Pima County Regional Flood Control District

Design Standards for Stormwater Detention and Retention

Supplement to Title 16, Chapter 16.48,

Runoff Detention Systems

Floodplain and Erosion Hazard Management Ordinance

Pima County Regional Flood Control District
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June 2014

PIMA COUNTY
FLOOD CONTROL

REVISIONS

Because of ongoing regulatory and technical changes in the fields of floodplain and stormwater management, revisions to this manual will be required from time to time. Such revisions will be approved by the Floodplain Administrator. Hard copy (printed) revisions will not be distributed. It is the holder's responsibility to keep the document current by periodically checking the Regional Flood Control District's web page for new digital versions. The revision history of the document is listed below.

Chronology of Publication, Updates and Revisions

Description	Date
First Edition	June 2014
Chapter 6 Revised to Include Benefits of Multiple-Use Basins	February 2015

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Symbol	Description
A	Watershed area
A_s	Watershed area flowing to or through stormwater harvesting
A_T	Total watershed area
C_w	Weighted runoff coefficient
C_{w-rp}	Weighted runoff coefficient for the return period
D_{50}	Median diameter of the rock size distribution
H_{rp}	Stormwater harvesting factor
P_{1-rp}	One-hour rainfall depth for the return period
P_t	T-hour rainfall depth
Q_i	Detention basin inflow
Q_o	Peak outflow from detention basin
$Q_{post-rp}$	Post-development peak discharge rate for the return period
Q_{pre-rp}	Pre-development peak discharge rate for the return period
Q_{swh-rp}	Post-development peak discharge rate with stormwater harvesting for the return period
T	Flow travel time
T_{AB}	Flow travel time between points A and B
t_c	Time of concentration
T_r	Hydrograph rise time
$T_{r'}$	Rise time of the 100-year synthetic flood hydrograph for on-site drainage
$T_{r''}$	Rise time of the 100-year synthetic flood hydrograph for an entire watershed
Δ_t	Length of time interval, minutes
V_{bas}	Volume of proposed stormwater harvesting basin(s)
$V_{post-rp}$	Post development runoff volume for the return period
V_s	Estimate of total required storage volume
V_{swh-rp}	Runoff volume with stormwater harvesting for the return period
W_A	Percent of watershed area draining to stormwater harvesting
X_{rp}	Ratio of stormwater harvesting basin volume to post-development runoff volume

1. INTRODUCTION

1.1 Purpose

The purpose of this manual is to provide guidance, design standards and policy direction when runoff detention and retention systems are required for development in Pima County. This manual is a supplement to, and has the same regulatory authority as, the floodplain management regulations throughout the jurisdictions of Pima County, including:

- Title 16 of the Pima County Code;
- Chapter 26 of the Tucson Code;
- Title 14 of the Sahuarita Town Code;
- Chapter 17 of the Oro Valley Town Code; and
- Title 21 of the Town of Marana Land Development Code.

Throughout the manual, these are collectively referred to as the Ordinances.

Since 1987, the Stormwater Detention/Retention Manual (Pima County Department of Transportation & Flood Control District and City of Tucson) has required runoff detention and retention systems to:

1. Protect adjacent properties from adverse impacts;
2. Preserve watershed-scale peak discharge characteristics; and
3. Retain a portion of stormwater runoff on site for re-use and infiltration.

This manual continues to require protection of adjacent properties and preservation of pre-developed peak discharges and also incorporates revisions that:

1. Require first-flush retention that may be located throughout the development. The retained volume may also be used to meet part of the project's detention volume requirement;
2. Include sustainability principles and promote early, integrated site planning;
3. Specify acceptable methods of analysis;

4. Provide detailed design standards;

5. Address maintenance responsibilities and expectations;

6. Standardize report and plan content requirements; and

7. Facilitate use of the manual by Floodplain Administrators in both incorporated and unincorporated areas of Pima County.

1.2 Ordinance Overview and Detention Requirements

The broad goals of the Ordinances are to protect the public health, safety and general welfare of the citizens of Pima County and to protect the natural character of our watercourses, water resources and environment. The Ordinances require the design of all new development to include elements which protect the site from flood damage and which protect adjacent and downstream properties from adverse drainage impacts.

The Ordinances mandate that post-development runoff rates be reduced to pre-development rates. In addition, the Ordinances stipulate that development plans and tentative plats demonstrate that improvements are compatible with the existing upstream and downstream drainage conditions and that any proposed grading and/or grade change will not have an adverse impact on surrounding properties. These provisions form the foundation for the requirements presented in this manual.

With a general requirement for no adverse impact, the standards also rely on the more specific requirements in the Ordinances, including:

1. Any new development will include some method of peak discharge and/or volumetric runoff reduction. Detention facilities may be omitted from project design if a waiver of this requirement is granted by the Floodplain Administrator. A fee may be required. Waivers may be granted when the parcel to be developed is less than 1 acre in size; is located within close proximity to a major watercourse; is of low residential density (less than two residences per acre) and maintains the natural drainage patterns; or when other engineering justification acceptable to the Floodplain Administrator can be demonstrated.

2. Within unincorporated Pima County, a watershed is considered a Balanced Basin unless it has been determined to be a Critical Basin. The Regional Flood Control District's (District) Critical Basin Map is available through the Rules and Procedures page of the District's web page and shows basin designations regulated by the District. For watersheds regulated by other jurisdictions within Pima County, other maps may be applicable.

Unless a Detention Waiver has been granted:

a. New development located within a Balanced Basin must provide sufficient detention to reduce the post-developed 2-, 10- and 100-year peak discharge rates to the pre-developed rates.
b. New development located within a Critical Basin must provide sufficient detention to reduce the post-developed 2-, 10- and 100-year peak discharge rates to 90% of the pre-developed peak discharge rates. Other reductions may be specified by the Floodplain Administrator.

85%

c. Properties within the City of Tucson that are currently in undesignated basins shall be treated as balanced basins.

3. Locations of post-developed concentration points at the downstream property boundary must approximate the locations of pre-developed concentration points at the downstream property boundary, and the Balanced and Critical Basin criteria are applicable at all downstream concentration points.

1.3 Applicability

This manual applies to the planning and design of runoff detention and retention systems when required for private development plans and subdivision plats. These standards do not apply to regional or public detention basins. The use of detention or retention within individual residential parcels to meet or offset any part of the detention or retention requirements for a project site is not allowed. For regional basins, where watersheds are greater than 1 square mile, refer to applicable regional basin standards.

1.4 Conflicting Requirements and Use of Alternative Requirements

If any of the requirements in this manual conflict with one another, the Ordinances or other policies of the Floodplain Administrator, the more restrictive requirement shall apply.

Requests to provide designs, analyses or reporting which are different from the requirements stated in this manual shall be made in writing to the Floodplain Administrator prior to submittal. A response shall be provided in writing to the applicant.

1.5 Low Impact Development Practices

This manual introduces the use of Low Impact Development (LID) practices. LID practices model the natural environment with design elements which manage runoff and water use using uniformly-distributed small-scale controls. One goal of LID practices is to mimic a site's pre-development hydrology using methods that effectively capture, detain, infiltrate and evaporate runoff close to its source.

Two components of LID practices are site planning and hydrologic analysis. Traditionally, site development has allowed runoff to be conveyed quickly to a central point, such as a

constructed channel or detention basin. This type of development is essentially devoid of natural features, and the result is an increase in runoff volume and peak discharge and an associated decrease in runoff travel time. In contrast, site development using LID practices contains features found in natural watersheds which can increase post-development travel time above that expected with traditional constructed conveyances, while reducing both peak discharge rate and runoff volume.

The use of LID practices accomplishes multiple goals including addressing State and Federal regulations requiring jurisdictions to reduce the contribution of pollutants from urbanized areas to our watercourses and providing a mechanism to direct runoff to landscape, bufferyards, and riparian areas in a way that also provides some flood control benefit.

Site design which incorporates LID practices includes elements such as water catchments immediately downstream of impervious surfaces and other disturbed or compacted areas and curvilinear flow paths which reduce the velocity of surface flow. An example of a site design incorporating LID practices is the Lester Street site at the University of Arizona and is illustrated in Figure 1.1.

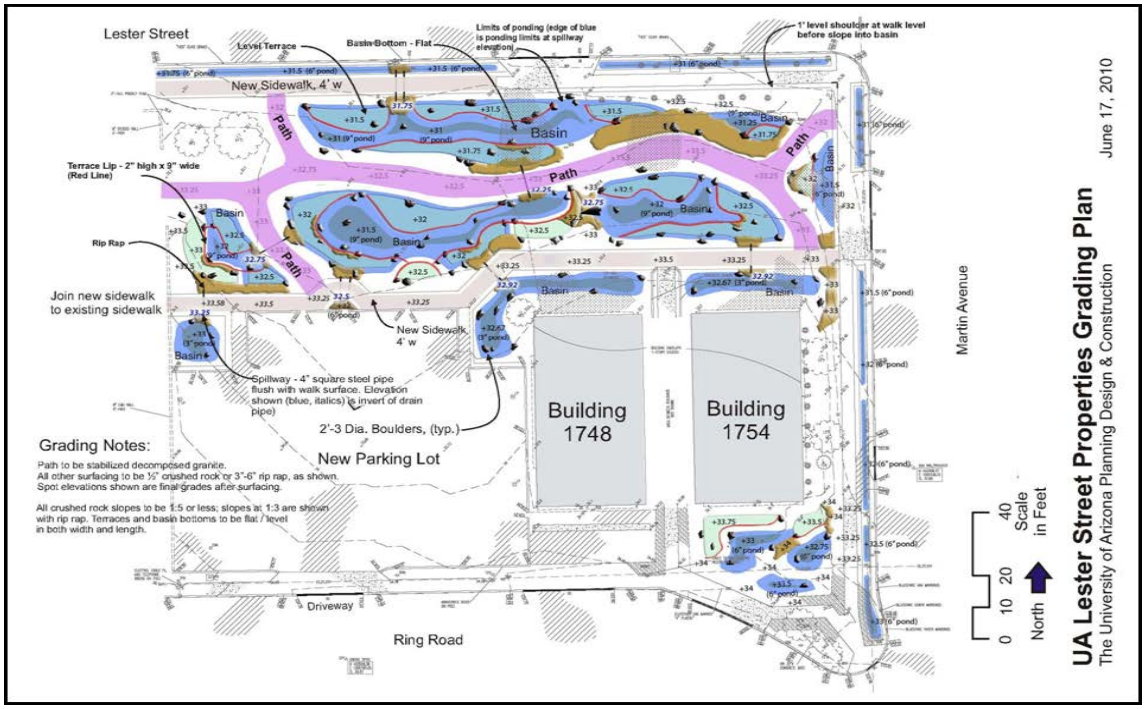


Figure 1.1 An Example LID Site Design
(University of Arizona, Department of Planning, Design & Construction).

In this example design, runoff from roofs and parking areas is directed to a series of shallow basins which are interconnected by pipes or berm spillways which reduce the volume and rate of flow at the downstream boundary of the project.

Landscaping creates aesthetically pleasing runoff paths and increases evapotranspiration. The landscape concept for the Lester Street project is shown in Figure 1.2.

The requirement, introduced with this manual revision, to provide first-flush retention can be satisfied by site designs which incorporate features similar to the example site design or by providing the retention volume within a detention basin.

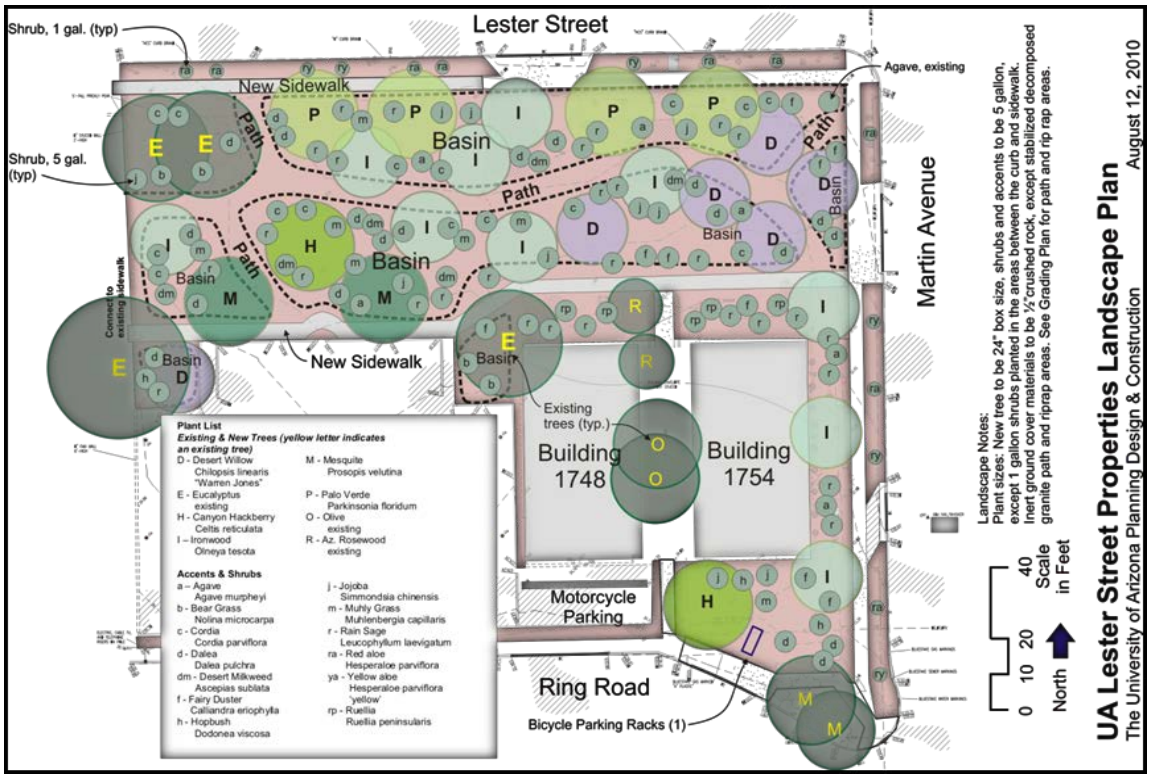


Figure 1.2 An Example LID Landscape Concept Plan
(University of Arizona, Department of Planning, Design & Construction).

