b. A trench shall be excavated approximately 8 inches wide and 12 inches deep along the line of posts and upslope from the barrier.

  c. When standard strength filter fabric is used, a wire mesh support fence shall be fastened securely to the upslope side of the posts using heavy-duty wire staples at least 1 inch long, tie wires or hog rings. The wire shall extend into the trench a minimum of 4 inches.

  d. The standard strength filter fabric shall be stapled or wired to the fence, and 20 inches of the fabric shall extend into the trench. When extra-strength filter fabric and closer post spacing are used, the wire mesh support fence may be eliminated and the filter fabric stapled or wired directly to the posts.

  e. The use of joints should be avoided. When joints are necessary, filter cloth shall be spliced together only at a support post, with a minimum 6 inch overlap and both ends securely fastened to the post.

  f. The trench shall be backfilled with 3/4-inch minimum diameter washed gravel or compacted native material.

SYMBOL	**SILT FENCE**
S.F. 	

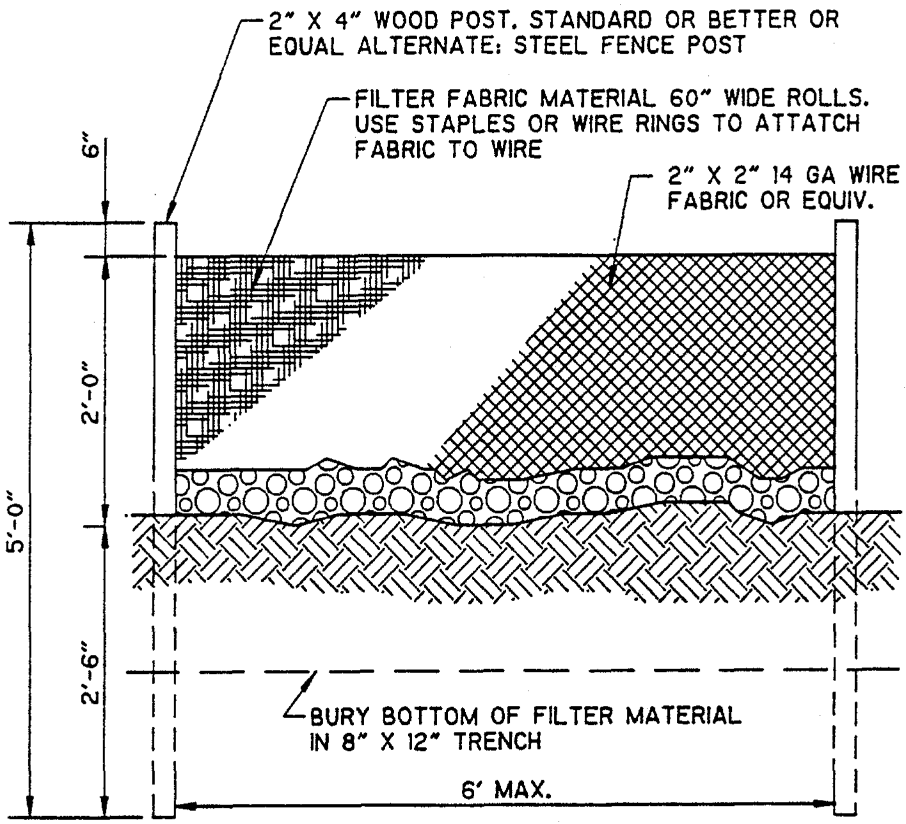
MAINTENANCE REQUIREMENTS

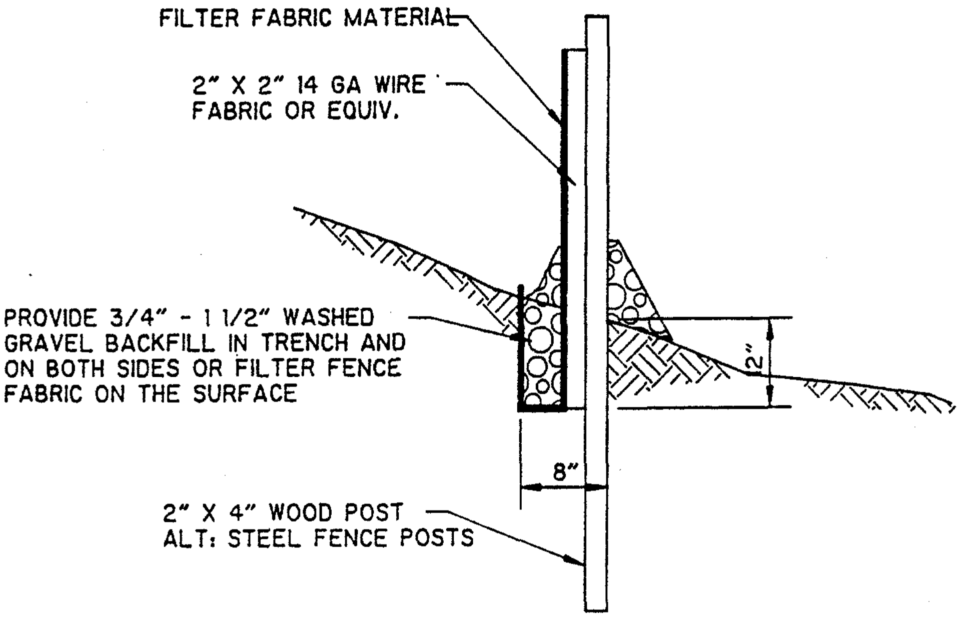
Inspect monthly during dry periods and immediately after each rainfall. Repair as necessary. Sediment must be removed when it reaches approximately one third the height of the fence, especially if heavy rains are expected.

Filter fences should not be removed until the upslope area has been permanently stabilized.

References (1,2,14)

SYMBOL	SILT FENCE
S.F.	





SILT FENCE

APPENDIX 2

YAVAPAI COUNTY CHECKLISTS

Yavapai County
Development Services Department
500 S. Marina Street; Prescott, AZ. 86303 Phone: (928) 771-3214 Fax: (928) 771-3432
10 S. 6th Street; Cottonwood, AZ. 86326 Phone: (928) 639-8151 Fax: (928) 639-8153

FLOOD CONTROL DISTRICT
CIVIL ENGINEERING REQUIRED FOR BUILDING PERMIT CHECKLIST

Please check your plan against the listed items for compliance. The following checklist should be used as a guideline. Additional data may be required based upon complexity of the design and location. All reports and plans must meet the requirements outlined in the County's Drainage Criteria Manual.

Site Plan

