DRAINAGE POLICIES and STANDARDS

Technical Design Manual #3

CHANDLER arizona

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1. INTRODUCTION

1.1 PURPOSE

The purpose of this manual is to provide guidance for the preparation of drainage studies and construction plans for storm water drainage systems within the City of Chandler.

In order to foster uniformity of analytical and technical guidance for drainage design throughout the Maricopa County region, the City relies on the most current version of the Maricopa County *Drainage Design Manual* (DDM) which consists of three volumes: *Volume I Hydrology, Volume II Hydraulics,* and *Volume III Erosion Control*. For construction contracts and drawings, the City periodically adopts the current version of the *Maricopa Association of Governments Uniform Standard Specifications and Details for Public Works Construction* (MAG Standards) as supplemented by the latest City *Standard Details and Specifications*.

This manual presents guidelines applicable to the City of Chandler to be used in concert with those regional documents. Where this manual does not provide complete guidance, or to meet the needs of the citizens of Chandler, the City Engineer may elect to require other criteria to ensure for their health, safety, and welfare.

1.2 DISCLAIMER

City's role in reviewing and permitting projects is limited to verifying general conformance to City requirements. The City does not assume liability for unsuitable design or improper construction. Review and acceptance does not absolve the owner, developer, engineer, or contractor of liability. Additionally, the engineer has the responsibility to design drainage facilities that meet the standards of practice for the profession and public interest. Compliance with the regulatory elements, policies, and design standards does not guaranty that property will be free from flooding or flood damage. The City assumes no liability for information, data, or conclusions prepared by private engineers and make no warranty whether expressed or implied in its review or approval of drainage projects.

1.3 DEFINITIONS

Detention – runoff temporarily detained in a storage facility with delayed and controlled flow.

Retention – contains and disposes of runoff after a storm event.

Low Outfall – Lowest lot, sub-area, and/or regional elevation outfall for ultimate design of the street/development. May be located within the roadway network.

Off-Site Flows – Runoff reaching development from outside. Includes sheet flow from vacant lands, flow along roadways, and overflows from canals and retention basins.

2. PLANNING

Refer to the Chandler *Stormwater Master Plan* for City-wide planned projects.

Refer to Maricopa County Flood Control District for Regional Plans that may affect your project on a local and regional level. Also refer to Section 2 – Drainage Planning of the *Drainage Policies and Standards for Maricopa County* as a model for good drainage planning.

Projects shall be designed and constructed to comply with all drainage requirements on a stand-alone basis. Projects encompassing more than 160 acres shall provide a comprehensive plan that includes consideration for any phasing of the project.

Refer to Section 6.13 for Chandler requirements for drainage studies based upon permit approvals.

3. POLICIES

3.1 PURPOSE

The policies contained in this chapter reflect the principles by which the City Engineer implements the requirements contained in City Code, as well as the requirements imposed by state law regarding flooding.

3.2 GENERAL

The relatively flat topography of Chandler and general lack of drainage channels necessitate special attention for controlling storm water collection and retention. Policies have been established to minimize storm water problems. Stormwater is in most cases collected and stored for disposal on each site.

Existing irrigation open channels adjacent to a development must be abandoned or piped.

3.3 PLANNING

Projects shall conform to goals identified in previous regional studies as well as the *Stormwater Master Plan*.

3.4 DRAINAGE PATTERNS & OUTFALL

Historic drainage patterns shall be perpetuated.

Ultimate outfall elevation and location shall be determined by considering the surface impediments for complete drainage of flooding. Within the drainage study area, the drainage engineer shall identify each drainage basin's point and elevation of outfall. Additionally, downstream of the project, the engineer shall identify locations and controlling elevations limiting free-flow towards the historic regional waterway – the Gila River. These controlling elevations may be grade breaks in the gutter downstream as well as roadway centerline crown elevations. The engineer shall demonstrate that there is at least 14 inches of elevation freeboard from the outfall to each finish floor elevation.

Positive drainage shall be provided for individual lots in the development site – land shall be graded for a minimum one-half percent slope.

3.5 HYDROLOGY

The following is the preferred order of hierarchy for obtaining peak discharges and runoff volumes for various floodplain and drainage purposes:

1. Flood Control District studies and flood insurance studies.
2. Drainage plans and design reports from adjacent properties. This information may be used if approved by the City.
3. DDM Volumes I – Hydrology and II - Hydraulics.

3.6 STORMWATER QUALITY

Projects shall conform to requirements of the City of Chandler and applicable Arizona Pollutant Discharge Elimination System (AZPDES) Permits. Refer to Arizona Department of Environmental Quality (ADEQ) for requirements.
Refer to the *City of Chandler Manual on Stormwater Quality Protection* for City requirements. That manual describes the required elements for submitting the Erosion and Sediment Control Plan.

3.7 FLOODPLAIN MANAGEMENT

Off-site flows entering the development as a result of the 100-year storm shall be accounted for in the conceptual storm water collection and retention plan, but are not required to be included in the retention volume requirements. The point of entry and exit for off-site flows from the 100-year storm shall not be altered by the site development from the existing condition. In the case where off-site flows are directed to a retention basin, or the basin watershed is located within the 100-year flood plain, the basin water depth shall not exceed four feet for the 100-year storm.

Stormwater plans for subdivisions which are located in whole or in part within a Federal Emergency Management Authority (FEMA) 100-year flood zone shall be submitted to the Flood Control District of Maricopa County (FCDMC) and approved by FCDMC prior to approval by the City. FCDMC requires building final floor elevations to be a minimum of 12-inches above the 100-year flood level. In no case shall any finished floor elevation be less than 14 inches above the flood plain low outfall elevation.

3.8 EROSION HAZARD MANAGEMENT

Erosion and scour at structures and pipe inlets and outlets shall be considered and mitigated.

Refer to the *City of Chandler Manual on Stormwater Quality Protection* for additional City requirements. The manual describes the required elements for submitting the Erosion and Sediment Control Plan.

3.9 STREET DRAINAGE

Depth of street flows shall be limited in accordance with Section 6.5 Street Drainage of this manual. Any runoff collected along median curb from the 10 year design storm shall be intercepted before spilling across roadway lanes.

3.10 CONVEYANCE FACILITIES

Open channels are discouraged and require City Engineer approval. They may be considered if the depth of flow is less than three feet and the flow velocity is less than 2.5 feet per second. They shall have significant landscaping with side slopes 4:1 or flatter.

3.11 STORAGE FACILITIES

The rainfall from a 100-year frequency, 2-hour duration storm that falls on a parcel, including adjacent half-streets shall be intercepted and stored within that parcel and outside of the City right-of-way. For the purpose of conforming to this requirement, 2.20 inches shall be the precipitation used.

Storage facilities shall be sized to retain 110% of the design volume due to potential for siltation and variations in construction.

Landscape plans in conformance to City criteria may be required for retention basins. Property frontage utilized for retention shall be limited to 50% of the area. Refer to zoning code and conceptual site review and civil checklists for requirements.

3.12 STORMWATER DISSIPATION

Drywells are permitted to drain surface retention areas only when no other means of disposal are available. Drywell permits shall be registered in the name of the property owner with ADEQ.

All drainage systems shall empty within 36 hours. The 100 year design runoff accumulated within permanent lake systems shall be dissipated within 36 hours.

3.13 OWNERSHIP AND MAINTENANCE OF FACILITIES

Drainage facilities shall be owned and maintained by the property owner.

Homeowner's Associations that own and/or operate drainage facilities shall include statements in their CC&Rs and on the recorded final plat clearly identifying that the Homeowner's Association is responsible for regular inspection, operation, maintenance and repair of the drainage facilities, including storm water quality.

Changes to sites require City approval.

A drainage easement shall be prepared and recorded with the County Recorder's Office for permanent storm water retention basins.