First-flush retention is defined as the capturing and retaining of the stormwater runoff volume from 0.5 inch of rainfall on all newly disturbed or impervious areas for new development or redevelopment as defined in Section 2.1. This requirement does not apply to those portions of the project site that are left undisturbed.

To incentivize the use of LID practices, the manual provides a method to reduce the required volume of detention facilities when stormwater harvesting basins are used throughout a site. LID practices additionally mitigate first-flush retention volume. The manual standards also incentivize other LID practices when quantifiable flood control benefits can be measured, although LID practices are not required.

Quantifiable flood control benefits include:

1. Optional LID practices that reduce the volume of post-development runoff:
   a. Minimization of disturbed and impervious surfaces. Surfaces designed with pervious pavement systems shall be analyzed as disturbed, rather than impervious, surfaces.
   b. Protection and maintenance of riparian habitat and other high permeability areas; and
   c. Use of stormwater harvesting throughout the site in depressed earthen areas.

2. Other Optional LID practices that increase roughness or lengthen the flow path for watersheds with times of concentration which exceed five minutes:
   a. Disconnection of impervious surfaces;
   b. Maximization of time of concentration through the use of swales, site design and increased lengths of flow paths; and
   c. Use of conveyance systems that mimic natural conditions.

In order to facilitate the use of LID practices, the Floodplain Administrator encourages applicants to satisfy other requirements within LID practice areas. Other requirements which might be satisfied within LID practice areas include landscaping, native plant, and riparian mitigation requirements. Locating mitigation areas within stormwater harvesting basins will maximize the effect of both the LID practice and the success of the mitigation area. Other regulatory requirements that could be met include open space set-aside, bufferyard, and park requirements.

Details and design standards for LID practices are presented in Chapter 5.

1.6 Site Planning

Early review of the project site for opportunities to optimize the use of LID practices, to consider riparian habitat preservation and to reduce the site area devoted to deeply-excavated detention basins is encouraged by the Floodplain Administrator. While this manual provides standards and guidelines for designing, constructing and maintaining detention basins, it also promotes use of alternatives to the construction of deeply-excavated basins or a combination of detention basins and alternative practices to achieve stormwater detention and retention volume requirements.

Site planning during rezoning processes and at the earliest stages of site review will allow for the most appropriate uses of LID practices, stormwater harvesting and riparian habitat and floodplain preservation. Site planners are encouraged to contact the Floodplain Administrator for consultation during preliminary site layout.

1.7 Design Standards

This manual presents the required design standards for detention basins and LID practices. Approval of the use of design standards not in this manual shall be obtained in writing from the Floodplain Administrator prior to submittal of the detention/retention analysis. As new construction methods and materials, environmental regulations and sustainable development practices evolve, new design standards may be incorporated into the manual.

2. FIRST-FLUSH RUNOFF VOLUME REDUCTION

Capturing and retaining stormwater throughout the project site results in a reduction in the size of infrastructure required to convey runoff to a central area. Additionally, it provides permeable area which allows more runoff to infiltrate into the ground.

Stormwater retention is required to address water quality protection goals, to reduce downstream adverse impacts related to the increased frequency of runoff from development, and to mimic natural features which allow for the beneficial re-use of stormwater on site.

2.1 Applicability of First-flush Retention and First-flush Runoff Volume Calculation

The first-flush runoff volume is the volume of stormwater runoff from 0.5 inch of rainfall that is expected to discharge from impervious and disturbed areas. The 0.5-inch rainfall event is the 85^{th} percentile storm event, discussed in Appendix A. New development shall provide the retention volume necessary to retain the first-flush runoff volume from impervious and disturbed areas as determined below:

1. When new development is proposed on vacant land, all proposed impervious and disturbed areas shall be used to determine the required first-flush runoff volume.

2. When expansion of existing development occurs, the first-flush runoff volume shall be calculated using:
   a. The total impervious and disturbed areas of the entire site, when more than 1 acre of new development is proposed and the new development is greater than 33% of the entire site.
   b. Only the impervious and disturbed area associated with the proposed expansion, when between 2,000 square feet and 1 acre of new development are proposed, or the new development is less than 33% of the entire site. Expansion area is cumulative over the life of the project.
   c. First-flush retention is not required when an expansion of less than 2,000 square feet is proposed. The 2,000-square-foot threshold is cumulative.

3. A change of use of a property that does not increase impervious surfaces or disturbed area does not require first-flush retention.

4. Where known drainage problems have been documented by the Floodplain Administrator, mitigation through retention may be required for sites which otherwise would not require first-flush retention.

2.2 First-flush Runoff Volume Calculation

The first-flush runoff volumes required for retention by this Section were determined using the Soil Conservation Service (SCS) Curve Number method with a 0.5-inch rainfall event (Table 2.1).

Appendix A presents supporting data for the use of the 0.5-inch standard.

The first-flush runoff volumes were found as the difference in runoff volume for post-developed and pre-developed conditions for a 0.5 inch rainfall event. For pre-developed conditions, Natural Resources Conservation Service (NRCS) Hydrologic Group B soils were assumed for Pima County Mapped Riparian Areas identified in the Pima County Riparian Classification Maps or other higher permeability areas designated by the Floodplain Administrator and NRCS Hydrologic Group C soils were assumed for Non-Riparian Areas or other lower permeability areas.

For post-developed conditions, impervious areas that replace Mapped Riparian Areas or other higher permeability areas were represented as 0.5 inch of runoff, and other impervious areas were represented as the runoff found from using an NRCS Curve Number of 99. Disturbed areas were assumed to be D soils under post-developed conditions.

Table 2.1 First-flush Retention Volume Required for Each Acre of Impervious or Disturbed Area by Type of Area

	Lower Permeability Area	Mapped Riparian Area or Other Higher Permeability Area
Applicable Impervious Area	1440 ft^3/ac	1815 ft^3/ac
Additional Disturbed Area	140 ft^3/ac	245 ft^3/ac

The first-flush retention volume shall be calculated according to the following:

1. The first-flush retention volume requirement shall be calculated separately for the impervious and disturbed areas of each developed watershed associated with flows that exit a project site. The calculation for the required first-flush retention volume shall be in accordance with Table 2.1 above, unless site-specific testing supports use of alternate values.

2. Within each developed watershed, retention areas that are used to meet the first-flush retention requirement shall be located downstream of an impervious area. Sites may contain some impervious or disturbed areas which do not drain to first flush retention.

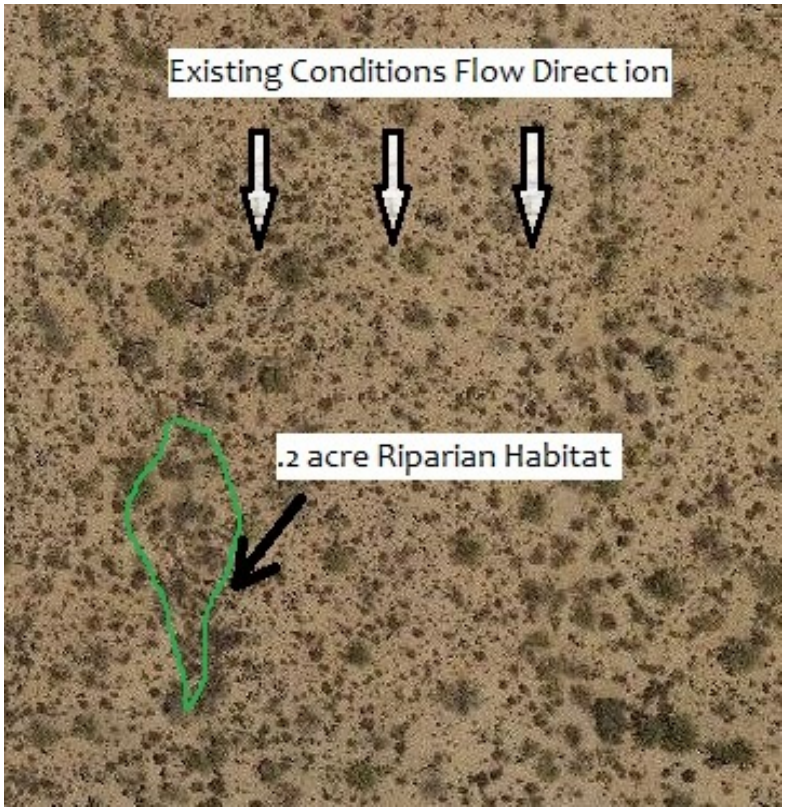
3. The total first-flush retention volume provided in each developed watershed shall satisfy the first-flush retention requirement for that watershed.

4. Retention volume in areas such as stormwater harvesting basins and retention within detention basins may be counted toward the required first-flush volume.

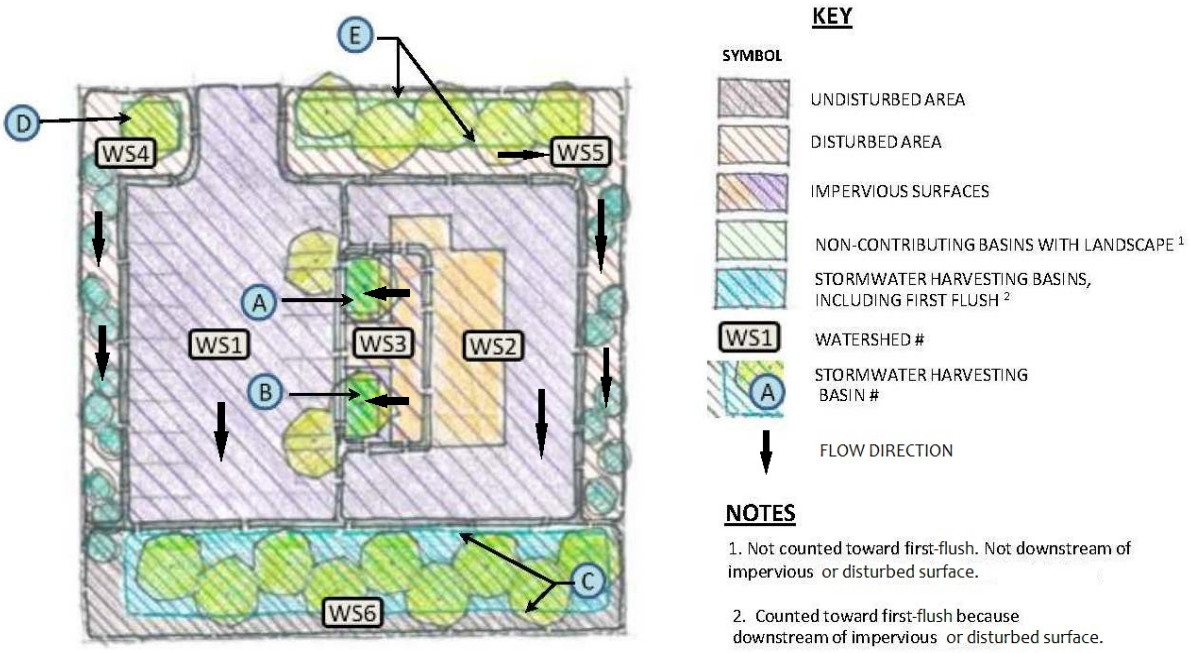
5. First-flush retention areas within stormwater harvesting basins may also be counted for reducing peak discharges as described in Section 3.3. First-flush retention volume within detention basins will be counted as volume within the detention routing procedures described in Section 3.4.

6. Disturbed areas include any areas of the project site which are graded, except for the detention basins and stormwater harvesting basins themselves.

To illustrate how first-flush retention volume could theoretically be distributed on a fictitious site, Figure 2.1 presents pre- and post-developed conditions.



Example Pre-Developed Conditions



Example Post-Developed Conditions

Figure 2.1 Example Commercial Site with First-flush Retention within Stormwater Harvesting Basins

The example presents a theoretical site to illustrate various combinations of permeability type, constructed surface type and stormwater harvesting basins, both downstream of runoff and non-contributing rainfall only basins. The example site is 2.3 acres, representing 1 pre-developed watershed of 2.3 acres of undisturbed natural desert flowing generally in a uniformly distributed manner to the downstream limit of the site. The site contains 0.2 acre of Mapped Riparian Habitat.

The proposed development includes a commercial building with parking and landscaped areas. The site grading is designed to create 6 on-site post-developed watersheds, WS1 – WS6. The Mapped Riparian Habitat falls within WS1. WS1, WS2 and WS3 are to be developed as impervious areas with downstream stormwater harvesting basins which are situated to satisfy first-flush retention.

WS4 and WS5 are areas disturbed by grading which also drain to stormwater harvesting in WS6 which can satisfy the first-flush requirement for WS4 and WS5. WS4 and WS5 contain Rainfall Only Non-Contributing Basins which do not satisfy any first-flush requirement because they are not downstream of impervious or disturbed surfaces.

The areas of both the Non-contributing Basins and the stormwater harvesting basins which receive runoff, .29 acre, are excluded from the area for which first-flush retention is required.

WS6, .30 acre, does not have a first-flush requirement because it includes only a stormwater harvesting basin and undisturbed area. However, the .15 acre of stormwater harvesting basin in WS6 counts toward first-flush volume.

Example calculations for first-flush volume for the post-developed on-site watersheds are provided in Table 2.2.

Table 2.2 Example Site First-flush Volume Required

1	2	3	4	5	6	7	8
Watershed	Type of Permeability	Constructed Surface Type	Watershed Area	SWH Area	Undisturbed Area	Watershed Area Subject to FF Col. 4 – Cols. 5 & 6	FF Volume Required Col. 7 X Table 2.1 Multiplier
			acre	acre	acre	acre	ft^3
WS1	Lower	Impervious	.75			.75	1080
WS1	Higher	Impervious	.20			.20	363
WS2	Lower	Impervious	.80			.80	1152
WS3	Lower	Impervious	.05	.04		.01	14
WS4	Lower	Disturbed	.08	.02		.06	86
WS5	Lower	Disturbed	.12	.08		.04	58
WS6	Lower	Undisturbed and SWH	.30	.15	.15	n/a	n/a
TOTAL			2.3	.29	.15	1.9	2753

Volumes of each basin were calculated using the PC-LID spreadsheet. Non-contributing Rainfall Only Basins do not count toward first-flush volume because runoff from constructed surfaces is not directed to them.

