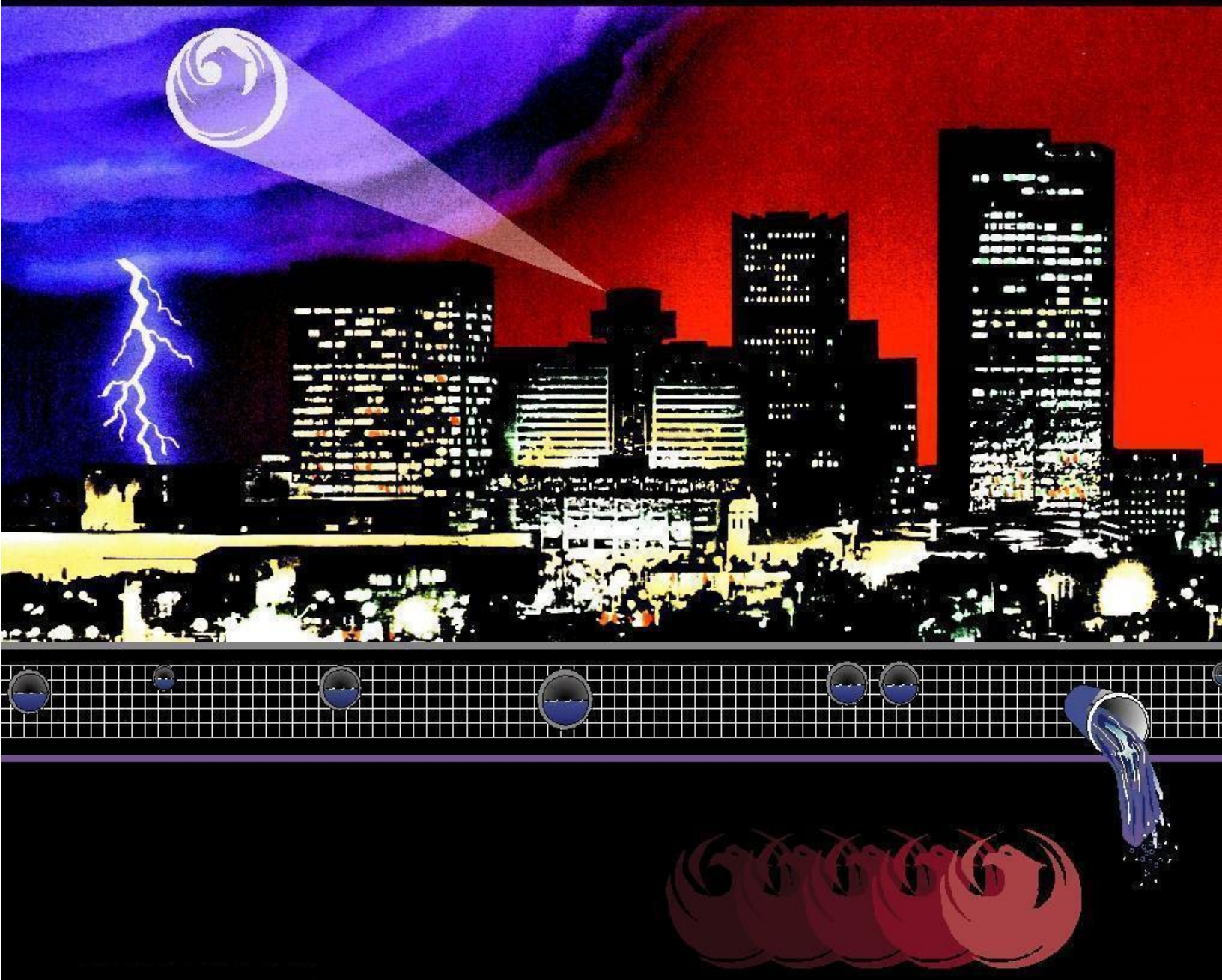
CITY of PHOENIX

Storm Water Policies and Standards



APRIL 2011

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Revisions

Because of ongoing regulatory and technical changes in the fields of drainage, floodplain, and stormwater management, revisions to this manual will be required from time to time. These revisions will take place in accordance with the procedures contained in Chapter 7. Hard copy (printed) revisions will not be distributed. It is the holder's responsibility to keep the document current by periodically checking the City of Phoenix web page for new digital versions. The revision / release history of this document is listed below.

Dates of Revisions

1st Edition March 2004

2nd Edition April 2011

Overview of changes made in the 2nd Edition

The following is a general summary list of the major changes to the March 2004 edition of the City of Phoenix Stormwater Policies and Standards Manual. This summary of the revisions is only presented as an aid for users of the previous edition, and does not document every minor revision to the manual. Typically corrections for spelling, typographical errors, and revisions for readability are not documented. Also, sections that were moved or renumbered are not identified in this overview of changes. Due to the use of a new word processing program as well as some re-organizing of the content, there may be significant differences in the page numbering or section numbering between this edition and the previous edition. The sections or page numbers used in this list refer to this new edition of the manual, unless otherwise stated.

General

- Removed most bullets and replaced with numbered sections and subsections.
- Reformatted the manual for 2-sided printing.

Revisions

- Added this section to summarize major changes.

Chapter 3 Drainage Policies

- Section 3.4.1 – Stormwater Pollution Policy, added SWPPP policy.

Chapter 4 Regulations

- Section 4.5 – Storm Water NPDES/AZPDES, revised NPDES requirements.

Chapter 5 Phoenix City Code

- Provided links to the Phoenix City Code.

Chapter 6 Drainage Standards

- Section 6.3.4.5 – Catch Basin Preferences, added section on preferred catch basin standards, types and sizes.
- Section 6.4.3 – D-Loads, procedure modified to use the Standard Installations Direct Design method published by the American Concrete Pipe Association.
- Figure 6.4.1 – Required D-Load for Reinforced Concrete Pipe, modified to reflect use of the Standard Installations Direct Design method published by the American Concrete Pipe Association.
- Section 6.4.5 – Soils Investigation for Storm Drains, added requirement for seismic refraction survey.
- Section 6.4.12 – Allowable Storm Drain Alternative Pipe Material, revised storm drain alternative pipe material requirements for using HDPE pipe.
- Section 6.4.16 – Storm Drain Bedding, added requirement for slurry bedding for storm drain pipe.
- Section 6.5.8 – Pipe Culvert Alternate Materials, added a section which allows alternate pipe materials for culverts.
- Section 6.5.9 – Pipe Culvert Bedding, added requirement for slurry bedding for culvert pipe.
- Section 6.5.10 – Box Culvert Dimensions, revised box culvert dimensions to require 6’ high and 6’ wide minimums.
- Section 6.5.11 – Pre-Cast Arch Culverts, added a section which allows pre-cast arch-shaped culverts.
- Section 6.5.14 – Bank and Channel Protection, allowable erosion protection materials are revised.
- Figure 6.5.1 – added a figure for typical pipe culvert crossing.
- Figure 6.5.2 and Figure 6.5.3 – added figures for typical box culvert crossing including sediment basins.
- Table 6.5.1 – Erosion Protection Design Criteria for Culvert Outlets, plain riprap is no longer allowed.
- Table 6.5.2 – added a box culvert design checklist.
- Section 6.6.15 – Allowable Channel Radius, added requirements for minimum channel radius for supercritical flow
- Section 6.6.16 – Superelevation, added requirements for channel superelevation

- Section 6.7.1 – Trash Rack Clogging Factor, changed the requirements for trash racks.
- Section 6.8.3 – First Flush, clarified the requirements for controlling the stormwater "first flush" and revised the equation for calculating the discharge.
- Section 6.10.2 – Sediment Basin Design, revised the requirements for basin design.
- Section 6.10.3 – Basins at Box Culverts, added requirement for sediment basin at box culverts.
- Section 6.10.4 – Right of Way, added requirement for basins to be in right of way, drainage easement or drainage tract.
- Table 6.11.1 – Storm Drain Design Checklist revised.

Chapter 8 Software

- Section 8.3 HYDROLOGY and Section 8.4 HYDRAULICS – revised to describe recent enhancements in the software.

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Notice:

This publication can be made available in Braille, large print, audio tape, or cassette tape upon request. Contact the Street Transportation Department at 602-262-6284 if you would like any of these services. Our TTY phone number is 602-256-4286.

Acronyms and Abbreviations

Term	Description
AC	Asphalt Concrete
ACDC	Arizona Canal Diversion Channel
ACP	Asbestos Cement Pipe
ACPA	American Concrete Pipe Association
ADA	Americans with Disabilities Act
ADEM	Arizona Division of Emergency Management
ADEQ	Arizona Department of Environmental Quality
ADMP	Area Drainage Master Plan
ADMS	Area Drainage Master Study
ADMSU	Area Drainage Master Study Update
ADOT	Arizona Department of Transportation
ADWR	Arizona Department of Water Resources
AGFD	Arizona Game and Fish Department
APP	Aquifer Protection Permit
ARS	Arizona Revised Statute
ASTM	American Society for Testing Materials
AZPDES	Arizona Pollutant Discharge Elimination System
BFE	Base Flood Elevation
BMP	Best Management Practice
BWCDD	Buckeye Water Conservation Drainage District
CAP	Central Arizona Project

Term	Description
CC&R's	Covenants, Conditions and Restrictions
CFR	Code of Federal Regulations
cfs	cubic feet per second
CIPP	Cast-in-Place Pipe
City	City of Phoenix
CLOMA	Conditional Letter of Map Amendment
CLOMR	Conditional Letter of Map Revision
CLOMR-F	Conditional Letter of Map Revision - Fill
CLSM	Controlled Low Strength Material
CMP	Corrugated Metal Pipe
CSP	Corrugated Steel Pipe
COP	City of Phoenix
CRS	Community Rating System
CSA	Cement Stabilized Alluvium
CWA	Clean Water Act
DCM	Design & Construction Management Division (City of Phoenix Street Transportation Department)
DDMSW	Drainage Design Management System for Windows
DSD	Development Services Department (City of Phoenix)
EGL	Energy Grade Line
EPA	Environmental Protection Agency
FCDMC	Flood Control District of Maricopa County
FEMA	Federal Emergency Management Agency
FHEMD	Flood Hazard and Erosion Management District

Term	Description
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
fps	feet per second
Fr	Froude Number
GIS	Geographic Information System
gpm	gallons per minute
GRIC	Gila River Indian Community
HDPE	High Density Polyethylene
HGL	Hydraulic Grade Line
HOA	Homeowners Association
hp	horsepower
HVAC	Heating, Ventilation and Air-conditioning
ID	Inside Diameter
Inv.	Invert
JD	Jurisdictional Delineation
LOMA	Letter of Map Amendment
LOMR	Letter of Map Revision
LOMR-F	Letter of Map Revision - Fill
LORS	Laws, Ordinances, Regulations and Standards
MAG	Maricopa Association of Governments
MCDOT	Maricopa County Department of Transportation
MDP	Master Drainage Plan
MSGP	Multi-Sector General Permit

Term	Description
NFIP	National Flood Insurance Program
NOI	Notice of Intent
NOT	Notice of Termination
NPDES	National Pollutant Discharge Elimination System
npsh	net pump suction head
NRCS	Natural Resource Conservation Service (formerly SCS)
OD	Outside Diameter
OEP	Office of Environmental Programs (City of Phoenix)
PCCP	Portland Cement Concrete Pavement
pcf	Pounds per cubic foot
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PMR	Physical Map Revision
PRD	Parks and Recreation Department (City of Phoenix)
RCBC	Reinforced Concrete Box Culvert
RGRCP	Rubber Gasketed, Reinforced Concrete Pipe
RCP	Reinforced Concrete Pipe
RID	Roosevelt Irrigation District
ROW	Right of Way
rpm	revolutions per minute
RUSLE	Revised Universal Soil Loss Equation
SCS	Soil Conservation Service (changed to NRCS)
SFHA	Special Flood Hazard Area
SHPO	State Historic Preservation Office

Term	Description
SIDD	Standard Installations Direct Design
SRP	Salt River Project
SRPE	Steel Reinforced Polyethylene pipe
SRPMIC	Salt River Pima Maricopa Indian Community
SSA	State Standard Attachment
SWMP	Storm Water Management Plan
SWPPP	Storm Water Pollution Prevention Plan
TDH	Total Dynamic Head
Typ.	Typical
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USDOT	United States Department of Transportation
USFW	United States Fish and Wildlife Agency
USGS	United States Geological Survey
WCMP	Watercourse Master Plan
WSPG	Water Surface Profile Gradient, computer program

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1 INTRODUCTION

1.1 PURPOSE

It is the intent of the City of Phoenix to have a comprehensive storm water management program that protects the health, safety, and welfare of its citizens, their property, and the environment. This document outlines the City's philosophy on planning for storm water facilities, the federal and state regulations pertaining to such facilities, and the City's storm water ordinances, policies, and standards. This document is intended to be used in concert with the Drainage Design Manuals for Maricopa County (Hydrology, Hydraulics, & Erosion Control). The objective of the Drainage Design Manuals for Maricopa County is to provide technical guidance for storm drainage facilities in Maricopa County. The Hydrology and Hydraulics Manuals provide a convenient source of analytical and design information that is specifically tailored to the unique hydrologic, environmental, and social character of Maricopa County. Together, these four documents supercede City of Phoenix "Storm Drain Design Manual – Storm Drains With Paving Of Major Streets" (July 1987) and the "Storm Drain Design Manual – Subdivision Drainage Design" (July 1988).

The City of Phoenix reviews and approves drainage reports and plans for construction projects for general conformance with the City's policies and standards. This not withstanding, the City does not assume liability for insufficient design or improper construction. This review and approval does not absolve the owner, developer, design engineer, or contractor of liability for inadequate design or poor construction. The design engineer has the responsibility to design drainage facilities that meet standards of practice for the industry and promote public safety. Compliance with the regulatory elements, policies, and design standards does not imply a guarantee that properties will be free from flooding or flood damage. The City, its officials, or employees assume no liability for information, data, or conclusions prepared by private engineers and makes no warranty expressed or implied in its review/approval of drainage projects.

1.2 BACKGROUND

In 1997, the City of Phoenix Street Transportation Department and Development Services Department embarked on an effort to update and bridge the differences between the 1987 and 1988 Phoenix drainage manuals. In 1998, the City of Phoenix started a collaborative effort with the Flood Control District of Maricopa County to meld their drainage manuals. This final collaboration provides three major benefits. First, various technical aspects of both the City and County's manuals have been updated with advances in the engineering science and further experience with applications unique to Maricopa County. Second, the advances in computer technology provide the opportunity to develop living manuals posted on the internet that also include unique engineering software for the design/evaluation of drainage facilities. Third, the "uniform policies" identified in the Drainage Design Manual for Maricopa County first edition have been removed to allow the City of Phoenix and Maricopa County to have their own individual policies and standards. In this sense, the Drainage Design Manuals for Maricopa County serve strictly as technical manuals, relegating Phoenix policies and standards to this City of Phoenix Storm Water Policies and Standards Manual. The Flood Control District of

Maricopa County has a similar “Policies and Standards” manual for work that is unique to their agency needs. In this way, other local agencies may easily adopt the County’s technical manuals and methodologies, while continuing to exercise their own individual policies and standards that best meet their needs and desires.

The users of these manuals are encouraged to routinely check the web-based version for updates as all addenda will be issued as needed by this means.

1.3 SCOPE

The City of Phoenix Storm Water Policies and Standards Manual, is divided into eight chapters that address the major administrative areas of storm water management. The intent of this manual is to provide regulatory guidance for the design of storm water facilities. Chapter 2, Drainage Planning, stresses the City of Phoenix’s vision for storm water management while providing guidance for the planning process. The storm water management policies provided in Chapter 3 build upon this vision and are supported by the City’s ordinances. Federal, State and other regulatory requirements are outlined in Chapter 4, Regulations. The Phoenix City Codes relating to stormwater and drainage are provided in Chapter 5. The drainage standards, provided in Chapter 6, identify specific criteria for the design of storm water facilities in conformance with the more general policies. Chapter 7 identifies the procedures for modifying Phoenix policies and standards. Finally, Chapter 8 describes the software developed by the City to facilitate drainage submittals and review.

2 DRAINAGE PLANNING

2.1 INTRODUCTION

Storm water runoff facilities are an integral part of public infrastructure systems and should be planned as such. The drainage engineer must be included in the formulation of both site-specific and regional drainage plans and all urban planning should be coordinated from the beginning with the drainage engineer. Drainage master plans need to be carefully prepared for all local and regional flood control and flood management projects, and this same general concept should be followed for land development of all sizes. A drainage master plan, in addition to providing a unified drainage plan, should be coordinated with planning for open space and recreation facilities, planning for transportation, and other urban considerations. Drainage planning should not be done after all the other decisions are already made as to the layout of a new subdivision, commercial or industrial area. It is this latter approach which creates drainage problems which are costly to correct.

Good planning ultimately results in lower cost drainage facilities and a better community. Natural drainage ways and street drainage patterns should be coordinated to achieve the policies and design criteria presented in this Manual. The construction and/or long term maintenance costs for drainage and flood control measures are high when planning is poor. The quality of the planning significantly impacts the costs to the developer and City. Furthermore, inadequate planning potentially affects residents and other infrastructure systems in terms of flood damages.

Supplemental or complimentary benefits and uses from drainage facilities should be considered. Both passive and active recreational uses are examples. Any effort made towards increasing local and community-wide benefits is appropriate and is encouraged.

Consideration of multiple uses and multiple benefits in drainage planning and engineering can minimize societal costs and increase benefits to the community. A way to maximize consideration of these multiple uses is by preparing practical drainage master plans so that the overall effort is coordinated with predetermined objectives.

2.2 DRAINAGE PLANNING PHILOSOPHY

Planning of drainage facilities should be based upon incorporating natural waterways, artificial channels, storm drains, and other drainage works into the development of a desirable and aesthetic community, rather than attempting to superimpose drainage works on a development after it is laid out. Channels and storm water storage facilities that are designed as a focal point of the community minimize misuse (e.g. dumping) and encourage proper maintenance.

Urban drainage should be considered on the basis of two design phases. The first is the planning phase where master drainage plans are developed. The second is the final design phase, which encompasses detailed engineering using the first phase as the basis for the final design. The first phase is a more global view, as discussed herein, and results in the

conceptualization of an overall drainage solution. The second phase is an extension of the first and it is here that the engineering details for the localized issues get worked out.

The drainage system is the backbone of good urban planning in that a well planned system can reduce or eliminate the need for costly underground storm drains, and it can protect the urban area from extensive property damage and loss of life from flooding. This system is generally designed for the more severe and less frequent storm water runoff, such as the 100-year return period. It generally consists of open channels; however, large storm drains can be used. It must be remembered that the drainage system exists in a community whether or not it is planned and designed, and whether or not development is situated wisely with respect to it. Water will obey the law of gravity and will flow downhill to seek its lowest level whether development and people are in its way or not.

2.3 BENEFITS OF PLANNING

Good drainage planning is a complex process. Basic planning considerations that should be taken up early include planning for the drainage system, developing a grading concept, and planning for the environment. When planning a new subdivision for residential purposes, various drainage concepts should be evaluated before decisions are made as to street location and block layout. It is perhaps at this point of the development process where the greatest impact can be made as to the cost of drainage facilities. When flood hazards are involved, the planner should take these hazards into consideration in land planning to avoid unnecessary complications.

Benefits that can be derived from a good drainage plan include:

1. Reduced street maintenance costs
2. Reduced street construction costs
3. Improved movement of traffic
4. Lower cost open space
5. Lower cost park areas and more recreational opportunities
6. Development of otherwise un-developable land
7. Opportunities for lower building construction cost
8. Avoidance of flood damage claims and resultant litigation.
9. Avoidance of fines and fees levied for non-compliance with Federal and State regulations, including NPDES Storm Water regulations.

2.4 TYPES OF DRAINAGE PLANS

Drainage plans can be divided into two types, master drainage plans and final drainage plans. Master drainage plans or preliminary drainage plans as they are sometimes referred, deal with the broad assessment of existing drainage conditions and development of conceptual solutions

to drainage problems, either existing or induced by a proposed project. Final drainage plans provide engineered solutions and details to support the final design of a project.

2.4.1 Regional Drainage Planning

On a watershed basis, regional master drainage plans, otherwise called Area Drainage Master Study's & Plans (ADMS & ADMP), are prepared to identify areas of existing flooding problems and present potential alternative solutions. Solutions typically include an array of storm water conveyance and storage alternatives. These plans are an excellent source for hydrology as sub-basin hydrographs are typically provided for the 6 and 24 hour storms. The ADMP is typically a more detailed study providing more robust flood prevention designs.

A Watercourse Master Plan (WCMP) is similar to an ADMP, except that a WCMP has more of a focus on the management of a particular watercourse and associated flood hazard zones.

2.4.2 Drainage Planning for Land Development

Master drainage plans are also prepared for land development projects. Here, the focus is to identify existing flooding conditions and to develop approaches to prevent the proposed development from exacerbating existing flooding conditions while protecting the proposed development. Master drainage plans for developments are typically required for large parcels of land (80 acres and larger), but the principles remain valid for all parcels regardless of size. The key to master drainage plans for land developments is determining the magnitude of flow entering the property, developing an approach to intercept this flow, identifying a workable means of conveying the flow through the project and discharging the flow to the downstream drainage network (whether natural or man-made) in a manner similar to existing conditions. Master drainage plans for land developments also identify locations for storm water storage facilities to accommodate on-site runoff.

2.4.3 Final Drainage Plans

As identified above, final drainage plans provide engineered solutions and details to support the final design of a project. Here, the hydrology and hydraulics of the selected approach from the master drainage plan is further refined to apply to the chosen drainage solution. The project may be a regional capital improvement project to alleviate existing flooding conditions or improvements associated with land development.

The primary difference between master drainage plans and final drainage plans is that master drainage plans are more conceptual and may assess more than one potential solution. The master drainage plan becomes a building block for the final drainage plan. The final drainage plan addresses details such as depth of flow in roadways and storm sewer geometry that are not generally fully defined at the master drainage plan level. Master drainage plans do not require detailed grading plans in order to develop conceptual drainage solutions whereas final drainage plans are prepared in concert with grading plans.

2.5 INFORMATION FOR DRAINAGE PLANNING

There is a significant amount of existing information available to the hydrologist or drainage engineer that should be considered when undertaking a master drainage plan. The following table highlights some of these.

Table 2.5.1 Drainage Planning Information

Item	Source	Description
Flood insurance studies	FEMA	Watershed peak discharges, floodwater levels, flood risk.
Area Drainage Master Plans & Studies (ADMP & ADMS)	FCDMC, Municipalities	Watershed hydrographs and peak discharges, conceptual storage and conveyance solutions.
Watercourse Master Plans (WCMP)	FCDMC, Municipalities	Management of a particular water course and its associated flood hazards
Studies & plans from existing flood control projects	FCDMC, USACE, USBR, NRCS	Examples: ACDC, Cave Buttes Dam, CAP dikes, Indian Bend Wash.
Transportation Plans & Studies	ADOT, MCDOT, Municipalities	Corridor studies address existing and proposed drainage conditions. Plans depict drainage improvements.
Land use zoning maps	Municipalities	Provides insight to future runoff characteristics. Zoning may limit type of drainage solution.
Soil maps	NRCS	Identifies runoff characteristics and engineering limitations
Aerial Photography	Municipalities, MCDOT, ADOT private	Identifies watershed and existing land- use characteristics
Topographic mapping	Municipalities, MCDOT, ADOT, USACE, USBR, USGS, private	Used to determine watershed boundaries, slopes, and water-course hydraulic characteristics
ALTA Surveys	Maricopa County Recorder's Office	Land ownership, boundary & utility easements (if available)
Drainage plans from adjacent developments	Municipalities, Developers, Home Owners Assoc.	Depicts existing or proposed conditions for adjacent properties that may affect the site under study
Specific regional and arterial street storm drain reports	FCDMC, Municipalities, ADOT, MCDOT	Provide specific final drainage plans for regional and arterial street storm drain systems

2.6 MASTER DRAINAGE PLANNING PROCESS

2.6.1 Plan Development

The master drainage planning process requires the collection and assimilation of information from most of the sources identified above. Consideration must be given to laws, ordinances, regulations and standards (LORS); permitting, environmental impacts, open space, zoning, regional hydrology, flood hazards, safety, and cost. As part of the initial layout design, the designer must consider and accommodate the future need of vehicular access for maintenance purposes. Preliminary design should minimize long-term maintenance requirements.

2.6.2 Waters of The U.S.

Plans that impact Waters of the U.S. must be permitted through the Army Corps of Engineers. For many areas under study, jurisdictional waters exist. Therefore, master drainage plans must consider the impacts to jurisdictional waters (See Chapter 4, Regulations). The professional preparing a master drainage plan must have a working knowledge of the requirements of Section 404 of the Clean Water Act to apply to the planning objective and may need to have the jurisdictional waters delineated early in the master drainage planning process. It is likely that the jurisdictional waters will have a significant impact on the overall drainage plan and on-going maintenance activities.

2.6.3 Ordinances and Policies

All master drainage plans must conform with the City ordinances and with the City of Phoenix Storm Water Policies and Standards. These set the guidelines for all storm water drainage improvement projects, be they public or private.

2.6.4 Linear Open Space

The concept of combined flood control / recreation uses can be applied to drainage corridors. Natural or semi-structural drainage corridors can be developed with landscaping and multi-use trails incorporated into the drainage design to provide recreational and multi-use opportunities. This concept can be applied to new drainage channels and storm water basins that are utilized for recreation and existing open channels that currently do not provide recreational opportunities. The multi-use trails should be located above the channel banks to minimize storm water runoff erosion, interaction with nuisance flows, and to minimize maintenance requirements.

The City stresses the establishment of natural or semi-structural drainage corridors. Utilizing natural corridors to accommodate storm water is the City of Phoenix preferred approach for several reasons.

1. Watercourses make excellent natural open spaces of high scenic quality due to their associated vegetation, wildlife and landforms.

2. Natural features such as topography and natural processes such as erosion have defined the land along natural watercourses as a storm water runoff corridor for intermittent drainage.

3. Desert adapted vegetation is dependent on natural watercourses for water supply and seed disbursement/germination.

4. Many desert wildlife species are adapted to seek watercourse areas for food and shelter.

5. Impacts to watercourses have environmental consequences such as habitat loss, reduced flood conveyance, loss of a valuable landscape amenity, and reduced ground water recharge.

6. Impacts to watercourses often have decreased property value implications as environmental impacts diminish abutting land value.

7. Designating open space along watercourses is often more cost effective for the developer due to the increased risk of flooding in these corridors.

8. Engineered storm water conveyances should be developed in a linear open space system, if one is existing or planned for the area.

2.6.5 Storm Water Storage

In the planning process, drainage corridors and storm water storage basins should be combined where feasible with open space, parks, and trails to create focal points for the community instead of isolated tracts. These combined uses should be planned and designed to augment City of Phoenix parklands. The benefits of this approach are an enhanced sense of community, increased open space with landscape amenities, and decreased crime.

The City encourages combined use of drainage and recreation facilities on both public and private lands. The desired location for storm water storage basins is adjacent to parks to increase the open space. Given the demand for organized sports such as soccer, football, baseball and softball which require large fields; basins should be used for more than one purpose. These basins should be designed with tiers or gentle slopes to allow for the collection of nuisance water and conveyance around fields to allow for dry field areas under normal conditions. Siting recreational facilities at the very bottom of basins should be avoided. It is recommended that storm water storage basins be non-geometrically designed to provide a more natural and aesthetically pleasing method of addressing runoff and storm water storage.

Design of multi-use basins or basins adjacent to parks should be coordinated with the City Parks and Recreation Department. Design of storm water storage facilities should also be coordinated with the Street Transportation Department to achieve compliance with water quality requirements.

2.6.6 Zoning

Zoning often dictates the nature of watercourse development and open space requirements for land development projects. Rezoning land to address flooding or erosion hazards, either through the use of an overlay or replacement zoning district (such as the flood hazard and erosion management district), or through conditions of zoning approval that limits the use of such land, is intended to provide a natural or limited structural design approach to watercourse management. Generally, this results in ideally situated open space. Even small washes lend themselves to regulation in the same manner as larger watercourses if the identification of the flood hazard and erosion impact is initiated early enough. Where Watercourse Master Plans have been completed, a Flood Hazard and Erosion Management Zoning District (or a district of similar design) may dictate land-use / drainage design options. In other areas, individual rezoning applications or zoning overlay districts (such as the desert maintenance character overlay) may include stipulations or design guidelines that address watercourse treatment and

the degree to which the watercourse may be altered or disturbed. Generally, zoning requirements will take precedence over other storm water regulations when they are more restrictive in nature.

2.6.7 Design Hydrology and Hydraulics

At the master plan level, the drainage engineer should concentrate on quantifying off-site flows that may impact the project and determine the means for conveying the flow through the project site. Review of a Flood Control District of Maricopa County (FCDMC) Area Drainage Master Study / Plan that encompasses the project area could provide the design team with valuable information pertaining to the magnitude of storm water affecting the project area. The Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) should also be reviewed to establish if regulated floodplains are within the project area. Where existing studies are not available, the drainage engineer should contact the City and FCDMC to see if any new studies are planned or are in progress[1]. "In-progress" information is often available, and if not, staff experience may be extensive.

A reasonable estimate of the design peak discharge is necessary to approximate the channel or drainage structure capacity and size. The improvements presented in a master drainage plan shall not adversely impact adjacent property owners. In other words, flood stage and velocity (when erosive) can not be increased off-site.

For the master drainage plan, on-site hydrology is typically performed to estimate storm water storage requirements[2] and the approximate size and layout of storm drains[3]. Here, drainage divides are often times set consistent with existing topography since the desired grades have yet to be determined. This is a reasonable assumption since earthwork costs become significant to appreciably change direction of slope from the existing direction.

2.6.8 Flood Hazards

Master drainage plans need to focus on more than flood levels derived from open channel hydraulic analysis. Agradation of channel beds caused by sedimentation and degradation of channels from erosive processes are threats to the performance of drainage systems that must be considered. In addition, the lateral migration of watercourses may threaten public health and welfare unless proper erosion hazard zones are provided. The determination of flood levels on alluvial piedmonts is particularly challenging because of active geomorphic processes. Finally, ponding areas upgradient of elevated roads, railroads, and irrigation canals must be considered during the development of the master drainage plan.

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[1] In areas where older studies exist, the professional should contact the FCDMC to determine if the area is under re-study.

[2] Storm water storage for most land-uses can be approximated on an ac-ft/acre basis. Storm water storage area requirements are often estimated as a percentage of the overall area.

[3] Storm drains are designed during the final design process. The size and alignment for storm drains are often dictated by proposed road configurations and contributing drainage area.

2.6.9 Safety

A basic tenet of any storm water improvement project is the promotion of public safety. Public safety must be a consideration taken throughout the development of a master drainage plan. Excessive storm water depth and/or velocity poses a threat to safety and public health.

2.6.10 Cost

During the development of a master plan, initial capital costs and long term maintenance costs must be considered. Ideally, the least societal costs necessary to provide the required level of protection to the public is the desired goal. Attainment of this goal is fostered by adherence to the City of Phoenix's policies and standards.

2.7 APPROACH TO MASTER DRAINAGE PLANNING

2.7.1 Open Channel Conveyance

The alignment of a drainage system is often set by following the natural watercourse flow line or low flow channel. In these cases, the alignment is a more straightforward matter, and essentially it need only be defined on mapping.

In many areas about to be urbanized, the runoff has been so minimal that well-defined natural channels do not exist. However, low flow channels nearly always exist which provide an excellent basis for location of improved channels. Use of these channels to convey storm water is likely to reduce development costs and minimize drainage problems. In some cases, the wise utilization of natural watercourses in the development of a drainage system will eliminate the need for an underground storm drain system. Where Watercourse Master Plans have been completed, setbacks for erosion hazard zones may have been identified. If setbacks have not been defined as part of the Watercourse Master Plan, then erosion hazard should be approximated following the methodologies identified in the Hydraulics Manual. Detailed lateral migration and long-term erosion analysis would be performed as part of final design in those circumstances.

In many urbanized areas, there is no well-defined watercourse, or the watercourse has been filled and built upon. In this instance, the master plan establishes channel alignments.

The master plan is where major decisions are made as to design velocities, location of structures, means of accommodating conflicting utilities, and the potential alternate uses in the case of an open channel. The choices of channel types available to the design team are numerous, depending only upon good hydraulic practice, environmental design, sociological impact, and basic project requirements. However, from a practical standpoint, the basic choice to be made initially is whether or not the channel is to be lined for higher velocities or if a natural channel already exists and can be effectively utilized with considerations to erosion setbacks and the 100-year flooding limits.

A more natural approach is preferred. The ideal channel is an undisturbed one. The benefits of such a channel are that:

1. Velocities are usually lower; resulting in longer concentration times and lower downstream peak flows.

2. Natural channel and overbank floodplain storage tends to decrease peak flows.

3. Maintenance needs are usually less than artificial channels because it is in dynamic equilibrium with the natural erosion/sedimentation process.

4. The channel provides desirable open space and recreational area adding significant social benefits.

5. The closer an artificial channel character can be made to that of a natural channel, generally the better will be the artificial channel.

For a master plan, the level of analysis necessary to establish artificial channel widths varies. If the artificial channel is for a major watercourse (say design discharge greater than 500 cfs) or a natural channel with varying geometry and slope, a detailed floodplain analysis is likely to be required. This is also dependent upon the existing/proposed land-use and whether encroachments, such as road culvert embankments, affect the flow regime. Otherwise, simple "normal depth flow" calculations may suffice. Watershed master planning typically requires the former level of analysis while the latter is usually adequate for subdivision master planning. Supercritical flow analysis may be warranted depending upon channel slope, channel lining, design discharge and other factors.