3.14 EROSION AND SEDIMENT CONTROL DURING CONSTRUCTION

All drainage components shall be protected from erosion and sediment contamination during construction. Refer to the Erosion and Sediment Control Plan requirements contained in the *City of Chandler Manual on Stormwater Quality Protection*.

3.15 CORRECTED 'AS-BUILT' DRAWINGS

It is of extreme importance that the public have a record of the constructed project. Projects will not be accepted for completion without certified notations on the approved plans corrected as-built.

3.16 CAPITAL IMPROVEMENT AND REDEVELOPMENT/INFILL PROJECTS

As a matter of public interest, the City Engineer may elect to waive certain requirements contained within this Manual. Such waivers must be obtained in writing by the design engineer prior to project approval. It may not be possible for the City project to mitigate all existing drainage problems upstream or within the project due to project scoping and funding.

When a City project affects existing retention facilities, the design shall account for such changes as increased runoff, decreased retention volume available, and differing layout for each development as originally permitted, and provide mitigating accommodations for such changes in the site drainage. The City shall not have a duty to quantify the site drainage conditions such as total site required and provided volumes. Existing retention volume shall be quantified and reserved for the use by the site. Any deficit to existing retention volume and additional volume caused by changes to the site shall be accommodated by the design. The site shall continue to be burdened with its existing duty of retaining the runoff from its frontage rights-of-way. The record of requirements shall comprise copies of the approved plans, drainage report, and constructed as-builts.

There are existing storm drain systems serving City streets whose capacities are not quantified. Connection to these systems may be permitted on a case-by-case basis to the extent that the City historically has not observed detrimental flooding at the outfall retention basins or excessive ponding at inlets and displaced manhole covers. Contact the Streets Division for citizen complaint and maintenance work records. Also refer to the latest Stormwater Master Plan.

For capital improvement projects, the selected consultant shall perform a preliminary study of the drainage area that affects the project and identify the scope of work necessary to design facilities to attenuate the adverse drainage impacts. The Consultant shall additionally provide in his scope of services an allowance for sufficient infiltration testing to assure that constructed retention basins will drain within 36 hours.

4. REGULATIONS (FEDERAL, STATE & COUNTY)

Refer to the Maricopa County *Drainage Policies and Procedures* Manual for a reference to applicable regulations.

5. REGULATIONS / ORDINANCES

5.1 INTRODUCTION

Site plans shall conform to International Building Code and International Plumbing Code, latest City-adopted edition.

An outline of relevant requirements incorporated in the City Code is presented below. The engineer shall review the latest adopted code for changes.

5.2 CITY CODE SECTION 45 - STORM DRAINAGE REQUIREMENTS

City Code Section 45 includes requirements on conceptual drainage plans, basin configurations, retention, disposal, maintenance of basins, and non-storm water discharges.

5.3 CITY CODE SECTION 43-6 FLOODPLAIN REGULATION

City Code Section 43-5 Delegation of Responsibility for Floodplain Management vests the authority for floodplain management with the Maricopa County Flood Control District (MCFCD). Development within areas designated as flood hazard zones shall be subject to the rules and regulations established by the MCFCD in conformance with the National Flood Insurance Program and State requirements as well as all City requirements.

The City Engineer shall receive requests for permits for floodplain development and shall review them prior to forwarding them to the Flood Control District. No permits will be issued until a valid floodplain use permit has been obtained by the applicant. Final City acceptance of the building construction will not be issued until the Elevation Certificate has been accepted by the MCFCD and provided to the City.

5.4 CITY CODE SECTION 35 ZONING ORDINANCE

City Engineer requires that Preplats and Site Development Plans shall have a conceptual report and plan for approval. City Code Section 35 Article 1902(4)b Retention Basins limit the footprint of certain retention basins and their shapes.

5.5 CITY CODE SECTION 48 SUBDIVISION REGULATION

City Code Section 48 Subdivisions contains requirements for land-division documents.
City Engineer requires that Preplats and Site Development Plans shall have a conceptual report and plan for approval.

5.6 CITY CODE SECTION 43 STORMWATER MANAGEMENT

City Code Section 43-4.5 Adoption of Public Works Standards provides for the City *Manual on Stormwater Quality Protection* which identifies requirements for conformance to the

AZPDES small municipal separate storm sewer systems (MS4) permit rules. The requirements for the submission of the Notice of Intent (NOI) and the Erosion and Sediment Control Plan are presented.

Permits will not be issued until the NOI has been approved by the ADEQ.

5.7 STORMWATER RELEASE

Permits will not be approved until a copy of the ADEQ drywell registration application has been submitted.

5.8 PERMITS

City Code Section 46-2.D Encroachment Permit Required, requires permits for construction within the right-of-way. City Code Section 47 Offsite Construction Improvement Requirements for Property Development requires permits for development projects.

The City Engineer shall require for review and approval the submittal of a Drainage Report wherever development and or grading is proposed within the City limits. Development shall mean any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation, or drilling.

6. STANDARDS

6.1 INTRODUCTION

For uniformity of construction contracts and drawings, the City periodically adopts the prior year's version of *Maricopa Association of Governments Uniform Standard Specifications and Details for Public Works Construction* (MAG Standards) as supplemented by the latest City *Standard Details and Specifications*.

6.2 PUBLIC SAFETY

Depth of ponding in retention basins shall be 3 feet. Side slopes shall be 4:1 or flatter unless otherwise approved by the City Engineer. Refer to DDM Vol II – Hydraulics Section 1.4 for design considerations to reduce drainage hazards.

Headwall and trash racks / access barriers are required for open ends of pipe 12'' in diameter or greater. Basin equalizer pipe with flared end sections may be exempted from this requirement.

A safety rail in accordance with MAG Std Dtl 145 is required along the top edge of structures adjacent to public pedestrian access when the grade difference is 30" or greater. Stormwater structures (headwalls, retaining walls, etc) which present a fall hazard of 48 inches or greater shall have guardrails per MAG Std Dtl 145. Vehicular barriers may also be required. In areas not expected to receive pedestrian travel (fenced off retention basins, etc.), a safety rail is required when fall hazard exceeds 72 inches.

Underground facilities and pipe shall be designed for HS-20 vehicular loads.

Grated catch basin inlets shall have bicycle-safe grates, those located in the roadway shall not intrude into an adjacent bicycle lane.

6.3 HYDROLOGY

Rainfall shall be based upon the NOAA Atlas 14, Volume 1, Version 5, dated 2011, 90% confidence interval, mean partial duration time series data.

The Rational Method shall be used for projects up to 160 acres. Triangular hydrograph methods will not be accepted for urban projects.

Calculations involving retention basin hydraulics, such as equalizer pipe sizing, shall consider the 100-year, 2-hour storm distribution as presented in DDM Volume I – Hydrology Section 2.4. Peak intensity occurs between the 60th and 65th minute, with 27.0% of the precipitation occurring in that interval. Therefore, if an upstream basin has not been sized to store 68.8% of the runoff (the 65th minute %-rainfall depth), the hydraulics of the outlet shall be based upon peak runoff.