Table 2.3 summarizes the first-flush volume provided by this example site design.

Table 2.3 Example Site First-flush Volume Provided

1	2	3	4	5	6	7
Basin	Rainfall Only Non-Contributing?	Top Area	Bottom Area	SWH Depth	SWH Volume	SWH Volume counted toward FF
		acre	acre	ft	ft^3	ft^3
A	No	.02	.014	.5	368	368
B	No	.02	.014	.5	368	368
C	No	.15	.134	.5	3091	3091
D	Yes	.02	.014	.5	368	n/a
E	Yes	.10	.089	.5	2057	n/a
Total					4198	3827

The site design provides 3827 ft^3 of first-flush volume which is more than the required 2753 ft^3 of first-flush retention volume. The retention volume in all basins can help meet the site detention requirements.

2.3 Site Planning and Preliminary Design of LID Practices to Minimize First-flush Volume

Minimizing a development's impervious footprint helps to preserve the natural hydrologic characteristics of a site. The objective of LID is to mitigate the potential for increased runoff due to disturbance. LID practices reduce runoff rates by minimizing the impervious and disturbed surface area and by promoting infiltration through preservation and enhancement of riparian areas and regulatory floodplains. Judicious layout of impervious areas can promote increased infiltration and reduced runoff.

LID practices which minimize impervious and disturbed areas, maximize the preservation/enhancement of riparian areas and regulatory floodplains, and maximize infiltration reduce the required first-flush retention volume. By incorporating these practices in site design during initial planning, an applicant can minimize the amount of first-flush runoff volume required.

During site planning, the following practices which can minimize the first-flush runoff volume shall be considered.

2.3.1 Minimize Disturbed, Compacted and Connected Impervious Surfaces

Fundamental elements of LID are reducing a development's impervious footprint and limiting construction disturbance. By incorporating these elements at the site planning stage, an applicant has the opportunity to reduce the amount post-development runoff volume generated. Table 2.4 summarizes acceptable practices to minimize imperviousness and disturbance.

Table 2.4 Acceptable Techniques to Minimize Disturbed, Compacted, and Impervious Surfaces

Phase	Techniques
Planning	• Consolidate buildings and other impervious areas. • Minimize developed footprint. • Locate impervious surfaces on the site's least permeable soils or previously disturbed areas. • Minimize use of fill and avoid compacting soils.
Design	• Follow the site layout proposed during planning. • Delineate grading limits. • Delimit undisturbed areas which will be fenced during construction. • Maximize use of pervious paving materials.

Disconnecting impervious surfaces provides a greater opportunity for runoff to infiltrate into the ground. At the site planning stage, an applicant has the opportunity to establish flow paths that avoid impervious areas and infiltrate runoff in permeable areas.

Mass-graded, traditional street configuration

Avoidance, loop roads, minimum lot frontages

Figure 2.2 Traditional Layout Compared to Alternative Compact Development Footprint

In addition, pervious pavements can be used to infiltrate or store water. Because pervious pavement systems include a permeable paving surface and a subsurface material that can hold

water, they can reduce both runoff peaks and volumes. Pervious pavement systems include porous gravel, concrete grid pavement, permeable interlocking concrete pavement, and pervious concrete. These pavement options are appropriate for low speed vehicular areas, such as parking lots, or for pedestrian areas, such as sidewalks.

2.3.2 Protect/Enhance Riparian Habitat and Other High Permeability Areas

Riparian habitat areas are frequently areas where infiltration rates are higher, where runoff occurs more frequently and at greater rates, and where natural flow paths have been established historically. Disturbance of these areas often causes the greatest impact to the hydrology of a project site. Avoidance of riparian areas and regulatory floodplains retains the site's natural drainage pattern, allows for flow attenuation and additional infiltration due to increased roughness, and provides additional buffer from the impacts of a development on a watercourse. Acceptable techniques for protecting riparian areas and regulatory floodplains are summarized in Table 2.5.

Table 2.5 Acceptable Techniques to Protect/Enhance Regulated Riparian Habitat and Regulatory Floodplains

Phase	Techniques
Planning	• Avoid regulated riparian habitat and regulatory floodplains. • Identify available planting sites adjacent to regulated riparian habitat and regulatory floodplains. • Identify regulated riparian habitat where vegetation has been degraded and propose appropriate plantings.
Design	• Follow the site layout proposed during planning. • Provide limits of regulated riparian habitat and regulatory floodplains. • Delimit avoidance areas and enhanced planting sites. • Avoid channelizing or bank protecting within regulatory floodplains. • Restore degraded stream banks.

At the site planning stage, protection of the regulated riparian habitat and regulatory floodplains will reduce the first-flush runoff volume, provide roughness to attenuate flows, and reduce or negate the requirement for riparian habitat mitigation. In addition, retention basins can be located immediately adjacent to existing riparian habitat in order to enhance this environment by creating a buffer between the developed and riparian areas and by providing supplemental irrigation through stormwater harvesting.

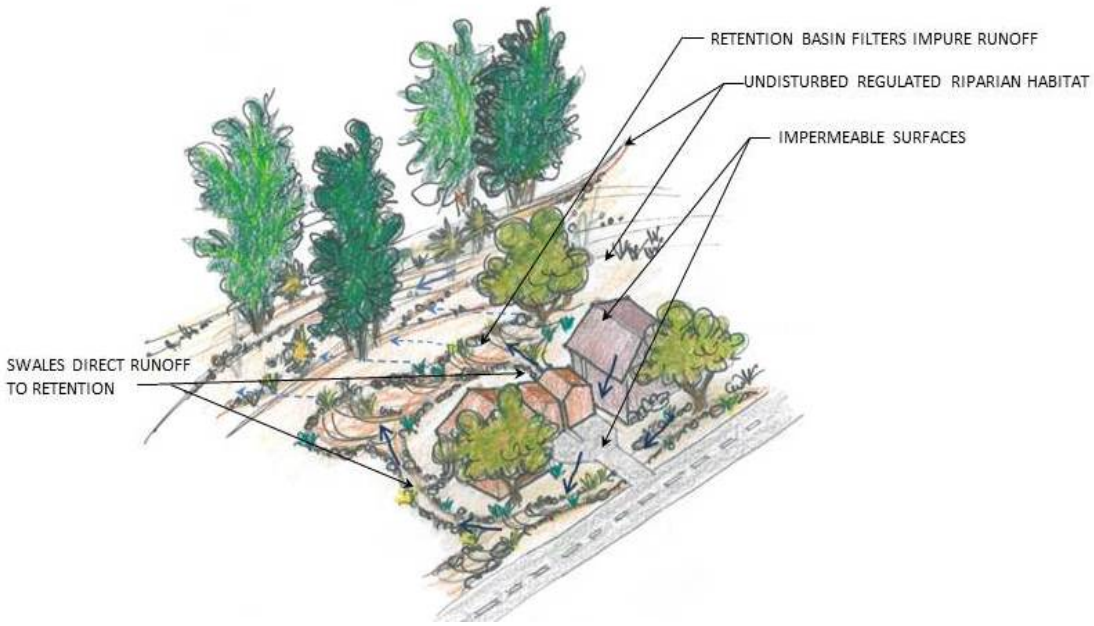


Figure 2.3 Illustration of Protection of Riparian Habitat Adjacent to Development

2.4 Use of LID Practices to Retain the First-flush Runoff Volume

The first-flush retention volume shall be calculated for the impervious and disturbed areas of each post-development on-site watershed using Table 2.1. The total retention volume in each watershed must equal or exceed the first-flush runoff volume emanating from the impervious and disturbed areas within that watershed. Retention areas that are counted towards the first-flush requirement must be located downstream of an impervious or disturbed area.

Although their use is encouraged, stormwater or rainwater harvesting facilities provided on individual residential lots shall not be counted toward the project's first-flush retention requirement.

The following LID practices can satisfy or reduce the first-flush retention requirement.

2.4.1 Stormwater Harvesting Basins

Stormwater harvesting basins are depressed earthen areas that are located and designed to collect and retain runoff from impervious or disturbed areas such as parking lots or rooftops or to capture and retain rainfall for irrigation of vegetation. If the runoff volume that is directed to a stormwater harvesting basin exceeds the capacity of the basin, an overflow shall be provided with the elevation of the overflow controlling how much water is collected and retained.

Except for basins designed to collect only rainfall, all stormwater harvesting basins shall have an inlet. The discharge rates from stormwater harvesting basins that exit a project site shall not exceed a Balanced or Critical Basin discharge rate.

Without infiltration testing the maximum depth of retention in detention basins is 9 inches. If the basin is sloped, the depressed area may contain internal berms or check dams to pond water in multiple cells with planting areas on the upstream side of the berm. Retention depth greater than 9 inches require infiltration testing to verify that the draw down time is in accordance with section 4.5.

Maximizing stormwater harvesting throughout the site areas reduces the post-developed discharge rates and volumes exiting the site. When stormwater harvesting areas are not large enough to collect all the runoff volume from adjacent impervious areas, overflows will be required. When stormwater collection systems such as storm drains are proposed, engineered features such as elevated grate inlets allow for runoff collection before flows enter the storm drain system. A concept sketch is shown in Figure 2.4.

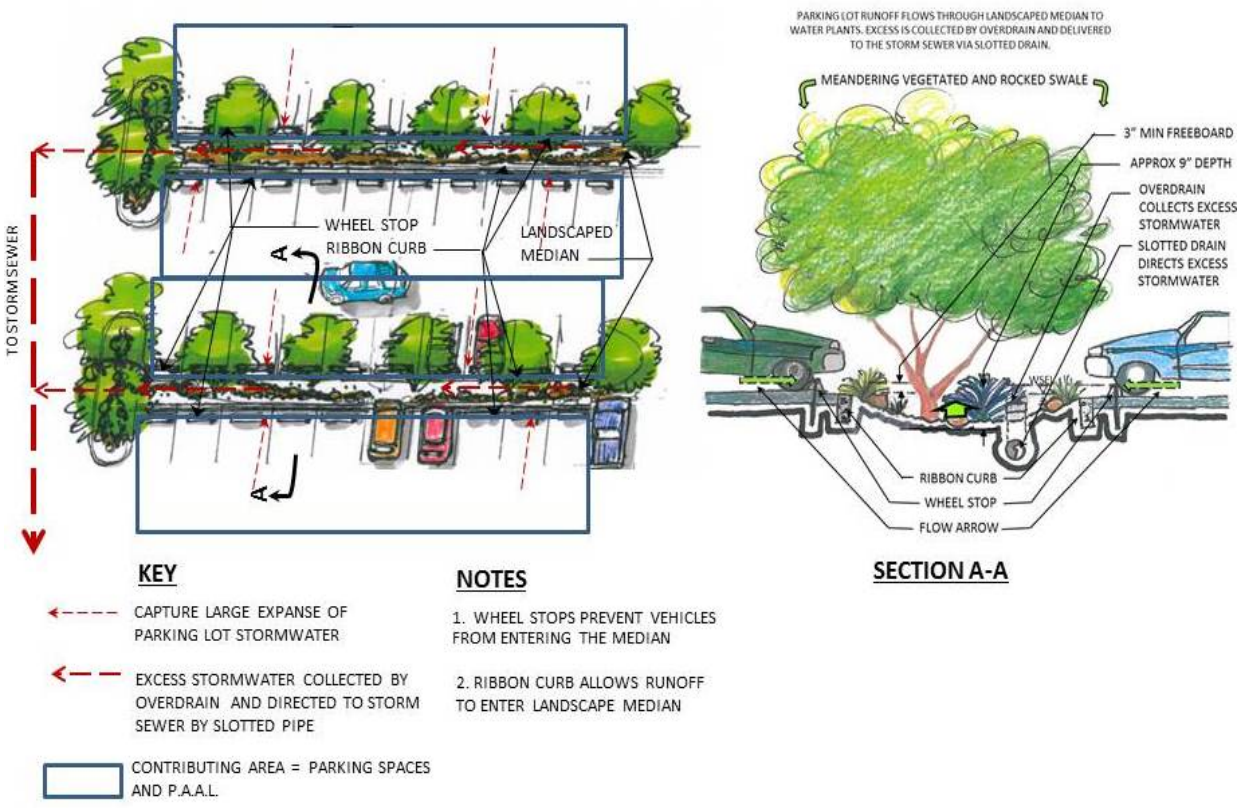


Figure 2.4 Elevated Grate Inlet which Maximizes Stormwater Harvesting

2.4.2 Roadside Stormwater Harvesting Basins

Roadside basins collect and retain runoff from impervious areas such as roadways or parking lots. Roadside basins should be located in appropriate areas after considering other factors

such as driveway and sidewalk locations, utility locations, site visibility triangles, soil conditions and catchment areas. Safety of pedestrians and vehicles shall be considered when locating roadside basins.

When roadside basins are proposed, they shall not be located at a roadway low point in order to assure continued flow conveyance within the roadway once the basin is full. Roadside basins require an inlet, but an outlet is not required because flow will follow the roadway slope rather than flowing into a basin when it is full. As shown in Figure 5.2, the design water surface elevation in the basin is set at or above the water surface elevation within the curbed roadway section. A roadside basin at full depth is shown in Photo 2.1.

Photo 2.1 Roadside Stormwater Harvesting Basin at Full Depth

2.4.3 Non-contributing Basins

Non-contributing Basins are stormwater harvesting basins designed to retain the entire 100-year stormwater volume which falls on the basin or on the basin and adjacent area. Non-contributing area basins do not contain any means of disposal other than infiltration or evapotranspiration; therefore, they do not contribute any runoff and should be excluded when determining post-development watersheds.

2.4.3.1 Types of Non-contributing Basins

Non-contributing Basins may be of two types. A Rainfall Only Non-contributing Basin is designed to collect only the rainfall which falls on it, with no contribution from upstream areas.