__ 1. Parcel number, metes and bounds description or subdivision name and lot number
__ 2. Site vicinity map
__ 3. Project engineer's and owner's name, address, phone number, fax number & email address
__ 4. Benchmark/on-site temporary benchmark (TBM)
__ 5. General notes/legend
__ 6. Arizona registered professional civil engineer's seal & signature
__ 7. North direction arrow & engineering scale (typically 1 inch equals 20 feet)
__ 8. Property lines/dimensions, distance of proposed structure from property boundaries
__ 9. Building envelope/tracts/easements/floodplain boundaries
__10. Finished floor elevation & statement, "all finished floors shown on this plan are free from inundation during a 100-year peak runoff event."
__ 11. Contour lines/spot elevations for existing and proposed conditions
__ 12. Drainage patterns/arrows/grade breaks
__ 13. Quantify 100-year peak runoff event & delineate floodplains for all washes with drainage areas of 80 acres or greater.
__ 14. Perpendicular cross sections through site. Detail existing and proposed contours, finished floor elevations, and floodplain water surface elevation.
__ 15. Erosion protection should be provided for structures 20 feet or less from the nearest wash bank. For washes with 100-year peak discharges of 500 cfs or greater, erosion and scour protection for proposed structures must meet Arizona State Standard 5-96. Structures within Floodplains and Floodways must meet the requirements outlined in Chapter 4 of the County Drainage Criteria Manual.
__ 16. Roadway and driveway locations and profiles. Any portion of a structure greater than 150 feet from the nearest paved road or County dedicated Right-of-Way will be required to develop the road to the requirements set forth by the local emergency service provider.
__ 17. Culvert cross-section and profile. The minimum allowable culvert diameter is 18 inches. Culverts must be designed with headwalls or adequate protection around the inlets and outlets.
__ 18. Fences/block walls with type & location of drainage openings
__ 19. Cut and fill slopes must not exceed 2:1 (horizontal to vertical), and should be re-vegetated with native plants or riprap for erosion control. Steeper slopes must be certified to be stable by an Arizona registered civil engineer or retaining walls should be constructed in these areas.
__ 20. Detail riprap pads or equivalent below all roof drains
__ 21. Septic tank location or detailed sewer line connection
__ 22. Foundation design plans