Another key component of planning for a channel at the master plan level is the transitioning of flow into and out of a proposed channel. As identified herein, a key City of Phoenix policy requires that proposed facilities do not exacerbate flooding conditions for abutting properties. Thus, any drainage improvement must not increase water levels or result in erosive velocities greater than existing conditions. Interceptor channels may be required to funnel flow into a channel. Similarly, spreading basins or channel expansions may be necessary to transition from an artificial channel to the existing floodplain.

2.7.2 Storage

The master plan is where decisions need to be made on the use of storm water storage facilities and their location. The siting of storage facilities where topography is favorable to the excavation of basins will provide significant benefits including the reduction of peak flows, the settling out of sediment and debris and the likely improvement to the quality of water downstream.

For preliminary sizing of storm water storage facilities, storage per unit area relationship along with a safety factor can be utilized to derive an approximate storm water volume for storage[4]. The storage per unit area is primarily dependent upon the land-use of the proposed project within the contributing drainage area.

For land development projects involving large acreage, establishing contributing drainage area prior to final design can be problematic for the inexperienced. Overlaying the proposed site plan with existing topography allows for the development of a conceptual or preliminary grading plan. Establishing proposed grade breaks consistent with existing drainage divides establishes drainage area. Maintaining existing watershed boundaries during the master planning effort

[4] By way of example, residential areas with a rational method "C" value of 0.65 require approximately 0.12 ac-ft of storage per acre of development. This translates to roughly 6 - 7 percent of the land depending upon basin depth, side slope/embankment grading and recreational features such as tot lots and ball courts located within basins that need to be elevated above nuisance water.

provides an additional benefit in that it minimizes earthwork and storm drainage expenditures pursuant to final design. Undertaking such an approach supports the basis for preliminary storm water storage design and will minimize dramatic revisions for storm water during final design.

2.7.3 Environmental Protection

As explained in the Regulations section of this manual, there are numerous federal, state, and municipal regulations that must be adhered to during plan development and implementation. At the federal and state level, 404 (Waters of the U.S.) and 401 (water quality) permitting are typically required during the project approval process and may be required for maintenance or other activities proposed in conjunction with the drainage facilities. For the City of Phoenix, the plan must comply with 40 CFR 122, Storm Water Quality. Taking the requirements of these regulations into account during the development of the master drainage plan will streamline the design and implementation process. For example, recognition of the trigger points in 404 permitting will provide guidance in developing mitigation plans (see Chapter 4, Regulations). The City of Phoenix strongly endorses minimizing disturbances to natural watercourses in order to lessen the impacts to jurisdictional waters and wildlife habitat.

2.8 FINAL DESIGN CONSIDERATIONS

With the major drainage system conceptualized, attention to the remainder of the project area can be given relative to localized drainage concerns. For land development projects, maintaining existing watershed boundaries during the master planning effort minimizes earthwork and storm drainage expenditures. Such an approach also supports the basis for preliminary storm water storage design.

The master drainage plan serves as the framework for final design. A thorough master drainage plan streamlines the final design process. That is not to say that changes will not occur during final design. However, wholesale changes will not occur due to drainage issues.

It is during final design that street drainage is analyzed and catch basins/storm drains are designed. The specifics and supporting analysis for open channels including culverts/bridges and the influences of sedimentation/scour are developed during final design. It is here that storm water storage facility details, including pump stations if appropriate, are enumerated to permit review by the City of Phoenix and subsequent construction. During final design, the design engineer applies the policies and standards of the City of Phoenix to minimize capital cost and long term maintenance of the drainage improvements while accommodating safety concerns. A Storm Water Management Plan is developed and submitted with the final design to the City for approval coincident with submittal of a 404 Permit application to the Army Corps of Engineers.

3 DRAINAGE POLICIES

3.1 INTRODUCTION

It is the intent of the City of Phoenix to have a comprehensive storm water management program that protects the health, safety and welfare of its citizens, their property, and the environment. The City's storm water management documents include the following:

3.1.1 Codes

- City Code – Chapter 32A, Grading and Drainage
- City Code – Chapter 32B, Floodplains
- City Code – Chapter 32C, Storm Water Quality Protection

3.1.2 Policies and Standards

- City of Phoenix Stormwater Policies and Standards Manual

3.1.3 Technical Manuals

- Drainage Design Manual for Maricopa County, Hydrology
- Drainage Design Manual for Maricopa County, Hydraulics (Draft)
- Drainage Design Manual for Maricopa County, Erosion Control (Draft)

The City has adopted floodplain management and storm water drainage policies that set forth guiding principles for storm water management. These drainage policies fall under the following categories:

- Drainage Character
- Hydrology
- Water Quality
- Floodplain Management
- Street Drainage
- Conveyance Facilities
- Storage Facilities

- Maintenance
- Erosion Control
- Permitting

These policies, together with the Phoenix City Codes, the Phoenix Drainage Standards (Chapter 6), and the Maricopa County Drainage Design Manuals, define the criteria and procedures to be used for storm water management and drainage design in the City of Phoenix.

Variances from policies and/or standards may be allowed under certain circumstances. For a variance, the design engineer must provide engineering justification and request approval by the management of the reviewing department. Requests must be made in writing. Prior to making such request, the engineer is encouraged to discuss options with City staff for further guidance.

3.2 DRAINAGE CHARACTER

The provision for facilities to convey storm water runoff is a necessary part of land development activity. Proper planning and design of drainage facilities is as important as that for water, wastewater, streets and other infrastructure needs in a growing community. In the natural environment, storm water runoff will determine its own course. Land development may require alteration of the natural alignment of a drainage system. This may result in realigned flow paths, larger peak discharges, greater volume of runoff, higher water surface elevations, increased flow velocities and other drainage modifications which can adversely impact adjacent property owners. To maintain existing drainage character, the following requirements shall be met.

3.2.1 Maintain Historic Drainage Patterns

Historic drainage patterns shall be maintained, to the extent possible, within practical and economical constraints.

3.2.2 Maintain Depth and Velocity

Drainage improvements shall not adversely change water surface elevations and flow velocities where runoff enters and exits a property being developed, such as the concentration of sheet flows or braided washes.

3.2.3 Minimize Disturbance

The City of Phoenix strongly endorses minimizing disturbances to natural watercourses in order to lessen the impacts to riparian vegetation, wildlife habitat, and jurisdictional areas. Use of elevated roadways adjacent to natural watercourses to facilitate the preservation of watercourses is accepted. A plant salvage plan shall be completed and approved by the reviewing department prior to any grading activities associated with roadway improvements or the issuance of a grading and drainage permit.

3.2.4 Follow City Standards

Any facility or structure that will be located within a watercourse, drainageway, or other means of conveying or storing storm water shall be designed and constructed to City Standards.

3.3 HYDROLOGY

Hydrology addresses surface water and the estimation of peak discharges, volumes and time distributions, which result from precipitation. Hydrologic data is fundamental in the design of drainage facilities.

3.3.1 Hydrology Policy

Peak discharges and runoff volumes shall be calculated in accordance with the procedures in the Drainage Design Manuals and for the durations and return frequencies specified in the City Standards.

3.4 STORMWATER QUALITY

In March 2003, Arizona municipalities within the urbanized area were brought into the municipal stormwater permitting program through Phase II of the Federal stormwater program called the National Pollutant Discharge Elimination System (NPDES). In Arizona, this program is called the Arizona Pollutant Discharge Elimination System (AZPDES), except for tribal lands, which are administered by the EPA. The City of Phoenix has been designated as a permittee under this program. The following are the City policies as they relate to stormwater pollution.

3.4.1 Stormwater Pollution Policy

No person or entity may cause the discharge of pollutants[5] into a public storm sewer system or facility. Pollutants released to the land surface that subsequently become a constituent of storm water runoff are considered a discharge of pollutants[6]. Soil is considered a pollutant when it is entrained in storm water runoff from construction sites in quantities greater than natural conditions. Erosion control measures for new developments shall be in conformance with the Flood Control District of Maricopa County Erosion Control Manual.

3.5 FLOODPLAIN MANAGEMENT

The City of Phoenix participates in the National Flood Insurance Program (NFIP) which provides flood insurance to its citizens, flood mitigation assistance and emergency assistance to flood victims. The Federal Emergency Management Agency (FEMA) oversees the NFIP. FEMA has regulations pertaining to floodplain management that must be followed in order for the City to continue as a member of the NFIP.

The City of Phoenix has local policies to manage floodplains in a uniform and consistent manner. These policies are categorized as being FEMA related and non-FEMA related in nature. The policies strictly adhere to Federal regulations governing floodplains and drainage design.

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[5] As defined in Chapter 32C of the Phoenix City Code.

[6] As of 11/30/01, excludes certain activities such as not-for-profit washing of vehicles, non-agricultural irrigation water discharges, fire hydrant/potable water system flushing, dust control watering, and discharge of residential evaporative cooler/air conditioning condensate. Since the federal regulations pertaining to this matter change periodically, the practitioner should review the relevant codes and ordinances for revision.

3.5.1 Watercourse Masterplans / Erosion Setbacks

Where a Watercourse Master Plan has been completed, is in progress, or is slated to be undertaken as identified by the City of Phoenix or the FCDMC, undisturbed watercourses (and their related land uses) shall conform to Erosion Hazard Management Zoning requirements. Conformance with erosion setbacks, if established as part of the Watercourse Master Plan or if expected as part of the Watercourse Master Plan process, shall be required. These setbacks shall be established by studies undertaken by or for the FCDMC or the City of Phoenix.

3.5.2 FEMA

FEMA is an independent agency of the federal government, reporting to the President. Since its founding in 1979, FEMA's mission has been clear: To reduce loss of life and property and protect our nation's critical infrastructure from all types of hazards through a comprehensive, risk-based, emergency management program of mitigation, preparedness, response and recovery.

The City of Phoenix's policies pertaining to FEMA regulatory floodways and floodplains are as follows[7]:

3.5.2.1 Development in Floodway

No development shall be allowed in a FEMA regulatory floodway.

3.5.2.2 Basements

Basements shall not be allowed in Special Flood Hazard Areas for residential structures.

Non-residential structures are allowed basements below the base flood elevation (BFE) as long as a registered professional engineer certifies all required "floodproofing" for the structure.

3.5.2.3 Finished Floor Elevations

Lowest floor elevation for houses and other buildings located within or adjacent to a Special Flood Hazard Area shall be a minimum of 1 foot above the FEMA regulatory base flood elevation (BFE).

3.5.2.4 Levees

Levees, berms, or floodwalls while discouraged, must comply with FEMA standards and be reviewed by the City of Phoenix Street Transportation Department, Floodplain Management Section, prior to approval by the Development Services Department.

3.5.2.5 Variances

Variances shall not be approved for conditions that do not meet FEMA regulatory standards.

3.5.2.6 Changes to Floodplains

Any change or proposed improvements within a mapped FEMA floodplain shall be required to follow FEMA submittal procedures.

[7] These policies apply to all floodplains/floodways designated on FEMA Flood Insurance Rate Maps or FEMA Flood Boundary and Floodway Maps.

3.5.3 Non-FEMA

The City of Phoenix's floodplain policies pertaining to developments not appearing on a FEMA Flood Insurance Rate Map or Flood Boundary and Floodway Map are as follows:

3.5.3.1 Finished Floor Elevation

Lowest floor elevation for houses and other buildings that are not located within or on property abutting a Special Flood Hazard Area shall be elevated above adjacent streets.

3.5.3.2 Stormwater Runoff on City Streets

New developments shall not increase runoff onto streets outside of the development.

3.5.3.3 Lot Grading

Lots shall be graded to drain to the front so as not to affect adjacent property owners. Runoff may drain onto or through adjacent property if a City owned property, dedicated right-of-way, or privately owned drainage tract is provided and such grading schemes promote undisturbed watercourses.

3.5.3.4 Base Flood Elevations

In locations where a FEMA regulatory base flood elevation does not exist and the 100-year discharge exceeds 500 cfs, a base flood elevation shall be established using the standards and procedures in the Drainage Design Manuals (Hydrology and Hydraulics) and shall require approval.

3.5.3.5 Erosion Setbacks

In locations where the 100-year discharge in a wash exceeds 500 cfs and is contained within the existing channel banks, erosion setbacks consistent with the ADWR standard[8] shall be required for all properties developed where watercourses are to be left in an undisturbed state.

3.5.3.6 Structure Locations

Residential, commercial, and industrial structures are not allowed in Flood Hazard and Erosion Management Districts with the exception of roadway/bridge/utility crossings, applicable drainage improvements reflecting a natural condition, and certain recreational features conforming to the designated zoning.

3.5.3.7 Development Review

Development not covered by a flood hazard and erosion management zoning district should be reviewed for stipulations or design guidelines relating to watercourse design or development that may be a condition of an individual zoning approval or an overlay zoning district.

3.5.3.8 Variances

Any variances to the City of Phoenix's floodplain policies shall require approval.

[8] State Standard for Watercourse System Sediment Balance, Guideline 1, Lateral Migration Setback Allowance for Riverine Floodplains in Arizona, SSA 5-96, Arizona Department of Water Resources, *September 1996.*

3.6 STREET DRAINAGE

The primary purpose of streets is to serve transportation needs. Accommodation of street drainage is provided so that motorists and emergency vehicles have a reasonable level of access and safety during storm events. Storm water flowing within or across a street shall be managed in accordance with the Phoenix Drainage Standards.

3.6.1 Increased Runoff

Street design shall not increase runoff onto adjacent properties.

3.6.2 Emergency Access

Streets shall be designed to convey storm water runoff so as to provide motorists and emergency vehicles access and safety during a storm event.

3.6.3 Standards for Design

Streets shall be designed to convey storm water in conformance with Phoenix Drainage Standards.

3.6.4 High Velocity Flow

Street flow velocities in excess of those established in the Phoenix Drainage Standards require approval.

3.6.5 Inverted Crowns

Inverted crown streets shall not be permitted for arterial, collector or parkway streets. Inverted crowns on local streets are discouraged and shall require design review and approval.

3.6.6 Surface Runoff in Streets

Arterial, collector or parkway streets shall not direct surface runoff onto local streets.

3.6.7 Culverts and Bridges

Culverts or bridges shall be provided for all streets which cross open channels or drainageways in accordance with the Phoenix Drainage Standards.

3.7 CONVEYANCE FACILITIES

Storm water conveyance facilities (drainageways) may include open channels, undisturbed watercourses, ditches and swales, streets, culverts, or storm drains.

3.7.1 Watercourse Conveyance Capacity

Watercourses shall be reviewed for conveyance capacity and erosion/sedimentation considerations in accordance with the Phoenix Drainage Standards and the Drainage Design Manuals (Hydrology and Hydraulics).

3.7.2 Erosion and Sediment Analysis

The designer of drainage facilities shall undertake the appropriate level of erosion and sedimentation analysis commensurate with the risk of undesirable consequences expected to the health, safety, and welfare of the general public from the privately or publicly funded improvement.

3.7.3 Conveyance Below Ground

Design water surface elevations shall generally be at or below adjacent natural ground or engineered fill. Conveyance provided above natural ground via levees, berms, or floodwalls shall require approval. The department responsible for plan and design review for new development or capital improvement projects including levees, berms, or floodwalls shall submit the plans to the Street Transportation Department, Floodplain Manager for Approval.

3.7.4 Interior Drainage

Levees, berms, or floodwalls shall not obstruct side or interior drainage to a channel. Side or interior drainage may not be conveyed by pumping. The use of levees, berms, or floodwalls to accommodate drainage is discouraged.

3.7.5 Irrigation Canals

Irrigation canals shall not be used as an outfall for storm water runoff.

3.7.6 Right of Way

For all conveyance facilities, City owned property, dedicated right-of-way, or privately owned drainage tract shall be provided and must accommodate access for maintenance.

3.7.7 Siphons

Siphons are not allowed.

3.7.8 Landscape Aesthetics

All engineered channels are to be designed to blend with the surrounding landscape. Earthen engineered channels shall blend in plant type and density with the surrounding landscape.

3.7.9 Phase Construction

Flood water conveyance must be provided at all times during construction in such a manner as to not increase flood depths, sedimentation, or erosive velocities above pre-construction levels for the areas adjacent to construction projects.

3.8 STORMWATER STORAGE FACILITIES

Land development can convert natural pervious areas to impervious or otherwise altered surfaces. These activities may cause an increase in runoff volume and/or peak discharge. The temporary storage of storm water runoff can decrease downstream peak discharges and associated impacts to drainage infrastructure.

3.8.1 Stormwater Retention

All developments shall make provisions to retain storm water runoff in accordance with the requirements in the Drainage Standards.

3.8.2 HOA Maintenance

A Homeowner's Association shall be formed to operate and maintain common storm water storage areas. Storm water storage areas shall be located within platted drainage or open area tracts.

3.8.3 Aesthetics

Storm water storage areas in residential developments may incorporate multi-use features and shall be graded with varying side slopes/land features to be aesthetically pleasing while accommodating safety features per the Phoenix Drainage Standards.

3.8.4 City Maintenance

Storm water storage facilities to be maintained by the City shall be designed to City standards. They shall be located in City Right of Way or Drainage Easement and shall be dedicated to the City.

3.8.5 Public Health and Safety

Storm water storage facilities shall be designed with public health and safety in mind.

3.8.6 Flood Control Objective

New regional flood control facilities located in previously developed neighborhoods shall have flood control as their primary objective.

3.8.7 Drainage

Storage facilities shall be designed to drain accumulated water in accordance with the requirements in the Phoenix Drainage Standards.

3.8.8 Depth and Side Slopes

Depth and side slopes of storm water storage facilities shall be in accordance with the requirements in the Phoenix Drainage Standards.

3.8.9 Outfall

All storm water storage facilities shall be designed to drain to appropriate drainage facilities.

3.8.10 Spillway

Flows in excess of basin capacity shall be directed to adjacent streets or drainage facilities.

3.8.11 Discharge Approval

The discharge of storm water to City owned or maintained drainage facilities shall require approval by the City.

3.8.12 Pumping

The use of a storm water discharge pump is prohibited without a Temporary Discharge Permit issued by the Street Transportation Department/Storm Water Management Section prior to the discharge. Laboratory analyses may be required by the Storm Water Management Section prior to any discharge of water. All costs associated with the laboratory analyses will be the responsibility of the owner. Other restrictions may also apply such as flow rates and monitoring. If approved, the pump shall be maintained and operated by the owner, including Homeowners Associations.

3.8.13 On-Lot Retention

On-lot stormwater storage shall not be allowed for residential developments except for in-fill areas[9] consistent with the Phoenix Drainage Standards. Rooftop storage is not allowed.

3.8.14 Multi-Use

Storm water storage and conveyance facilities must consider multiple use opportunities. For storm water facilities, a preliminary landscaping plan must be submitted prior to the issuance of a final grading permit. A plant salvage plan must be approved prior to the issuance of any grading permit. Aesthetics as well as functionality must be considered in the design of storm water storage and conveyance facilities.

3.8.15 Off-site Flows

Off-site flows may not be routed through a storm water storage facility without City approval.

3.8.16 Landscape Aesthetics

All storm water storage facilities, that are not multiple use, are to be designed to blend, in plant type and density, with the surrounding landscape.

3.8.17 Waivers

Storm water storage requirements may be waived in cases for in-fill areas or re-development parcels, or where post-development peak discharges are less than pre-development and post-development times of concentrations do not exacerbate downstream conditions. This later exception will only be allowed after City acceptance of comprehensive hydrologic analysis undertaken in conformance with the Flood Control District of Maricopa County Hydrology Manual. NPDES requirements must be met regardless of storm water storage provisions.

3.8.18 Native Materials

Basins shall incorporate native materials (including native stone and boulders) and be revegetated in such a manner consistent with the engineering intent of the facility and conducive to maintenance activities.

[9] In-fill areas are considered to be undeveloped individual lots that are not developed as part of the normal build-out of a subdivision. The last phase of a subdivision is not considered to be an in-fill area for these purposes.

3.9 MAINTENANCE

It is essential that maintenance be considered during the planning, design and construction of drainage facilities. Maintenance is provided so that the facilities can function as they were originally designed and constructed, and so that the service life of the facility is maximized. Common maintenance problems associated with drainage facilities include growth of unwanted vegetation, debris accumulation, sedimentation, erosion, scour, soil piping, soil settlement and structural damage. Culverts and bridges are to be designed to avoid impacts to existing sediment transport conditions.

Provision for permanent drainage facility accessibility, including access for maintenance equipment into channels and culverts, is necessary for regularly scheduled maintenance activities.

3.9.1 Maintenance Accessibility

All drainage facilities shall be accessible for maintenance equipment.

3.9.2 Operation & Maintenance Cost

All drainage facilities shall be designed and constructed with consideration to the cost of ongoing operation and maintenance.

3.9.3 City Right of Way

All drainage facilities that are to be maintained by the City of Phoenix shall be encompassed within a designated City owned property or right-of-way[10] and clearly shown on the recorded plat. To eliminate ambiguity and term confusion, drainage easements are not accepted as a means to describe public or private ownership.

3.9.4 Private Drainage Tracts

All drainage facilities that are to be privately maintained shall be encompassed within a platted drainage tract with said tract clearly identified as private property without public access.

3.9.5 Private Maintenance

All drainage facilities owned and/or operated by private entities, including Homeowner's Associations, shall be properly maintained to promote performance of the drainage facilities consistent with the original design intent.

Homeowners Associations that own and/or operate drainage facilities shall include statements in its CC&R's clearly identifying that the Homeowners Association is responsible for operation, maintenance and repair of the drainage facilities.

3.9.6 Alteration

Drainage features/facilities that are the responsibility of entities other than the City of Phoenix (i.e. Homeowner's Associations, developers, management companies, private owners) may not be altered in form or function that detrimentally impacts the performance of the feature.

[10] A right-of-way encompasses land owned by the public.

3.9.7 Access Barriers

Trash racks at entrances and access barriers at outlets shall be provided for storm water conduits as specified in Chapter 6, Drainage Standards.

3.9.8 Permits

Where required, Section 404 permits shall be obtained prior to the start of maintenance activities.

3.10 EROSION CONTROL DURING CONSTRUCTION

Construction activity disturbs the land surface, thereby exposing native soils to increased rates of erosion by wind and rain. Airborne soil poses detrimental health risks and reduces visibility. Erosion of soil from construction sites by storm water increases the rate of siltation of drainageways, which can exacerbate flooding and increase the cost of on-going maintenance. Appropriate erosion control measures shall be required at construction sites.

3.10.1 Storm Water Management

Storm Water Management Plans (SWMP) or Storm Water Pollution Prevention Plans (SWPPP) that incorporate best management practices shall be required of new developments as specified in the Phoenix Drainage Standards. See AZPDES Storm Water construction requirements for full details.

3.10.2 Erosion Control

Erosion control shall be in accordance with the Erosion Control Manual of the Flood Control District of Maricopa County.

3.11 PERMITTING

There are a myriad of federal, state, and city permits that may be required prior to the start of construction of a project (see Chapter 4, Regulations). It is not the City's responsibility to ensure that the plans for a proposed project satisfy state and federal permit requirements. This not withstanding the following requirements:

3.11.1 Permits

The City will not issue a Grading and Drainage Permit until the applicant documents that all of the applicable state and federal permits have been obtained.

3.11.2 Grading Permits

"At risk" grading permits may be obtained upon receipt of documentation that the developer/owner has made proper permit applications to the appropriate state and federal agencies. Section 32A of the City Code identifies conditions that may be attached to grading and drainage permits (Section 32A-10-e-5). Specifically, as it relates to the protection of hillside and desert preservation areas (such as undisturbed watercourses), temporary fencing may be called for to restrict/prevent construction activities within these designated areas. Failure to protect these areas may result in revocation of the grading and drainage permit, payment of cash for the restoration, and / or the calling of a previously mandated surety bond.

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4 REGULATIONS

4.1 INTRODUCTION

Engineers responsible for drainage design must conform to all regulations that may affect their project including federal, state and local acts, codes, laws, regulations, ordinances and policies[11]. Although these regulations are constantly changing, the following discussion provides some guidance as to the areas where governmental agencies exercise control over drainage related activities.

4.2 CONTACT LIST

The list that follows identifies the various water resource and cultural resource agencies one may need to contact to obtain information or file a permit for drainage projects. This list is provided as assistance and for information purposes only. This list may not include all agencies or environmental reviews or permits that are required for a given project. Telephone numbers and addresses are subject to change.

General Information

Environmental Protection Agency (EPA)
http://www.epa.gov/region09/
Public Info. Center:
(415) 744-1500

Arizona Department of Environmental Quality (ADEQ)
http://www.azdeq.gov/
(602) 207-2300

Arizona Department of Water Resources
http://www.azwater.gov/dwr/
(602) 417-2400

Maricopa County
Department of Environmental Services
http://www.maricopa.gov/envsvc/
(602) 506-6970

City Departments

City of Phoenix
Street Transportation
(602) 262-4960
http://phoenix.gov/STREETS/index.html

City of Phoenix
Street Transportation
Storm Water Management
(602) 495-5326

City of Phoenix
Planning and Development
(602) 262-7811
http://phoenix.gov/development/index.html

City of Phoenix
Fire Department
(602) 262-6771
http://phoenix.gov/FIRE/index.html

[11] In addition, there are many computer programs available to help in the design of drainage systems. These programs may use different methods of analysis than those presented in the Design Manual. Therefore, the designer of the storm drain system should check with the governing agency before using particular software packages.

Floodplain Information

Federal Emergency Management Agency
http://www.fema.gov/
(415) 923-7100 (San Francisco)
(202) 646-4600 (Washington D.C.)

Flood Control District of Maricopa County
http://www.fcd.maricopa.gov/
(602) 506-1501

Clean Water Act Section 404 Permits

US Army Corps of Engineers
http://www.usace.army.mil/
(602) 640-5385

National Pollutant Discharge Elimination System (NPDES) Permits

EPA (415) 744-1906
ADEQ (602) 207-4665

Aquifer Protection Permits

Arizona Department of Environmental Quality
http://www.azdeq.gov/
(602) 207-2315

Drywell Permits

ADEQ
(602) 207-4686
(877) 800-3207 - Hotline

Groundwater & other Water Permits

ADEQ (602) 207-4428
http://www.azdeq.gov/

ADWR (602) 417-2400
http://www.azwater.gov/dwr/

Water Quality 401Certification

http://www.azdeq.gov/
ADEQ (602) 207-4502

State Species of Concern

Arizona Game & Fish Department,
Habitat Branch
(602) 789-3605
http://www.gf.state.az.us/

Native Plant Law

Arizona Dept. of Agriculture
Plants and Cactus Division
(602) 542-7182
http://www.azda.gov/

Endangered Species Act

U.S. Fish & Wildlife
Service
http://www.fws.gov/southwest/
(602) 640-2720

Historic & Prehistoric Sites

State Historic Preservation Office
http://azstateparks.com/partnerships/shpo/shpo.html
(602) 542-4009

City of Phoenix Archeologist Office
Pueblo Grande Museum
602-495-0901

City of Phoenix Historic
Preservation Office
(602) 261-8699

Native American Community Contacts, Maricopa County

Ak Chin Indian
Community
(520) 568-2618

Ft. McDowell Mohave - Apache Tribe
(480) 837-5121

Gila River Indian
Community
(520) 562-6000

Salt River Pima
Maricopa Indian
Community
(480) 850-8001

4.3 NATIONAL FLOOD INSURANCE PROGRAM

4.3.1 Introduction

The National Flood Insurance Act of 1968, as amended in 1973, provides for a federally subsidized National Flood Insurance Program (NFIP) conditioned on active management and regulation of floodplain development by states and local governments. FEMA administers the NFIP as a part of its overall responsibilities in preventing and responding to natural events that damage private and public property and any life-threatening natural event including floods. The NFIP provides flood insurance at affordable rates through Federal subsidy of the insurance offered by licensed insurance agents. This insurance is designed to provide an insurance alternative to disaster assistance to meet the escalating costs of repairing damage to buildings and their contents caused by floods.

Participation in the NFIP is based on an agreement between local communities and the Federal Government. This agreement states if a community will adopt and enforce a floodplain management ordinance to reduce future flood risks to new construction in Special Flood Hazard Areas, the Federal Government will make flood insurance available within the community as a financial protection against flood losses.

Availability of the subsidized flood insurance is contingent upon the development of a floodplain management system by the local municipality. Prevention of floods and resultant property damage is achieved through the delineation of property subject to flood events and the establishment of specific rules concerning development within these designated areas. FEMA publishes Flood Insurance Rate Maps (FIRM's) for certain flood prone areas that delineate different special flood hazard areas.

The City of Phoenix participates in the NFIP and has adopted floodplain regulations and ordinances so that its citizens have access to the subsidized insurance. The role of the community is to enact and implement floodplain regulations required for participation in the NFIP.

4.3.2 Community Rating System

The NFIP Community Rating System (CRS) was implemented in 1990 as a program for recognizing and encouraging community floodplain management activities that exceed the minimum NFIP standards. The National Flood Insurance Reform Act of 1994 codified the Community Rating System in the NFIP. Under the CRS, flood insurance premium rates are adjusted to reflect the reduced flood risk resulting from community activities that meet the three goals of the CRS: (1) reduce flood losses; (2) facilitate accurate insurance rating; and (3) promote the awareness of flood insurance.

4.3.3 FEMA Special Flood Hazard Areas

Citizens within the City of Phoenix are required to ascertain whether or not their respective property is located in a FEMA special flood hazard area (SFHA) before commencing with any building or land disturbance activity. FEMA special flood hazard maps, FIRM's, are available for review at the City of Phoenix, the Flood Control District of Maricopa County and the Arizona Department of Water Resources. The FIRM's are used to determine if a property is located within a special flood hazard area regulated by FEMA.

4.3.4 Flood Hazard Zones

The flood hazard maps are subdivided into zones that relate to flooding depths. These are defined as follows:

100-year Floodplain: Floodplain resulting from the occurrence of the 100-year rainfall. FEMA sets its jurisdictional limits to the 100-year event, which is cited as the base flood elevation. Jurisdictional limits are defined by horizontal flooding limits using the base flood elevation.

Floodway: That portion of the 100-year floodplain that is required to convey the 100-year flood with a rise in water surface no greater than 1 foot. The allowable rise and the limits of the floodway are predetermined by the governing municipality. The City of Phoenix allows landowners to encroach into the 100-year floodplain equally on both sides in terms of conveyance, except where a Flood Hazard and Erosion Management District has been adopted.

4.3.4.1 Special Flood Hazard Areas

One of these areas is the SFHA, which is defined as the area that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year. The 1 percent annual chance flood is also referred to as the "base flood." SFHA's are labeled as Zone A, Zone AO, Zone AH, Zones A1-A30, Zone AE, Zone 99, Zone AR, Zone AR/AE, Zone AR/AH, Zone AR/AO, Zone AR/A1-A30, Zone AR/A, Zone V, Zone VE, and Zones V1-V30. V Zones define coastal flooding hazards which do not apply to the City of Phoenix.

Zone A: Areas subject to inundation by the 1 percent annual chance flood event. Because detailed hydraulic analyses have not been performed, no BFE's or flood depths are shown. Mandatory flood insurance purchase requirements apply.

Zones AE and A1-A30: Areas subject to inundation by the 1 percent annual chance flood event determined by detailed methods. BFE’s are shown within these zones. Mandatory flood insurance purchase requirements apply. (Zone AE is used on new and revised maps in place of Zones A1-A30.)

Zone AH: Areas subject to inundation by 1 percent annual chance shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. BFE's derived from detailed hydraulic analyses are shown in this zone. Mandatory flood insurance purchase requirements apply.

Zone AO: Areas subject to inundation by 1 percent annual chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average flood depths derived from detailed hydraulic analyses are shown within this zone. Mandatory flood insurance purchase requirements apply.

Zone A99: Areas subject to inundation by the 1 percent annual chance flood event, but which will ultimately be protected upon completion of an under-construction Federal flood protection system. These are areas of special flood hazard where enough progress has been made on the construction of a protection system, such as dikes, dams, and levees, to consider it complete for insurance rating purposes. Zone A99 may only be used when the flood protection system has reached specified statutory progress toward completion. No BFE's or flood depths are shown. Mandatory flood insurance purchase requirements apply.

Zone AR: Areas that result from the decertification of a previously accredited flood protection system that is determined to be in the process of being restored to provide base flood protection. Mandatory flood insurance purchase requirements apply.

Zones AR/AE, AR/AH, AR/AO, AR/A1-A30, AR/A: Dual flood zones that, because of the risk of flooding from other water sources that the flood protection system does not contain, will continue to be subject to flooding after the flood protection system is adequately restored. Mandatory flood insurance purchase requirements apply.

Moderate flood hazard areas, labeled Zone B or Zone X (shaded), are also shown on the FIRM, and are the areas between the limits of the base flood and the 0.2 percent annual chance.

The areas of minimal flood hazard, which are the areas outside the SFHA and higher than the elevation of the 0.2 percent annual chance flood, are labeled Zone C or Zone X (unshaded). The definitions for the various flood hazard areas are presented below.

Zones B, C, and X: Areas identified in the community FIS as areas of moderate or minimal hazard from the principal source of flood in the area. However, buildings in these zones could be flooded by severe, concentrated rainfall coupled with inadequate local drainage systems. Local stormwater drainage systems are not normally considered in the community's FIS. The failure of a local drainage system creates areas of high flood risk within these rate zones. Flood insurance is available in participating communities but is not required by regulation in these zones. (Zone X is used on new and revised maps in place of Zones B and C.)

Zone D: Unstudied areas where flood hazards are undetermined, but flooding is possible. No mandatory flood insurance purchase requirements apply, but coverage is available in participating communities.

4.3.5 Application Process

Flood insurance through the NFIP is available for those properties located within the special flood hazard area. The following figures illustrate a generic representation of the permitting process for a single building lot and a larger community tract.