An example of a Rainfall Only Basin is a landscape bufferyard with no inflow from upstream drainage areas. A Rainfall Only Basin must be a minimum of 9 inches in depth to allow a minimum of 3 inches of rainfall from a single event, allow for small variations in the basin bottom for plantings and provide a freeboard of 3 inches. When a Rainfall Only Basin is proposed and designed to the minimum depth, the area of the basin is not included in any peak discharge calculations.

Photo 2.2 Rainfall Only Non-contributing Basin

An Expanded Area Non-contributing Basin is located at a local low point of a project site, such as within a paved or disturbed area of the site. When this type of Non-contributing Basin is proposed, the ratio of the immediately upstream drainage area to the pervious basin bottom area must not exceed 2:1. The Expanded Area Basin shall be 12 inches deep to account for 9 inches of water storage, and 3 inches of freeboard to the top of the adjacent drainage area shall be provided. An Expanded Area Basin and the area draining to it that meet the above criteria are not included in any peak discharge calculations. Figure 5.3 illustrates an application of an Expanded Area Basin within a parking lot median.

2.4.4 Bioretention Basins

Bioretention is the practice of constructing a depressed area specifically to capture and infiltrate water using a constructed soil medium planted with vegetation. Bioretention basins may be used in the same location as stormwater harvesting basins or roadside basins but contain a soil medium that encourages infiltration, soil moisture storage and plant growth. Bioretention basins enhance infiltration characteristics, allowing the same surface planting area to collect more water, potentially reducing the areal extent of stormwater harvesting basins.

The volume captured by a bioretention feature includes both the surface capture volume and the void space of the engineered medium (assumed to be 30%, unless otherwise approved by the Floodplain Administrator).

When bioretention is used, the inlet shall have a sediment trap to capture sediment and organic compounds that may reduce infiltration.

2.5 Retention within Detention Basins

A detention basin also can be designed to retain stormwater, and the volume of the retention within the detention basin can be used to meet the first-flush retention requirement.

Detention basins with uniform side slopes and no terraces may incorporate retention for a maximum depth of 9 inches below the lowest outlet elevation. The volume provided below the outlet can be counted as retention volume. If infiltration testing is provided, the retained depth may be increased.

Detention basins with uniform side slopes and no terraces may incorporate retention for a maximum depth of 9 inches below the lowest outlet elevation. The volume provided below the outlet can be counted as retention volume. If infiltration testing is provided, the retained depth may be increased.

3. PEAK DISCHARGE RATE REDUCTION

3.1 Peak Discharge Rate Reduction Requirements

The required reduction of post-developed 2-, 10- and 100-year peak discharge rates depends on whether the project site is located in a Balanced or Critical Basin.

Within a Balanced Basin, post-developed peak discharge rates shall not exceed pre-developed peak discharge rates at the project boundary.

Within a Critical Basin, post-developed peak discharge rates shall not exceed 85% of pre-developed peak discharge rates at the project boundary, unless a different percentage is specified by the Floodplain Administrator.

A Critical Basin map is available through the Rules and Procedures page of the District's web page. All areas of unincorporated Pima County which are not designated as being located within a Critical Basin are designated as being located within a Balanced Basin.

3.2 Peak Discharge Rate Determination

3.2.1 Pre-Developed Conditions

The pre-developed conditions peak discharge rates for each return period(Qpre-rp) may be established using the City of Tucson STANDARDS MANUAL FOR DRAINGE DESIGN AND FLOODPLAIN MANAGEMENT, modeling methods described in the District's Technical Policy, TECH-015, Acceptable Methods for Determining Peak Discharges, and Technical Policy, TECH-018, Acceptable Model Parameterization for Determining Peak Discharges, and any other technical policies as specified by the Floodplain Administrator. The District's Technical Policies are available through the Rules and Procedures page of the District's web page.

3.2.2 Post-Developed Conditions

Post-developed conditions peak discharge rates for each return period ($Q_{post-rp}$) shall be established using the same methods as for pre-developed conditions.

3.3 Peak Discharge Rate Reduction by Stormwater Harvesting Basins

The optional use of stormwater harvesting basins throughout a project site can reduce the size of or eliminate downstream detention basins. Distributing stormwater retention throughout the site reduces the volume of runoff flowing to a detention basin or other conveyance downstream and may increase the time of concentration.

Where stormwater harvesting basins are proposed, the following method, or other acceptable methods approved by the Floodplain Administrator, shall be used to quantify the peak discharge rate reduction for each return period. Example calculations are presented in Appendix B.

1. Calculate the post-development runoff volumes ($V_{post-rp}$) and peak discharge rates ($Q_{post-rp}$) for the 2-, 10-, and 100- year events (e.g. $V_{post-2}, V_{post-10}, V_{post-100}$) for each watershed. Runoff volume shall be obtained from Equation 3.1.

   $Equation\ 3.1 \qquad V_{post-rp} = \frac{C_{w-rp}\, P_{1-rp}\, A}{12}$

   Where: A = Watershed area
   C_{w-rp} = Weighted runoff coefficient for the return period, dimensionless
   P_{1-rp} = 1-hour rainfall depth for the return period, inches
   $V_{post-rp}$ = Runoff volume for the return period, acre feet

   The solution to Equation 3.1 is the runoff volume reported in the PC-Hydro hydrograph report. The total runoff volume obtained from addition at all-time steps of the PC-Hydro hydrograph is an approximation of the runoff volume obtained from Equation 3.1.

2. Calculate the volume of proposed stormwater harvesting basins (V_{bas}) for each post-developed watershed. Retention volume within a detention basin is not included as stormwater harvesting basin volume because retention volume within a detention basin is incorporated in detention routing calculations.

3. Determine the area of the watershed that will flow to or through stormwater harvesting basins (A_s) and the total watershed area (A_t). Calculate the percent watershed area draining to stormwater harvesting (W_A) by Equation 3.2.

   $Equation\ 3.2 \qquad W_A = \frac{A_s}{A_t}$

4. Calculate the ratio (X_{rp}) of the basin volume (V_{bas}) to the post-development runoff volume ($V_{post-rp}$) for each return period by Equation 3.3.

   $Equation\ 3.3 \qquad X_{rp} = \frac{V_{bas}}{V_{post-rp}}$

   Or

$X_{rp} = W_A$, whichever is less.

For example, $X_2 = \frac{V_{bas}}{V_{post-2}}$

5. The Stormwater Harvesting Factor (H_{rp}) for each return period is calculated by Equation 3.4. See Appendix C for details on how the Stormwater Harvesting Factor was developed and for a table of factors.

   $Equation\ 3.4 \qquad y = -0.3843{X_{rp}}^2 + 1.4618X_{rp} - 0.133$

   For project submittals where stormwater harvesting basins are proposed, a spreadsheet, PC-LID, which automatically returns the correct factor and calculates the peak discharge rate reduction due to stormwater harvesting basins is provided on the Rules and Procedures page of the District's web page.

6. Use H_{rp} to determine the post-development peak discharge rate with stormwater harvesting for the return period, Q_{swh-rp}, by Equation 3.5.

   $Equation\ 3.5 \qquad Q_{swh-rp} = Q_{post-rp}(1 - H_{rp})$

   If Q_{swh-rp} is equal to or less than Q_{pre-rp} required for Balanced or Critical Basins for all 3 return periods, then additional detention is not required.

   If Q_{swh-rp} is greater than Q_{pre-rp} required for Balanced or Critical Basins for any return period, then additional detention is required.

   In calculating the required amount of additional detention, an adjusted inflow hydrograph which accounts for the storage volume and attenuation provided by stormwater harvesting basins can be incorporated in the detention basin routing methods of Section 3.4.

   If an adjusted inflow hydrograph is desired, PC-LID shall be used to convert the detention basin inflow hydrographs without stormwater harvesting into detention basin inflow hydrographs with stormwater harvesting. The parameters provided in this section shall be used. The method used by PC-LID to modify a PC-Hydrograph to account for stormwater harvesting is presented in Appendix E.

   In addition to attenuating the peak discharge rate for a given return period, Q_{swh-rp}, stormwater harvesting basins reduce the post-development runoff volume, V_{swh-rp}.

The amount of volume reduction for a given return period can be estimated by Equation 3.6 as:

$$Equation\ 3.6 \qquad V_{swh-rp} = V_{post-rp}\left(1 - X_{rp}\right)$$

Volume reduction, as well as peak discharge reduction, can be calculated by PC-LID.

3.4 Methods to Calculate the Peak Discharge Rate Reduction by Detention Basins

Incorporation of LID practices and site layout practices can minimize or eliminate the requirement for detention basin volume. When optional LID practices are not included in site design or when LID practices do not reduce peak discharge rates to required levels, detention basins must be included in site design.

The amount of peak discharge rate reduction provided by a detention basin shall be determined by the storage-indication method which calculates change in storage over a time step by Equation 3.7:

$$Equation\ 3.7 \qquad \frac{(I_{t+1} + I_t)}{2}\Delta t - \frac{(O_{t+1} + O_t)}{2}\Delta t = S_{t+1} - S_t$$

Where:

I_t	=	Inflow at time t
I_{t+1}	=	Inflow at time t + 1
O_t	=	Outflow at time t
O_{t+1}	=	Outflow at time t + 1
S_t	=	Storage volume at time t
S_{t+1}	=	Storage volume at time t + 1

The average inflow over a time step minus the average outflow over a time step equals the change in storage volume during that time step.

Developing a basin design with sufficient storage volume and an outlet design with an appropriate storage-discharge relationship, results in an outflow hydrograph with the target peak discharge. The target discharge will be the pre-developed peak discharge for Balanced Basins or 90% 0of the pre-developed peak discharge for Critical Basins. The Floodplain Administrator may specify a percentage other than 90% for Critical Basins.

The District's PC-Route spreadsheet is recommended for basin routing because results are standardized and consistent across projects. Reviewer proficiency is required and not possible when software not available to the District is utilized. An instruction manual and example are available on the District's web page. HEC-HMS is also acceptable software for basin routing.

Other programs in the public domain may be used if approved by the Floodplain Administrator. Permission to utilize software other than the District's spreadsheet or HEC-HMS must be obtained in writing from the Floodplain Administrator prior to submittal of the detention analysis.

The process of designing a basin and associated outlets is usually iterative. That is, an estimated volume and basin shape are assumed for the first iteration. The estimated basin volume may be obtained from Equation 3.8:

$$Equation\ 3.8 \qquad V_s = \frac{C_w P_t A}{12}\left[1 - \frac{Q_o}{Q_i}\right]$$

Where:

	A	=	Watershed area, acres
	C_w	=	Weighted runoff coefficient reported by PC-Hydro for developed conditions, dimensionless
	P_t	=	1-hour rainfall depth for the design storm under investigation, inches
	Q_i	=	Detention basin inflow, cubic feet per second
	Q_o	=	Detention basin outflow, cubic feet per second
	V_s	=	Estimate of required storage volume, acre feet

Once an initial estimate of the storage volume is obtained, the size of outlet structures is assumed. A trial run gives results which may reach the target for all or none of the 3 design storms. By adjusting the basin and outlet configurations, the designer can successively approximate the design needed to reach regulatory criteria for all 3 design storms. First-flush retention volume, calculated by Table 2.1, when provided within a detention basin should be included in the detention routing calculations.

4. DETENTION BASIN DESIGN STANDARDS

The following design standards apply when detention basins are proposed. Deviation from these standards requires written approval of the Floodplain Administrator. Additional standards to address specific site conditions may apply. If retention is proposed within a detention basin, design shall also follow the standards in Section 5.8 which supersedes any conflicts with this Chapter.

Requirements for drainage reports are provided in Chapter 10, Drainage Report Content. Requirements for plats, development plans and construction plans are provided in Chapter 11, and Chapter 12 includes required content for as-built plans. Inspection and maintenance requirements are provided in Chapter 7. Typical details required on plans are provided in Appendix E.

4.1 Detention Basin General Requirements

1. Inspection and maintenance are required for all basins. An inspection and maintenance protocol including frequency of inspection, a checklist of items to be inspected and recommended maintenance when an inspection identifies a maintenance requirement shall be prepared by an Arizona registrant. The protocol may be included in the project drainage report or prepared as a separate document. The protocol shall be reviewed and approved by the Floodplain Administrator prior to approval of the tentative plat or development plan. The protocol shall be delivered to the entity responsible for inspection and maintenance. An example of a detention basin inspection and maintenance checklist is provided in Appendix F.

2. To allow performance of inspection and maintenance, basins shall be legally and physically accessible.

3. Upon completion of construction of all basins, an As-built Certification of the basin shall be prepared by an Arizona registrant and submitted to the Floodplain Administrator and entity responsible for basin maintenance. The plan associated with the As-built Certification shall be used by the responsible party when performing periodic inspections and when restoring the basin to design specifications. The Floodplain Administrator may utilize the certification during enforcement actions.

4. Any modification of a basin, other than routine maintenance, that would affect volume or performance requires a Floodplain Use Permit.

5. When detention basins are to be maintained by a private entity, such as a Homeowners Association, this responsibility shall be described in the association's Covenants, Conditions and Restrictions which shall refer to the inspection and maintenance protocol and As-built Certification.

4.2 Detention Basin General Prohibitions

1. Although the use of stormwater and rainwater harvesting facilities on private residential lots is encouraged, any retention volume on private residential lots shall not be counted towards reducing the required detention volume for the project.

2. Counting rainwater harvesting cistern volume to reduce the required detention volume is prohibited.

3. On-line detention within regulatory floodplains is prohibited without the approval of the Floodplain Administrator.

4. Walls within detention basins are not allowed without the approval of the Floodplain Administrator.

4.3 Detention Basin Location and Collection

4.3.1 Detention Basin Location and Collection Standards

1. Basins shall be located within the project boundary.

2. Basins shall be located to ensure that post-development flow depth, width and velocity approximate pre-developed flow conditions when flow exits the project boundary.

3. To allow maintenance access, a minimum 4-foot setback from basins and appurtenances, including basin outlets and outer toes of embankments (but not including outlet protection), to the project boundary shall be provided, unless:
   a. A greater setback is required to comply with Section 4.3.1.2, or
   b. Other adequate access space exists adjacent to the basin, such as right-of-way.