Drainage Report

__ 1. USGS or best available drainage area map
__ 2. Location of lot and structure on the current FEMA Flood Insurance Rate Map
__ 3. Hydrologic analysis and channel/wash hydraulic analysis
__ 4. Culvert analysis
__ 5. Floodway/Floodplain and foundation scour analysis with "No Rise Certification"
__ 6. Lateral erosion setback or structure design per Arizona State Standard 5-96
__ 7. Arizona registered professional civil engineer's seal & signature

If you have any questions, please contact the Flood Control District at (928) 771-3196.

Yavapai County
Development Services Department

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Addressing – Building Safety – Customer Service & Permitting – Environmental – Flood Control – Land Use – Planning & Design Review

FLOOD CONTROL DISTRICT
COMMERCIAL SITE BUILDING PERMIT SUBMITTAL CHECKLIST

All submittals must be completed by an Arizona registered civil engineer, unless these details are not required due to site conditions as determined by the Flood Control District. Submittals must meet the requirements outlined in the County's Drainage Criteria Manual.

___ 1. **Off-Site Hydrology.** Need to determine the quantity, peak flow rate, velocity, the entrance and exit points, and how the flow is to be routed through the site. Historical drainage patterns should be maintained at the property boundaries without adversely impacting neighboring properties.

___ 2. **On-Site Hydrology.** Need to show how drainage is routed away from proposed structures and into proposed drainage facilities. For most commercial developments, retention/detention facilities will be required to detail pre- minus post-development conditions will not increase drainage from the site.

___ 3. **On-Site Hydraulics.** Provide hydraulic calculations for any channels, culverts, storm drains, or street drainage. Floodplain delineations are required for sites with washes with drainage areas greater than 40 acres.

___ 4. **Topography.** Must provide existing and proposed elevation contours for the property. Typical contour intervals are at 1 foot unless otherwise approved by the Flood Control District.

___ 5. **Cross Sections.** Need to show perpendicular cross sections through the site indicating property lines, swales, detention/retention areas, floodplain elevations, finished floor elevations, and street details.

___ 6. **Dry Wells.** Provide detailed drawings of the dry well and a copy of the well registration with the Arizona Department of Environmental Quality.

___ 7. **Erosion Setback and Scour Depth Analysis.** Provide an analysis per Arizona State Standard 5-96 indicating that all proposed developments are outside of any erosion hazard area.

___ 8. **Finished Floor Elevation.** Need to show the finished floor elevations and provide a certification statement, "All finished floor elevations detailed on these plans are free from inundation during the 100-year peak runoff event."

___ 9. **Storm Water Pollution Prevention Plan**. Provide a copy of the Stormwater Pollution Prevention Plan for our review. A copy of the Arizona Department of Environmental Quality's Notice of Intent submittal should be provided for our files.

Any questions should be directed to the Flood Control District at (928) 771-3196.