Figure 4.3.1 Single Lot Development Process

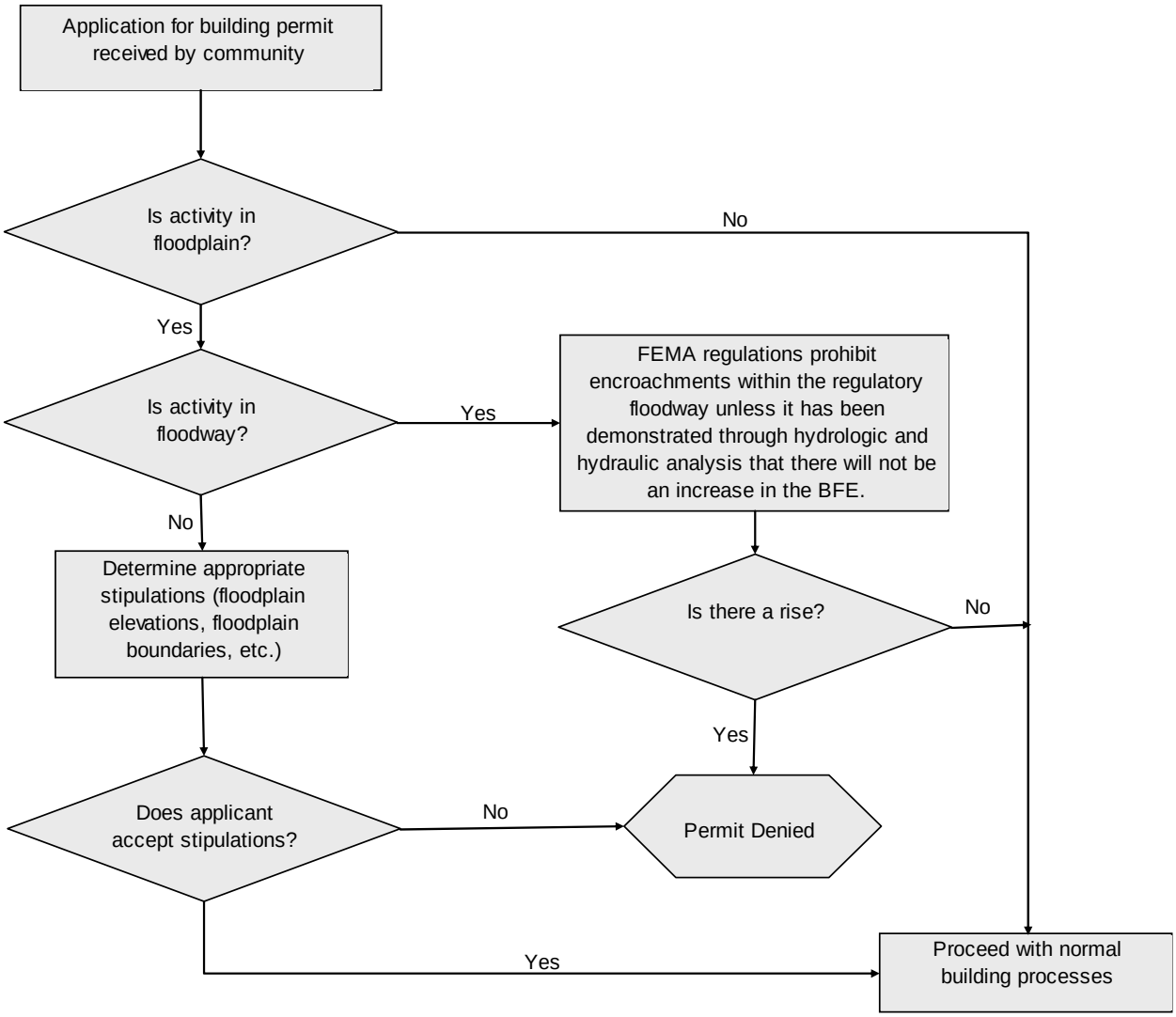
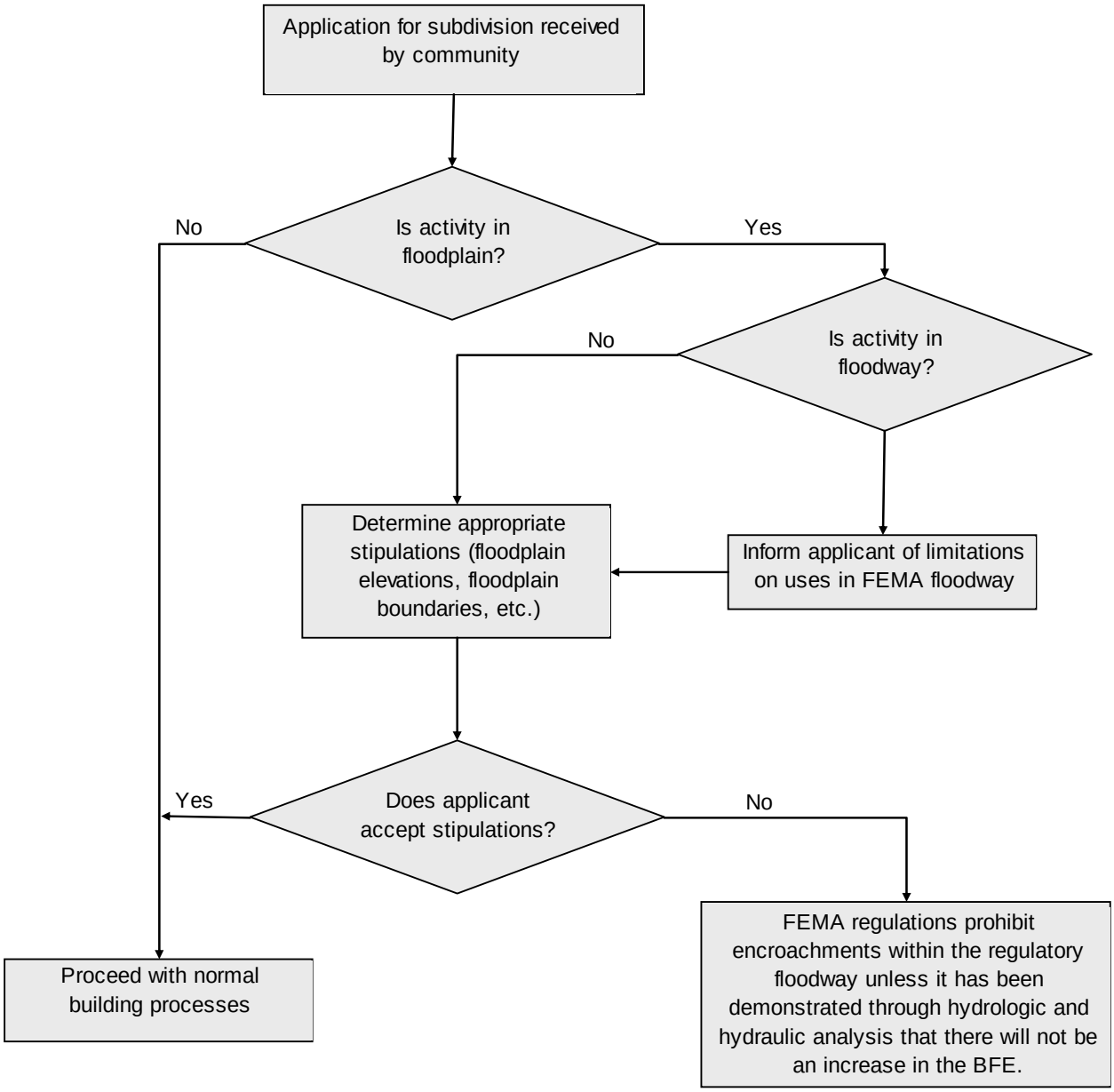


Figure 4.3.2 Community Development Process



4.3.6 Approval Actions Taken by FEMA

If a property is determined to be located within a FEMA special flood hazard area after reviewing the appropriate FIRM, there are several approval options available that the landowner must process through FEMA. The landowner must select the permit option that best fits the need of the property and satisfies FEMA requirements. Each permit option requires completion of specific application forms and may require that a registered land surveyor or professional engineer complete the forms. Each permit/application form is identified below by name followed by a brief description of the approval response to be expected from FEMA.

Conditional Letter of Map Amendment (CLOMA)

A letter from FEMA stating that a proposed structure that is not to be elevated by fill would not be inundated by the 100-year flood if built as proposed.

Letter of Map Amendment (LOMA)

A letter from FEMA stating that an existing structure or parcel of land that has not been elevated by fill would not be inundated by the 100-year flood.

Conditional Letter of Map Revision Based on Fill (CLOMR-F)

A letter from FEMA stating that a parcel of land or proposed structure that is to be elevated by fill would not be inundated by the 100-year flood if fill is placed on the parcel as proposed or the structure is built as proposed.

Letter of Map Revision Based on Fill (LOMR-F)

A letter from FEMA stating that an existing structure or parcel of land that has been elevated by fill would not be inundated by the 100-year flood.

Application forms for the four items listed above can be obtained from FEMA by reference MT-1 FEMA Form 81-87 Series.

Conditional Letter of Map Revision (CLOMR)

A letter from FEMA commenting on whether a proposed project, if built as proposed, would justify a map revision.

Letter of Map Revision (LOMR)

A letter from FEMA officially revising the current FIRM to show changes to floodplains, floodways, or flood elevation. Physical changes include watershed development, flood control structures, etc.

Physical Map Revision (PMR)

A reprinted FIRM incorporating changes to floodplains, floodways, or flood elevations. Because of the time and cost involved to change, reprint, and redistribute a FIRM, a PMR is usually processed when a revision reflects increased flood hazards or large-scope changes.

Application forms for the three items listed above can be obtained from FEMA by reference MT-2 FEMA Form 81-89 Series. FEMA's contact address is provided in Section 4.3.14.

Projects receiving a conditional letter must apply for a letter of map revision upon completion of construction. The conditional letter allows financing and local approvals of plans and permits for the project to take place. No building permit will be issued until a letter of map revision is issued by FEMA. To initiate FEMA review for a specific activity or location, a letter to FEMA requesting one of the “conditional” letters is sent to FEMA along with supporting data which includes a signed letter from the City of Phoenix indicating its concurrence with the request. Supporting data may be in the form of improved methodology or improved survey data. Improved methodology may be a different technique (model) or adjustments to models used in the effective FIS. Improved survey data include revised as well as new data. Floodway revisions

involve any shift in the FEMA-designated floodway boundaries, regardless of whether the shift results in a change in the mapped floodway.

4.3.7 Approval and Denial

Once the review is completed and if the proposed development complies with the local floodplain management ordinance, a letter is issued identifying acceptance. The day the letter is issued is considered to be the date of the "start of construction" provided that actual construction begins within a certain timeframe. Otherwise, the applicant receives a letter identifying deficiencies in the information provided to FEMA.

4.3.8 Construction in Special Flood Hazard Areas

The lowest floor of all residential structures constructed in the Special Flood Hazard Area (SFHA) must be a minimum of one foot above the Base Flood Elevation (BFE)[12]. Building structures located within the SFHA (but not within the Floodway) may be protected from floods up to and including the 100-year flood by placement of fill to elevate the structure above the BFE. See FEMA guidelines for further specifications.

Basements of residential structures located in the SFHA must be elevated above the BFE. The NFIP regulations allow nonresidential buildings such as commercial structures, garages, warehouses, etc. the option to floodproof rather than elevate as a means of protection from the base flood.

4.3.8.1 Floodproofing

Non-residential structures can be flood proofed to one foot above the BFE instead of being elevated. Modular buildings must have the bottom of the structure raised one (1) foot above the Base Flood Elevation (BFE) regardless of its use. Detached garages, small barns, and storage sheds are some examples of buildings that may not have to be elevated or dry floodproofed if openings are installed to allow floodwaters to enter or exit a structure and meet all other wet floodproofing requirements. Wet floodproofing requires the use of flood-resistant materials below the BFE and elevating items subject to flood damage above the BFE. Floodproofed structures must comply with appropriate sections of the NFIP regulation 60.3.

4.3.8.2 Levees

Levees, berms, and floodwalls must meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with the criteria established by NFIP regulation 60.3.

4.3.8.3 Protection of Ancillary Facilities

All new construction and substantial improvements shall be constructed with electrical, HVAC, plumbing, and other service facilities that are designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding. Mechanical and electrical equipment must be installed one foot above the BFE. Septic tanks within a SHFA

[12] All new construction and substantial improvements of residential structures located within Zones A1-30, AE, and AH shall have the lowest floor, including the basement, elevated at or above the Base Flood Elevation.

must be above the BFE. All other below ground tanks must be anchored against floatation. Above ground tanks are considered structures for floodplain management purposes.

4.3.8.4 Water Systems

The community must require new and replacement water supply systems within floodprone areas to be designed to minimize or eliminate infiltration of floodwaters into the systems. The location and design of on-site waste disposal systems should be reviewed in order to prevent possible operational failure and potential contamination to the environment during flooding. The system should be protected from flood damage such that it can resume operation after the flood recedes. Manholes should be raised above the 100-year flood level or equipped with seals to prevent leakage. Pump stations should be located to allow access during a flood and designed to not release contamination. Automatic backflow valves should be installed to prevent sewage from backing up into buildings during a flood event.

4.3.8.5 No Rise in Floodway

Under no circumstances can filling or other construction activity be allowed within a floodway that may cause any rise in the water surface elevation above the designated floodway elevation.

4.3.8.6 Elevation Certificate

An “Elevation Certificate” (FEMA Form 81-31) must be completed for each structure constructed in the SFHA prior to the electrical clearance and final acceptance for that structure. One copy of the “Elevation Certificate” is to be submitted to the General Building Safety Inspector on site and one copy is to be submitted to the City of Phoenix Floodplain Manager. See City Code and Federal Code for a complete list of requirements. Show the limits of the floodplain and Base Flood Elevations on the Site Plan and Grading and Drainage Plan.

4.3.9 Floodplain Requirements for Alluvial Fans

In addition to or in place of the above requirements, the following is required for alluvial fan floodplains.

The lowest floor of all residential structures in the SFHA must be elevated one foot above the highest adjacent grade in accordance with the Code of Federal Regulations (CFR) Section 60.3c(7). Non-residential structures may be floodproofed in lieu of elevation.

Adequate drainage paths must be provided in accordance with Section 60.3c(11) of the CFR.

4.3.10 Post Construction Review

After the proposed improvements have been constructed, the owner/developer is required to submit as-built / documents of record to FEMA and the City of Phoenix Floodplain Manager along with a request for a letter of map revision or amendment as appropriate.

4.3.11 Fees

Fees will be assessed by FEMA for it’s review of proposed and “as-built” projects, as outlined in NFIP regulations 44 CFR Ch. 1, Part 72. In addition, the City of Phoenix levies a fee to help defray its cost for administering floodplain management in conformance with the NFIP.

4.3.12 Additional Information

FEMA publishes numerous documents to aid those within or adjacent to a special flood hazard area that can be located using FEMA's contact address at the end of this section. Documents that are very useful to consult if a property is determined to be within a special flood hazard area are:

1. "National Flood Insurance Program (Regulations for Floodplain Management and Flood Hazard Identification)," Federal Emergency Management Agency, 44 CFR, Part 1 Revised as of October 1, 1999.

2. "Guidelines and Specifications for Flood Hazard Mapping Partners", Federal Emergency Management Agency, April 2003. (or latest edition)

3. "Technical Bulletin 2-93, Flood-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas in accordance with National Flood Insurance Program," Federal Emergency Management Agency, April, 1993.

4. "Technical Bulletin 3-93, Non-Residential Floodproofing Requirements and Certification for Buildings Located in Special Flood Hazard Areas in accordance with National Flood Insurance Program," Federal Emergency Management Agency, April, 1993.

4.3.13 Non-FEMA Flood Hazard Areas

The State of Arizona has set minimum floodplain management requirements for areas that are not studied and identified by FEMA as a special flood hazard area. The Arizona Department of Water Resources (ADWR) and the Arizona Division of Emergency Management (ADEM) are responsible for floodplain management statewide and for administering the NFIP at the state level. ADWR has developed a series of State Standards to aid in floodplain management for the non-FEMA studied areas of the state. Each State Standard has a companion document called the State Standard Attachment (SSA). The SSA is the technical document that provides the methodology and examples of how to apply it.

4.3.13.1 State Standards

The following is a list of State Standards currently available from ADWR. It is the responsibility of each person to obtain the most current version of the State Standard available. ADWR does update existing State Standards periodically and is developing new State Standards where a need exists.

SS1-97 Requirement for Flood Study Technical Documentation

Sets technical documentation standards for Flood Studies that are to be submitted to ADWR or FEMA.

SS2-96 Requirement for Floodplain and Floodway Delineation in Riverine Environments

Provides methodologies for estimating 100-year peak discharges, delineating 100-year floodplain limits, and determining administrative floodway boundaries for riverine floodplains in Arizona.

SS3-94 State Standard for Supercritical Flow (Floodway Modeling)

Provides guidelines to be used when modeling floodways for supercritical or near-critical flow conditions in Arizona.

SS4-95 State Standard for Identification of and Development within Sheet Flow Areas

Details minimum floodplain management standards for identification of and development within sheet flooding areas in Arizona.

SS5-96 State Standard for Watercourse System Sediment Balance

Provides guidelines for identification of and development within erosion hazard areas, watercourses with a net sediment deficit, and watercourses with a net sediment surplus. Individual guidelines for: Lateral Migration Setback Allowance, Channel Degradation Estimation, and River Stability Impacts associated with Sand and Gravel Mining.

SS6-05 State Standard for Development of Individual Residential Lots within Floodprone Areas

Site Plan Checklist, Typical Plan and Cross-Section requirements for Individual residential lots within floodprone areas.

SS7-98 State Standard for Watercourse Bank Stabilization

Provides minimum design standards for several bank stabilization techniques.

SS8-99 State Standard for Stormwater Detention/Retention

Provides minimum criteria for sizing Detention and/or Retention facilities.

SS9-02 State Standard for Floodplain Hydraulic Modeling

Provides guidance on mathematical modeling of hydraulic processes in watercourses and floodplains.

SS10-07 State Standard for Hydrologic Modeling Guidelines

Provides guidance on the unique modeling conditions encountered in the state of Arizona.

4.3.14 Contact

City of Phoenix Street Transportation
Department Floodplain Management
200 West Washington Phoenix, AZ 85003
(602) 262-4960
http://phoenix.gov/STREETS/index.html

State of Arizona
Department of Water Resources
Flood Mitigation Section
500 North 3rd Street Phoenix, AZ 85004-3903
(602) 417-2400
http://www.azwater.gov/dwr/

Flood Control District of Maricopa County
2801 West Durango Street Phoenix, AZ 85009
(602) 506-1501
http://www.fcd.maricopa.gov/

Federal Emergency Management Agency
Region IX Mitigation Division
Presidio of San Francisco, Building 105
San Francisco, CA 94129-1250
(415) 923-7177
http://www.fema.gov/about/regions/regionix/index.shtm

4.4 SECTION 404 PERMIT FOR WATERS OF THE UNITED STATES

The U.S. Army Corps of Engineers (USACE) has been involved in regulating certain activities in the nation's waterways since the 1890's (River and Harbors Act of 1899). Until 1968, the primary thrust of the USACE regulatory program was the protection of navigation. As a result of several new laws and judicial decisions (Clean Water Act of 1968; Marine Protection, Research, and Sanctuaries Act of 1972), the program evolved into one that considers the full public interest by balancing the favorable impacts against the detrimental impacts. Section 404 of the Clean Water Act is to protect the physical, biological, and chemical quality of our nation's water from irresponsible and unregulated discharges of dredged or fill material that could permanently alter or destroy these valuable resources.

Any person, firm, or agency (including federal, state, and local government agencies) planning to work in or place dredged or fill material in Waters of the United States, must first obtain a permit from the USACE. The regulatory area is designated “Waters of the United States” or “jurisdictional waters." Waters of the United States includes essentially all surface waters such as all navigable waters and their tributaries, all interstate waters and their tributaries, all wetlands adjacent to these waters, and all impoundment's of these waters. In the Phoenix metropolitan area, ephemeral streams (washes) may be jurisdictional if they exhibit certain characteristics. The width of the wash, presence of hydraulic sorting, and the presence of riparian habitat, are factors, among other things, considered by the USACE. The regulations governing waters of the U.S. (including wetlands) apply to both public and private property.

Determination of the presence and extent (if present) of jurisdictional waters should be undertaken during the early stages of project planning. A jurisdictional delineation establishes the USACE regulatory area. It is highly recommended that the inexperienced seek guidance from the USACE or other environmental professionals.

4.4.1 Permits

Physical work in a watercourse or wetland may require a USACE permit. The program provides for the consideration of all concerns of the public including environmental, social, and economic in the USACE decision-making process to either issue or deny permits. As part of its responsibility to protect water quality, the USACE Section 404 permit program extends to many areas that were not regulated prior to the Clean Water Act.

Capital improvement projects undertaken on behalf of and paid by the City of Phoenix must coordinate their efforts with their client department[13] and/or the City’s Office of Environmental

[13] Consultants should contact their client department to determine the best means of communication.

Programs (OEP) prior to contacting the USACE. Joint ventures between the City and private entities must coordinate with the OEP prior to any inquiries or submittals to the USACE. Privately funded projects that are later to be conveyed to the City may need to certify proper compliance with 404 requirements.

Should a permit be required, there are several options depending on the type of land disturbance activity.

4.4.2 Individual Permits

Individual permits are issued following a full public interest review of an individual application for a USACE permit. A public notice is distributed to all known interested persons. After evaluating all comments and information received, final decision on the application is made.

The permit decision is generally based on the outcome of a public interest balancing process where the benefits of the project are balanced against the detriments. A permit will be granted unless the proposal is found to be contrary to the public interest.

An individual permit requires a 401 Water Quality Certification from the Arizona Department of Environmental Quality.

Application forms for individual permits are available from all USACE regulatory offices.

4.4.3 Nationwide Permits

A nationwide permit (NWP) is a form of general permit that authorizes a category of activities throughout the nation. These permits are valid only if the conditions applicable to the permits are met. If the conditions cannot be met, a regional or individual permit will be required.

Nationwide permits listed below may be modified to accommodate regional conditions. Contact the USACE office provided at the end of this section to obtain the most current information on the NWP program changes. A list of the more pertinent, presently available, nationwide permits follows. The reader should contact the USACE for a complete listing, permit details, and regional limitations placed upon nationwide permits. Some activities under nationwide permits require notification submittals to the USACE prior to the carrying out of those activities. Notification requirements may be determined by contacting the local USACE regulatory office. All nationwide permits must comply with the requirements of the particular nationwide permit, the nationwide permit general conditions, the 401 conditions (for water quality), and, if adopted, the Los Angeles District regional conditions.

NWP 3 - Maintenance

The repair, rehabilitation, or replacement of any previously authorized, currently serviceable, structure or fill, or of any currently serviceable structure or fill authorized by 33 CFR 330.3. Discharges of dredged or fill material, including excavation, into all waters of the United States to remove accumulated sediments and debris in the vicinity of, and within, existing structures and the placement of new or additional rip rap to protect the structure.

NWP 6 - Survey Activities

Survey activities including core sampling, seismic exploratory operations, plugging of seismic shot holes and other exploratory-type bore holes, soil survey and sampling, and historic resources surveys.

NWP 7 - Outfall Structures

Activities related to construction of outfall structures and associated intake structures where the effluent from the outfall is authorized, conditionally authorized, or specifically exempted, or are otherwise in compliance with regulations issued under the National Pollutant Discharge Elimination System program (NPDES) (Section 402 of the Clean Water Act).

NWP 12 - Utility Lines

The construction, maintenance, or repair of utility lines, including outfall and intake structures and the associated excavation, backfill, or bedding for the utility lines, in all waters of the United States, provided there is no change in preconstruction contours.

NWP 13 - Bank Stabilization

Bank stabilization activities necessary for erosion prevention, provided the activity meets all of the following criteria:

a. no material is placed in excess of the minimum needed for erosion protection

b. the activity is no more than 500 feet in length along the bank, unless this criterion is waived in writing by the district engineer

c. the activity will not exceed an average of one cubic yard per running foot placed along the bank below the plane of the ordinary high water mark or the high tide line, unless this criterion is waived in writing by the district engineer

d. the activity does not involve discharges of dredged or fill material into special aquatic sites, unless this criterion is waived in writing by the district engineer

e. no material is of the type, or is placed in any location, or in any manner, to impair surface water flow into or out of any water of the United States

f. no material is placed in a manner that will be eroded by normal or expected high flows (properly anchored trees and treetops may be used in low energy areas)

g. the activity is not a stream channelization activity

NWP 14 - Linear Transportation Crossings

Activities required for the construction, expansion, modification, or improvement of linear transportation crossings (e.g., highways, railways, trail, and airport runways and taxiways) in waters of the United State subject to acreage limitations.

NWP 18 - Minor Discharges

Minor discharges of dredged or fill material into all waters of the United States subject to volume or acreage limitations.

NWP 20 - Oil Spill Cleanup

Activities required for the containment and cleanup of oil and hazardous substances which are subject to the National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR Part 300) in accordance with certain state and federal requirements.

NWP 23 - Approved Categorical Exclusions

The activity is categorically excluded from environmental documentation, because it is included within a category of actions which neither individually nor cumulatively have a significant effect on the human environment.

NWP 25 - Structural Discharges

Discharges of material such as concrete, sand, rock, etc. into tightly sealed forms or cells where the material will be used as a structural member for standard pile supported structures, such as bridges, transmission line footings, and walkways.

NWP 29 - Single-Family Housing

Discharges of dredged or fill material into non-tidal waters of the United States, including non-tidal wetlands for the construction or expansion of a single-family home and attendant features (such as a garage, driveway, storage shed, and/or septic field) for an individual permittee.

NWP 31 - Maintenance of Existing Flood Control Facilities

Discharges of dredged or fill material for the maintenance of existing flood control facilities, including debris basins, storm water storage basins, and channels. The maintenance is limited to that approved in a maintenance baseline determination made by the District Engineer.

NWP 33 - Temporary Construction, Access, and Dewatering

Temporary structures, work, and discharges, including cofferdams, necessary for construction activities or access fills or dewatering of construction sites, provided that the associated primary activity is authorized by the Corps of Engineers.

NWP 38 - Cleanup of Hazardous and Toxic Waste

Specific activities required to effect the containment, stabilization, or removal of hazardous or toxic waste materials that are performed, ordered, or sponsored by a government agency.

NWP 39 -Commercial, and Institutional Developments

Discharges of dredged or fill material into non-tidal waters of the United States for the construction or expansion of commercial, and institutional building foundations and building pads and attendant features that are necessary for the use and maintenance of the structures.

NWP 40 - Agricultural Activities

Discharges of dredged or fill material into non-tidal waters of the United States for the purpose of improving agricultural production and the construction of building pads for farm buildings. Authorized activities include the installation, placement, or construction of drainage tiles, ditches, or levees; mechanized land clearing; land leveling; the relocation of existing serviceable drainage ditches constructed in waters of the United States; and similar activities.

NWP 41 - Reshaping Existing Drainage Ditches

Discharges of dredged or fill material into non-tidal waters of the United States to modify the cross-sectional configuration of currently serviceable drainage ditches constructed in these waters. The reshaping of the ditch cannot increase drainage capacity beyond the original design capacity or expand the area drained by the ditch as originally designed (i.e., the capacity of the ditch must be the same as originally designed and it cannot drain additional wetlands or other waters of the United States).

NWP 42 - Recreational Facilities

Discharges of dredged or fill material into non-tidal waters of the United States, excluding non-tidal wetlands adjacent to tidal waters, for the construction or expansion of recreational facilities.

NWP 43 - Storm Water Management Facilities

Discharges of dredged or fill material into non-tidal waters of the United States for the construction and maintenance of storm water management facilities, including activities for the excavation of storm water ponds/facilities, detention basins, and retention basins; the installation and maintenance of water control structures, outfall structures and emergency spillways; and the maintenance dredging of existing storm water management ponds/facilities and detention and retention basins.

NWP 44 - Mining Activities

Discharges of dredged or fill material into: (i) Isolated waters, streams where the annual average flow is 1 cubic foot per second or less, and non-tidal wetlands adjacent to headwater streams, for aggregate mining and other mining activities subject to certain limitations.

To apply for a nationwide permit, an application form must be completed. This application is available from all USACE regulatory offices.

NWP 46 - Discharges in Ditches

Discharges of dredged or fill material into non-tidal ditches that are: (1) constructed in uplands, (2) receive water from an area determined to be a water of the United States prior to the construction of the ditch, (3) divert water to an area determined to be a water of the United States prior to the construction of the ditch, and (4) are determined to be waters of the United States. The discharge must not cause the loss of greater than one acre of waters of the United States.

4.4.4 Regional Permits

Regional permits are issued by the District Engineer for a general category of activities when:

- The activities are similar in nature and cause minimal environmental impact (both individually and cumulatively)
- the regional permit reduces duplication of regulatory control by State and Federal agencies

Contact the USACE District Regulatory office for information regarding regional permits.

4.4.5 Contact

U.S. Army Corps of Engineers
Los Angeles District Regulatory Branch
3636 North Central Avenue Suite 970
Phoenix, AZ 85012-1936
(602) 640-5385

http://www.spl.usace.army.mil/cms/index.php

http://www.spl.usace.army.mil/regulatory/

Arizona Department of Environmental Quality
Reuse and Federal Permits Unit
1110 W. Washington St., 5415B-3
Phoenix, AZ 85007
(602) 771-2300

http://www.azdeq.gov/function/permits/index.html

City of Phoenix
Office of Environmental Programs
200 West Washington Phoenix, AZ 85003
(602) 534-1775

http://www.phoenix.gov/

4.5 STORM WATER NPDES/AZPDES

Stormwater systems are subject to the requirements and permitting process of the National Pollutant Discharge Elimination System (NPDES), which is a U.S. Environmental Protection Agency (EPA) program and is the administrative mechanism chosen for stormwater permitting. The EPA issued regulations in 1990 authorizing the creation of a NPDES permitting system for stormwater discharges from a large group of industrial activities (including construction activities) and for discharges from municipal separate storm sewer systems located in municipalities with a population of 100,000 or more. In 1999, Phase II of the stormwater program added small municipal separate storm sewer systems from any other municipalities located wholly or partially in urbanized areas if they were not already covered by Phase I of the stormwater program. In addition, construction sites that disturb one acre but less than five acres were also added. In Arizona, the NPDES program is called AZPDES, which stands for Arizona Pollutant Discharge Elimination System. An AZPDES permit is required for any point source discharge of pollutants to a water of the United States. Because stormwater runoff can transport pollutants to either municipal storm sewer systems or to Waters of the United States, permits are required for those discharges. In addition to stormwater permits, there are also NPDES / AZPDES permits required for the discharge of processed wastewater and the land application of sludge. The application process for both general permits is similar.

4.5.1 Permits

Most stormwater discharges are permitted under various general permits. However, an individual permit is required when the general permit requirements do not accurately represent the activity at a facility / municipality and a permit is customized to the site / for the permittee. An individual permit may be necessary if the Limitations of Coverage section of a general permit does not allow the facility's discharge to be covered within the general permit. It is the responsibility of every applicant to determine if any of the Limitations of Coverage apply to the facility seeking a general permit.

4.5.2 Construction Activities

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. In many areas, however, the effectiveness of ordinances in reducing pollutants is limited due to inadequate enforcement or incomplete compliance with local ordinances by construction site operators.

4.5.3 Construction General Permit Coverage

This general permit authorizes discharges of stormwater associated with construction activity provided the operator complies with all the requirements of the general permit and submits a Notice of Intent (NOI) in accordance with the general permit.

Stormwater associated with large construction activity refers to the disturbance of five or more acres, as well as the disturbance of less than 5 acres of total land area that is a part of a larger common plan of development or sale if the larger common plan will ultimately disturb five acres or more (40 CFR 122.26(b)(14)(x)).

Stormwater associated with small construction activity, as defined in 40 CFR 122.26(b)(15), refers to the disturbance of equal to or greater than 1 and less than 5 acres of land for construction, or the disturbance of less than 1 acre of total land area that is part of a larger common plan of development or sale if the larger common plan will ultimately disturb equal to or greater than 1 and less than five acres.

4.5.4 Permit Waivers

There are two waivers available for small construction activities. The first is where the construction site operator has determined that the rainfall erosivity factor (R) in the Revised Universal Soil Loss Equation[14] (RUSLE) is less than 5. The second waiver is available where the operator certifies that stormwater controls are not needed based upon a total maximum daily load (TMDL). Currently Arizona TMDL's do not address this issue, but the permit includes the TMDL waiver as a potential future option.

4.5.5 How to Obtain Coverage

The operator of a construction site is responsible for obtaining coverage under an AZPDES 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 Storm Water Pollution Prevention Plan (SWPPP). Submit a NOI to the Stormwater

[14] Information on RUSLE available on the USDA website.

Coordinator, Arizona Department of Environmental Quality, 1110 West Washington Street, Phoenix, Arizona 85007. This form must be complete and accurate and signed by the appropriate party in order for you to obtain coverage. The form also serves as a promise by the operator that there will be compliance with the permit conditions. ADEQ now offers a web-based service to assist individuals in applying for construction stormwater discharge permits.

The operator must also develop and implement a SWPPP that satisfies the conditions of the permit. If the site is located within 1/4 mile of unique or impaired water, the SWPPP must be submitted with the NOI. In all other cases, do not submit the SWPPP to ADEQ, however the SWPPP must be available for ADEQ review. Once the SWPPP is prepared and a complete and accurate NOI is received by ADEQ, the operator must wait at least 2 business days before discharging. If ADEQ does not contact the operator within the waiting period, the operator may assume permit coverage has been granted. Whether or not ADEQ notifies the operator of a deficiency in the NOI, discharges are not authorized under this permit if the operator submits an incomplete or incorrect NOI. The SWPPP can be requested by any agency (including Maricopa County) and should remain available for review at the project site. For a more detailed description of unique or impaired waters,

see ADEQ's website at:
http://www.azdeq.gov/environ/water/permits/azpdes.html

For information on the Revised Universal Soil Loss Equation, see the USDA website at:
http://www.ars.usda.gov/Research/

Permit information and forms may be obtained from the agencies listed below.