   The measurement from the outlet to the property line is illustrated in Figure 4.1.

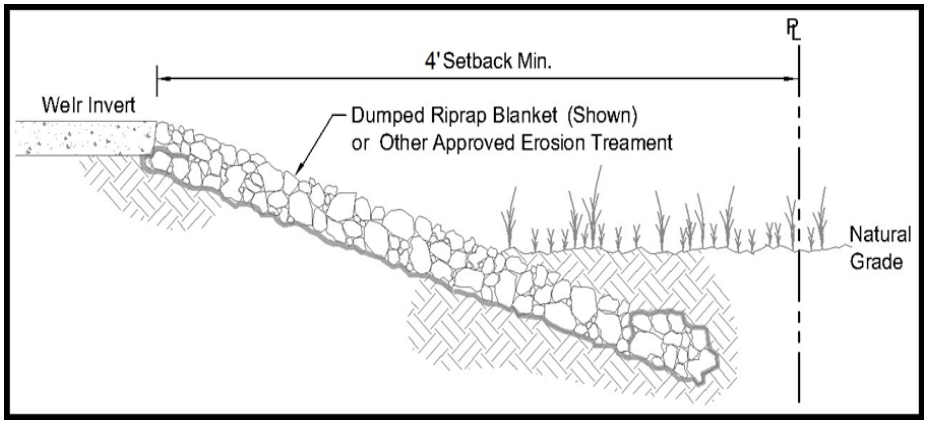


Figure 4.1 Minimum Setback from Property Line

4. In subdivisions, detention basins shall be located in Common Area for Drainage.

5. Basins shall be located to avoid the use of embankments, if possible.

6. When basins are located to accept flows from predominantly natural areas, sediment basins shall be required at inlets. The configuration and volume of the sediment basin shall be determined by an engineer registered in the State of Arizona.

7. When basins are proposed within a regulatory floodplain or erosion hazard area, they shall be designed to withstand all flood and erosion hazards. In addition, it shall be demonstrated that the basin will provide required detention for the 2-, 10- and 100-year on-site flows during a flood event on the regulatory water course.

4.3.2 Detention Basin Location and Collection Prohibitions

1. Inlets or outlets which direct flow to a sidewalk or other paved pedestrian pathway shall include a scupper or other conveyance to prevent sidewalk or pathway overtopping by the 10-year design discharge. Inlets or outlets shall not direct flow over decomposed granite or other erodible pedestrian pathways.

2. Inlets or outlets shall not direct flow through a handicap accessible ramp or handicap parking space.

3. Post-development alterations that affect the function or design of drainage infrastructure are prohibited unless prior approval is obtained from the Floodplain Administrator. Alterations requiring approval include, but are not limited to, alteration of drainage structures, construction of new improvements and post-development site grading which increases flows or causes flows to bypass the basin.

4.4 Detention Basin Depth and Freeboard

4.4.1 Detention Basin Depth and Freeboard Standards

1. Minimum freeboard shall be 6 inches within basins constructed below natural grade and 12 inches within basins designed with an embankment.

2. Freeboard is measured from the 100-year water surface elevation to the lowest top of the basin bank, as shown in Figure 4.2. The freeboard requirement does not apply to weirs or spillways.

3. The water depth is measured from the lowest elevation on the basin floor to the top of the 100-year water surface elevation, as shown in Figure 4.2.

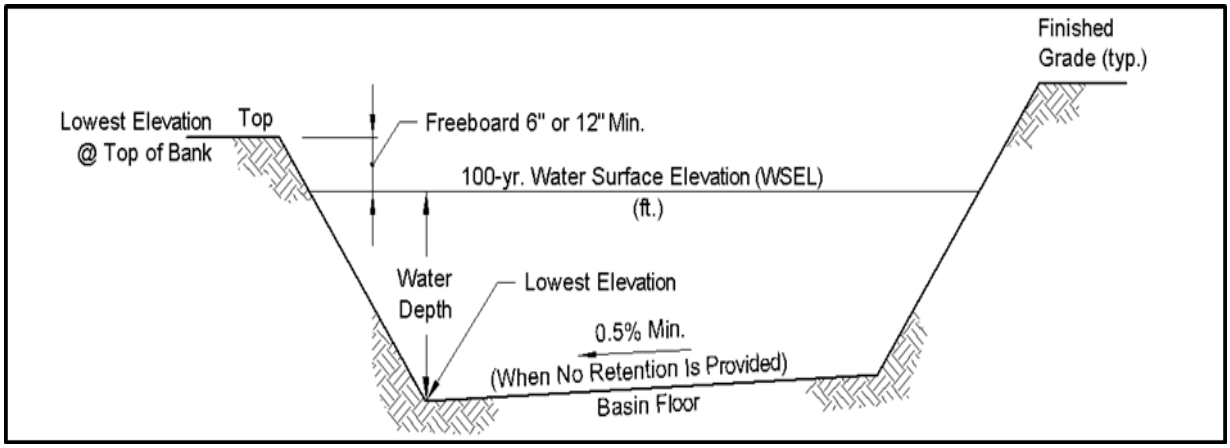


Figure 4.2 Basin Depth and Freeboard Requirements

4. Basins shall have a minimum of 1 sediment level measurement device, which can be incorporated into the weir or the side slope, or constructed as a separate stand-alone device. The device(s) shall be located where sediment is likely to accumulate.

5. Basins designed for 100-year water depths of greater than 2 feet and with side slopes steeper than 4:1 shall have a security barrier at all locations where side slopes are steeper than 4:1. Security barriers shall meet the requirements found in Section 4.11.

4.4.2 Detention Basin Depth Prohibition

1. 100-year water depth shall not exceed 6 feet, unless approved by the Floodplain Administrator.

4.5 Storage Time

4.5.1 Storage Time Standards

1. The maximum storage time for a basin that intercepts runoff from a watershed up to 10 acres in size is 12 hours. The storage time is defined as the time required for stormwater to be removed from the basin.

2. The maximum storage time for a basin that intercepts runoff from a watershed greater than 10 acres in size is 24 hours. The storage time is defined as the time required for stormwater to be removed from the basin.

4.5.2 Storage Time Prohibitions

1. Storage times which exceed the times specified in Section 4.5.1 are prohibited.

2. Ponding times which result in health and safety issues are prohibited, and an enforcement action may be initiated by the Floodplain Administrator for correction of the ponding times.

4.6 Basin Floor

4.6.1 Basin Floor Standards

1. Unless retention is provided in the basin, the basin floor shall be graded to a minimum slope of 0.5% to provide positive drainage to the basin outlet, as illustrated in Figure 4.3.

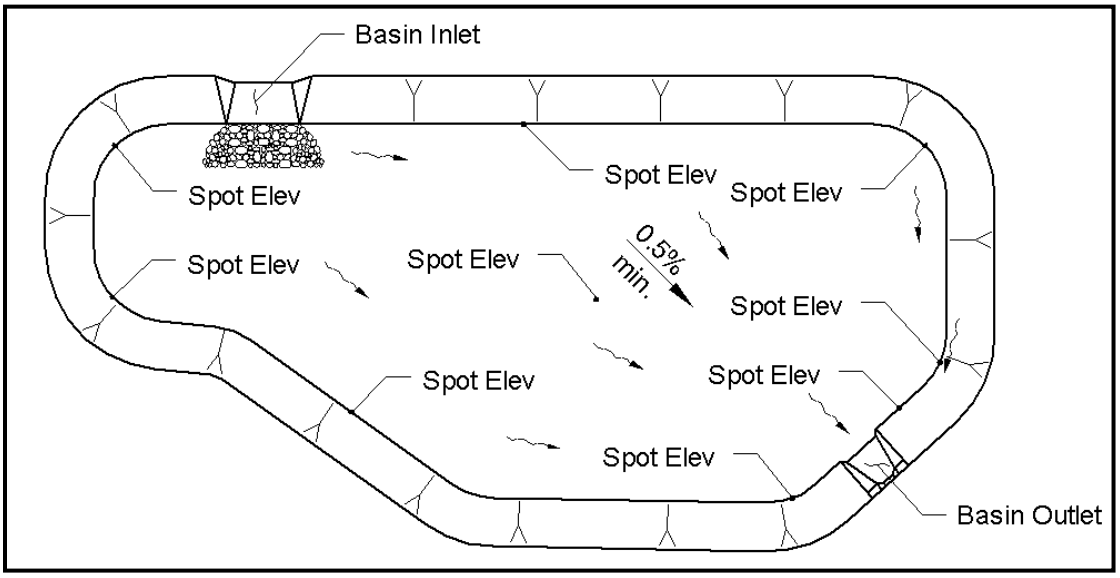


Figure 4.3 Basin Floor Minimum Slope for Positive Drainage

2. The basin floor may be hydroseeded. If hydroseeding is proposed, plant species used in the seed mix shall be selected from the Approved Plant List provided in Appendix B of the Pima County Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines available on the Rules and Procedures page of the District's web page.

3. Other types of vegetation shall comply with Section 4.17.

4.6.2 Basin Floor Prohibitions

1. Except for paths within multi-use basins, the use of decomposed granite or rock less than 4 inches in diameter on the basin floor is prohibited.

2. Invasive non-native plants on the basin floor are prohibited, except for turf grass in multi-use basins.

4.7 Side Slopes

4.7.1 Side Slope Standards

1. Recommended side slope stabilization is presented in Table 4.1, or as otherwise specified in the geotechnical report.

Table 4.1 Side Slope Stabilization

Side Slope Ratio	Stabilization Method
3H:1V or flatter	Approved hydroseed Screened rock with minimal fines Dumped riprap with filter fabric
no steeper than 2H:1V	Hand placed riprap with filter fabric Gabion mattress
no steeper than 1.5H:1V	Articulated revetment units
no steeper than 1H:1V	Grouted riprap Concrete lining with welded wire fabric Gabions
steeper than 1H:1V	Retaining wall

2. The following standards apply to riprap side slope treatments:
   a. Dumped riprap shall have a D_{50} of at least 6 inches and be placed with a blanket thickness of 2 times the D_{50} .

b. Hand placed or dumped riprap shall consist of hard, durable angular stone in erosive environments. In non-erosive environments, non-angular stone is allowed. Gradation shall be provided as described in Table 4.2.

Table 4.2 Dumped or Hand Placed Riprap Gradation

Dumped/Hand Placed Riprap Gradation	
% Passing	Size
100 - 90	2.00 D_{50}
85 - 70	1.50 D_{50}
50 - 30	1.00 D_{50}
15 - 5	0.67 D_{50}
5 - 0	0.33 D_{50}

c. Unless grouted, rock riprap shall be underlain with filter fabric. The filter fabric shall be woven for a minimum of 2 feet into the upper end of the blanket and wrapped for a minimum of 2 feet around the riprap base of the blanket as illustrated in Figure 4.4.

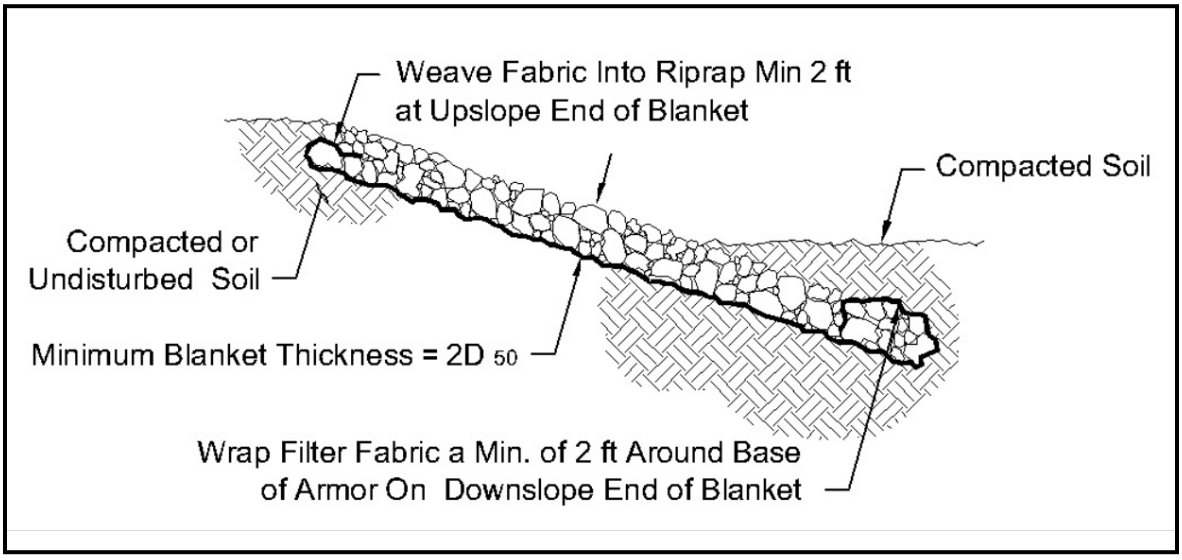


Figure 4.4 Riprap Blanket with Filter Fabric End Treatment

d. Grouted riprap shall be placed on a grout bed at least 6 inches thick. Stones shall be hard, durable and hand-embedded into the grout bed to a minimum depth of one-half the grout depth.

3. When a retaining wall is proposed as a basin side slope, stability design for the retaining wall shall be provided with the development plan or tentative plat. A detail, accompanied by a report clearly stating the assumptions about all soil parameters under saturated conditions, shall be provided and sealed by an Arizona registrant.

4. When hydroseeding is proposed as slope treatment, plant species used in the seed mix shall be selected from the Approved Plant List provided in Appendix B of the Pima County Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines available on the Rules and Procedures page of the District's web page.

4.7.2 Side Slope Prohibitions

1. Free-standing walls are not allowed as a basin side, without prior approval of the Floodplain Administrator.

2. Retaining walls greater than 4 feet measured from the top of the footing are not allowed as a basin side unless prior approval is obtained from the Floodplain Administrator.