Table 6.1 ref: DDM I Sec 2.4.1
2-Hour Storm Distribution for Stormwater Storage Design (2.2 inches of precip)

Time (min)	Rainfall Depth (%)	Intensity (in/hr)	Time (min)	Rainfall Depth (%)	Intensity (in/hr)
0	0.0	0.00			
5	0.7	0.18	65	68.8	7.13
10	1.4	0.18	70	79.3	2.77
15	2.1	0.18	75	85.3	1.58
20	2.8	0.18	80	89.1	1.00
25	3.9	0.29	85	92.3	0.84
30	4.9	0.26	90	95.1	0.74
35	7.7	0.74	95	96.1	0.26
40	10.9	0.84	100	97.2	0.29
45	14.4	0.92	105	97.9	0.18
50	19.6	1.37	110	98.6	0.18
55	26.7	1.87	115	99.3	0.18
60	41.8	3.99	120	100.0	0.18

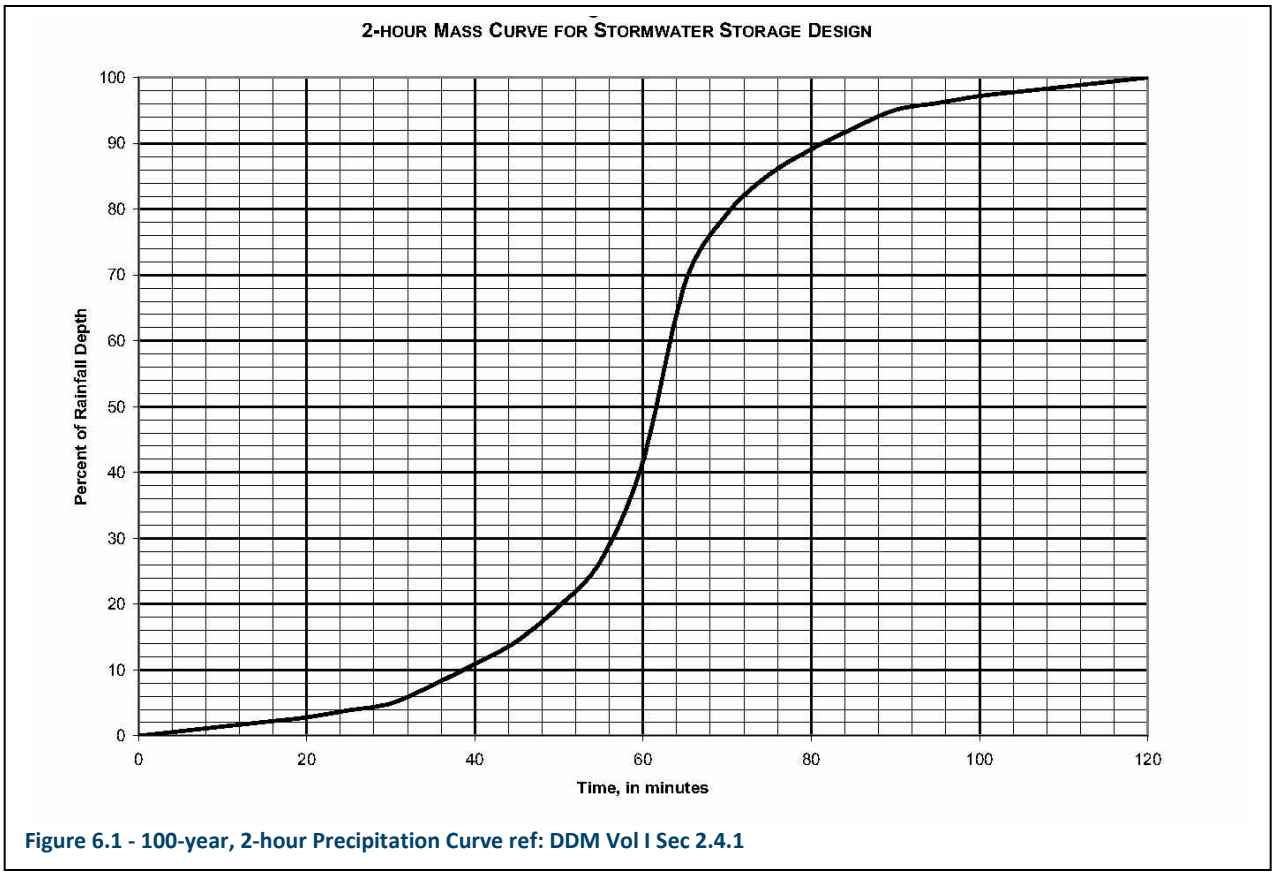


Figure 6.1 - 100-year, 2-hour Precipitation Curve ref: DDM Vol I Sec 2.4.1

6.3.1 INTENSITY

Intensity-duration-frequency curves shall be based upon a singular location in Chandler: at the intersection of Price and Chandler Heights Roads. (lat. 33.2314 degrees N, lon. 111.8929 W)

Table 6.2
Intensity Duration Frequency Values

	intensity (inches/hour)	
duration	10 year	100 year
5 min:	4.78	7.57
10 min:	3.64	5.76
15 min:	3.00	4.76
30 min:	2.02	3.20
60 min:	1.25	1.98
2 hour:	0.70	1.10

A best-fit equation in the form of i = a / (Tc + b) ^ c may be utilized, provided that the resultant intensity values are not less than the NOAA values by 0.05 inch/hour. Refer to

HEC12 Appendix 'A' for determining appropriate coefficients. The following coefficients may be used:

Table 6.3		
	10 year	100 year
a:	45.95	51.2
b:	9.3	7.0
c:	0.851	0.769

6.3.2 RUNOFF

Runoff shall be calculated based upon the Rational Method.

Time of Concentration (Tc) shall be utilized for obtaining peak intensity. It shall be computed by adding the Initial Runoff Time to the street flow time. The following lag times may be allowed:

Table 6.4	
Drainage Area Characteristic	**Initial Runoff Time (minutes)**
Single-Family Residential	10
Industrial, Commercial, Cluster Development, Multi-Family	5
Street	0

Time of concentration shall be based upon an evaluation of the time of flow in accordance with Manning's velocity. Calculations based upon the Papadakis and Kazan Equation are not acceptable.

Street Flow Time shall be calculated by dividing the distance of the longest flow path by the average velocity of the street flow as calculated by the Manning's Equation. In accordance with HEC12, where initial spread is zero, the average velocity occurs where the spread is 65% of the spread at the downstream end of the reach.

Maximum intensity from the i-d-f curve may be obtained from a limiting value of time of concentration of 5 minutes.

The following runoff coefficients shall be used for all design frequencies:

Table 6.5 **Runoff Coefficients for the Rational Method**	
Surface	**C**
Farm Land	0.10
Grass Lawn (average slope 0-7%)	0.20
Bare Ground (undeveloped vacant lots)	0.25
Grass Lawn (average slope > 7%)	0.35
Undeveloped Desert	0.50
Desert or Rock Landscaping	0.50
Playgrounds	0.60
Impermeable Surfaces (pavement, roofs, etc.)	0.95
Table 6.6 **Weighted Runoff Coefficient (includes R/W and pavement)**	
Area	**C**
Street Right-of-Way	0.95
Commercial or Industrial	0.90
Multi-Family	0.80
Cluster Developments	0.75
Detached Single Family	0.65

6.3.3 FLOW

The Manning's Equation and Modified Manning's Equation shall be utilized to calculate flow characteristics. Roughness shall be in accordance with DDM Volume II - Hydraulics.

6.4 STORMWATER QUALITY

Refer to the *Manual on Stormwater Quality Protection*.

6.5 STREET DRAINAGE

Roll curb shall conform to MAG Std Dtl 220, Type 'C'.

Valley gutter transverse to through traffic (non-stop controlled) shall be 8 feet wide in conformance to C-233.

6.5.1 STREET FLOW

Runoff in streets shall be limited to the following characteristics by the installation of inlets and underground storm drain conduits.

6.5.1.1 10 Year Design Storm

Depth of flow and spread on the pavement shall be calculated at the gutter flowline upstream of the local inlet depression. Depth of flow and sump depth at inlets shall not exceed the curb height (7" maximum allowable curb height only with approval).

Spread shall be limited in the street section by classification:

Arterial and Collectors with Medians:	median and adjacent lane each direction shall not be submerged
Other Collectors:	single lane in center shall not be submerged

6.5.1.2 100 Year Design Storm

Depth of flow shall not exceed curb height plus 6 inches. Flow area shall be computationally limited to right-of-way. Flows shall be limited to 100 cfs and 10 feet per second.

6.5.2 STREET INLETS

Scuppers are the preferred inlet type and shall conform to C-500. Where design calls for a longer inlet, the inlet shall be constructed in whole multiples of the four-foot cell length. Scuppers shall be detailed in profile on the plans, and shall be designed and noted such that the retention 100-year design high water surface is outside of the street right-of-way.