4.5.6 Contact

Arizona Department of Environmental Quality
1110 W. Washington St., 5415B-3
Phoenix, Arizona 85007
(602) 771-2300

http://www.azdeq.gov/index.html

City of Phoenix
Street Transportation Department
Storm Water Management Section
200 W. Washington St. 5th Floor
Phoenix, AZ 85003
(602) 262-6284

http://www.phoenix.gov/streets/index.html

City of Phoenix
Planning and Development Department
200 West Washington St. Phoenix, AZ 85003
(602) 262-7811

http://www.phoenix.gov/development/index.html

4.6 DAMS

Dams in the state, except those owned or operated by an agency or instrumentality of the federal government, are under the jurisdiction of the Arizona Department of Water Resources (ADWR). A dam is any artificial barrier that impounds or diverts water above the natural ground surface. A detention basin or retention basin that impounds storm water above the natural

ground surface may be considered as being a dam under the authority of ADWR. The following do not fall under the authority of ADWR.

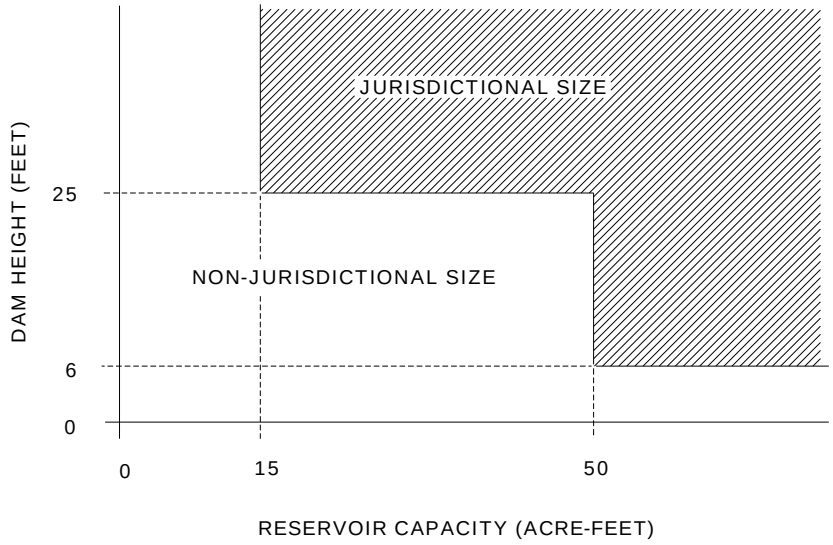
Any artificial barrier:

1. Less than 6 feet in height, regardless of storage capacity.
2. Fifteen acre-feet or less of storage capacity, regardless of height.
3. Between 6 and 25 feet in height with a storage capacity less than 50 acre-feet.

Any impoundment or diversion structure that exceeds the criteria above will require a permit from ADWR. Individuals having questions should contact the Dam Safety Section of ADWR.

A JURISDICTIONAL DAM is either 25 or more feet in height or has capacity to store more than 50 acre-feet. If a dam is less than six feet in height, regardless of storage capacity, it is not jurisdictional. If the dam has 15 acre-feet or less of storage capacity, regardless of height, it is not jurisdictional. HEIGHT is the vertical distance from the lowest point on the downstream toe (at natural ground) to the emergency spillway crest. CAPACITY is the maximum storage that can be impounded when there is no discharge of water. Dam jurisdiction as regulated by ADWR is illustrated in Figure 4.6.1, Dam Jurisdiction.

Figure 4.6.1 Dam Jurisdiction



4.6.1 Permits

A permit is required for all new dams or the repair, alteration or removal of an existing dam. Application forms are available from ADWR. An administrative review fee is required by ADWR.

4.6.2 Contact

State of Arizona
Department of Water Resources
Dam Safety Section
500 North 3rd Street
Phoenix, AZ 85004-3903
(602) 417-2400
http://www.azwater.gov/dwr/

4.7 DRY WELL REGISTRATION

A person who owns an existing dry well that is or has been used for storm water disposal shall register the dry well with the Arizona Department of Environmental Quality (ADEQ). A dry well is a bored, drilled, or driven shaft or hole whose depth is greater than its width and is designed and constructed specifically for the disposal of storm water. They must be registered by completing a form by ADEQ, and submitting a registration fee for each dry well.

4.7.1 Permits

Dry wells are regulated by Arizona Revised Statute (A.R.S.) § 49-241 and §49-331 through §49-336, and Aquifer Protection Permit statutes and rules. Dry wells that drain areas where hazardous substances are used, stored, loaded, or treated are subject to the General Permit or full Aquifer Protection Permit (see Section 4.8). Specific rules regarding dry wells are found in R-18- 9-102-A and R18-9-A301. Program guidance documents are available from ADEQ, and should be followed for dry well construction, maintenance, siting, investigation, decommissioning, and closure. Registration is generally not required for dry wells used in conjunction with golf course maintenance, and they are exempted from regulation under the dry well program. However, vadose zone injection wells (including dry wells) that receive storm water mixed with reclaimed wastewater or groundwater from manmade bodies of water associated with golf courses, parks, and residential areas must be registered. In this situation, a general permit issued by statute in lieu of an individual permit, provided that six criteria, including registration, are met (A.R.S. §49 - 245.02).

Dry well registration and permit information and forms may be obtained from ADEQ at the location provided below.

4.7.2 Contact

Arizona Department of Environmental Quality
1110 W. Washington St., 5415B-3
Phoenix, Arizona 85007
(602) 771-2300
http://www.azdeq.gov/index.html

4.8 AQUIFER PROTECTION PERMIT

An individual will need to obtain an Aquifer Protection Permit (APP) if they own or operate a dry well that discharges a pollutant either directly to an aquifer or to the land surface or the vadose zone in such a manner that there is a reasonable probability that a pollutant will reach an aquifer. ADEQ may provide an "APP Determination of Applicability Form" for dry wells in areas

where hazardous substances are used, stored, loaded, or treated. Dry wells that are used solely for the disposal of storm water runoff do not require an Aquifer Protection Permit, however, dry well registration is still a requirement.

4.8.1 Permits

The following Aquifer Protection Permits are available:

Individual Permits

Individual permits are issued for a term not to exceed the operational lifetime of the facility. Individual permits take, on average, from 6 months to over 2 years. Processing time is approximately 6 months, however, incomplete applications often result in delays.

Area-Wide Permits

Area-wide permits may be issued in lieu of an individual permit to cover facilities under common ownership in a contiguous geographic area. Discharge reduction in the pollutant management area and the demonstration that aquifer water quality standards will not be violated or further degraded can be evaluated collectively for existing facilities. This type of permit is most applicable to large mining and industrial sites.

General Permits

There are currently 15 different types of general permits. These are issued by rule or statute, and the facility is automatically permitted, provided that certain conditions are adhered to. A separate permit document is not required to operate under these conditions and no fee is required.

Information regarding APP's are available from ADEQ at the locations listed below.

4.8.2 Contact

Arizona Department of Environmental Quality
1110 W. Washington St., 5415B-3
Phoenix, Arizona 85007}
(602) 771-2300
http://www.azdeq.gov/index.html

4.9 CITY OF PHOENIX STORM WATER MANAGEMENT

It is the goal of the City of Phoenix to protect, maintain, and enhance the public health, safety and general welfare by establishing requirements and procedures to control the adverse affects of storm water runoff and pollution and associated with land development. This manual sets forth the policies and standards for management of urban drainage and floodplains.

The City of Phoenix Development Services Department administers the approval and permit processes established for grading, drainage and floodplain management

4.9.1 Permits

The City of Phoenix has permit requirements for storm water facilities. Individual permits are available for the following:

1. Drainage Facilities Permit
2. Grading and Drainage Permit
3. Storm Water Management Plan Permit.

Drainage Facilities Permit

A Drainage Facilities Permit is required in order to connect and discharge storm water into the City storm drain system. New storm drain segments or inlets, low-flow bleed-off lines from detention basins, or storm water discharge pumps are examples of drainage facilities requiring a permit. This permit provides a procedure for the City to track additions and connections to the City's storm drain system.

Grading and Drainage Permit

A Grading and Drainage Permit is required for development activities that include excavation, fill, drainage swales and channels, drainage structures and pipes, detention / retention areas, and dry wells.

Storm Water Management Plan Permit

A Storm Water Management Plan Permit may be required for proposed construction activities within the City of Phoenix. Storm water management permit information and forms are available at the City of Phoenix at the location below.

As part of the City of Phoenix Storm Water Quality Protection ordinance effective 1992, all commercial and industrial facilities with the potential to pollute storm water must prepare, submit and implement a Storm Water Management Plan (SWMP). Since contractors completing the construction end their involvement by filing a NOT, the Development Services Department will inform the property representative who receives the Certificate of Occupancy of the requirement to submit the SWMP. The owner/operator(s) will submit a Storm Water Management Plan (SWMP) to the City before they begin operations at the facility. Failure to develop specific Best Management Practices (BMP's) or to implement these BMP's located in the SWPPP or SWMP may subject the permittee(s) to fines of up to $2,500 per day per violation. A SWPPP may be submitted in lieu of a SWMP. The SWMP will be submitted to the City of Phoenix Storm Water Management Section identified below.

4.9.2 Contact

City of Phoenix
Planning and Development Department
200 West Washington St. Phoenix, AZ 85003
(602) 262-7811

http://www.phoenix.gov/development/index.html

For industrial specifications:

City of Phoenix
Street Transportation Department
Storm Water Management Section
200 W. Washington St. 5th Floor
Phoenix, AZ 85003
(602) 495-5326
http://www.phoenix.gov/streets/index.html

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5 PHOENIX CITY CODE

It is the intent of the City of Phoenix to have a comprehensive storm water management program that protects the health, safety and welfare of its citizens, their property, and the environment. This includes the Stormwater Policies and Standards as well as the City ordinances relating to drainage. The City's stormwater drainage and flood control ordinances are contained within the City Code and are not reproduced within this manual. Codes which specifically address stormwater include the following:

- Chapter 32A, Grading and Drainage
- Chapter 32B, Floodplains
- Chapter 32C, Storm Water Quality Protection

In addition to these codes, the entire city code may be found at the following locations:

- Phoenix, Arizona (MuniCode.com)

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6 DRAINAGE STANDARDS

6.1 SAFETY AND PROTECTION OF THE NATURAL ENVIRONMENT

Designs for hydraulic structures must address the issue of safety.

6.1.1 High Velocity Channels

For engineered portions of channels with actual water depths greater than three feet in the 100-year event; and for shallow, fast-flowing, engineered channels where the product of maximum depth and average velocity exceeds nine ft^2/sec for the 100-year event, the following standards apply:

6.1.1.1 Restrict Public Access

Appropriate measures must be designed to keep the public away from these locations.

6.1.1.2 Fencing

Adequate fencing or railings must be provided along all walls, such as wing walls or training walls (excluding vertical drops in channel bottom.)

6.1.2 Channel Drop Structures

For channel drop structures, the maximum vertical drop height from invert crest to invert toe for any single step shall be 2.5 feet. A six foot wide (minimum) horizontal apron shall be provided for every 2.5 feet of vertical drop in a "stair step" fashion. Drop structures constructed of concrete or shotcrete shall have a roughened surface to discourage inappropriate recreational use.

6.1.3 Emergency Steps

All concrete, shotcrete, or smooth sided soil cement channels flowing in a subcritical flow regime with design flow depth greater than three feet shall have emergency escape stair- steps formed; alternating every 300 feet from one side of the channel to the other.

6.1.4 Depth of Ponds

For storm water storage ponds with a permanent water body in the bottom, the pond edge shall be designed to minimize safety hazards. Water depth should be limited to 1.5 to 2 feet within eight feet of the edge of the water feature, and gradually get deeper as needed.

6.1.5 Basin Amenities

Amenities placed within the inundation area of a storm water facility shall be adequately secured to prevent them from becoming waterborne debris. Methods for securing items shall be shown on the design approval and construction plans.

6.1.6 Basin Fencing

Where accessible, adequate fencing is required along portions of engineered basins or engineered channels greater than three-feet deep where side-slopes are steeper than 4:1.

6.1.7 Grates and Barriers

Grates or trash racks (inlet end) and access barriers (outlet end) are required on exposed inlet or outlet ends of all storm drains 18 inches or greater in diameter. Access barriers shall be constructed in accordance with City Detail P1562 and P1563. Trash racks shall be constructed in accordance with MAG Detail 502-1 or 502-2.

6.1.8 Lighting

Area security and pathway lighting shall be placed as needed to provide illumination within multi-use stormwater storage facilities. Lighting shall conform to City of Phoenix Parks and Recreation Department standards.

6.1.9 Walkways

Walkways shall meet the Americans with Disabilities Act (ADA) requirements and be elevated at least one foot above the invert of any low flow channel.

6.1.10 Access

All drainage facilities must be readily accessible by emergency or ordinary maintenance vehicles (e.g., pickup truck, loader, backhoe, etc).

6.1.10.1 Access for Basins and Channels

For engineered channels and storm water storage facilities/basins with geometric depths greater than three feet deep, accessways to the channel or basin; and ramps into the channel or basin shall be required. For engineered channels or storm water storage facilities/basins with geometric depths of three feet deep or shallower with a portion of side slope set at 6:1 or flatter along at least one side to allow emergency or ordinary maintenance vehicle access, ramps into the channel or basin are not required.

6.1.10.2 Access for Natural Washes

For natural washes, a minimum 16-feet wide accessible clear-zone area for emergency and ordinary maintenance vehicle access shall be provided.

6.1.10.3 Access to Minor Drainageways

For all other small engineered channels such as swales, roadside drainage ditches, etc., reasonable access for emergency and ordinary maintenance vehicles shall be provided.

6.1.10.4 Access Ramps

Access ramps shall be a minimum of 16 feet wide with a longitudinal slope no steeper than 10%. Access ways approaching channels or basins shall be a minimum of 12 feet wide within a clear 16-feet wide tract (included as part of a City owned property, right-of-way, or privately owned drainage tract) such that emergency and ordinary maintenance vehicles can freely maneuver.

At a minimum, hard surface paving (such as concrete, soil cement, etc.) shall be required for the portions of access ramps that will be inundated during the 100-year event, and shall be properly "toed-down" to protect the ramp from erosion during storm events.

6.1.10.5 Access From Trails

Portions of access ways or ramps may be combined with portions of multi-use trails, subject to approval by the reviewing department(s).

6.1.10.6 Access to Temporary Channels

To minimize the extent of off-site temporary easements, access ways are not required for temporary collector channels constructed on adjacent developable properties provided that the channels are accessible by ordinary maintenance equipment. Should these temporary collector channels become a permanent component of the drainage system under future developed conditions, then access ways will be required at that time.

6.1.10.7 Alternative Access

The design engineer may propose other means of providing access for maintenance by ordinary maintenance equipment subject to approval by the appropriate reviewing department(s).

6.1.10.8 Temporary Fencing

The City staff of the reviewing department may require temporary fencing around certain environmentally important areas of a project (such as washes or open desert areas that are to remain undisturbed) to restrict or prevent construction activities within those designated areas. This requirement will be determined on a case-by-case basis.

6.1.11 SWPPP

For all construction projects that have the potential to disturb more than one acre of property the developer/contractor must prepare and submit a Storm Water Pollution Prevention Plan (SWPPP) along with a Notice of Intent (NOI) to ADEQ at least 48 hours prior to groundbreaking. Best Management Practices (BMP's) must be included in the SWPPP. Upon completion of the project, the developer/contractor must prepare and submit a Notice of Termination (NOT) to ADEQ. See the Federal Register and the Drainage Design Manual for Maricopa County, Erosion Control for more details on these requirements.

6.2 Hydrology

Table 6.2.1 Rainfall Criteria

Purpose	Criteria
Street Storm Drains	2-year
Storm Water Storage Facilities	100-year, 2-hour rainfall as defined in the Design Manual for stormwater volume.
Analysis for undisturbed drainageways and design of engineered channels, bridges, and culverts.	
Drainage area: 160 acres to 20 square miles	100-year, 6-hour local storm as defined in the Design Manual.
Drainage area: 20 to 100 square miles	Either a critically centered 6-hour local storm as defined in the Design Manual, or a 24-hour general storm using the SCS Type II distribution for the 100-year event.
Drainage area: 100 to 500 square miles	100-year, 24-hour general storm using the NRCS Type II distribution as defined in the Design Manual.

6.2.2 Rational Method Criteria

Table 6.2.2 Runoff Coefficients "C" for Use with the Rational Method

Land Use	Return Period	
	2-10 Year	100 Year
Paved Streets, Roads, and Parking Lots	0.95	0.95
Industrial Areas	0.70	0.90
Business/Commercial Areas	0.75	0.90
Lawns, Parks, Cemeteries	0.25	0.30
Graveled Surfaces	0.70	0.85
Agricultural Areas	0.15	0.20
Undeveloped Desert	0.35	0.45
Mountain Terrain (Slopes >10%)	0.70	0.85

Land Use	Return Period	
Residential Areas		
Single Family Zoning District RE-35	0.45	0.55
Single Family Zoning District R1-18	0.50	0.60
Single Family Zoning District R1-10	0.55	0.65
Single Family Zoning District R1-8	0.60	0.70
Single Family Zoning District R1-6	0.65	0.75
Single/Multi Family Zoning District R-2	0.70	0.80
Single/Multi Family Zoning District R-3	0.70	0.80
Single/Multi Family Zoning District R-3A	0.75	0.85
Single/Multi Family Zoning District R-4	0.75	0.85
Single/Multi Family Zoning District R-5	0.75	0.85

6.2.2.1 Maximum Area

The Rational Method shall only be allowed for estimation of storm water peak flow and run-off volume estimates for design of storm drains, minor channels and retention storm water storage facilities with contributing drainage areas up to 160 acres.

6.2.2.2 Limitations

The Rational Method shall not be used for channel routing procedures or detention storm water storage facilities. For contributing drainage areas greater than 160 acres, and for channel routing and detention storm water storage facilities design, the HEC-1 methodology described in the Design Manual shall be used.

6.2.2.3 Runoff Coefficients

The run-off coefficients above shall be used with the Rational Method. The Engineer shall assign separate coefficients to streets, residential lots, landscape areas, etc. and may provide an area-weighted coefficient for the watershed in analysis. The Engineer may assign alternate coefficients where appropriate justification and documentation can be provided.

6.2.2.4 Time of Concentration

The minimum time of concentration allowed shall be ten minutes for storm drain design.

6.2.2.5 Offsite Analysis

Hydrology analysis of off-site areas shall be based on existing conditions at time of design drainage analysis.

6.2.3 Hydrologic Design Criteria

Table 6.2.3 Hydrologic Design Criteria

Drainage Feature	Peak Frequencies	
	2 Year	100 Year
Street with Curb and Gutter (longitudinal flow) Storm drain systems installed as needed to meet street drainage criteria)	Runoff contained within street curbs. For major collector and arterial streets, one 12-foot dry driving lane in each direction must be maintained in each direction and sump depths shall not exceed 0.4 foot measured upgradient, immediately adjacent to catch basin. Historic drainage divides shall be retained. Flows within existing streets shall follow historic drainage paths.	Runoff to be contained below the finished floor of building. Q max = 100 cfs V max = 10 fps D max roadway = 8 inches
Street without Curb and Gutter (longitudinal flow).	Runoff contained within the roadside channels with the water surface eleva tion below the road subgrade. Historic drainage divides shall be retained. Flows within existing streets shall fol low historic drainage paths.	Same as Street with Curb and Gutter (8 inch depth at edge of pavement).
Cross Road Culvert for Collector and Arterial Streets.	N/A	All runoff to be conveyed by culvert with no roadway overtopping allowed. V max = 15 fps
Cross Road Culvert for Local Streets	N/A	Runoff to be conveyed by culvert with overtopping flow no more than six inches deep. V max = 15 fps D max (at crown) = 6 inches
FEMA Floodplain Channel	N/A	100-year peak storm to delineate a floodplain for discharges greater than 500 cfs
Channel to Convey Off-site Flow Through Development.	N/A	100-year peak storm
Lowest floor elevation for buildings within a FEMA Floodplain Area.	N/A	Lowest floor elevation to be a minimum of one foot above the floodplain water surface elevation.

Drainage Feature	Peak Frequencies	
	2 Year	100 Year

Drainage Feature	Peak Frequencies	
	2 Year	100 Year
FEMA AO Zones and alluvial fans	N/A	Retained natural watercourses shall contain the 100-year peak storm. Floodproofed freeboard shall be required in these drainageways. Cutoff walls to protect from lateral migration and/or headcutting may be required. Drainage that leaves the development shall be re-distributed in a manner similar to existing conditions. At a minimum, the lowest floor elevation shall be set above the highest adjacent grade by the designated AO zone depth or 2' if no depth is specified. A registered professional engineer / surveyor shall certify the finish floor elevations comply with the above. The engineer shall certify that the structure foundation will not be inundated as a result of the 100-year storm flows. Levees, berms, or floodwalls while discouraged, must comply with FEMA standards and be submitted to the City Floodplain Manager for approval by the department responsible for plan/ design review. All finish floors shall be a minimum of 14 inches above the low curb elevation of the residential lot.
Lowest floor not in a FEMA Designated Floodplain.	N/A	See section 6.3
Storm water storage basin.	N/A	100-year 2-hour storm for determining storm water storage volume.

6.3 STREET DRAINAGE

The conveyance of storm water in a roadway is influenced by the typical roadway cross-section, cross-slope, longitudinal slope and roadway material. The following are standards to be used in the evaluation of roadway conveyance:

6.3.1 Finished Floor Elevations

Finished floor elevations of buildings, shall be a minimum of 0.5 foot above the crown of an adjacent street. As measured perpendicular to the street, no portion of a structure shall have its finish floor less than 0.5 foot above the crown of the adjacent street.

Finished floor elevations shall be a minimum of 14 inches above the top of adjacent low curb or outfall and, for all lots except hillside lots, a minimum of six inches above the top of adjacent high curb. In areas of natural topographic or engineered sumps, the finished floor elevations for new construction shall be a minimum of 14 inches above the outfall or 0.5 foot above the maximum 100-year water surface elevation, whichever is greater.

6.3.2 Storm Drain Inlets and Connector Pipes Sizing

Runoff calculations for the sizing of storm drain catch basin inlets and connector pipes shall be based on the Rational formula.

6.3.3 Pavement Runoff Design Criteria

6.3.3.1 Manning's "n"

A minimum Manning's "n" value of 0.015 shall be used for street flow on paved streets (asphalt concrete or portland cement concrete) unless special conditions exist.

6.3.3.2 Valley Gutters

Valley gutters are only allowed on local and minor collector streets. For valley gutters crossing minor collector streets, the valley gutters shall provide mild slope transitions (maximum 5% total algebraic breakover) to provide smooth vehicular ride across them, and shall be at least seven-feet wide.

6.3.3.3 Curb Returns

Curb returns should have a minimum slope of 0.01 foot of fall for every one foot of curb radius. For example, a 25 foot radius curb return should have at least 0.25 foot of fall from one end to the other.

6.3.3.4 Gutter Flow Depth

For arterial and collector streets, the maximum flow depth at the gutter invert for the 2-year event shall be 0.5 feet as measured immediately up gradient of the catch basin or scupper (catch basins are depressed to provide a 5-inch opening to receive flow). Maximum flow depth in gutter sump conditions at catch basins shall be no more than 0.4 feet, beyond which, the storm water shall be allowed to "break out" and continue flowing in the original historic path direction.

6.3.3.5 Dry Lanes

For multi-lane collector streets and all arterial streets, a 12-foot dry lane in each direction shall be provided for the 2-year event.

6.3.4 Catch Basin Design Criteria

6.3.4.1 Catch Basin Spacing

For major collector and arterial streets, the maximum distance that drainage may be carried as surface flow in the street is 660 feet before reaching a catch basin or outfall. This requirement may be waived for streets with longitudinal slopes of 2% or greater, or portions of streets with very minimal flow (less than 2 cfs in the 2-year design event).

6.3.4.2 Catch Basin Efficiency

Catch basins on continuous grade are not required to intercept 100% of the 2-year flow.

6.3.4.3 Curb Opening Size

The curb opening for a catch basin shall not be greater than five inches in height. Permissible catch basins are contained in the City of Phoenix Standard Details. The reduction factors, as identified in Table 6.3.1 below, shall be applied to the theoretical catch basin capacity to obtain the interception capacity used for design.

Table 6.3.1 Reduction Factors to Apply to Catch Basins

Condition	Inlet Type	Reduction Factor
Sump	Curb Opening	0.80
Sump	Grated[15]	0.50
Sump	Combination	Apply factors separately to grate and curb opening
Continuous Grade	Curb Opening	0.80
Continuous Grade	Grated	0.50
Continuous Grade	Combination	Apply factors separately to grate and curb opening
Shallow Sheet Flow [16]	Slotted Drain	0.75

6.3.4.4 Catch Basin Minimum Size

Regardless of the calculated "Q", no curb inlet type catch basin shall be smaller than an M-1, L=3' basin constructed in accordance with City of Phoenix Detail P1569-1 or P1569-2.

6.3.4.5 Catch Basin Preferences

Preferred catch basins in the City of Phoenix are the City of Phoenix Standard Details. Catch basin types that should be used, in order of preference, are as follows:

1. M-Type, curb opening inlet
2. P-Type or L-Type, curb opening inlet where appropriate
3. R-Type, combination curb opening / grated inlet
4. Q-Type, combination curb opening / grated inlet
5. N-Type, grated inlet[17]

[15] Grated inlets in sump condition should be avoided whenever possible.

[16] Slotted drains are most effective for shallow sheet flow conditions or sumps. With greater depths and flows, a different type of inlet should be used.

[17] Do not use grated inlets in street sump situation, use curb opening or combination

6.4 STORM DRAINS

Table 6.4.1 Minimum Hydraulic Design Standards

Storm Drain Standard	Requirement
Minimum Velocity	5 fps for 2-Year Q design 3 fps for 0.5 x Q design
Minimum Pipe Size Main Line Catch Basin Connector Pipe	18 inches 15 inches
Maximum surface flow distance within street to first catch basin or outfall, and maximum distance between catch basins or outfalls	660 feet [18]

Storm Drain Standard	Requirement	
Maximum Manhole Spacing (D = Storm Drain Diameter)	D < 30 inches	330 feet
	33 < D < 45 inches	440 feet
	D > 48 inches	600 feet

Storm Drain Standard	Requirement
Maximum design hydraulic grade line (HGL) elevation	Ideally, at the top of main line storm drain pipe, but generally no higher than 1-foot above the top of pipe at the design Q. In certain circumstances, it may be allowed to go higher than this for short reaches of pipe, but in no case should the HGL reach higher than 5-feet below the ground or roadway surface elevation over the pipe.
Minimum catch basin freeboard elevation	12 inches below bottom of curb inlet or 12 inches below top of grate at the design intercept Q for the catch basin.

Storm Drain Standard	Requirement
Minimum Manning's "n" Values	
Reinforced Concrete Pipe (RCP)	0.013

[18] May be waived for major collector or arterial streets with longitudinal slopes of 2% or greater, or with very minimal flow (less than 2 cfs in the 2-year design event)

Storm Drain Standard	Requirement
Reinforced Concrete Box Culvert (RCBC)	0.015
Corrugated Metal Pipe (Concrete-lined)	0.013
Corrugated Metal Pipe (Unlined)	0.024
High Density Polyethylene Pipe (HDPE)	0.013

The following standards shall be met for the design of storm drains:

6.4.1 Storm Drain Plan and Profile

Storm drain pipes and manholes shall be shown in plan and profile along with existing and proposed grades of the pipeline and ground surface above the pipeline. Catch basin and connector pipe profiles shall also be provided in the design drawings. The pipe size and slope to four significant figures shall be shown. All existing utilities, including water and sanitary sewer, crossing the proposed storm drain shall be shown in plan, and in profile at their proper elevation. Proposed new utilities shall be labeled and shown at anticipated locations and standard depths when exact information is not yet known. Clearance with City of Phoenix water and sewer facilities require a minimum of six feet horizontally and one foot vertically. Salt River Project utilities require a minimum of two feet clearance horizontally and one foot vertically. Clearance with other utilities shall be a minimum of one foot both horizontally and vertically.

6.4.2 Storm Drain Design Calculations

The design engineer shall submit hydraulic and energy grade line calculations for all main line storm drain pipes. The information shall be provided in tabular and profile format and shall include: pipe stationing, pipe size, pipe discharge (Q), pipe velocity, pipe material, hydraulic grade line, energy grade line, and finish grade over pipe. See Section 6.12 for construction drawing requirements.

6.4.3 D-Loads

Minimum cover over storm drain pipe should be at least five feet, and pipe shall be designed to fall within the allowable ranges identified in Figure 6.4.1. D-Load requirements shall be determined using a 140 pcf earth load and the appropriate live load. In ordinary soil conditions, positive projection embankment condition shall be used up to 10 feet of cover. Trench condition may be used for deeper trenches in stable soil conditions. Otherwise, positive projection embankment condition shall be used exclusively in determining all D-Load requirements.

Storm drain pipes with two feet of cover or less shall be minimum Class III pipe; and if also passing through major intersections, shall be upgraded to minimum Class V pipe from curb return to curb return. Major intersections are defined as:

- Major – Major
- Major – Collector

D-Load shall be determined by using the following procedure or by selecting the appropriate value from Figure 6.4.1.

To determine D-Load and select an appropriate pipe class for pipe sizes not listed on Figure 6.4.1, the steps below shall be followed, in accordance with the American Concrete Pipe Association (ACPA) Concrete Pipe Design Manual, 2007 Edition, Standard Installations Direct Design (SIDD) method. Note the Fluid Load (W_{fluid}) used in the D-Load calculations equals 62.4 pcf.

Step 1
Add the pipe ID (inner diameter) in inches to the wall thickness (2 walls) to determine the outside diameter of the pipe D_O.

Step 2
Calculate the Earth Prism Load on the pipe (P_L) per the following Equation from the ACPA Manual.

$$P_L = w\left[H + \frac{D_O(4-\pi)}{8}\right]D_O$$

where:

w	=	Soil unit weight, (lbs.ft^3)
H	=	Height of fill, (ft)
D_O	=	Outside diameter of pipe, (ft)

Step 3
Select the Vertical Arching Factor (VAF) for the Type 4 Standard Installation Method from Table 6.4.2.

Table 6.4.2 Vertical Arching Factors

Standard Installation	VAF
Type 1	1.35
Type 2	1.40
Type 3	1.40
Type 4	1.45

Step 4
Calculate the Earth Fill Load on the pipe (W_E) by multiplying the P_L by the VAF.

Step 5
Select the Live Load (W_L) from the appropriate chart for the depth of fill or calculate it per instructions in the ACPA Manual.

Step 6
Determine a bedding factor (B_{fe}) for the Earth Load from the values in the Table 6.4.3.

Table 6.4.3 Bedding Factors for Embankment Condition

Pipe Diameter (inch)	Standard Installation Type 1	Type 2	Type 3	Type 4
12	4.4	3.2	2.5	1.7
24	4.2	3.0	2.4	1.7
36	4.0	2.9	2.3	1.7
72	3.8	2.8	2.2	1.7
144	3.6	2.8	2.2	1.7

For pipe diameters other than listed above, B_{fe} can be obtained by interpolation

Step 7
Determine Live Load Bedding Factor, B_{fLL} using the values in Table 6.4.4. For H greater than 5 feet, use B_{fLL} = 1.0.