3. Riprap that consists of rock that is not hard and durable is not allowed.

4. Invasive non-native plants located on a basin side slope are not allowed. A list of the invasive non-native plants can be found in Appendix E of the Pima County Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines available on the Rules and Procedures page of the District's web page.

4.8 Inlet Structures

4.8.1 Inlet Structure Standards

1. The capacity of an inlet structure shall be determined by methods provided in:
   a. *Drainage and Channel Design Standards for Local Drainage for Flood Plain Management within Pima County, Arizona;*
   b. The *City of Tucson Standards Manual for Drainage Design and Floodplain Management in Tucson, Arizona*; or
   c. Other methods accepted by the Floodplain Administrator.

2. When flow crosses a sidewalk or other paved pedestrian pathway, a scupper or other conveyance to prohibit overtopping of the 10-year design discharge shall be used. Inlets shall not direct flow over decomposed granite or other erodible pedestrian pathway.

3. When pipes are used as an inlet, the minimum size allowed is 12 inches.

4. Inlets shall have erosion protection with dimensions determined by the methods provided in the:
   a. *Drainage and Channel Design Standards for Local Drainage for Flood Plain Management within Pima County, Arizona*;
   b. The *City of Tucson Standards Manual for Drainage Design and Floodplain Management in Tucson, Arizona*;
   c. *Federal Highway Administration, Hydraulic Engineer Circular No. 14; HEC-14*; or
   d. Other methods accepted by the Floodplain Administrator.

5. The erosion protection shall extend below the finished grade of the basin floor and/or side slope to the appropriate design depth. The surface of the erosion protection shall be level with the finished grade.

6. Unless grouted, rock riprap shall be underlain with filter fabric. The filter fabric shall be woven for a minimum of 2 feet into the upslope end of the blanket and wrapped for a minimum of 2 feet around the riprap base of the blanket on the down-slope end as shown in Figure 4.4.

   Photo 4.1 shows a basin inlet in service which does not exhibit degradation of the basin slopes or floor near the inlet, indicating that an adequate riprap transition was provided. The standards in this manual attempt to provide guidance for designs which will remain well-maintained during the project life.

Photo 4.1 Basin Inlet with Riprap Protection

Photo 4.2 illustrates inadequate riprap placement resulting in erosion extending away from the basin inlet erosion protection.

Photo 4.2 Basin Inlet with Inadequate Riprap Placement

4.8.2 Inlet Structure Prohibitions

1. Inlets shall not direct flow through a handicap accessible ramp or handicap parking space.

2. Ponding exceeding 12 inches in depth at an inlet located in a vehicular use area is prohibited.

4.9 Outlet Structures

4.9.1 Outlet Structure Standards

1. Outlets shall be designed to ensure that flows exiting the project boundary are compatible with the existing downstream drainage conditions and will not have an adverse impact on surrounding properties.

2. Outlets shall be designed to release flow from the basin at rates that do not exceed the 2-, 10- and 100-year pre-development peak discharge rates as determined by the methods specified in Chapter 3. Illustrations of outlet structures indicating that outlets must be

designed for 3 design storms are shown in Figures 4.5 and 4.6 and Photo 4.3. The examples are illustrative only and not intended to be proposed or required designs.

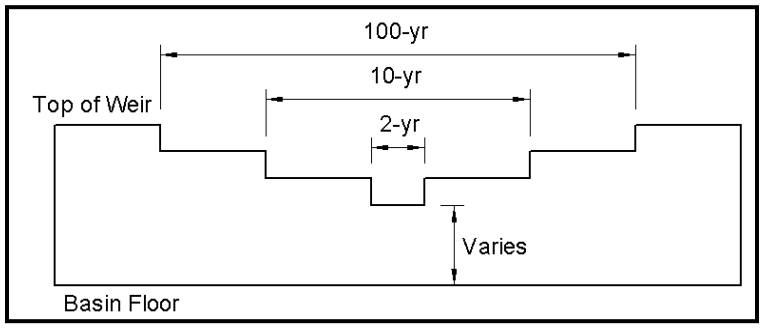


Figure 4.5 Multi-Level Weir Outlet for the 2-, 10-, and 100-year Storms

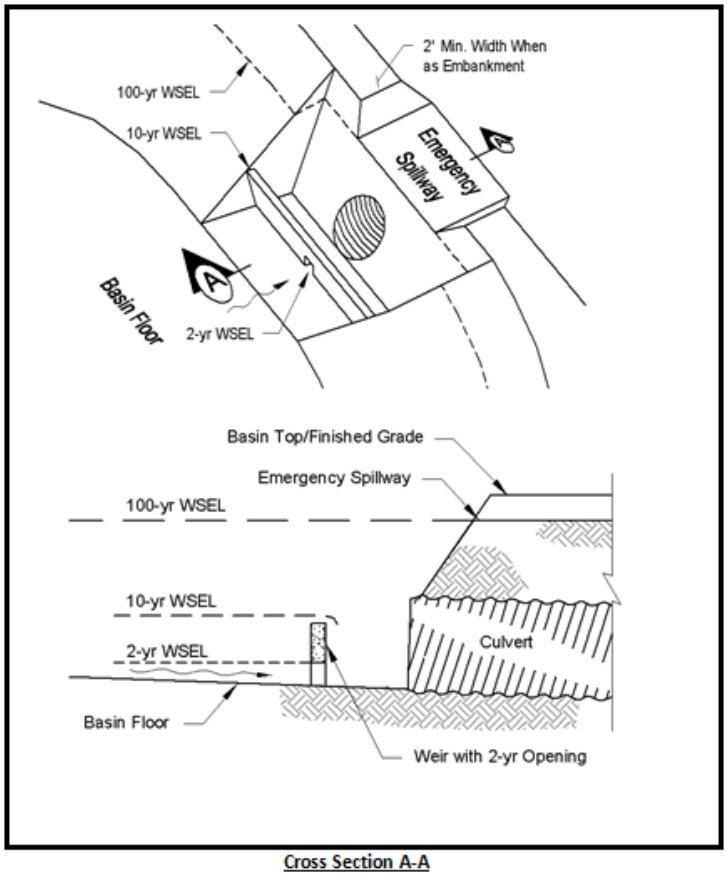


Figure 4.6 Combination Weir – Culvert Outlet

Photo 4.3 Combination Weir Box

3. The capacity of outlet structures shall be determined using methods provided in:
   a. *Drainage and Channel Design Standards for Local Drainage for Flood Plain Management within Pima County, Arizona*;
   b. The *City of Tucson Standards Manual for Drainage Design and Floodplain Management in Tucson, Arizona*; or
   c. Other methods accepted by the Floodplain Administrator.

4. Outlets which direct flow to a sidewalk or other paved pedestrian pathway shall include a scupper or other conveyance to prevent sidewalk or pathway overtopping by the 10-year design discharge. Outlets shall not direct flow over decomposed granite or other erodible pedestrian pathway.

5. Outlets shall have erosion protection with dimensions determined by the methods provided in:
   a. *Drainage and Channel Design Standards for Local Drainage for Flood Plain Management within Pima County, Arizona*;
   b. The *City of Tucson Standards Manual for Drainage Design and Floodplain Management in Tucson, Arizona*;
   c. *Federal Highway Administration, Hydraulic Engineer Circular No. 14; HEC-14; or*
   d. Other methods accepted by the District.

6. The erosion protection shall be placed beneath the finished grade of the downstream side of the outlet to the appropriate design depth. The surface of the erosion protection shall be level with the finished grade.

7. Unless grouted, rock riprap shall be underlain with filter fabric. The filter fabric shall be woven a minimum of two feet into the upslope end of the blanket and wrapped for a minimum of two feet around the riprap base of the blanket on the down-slope end as shown in Figure 4.4.

4.9.2 Outlet Structure Prohibition

1. Outlets shall not direct flow to a handicap accessible ramp or handicap parking space.

4.10 Embankments

An embankment, for the purposes of this manual, is a side of a detention basin constructed above natural grade. A typical embankment is illustrated in Photo 4.4.

Photo 4.4 Residential Subdivision Basin with Embankment

4.10.1 Embankment Standards

1. When site constraints prevent a basin from being constructed entirely below grade, an embankment is allowed. Site constraints include topography, existing infrastructure and conflicting code requirements.

2. When an embankment is proposed, the applicant shall include an embankment section in the drainage report describing at least the following:
   a. The physical environment downstream of the embankment, such as natural drainage paths, drainage infrastructure, developed property, and distance to property boundary;

8. A bleed pipe or other outlet may be added to the basin provided that its discharge rate and invert elevation meets the requirements of section 9. Unless a waiver has been granted per Section 9, the bleed pipe shall be capped and for maintenance purposes only.

b. Expected flow conditions in the event of embankment failure; and
c. Possible effects to public safety and property in the event of embankment failure.

3. Embankments shall have a top width of the 100-year ponding depth or 2 feet, whichever is greater.

4. Embankments shall have at least 1 foot of freeboard above the 100-year water surface elevation in the basin.

5. Embankments shall be compacted to at least 95% of Standard Proctor density.

6. A minimum of 6 inches, or depth recommended by an engineer registered in the State of Arizona, of in-situ soil beneath the embankment base shall be excavated prior to embankment construction.

7. When an outlet is placed through an embankment, an anti-seep collar or equal, shall be provided as specified by an Arizona registered engineer.

8. To allow maintenance access, a minimum 4-foot setback from the outer toes of embankments (not including outlet protection) to the project boundary shall be provided, unless:
   a. A greater setback is required to comply with Section 4.3.1.2; or
   b. Other adequate access space exists adjacent to the basin, such as right-of-way.

   Width, spillway, and setback measurement are illustrated in Figure 4.7.

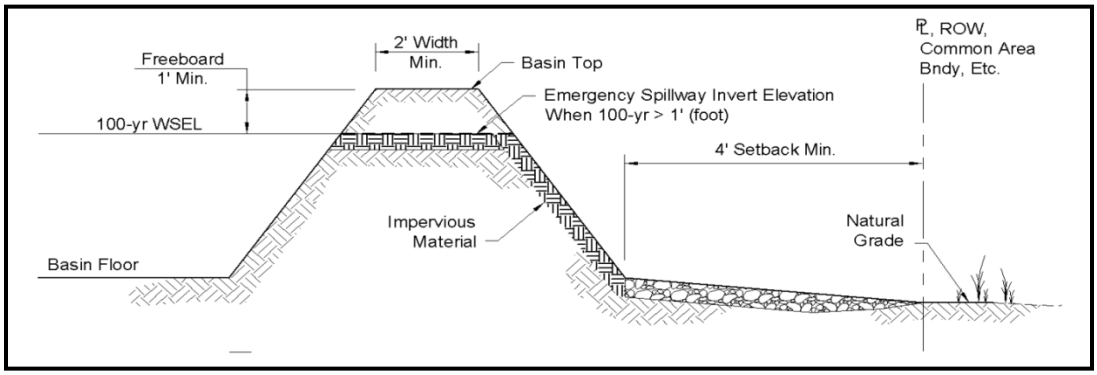


Figure 4.7 Embankment Requirements

9. When embankments are designed to impound greater than 1 foot of water,
   a. An emergency spillway shall be provided;
   b. The emergency spillway invert elevation shall be at the 100-year water surface elevation;

c. The invert and the downstream side of the emergency spillway, as shown in Figure 4.7, shall be constructed of impervious material;
d. The design capacity of the emergency spillway shall be the pre-developed 100-year peak discharge outflow rate. The outlet is not included in the routing because it is at the 100-year water surface elevation which is the highest water surface elevation used for routing; or
e. The location of the emergency spillway shall not create any adverse impact to surrounding properties.

10. When an embankment is located within an erosion hazard setback or regulatory sheet flood area, an engineering analysis shall be provided to determine erosion protection requirements which will protect the embankment from lateral migration of the watercourse or other erosion hazards.

11. A separate covenant which specifies, or Conditions, Covenants and Restrictions (CCRs) which include, inspection and maintenance responsibilities shall be recorded when a basin includes an embankment. An example covenant can be found in Appendix G. The covenant or CCRs shall be reviewed and approved by the Floodplain Administrator prior to approval of the development plan or plat. For separate covenants, a properly executed covenant shall be provided to the Floodplain Administrator for recording prior to approval of the development plan. For CCRs, Floodplain Administrator approval is required prior to plat approval, and the CCRs will be recorded by the development services department.

4.10.2 Embankment Prohibition

1. Embankments that are classified as dams pursuant to Arizona Revised Statutes §45-1201 are prohibited.

4.11 Security Barrier

4.11.1 Security Barrier Standards

1. Basins designed for 100-year water depths of more than 2 feet and with side slopes steeper than 4:1 shall have a security barrier at all locations where side slopes are steeper than 4:1.

2. Security barrier shall be a minimum of 42 inches high.

3. The security barrier shall consist of metal, masonry or a combination of the two, meeting the minimum standards in the latest edition of the *City of Tucson/Pima County Standard Details for Public Improvements*.

4. When 100-year water depths exceed 2 feet and pedestrian circulation occurs within 5 feet of the top of a basin, a security barrier shall be constructed. Pedestrian circulation includes ingress/egress to structures, sidewalks, parking or other accessory structures.

5. When vehicle maintenance access is required, a gate or bollards shall be provided at the appropriate location.

4.11.2 Security Barrier Prohibitions

1. The use of vegetation as a security barrier is prohibited.

2. Security barriers shall not restrict the hydraulic capacity of basin inlet and outlet structures.

4.12 Perimeter Walls

4.12.1 Perimeter Wall Standards

1. When perimeter walls have openings that allow flow to enter into a basin, erosion protection that meets the minimum standards of Section 4.8 for inlets shall be provided.

2. When a wall is proposed within 5 feet of the horizontal location of the 100-year water depth, a report from an engineer registered in the State of Arizona shall be provided prior to approval of the construction permit that contains at least the following:
   a. The appropriate minimum setback from the top of slope; and
   b. Specific structural design requirements with details.