When scuppers cannot be utilized, a combination curb opening grated catch basin may be allowed per MAG Std Dtl 533-1. Grated catch basins shall be equipped with a bicycle-safe grate.

Grates shall be considered to be 50% efficient due to clogging, curb openings: 80%; therefore, required grates shall be sized twice as large as design capacity, and required curb openings shall be 1.25 times longer than design capacity. Refer also to Drainage Design Manual For Maricopa County Volume II – Hydraulics.

The hydraulic grade line for the 10-year design flow from a catch basin shall be 6 inches below gutter flow line and shall reflect pipe inlet losses. The energy grade line for the 100-year design shall not be higher than the calculated depth of ponding of each inlet and shall reflect inlet and pipe inlet losses.

All storm drain inlets shall be marked with a storm drain inlet pollution awareness marker in accordance with C-508.

Slotted drains are not permitted within the public rights-of-way.

6.6 STORM DRAINS

6.6.1 GENERAL

Pipe subject to wheel loading shall have HS-20 capacity. Refer to the City *List of Approved Products* for acceptable storm drain pipe materials. RGRCP class of pipe shall be identified in the construction drawings profile; see Figure 6.1, below. Manning's Roughness values shall be in accordance with DDM Volume II - Hydraulics.

Within public streets, storm drain mains shall have a minimum 18" diameter and a minimum 15" for laterals. Outside public streets or on-site, mains and laterals shall have a minimum 12" diameter. Connections between mains shall be constructed with manholes. Prefabricated pipe fittings will only be allowed for drywell connections within 5 feet of an underground retention tank and lateral connections.

Mains shall be located a minimum 6' clear of parallel utilities. The main alignment will be located to avoid manholes within the wheel path of traffic. Mains 24" in diameter and larger may have a curved alignment with a radius no greater than 75% of the allowable deflected-pipe radius. Maximum manhole spacing shall be 400 feet. Mains shall have an invert slope such that the pipe-full velocity is greater than 3 feet per second, and less than 10 feet per second.

Table 6.7

Minimum RGRCP Pipe Class

Pipe Diameter (inches)	Depth of Cover in Feet (from subgrade)							
	< 1'	1'-3'	3'-5'	5'-8'	8'-11'	11'-15'	15'-20'	20'-25'
15	V	IV	II	II	IV	IV	V	V
18	IV	IV	II	II	III	IV	V	V
21	IV	IV	II	II	III	IV	IV	V
24	IV	III	II	II	III	IV	IV	V
30	III	III	II	II	III	IV	IV	V
36	III	IV	II	II	III	IV	IV	V
42	II	II	II	II	III	IV	IV	V
48	II	II	II	II	III	IV	IV	V
54	II	II	II	II	III	IV	IV	V
60	II	II	II	II	III	IV	IV	V

Table 6.7

Minimum RGRCP Pipe Class

Pipe Diameter (inches)	Depth of Cover in Feet (from subgrade)							
	< 1'	1'-3'	3'-5'	5'-8'	8'-11'	11'-15'	15'-20'	20'-25'
66	II	II	II	II	III	IV	IV	V
72	II	II	II	II	III	IV	IV	V
78	II	II	II	II	III	IV	IV	--
84	II	II	II	II	III	IV	IV	--
90	II	II	II	II	III	II	--	--
96	II	II	II	II	III	II	--	--

Note: Based upon worst case trench and non trench conditions.
Loads - AASHTO HS-20.
ASTM C-76, B-wall circular pipe.

6.6.2 WATER SURFACE PROFILE CALCULATIONS

Where there is no other outfall for flows exceeding the 10 year design, the inlet and storm drain shall be designed for the 100-year flow.

All storm drain submittals shall be accompanied with hydraulic grade line computations prepared in accordance with DDM Volume II – Hydraulics Section 4 Storm Drains and these guidelines.

Computations shall account for both the hydraulic grade line (representative of the water surface) and the energy grade line (representative of both the water surface and the energy due to velocity). Generally, computations will proceed upstream from a standing pool representing the outfall retention basin. The depth of the pool shall be considered to be 68.8% of design depth in accordance with Section 6.3. If the outlet is submerged, the energy headloss of quiescent ponding as well any head losses due to outlet structure flow re-direction and/or flow impediment shall be considered. If a pipe outlet is unsubmerged, the hydraulic grade line shall be considered to intersect the crown of the outlet as the initial elevation for computations.

Computations shall consider whether the pipe flows full in determining the appropriate slope of the energy grade line and the types of minor losses.

If the outlet is submerged, match pipe inverts at transitions. Combine transition loss with manhole loss and utilize the main's velocity. Use highest flow velocity for computations at junctions. Account for the headloss of flow re-direction at lateral connections. Computations shall include the catch basins and shall demonstrate that the 10 year design flow shall pond not greater than 6" below the inlet. The 100 year design flow shall be analyzed and demonstrated to comply with City requirements.

Utilize minor loss coefficients from DDM Vol II – Hydraulics Table 5.1 for pipe inlets and outlets at catch basins, structures, and headwalls. Include an additional unit k=1 per DDM Vol II equation 4.17 where drainage ponds to enter the pipe network.

6.7 EQUALIZERS, CULVERTS, AND BRIDGES

Refer to DDM Vol II – Hydraulics, Section 5. Equalization pipe between retention basins on private property shall be minimum of 10 inches in diameter (and dual 10” pipe is required) and shall have flared end sections with scour aprons. For pipes 12 inches in diameter and larger, headwalls and trash racks / access barriers may be required. Hydrologic routing and hydraulic calculations shall be provided to demonstrate that the equalization pipe has adequate capacity.

Culvert inlet highwater may not exceed three feet unless floodplain flows are a factor, in which case the highwater may reach four feet. Any increase in floodplain spread shall be confined within a public drainage easement and shall not rise to within 12 inches of finish floor elevation.

Bridge design shall be performed in accordance with ADOT design/drawing standards. At the City's request, the developer shall provide third-party consultant engineer review prior to approval.

6.8 ON-SITE

All on-site storm drain and catch basins must meet requirements per City *List of Approved Products*.

6.9 OPEN CHANNELS

Open channels shall be designed in accordance with DDM Volume II – Hydraulics procedures. Maximum permitted channel depth is three feet, maximum velocity 2.5 feet per second. They shall be designed for the 100-year design storm.

6.10 HYDRAULIC STRUCTURES

Retention basin inlets shall be outlet headwall with a trash rack for all pipe ends and openings 12" diameter or greater, conforming to C-503, or a bubbler inlet conforming to C-504 or C-507. Inlets located below basin bottoms shall be connected to a drywell or multiple drywells, via a 12" drain pipe at 2% slope in order to drain the storm drain system within 36 hours. Storm drain pipe may outlet to the retention basin directly through the drywell interceptor if the hydraulic grade line calculations demonstrate compliance with criteria. The connector pipe between the drywell interceptor and injector chambers shall be located deep enough to drain any connected storm drain system.

The invert of storm drain pipe at outlet headwalls shall be 6" above the basin bottom. Erosion protection shall be provided.

6.11 STORMWATER STORAGE

The volume of retention provided shall exceed the calculated required volume by 10% due to potential for siltation and construction tolerances.

V (cubic ft) = 1.1 x 100yr 2hr precipitation depth (ft) x tributary basin area (square ft) x runoff coefficient

100yr-2hr precipitation depth = 2.20 inches = 0.183 ft

Stormwater infiltration or disposal which occurs during the storm may not be used to decrease the volume of storage.

Ponded levels may spread on to parking areas on commercial and industrial sites. The required number of parking spaces may not be adversely affected, therefore, the maximum ponding level may not exceed six inches and the front 1/3 of the automobile must park on dry pavement.