Table 6.4.4 Bedding Factors for HS20 Live Loading Condition

Fill Height	**Pipe Diameter, Inches**										
Ft	12	24	36	48	60	72	84	96	108	120	144
0.5	2.2	1.7	1.4	1.3	1.3	1.1	1.1	1.1	1.1	1.1	1.1
1.0	2.2	2.2	1.7	1.5	1.4	1.3	1.3	1.3	1.1	1.1	1.1
1.5	2.2	2.2	2.1	1.8	1.5	1.4	1.4	1.3	1.3	1.3	1.1
2.0	2.2	2.2	2.2	2.0	1.8	1.5	1.5	1.4	1.4	1.3	1.3
2.5	2.2	2.2	2.2	2.2	2.0	1.8	1.7	1.5	1.4	1.4	1.3
3.0	2.2	2.2	2.2	2.2	2.2	2.2	1.8	1.7	1.5	1.5	1.4
3.5	2.2	2.2	2.2	2.2	2.2	2.2	1.9	1.8	1.7	1.5	1.4
4.0	2.2	2.2	2.2	2.2	2.2	2.2	2.1	1.9	1.8	1.7	1.5
4.5	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.0	1.9	1.8	1.7
5.0	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.0	1.9	1.8

For pipe diameters other than listed, values of B_{fLL} can be obtained by interpolation

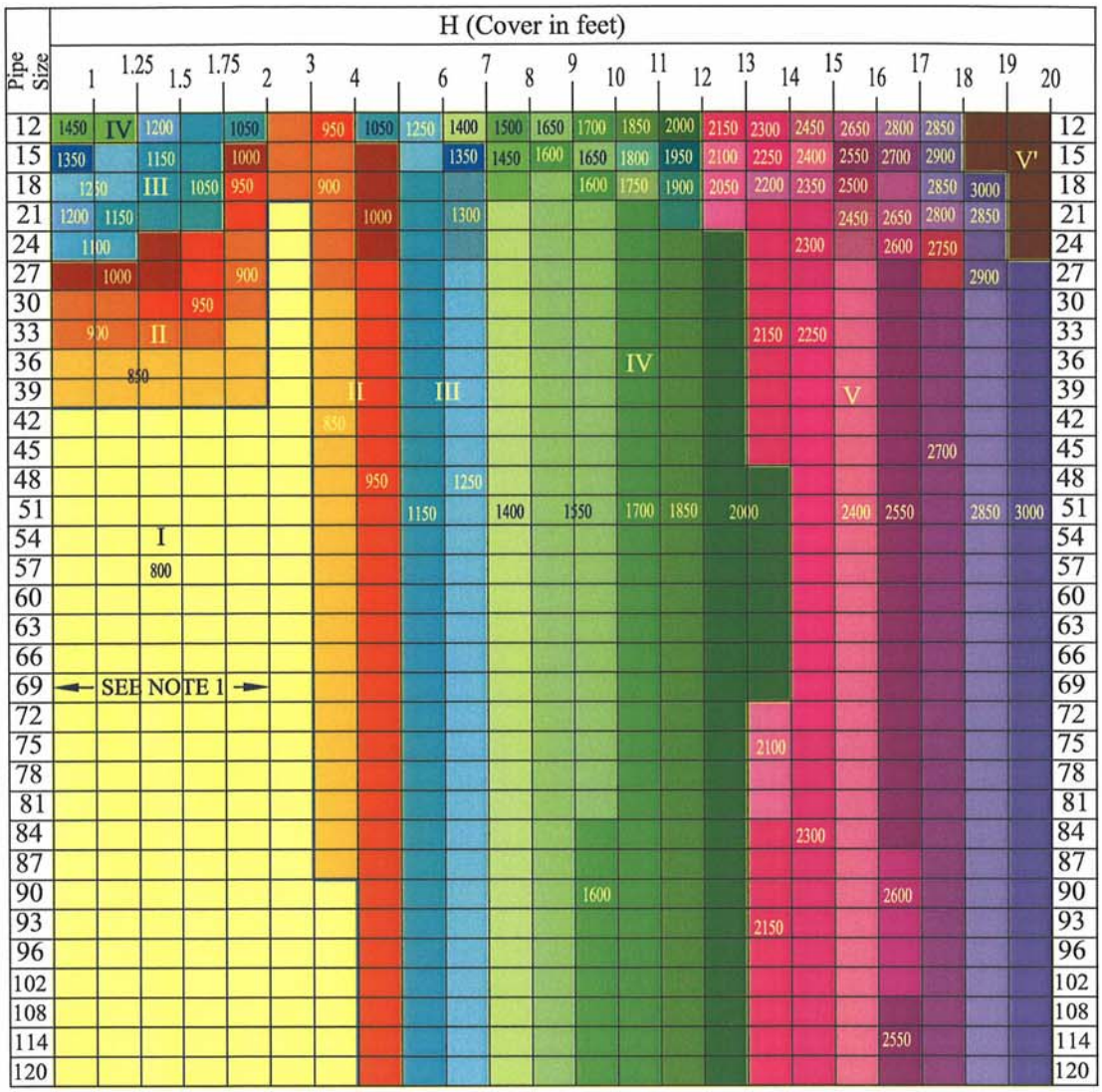
Step 8
Determine the bedding factor which shall be the greater of B_{fe} or B_{fLL}.

Step 9
Calculate the D-Load ($D_{0.01)}$ using the following equation:

$$D_{.01} = \left[\frac{W_e}{B_{fe}} + \frac{W_L}{B_{fLL}} \right] x \frac{FS}{D_o}$$

where FS (Factor of Safety) = 1.0.

Figure 6.4.1 Required D-Load for Reinforced Concrete Pipe



Design Criteria (ACPA Standard Installation Direct Design Method):

1. Positive Projection Embankment Condition
2. Ku = 0.1924
3. Installation Type 4
4. Vertical Arching Factor (VAF)=1.45
5. Water Weight (Wf)= 62.4 lb/cuft
6. Safety Factor (FS) = 1.0
7. Unit Weight of Soil (w) = 140pcf
8. Live Load: HS-20, Truck, AASHTO Impact

(*This Figure is for a circular concrete pipe only.)

Class	Maximum D-Load
I	800
II	1000
III	1350
IV	2000
V	3000
V'	Special calculations required

Example

Pipe Size	Depth to Top of Pipe Min	Max	D-Load	Class
15"	3	8	1450	IV
48"	8	11	1700	IV

NOTE 1: Storm Drain Pipes with two feet of cover or less shall be minimum Class III pipe; and minimum Class V pipe where crossing major-major or major-collector intersections.

6.4.4 Manholes

Manholes are required for all mainline storm drain pipe size changes, vertical grade breaks, horizontal angle deflections great than five (5) degrees, mainline pipe intersections, and periodic locations for access and maintenance. Maximum manhole spacing shall conform to the requirements in Table 6.4.1.

Typically, when mainline pipe size changes, the inside top of pipe elevations (pipe soffits) shall be matched. In the rare event where the downstream pipe is smaller than the upstream (such as when a required 6-inch oversized alternate pipe is attached to RGRCP), then the pipe invert elevations shall be matched.

6.4.5 Soils Investigation for Storm Drains

Soil boring information is required for all pipe materials. Soil boring logs shall be provided with the design documentation for all storm drains within public right-of-way. Storm drains in excess of 660 feet in length shall have multiple borings at intervals not to exceed 660 feet. Boring depths shall be at least two feet below the proposed pipe invert. If cemented or rock material is encountered during drilling which results in refusal, then sufficient rock cores shall be taken to define the specific limits of rock and to identify the type and extent of refusal to at least two feet below the proposed pipe invert. Borings shall be located in plan and tied to the same vertical datum as the proposed project. Resistivity and pH testing of the soils shall be required to support pipe design in terms of alternate pipe material selection. If resistivity readings fall below 1500 ohms per cubic centimeter, additional readings shall be made at intervals of not less than 25 feet or more than 100 feet until the limits of the area of low resistance soil are fully defined.

Seismic refraction / reflection surveys shall also be performed for the full length of all proposed storm drain mainlines. This information shall be correlated with the soil boring data to provide clear expectations on soil and trenching conditions that can be anticipated.

6.4.6 Soil Borings and Seismic Refraction Surveys

Soils boring log data shall include the following information:

a. The name of the company that produced the soils report.

b. The date the test boring was made.

c. The type of equipment used to drill the hole and take the samples.

d. The size of the auger used.

e. A description of caving that occurred during the excavation, if any.

f. Horizons of each type of soil encountered.

g. Description of the soil.

h. Classifications by the Unified Soil Classification System.

i. Plasticity index.

j. Percent passing No. 200 sieve.

k. Water encountered.

l. Pavement structure (AC thickness, sub-base thickness, if applicable).

m. Relative moisture content (specify depth taken).

n. Representative unit weight of native material (specify depth taken)

o. Laboratory calculated optimum moisture content.

p. Resistivity and pH readings.

Seismic refraction surveys shall provide the following information as applicable:

q. Ground acceleration data

r. Mapping of bedrock topography

s. Depth of gravel, sand or clay deposits

t. Delineation of perched water tables

u. Depth to the water table

v. Detection of subsurface caverns or voids

w. Estimation of rippability (refer to standard dozer / excavator / avg horsepower ratings for trenching such as the standard tractor tables provided by Caterpillar)

x. Detection of shallow faults and fracture zones

y. Detection of large boulders or structures

6.4.7 Storm Drain Velocity Limits

Storm drains with flow velocities less than 5 fps for Q_{Design} or in excess of 15 fps shall require approval.

6.4.8 Storm Drain Connections

Catch basin connector pipes shall be connected to new mainline storm drain pipes with prefabricated tees. Catch basin connector pipes may be joined to the mainline at a manhole if the standard required mainline manhole spacing provides a convenient location for it. Where connector pipes are to be joined to existing mainline storm drains, they shall be connected by manhole or junction structure; or in accordance with City of Phoenix Standard Detail P1577; or City of Phoenix Detail P1576 for connections to cast-in-place-pipe; or City of Phoenix Detail P1578 when a new reinforced concrete connector pipe outside diameter (O.D.) is greater than one-half (1/2) the inside diameter (I.D.) of the existing reinforced concrete pipe main and a manhole or junction structure is not feasible (e.g., extremely limited space availability for structure).

Connection of new mainline pipe to new mainline pipe shall generally be made by manhole or special junction structure depending on size. Connection of new mainline pipe to existing mainline pipe shall generally be made by manhole, special junction structure, or in rare cases using City of Phoenix Detail P1578, depending on size and feasibility of manhole or special junction structure installation. Manholes are required for all mainline storm drain pipe size changes, vertical grade breaks, and horizontal angle deflections greater than five degrees.

To minimize friction loss and maintain structural integrity of the mainline pipe, opposing catch basin connector pipes connecting to a mainline storm drain pipe shall be offset a minimum of five feet horizontally as measured from the centerline of each connector pipe. Opposing storm drain laterals greater than 24 inches in diameter shall be joined by a special junction structure designed to minimum HS-20 loading by a registered professional engineer. The junction structure shall be designed to be hydraulically efficient.

6.4.9 Storm Drain Joints and Bends

Pulling joints for storm drain pipe deflection shall be allowed only within manufacturer's tolerances. Specifications for horizontal deflection using this method shall be noted on the construction plans, citing manufacturer's requirements. An angular bend in catch basin connector pipe (horizontal or vertical), up to, and including 22 ½ degrees may be accomplished by using a standard COP Detail P1505 pipe collar. Prefabricated pipe bends shall be required for deflections in catch basin connector pipes greater than 22 ½ degrees. In addition, the maximum angle for a catch basin connector pipe to exit any wall of a catch basin shall be 22 ½ degrees from perpendicular.

6.4.10 Storm Drain Right of Way

A City owned property, dedicated right-of-way, or privately owned drainage tract shall be a minimum of 16 feet wide for underground storm drains if not under a designated road right of way.

6.4.11 Storm Drain Pipe Material

All storm drain designs shall be prepared on the basis of using pre-cast reinforced concrete storm drain pipe (RCP). RCP storm drain mainline, laterals and catch basin connector pipes shall be rubber gasketed.

6.4.12 Allowable Storm Drain Alternative Pipe Material

Alternate Pipe Information:

a. Alternate pipe information shall be presented on the City of Phoenix Storm Drain Alternate Pipe Table, see Figure 6.15.2.

b. Cast in place, non-reinforced concrete pipe (CIPP) is not allowed within the curb returns of any major arterial or collector street, or within any other signalized or potentially signalized intersection.

c. Minimum allowable thickness, in inches, for concrete CIPP storm drain pipe is equal to the sum of the inside diameter of the pipe (in feet) plus one inch with the minimum thickness being four inches.

For example:

The thickness required for a 48 inch CIPP is $\frac{48}{12}+1=5$ inches.

d. CSP mainline storm drain pipe shall be concrete lined, Type "F" pipe. CSP catch basin connector pipe shall be Type 2, aluminized pipe.

e. The minimum gauge for Corrugated Steel Pipe (CSP) storm drain pipe shall be 14 gage. The specific gage specified shall provide a design life of at least 75 years to first perforation based on soil conditions. See Tables 6.15.4, 6.15.5, 6.15.6

f. For CIPP and CSP mainline storm drain pipes, soil boring and resistivity information shall be provided and shown on the construction drawings in plan view. If the soil cannot stand vertically in the trench, CIPP will not be allowed as an alternate material. If soil resistivity readings are below 1500 ohms per cubic centimeter, CSP will not be allowed.

g. The minimum diameter allowed for CIPP shall be 30 inches. If CIPP or CSP alternate is specified for mainline storm drain pipe, the required inside diameter shall be a minimum of six inches greater than the calculated design diameter for RCP.

h. HDPE may be used for mainline storm drain pipes and catch basin connector pipes with a diameter of 48 inches or smaller, provided Type S pipe is specified with water tight joints and watertight connections to manholes, junction strucures and catch basins, meeting or exceeding 10.8 psi (25 column feet of water head) water pressure test criteria as specified in ASTM D-3212.

i. HDPE pipe shall not be allowed within the last 24 feet adjacent to an open end (either inlet or outlet).

6.4.13 Storm Drain Standard Details

The City Of Phoenix Standard Details, 1500 series, shall be used for storm drain systems. MAG or ADOT standards may be used for applications not covered by the 1500 series.

6.4.14 Storm Drain Outfalls

Where storm drain systems discharge into undisturbed or naturalistic drainageways, headwalls shall have aesthetic treatment to blend with the surroundings. The area surrounding the headwall (exclusive of the wash bottom) shall be revegetated and landscaped using boulders and native stone where indigenous. Railings shall be designed compatible with the colors and form of the surrounding area and the development or village theme.

6.4.15 Storm Drain Safety Standards

Additional standards pertaining to Storm Drains are listed in Section 6.1, Safety.

6.4.16 Storm Drain Bedding

The Contractor shall utilize a ½ sack cement-enriched slurry aggregate base course (CLSM) bedding at a minimum from the outside bottom of the pipe to the springline of the pipe for all mainline storm drain pipe, except cast-in-place pipe. CSP and HDPE pipe shall be fully bedded (to 1 foot over the top of the pipe) with cement-enriched slurry aggregate base material. The slurry aggregate base course shall meet the requirements of City of Phoenix Supplements to

MAG Specification Section 623. The slurry shall have a minimum 8-inch slump, and a minimum of 25 psi compressive strength and a maximum of 100 psi based on a 28-day test. Slurry aggregate base course bedding is not required for catch basin connector pipes.

6.4.17 Private Irrigation Pipes

All private irrigation pipe in street right of way shall be rubber gasketed, pre-cast reinforced concrete pipe. Un-reinforced, pre-cast concrete pipe shall not be allowed.

6.5 CULVERTS AND BRIDGES

The following standards shall be met for the design of culverts and bridges:

6.5.1 Required Culvert Locations

All watercourses meeting 404 permit jurisdictional criteria shall be culverted or bridged.

6.5.2 Maintenance Access

Access by maintenance vehicles to the watercourse bottom shall be provided such that maintenance activities can be undertaken without encumbering traffic flow.

6.5.3 Right of Way for Culverts

A City owned property, right-of-way, or privately owned drainage tract shall be provided for the area inundated by backwater from culverts and bridges for the 100-year event.

6.5.4 Culvert Capacity

Culverts for major collector and arterial streets are to be designed to convey, as a minimum, the 100-year peak discharge with no flow crossing over the roadway. Culverts for minor collector and local streets shall be designed to convey the 100-year peak discharge with a maximum 0.5 foot flow depth over the roadway. Dip sections without culvert are not allowed.

6.5.5 Culvert Headwalls

Concrete headwalls are required on all culvert installations at both ends. All culvert headwalls shall have beveled edges.

Culvert headwalls shall have cut-off walls. Cut-off wall depths shall be a minimum of 2.5 feet below the invert for 30 inch diameter pipe and smaller. Cut-off wall depths shall be a minimum of six feet below the invert for pipes with diameters greater than 30 inches up to 84 inches. Minimum cut-off wall depths for pipes greater than 84 inches and for all box culverts shall be per ADOT standards.

6.5.6 Headwall Treatment

Where culverts convey flow in undisturbed or naturalistic drainageways, the culvert headwalls shall have aesthetic treatment designed to blend with the surroundings. The area surrounding the headwall (exclusive of the watercourse bottom) shall be revegetated and landscaped using boulders and native stone where indigenous. Railings shall be designed compatible with the colors and form of the surrounding area and the development or village theme.

6.5.7 Pipe Culvert Dimensions

Pipe culverts shall not exceed a maximum length of 80 feet. The maximum diameter shall be 36 inches. The minimum diameter for a culvert is 18 inches[19]. See Figure 6.5.1 for a typical pipe culvert crossing. Any culvert longer than 80 feet shall be box culvert.

6.5.8 Pipe Culvert Alternate Materials

Alternate pipe culvert materials may be Type 2 aluminized corrugated steel pipe (CSP) or reinforced concrete pipe (RCP) only. No other materials shall be allowed.

6.5.9 Pipe Culvert Bedding

A cement-enriched slurry aggregate bedding (minimum outside bottom of pipe to springline of pipe) is required for culvert pipes as specified in Section 6.4.16.

6.5.10 Box Culvert Dimensions

For maintenance purposes, minimum box culvert width shall be six feet and minimum height shall be six feet. Maximum desirable length shall be 200 feet. Where roadway profiles are low and design depth of flow is two feet or greater, the allowable minimum vertical clear opening in a six foot high box may be reduced to four feet with the invert of a 6 foot high box set two feet below the natural invert of the adjacent channel. See Figures 6.5.2 and 6.5.3.

Where a public or private multi-use path/trail easement/right-of-way is located in a watercourse corridor, and the path/trail is to go under a roadway, the minimum box culvert width shall be ten feet and the minimum height shall be ten feet. Where equestrian access is anticipated, the desired minimum height is 12 feet. Multi-use culverts shall be lighted in accordance with Parks and Recreation Department standards.

6.5.11 Pre-Cast Arch Culverts

Pre-cast arched culverts as manufactured by Con-Span Bridge Systems® have been approved by the City of Phoenix Street Transportation Department and may be constructed as an alternative to standard rectangular concrete box culverts. However, to allow sediment maintenance inside the arch, a 6 foot minimum vertical clearance is required across the entire width of the culvert.

6.5.12 Culvert Maintenance Ramps

Ramped, vehicular access for maintenance is required at the upstream and downstream ends of all culverts (See Section 6.1.10). Ramps shall have lockable bollards or gates near the top of the ramps and shall be accessible from the road by use of mountable curbs (MAG Detail 220-2, Type E) and 9-inch thick MAG Class “A” concrete or soil cement slab with erosion protection.

6.5.13 Culvert Velocities

Culverts are to be designed with consideration to the guidelines presented in the Culverts and Bridges, and Sedimentation chapters in the Drainage Design Manual, Hydraulics. Minimum velocities through the culvert shall promote sediment transport to keep the culvert as clean and clear as possible.

[19] There is no limit to the number of pipes allowed at a culvert crossing

Culvert inlet and outlet velocities shall be kept below 15 feet per second unless special conditions exist. The maximum velocity should be consistent with channel stability requirements at the culvert outlet. Agradation or degradation at culvert crossings must be examined in the design of culverts. See Table 6.5.1 for allowable velocities at culvert outlets.

6.5.14 Bank and Channel Protection

The size, depth, and lateral extent of bank and channel protection adjacent to a culvert or bridge shall be designed in conformance with City of Phoenix Standards and with the Culvert and Bridges Chapter of the Drainage Design Manual, Hydraulics. Bank and channel protection adjacent to culverts shall be gabions and gabion mattresses, as shown in Figures 6.5.2 and 6.5.3. Bank and channel protection adjacent to bridges may be various types, including gabions, angular stone riprap or soil cement / Cement Stabilized Alluvium (CSA). The use of grouted riprap is not permitted. Riprap may be grouted to minimize vandalism and / or inhibit the growth of nuisance vegetation in order to minimize maintenance; however grouting shall not reduce the required size, depth, or lateral extent of riprap. Rock embedded into structural concrete linings is acceptable.

6.5.15 Bridge Freeboard

Bridges shall be designed to have a minimum freeboard of two feet from the design water surface elevation to the low chord elevation for the 100-year event. Freeboard for bridges over channels flowing under supercritical conditions shall be the greater of two feet or the velocity head for thalweg velocities. The structural design of the bridge shall take into account the possibility of debris build up and flows impacting the bridge. As a minimum, hydraulic modeling of bridges shall reflect piers as twice their design width to account for debris. Bridge footings shall be founded below the depth of total scour as defined in the Drainage Design Manual.

Where a public or private multi-use trail easement / right-of-way is located in a wash, the minimum span between piers shall be ten feet and the minimum height between low chord and the wash bottom shall be 12 feet.

6.5.16 Bridge Aesthetics

Where bridges convey flow in undisturbed or naturalistic drainageways, bridge designs shall incorporate materials, colors, and forms compatible with the surroundings and the theme of the development or the village. Where it is indigenous, the use of native stone in bank protection is encouraged if it meets the engineering requirements. Wingwalls shall have aesthetic treatment to blend with the surroundings. The area near the bridge (exclusive of the wash bottom) shall be revegetated and landscaped using indigenous boulders and stones where possible.

6.5.17 Bridge Spans

Bridges crossing undisturbed watercourses with designated erosion setbacks shall span across the watercourse from setback to setback. Alternatively, a comprehensive hydraulic and sediment transport analysis that assesses sediment transport in time and space (i.e. dynamic modeling consistent with tier 3 analysis as identified in the Drainage Design Manual, Hydraulics) shall be undertaken to support the design.

For channels carrying supercritical flow, there shall be no reduction in cross sectional area at bridges and culverts; or any obstructions (including bridge piers) in the flow path.

Figure 6.5.1 Typical Local or Minor Collector Street Pipe Culvert Crossing Plan

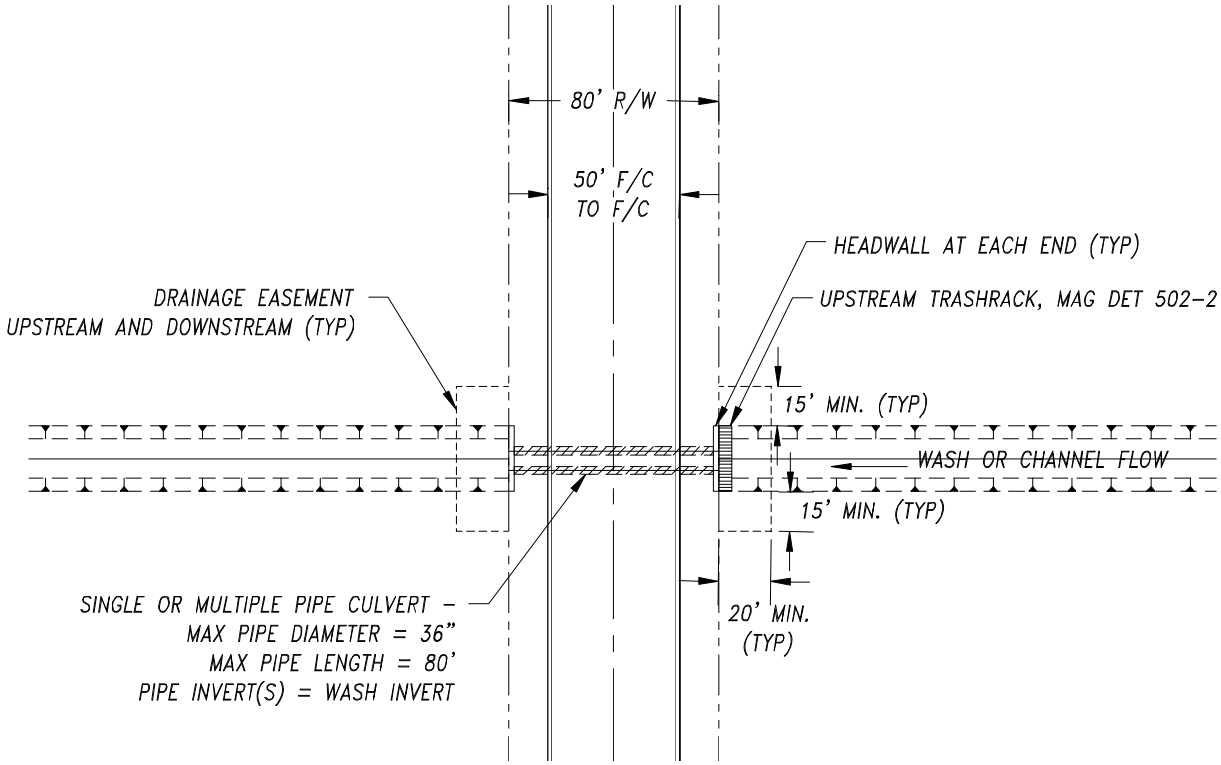
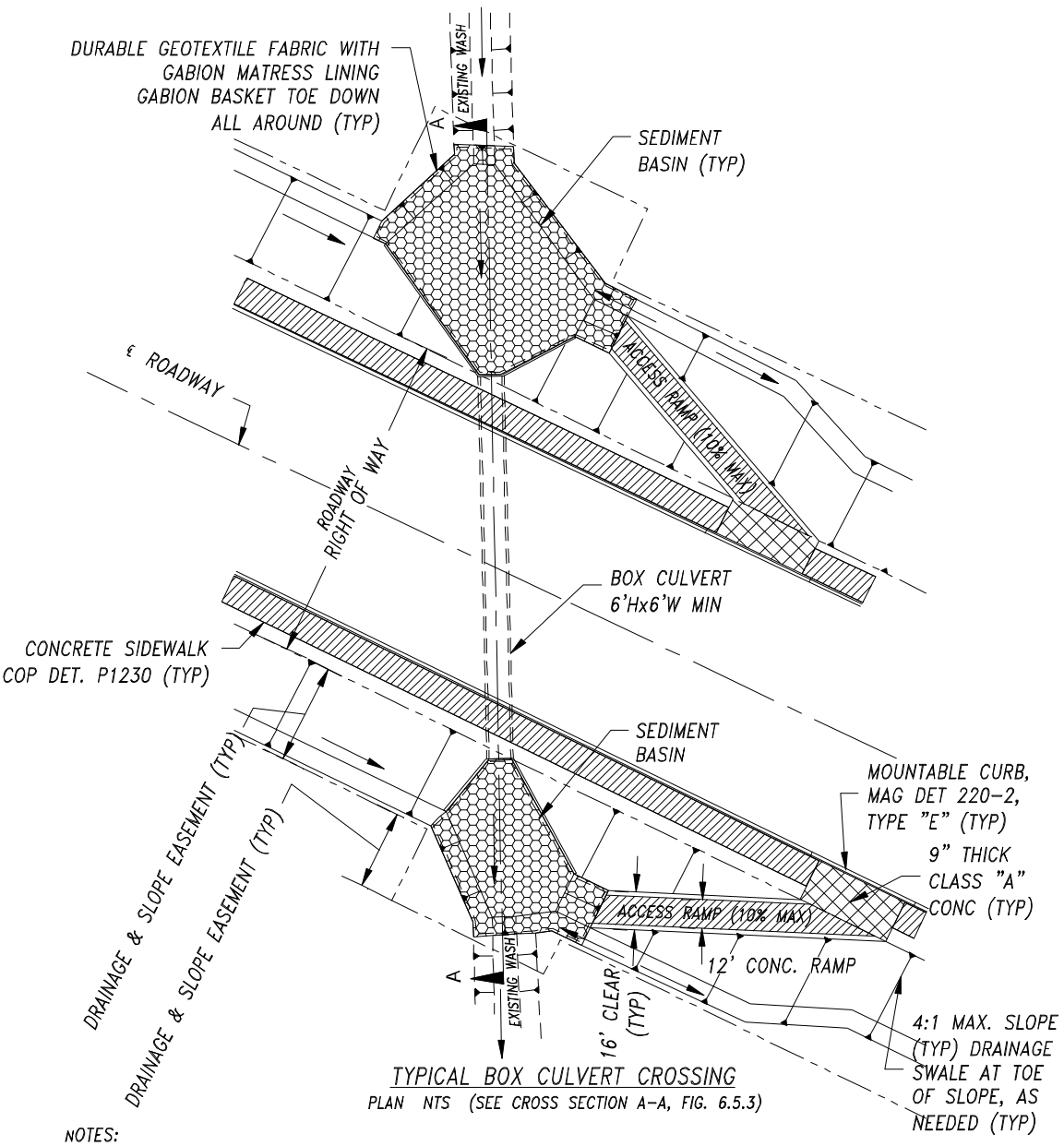
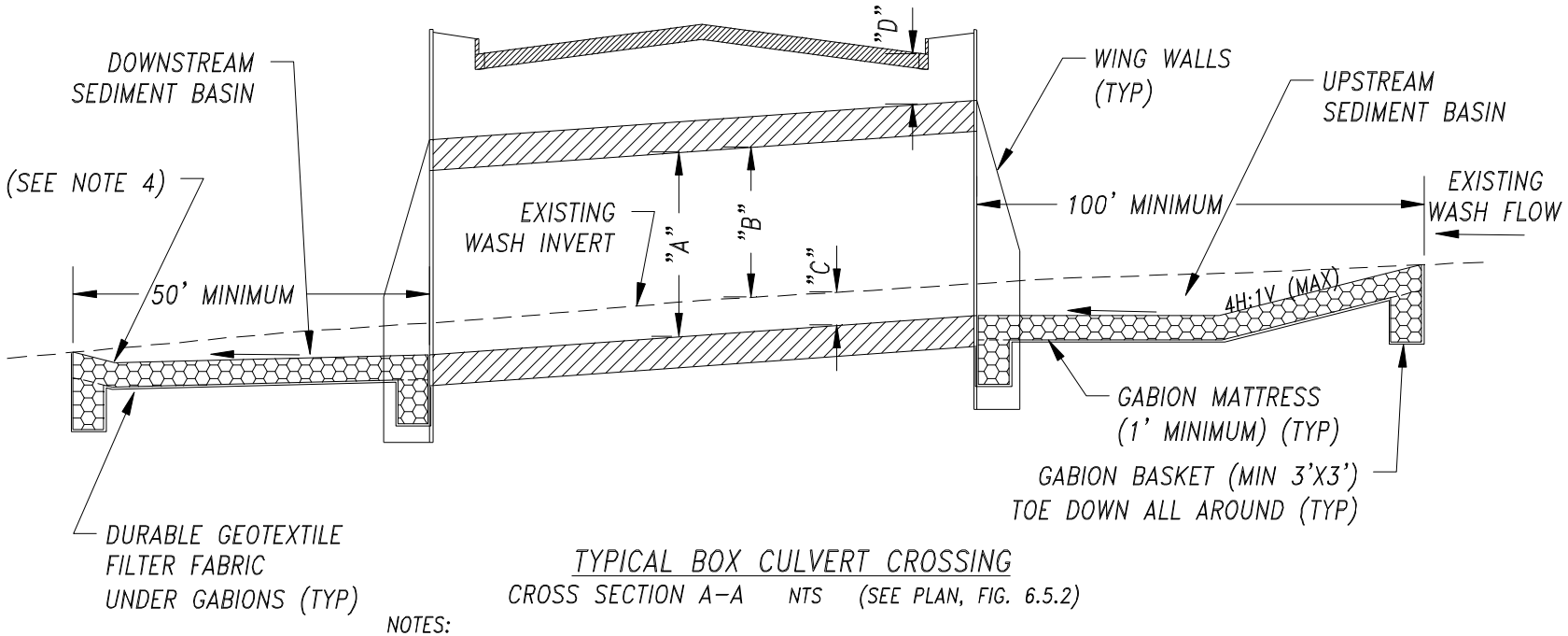


Figure 6.5.2 Typical Box Culvert Plan



NOTES:
1. MINIMUM LENGTH DIMENSIONS OF BASINS SHALL BE 100 FEET UPSTREAM AND 50 FEET DOWNSTREAM.
2. MINIMUM WIDTH DIMENSION OF BASINS SHALL BE 50 FEET.
3. SEDIMENT BASIN AT THE INLET OF BOX CULVERT SHALL BE DESIGNED SO THAT FLOW VELOCITY IS REDUCED TO 2 FEET PER SECOND.
4. BASIN SIDE SLOPES SHALL BE NO STEEPER THAN 4H:1V.
5. SEDIMENT BASINS SHALL BE SIZED TO ACCOMMODATE A MINIMUM OF 2 YEARS OF ESTIMATED SEDIMENT ACCUMULATION (SEE SECTION 6.10).
6. MINIMUM 16' WIDE CLEAR ZONE WITH MINIMUM 12' WIDE PAVED RAMP AT MAXIMUM LONGITUDINAL SLOPE OF 10% REQUIRED AT EACH BASIN TO PROVIDE MAINTENANCE ACCESS. RAMP SHALL BE STABILIZED WITH HARD-SURFACE PAVING MATERIAL (9" THICK CLASS 'A' CONCRETE OR SOIL CEMENT) WITH SUFFICIENT CUT-OFF BARRIER BELOW GRADE TO PREVENT EROSION WASH-OUT UP TO AT LEAST THE 100-YEAR WATER SURFACE ELEVATION.

Figure 6.5.3 Typical Box Culvert Profile



TYPICAL BOX CULVERT CROSSING

CROSS SECTION A–A NTS (SEE PLAN, FIG. 6.5.2)

DIMENSIONS	
"A"	6' MINIMUM
"B"	4' MINIMUM
"C"	2' MAXIMUM
"D"	1' MINIMUM

NOTES:

1. BOX CULVERT SHALL BE MINIMUM 6' HIGH X 6' WIDE FOR MAINTENANCE PURPOSES.
2. BASINS SHALL BE LINED WITH GABIONS. GABION MATTRESS SHALL BE MINIMUM 1 FOOT THICK. DURABLE GEOTEXTILE FILTER FABRIC SHALL BE INSTALLED UNDER ALL GABIONS.
3. GABION LINING SHALL BE CONSTRUCTED WITH TOE DOWN ALL AROUND TO PREVENT UNDERMINING. MINIMUM DEPTH OF TOE DOWN SHALL BE AS REQUIRED TO PROTECT AGAINST CALCULATED SCOUR DEPTH, BUT IN NO CASE LESS THAN 3' DEEP X 3' WIDE.
4. POSITIVE GRADIENT TO OUTFALL SHALL BE PROVIDED WHEN POSSIBLE; OTHERWISE 4:1 MAX SLOPE UP TO MATCH EXISTING.
5. MINIMUM SLOPE OF 0.2% ON BASIN BOTTOM SHALL BE PROVIDED FOR POSITIVE DRAINAGE.
6. MAXIMUM BASIN DEPTH SHALL BE 2 FEET.