4.12.2 Perimeter Wall Prohibitions

1. Perimeter walls shall not block maintenance access.

2. Perimeter walls shall not restrict the hydraulic capacity of inlet or outlet structures.

3. Perimeter walls are not allowed on embankments.

4.13 Underground Storage

4.13.1 Underground Storage Standards

1. Design considerations shall include underground storage location and emergency flow conveyance to assure foundation stability and safe conveyance of flow in the event of blockage or failure of an underground storage system.

2. All stormwater collected during a storm event shall be removed within the disposal time specified in Section 4.5.

3. Underground storage shall have inlets and outlets which meet the design standards found in Sections 4.8 and 4.9.

4. Underground storage systems shall provide 1.5 times the required 100-year detention volume. The additional 50% of the volume can be provided on the surface so that issues with improper drainage are observable.

5. Minimum underground storage chamber size shall be 5 feet, unless manholes are provided for inspection and maintenance.

6. To provide for safe discharge of flow when the volume of an underground storage system is exceeded, an overflow outlet shall be provided which discharges to a drainage path which can convey flow away from structures, electrical equipment, pedestrian pathways, handicap-accessible ramps, hazardous materials, and other areas where stormwater is likely to create damage to health, welfare or property.

7. A separate covenant which specifies, or Conditions, Covenants and Restrictions (CCRs) which include, inspection and maintenance responsibilities shall be recorded when a project includes an underground storage system. An example covenant can be found in Appendix G. The covenant or CCRs shall be reviewed and approved by the Floodplain Administrator prior to approval of the development plan or plat. For separate covenants, a properly executed covenant shall be provided to the Floodplain Administrator for recording prior to approval of the development plan. For CCRs, Floodplain Administrator approval is required prior to plat approval, and the CCRs will be recorded by the Development Services Department.

8. Prior to approval of the tentative plat or development plan, a report from an engineer registered in the State of Arizona shall be provided that contains at least the following:
   a. Appropriate building setbacks from the underground storage system related to structural integrity;

b. Certification that the load bearing capacity of the soils underlying the underground storage structure is adequate and the soil complex is appropriate bed material;
c. Structural design details; and
d. Other design recommendations if appropriate.

4.13.2 Underground Storage Prohibitions

1. Where underground storage is proposed, failure or blockage of the system shall not pose a hazard to public safety or property.

2. Infiltration as a means of disposal is prohibited, without prior approval of the Floodplain Administrator.

3. Providing first flush retention underground is prohibited, without prior approval of the Floodplain Administrator

4.14 Setbacks

4.14.1 Setback Standards

1. For maintenance access, a minimum 4-foot setback from basins and appurtenances, including basin outlets and outer toes of embankments but not including outlet protection, to the project boundary or to the limit of other access space shall be provided.

2. Because soil bearing capacity within a potential zone of saturation may be reduced, structures shall be set back at least 15 feet from a basin, unless an appropriate alternative setback is justified by an engineer registered in the State of Arizona prior to approval of the tentative plat or development plan.

3. When a wall is proposed within 5 feet of the horizontal location of the 100-year water surface elevation, a report from an engineer registered in the State of Arizona shall be provided prior to approval of the construction permit that contains at least the following:
   a. The appropriate setback; and
   b. Specific structural design requirements with details.

4.14.2 Setback Prohibition

1. Structures, walls, or other obstructions are prohibited within maintenance access setbacks.

4.15 Elevation Requirements

1. Any electrical equipment, excluding submersible pumps, within the basin shall be elevated 1 foot above the 100-year water surface elevation of the basin, unless an engineer registered in the State of Arizona certifies that the electrical equipment when inundated does not pose any hazard to public health or safety.

4.16 Maintenance Access

4.16.1 Maintenance Access Standards

1. Maintenance access is required for all basins, and the access must be shown on the plans and described in the project drainage report.

2. In order to provide maintenance access, a minimum 4-foot setback from basin appurtenances and outer toes of embankments, not including outlet protection, to the project boundary or to the limit of other access space, such as right-of-way, shall be provided. An example of a setback from a property line is shown in Figure 4.1.

4.16.2 Maintenance Access Prohibition

1. Obstruction of maintenance access or a maintenance access ramp is prohibited.

4.17 Landscaping other than Riparian Habitat Mitigation

4.17.1 Landscaping Standards

1. Vegetation may be planted on a basin floor or on a basin side slope that is 3:1 or flatter except in areas within a 20-foot radius of the basin inlet, outlet or maintenance access ramp. Plants on the perimeter of a basin shall not obstruct drainage entering or exiting the basin.

2. Plants which can withstand inundation shall be selected.

3. Plants shall be spaced to allow access for maintenance.

4. Trees located adjacent to a required security barrier shall be placed an appropriate distance from the barrier to assure that the tree at maturity does not reduce the structural integrity of the security barrier.

5. Hydroseeding is allowed on the basin floor and 3:1 or flatter side slopes. Plant species used in the seed mix shall be selected from the Approved Plant List provided in Appendix B of the Pima County Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines available on the Rules and Procedures page of the District's web page.

4.17.2 Landscaping Prohibitions

1. Any vegetation within the 20-foot radius described in Section 4.17.1 is prohibited.

2. Landscaping shall not be located within maintenance access ramps.

3. The use of decomposed granite or rock less than 4 inches in diameter on the basin floor is prohibited, except paths within multi-use basins.

4. Invasive non-native plants located within a basin are not allowed, except turf grass within multi-use basins.

4.18 Pumps

4.18.1 Pump Standards

1. The use of a pump may be allowed if site constraints prevent the basin from having positive drainage. Site constraints may include topography, existing infrastructure and conflicting code requirements. Approval to use a pump shall be obtained from the Floodplain Administrator prior to the first submittal of the tentative plat or development plan.

2. If a pump is proposed, the detention system shall provide an emergency spillway directed to a local watercourse that does not cause an adverse impact to the watercourse or neighboring properties and one of the following:
   a. Additional basin volume to contain the entire volume of the 100-year post-developed hydrograph from the drainage area contributing to the basin; or
   b. A back-up pump with an emergency power source. If an emergency back-up generator is proposed, the generator shall be elevated 1 foot above the 100-year water surface considering total pump failure or shall be waterproofed.

3. Service equipment (excluding components whose design requires submersion) shall be set at an elevation 1 foot above the unattenuated 100-year water surface elevation, considering total failure of the pump system.

4. Outlets shall be designed to meet the requirements found in Section 4.9.

5. Pumps shall be in an accessible location for routine maintenance and emergency service.

6. Basins with a pump shall meet the storage time standards found in Section 4.5.

7. The collection system shall discharge into a separate sump that screens the water before entering the pump sump. The sump location and dimensions shall be shown on the plan set.

8. A clogging factor of 2.0 shall be used for the trash rack/screen design.

9. The pump shall be designed to pass 3-inch solids.

10. A pump shall be provided with an automatic control switch with a vertical float mechanism as well as a manual control.

11. A potable water supply with hose bibs shall be provided to aid in removal of silt and trash.

12. Each pump shall have an alarm system for high water and low water alarm with, at minimum, the following:
    a. A light that provides a visual alert;
    b. The name and phone number of a responsible party clearly displayed on the pump housing and alarm system;
    c. Housing that is vandal proof and weather resistant; and
    d. Other Floodplain Administrator recommendations as appropriate.

13. A separate covenant which specifies, or Conditions, Covenants and Restrictions (CCRs) which include, inspection and maintenance responsibilities shall be recorded when a project includes a pump. An example covenant can be found in Appendix G. The covenant or CCRs shall be reviewed and approved by the Floodplain Administrator prior to approval of the development plan or plat. For separate covenants, a properly executed covenant shall be provided to the Floodplain Administrator for recording prior to approval of the development plan. For CCRs, Floodplain Administrator approval is required prior to plat approval, and the CCRs will be recorded by the development services department.

14. The project's drainage report shall provide the following information:
    a. Emergency back-up plan;
    b. Drainage exhibit showing drainage flow under clogged conditions; and
    c. Maintenance Plan with at minimum the following:
        i. Maintenance schedule;
        ii. Type of maintenance activities; and
        iii. Exhibit showing the location of the pump, alarm systems and other equipment.

15. A pump system analysis shall be submitted for Floodplain Administrator review and approval with the tentative plat or development plan. The analysis shall include:
    a. Site Data
        i. Contributing drainage area(s);
        ii. Location of outfall;
        iii. Capacity of outfall; and
        iv. Inflow hydrograph(s).

b. Pump System Components
   i. Specifications for the model and type of pump(s) proposed including pump curves (single pump and parallel operation). Overloading the pump anywhere on the pump curve is not permitted.
   ii. Location and specifications for intakes and catch basins;
   iii. Controls and alarm system;
   iv. Debris handling;
   v. Location of potable water supply; and
   vi. Location and design of emergency overflow.

c. Hydrologic/Hydraulic Analysis
   i. Headloss calculations for the entire system, including maximum and minimum Total Dynamic Head (TDH) and flow rate;
   ii. Net positive suction head (NPSH) and pump level settings for on, off and alarm positions; and
   iii. Inflow and outflow hydrographs and accumulated inflow and outflow curves (mass flow curves). The use of HEC-HMS is not appropriate for the design of pump systems. A real-time procedure which routes the design inflow hydrograph using pump on and off elevations and actual pump performance curves must be used.

4.18.2 Pump Prohibition

1. The pump's discharge rate shall not exceed the pre-developed conditions 2-year peak discharge rate.

4.19 Dry Wells

4.19.1 Dry Well Standards

1. When site constraints justify use of a dry well or dry wells to dispose of detention volume, approval to include a dry well or dry wells in basin design shall be obtained from the Floodplain Administrator prior to the first submittal of the tentative plat or development plan. When requesting the approval, the engineer must submit field investigation results and a preliminary site plan.
   a. The field investigations shall include:
      i. Logs for soil borings to the anticipated depth of the dry well;
      ii. Determination of depth to groundwater in the proposed locations of drywells; and
      iii. A percolation testing report by an Arizona registered engineer. The percolation testing report shall include the testing methods and results.
   b. The preliminary site plan shall include at minimum:
      i. The location of the proposed dry well(s) and test well(s);
      ii. The location of proposed structures with building footprints;

iii. Parking lot layout including pedestrian circulation; and
iv. The general drainage scheme.

2. Where dry wells are proposed as the sole method of outflow, the basin shall be designed to retain the total of the 100-year storm.

3. Where a dry well is proposed, failure of the system shall not pose a hazard to public safety or property.

4. Dry wells shall be registered with the Arizona Department of Environmental Quality (ADEQ) and designed, operated, and maintained in conformance with the most current ADEQ guidelines.

5. To obtain percolation rates to use in the design of the dry well(s) a percolation test shall be performed to determine a stabilized infiltration rate.

6. De-rating is required to compensate for deterioration of the percolation capacity over time and to provide a factor of safety for silting and grate obstruction. Test results shall be de-rated, using Equation 4.1, based on the in-situ soil conditions.

$Equation\ 4.1 \qquad P_d = \frac{P_r}{D_r}$

Where: D_r = The de-rating factor.
P_d = The design percolation rate in inches/hour,
P_r = The measured stabilized percolation rate in inches/hour, and

a. The following de-rating factors shall be used:
   i. A de-rating factor of 2 for coarse-grained soils (cobbles, gravels and sands),
   ii. A de-rating factor of 3 for fine grained soils (silts and loams), and
   iii. A de-rating factor of 5 for clay soils.
b. The design disposal rate for a dry well, after application of the de-rating factor, should not be less than 0.1 cfs per well nor more than 0.5 cfs. Upon approval of performance, adjusted as presented above, a test well may then be used as one of the functioning dry wells for the project.
c. Drywells not performing to the original design standards shall be refurbished or replaced by the owner or a representative.

7. Dry wells shall be located into a permeable porous stratum to provide a minimum distance of 10 feet between the water table or an impermeable layer and the base of the injection screen and shall be a minimum distance of 100 feet from any water supply well.

8. When dry wells are proposed, the basin floor shall be sloped to the dry wells at a minimum of 0.5% to assure that all wells are utilized for lower water levels.

9. Multiple drywells shall be spaced a minimum of 100 feet apart.

10. A dry well shall be located a minimum of 20 feet from the basin inlet.

11. If landscaping is proposed on the basin floor, the dry well inlet shall be raised 3 inches above the basin bottom elevation.

12. The dry well shall be accessible for routine maintenance and inspection and shall be protected from damage by vehicles.

13. The design of a dry well shall include provisions for trapping sediment within a settling chamber.

14. The system shall use a floating absorbent blanket or pillow to enhance the removal of petroleum-based organics floating on the water, and a hydrophobic petrochemical absorbent with a minimum capacity of 100 ounces per chamber shall be provided.

15. During site development, 1 dry well per basin shall be tested. All dry wells shall be securely covered with filter cloth or other material to prevent silt infiltration during construction. Prior to Release of Assurances for plats and prior to Certificate of Occupancy for development plans, dry wells shall be re-tested if a dry well has been compromised during construction. If the re-test indicates reduced dry well performance, the dry well shall be restored to design specifications prior to Release of Assurances for plats or prior to Certificate of Occupancy for development plans.

16. Landscaping shall be installed a minimum of 4 feet from the perimeter of the bolted ring and grate.

17. The words “Stormwater Only” shall be stamped in raised letters on the drywell grate.

18. A separate covenant which specifies, or Conditions, Covenants andr Restrictions (CCRs) which include, inspection and maintenance responsibilities shall be recorded when a dry well is used as a method of stormwater disposal. An example covenant can be found in Appendix G. The covenant or CCRs shall be reviewed and approved by the Floodplain Administrator prior to approval of the development plan or plat. For separate covenants, a properly executed covenant shall be provided to the Floodplain Administrator for recording prior to approval of the development plan. For CCRs, Floodplain Administrator approval is required prior to plat approval, and the CCRs will be recorded by the Development Services Department.

19. A typical dry well installation is shown in Figure 4.8. A photo of a commercial basin with a dry well installation is shown in Photo 4.5. Debris that has collected after a storm event is evident in Photo 4.5. Regular maintenance and providing clearance around the inlet are important management practices for dry wells.