Certain areas of the downtown, bordered by Ray Road and Pecos Road, between Arrowhead Drive and McQueen Road have reduced onsite retention requirements due to existing storm drain mains and regional retention basins. Construction of lateral connections to the existing storm drain system may be required. See Figure 6.2 Downtown Drainage Areas.

Table 6.8

Drainage Area	**Design Precipitation Depth**
Arrowhead Basin	0.0"
Denver Basin	0.0"
Detroit Basin	0.0"
Galveston Basin	1.2"

Of the four areas, only those sites within the Galveston Basin overlay shall be required to store 1.2" of precipitation from its tributary area on site. Developments within the Denver Basin shall participate in the Downtown storm drain system.

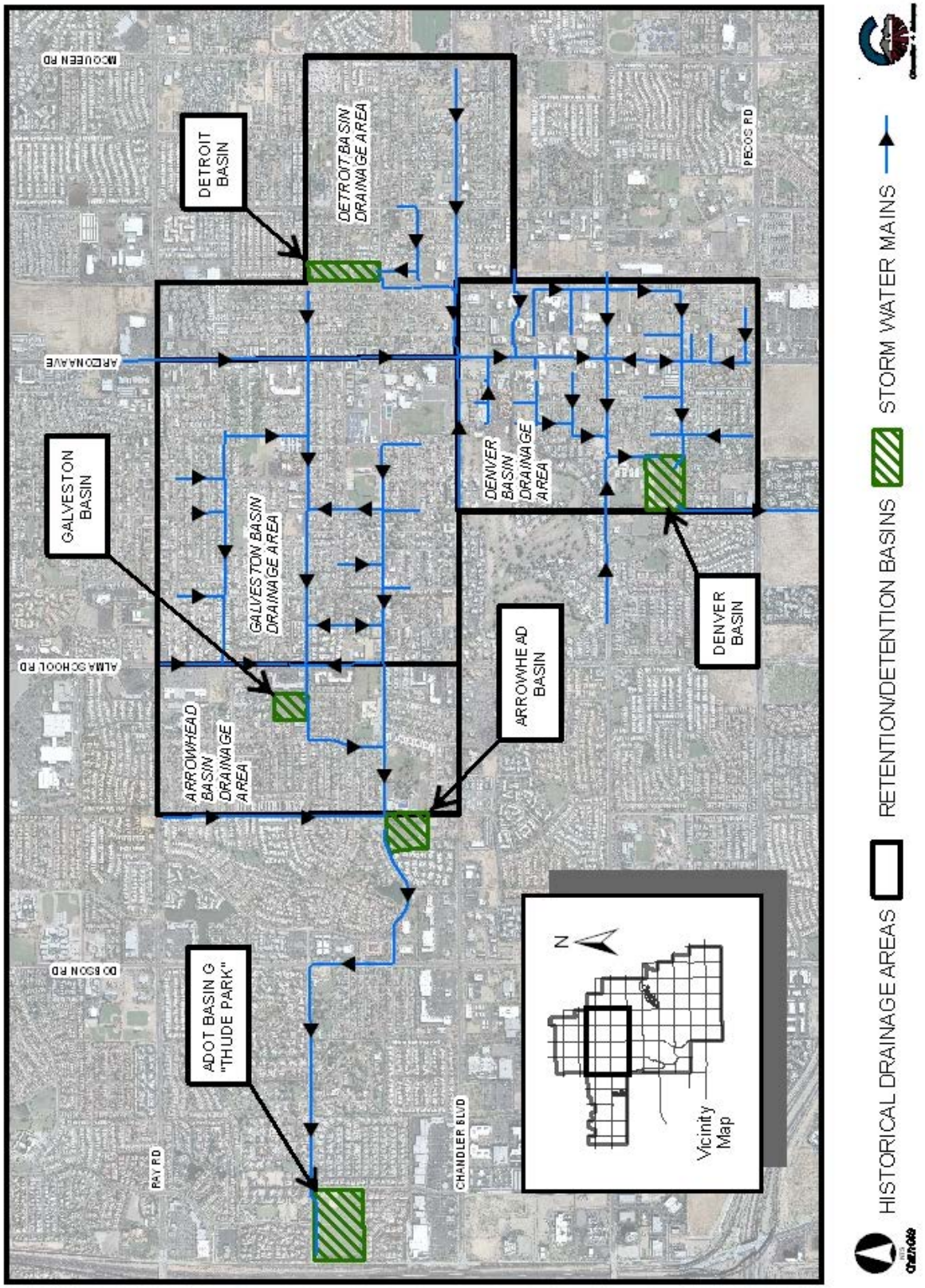


Figure 6.2 Downtown Drainage Areas

6.11.1 SURFACE BASINS

Surface basins shall have side slopes of 4:1 or flatter. Exceptions to this requirement may be granted by the City Engineer for designs with innovation, if aesthetics are presented and public safety not compromised. Vertical walls may not be located adjacent to any public street right-of-way. Access to the bottom must be provided for maintenance vehicles. The shape and layout of basins shall be reviewed and approved by Planning Division staff for conformance to Zoning Code. Capacity computations shall consider berming and amenities. Any required outdoor amenities shall be elevated above the 10-year ponding level. No swimming pools may be located within the boundaries of retention basins.

Depth of ponding for the 100-year, 2-hour precipitation shall not exceed 3 feet unless a positive method of disposal is provided, under government control.

Permanent retention shall not be allowed within the right-of-way. In redevelopment areas where onsite retention is not possible and cases involving extreme hardship, the City Engineer may waive or modify this requirement.

Permanent lakes may be used for retention if the required volume of storm water retention will be disposed of within the required 36 hours.

When roadways are constructed, temporary retention basins may be required until permanent basins are constructed. Temporary basins shall accommodate the roadway runoff from the 100yr-2hr storm (2.20 inches) plus 10%, at a level allowing for a minimum of 1' of freeboard to the top of the basin. Any scuppers or piping shall be constructed to the permanent size. The temporary basin shall be protected from extraneous sheet flow.

For Capital Improvement Projects a minimum 1' berm shall be constructed around temporary retention basins located in undeveloped parcels. The basin shall include capacity for the runoff incident to its limits and a mulch pit per City Detail C-510.

6.11.2 UNDERGROUND RETENTION STORAGE CHAMBERS

Underground storage chambers may be permitted for sites governed by a property owner's association or property management company. Residential use properties may only use underground retention if they consist of three or more attached dwelling units per structure.

Underground storage chambers are not permitted within public right-of-way.

If underground retention facilities are located under landscaped or other pervious areas, such areas shall be considered impervious (95%) for purposes of calculating required storage volumes.

Non-commercial developments must record CC&R's that include Operations and Maintenance (O&M) requirements. Such O&M requirements shall meet or exceed ADEQ and other relevant agencies requirements for drywells. Commercial developments shall prepare documents

specifying O&M requirements. All developments shall maintain records that document all maintenance performed.

Underground facilities must be located a sufficient distance from property lines so as not to negatively impact future or existing development on the adjacent parcel or parcels.

Roof drains may drain directly to underground retention facilities.

Elevator sumps shall not connect to the underground retention facilities.

Overland flow (ultimate outfall) for storms greater than the 100 year 2 hour event must be provided.

Chambers shall be polypropylene, conforming to ASTM F 2418 and F 2787. The installation shall provide a structural design in conformance to AASHTO LRFD Bridge Design Specifications. Construction shall be in accordance with manufacturer's recommendations and these requirements.

Pre-treatment of runoff before entering the storage chambers is necessary to prevent degradation of the system. Provide a sedimentation chamber, lined with a double-layer filtration geosynthetic Class 1 woven fabric conforming to AASHTO M288, sized to hold ½ inch of drainage area precipitation. The sedimentation chamber shall have a manhole suitable for maintenance and clean out.

The foundation for chamber rows connected to a manifold shall be protected from scour by a filtration geosynthetic Class 1 woven fabric conforming to AASHTO M288.