Table 6.5.1 Erosion Protection Design Criteria for Culvert Outlets

Outlet Protection	Natural Channel	Artificial Channel
Gabion mattress transition apron	Up to 2.5 times existing channel velocity	Up to 2.5 times allowable channel lining velocity
Energy Dissipater	Velocities greater than 2.5 times existing channel velocity	Velocities greater than 2.5 times allowable channel lining velocity

Table 6.5.2 Box Culvert Design Checklist

No		Status	Item
1			6 foot minimum height provided.
2			6 foot minimum width provided.
3			Culvert invert set no more than 2 feet below channel invert
4			Culvert flow capacity based on buried portion of culvert being completely filled with sediment.
5			Sediment basins provided at both ends of the culvert
6			Minimum dimension requirements for basins provided as shown on Figure 6.5.2 and Figure 6.5.3
7			Upstream basin widened so that flow velocity is reduced to allow sediment to drop out. (2 feet per second maximum)
8			12 inch thick gabion mattress lining provided in basins
9			Toe downs (minimum 3' x 3' gabions) provided all around to prevent undermining of gabion mattress.
10			Reinforced concrete cutoff walls provided on headwall and aprons at each end
11			16 ft. wide minimum clear zone with minimum 12 feet wide maintenance access ramps provided into each basin.
	a		Maximum slope on ramps no steeper than 10H:1V
	b		Hardened surface with 9 inch thick class "A" concrete with toe down protection provided on ramp
	c		Protected from erosion when channel is flowing
	d		Right of Way or drainage easements provided for basins
12			Minimum 1 ft cover provided over top of box to finish grade of roadway
13			Outlet velocity less than 15 feet per second.

6.6 OPEN CHANNELS

The following standards shall be employed in all designs of engineered open channels (does not apply to undisturbed natural drainageways):

6.6.1 Plan Requirements

All engineered channel construction drawings shall contain a plan and profile or detailed grading plan as well as adequate cross sections (to describe geometry) for channels conveying 100-year discharges of 500 cfs or greater. Engineered channels or ditches designed for flows less than 500 cfs may be shown more simply in plan view only, with spot elevations, flow direction arrow, and typical section. The channel plan shall show the horizontal alignment and dimensions as well as the type and extent of the proposed work. For channels greater than 500 cfs or channels designed for supercritical flow, the plan shall also show the following: Q_{100}; proposed invert and top of bank; estimated water surface profile; energy grade line; hydraulic jump location and length; original ground at channel centerline; all utilities and structure crossings; freeboard; and if necessary, top of proposed embankment fill.

6.6.2 Channelization in FEMA Floodplain

All channelization within FEMA mapped floodplains must be designed so that the cumulative effect of all new development does not raise the 100-year water surface (or energy grade line for supercritical flow) more than one foot. In addition, when determining encroachments of fill or other development, the “equal conveyance from both sides of channel” rule shall apply. The one foot rise in water surface may not come from one side of the channel at the expense of the adjacent property owner.

6.6.3 Bank Stabilization

Encroachment and/or stabilization on one bank must address increased erosion potential on the opposite bank.

6.6.4 Drainage Channel Design

Channels shall be designed consistent with the guidelines provided in the Open Channels and Sedimentation Chapters of the Drainage Design Manual for Maricopa County, Hydraulics.

6.6.5 Concrete-Lined Channels

Use of concrete-lined channels shall generally not be permitted in residential or recreational areas with 100-year design storm discharges of 100 cfs or greater. Concrete-lined channels may be allowed in certain circumstances where public access is limited due to specific site conditions or where adequate treatment by landscape screening, concrete color integration, etc. is provided, with adequate justification and approval by the appropriate reviewing department(s).

6.6.6 Concrete Reinforcement

All concrete and shotcrete lined channels shall have continuous reinforcement extending both longitudinally and transversely. Shotcrete channels shall be designed to the same structural integrity as concrete channels.

6.6.7 Surface Finish for Concrete Channels

All sloping and flat concrete, shotcrete, and soil cement finished surfaces shall have roughened surfaces (e.g. embedded rock, rough grooving from ¼ inch steel tined rakes, etc.) to discourage inappropriate recreational use.

6.6.8 Concrete Channel Lining Thickness

The minimum thickness of concrete channel lining on the invert and ramp areas shall be eight inches MAG Class “A concrete to accommodate periodic maintenance vehicle traffic.

6.6.9 Bank and Channel Protection

The size, depth, and lateral extent of bank and channel protection shall be designed in conformance with City of Phoenix Standards and with the Drainage Design Manual, Hydraulics. Bank and channel protection may be various types, including gabions, concrete, shotcrete, angular stone riprap or soil cement / Cement Stabilized Alluvium (CSA). The use of grouted riprap is not permitted. Angular riprap may be grouted to minimize vandalism and / or inhibit the growth of nuisance vegetation in order to minimize maintenance; however grouting shall not reduce the required size, depth, or lateral extent of riprap. Rock embedded into structural concrete linings is acceptable.

6.6.10 Stone Riprap Channel Lining

The minimum thickness of stone riprap linings shall be the greater of d_{100} or 1.5 times d_{50}. In a well graded stone riprap lining, the recommended maximum stone size is two times the d_{50} and the recommended minimum size is one-third of the d_{50}.

All stones composing the riprap shall be angular, with a minimum specific gravity of 2.4, following the standard test ASTM C127.

6.6.11 High Velocity Channels

Due to erosion and scour of erodible channels and safety concerns with excessively high velocities, the upper limit of Froude Number (Fr) shall be 2.0. The Froude Number for all types of channel linings shall be $Fr < 0.86$ for subcritical flow regime. For concrete, soil cement, and shotcrete lined channels functioning in supercritical flow regime, the additional range of $1.13 < Fr < 2.0$ is allowed. The design Froude Number shall not fall between 0.86 and 1.13. At locations where there are to be planned hydraulic jumps, concrete, soil cement, and shotcrete lined channels may pass through $0.86 < Fr < 1.13$. No other linings, other than concrete, shotcrete, soil cement or roller compacted concrete may be used in channels that fall in the range of 1.13 to 2.0.

6.6.12 Soft Bottom Channels

Earthen bottom channels with lined side slopes buried below the depth of expected total scour are allowed with supporting engineering justification including sediment transport analysis, scour analysis, soil boring logs, and long term watershed yield analysis to support equilibrium longitudinal slopes. Gabions, soil cement, angular dumped riprap, roller compacted concrete or reinforced structural concrete may be used to line side slopes.

6.6.13 Use of Gabions on Channel Bottom

Gabions are not allowed on channel bottoms except at grade control, drop structures, sediment basins or other similar hydraulic structures. Gabions shall be backfilled with native material or stones when possible and may be seeded or planted with native vegetation.

6.6.14 Allowable Channel Velocity

Maximum channel velocities shall be governed by Table 6.6.1 through Table 6.6.4 and also by the requirements in Section 6.6.11.

Table 6.6.1 Permissible Velocities for Unlined Drainage Channels

Soils Type (Earth, No Vegetation)	Maximum Permissible Velocity[20,21], ft/s
Fine Sand (noncolloidal)	2.5
Sandy Loam (noncolloidal)	2.5
Silt Loam (noncolloidal)	3.0
Ordinary Firm Loam	3.5
Fine Gravel	5.0
Stiff Clay (very colloidal)	5.0
Graded, Loam to Cobbles (noncolloidal)	5.0
Graded, Silt to Cobbles (noncolloidal)	5.5
Alluvial Silts (noncolloidal)	3.5
Alluvial Silts (colloidal)	5.0
Coarse Gravel (noncolloidal)	6.0
Cobbles and Shingles	5.5
Shales and Hard Pans	6.0

[20] Adopted from USDOT, FHWA, 1961 and 1983.

[21] For sinuous channels multiply permissible velocity by: 0.95 for slightly sinuous; 0.90 for moderately sinuous; and 0.80 for highly sinuous.

Table 6.6.2 Permissible Velocities for Well Maintained Grass Lined Channels

Cover	Maximum Permissible Velocity, fps[22, 23, 24]	
	Erosion Resistant Soils	Easily Eroded Soils
Bermuda Grass	6.0	4.5
Desert Salt Grass, Vine Mesquite	5.0	4.0
Lehman Lovegrass, Big Galleta, Purple Threeawn, Sand Dropseed	3.5	2.5

Table 6.6.3 Criteria for Rigid Lined Artificial Channels

Type of Channel Lining[25]	Maximum Side Slope H:V (%)	Maximum Velocity, fps[26]
Structural Concrete [27]	Vertical	15
Soil Cement / Roller Compacted Concrete	2:1 (50%)	7 [28]

[22] Adopted from USDOT, FHWA, 1961 and 1983.

[23] Use velocities over 5 fps only where good covers and proper maintenance can be obtained.

[24] Grass is acceptable only if an irrigation system is provided and maintained. Cover should be uniform.

[25] The values in this table are for channel sections with the same lining material for bottom and sides. For conditions where the bottoms and sides of the channels are different, the most critical applicable criteria shall be used.

[26] Maximum flow velocity in artificial channels shall be calculated by an appropriate method and shall not exceed the maximum allowable velocity or the maximum allowable Froude number.

[27] Shotcrete is allowed provided it is designed with the same reinforcement as cast in place concrete.

[28] Higher velocities for soil cement or RCC lined channels / drop structures are acceptable upon submittal of a geotechnical analysis that assesses the suitability of the in-situ materials for soil cement or RCC applications and presents cement mixture specifications for the in-situ soils for the proposed maximum design velocities. The submittal shall be stamped by a registered professional civil engineer. Velocities greater than 15 fps are not recommended.

Table 6.6.4 Criteria for Artificial Channels

Type of Channel Lining [29]	Maximum Side Slope, H:V (%)	Maximum Velocity, fps [30]
Angular Rock Riprap	3:1 (33%)	9 [31]
Rock Filled Gabion Baskets	Per manufacturers' specifications	9 [32]
Grass (irrigated & maintained)	5:1 (20%)	2.5 to 6.0
No Lining (Earth)	4:1 (25%)	2.5 to 6.0

Note: The criteria listed in these tables are boundary values. The designer is responsible for determining adequacy of criteria for each specific application. For design of lining materials, analyses of soil conditions and subsurface drainage may be required.

6.6.15 Allowable Channel Radius

For channels with Froude Numbers less than 0.86, the ratio of the channel radius (at the centerline) to the design width of the water surface shall be greater than or equal to 3.0. Design of supercritical curved channels should be avoided. However, if unavoidable, then the recommended minimum channel radius for channels with Froude Numbers greater than or equal to 1.13 shall be calculated using the following equation:

$$r_c = \frac{4V^2W}{gy}$$

where:

r_c = minimum radius of channel curve centerline in feet,
y = flow depth in feet,
V = average channel velocity in ft/s,
W = channel width at water surface in feet, and
g = acceleration due to gravity in ft/s^2.

[29] The values in this table are for channel sections with the same lining material for bottom and sides. For conditions where the bottoms and sides of the channels are different, the most critical applicable criteria are to be used.

[30] Maximum flow velocity in artificial channels shall be calculated by an appropriate method and shall not exceed the maximum allowable velocity.

[31] Guideline only. Strict limits have not been set because this manual recommends that these channels flow subcritically.

[32] Guideline only. Strict limits have not been set because this manual recommends that these channels flow subcritically. See Table 6.6.1 for maximum velocity requirements for various types of soils.

Design of channels with Froude Numbers between 0.86 and 1.13 shall be avoided, especially within curved channel reaches.

6.6.16 Superelevation

Centrifugal force caused by flow around a curve results in a rise in the water surface on the outside wall of a channel and a depression of the surface along the inside wall. The consequent rise in the water surface is referred to as superelevation. The shift in the velocity distribution may cause cross-waves to form, which will persist downstream and could severely limit the hydraulic capacity of the channel. Design of curves in channels with supercritical flows should be avoided and curvature of channels should be limited.

Where minimum allowable channel radius cannot be economically obtained, channel inverts may be super-elevated, channel wall heights may be raised on the outside of the curve to account for the height of the superelevated flow or dividing walls may be constructed. Detailed analysis of the flow around the curve shall be provided.[33]

The equation[34] for superelevation of the water surface around a curve is:

$$\Delta y = C\frac{V^2 W}{gr}$$

where:

Δy = rise in water surface between a theoretical level water surface at the centerline and outside water surface elevation (superelevation) in feet

C = coefficient (see Table 6.6.5)

V = mean channel velocity in ft/s

W = channel width at elevation of centerline water surface in feet

g = acceleration due to gravity in ft/s^2

r = radius of channel centerline curvature in feet

Use of the coefficient C allows computation of the total rise in water surface due to superelevation and standing waves for the conditions listed in Table 6.6.5.

Table 6.6.5 Superelevation Formula Coefficients

Flow Type	Channel Cross Section	Type of Curve	Value of C
Tranquil	Rectangular	Simple Circular	0.5
Tranquil	Trapezoidal	Simple Circular	0.5

[33] Further information on design of curved channels may be obtained in USACE EM1110-2-1601, Hydraulic Design of Flood Control Channels

[34] Woodward and Posey, 1941

Flow Type	Channel Cross Section	Type of Curve	Value of C
Rapid	Rectangular	Simple Circular	1.0
Rapid	Trapezoidal	Simple Circular	1.0
Rapid	Rectangular	Spiral Transitions	0.5
Rapid	Trapezoidal	Spiral Transitions	1.0
Rapid	Rectangular	Spiral Banked	0.5

6.6.17 Channel Freeboard

Required freeboard shall be computed according to the following formula:

$$FB = 0.25\left(Y + \frac{V^2}{2g}\right)$$

where:

FB = freeboard in feet,
Y = depth of flow in feet,
V = velocity of flow in ft/s, and
g = acceleration due to gravity in ft/s^2.

The minimum freeboard value for rigid channels shall be one foot for subcritical and two feet for supercritical flows. The freeboard requirements are to be added to the superelevated water surface elevation at channel bends for both subcritical and supercritical flow conditions (See Drainage Design Manual, Hydraulics for superelevation analysis). Using a smaller freeboard in specific cases requires approval. Freeboard exceeding the minimum standard is strongly recommended in undeveloped or developing areas. Levees, berms, or floodwalls, although discouraged, must meet FEMA freeboard requirements. In all FEMA jurisdictional floodplains, the greater of the above equation or FEMA's freeboard requirement shall prevail for design freeboards.

To reflect sporadic maintenance conditions, additional freeboard is required when water surface elevations exceed top of bank for the design discharge analyzed at a Manning's "n" value 0.05 greater than the design "n" value. The depth added shall only be that depth needed to accommodate the design discharge within the channel banks (i.e. utilizing the conveyance area associated with the freeboard to convey the design discharge at the higher "n" value).

6.6.18 Channel Right of Way

Open channels shall be constructed within a City owned property, right-of-way, drainage easement, or private drainage tract that must be platted. This does not apply to off-site, adjacent developable property where temporary easements have been obtained for temporary collector channels provided these collector channels are accessible by ordinary maintenance equipment. A City owned property, dedicated right-of-way, drainage easement, or private drainage tract shall be a minimum of the top width of an appropriately sized open channel plus 16 feet contiguous on one side if maintenance access is not provided within the channel bottom. In no

case shall a City owned property, right-of-way, drainage easement, or private drainage tract be less than 20 feet wide without approval.

6.6.19 Ditches and Swales

Roadside ditches and swales that are intended to convey 100-year flows less than 100 cfs shall be no deeper than two feet. The side slopes of roadside ditches should be as mild as practical and shall be no steeper than 4H:1V. For maintenance purposes, ditches shall be trapezoidal and minimum bottom widths shall be four feet for ditches adjacent and parallel to streets or access roads.

6.6.20 Grass Lined Channels

Artificial channels that are to be maintained by the City shall not be grass lined except as approved by the City.

6.6.21 Channel Landscaping

Landscaping and revegetation, in its mature size and state, must not prevent access by ordinary maintenance equipment (e.g. pick-up truck, loader, backhoe, Bobcat, etc.). The mature vegetation shall comply with the design intent of the channel in terms of conveyance and freeboard.

6.6.22 Floodplain Delineation

During the course of the Master Planning process, the 100-year runoff will be used to delineate a floodplain for major channels with discharges of more than 500 cfs. The final drainage plan shall show the floodplain delineations for pre-project and post-project conditions. The drainage report shall discuss any disparity in these delineations on adjacent properties.

6.6.23 Special Flood Hazard Areas

For projects where buildings may be placed within a Special Flood Hazard Area, the following note shall be added to the Final Site Plan/Final Plat and Setback Exhibit.

> *A Federal Emergency Management Agency (FEMA) "Elevation Certificate" must be completed for each structure constructed in a Special Flood Hazard Area (SFHA) prior to an Electrical Clearance for that structure. One copy of the "Elevation Certificate" is to be submitted to the General Building Safety Inspector onsite and one copy is to be submitted to the City of Phoenix Floodplain Manager.*

6.6.24 Floodplain Certification

Floodplain analysis of an AO zone is required to verify that all new construction of residential structures have the lowest floor set above the highest adjacent grade by the designated AO zone depth or two feet if no depth is specified. A professional engineer or land surveyor registered in Arizona shall certify the finished floor elevation and shall certify that it will not be inundated as a result of the adjacent 100-year storm flows. Certifications are required to be submitted to the Development Services Department after the pad elevation has been set and prior to the construction of foundations or stem walls. Levees, berms, or floodwalls while discouraged, must comply with FEMA standards and be submitted to the City Floodplain Manager for approval from the department responsible for plan/design review.

6.6.25 Channel Safety

Additional standards pertaining to open channels are listed in Section 6.1, Safety.

6.7 HYDRAULIC STRUCTURES

The following standards shall be followed in the design of hydraulic structures:

6.7.1 Trash Rack Clogging Factor

A clogging factor of 50 percent of the rack area shall be used in the hydraulic analysis of all trash racks. Trash racks shall have an angled entrance shape and vertical support bars only to encourage larger trash and floatable debris to float upward towards the top of the rack and allowing as much flow capacity as possible. MAG Detail 502 provides a good example. Cross grates with horizontal and vertical bars should not be used, as these tend to trap debris and may clog up to 100 percent.

6.7.2 Channel Drop Structures

At drop structures, a hydraulic jump analysis shall be conducted for a range of flows, since flow characteristics at the drop may vary with discharge. This analysis is to be used to support the design of the structure and erosion control measures.

Due to a high failure rate and excessive maintenance costs, drop structures having loose riprap on a sloping face are not permitted.

6.7.3 Aesthetic Treatment

Where hydraulic structures are located within or adjacent to undisturbed or naturalistic drainageways, the structures shall have aesthetic treatment to blend with the surroundings. Trash racks shall have an exterior color to blend with the surrounding native soil.

6.7.4 Low Flows

Open channels are recommended in lieu of pipes for conveyance of low flows through drop structures. Pipes, if approved for conveying low flows through drop structures, shall be no smaller than 24 inches in diameter.

6.7.5 Safety

Additional standards pertaining to hydraulic structures are listed in Section 6.1, Safety.

6.8 STORM WATER STORAGE

The analysis and design of storm water storage facilities shall meet the following standards:

6.8.1 Requirements for Developments

All new developments shall make provisions to retain the storm water runoff from a 100-year, 2-hour duration storm falling within its boundaries. This requirement may be waived by the Development Services Director for isolated developments under ½ acre in area if there will be no critical drainage problem created by the additional runoff from the proposed development.

The finding of no detrimental impact must be documented following the methodologies established in the Drainage Design Manual.

6.8.2 Collector and Arterial Streets

Stormwater retention is not required for collector and arterial street rights of way. Classification of streets shall be per the Street Transportation Department "Street Classification Map".

6.8.3 First Flush

In the special case when a detention facility is allowed, the requirement to retain the 100-year, 2-hour runoff volume may be waived. Post-development peak discharges shall not exceed pre-development peak discharges for the 2-, 10-, and 100-year storm events.

The City has established a minimum level of control for new development at which stormwater pollution prevention practices must be put in place. This minimum standard is “First Flush”, and consists of retaining or treating the first 0.5 inch of direct runoff from a storm event. Normally, this minimum level of control is met by following the City retention requirement to capture the 100-year, 2-hour storm. In the event that normal city retention standards are waived (100-year, 2-hour storm), or a surface based bleed off for the retention basin is proposed, the first flush provisions shall apply. This first flush policy is the result of City Code, Chapter 32C Stormwater Quality Protection where the City may regulate the use of the public storm drain system through administrative rules, permits, and other written forms of approval for activities that could release pollutants or stormwater to a public storm drain system.

Discharges into a structure owned or operated by the City must comply with the First Flush Policy providing stormwater runoff control. The First Flush requirement can be addressed by retaining the required minimum First Flush volume, treating the first flush discharge, or utilizing a combination of both approaches. The minimum First Flush volume is calculated as follows:

$$V_{FF} = C\frac{P}{12}A$$

where:

V_{FF} = minimum First Flush volume in ac-ft,
C = runoff coefficient (set at 1.00),
P = first 0.5 inch of direct runoff[35], and
A = area of project site, in acres.

The minimum First Flush treatment discharge design flow rate is calculated as follows:

$$Q_{FF} = CIA$$

where:

[35] First flush precipitation depth in feet, set at 0.5 inch ÷ 12 = 0.04 feet

Q_{FF} = minimum First Flush discharge in cfs
C = runoff coefficient (set at 1.00)
A = area of project site, in acres
T_C = time of concentration (minutes) – minimum of 10 minutes
I = 0.5 inches/hour rainfall excess intensity divided by time of concentration, calculated according to the following formula:

$$I = \frac{0.5in/hr \times 60\,min/hr}{T_C}$$

Example: Calculate the volume for a stormwater storage basin that must be constructed to capture the first flush from a commercial site with 100 acres of developed area. Also calculate the discharge that must be treated if the storage option is not selected. Assume the time of concentration is 20 minutes.

$$V_{FF} = \frac{1.0 \times 0.5in/hr \times 100ac}{12in/ft}$$

$$V_{FF} = 4.17ac - ft$$

$$Q_{FF} = \frac{1.0 \times 0.5in/hr \times 60\,min/hr \times 100ac}{20\,min}$$

$$Q_{FF} = 150cfs$$

6.8.4 Retention Volume

Required retention basin volume shall be obtained by using the following equation:

$$V = C\left(\frac{P}{12}A\right)$$

where:

V = Calculated volume in acre-feet
C = Runoff coefficient (See Table 6.2.2)
P = 100 year, 2 hour rainfall depth in inches
A = Drainage area in acres

6.8.5 Outfall

All developments shall be designed to have a positive outfall to adjacent streets once the on-site storm water storage basins are filled. An additional 25% retention volume for the design storm event will be required when the storm water storage basin does not outfall to public right of way or public drainage easement.

6.8.6 Sediment Basins

Sedimentation basins as required per Section 6.10 shall be located at the upstream (inlet) end of stormwater storage facilities. All stormwater storage facilities receiving flow from undisturbed

watercourses shall incorporate sediment settling basins at the terminus of the undisturbed watercourse(s) as identified in Section 6.10. The sediment settling basins shall be easily accessible by maintenance equipment (such as backhoes and loaders) and shall have a minimum storage capacity as required in Section 6.10.

6.8.7 Basin Requirements

Stormwater storage basins shall meet the following requirements:

6.8.7.1 Maximum Water Depth

Storm water storage basins shall have a maximum water depth of three feet for the 100-year, 2-hour storm event. Deeper water depths for the design event shall require approval by the reviewing department(s).

6.8.7.2 Location on Private Property

The required stormwater storage volume shall be provided on private property and not intrude upon the ultimate road right-of-way as shown on the Street Classification Map.

6.8.7.3 Depth and Setback from Right of Way

The maximum depth of the stormwater storage basin within ten feet of the right-of- way shall be 18 inches; and within 20 feet of the right of way shall be 24 inches. The basin side slope shall not begin closer than two feet from back of sidewalk. If there is no sidewalk, storm water storage shall begin no closer than seven feet from the back of curb.

6.8.7.4 Berms

Berms shall not be placed closer than 2-feet from a sidewalk or roadway curb. Berms shall not be higher than 2 ½ feet above the top of sidewalk or curb. Berms shall have gentle, stable side slopes and a minimum top width of 2-feet with an erosion protected overflow area (emergency spillway) cut into the berm.

6.8.7.5 Side Slopes

Side slopes of storm water storage facilities shall be no steeper than 5:1 for irrigated grass areas and 3:1 for landscaped areas. The drainage plans must provide slope stabilization measures for all slopes steeper than 5:1. The slope stabilization measures must be readily maintainable using common maintenance equipment and be designed with consideration to aesthetics. The slope stabilization measures shall be consistent with commonly used engineering practices. Un-stabilized decomposed granite is not allowed on slopes steeper than 5:1.

6.8.7.6 Retaining Walls

Where necessary, vertical retaining walls may be utilized for portions of basin sides, subject to public safety requirements (fences, railing, etc.) as needed and described elsewhere in this Manual.

6.8.7.7 Basin Geometry

Stormwater storage basin sides, edges, or top of slopes shall be of irregular geometry. Basins shall incorporate native materials (including native stone and boulders) and be revegetated in such a manner consistent with the engineering intent of the facility and conducive to

maintenance activities. Storm water storage facilities in excess of 0.5 acre-ft design storage (excluding freeboard) and over 3 feet in depth shall incorporate benches no narrower than ten feet (level bench width) for at least 40 percent of the circumference of the basin. The bench shall be at least two feet higher than the basin bottom.

6.8.7.8 Basin Plan Submittal

The designer is encouraged to discuss proposed slopes, landscaping and stabilization measures with the reviewing department staff prior to submittal of plans.

6.8.8 Stormwater Storage in Parking Areas

The maximum depth of ponded water within any parking lot location shall be six inches with the deeper portions confined to remote areas of parking lots, whenever possible. The minimum longitudinal slope permitted within parking lot storage facilities is 0.005 ft/ft, unless concrete valley gutters are provided. With concrete valley gutters, a minimum longitudinal slope of 0.002 ft/ft is permitted.

6.8.9 Ponding in Streets

All storm water storage basins shall be designed to have positive outfall without ponding in local streets. When a design does utilize ponding in local streets, the storm water storage basin must have at least 0.5 foot freeboard above the design storm event and the maximum ponding in the local street shall not exceed 0.5 foot before positive outfall. Ponding in major and collector streets is not allowed. These criteria do not take into account off-site flows being routed through the storm water storage basin.

6.8.10 Basin Drain Time

The design of all storm water storage facilities shall be such that the stored runoff shall be emptied completely from the facility within 36 hours after the runoff event has ended by either infiltration, controlled bleed-off, dry well or discharge pump to an approved facility. Where bleed-off pipes are to be used as the primary means of draining the storm water storage basin, the calculated outlet diameter shall drain the 100-year (design) storm water storage volume within 36 hours, but not less than 24 hours. The proposed diameter may be rounded up to the nearest standard size made by pipe manufacturers. The minimum allowable pipe size for primary outlet structures is 18 inches in diameter. If the flow capacity of an outlet pipe must be further reduced, a permanently attached, hinged orifice plate shall be used. Maximum bleedoff rate into a City of Phoenix storm drain system shall be limited to ONE cfs.

6.8.11 Compliance with NPDES

Discharges from storm water facilities must be in compliance with 40 CFR 122, the National Pollution Discharge Elimination System (NPDES) and City Code Chapter 32C Storm Water Quality Protection.

6.8.12 Percolation Testing

Field investigations shall include percolation tests to obtain permeability rates for use in the design of the storm water storage facility. Such tests shall be in the receiving layer below the proposed basin.

6.8.13 Dry Wells

Dry wells shall be designed in conformance with ADEQ guidelines. The accepted design disposal rate for a dry well shall not exceed 0.1 cfs per well unless a greater rate can be supported by a detailed, certified soils report. Should the soils report indicate a higher rate, a conservative value of 50 percent of the higher rate (not to exceed 0.5 cfs per well) shall be used to compensate for deterioration over time and for silting and grate obstruction. Dry wells that cease to drain a facility within the 36 hour period shall be replaced/refurbished by the owner with new ones and such a requirement shall be written in the CC&R's for all subdivisions where drywells are used to drain storm water storage facilities. Dry wells are not allowed within City right-of-way unless otherwise approved by the maintaining department of the City. Dry wells, when required, shall be drilled a minimum of ten feet into permeable porous strata or percolation tests will be required after construction. The City inspector must inspect and approve the well before backfill or well pipes are placed within any dry well bore holes. Where dry wells are installed, it shall be the owner's responsibility to clean and maintain each structure to assure that each remains in proper working order. Under no condition shall the regular maintenance schedule be greater than every three years.

6.8.14 Dam Spillways

Emergency spillways of jurisdictional dams (see Section 4.6) shall comply with the rules and regulations of ADWR. Emergency spillways for non-jurisdictional dams that are less then six feet in height shall have the capacity to discharge the 100-year inflow flood with no attenuation due to storage routing. Emergency spillways for non-jurisdictional dams that are more than six feet but less than 25 feet in height shall have the capacity to discharge the ½ probable maximum flood (PMF) when routed through the storage basin. The residual freeboard for all non-jurisdictional dams shall be a minimum of one foot. Spillways shall be designed to resist failure due to erosion during the design flood. If spillways result in a diversion of flood flows in either magnitude or direction from its normal and natural course, then down-gradient properties shall be protected from damage caused by spillway release. Dam height is the vertical distance from the lowest point along the downstream slope to the emergency spillway crest or to the top of the dam if no spillway exists. Residual freeboard is the vertical distance between the top of the dam and the design water surface elevation when passing the maximum discharge through the spillway. The probable maximum flood (PMF) is defined by ADWR as the flood runoff expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The ½ PMF is that flood hydrograph equivalent to ½ the ordinates of the PMF hydrograph.

6.8.15 Spillway Elevations

The finish floor elevation of structures (within the dam impoundment area) must be at least 0.5 foot above the overflow water surface elevation at the crest of the emergency spillway. Finished floor elevations of structures shall be a minimum of one foot above the 100-year water surface of the stormwater storage facility for the 6- or 24-hour storm event (whichever is greater).

6.8.16 Maximum Water Surface Elevation

The maximum water surface elevation resulting from the storage of the required stormwater storage volume shall be below the elevation of the emergency spillway crest.

6.8.17 Sumps

In areas of natural topographic low areas or engineered sumps, the finished floor elevations for new construction shall be a minimum of 14 inches above the outfall.

6.8.18 Landscaping Plan

A preliminary landscaping plan for the storm water storage area must be submitted prior to the issuance of a final grading permit. The landscaping plan must accommodate access by maintenance equipment commonly used by the City of Phoenix such as backhoes and loaders among other equipment.

6.8.19 Maintenance

Storm water storage basins are to be privately maintained and located within a designated drainage tract unless sited in conjunction with a City owned and operated facility. Privately maintained facilities shall have the words *"Private Drainage Facility - No City Maintenance"* legibly embedded or stamped in concrete using three inch lettering at a conspicuous place in the vicinity of all entrance and exit points of the drainage facility. The construction plans supporting the drainage design shall clearly call out location, size and text for this signage.

6.8.20 Stormwater Storage in Parks

Storm water storage facilities sited in conjunction with recreational parks that are to be owned and operated by the City of Phoenix Parks and Recreation Department (PRD) shall have the following additional requirements:

a. Positive drainage out of the basin shall be provided.

b. Site shall be graded in a manner to provide some high ground and/or non-flooding area, with a minimum acreage to be determined by the PRD. Five acres is the minimum size and 15 acres is preferred for a multi-use basin. The amount of area above the 100 year water level is contingent upon the facilities to be provided which are established upon consultation with the PRD.

c. Street frontage shall be provided on at least one side.

d. Site shall be located within a dedicated right-of-way with fee simple title transferred to the City.

e. Ground cover shall be of similar materials. Mixing materials can create maintenance problems.

f. Street nuisance water should not enter park, or shall be accommodated with an approved low flow channel or other storm drain system.

g. Grading, landscaping, and irrigation shall be provided by the Owner or Developer with PRD approval.

h. Location of site and street access shall be approved by the PRD and the Street Transportation Department.

i. Existing vegetation shall be preserved when possible.

j. The top one foot of soil on the bank and the basin floor shall be free of gravel and rock, suitable for establishing turf.

k. Depths greater than three feet must be approved by PRD.

l. Where sediment transport analysis is required (See Section 6.10), sediment settling basins at the upstream end of the basin shall be required.

6.8.21 Safety

Additional standards pertaining to storm water storage are listed in Section 6.1, Safety.

6.9 PUMP STATIONS

6.9.1 Water Quality Testing

Water quality testing and approval from City of Phoenix Storm Water Management Section is required prior to the operation of pump station for every pumping event.

6.9.2 Capacity

Pump capacity shall be sufficient to empty the facility within 36 hours and shall have a maximum output of one cfs, unless otherwise permitted.

6.9.3 Inlet

A six feet wide minimum paved apron shall be provided around the inlet opening. Full access to maintenance vehicles shall be provided to the inlet.

6.9.4 Automatic Control

An automatic switch control with vertical float controlled mechanism shall be provided and installed to the manufacturer's recommendations.

6.9.5 Accessibility

The pump shall be accessible with the basin completely full of water.

6.9.6 Screen

The pump inlet shall be protected with 3/4-inch mesh screen for both vertical and horizontal faces.

6.9.7 Redundancy

Design /performance redundancy shall be required for all facilities in which failure of the pump station will potentially threaten lives or cause significant property damage.

6.9.8 Discharge Location

Pump stations shall not discharge into the street right-of-way. Pumped discharges from storm water storage facilities to storm drain systems may be allowed with approval of the City Street Transportation Department. Pump stations used to drain storm water from a storm water retention storage facility shall not be operated during storm events.

6.9.9 Water Quality Compliance

Pump discharges shall conform to the requirements of the Clean Water Act.

6.10 SEDIMENTATION

Recognizing that sedimentation and sediment transport is either supply or transport control (see the Maricopa County Drainage Design Manual, Hydraulics) and that storm water runoff may produce sedimentation or erosion, the following standards shall be applied.

6.10.1 Sediment Analysis Requirements

To support the design for engineered drainage features with less than 50% of the definable watercourse exhibiting engineered improvements or with contributing drainage areas[36] less than 75% developed, the following sediment transport analysis shall be undertaken consistent with the methodologies identified in the Drainage Design Manual, Hydraulics, Chapter 10, Sedimentation:

Table 6.10.1 Requirements for Sediment Transport Analysis

100-Year Design Discharge	Sediment Transport Analysis
Less than 200 cfs	No analysis required
200 to 500 cfs	Qualitative
501 to 2,000 cfs	Qualitative and Quantitative
greater than 2,000 cfs	Qualitative, Quantitative, & Dynamic Modeling

6.10.2 Sediment Basin Design

Where sediment transport analysis is required (See Table 6.10.1), sedimentation basins/structures shall be designed and constructed as an integral part of storm water storage and/or conveyance facilities. Figure 6.10.1 illustrates the trigger points for analysis of sedimentation.

Sedimentation basins/structures shall be designed to hold a minimum of two years of watershed sediment yield using an annual sediment yield of 0.25 ac-ft/sq-mi/year or the site-specific sediment yield based upon in-situ geomorphic analysis meeting or exceeding those identified in the sedimentation chapter of the Drainage Design Manual, Hydraulics. Unlined sediment basins shall be designed with minimum 4:1 side slopes and minimum 16-foot wide clear access ways with a minimum 12-foot wide concrete or soil cement paved ramp for maintenance access. Sediment basins shall be designed to slow but not prevent the passage of runoff. Sediment check structures shall have low flow outlets with inverts set equal to the invert of the drainageway and shall be no higher than 18 inches. All outlets shall be designed to be protected from scour per the Drainage Design Manual.

[36] For land development projects, the area considered is the "off-site" drainage area.

6.10.3 Basins at Box Culverts

Sediment basins shall be constructed at the inlet and outlet ends of box culverts where they convey flow from unlined, natural washes. Details of typical box culvert requirements are shown on figures 6.5.2 and 6.5.3. Minimum basin dimensions are shown in figures 6.5.2 and 6.5.3 and the basins shall be configured to allow maintenance and removal of sediment using typical construction equipment. Maximum basin depth is 2 feet. Minimum basin size shall be per figures 6.5.2 and 6.5.3 for washes with flows less than 500 cfs. For larger washes, a sediment transport analysis shall be performed for the watershed. Basins at the inlet of box culverts shall be designed such that flow velocity is reduced to 2 fps or less to allow sediment bed loads to settle in the basin. Ramps, as described in Section 6.10.2, shall be provided in basins at both ends of culverts.

6.10.4 Right of Way

Sediment basins shall be constructed in a City-owned property, dedicated right of way, drainage easement, or privately-owned and maintained drainage tract that must be platted and recorded.

Figure 6.10.1 Trigger Points for Sediment Control Facilities

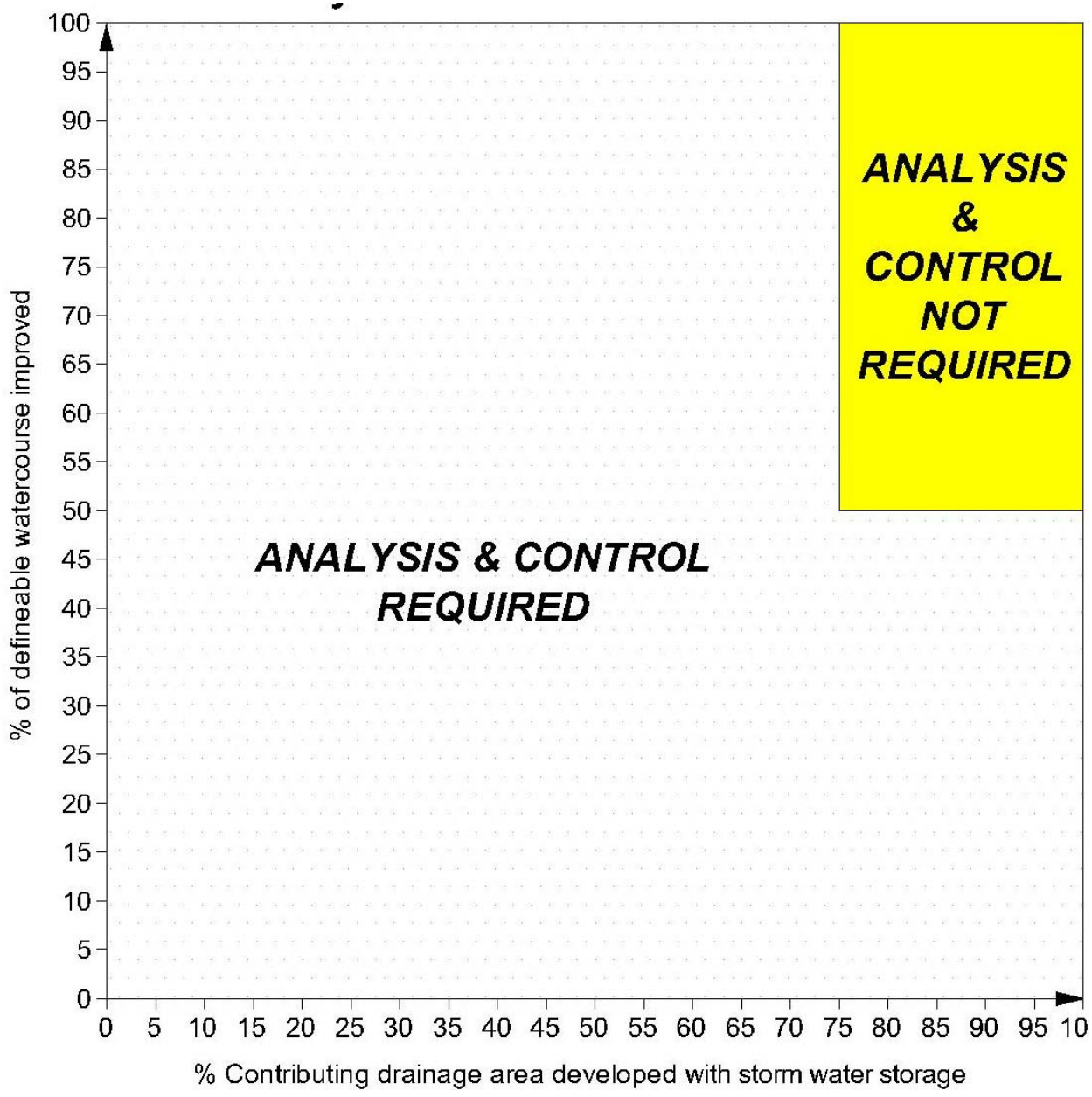
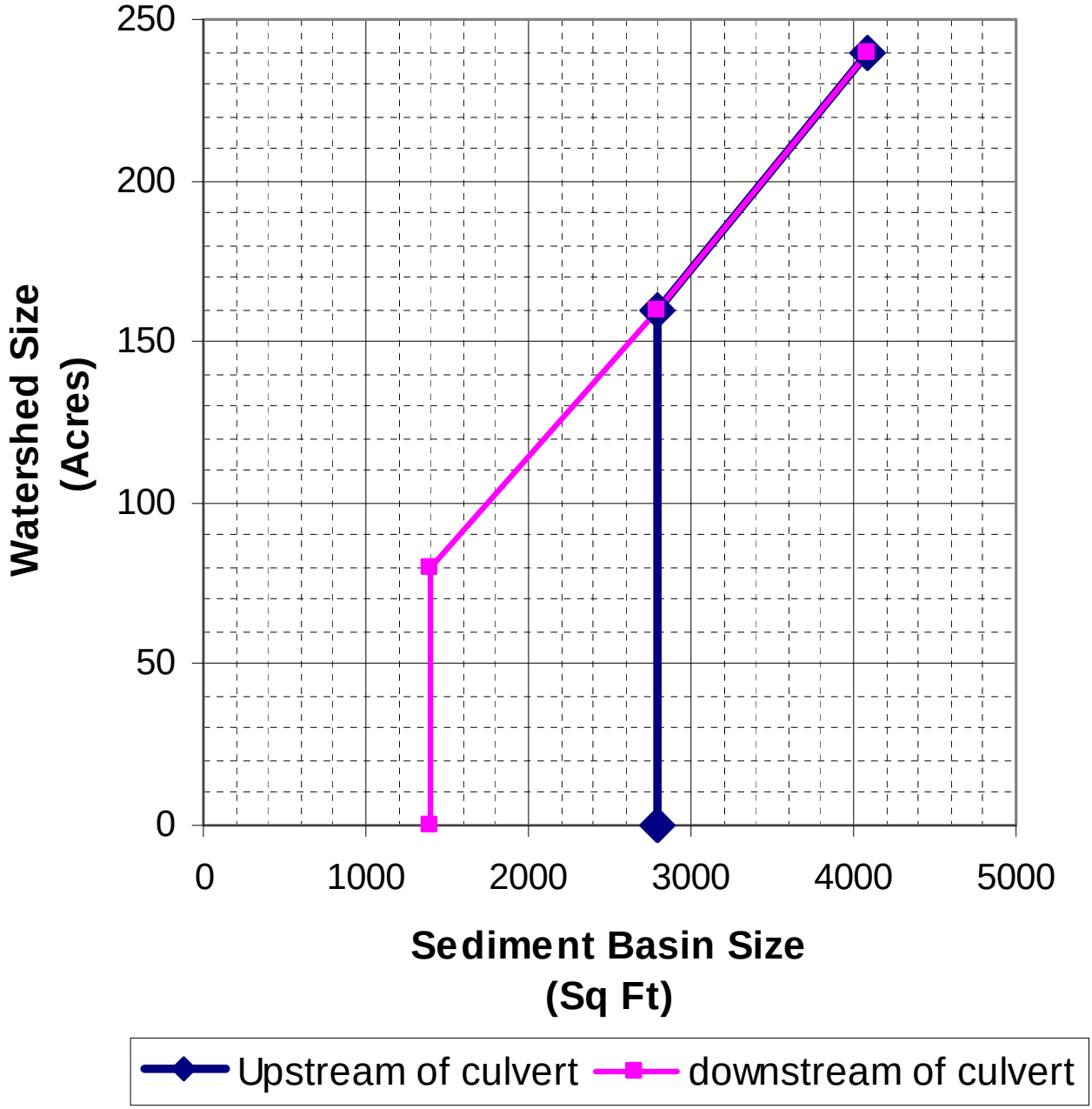


Figure 6.10.2 Minimum Sediment Basin Size for Box Culverts in Natural Washes[37]



[37] 2-year Maintenance Interval provided

6.11 HYDROLOGY AND HYDRAULICS REPORTS

6.11.1 Report Organization

Hydrology reports shall be organized to include the following appropriate sections (as a minimum) in the order given:

TABLE OF CONTENTS

1.0 Storm Drain Checklist
2.0 Introduction
3.0 Location
4.0 Site Description and Proposed Development
5.0 FEMA Floodplain Classification
6.0 Off-site Drainage
  6.1 Background
  6.2 Proposed Offsite Flow Management
7.0 On-site Drainage
8.0 Retention Requirements
9.0 Finished Floor Elevations
10.0 References

FIGURES

Figure 1 Area Location Map
Figure 2 Aerial Photo Map
Figure 3 FIRM Map
Figure 4 Off-site Drainage Map
Figure 5 On-site Drainage Map

APPENDICES

Appendix A Offsite Drainage
Appendix B Peak Flow Calculations
Appendix C Street Capacities & Storm Drain Analysis
Appendix D Retention Requirements

6.11.2 Storm Drain Checklist

Each report shall contain the Storm Drain Design Checklist, see Table 6.11.1, completed as appropriate for the proposed project.

6.11.3 Drainage Report Requirements

Drainage reports shall include, but not be limited to, the following items:

a. Professional engineer seal, signed and dated.

b. A drainage map that shows the Q's at points of concentration and clearly identifies the existing drainage system. Minimum scale shall be 1 inch equals 500 feet (1 inch = 200 feet for submittals to Street Transportation Department). Where drainage areas are large or otherwise inappropriate, other scales may be approved.

c. Detailed street hydraulic analysis and storm drain analysis as appropriate.

d. Calculations for the proposed stormwater storage facilities showing storage volume required and storage volume provided. If more than one facility is proposed, calculations must be separated for each area and each tributary area referenced to its respective storm water storage facility. Analysis confirming basin dry up within 36 hours of the end of the design precipitation event is required.

e. If adjacent land drains into or is diverted around the development, adjacent contributory drainage area must be shown and quantified. Size of the adjacent drainage area and slope of the land information shall be shown.

f. A line drawing of the proposed drainage system in plan view showing design flow and capacity.

g. Sufficient information to determine the path of the water entering and leaving the project property under pre-development and post-development conditions. Sufficient information to show that proposed conditions do not pond water on adjacent properties or discharge at erosive velocities above pre-project conditions.

h. Average slope and typical cross sections of all streets.

i. FEMA floodplains in and adjacent to the project area as an exhibit or figure.

j. Summary of previously prepared drainage reports pertinent to the subject area.

Table 6.11.1 Storm Drain Design Checklist

No		Status	Item
1			A complete drainage report, sealed by a Civil Engineer licensed to practice in Arizona containing the following:
	a		A drainage area map at an appropriate scale.
	b		Each sub-basin area delineated and labeled with an alpha-numeric character on the Drainage Area Map.
	c		Directional drainage arrows on all streets, parking lots, paved areas, and vacant land.
	d		Zoning shown on each parcel.
	e		Catch basins shown (existing catch basins dashed lined to distinguish as existing).
	f		Each catch basin number corresponding to the number of the subbasin area which contributes to it.
	g		Catch basins numbered, beginning with number 1 as the first catch basin contributing to the storm drain at the upstream end; the next catch basin contributing shall be number 2, etc.
	h		The same catch basin number is used throughout the project – on the drainage area map, in the design report, on the Storm Drain Design Summary Sheet, and on the plans.
	i		Minimum catch basin freeboard provided per Table 6.4.1.
	j		Completed Storm Drain Design Summary Sheet is included in report and plans. Downloadable Cadd file available at City of Phoenix website.
2			Conformance with previous drainage studies checked and differences discussed.
3			Completed Storm drain quantity summary sheet included in plans (only required for “Storm Drain Only” type projects)
4			Completed Storm Drain Design Summary sheet included in plans.
5			Hydraulic & Energy Grade Line Profile included in report and plans.
	a		Maximum design HGL meets requirements specified in Table 6.4.1.
6			Design complies with design velocity standards established by the

No		Status	Item
			City of Phoenix.
7			Dry lane requirements are met.
8			Appropriate drainage runoff was assumed:
	a		No contributing runoff was assumed for properties with existing 100-year on-site retention, or properties with plans for 100-year on-site retention which have been reviewed and approved by the City.
	b		Existing condition land-use runoff coefficients were used where contributory land is vacant or developed prior to storm water storage requirements.
9			All underground utilities identified in plan & profile.
10			Utility potholes requested (as needed).
11			Water, sewer, and natural gas service taps shown in plan & profile.
12			All sanitary sewer manhole rim and invert elevations shown on plans.
13			Existing top of water valve nut elevations noted on storm drain plans.
14			Storm drain and catch basin connector pipe conflicts with other utilities identified.
15			SRP, RID, and private irrigation facilities checked for conflicts.
16			Waterline thrust block conflicts shown.
17			Pipe supports for sanitary sewer lines above main storm drain identified and shown on plans.
18			Any existing Portland Cement concrete pavement (surface or underlayment) shown.
19			Existing topography and buildings shown at least 30 feet beyond street ROW.
20			Intersecting side street elevations at least 100 feet beyond curb returns noted on plans.
21			Potential ponding behind sidewalks checked and resolved.
22			Driveway/catch basin conflicts checked and resolved.
23			Finish floor elevations checked relative to 100-Year water surface elevations:

No		Status	Item
			6 inches above top of curb elevation 14 inches above low curb 6 inches above street crown elevations 6 inches above sump outfall elevations as appropriate.
24			One typical full-street cross-section with storm drain and all other underground utilities drawn at 1" = 10' H & V scale on each storm drain profile sheet. The section should be taken at a specific station location on that sheet, and that station location shall be noted on the cross-section.
25			Main line storm drain plans shall be 1" = 20' horizontal and 1" = 2' vertical (unless otherwise approved).
26			Scales for connector pipe/catch basin profiles shall be 1" = 5' horizontal and 1" = 5' vertical (unless otherwise approved).
27			Mainline storm drain has minimum 5-foot cover (unless otherwise approved).
28			Maximum distance that surface drainage is carried in a collector/arterial is 660 feet before reaching a catch basin.
29			Maximum manhole spacing meets requirements specified in Table 6.4.1.
30			At mainline storm drain pipe size changes, inside top of pipe (soffit) elevations are matched, unless otherwise approved.
31			Geotechnical Investigation:
	a		Soil boring(s) extending at least 2 feet below proposed storm drain have been taken and shown on the plans.
	b		Soil boring logs and information including pH & resistivity shown on plans. Alternate pipe materials selected are appropriate for soil conditions.
	c		Seismic refraction survey completed and shown on plans.
32			Existing and proposed ground elevation shown for all mainline and connector pipe profiles.
33			Storm Drain Key Map included.
34			Completed Alternate Pipe Material sheet included.
	a		D-loads for reinforced concrete pipe calculated and shown.

No		Status	Item
	b		Existing soil conditions meet requirements for CIPP or concrete-lined CSP alternate mainline pipe.
	c		Alternate pipe chart shows required CIPP and CSP storm drain pipe diameters 6 inches larger than designed pre-cast concrete pipe diameters. The calculated pipe wall thickness for CIPP is based on the required larger size.
	d		Alternate pipe chart shows no CIPP smaller than 30 inches in diameter.
	e		Maximum allowable pipe size for HDPE pipe is 48 inches in diameter.
35			Checked for all necessary permanent pipe supports per detail 403.
36			Checked and specified ductile iron pipe replacement for all ACP waterline under crossings per COP Supplement to MAG Specifications, Section 601.2.8.

6.12 GENERAL CONSTRUCTION DRAWING REQUIREMENTS

6.12.1 Drainage Patterns

The following information is required on grading and drainage plans:

a. Information to determine existing and proposed drainage patterns.

b. Information to determine that an adjacent property drainage pattern will not be adversely affected.

6.12.2 Storm Drain Profiles

A plot of hydraulic and energy grade lines profiles for storm drain pipe with diameter 18 inch or larger shall be provided. The profiles shall be submitted in summary form in plan and profile at a reduced scale, intended to highlight the general alignment and hydraulic connectivity of the system herein referred to as the Hydraulic & Energy Grade Line Profile Sheet(s). This information shall be provided with the storm drain design data sheet(s) from the hydrology / hydraulics report.

The following data shall also be included with the hydraulic / energy grade lines profiles:

a. The finished street elevation over the storm drain pipe.

b. The pipe profile and size shown.

c. The design peak discharge (cfs) in the storm drain pipe segments.

d. The velocity (fps) in the storm drain pipe segments.

e. Appropriate stationing.

6.12.3 Connector Pipe Profiles

Profiles of catch basins and connector pipes shall be provided. These profiles shall show pavement surface elevation, gutter elevation, top of curb elevation, catch basin type, "V" depth (minimum depth is four feet), size and cross-section, connector pipe invert at the catch basin and at the inlet to the main line storm drain (as well as any grade breaks), connector pipe size and slope in ft/ft, and the location and size of existing and proposed utilities along the profile and in the vicinity of the catch basin. Each catch basin profile shall be labeled by road centerline station (or main storm drain stationing if different). Connector pipe/catch basin profiles shall have horizontal and vertical scales of 1” = 5’.

6.12.4 Existing and Proposed Utilities

a. On the storm drain plan sheets, the engineer shall show the rim and invert elevations at all existing sanitary sewer manholes.

b. The engineer shall identify valve nut elevations for all water valves on the project. The valve nut elevations shall be called out in plan view next to the water valve.

c. In plan and profile, existing and proposed underground utilities shall be labeled according to size and type. Corresponding alphanumeric labels shall be shown for each utility and depicted in the legend. If the utility is an underground conduit, give all the details such as number of ducts and whether or not the conduit is encased in concrete. Any known utilities to be constructed prior to the project shall be shown and so indicated. Conflicts between existing utilities and proposed construction are to be identified. Utilities that are abandoned or to be abandoned shall be indicated as well as those designated to be relocated or removed. The engineer shall contact the appropriate utility if any questions arise about types or locations of underground facilities. Existing and proposed underground tanks shall also be shown.

d. The minimum vertical clearance between a proposed storm drain and all existing utilities shall be one foot unless otherwise required by the given utility.

e. Below ground utilities shall be dimensioned from the road center or monument line.

f. Above ground utilities such as power poles, light poles, guys and anchors, irrigation structures, utility pedestals, transformers, switching cabinets, gas regulators, waterline back-flow prevention units, etc. shall be called out including size and pad elevation, shown in plan, with stations and offsets relative to the adjacent road monument line or centerline to the street-side face / centerline of the utility (e.g. Sta. 12+33, 32' ± Rt.).

g. When below ground appurtenances (utilities, monuments, tanks, valve boxes etc.) depicted on “As-Built” or "Record" drawings cannot be field located, they shall be shown on the plans and labeled as "Not Found".

6.12.5 Storm Drain Plan Requirements

The following items shall be shown on storm drain plan and profile sheets:

a. New storm drain pipe

b. Manholes/Junction structures

c. Catch basins

d. Connector pipe

e. Pipe collars

f. Prefabricated pipe fittings

g. Other drainage appurtenances (headwalls, trash racks, drop inlets, hand rails, pipe supports, etc.).

6.12.6 Side Streets

Where new street paving work joins existing side streets, pavement crown and gutter elevations shall be shown in plan view for a minimum of 100 feet beyond the curb return on the side street. Where new street paving work joins an existing street linearly, existing pavement crown and gutter elevation shall be shown a minimum of 300 feet beyond the new work to ensure proper drainage and smooth ride for vehicular traffic.

6.12.7 Storm Drain Plan Format

All storm drain plans shall have the following format:

a. Storm drain designs shall be depicted on single plan/profile sheets.

b. Mainline storm drain plans shall be shown at 1 inch = 20 feet horizontal and 1 inch = 2 feet vertical, unless otherwise approved.

c. Connector pipe/catch basin profiles shall be shown at 1 inch = 5 feet horizontal and 1 inch = 5 feet vertical, unless otherwise approved.

d. One typical full-street cross-section with storm drain and all other underground utilities drawn at 1" = 10' H & V scale on each storm drain profile sheet. The section should be taken at a specific station location on that sheet, and that station location shall be noted on the cross-section

e. Profile slopes shall be shown in feet per foot dimensions to four significant figures.

f. Grade breaks shall be stationed with elevations shown. Station and elevations shall also be shown at sheet matchlines and at the beginning/end of the storm drain.

g. Centerline stationing shall be shown on plan and profile. Stationing shall run from the low point, or outfall, and increase toward the high point or inflow. Where the storm drain is being installed in conjunction with a paving project (i.e. depicted on corresponding paving plans), the stationing shall be correlated with the paving project stationing.

h. All plans shall use standard City of Phoenix symbols.

i. Final plan sheets shall be 22 inch x 34 inch, ink on mylar.

j. Lettering size on full size drawings shall be 14 point minimum.

k. Title blocks shall be located in the lower right-hand corner of the plans and shall include the title "Storm Drain".

l. Storm drain diameters shall be shown in plan and profile without reference to material type.

m. Standard AutoCad base sheets may be downloaded from the City of Phoenix Website.

6.13 SUBMITTALS TO DEVELOPMENT SERVICES DEPARTMENT

6.13.1 Transmittals

All grading and drainage submittals shall be accompanied by a transmittal letter and the Grading and Drainage Plan Checklist (in addition to the Storm Drain Checklist identified previously). The transmittal letter shall include the project name, Development Services Department (DSD) project number, Engineer's name, materials submitted, and purpose of submittal. All plans shall have the DSD project numbers and quarter section number placed in the lower right-hand corner of the plans. An approved preliminary site plan shall be submitted. In

addition, a Storm Water Pollution Prevention Plan and Checklist will be required per AZPDES criteria if applicable. All checklists shall be obtained from DSD.

6.13.2 Permits

Approved hydrology reports and grading and drainage plans must precede recordation of instruments of dedication when such data is necessary to determine required rights-of way, City owned properties, facilities for drainage, or finish floor elevations. A permit for off-site construction cannot be issued prior to the grading and drainage permit.

6.13.3 Submittals

All submittals must be logged in with the Central Login Counter and shall be accompanied by a letter of transmittal. The project name, Engineer's Name, project numbers, material submitted and purpose of submittal (i.e. preliminary review, review of calculations, revision approval, etc) shall be given on the letter. Grading and Drainage Plan Review Fees are authorized by Ordinance and payment is required at time of login.

6.13.4 Additional Requirements

In addition to the requirements of Section 6.12, plans submitted to DSD shall include:

a. Information to determine drainage outfalls. All drainage outfalls shall be shown on plan and profile, extending until a definite day light condition is established. All temporary outfalls shall be shown in plan and profile, and clearly called out.

b. Topographic information showing 2-foot contours (or similar detail) within 100-feet of the project property must be provided.

6.14 SUBMITTALS TO STREET TRANSPORTATION DEPARTMENT

6.14.1 Drainage Report

A drainage report (per Section 6.11), drainage plans, and a completed storm drain checklist must be submitted for review and approval on all capital improvement projects submitted to the City of Phoenix Street Transportation Department.

6.14.2 Plans

The sheet sequence for all storm drain plans shall be as follows:

a. Cover Sheet

b. Legend & Notes

c. Storm Drain Key Map

d. Storm Drain Quantity Summary

e. Hydraulic & Energy Grade Line Profile

f. Storm Drain Design Summary

g. Soil Boring Logs and Seismic Refraction Survey Information

h. Storm Drain Plan/Profiles

i. Catch Basin and Connector Pipe Profiles

j. Alternate Pipe Chart

k. Special Details

6.14.3 Required Plan Information

All plans shall include the following Items:

a. Elevation datum and benchmarks (City datum required, plans shall be tied to two benchmarks minimum).

b. Engineer's seal, signed and dated.

c. Existing contours or spot elevations with drainage arrows to indicate drainage pattern.

d. Topography and all man-made features (including buildings, canopies, asphalt aprons, and overhangs) within all permanent and temporary rights of way, easements and 30 feet beyond these boundaries shall be shown.

e. The diameter and types of all trees and cacti must be shown. Limits of shrubs and ground cover shall be shown.

f. The finish floor elevations of all buildings and the elevation of the lowest level of underground parking structures or basements adjacent to the project shall be shown in profile view with corresponding offset dimensions.

g. The location of all utilities. The Consultant shall request potholes in writing to the City for any utility deemed as a possible conflict with proposed work. Specific horizontal and vertical locations will be provided at these pothole locations. Pothole requests on waterlines 12 inches in diameter or less, and sanitary sewer mains or taps will generally not be approved. Waterlines that may conflict with construction shall be called out for realignment. Sewer line elevations shall be interpolated from nearby manhole invert elevations. The written request shall accompany plans showing the locations of requested potholes. The City will make arrangements to have potholes excavated. Potholed utility information shall be shown on profiles/cross-sections at the elevation determined in the field, with the elevation called-out, and information shall be noted as "potholed elevation".

h. All existing underground portland cement concrete pavements (if such slabs are suspected and no As-Built drawings can be found to verify their existence, the Consultant shall notify the City and seek guidance regarding the necessity for core borings).

i. Construction note indicating that the contractor is responsible for locating and confirming depths of all underground utilities within the project area.

j. Construction note for proposed dry wells indicating that dry wells are to be inspected by the City prior to backfilling and installation of pipes.

k. Construction note indicating that storm water conveyance allowing for the discharge to historic pathways are to be provided during all phases of construction.

6.14.4 Pay Items

For City of Phoenix capital improvement combined paving and stormdrain projects, the following items shall be shown in the right-hand column of the PAVING PLAN sheets as pay items (unless otherwise approved):

a. Catch basins

b. Connector pipe

On the PAVING PLANS, the mainline storm drain and prefabricated tees shall be screened back. A note shall be added to the "Roadway Summary" sheet of the PAVING PLANS indicating that mainline storm drain pipe and catch basin pipe quantities are listed on the Alternate Pipe Chart. The Alternate Pipe Chart shall be included with the STORM DRAIN PLANS. The Roadway Summary sheet shall include quantities for the catch basins and connector pipes, manholes, junction structures and pre-fab tees. On combined paving / storm drain projects, no separate storm drain quantity summary sheet is required.

The following items shall be shown in the right-hand column of the STORM DRAIN PLANS as pay items:

a. New storm drain pipe (mainline)

b. Manholes/junction structures

c. Pipe collars when 24 inch or larger in diameter

d. Prefabricated catch basin connector pipe tees

e. Other major drainage appurtenances (e.g. headwalls, splitters, access barriers/ trash racks, etc).

On the STORM DRAIN PLANS, the catch basin connector pipes and catch basins shall be screened back.

For capital improvement projects that are Storm Drain only (no associated paving improvements), all information shall be shown on STORM DRAIN PLANS and a Storm Drain Quantity Summary sheet shall be provided.

6.14.5 Alternate Pipe Chart

The Alternate Pipe Chart shall have the format as shown in Figure 6.15.2.

6.14.6 CAD Base Sheets

Free downloadable AutoCAD base sheet files are available on the City of Phoenix website.

6.15 SUPPLEMENTAL TABLES AND CHARTS

The following tables and charts are reproduced for reference:

Figure 6.15.1 Storm Drain Design Summary Sheet

Figure 6.15.2 Storm Drain Alternate Pipe Table

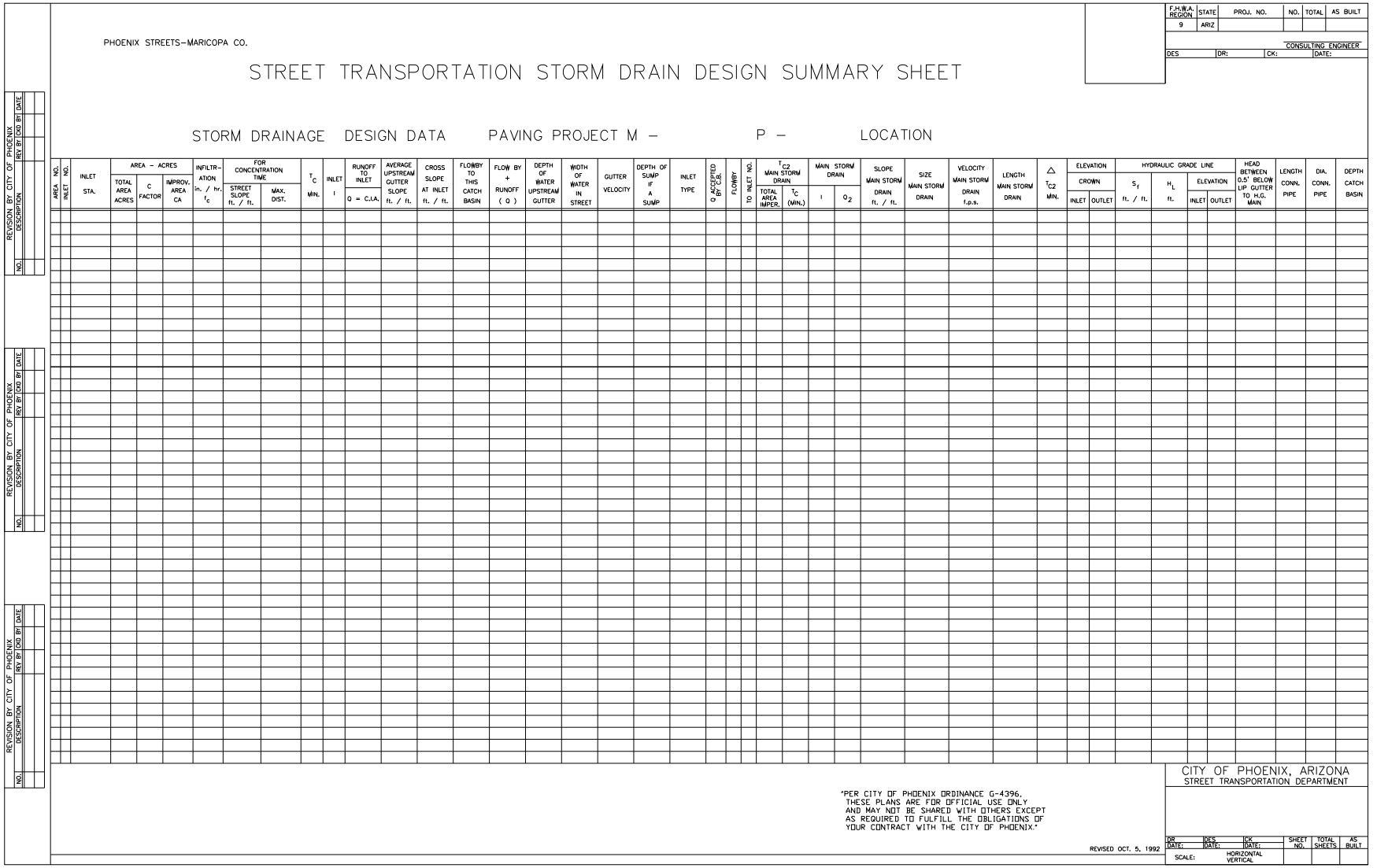
Figure 6.15.3 Flow Capacity of "M" Type Catch Basins in Sump Condition

Figure 6.15.4 Gage Thickness for CMP Storm Drain Pipe Based on Resistivity Measurement Chart – pH=6.5

Figure 6.15.5 Gage Thickness for CMP Storm Drain Pipe Based on Resistivity Measurement Chart – pH=7.3

Figure 6.15.6 Gage Thickness for CMP Storm Drain Pipe Based on Resistivity Measurement Chart – pH > 7.3

Figure 6.15.1 Storm Drain Design Summary Sheet



PHOENIX STREETS–MARICOPA CO.