The foundation for underground storage chambers located underneath drive areas shall be characterized by a geotechnical investigation. The report, to be submitted for approval, shall recommend allowable bearing capacity for the dry and saturated state subgrade soils, depth of aggregate foundation, as well as double-ring infiltrometer testing to determine the infiltration rate of that subgrade. The geotechnical engineer shall document the rationale for determining the number of tests and the methodology for characterizing bearing capacities. Infiltration testing shall be conducted in accordance with County methods described in DDM Vol II – Hydraulics Section 9.3.1. Depth of aggregate foundation shall be determined from the saturated bearing capacity recommendation in concert with manufacturer's published charts or technical guidance.

The foundation and embedment aggregate shall be open-graded, clean, crushed, angular rock, meeting the gradation requirements of AASHTO Specification M43, sizes 3 through 57. The presumptive porosity (volume voids / total volume) for retention computations shall be 40%. The open-graded aggregate shall be separated from fine grained soils with a moderate survivability separation geosynthetic Class 2 nonwoven fabric conforming to AASHTO M288.

An underdrain system shall be connected to a minimum of one drywell. The retained volume shall infiltrate through the subgrade and a sufficient number of drywells within 36 hours.

6.11.3 UNDERGROUND RETENTION STORAGE TANK

Underground storage tanks may be permitted for sites governed by a property owner's association or property management company. Residential use properties may only use underground retention if they consist of three or more attached dwelling units per structure.

Underground storage tanks are not permitted within public right-of-way.

If underground retention facilities are located under landscaped or other pervious areas, such areas shall be considered impervious (95%) for purposes of calculating required storage volumes.

Non-commercial developments must record CC&R's that include Operations and Maintenance (O&M) requirements. Such O&M requirements shall meet or exceed ADEQ and other relevant agencies requirements for drywells. Commercial developments shall prepare documents specifying O&M requirements. All developments shall maintain records that document all maintenance performed.

Pre-treatment of runoff before entering the storage tank is preferable to prevent degradation of the system. Runoff may be directed to a surface basin with an elevated inlet designed to de-silt runoff prior to entering the underground tanks, or to an interceptor chamber with a manhole suitable for maintenance and clean out or other pre-treatment methods may be considered.

Underground facilities must be located a sufficient distance from property lines so as not to negatively impact future or existing development on the adjacent parcel or parcels.

Roof drains may drain directly to underground retention facilities.

Elevator sumps shall not connect to the underground retention facilities.

Overland flow (ultimate outfall) for storms greater than the 100 year 2 hour event must be provided.

A geotechnical investigation shall be provided with soils profile a minimum of 10 feet below the proposed installation. The report shall document the anticipated depth to natural groundwater and the soils pH and resistivity at the depth of installation. A water-tight storage facility may be required if the subgrade soil's bearing capacity is significantly affected by saturation as may be experienced with expansive soils. For the foundation to be considered a storm water disposal surface, double-ring infiltrometer tests shall be performed in accordance with Section 6.11.5.

Systems shall be designed for a 75 year service life. For corrugated metal pipe (CMP), utilize industry guides and charts (see Figure 6.3) for specifying pipe gage and coating meeting minimum

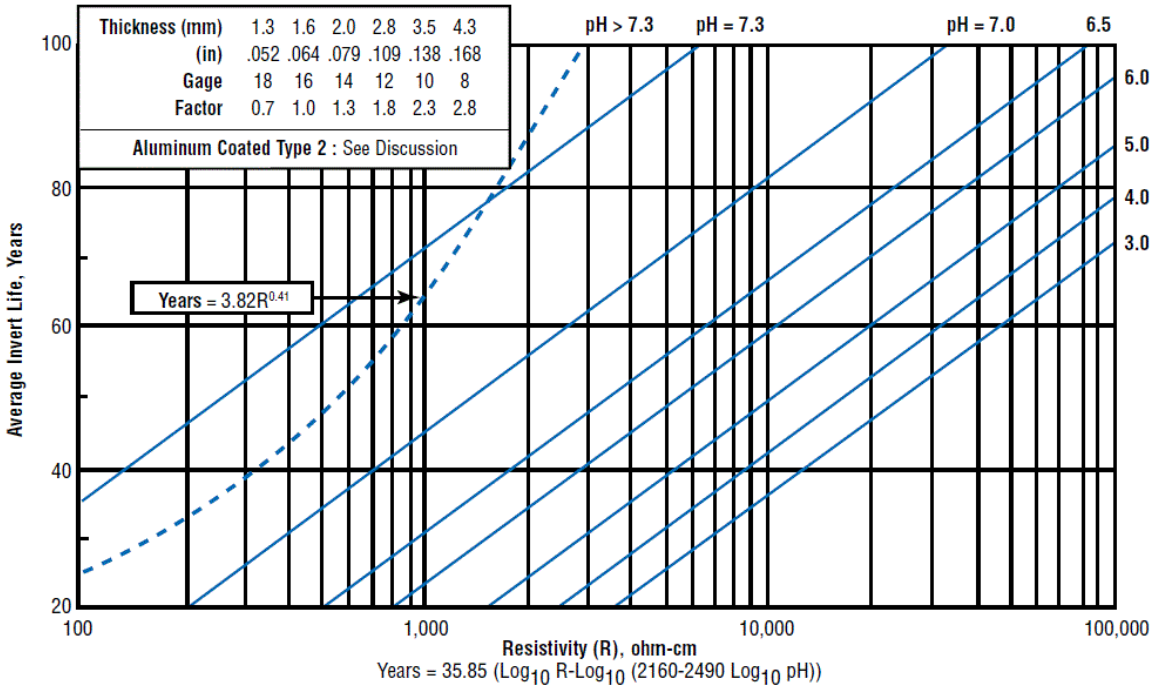
service life. Provide a letter from manufacturer, as part of plan submittal, which confirms service life. Call out pipe gage, coating and corrugation size on the plans.

Traffic and load bearing capacity shall be documented with the submittal for permit. There shall be a minimum of 3 feet of cover from tank to pavement subgrade or in accordance with manufacturer's recommendations.

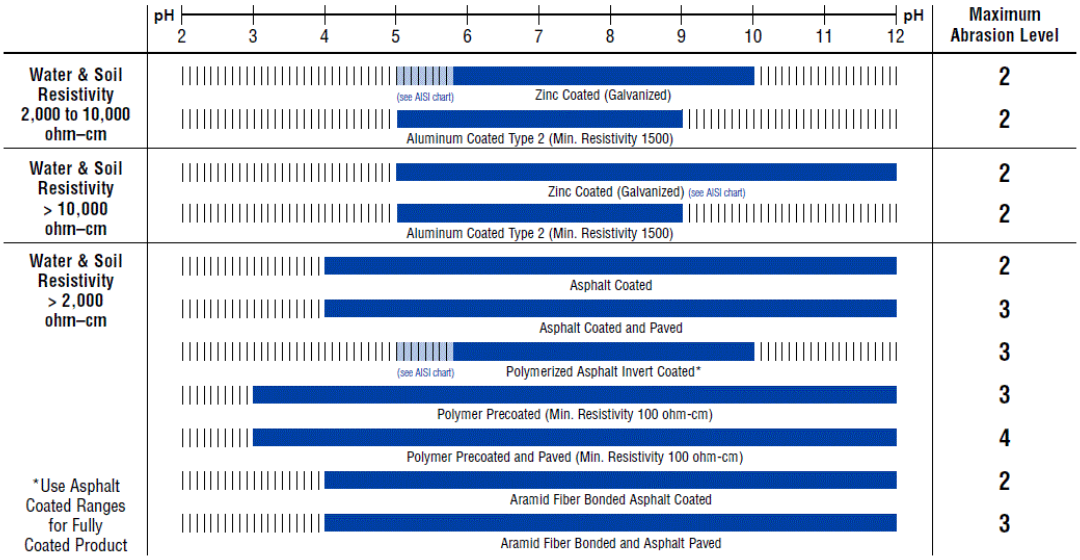
Provide a detail of the connection to the drywell. The drywell connector pipe shall be shown installed at an elevation to drain.