STREET TRANSPORTATION STORM DRAIN DESIGN SUMMARY SHEET

F.H.W.A. REGION 9 | STATE ARIZ | PROJ. NO. | NO. | TOTAL | AS BUILT

CONSULTING ENGINEER

DES | DR: | CK: | DATE:

STORM DRAINAGE DESIGN DATA PAVING PROJECT M – P – LOCATION

REVISION BY CITY OF PHOENIX — NO. | DESCRIPTION | REV BY | CKD BY | DATE

REVISION BY CITY OF PHOENIX — NO. | DESCRIPTION | REV BY | CKD BY | DATE

REVISION BY CITY OF PHOENIX — NO. | DESCRIPTION | REV BY | CKD BY | DATE

AREA NO.	INLET NO.	INLET STA.	AREA – ACRES: TOTAL AREA ACRES	AREA – ACRES: C FACTOR	AREA – ACRES: IMPROV. AREA CA	INFILTRATION: in. / hr. f_c	FOR CONCENTRATION TIME: STREET SLOPE ft. / ft.	FOR CONCENTRATION TIME: MAX. DIST.	T_C MIN.	INLET I	RUNOFF TO INLET: Q = C.I.A.	AVERAGE UPSTREAM GUTTER SLOPE ft. / ft.	CROSS SLOPE AT INLET ft. / ft.	FLOW BY THIS CATCH BASIN	FLOW BY + RUNOFF (Q)	DEPTH OF WATER UPSTREAM GUTTER	WIDTH OF WATER IN STREET	GUTTER VELOCITY	DEPTH OF SUMP IF A SUMP	INLET TYPE	Q ACCEPTED BY C.B.	FLOW BY INLET NO.	TO INLET NO.	T_{C2} MAIN STORM DRAIN: TOTAL AREA IMPER.	T_{C2} MAIN STORM DRAIN: T_C (MIN.)	MAIN STORM DRAIN: I	MAIN STORM DRAIN: Q_2	SLOPE MAIN STORM DRAIN ft. / ft.	SIZE MAIN STORM DRAIN	VELOCITY MAIN STORM DRAIN f.p.s.	LENGTH MAIN STORM DRAIN	$\triangle T_{C2}$ MIN.	ELEVATION: CROWN INLET	ELEVATION: CROWN OUTLET	HYDRAULIC GRADE LINE: S_f ft. / ft.	HYDRAULIC GRADE LINE: H_L ft.	HYDRAULIC GRADE LINE: ELEVATION INLET	HYDRAULIC GRADE LINE: ELEVATION OUTLET	HEAD BETWEEN 0.5' BELOW LIP GUTTER TO H.G. MAIN	LENGTH CONN. PIPE	DIA. CONN. PIPE	DEPTH CATCH BASIN

PER CITY OF PHOENIX ORDINANCE G-4396, THESE PLANS ARE FOR OFFICIAL USE ONLY AND MAY NOT BE SHARED WITH OTHERS EXCEPT AS REQUIRED TO FULFILL THE OBLIGATIONS OF YOUR CONTRACT WITH THE CITY OF PHOENIX.

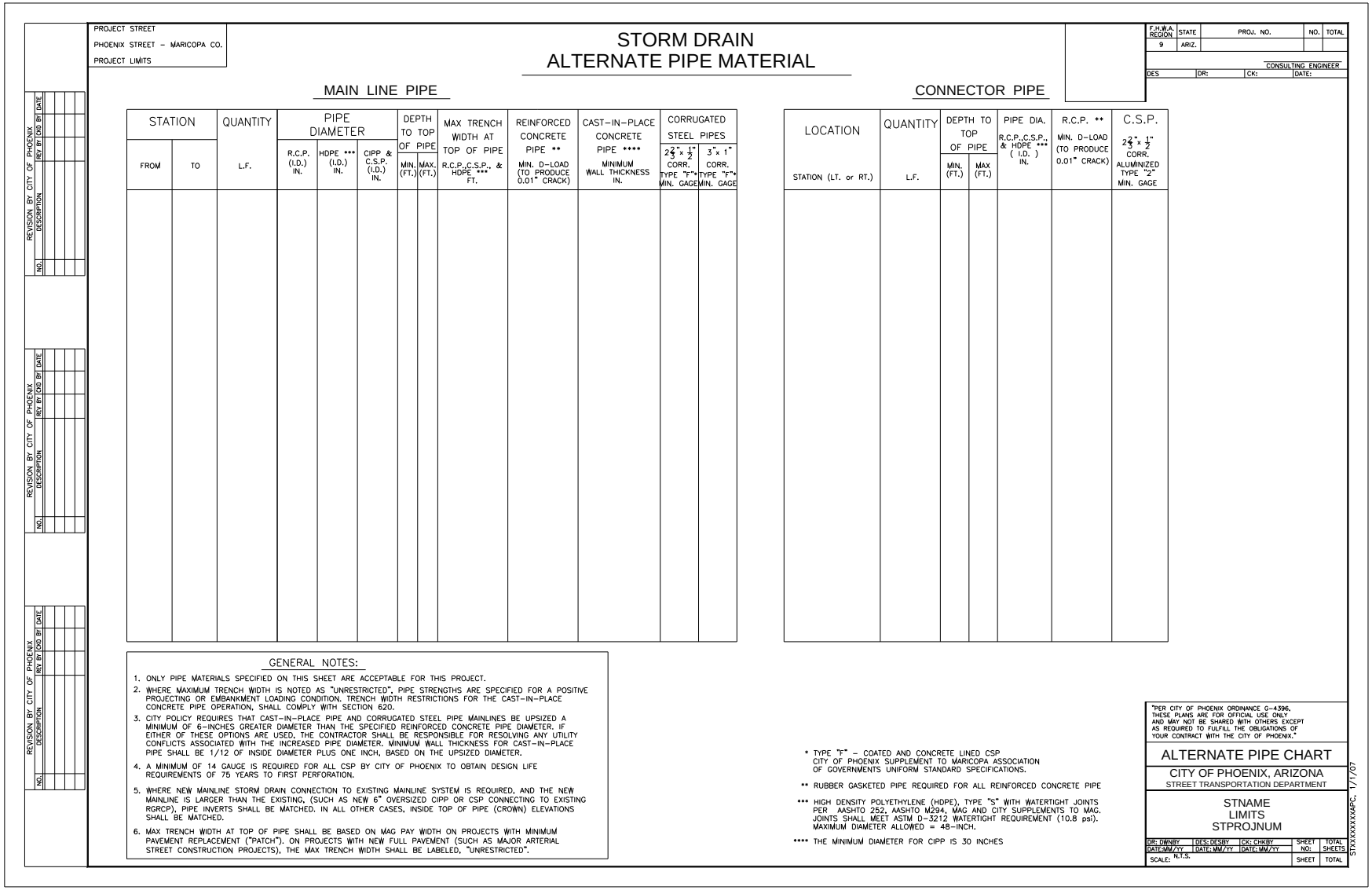
REVISED OCT. 5, 1992

CITY OF PHOENIX, ARIZONA
STREET TRANSPORTATION DEPARTMENT

DR DATE: | DES DATE: | CK DATE: | SHEET NO. | TOTAL SHEETS | AS BUILT

SCALE: HORIZONTAL VERTICAL

Figure 6.15.2 Storm Drain Alternate Pipe Table



PROJECT STREET
PHOENIX STREET – MARICOPA CO.
PROJECT LIMITS

STORM DRAIN
ALTERNATE PIPE MATERIAL

F.H.W.A. REGION	STATE	PROJ. NO.	NO.	TOTAL
9	ARIZ.			

CONSULTING ENGINEER
DES | DR: | CK: | DATE:

REVISION BY CITY OF PHOENIX
NO. | DESCRIPTION | REV BY | CKD BY | DATE

REVISION BY CITY OF PHOENIX
NO. | DESCRIPTION | REV BY | CKD BY | DATE

REVISION BY CITY OF PHOENIX
NO. | DESCRIPTION | REV BY | CKD BY | DATE

MAIN LINE PIPE

STATION FROM	STATION TO	QUANTITY L.F.	PIPE DIAMETER R.C.P. (I.D.) IN.	PIPE DIAMETER HDPE *** (I.D.) IN.	PIPE DIAMETER CIPP & C.S.P. (I.D.) IN.	DEPTH TO TOP OF PIPE MIN. (FT.)	DEPTH TO TOP OF PIPE MAX. (FT.)	MAX TRENCH WIDTH AT TOP OF PIPE R.C.P.,C.S.P., & HDPE *** FT.	REINFORCED CONCRETE PIPE ** MIN. D-LOAD (TO PRODUCE 0.01" CRACK)	CAST-IN-PLACE CONCRETE PIPE **** MINIMUM WALL THICKNESS IN.	CORRUGATED STEEL PIPES 2⅔" x 1½" CORR. TYPE "F"* MIN. GAGE	CORRUGATED STEEL PIPES 3" x 1" CORR. TYPE "F"* MIN. GAGE

CONNECTOR PIPE

LOCATION STATION (LT. or RT.)	QUANTITY L.F.	DEPTH TO TOP OF PIPE MIN. (FT.)	DEPTH TO TOP OF PIPE MAX. (FT.)	PIPE DIA. R.C.P.,C.S.P., & HDPE *** (I.D.) IN.	R.C.P. ** MIN. D-LOAD (TO PRODUCE 0.01" CRACK)	C.S.P. 2⅔" x 1½" CORR. ALUMINIZED TYPE "2" MIN. GAGE

GENERAL NOTES:

1. ONLY PIPE MATERIALS SPECIFIED ON THIS SHEET ARE ACCEPTABLE FOR THIS PROJECT.
2. WHERE MAXIMUM TRENCH WIDTH IS NOTED AS "UNRESTRICTED", PIPE STRENGTHS ARE SPECIFIED FOR A POSITIVE PROJECTING OR EMBANKMENT LOADING CONDITION. TRENCH WIDTH RESTRICTIONS FOR THE CAST-IN-PLACE CONCRETE PIPE OPERATION, SHALL COMPLY WITH SECTION 620.
3. CITY POLICY REQUIRES THAT CAST-IN-PLACE PIPE AND CORRUGATED STEEL PIPE MAINLINES BE UPSIZED A MINIMUM OF 6-INCHES GREATER DIAMETER THAN THE SPECIFIED REINFORCED CONCRETE PIPE DIAMETER. IF EITHER OF THESE OPTIONS ARE USED, THE CONTRACTOR SHALL BE RESPONSIBLE FOR RESOLVING ANY UTILITY CONFLICTS ASSOCIATED WITH THE INCREASED PIPE DIAMETER. MINIMUM WALL THICKNESS FOR CAST-IN-PLACE PIPE SHALL BE 1/12 OF INSIDE DIAMETER PLUS ONE INCH, BASED ON THE UPSIZED DIAMETER.
4. A MINIMUM OF 14 GAUGE IS REQUIRED FOR ALL CSP BY CITY OF PHOENIX TO OBTAIN DESIGN LIFE REQUIREMENTS OF 75 YEARS TO FIRST PERFORATION.
5. WHERE NEW MAINLINE STORM DRAIN CONNECTION TO EXISTING MAINLINE SYSTEM IS REQUIRED, AND THE NEW MAINLINE IS LARGER THAN THE EXISTING, (SUCH AS NEW 6" OVERSIZED CIPP OR CSP CONNECTING TO EXISTING RCRCP), PIPE INVERTS SHALL BE MATCHED. IN ALL OTHER CASES, INSIDE TOP OF PIPE (CROWN) ELEVATIONS SHALL BE MATCHED.
6. MAX TRENCH WIDTH AT TOP OF PIPE SHALL BE BASED ON MAG PAY WIDTH ON PROJECTS WITH MINIMUM PAVEMENT REPLACEMENT ("PATCH"). ON PROJECTS WITH NEW FULL PAVEMENT (SUCH AS MAJOR ARTERIAL STREET CONSTRUCTION PROJECTS), THE MAX TRENCH WIDTH SHALL BE LABELED, "UNRESTRICTED".

* TYPE "F" – COATED AND CONCRETE LINED CSP
CITY OF PHOENIX SUPPLEMENT TO MARICOPA ASSOCIATION OF GOVERNMENTS UNIFORM STANDARD SPECIFICATIONS.

** RUBBER GASKETED PIPE REQUIRED FOR ALL REINFORCED CONCRETE PIPE

*** HIGH DENSITY POLYETHYLENE (HDPE), TYPE "S" WITH WATERTIGHT JOINTS PER AASHTO 252, AASHTO M294, MAG AND CITY SUPPLEMENTS TO MAG. JOINTS SHALL MEET ASTM D-3212 WATERTIGHT REQUIREMENT (10.8 psi). MAXIMUM DIAMETER ALLOWED = 48-INCH.

**** THE MINIMUM DIAMETER FOR CIPP IS 30 INCHES

"PER CITY OF PHOENIX ORDINANCE G-4396, THESE PLANS ARE FOR OFFICIAL USE ONLY AND MAY NOT BE SHARED WITH OTHERS EXCEPT AS REQUIRED TO FULFILL THE OBLIGATIONS OF YOUR CONTRACT WITH THE CITY OF PHOENIX."

ALTERNATE PIPE CHART
CITY OF PHOENIX, ARIZONA
STREET TRANSPORTATION DEPARTMENT

STNAME
LIMITS
STPROJNUM

DR: DWNBY	DES: DESBY	CK: CHKBY	SHEET NO:	TOTAL SHEETS
DATE: MM/YY	DATE: MM/YY	DATE: MM/YY		
SCALE: N.T.S.			SHEET	TOTAL

STXXXXXXXAPC, 1/1/07

Figure 6.15.3 Flow Capacity of "M" Type Catch Basins in Sump Condition

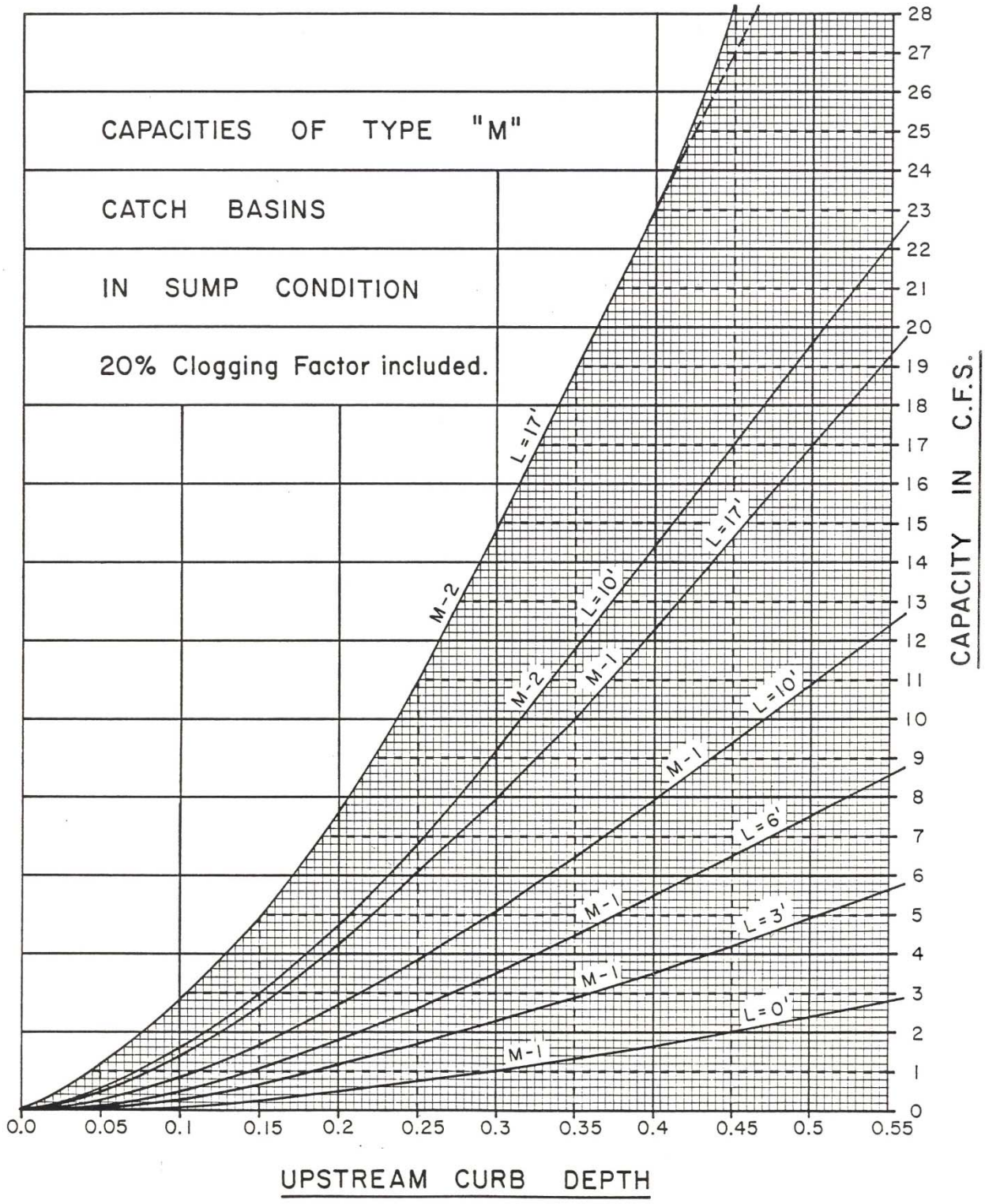
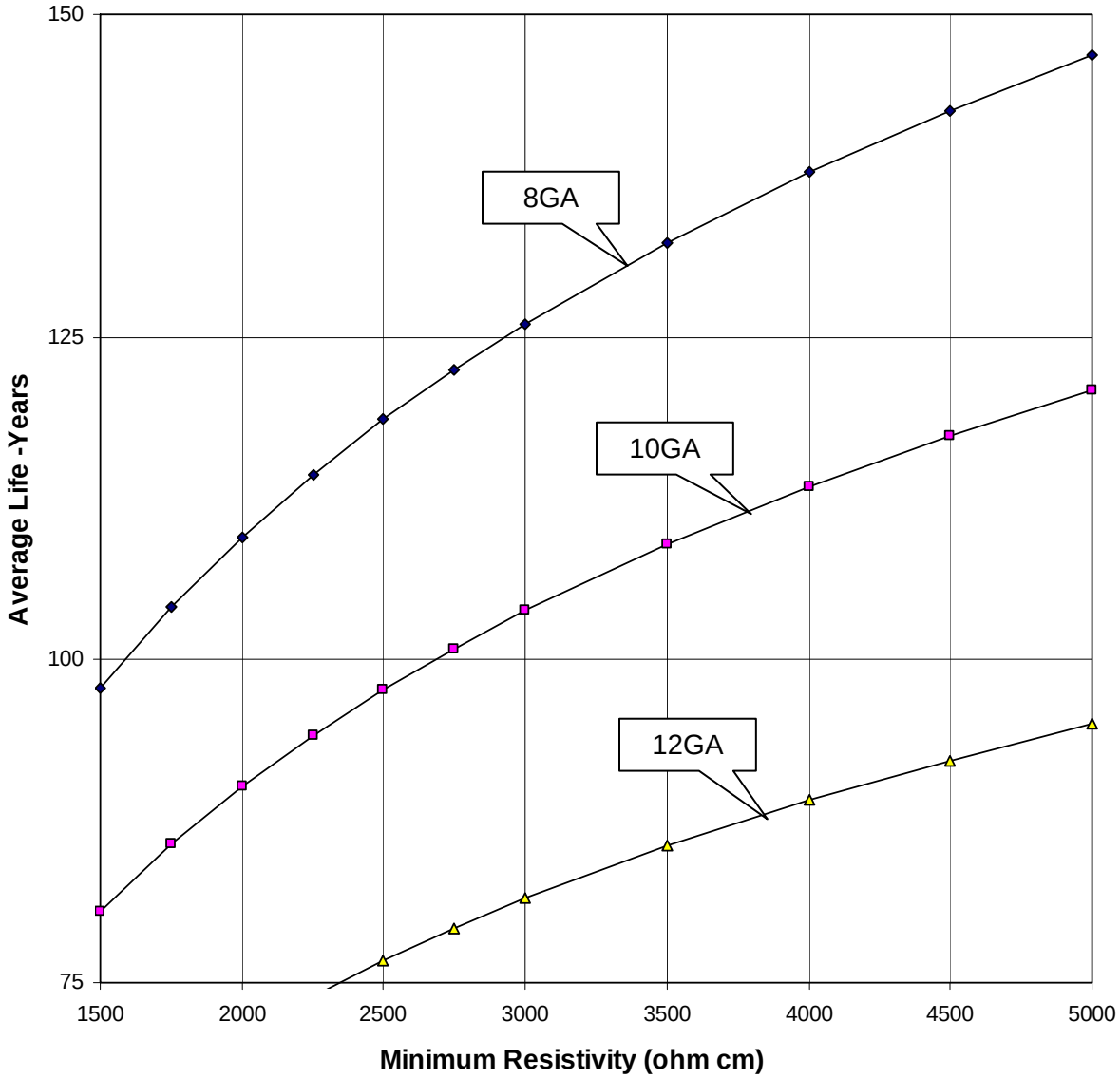


Figure 6.15.4 Gage Thickness for CMP Storm Drain Pipe Based on Resistivity Measurement Chart – pH=6.5



1) Min soil Resistivity allowed for CMP storm drain pipe = 1,500 ohm cm
2) Minimum Design Life required = 75 Years
3) Minimum CMP gage thickness allowed = 14 GA
4) Only Type "F" concrete lined CMP allowed for alternative mainline storm drain pipe
5) Only aluminized, Type 2 CMP allowed for alternative catch basin connector pipe and culvert pipe

Figure 6.15.5 Gage Thickness for CMP Storm Drain Pipe Based on Resistivity Measurement Chart – pH=7.3

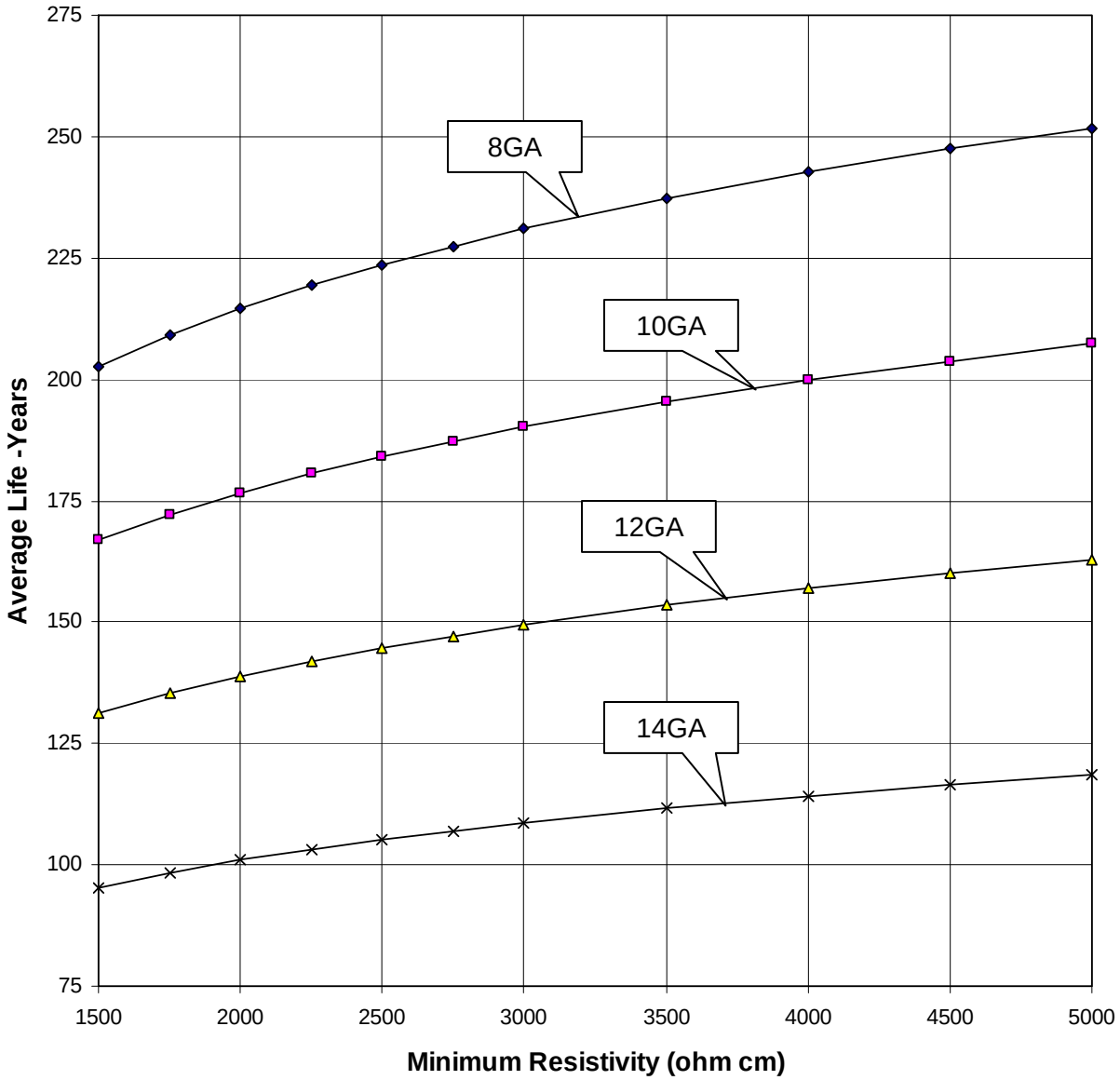


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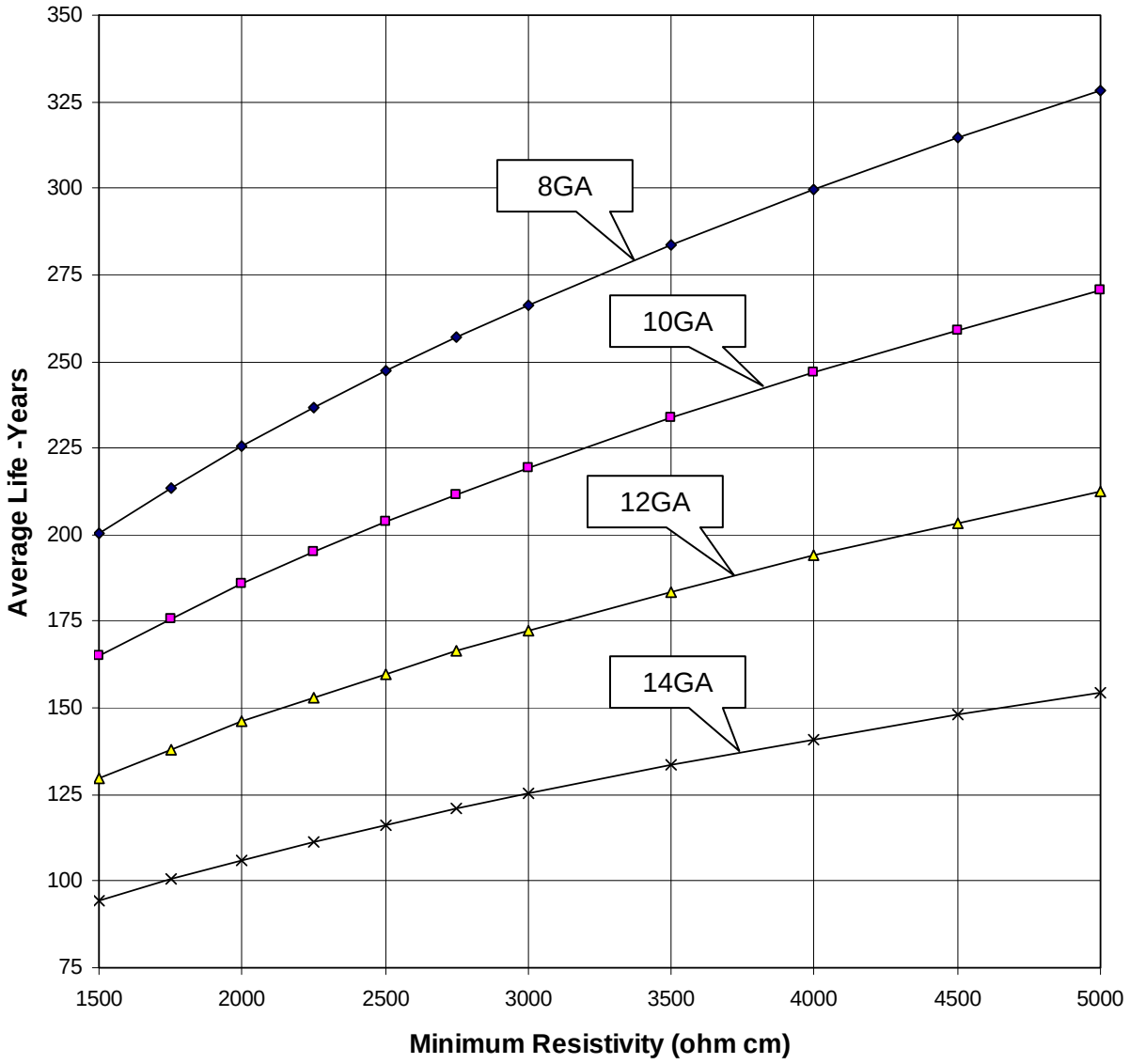
Figure 6.15.6 Gage Thickness for CMP Storm Drain Pipe Based on Resistivity Measurement Chart – pH > 7.3



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4) Only Type "F" concrete lined CMP allowed for alternative mainline storm drain pipe
5) Only aluminized, Type 2 CMP allowed for alternative catch basin connector pipe and culvert pipe

7 REVISION PROCESS

The City of Phoenix utilizes a multi-disciplinary, multi-departmental committee to review and adopt proposed changes to stormwater policies and standards. This committee is made up of multi-disciplined professionals in order to best reflect the multitude of societal resources influenced by storm water runoff. A representative from Development Services Department, Floodplain Management, Parks and Recreation Department, Street Transportation Department, Planning Department, and Environmental Programs will serve on this committee to represent the concerns of their respective departments/programs.

Those seeking changes to policies or standards shall make a formal request submittal to the committee chair (currently the Chief Design Engineer, Zone A, Street Transportation Department, Design and Construction Management Division, 1034 E. Madison Street, Phoenix, Arizona 85034). The request shall state the present policy/standard, identify the proposed change(s), and provide comprehensive justification for the change. The committee shall convene as needed, and at least once a year to review requested changes. An amendment application form is available in this manual. Six copies of the completed application and supporting documents shall be delivered to the committee chair in the Street Transportation Department (as described above). Upon review and certification of a complete submittal, a date will be assigned at which time the committee will review the requested amendment.

Once every year, the committee will convene to review the entire City of Phoenix Storm Water Policies and Standards Manual to discuss and update as needed.

The Street Transportation Department keeps a current list of the representatives from each of the departments/programs referenced above who are assigned to serve on this committee.

Significant changes to policies or standards are posted on the City's web site. The Revisions section at the beginning of this manual summarizes changes made to the manual with the latest edition.

The website contains the following documents relating to this manual:

- the current City of Phoenix Stormwater Policies and Standards Manual
- the most recent previous version of this manual
- the City of Phoenix stormwater design software – Drainage Design Management System for Windows (Phoenix – DDMSW)

Outdated versions of these manuals are archived, but available for use as needed. In addition, convenient links to the Flood Control District of Maricopa County Hydrology, Hydraulic and Erosion Control Manuals are provided on this website.

Requested Changes to City of Phoenix Storm Water Policies and Standards

Submit 6 copies of each request Submit a separate form for each request

Date	
Name	
Company	
Phone	Fax
Email	
Subject	
Chapter/Section/Item No.	
Problem or Concern	
Requested Modification	

Attach additional sheets if necessary

Sheet ____ of ____

8 SOFTWARE

8.1 INTRODUCTION

The City is finalizing development of a Drainage Design Management System software for Windows (Phoenix-DDMSW) to facilitate drainage analysis, submittals, review and archival. The software has been written in conformance with the procedures developed in the Flood Control District of Maricopa County Hydrology and Hydraulics manuals. Data may be hand entered or imported from data developed in a Geographic Information System (GIS) or other environment. When this software is available, notice will be provided on the City website.

Phoenix-DDMSW is a relational database that can manage multiple projects from one single location. Features include pull-down menus, user-friendly screens and editing tools to facilitate data entry. Phoenix-DDMSW includes tables for data entry and editing. The tables are related based on a key ID that is established when starting a new project. Model runs are automated from data extracted from the various tables in the database. Modules in Phoenix-DDMSW include file management, hydrology, hydraulics and submittals.

8.2 FILE MANAGEMENT

File management is used to establish new projects, default parameters and project paths and to import, export, backup and copy project data. Projects can be automatically “Backed Up” to a self-contained zip file that contains all the information for the project. It is intended that this file be included with submittals to facilitate review and archival.

8.3 HYDROLOGY

The hydrology module currently supports the HEC-1 and Rational Method. The module establishes rainfall, land use and sub basin data used for analysis and includes networks for HEC-1 and the Rational Method to facilitate model development. Land use defaults are imported from City of Phoenix default tables and are maintained with the project.

8.4 HYDRAULICS

The hydraulics module includes conveyance facilities, connector pipes, street drainage and the Los Angeles County backwater model (WSPG) called StormPro in this application. The module also includes data for natural cross sections, roadway cross-sections and drainage inlets. Roadway cross-sections and inlets defaults are imported from City of Phoenix default tables and are maintained with the project.

8.5 SUBMITTALS

The submittals module establishes the data for the City's Storm Drain Design Summary and provides an export tool to facilitate placing this data on a plan sheet. The data is extracted automatically from calculations developed for the project in accordance with a Design Summary Order established by the user.

All projects in the City of Phoenix which utilize the Rational Method to develop a storm drain system, whether public or private, shall be submitted using this standard submittal module.