Bedding and backfill shall be in accordance with C-509. Provide a minimum of 2 access points with 48 inch minimum manhole shafts. Provide 30 inch manhole frames and covers with a concrete collar detail shown not directly bearing on manhole shaft. Provide a non-perforated tank and watertight joints if the subgrade has not been characterized as a disposal surface with appropriate tests. Detail the manhole risers, inlets, outlets and tank end walls in accordance with manufacturer's standards. Call out construction in accordance with MAG Section 621.

AISI Chart for Estimating Average Invert Life for Galvanized CSP



Environmental Guidelines for Corrugated Steel Pipe



Source: National Corrugated Steel Pipe Association CSP Durability Guide, May 2000

Figure 6.3 - Service Life and Coatings

6.11.4 ON-LOT RETENTION

Items required for submittal with building permit applications where single-family residential lots are subject to on-lot retention include:

1. Two sets of Grading and Drainage Plans for each lot; both sets with original seal and signature from a registered civil engineer. Make sure to show elevations on property corners (outfall included), bottom retention basin elevation, HWE, finish floor and pad elevations.

2. Calculations for weighted "C" coefficients:

0.95 for roof areas, concrete and pavement
0.95 for adjacent half street
0.95 for future pool (min 750 sf) not to be used as retention
0.50 for landscaping, unless a landscaping plan is submitted with application, then use 0.20 for grass and 0.50 for desert landscape
(Use calculated weighted C value or 0.65, whichever is greater.)

3. Calculations demonstrating required retention volume for subject property and the adjacent half street.

$V_{required}$ =CIA*1.1
Where V=volume, C=coefficient calculated above, I (intensity)=2.2in/hr, A (sf)=total area (lot + half street) and 1.1 is an additional 10% required for sedimentation.
All basins must be connected (6" minimum equalization pipe) or provide separate calculations for each basin.

4. Calculations demonstrating provided retention volume:

$V_{proposed}$ = [(area of the top) + (area of the bottom)]/2 * depth of ponding
1' depth preferred, 1.5' depth max
No underground storage of any kind permitted.

5. An original as-built plan and calculations, certified by a registered civil engineer, will be required.

6. Any changes to the single-family lot (including a pool) will require a revised submittal and all the above listed requirements will apply.

7. Completed Water Retention Addendum acknowledging on-lot retention requirements.

6.11.5 DISPOSAL OF STORMWATER

6.11.5.1 basin infiltration

The infiltration rate of the bottom surface of proposed retention basins shall be characterized by double-ring infiltrometer tests in accordance with ASTM D3385 and DDM Volume II – Hydraulics Section 9.3.1 before grading permit approval. Tests may be required for each separate basin in a

project. Submit testing plan for approval to Civil Plan Review Section. Unless otherwise approved, the number of tests shall conform to DDM Volume II – Hydraulics Table 9.1.

Each basin shall be demonstrated to be dry within 36 hours, by utilizing one-half of the tested basin infiltration rate and drywells.

6.11.5.2 rock pit

The use of rock and mulch pits shall be limited to case-by-case City Engineer approval. An open-graded stone shall be used, and separated from adjacent fine-grained soils by a non-woven, moderate survivability separation geosynthetic fabric. The infiltration rate for the surfaces of proposed rock pit shall be characterized by a double-ring infiltrometer test in accordance with ASTM D3385 and DDM Volume II – Hydraulics Section 9.3.1 before grading permit approval.

6.11.5.3 drywell

Drywells shall conform to C-501 or C-502. Where drywells are located within the same watershed of petroleum product storage or dispensing areas, the drywells must be oil interceptors in accordance with C-502.

Drywells will be permitted where there is inadequate surface infiltration. For design and permitting purposes, each drywell shall have a presumptive capacity of 0.1 cfs (12,960 cubic feet in 36 hours). During construction, each drywell shall be field tested. Credit may be allowed towards the total remaining drywells to be constructed at one-half of the tested capacity, limited to 0.5 cfs. That is to say, in the most favorable condition, one drywell with a field test of 1 cfs or greater may offset the need to construct 4 additional drywells.

Drywell rim grades shall be flush with road surface or turf, and shall be 1-1/2" above decomposed granite landscaped areas.

Drywells shall conform to ADEQ *Guidance for Design, Installation, Operation, Maintenance, and Inspection of Drywells*. They must be registered with ADEQ and shall be constructed by an ADEQ-licensed contractor. A copy of the ADEQ application for registration must be submitted prior to approval of the grading plans.

Drywells must penetrate at least 10' into a permeable stratum.

Drywell locations shall be shown on the grading plans with identifying number. The as-builts grading plan cover sheet shall contain a log of each drywell with its registration number and percolation rate.

Drywells shall be located a minimum of 100' apart, unless otherwise waived by the City Engineer. Drywells shall be located 20' from the basin inlet. Drywells shall be located a minimum of 100' from water wells and underground gasoline storage tanks. Privately-owned drywells shall not be

located in public right-of-way or private street tracts without the City Engineer's authorization. Any drywell within the right-of-way may only accept drainage from the public right-of-way.

The property owner shall be responsible for the design, performance, operation, and maintenance of drywells on his property. Drywells that cannot drain retention areas within 36 hours shall be replaced with new ones.

6.11.5.4 recessed loading docks

Recessed loading docks without positive drainage to a surface retention basin shall be constructed with a sump pit and manual switch pump to pump accumulated storm water to daylight.

Multiple loading docks may be interconnected to one central sump pump with a manual switch.

Under no circumstances shall storm water runoff from a recessed loading dock be directly connected into an underground retention tank, bubbler structure or other underground facility directly connected to a drywell.

6.12 PUMP STATIONS

Pump stations shall comply with DDM Vol II – Hydraulics Section 10, except as noted:
Pumping facilities shall be set at an elevation above the 100-yr event, considering power failure.
Screening devices will not be used at the entrances to the pump station. Grates shall be used on catch basins.

6.13 (SEDIMENTATION) MAINTENANCE

6.13.1 GENERAL

All drainage, flood, and erosion control facilities shall be regularly maintained. Accumulations of silt, trash, litter, or stagnant water which create a health or safety hazard or which endanger the design function are not permitted. Excessive growth or woody vegetation in channels and on dams or levees shall be removed. Areas of active wind or water erosion shall be protected with surface treatments.

Private drainage, flood, and erosion control facilities shall be maintained. Adjacent upstream or downstream public or private facilities shall not be damaged or endangered.

6.13.2 RETENTION BASINS

Silt removal shall occur when silt depth exceeds 6 inches outside of the sediment traps.

Basin bottom infiltration surfaces which are non-vegetated shall be scarified to break up silt and surface crusting annually without using equipment that is detrimental to the infiltration surface.

6.13.3 DRYWELLS

Any loss of efficiency due to screen clogging and accumulation of silt shall be remedied by jetting with water and compressed air. The interception chamber of the drywells traps heavy sediments and trash. They shall be cleaned periodically as described below. The construction and maintenance of a sediment trap around the inlet can reduce the sediment in the chamber.

6.13.3.1 inspection

Inspections shall be performed annually or when ponding is remains 36 hours after a storm. Inspections shall be documented using the ADEQ inspection checklist form and retained on file by the owner.

Maintenance shall occur when:

- for drywells in paved areas – when 10% of capacity of the interception chamber is filled with sediment and debris.
- for drywells in landscaped areas – when 20% capacity of the interception chamber is filled with sediment and debris.
- when drainage time exceeds 36 hours.
- non-storm water discharge has entered the drywell.
- upon change of ownership.

6.13.3.2 maintenance

Maintenance shall include:

- dirt and debris removal.
- replacement of petrochemical absorbent and any filter fabrics.
- cleaning of the screens .
- opening of liner weep holes.
- purging of silt accumulated in aggregate by jetting, surging, or pumping.

If inspection determines that the drywell is not effective, and cannot be restored to service, a new drywell shall be installed.

6.14 HYDROLOGY AND HYDRAULICS REPORTS (NON-FIS)

Project datum shall be NAVD 88 with equations to legacy City Datum NGVD 29 and any as-built plans that affect the project. The nearest City CMCN benchmark shall be utilized for establishing City Datum.

6.14.1 CONCEPTUAL DRAINAGE REPORT

The City requires for review and approval that a conceptual storm water collection and retention plan be submitted with a preliminary plat or site development plan, and approved prior to the approval of such plat or plan. The storm water plan shall include, but not be limited to, the following:

By City Code:

- Method of collection (surface and/or subsurface).
- Depth, side slopes and volume of retention basins.
- Calculations showing retention required and provided.
- High-water elevation, pipe inverts and site outfall.
- Method of disposal of water within thirty-six (36) hours.
- Results of percolation test.
- Areas tributary to each retention basin.
- The effect of a basin overflow due to back-to-back storms or a storm greater than the design storm.
- Any other data required to form a complete plan.
- Identify long-term maintenance responsible party.

Additionally:

- The watershed boundaries, both on-site and off-site, shall be delineated on the drainage map. Indicate any existing drainage or irrigation structures such as waste or delivery ditches, natural drainage channels, etc., and the proposed development's impact on existing features.

- A topographic map which shows the location of the project area; a 1- or 2-foot contour interval must be used as the base map for both existing and proposed. The map must also show the location of the property with respect to the street system and other features such as existing and proposed storm water retention basins, RWCD Canal, Consolidated Canal, etc.

- Method of collection (surface and/or subsurface).

- Depth, side slopes, and volume of retention basins.

- Calculations showing retention required and provided. Provide a summary table, itemizing individual drainage area values for required storage and provided. Demonstrate that the gross project acreage has been considered.

- Method of disposal of water within 36 hours.

- Areas tributary to each retention basin.

- Discuss the development's low outfall elevation and location relative to City and County datum. Indicate location on all watershed and topographic maps.

- Indicate the drainage pattern of all streets within and adjacent to the proposed development on the drainage map.

- Present a preliminary retention basin plan including size, depth, and possible methods of draining the retention basin.

- Indicate areas within the 100-year floodplain.

6.14.2 FINAL DRAINAGE REPORTS

Paving, grading and site construction plans submitted for approval shall be accompanied with a drainage report that includes:

- Cover sheet: submittal number, name, and address of project, parcel, or development for which the report is submitted. Include name, address, and phone number of engineer and property owner.

- A narrative with topographic maps that describe the location and condition of the property the project is located on (on-site conditions); and the upstream (off-site) watersheds as well as any downstream constraints which affect the property.

- Provide calculations demonstrating required retention volume, tributary areas to each basin, and volume provided. Indicate basin grades, depth, high water elevation, pipe invert elevations, basin outfall elevation, and side slopes.

- Provide elevation and indicate location of low outfall elevation for the development, sub area or site improvement.

- Describe the effect of a basin overflow due to back-to-back storms or a storm greater than the design storm.

- Provide street and pipe capacity calculations for the 10-year and 100-year storm.

- Provide time of concentration calculations.

- Provide drainage area map. Map shall have lots and streets labeled, drainage areas and concentration points labeled. Curb height changes noted. Street grade and flow arrows.
- Discuss Flood Insurance Rate Zone.

- Provide storm drain piping and catch basin hydraulic calculations.

- Indicate the routing of off-site flows through or around the proposed development.

- Indicate the County datum to which all site and facility elevations are referenced and equate to the City benchmark.

- Indicate tailwater and backwater elevations at all culverts.
- Indicate finished floor elevations of all structures.
- Indicate method of disposing of retained storm water within 36 hours, and provide double-ring percolation test results and calculations and project geotechnical report.
- Indicate inflow and outflow points at retention/detention basins and culverts.
- Indicate points of concentration and intake point for catch basins, scuppers, channels, and street intersections.
- Calculations of the number of drywells.
- Drainage report based upon computerized hydraulic models shall have all values and variables identified in the report. Software manuals and documentation shall be made available upon request by the City.
- Long-term maintenance responsibility: Specify the name, address, and phone number(s) of the person(s), firm(s), or agency responsible for ownership, operation, liability, and maintenance of drainage improvements. List other documents where these responsibilities are documented (i.e., CCRs, final plats, etc.).
- Water surface calculations.

The following calculations as required:

- Calculations for earth-load and HS-20 live-load on buried pipe. Calculations for required pipe strength (D-Load on reinforced concrete pipe).
- Channel hydraulics.
- Special structures.

The following is a suggested outline for a drainage report:

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Introduction

- **Purpose**
- **Watershed Boundaries**

Existing Conditions

- **Landform**
- **Regulatory Setting**
  - **Federal**
  - **Local**
- **Offsite Drainage Conditions**
- **Drainage within the Project**

Proposed Improvements

- **Project Impact**
- **Hydrology**
  - **Rainfall**
  - **Runoff**
- **Hydraulics**
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  - **Inlet Performance**
  - **Pipe Systems and Capacity**
- **Stormwater Storage**
- **Stormwater Dissipation**
  - **Basin Infiltration**
  - **Drywell**
- **Handling the Extraordinary Storm Event**
  - **Outfall**

Appendix A – Drainage Area and Peak Flow Computations

Appendix B – Catch Basin Interception Computations

Appendix C – Hydraulic Grade Line Calculations

6.15 GENERAL CONSTRUCTION DRAWING REQUIREMENTS

6.15.1 PLAN APPROVAL

- All pipes shall be shown in profile.
- Professional Registrant
- 24x36" plans
- 20 or 40 scale
- Need landscaping plan for retention basins. Comply with zoning code and conceptual site review and civil checklists.

6.15.2 PROJECT ACCEPTANCE (AS-BUILT APPROVAL)

Following completion of storm drainage improvements, an As-Built final grading plan shall be submitted for approval. The plan shall be sealed by a Civil Engineer and a Registered Land Surveyor each registered in the State of Arizona. Plans shall be marked As-Built with all changes noted. As-Built drawings shall contain the following:

- Certification of catch basin inlet and outlet elevations.
- Certification of retention basin dimensions, grades, volumes, and side slopes.
- Certification of retention basin percolation rate, both the pre-construction and the post construction double-ring infiltrometer tests shall be submitted.
- Approved ADEQ drywell registration, drilling logs, and certified testing results with key to location on plan.
- Show the As-Built maximum water depth of the retention basin for a 100-year, 2-hour storm.
- Show the As-Built finished floor elevation of buildings and or building pads and the As-Built elevation of the development low outfall.
- Present final plan for carrying runoff from outside the proposed development (through or around the development).
- For projects constructed within regulatory flood insurance areas, flood plain limits, elevations and permit number shall appear on As-Builts. An approved MCFCD Elevation Certificate shall be submitted with the As-Built plan.

6.16 REFERENCES

Drainage Policy and Standards Manual for Maricopa County:
http://www.fcd.maricopa.gov/Pub/manuals/policy.aspx

Drainage Design Manual (DDM):

- Volume I - Hydrology: http://www.fcd.maricopa.gov/Pub/manuals/hydrology.aspx
- Volume II - Hydraulics: http://www.fcd.maricopa.gov/Pub/manuals/hydaulics.aspx
- Volume III - Erosion Control: http://www.fcd.maricopa.gov/Pub/manuals/erosionControl.aspx

HEC 12 : http://www.fhwa.dot.gov/engineering/hydraulics/pubs/hec/hec12.pdf

NOAA Altas 14 Precipitation Frequency Data Server:
http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=az