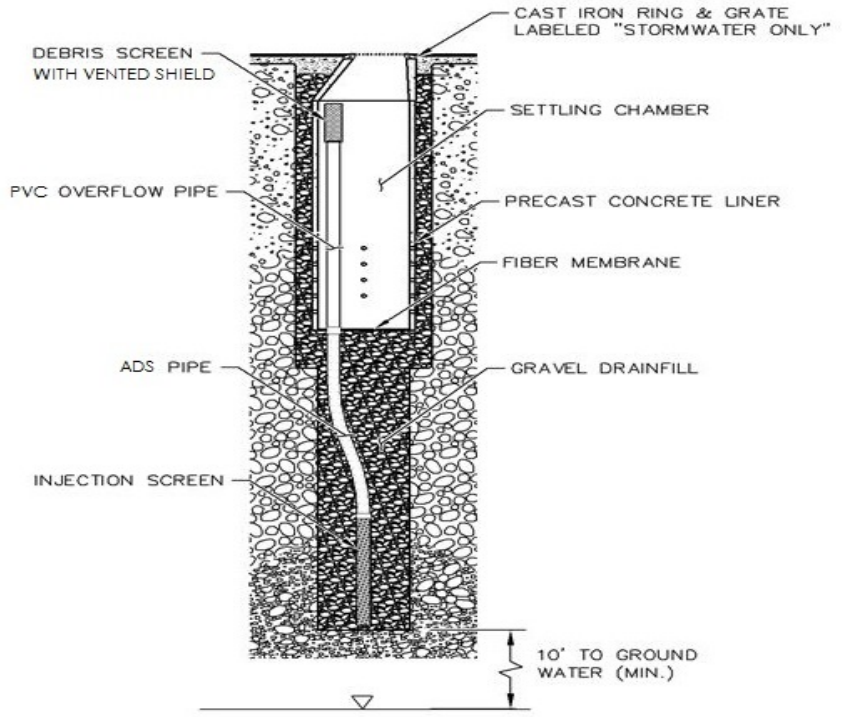


Figure 4.8 Typical Dry Well Installation

Photo 4.5 Detention Basin Dry Well Installation

20. The project's drainage report shall provide the following information:
    a. Plan for emergency stormwater disposal in the event the dry well(s) cease(s) to function; and
    b. Maintenance Plan with at minimum the following:
        i. Maintenance schedule,
        ii. Type of maintenance activities,
        iii. Exhibit showing the location(s) of the dry well(s),
        iv. Contact information of the driller or authorized maintenance professional, and

4.19.2 Dry Well Prohibitions

1. Disposal methods using infiltration shall not be permitted for stormwater runoff which carries significant concentrations of sediment. This includes stormwater runoff flowing through sand bed channels, as well as stormwater runoff emanating from a predominantly natural watershed.

2. Dry wells are prohibited for industrial developments and other areas where hazardous waterborne pollutants may enter a dry well.

3. In multi-use basins, dry well inlets shall not pose a hazard to pedestrian safety.

4. Landscaping shall not impair dry well function.

5. LOW IMPACT DEVELOPMENT DESIGN STANDARDS

Low Impact Development (LID) requires a shift in stormwater management away from conveying runoff to a small number of downstream points through hydraulically efficient infrastructure toward retaining and using the runoff as close as possible to the source of the runoff. The use of distributed stormwater management infrastructure should be evaluated during site planning and site design.

During site planning, the planner must consider the site's natural hydrology when locating proposed improvements. The planner should identify hydrologic features including existing flow paths, areas with higher permeability soils, and riparian areas. Objectives of LID are to minimize the impact to these areas and to attempt to mimic natural hydrologic processes in impacted areas.

Another goal of site planning is to design the development to function within the smallest possible footprint.

Once site layout is completed, the designer must consider the appropriateness of other LID practices that can be constructed to reduce runoff discharge rates and volumes by slowing down flow and retaining runoff for beneficial use.

This chapter provides minimum criteria for constructed LID practices proposed during site design.

5.1 Low Impact Development General Requirements

1. Projects shall retain the first 0.5 inch of rainfall that flows off of impervious and disturbed surfaces (first-flush retention). The applicant shall demonstrate that the required retention volume, calculated by Table 2.1, is provided within stormwater harvesting basins or within a detention basin.

2. Site planning shall occur to minimize disturbed, compacted and connected impervious surfaces and to protect and enhance regulated riparian habitat, regulatory floodplains and other high permeability areas.

3. Where present, connections between impervious and disturbed areas shall be minimized.

4. LID practices shall be distributed throughout the project site.

5. Inspection and maintenance protocols are required for all projects using LID practices. The inspection and maintenance protocols shall be reviewed and approved by the Floodplain Administrator prior to approval of the tentative plat or development plan.

6. To allow for inspection and maintenance, LID practices shall be legally and physically accessible.

7. Upon completion of construction of all LID practices, an As-built Certification shall be prepared and submitted to the Floodplain Administrator and to the entity responsible for maintenance. The As-built Certification shall be used by the responsible party when performing periodic inspections and when restoring the LID practices to design specifications, if required. The Floodplain Administrator may use the As-built Certification during enforcement actions.

8. When LID practices are to be maintained by a private entity, such as a homeowners association, this responsibility shall be described in the association's Covenants, Conditions and Restrictions which shall refer to the inspection and maintenance protocol and As-Built Certification.

5.2 Low Impact Development General Prohibitions

1. Although the use of stormwater and rainwater harvesting facilities on private residential lots is encouraged, any retention volume on private residential lots shall not be counted towards the first-flush retention or detention requirement.

2. The volume of rainwater harvesting cisterns or other practices that do not allow for infiltration of runoff to occur shall not be counted towards satisfying the first-flush retention requirement.

5.3 Stormwater Harvesting Basins

5.3.1 General Standards for Stormwater Harvesting Basins

The following standards are applicable to all stormwater harvesting basins.

1. Stormwater harvesting basins shall be located so that the basin can effectively capture and retain stormwater.

2. Stormwater harvesting basins shall be designed to retain no more than 9 inches and no less than 6 inches of stormwater. The depth is measured from the lowest elevation on the basin floor to the 100-year water surface of the basin.

3. Minimum freeboard for stormwater harvesting basins is 3 inches.

4. Basin floors shall allow for uniform ponding across the entire basin.

5. When terraced cells are proposed, each cell of a terraced basin may be considered separately when determining basin depth, and each cell shall allow for uniform ponding.

6. Stormwater harvesting basins shall be constructed entirely below finished grade, except when designing basins within existing natural flow paths. Alternative designs require approval by the Floodplain Administrator.

7. All side slopes of a stormwater harvesting basin shall be 3:1 or flatter unless the side slope is rock lined.

8. Except for Rainfall Only Non-contributing Basins, stormwater harvesting basins shall be designed with an inlet. The inlet shall meet the following criteria:
   a. The inlet shall be located to accept flow from the contributing watershed.
   b. Inlet erosion protection shall be placed at a width sufficient to encompass flow expansion downstream of the inlet. Non-grouted rock shall consist of minimum 4-inch rock hand-placed in 2 layers on filter fabric level with finished grade. Grouted rock shall be embedded into the concrete a minimum of ½ the rock diameter with flat faces placed to provide a level surface. Other inlet protection as approved by the Floodplain Administrator may be utilized.
   c. Rock berms or other pervious rim 4 to 6 inches high shall be placed at the downstream end of the inlet to provide a sediment trap, as shown in Figure 5.1.

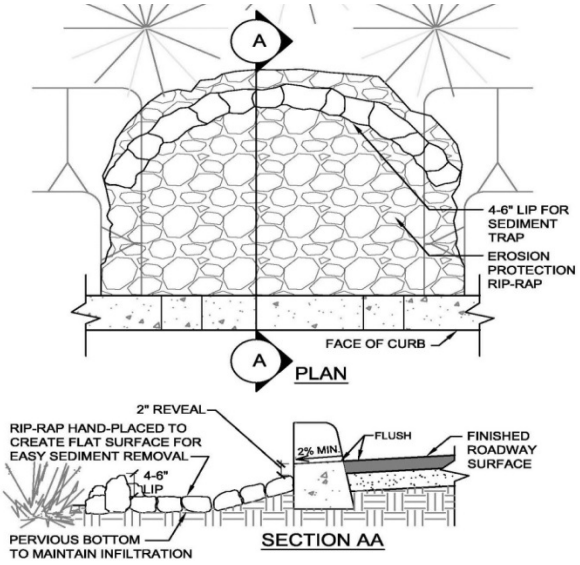


Figure 5.1 Sediment Trap

d. When a stormwater harvesting basin is located adjacent to a parking area, the inlet shall be sized to prevent ponding greater than 1 foot deep during the 100-year event within the parking area.

9. When an outlet is proposed, the outlet shall meet the following criteria:
   a. The outlet shall be located where it does not pose a hazard to pedestrian circulation or create an adverse impact to structures, infrastructure or adjacent properties. The outlet discharge shall not exceed the capacity of downstream infrastructure or Balanced or Critical Basin discharge requirements.
   b. Outlet erosion protection shall be provided as follows:
      i. For outflows onto earthen surfaces, outlet protection shall be provided at a width sufficient to encompass flow expansion downstream of the outlet. When rock is not grouted, it shall consist of minimum 4-inch angular rock hand-placed in 2 layers on filter fabric. Grouted rock shall be embedded in concrete a minimum of ½ the rock diameter; or
      ii. For outflows onto pavement, a 4-inch thick concrete cut-off wall shall be placed at the outlet extending to the basin floor.

10. When stormwater harvesting basins with terraced cells are proposed, internal check dams to pond water shall be provided.
    a. The minimum freeboard shall be measured from the top of the check dam to the lowest finished grade adjacent to each cell.
    b. Check dams shall be keyed in a minimum 12 inches into the side of the basin.

11. For safety and access purposes, stormwater harvesting basins shall have the following setbacks, as measured from the top of the basin slope:
    a. Minimum 1 foot from a sidewalk or other pedestrian access path and from off-street parking areas.
    b. Minimum 2 feet from back of curb or edge of pavement for streets with on-street parking.
    c. Minimum 6 inches from back of curb or edge of pavement for streets with no on-street parking.
    d. Minimum 10 feet from structures, or minimum setback specified in a geotechnical report for the project.
    e. Minimum 4 feet from the property boundary or other access space for maintenance access.

12. Landscaping within stormwater harvesting basins is encouraged with the following conditions:
    a. All areas within a stormwater harvesting basin except for check dams may be used for planting area.

b. Planting domes or other raised areas on the basin floor are acceptable as long as retention volume is maintained.
c. Hydroseeding is allowed within a stormwater harvesting basin. The seed mix shall have plant species from the Approved Plant List provided in Appendix B of the Pima County Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines available on the Rules and Procedures page of the District's web page.
d. Original design volume shall be maintained over the life of the project.

13. LID practices in subdivisions shall be located in Common Area, easement designated for drainage, or other publicly accessible space.

5.3.2 Stormwater Harvesting Basin Prohibition

1. Invasive non-native plants located within a stormwater harvesting basin are not allowed and must be removed if found within the basin. A list of the invasive non-native plants can be found in Appendix E of the Pima County Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines available on the Rules and Procedures page of the District's web page.

5.4 Roadside Stormwater Harvesting Basins

When a roadside stormwater harvesting basin is proposed to be located within a public right-of-way, a right-of-way use permit shall be obtained prior to construction as required.

When a roadside stormwater harvesting basin is proposed to be located adjacent to a private street, the basin should be located within Common Area or within a drainage easement.

Whether the location is public right-of-way or private property, site design shall include careful consideration of the location of utilities and access points.

The following standards apply to stormwater harvesting basins that are located adjacent and parallel to a street for the purpose of collecting runoff from the street:

1. Curb openings for roadside stormwater harvesting basins shall meet the following criteria:
   a. Curb openings shall be separated from driveway aprons and other curb openings by a minimum distance of 10 feet;
   b. Curb openings shall be located a minimum of 20 feet from an end of a curb return (corner);
   c. Curb openings proposed on existing curbs (retrofit) shall be made by a saw cut method; and
   d. Curb openings shall be a maximum of 2 feet in width with 45-degree sloped sides.

e. The bottom of the curb cut shall be a minimum 4 inches below any other point along the edge of the basin.

2. Basin side slopes shall be 3:1 or flatter.

3. The maximum water storage depth shall be 9 inches, and freeboard depth shall be a minimum of 3 inches.

A typical cross section is provided in Figure 5.2.

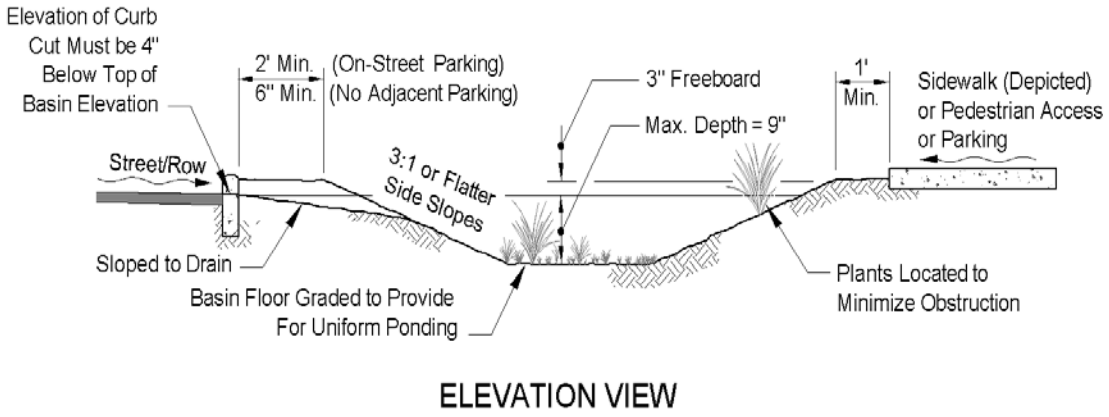


Figure 5.2 Roadside Stormwater Harvesting Basin

5.5 Stormwater Harvesting Basins Adjacent to Parking Areas

When stormwater harvesting basins are proposed adjacent to parking areas, the top of the basins shall be separated horizontally from edge of the parking area by a minimum of 1 foot.

5.6 Non-contributing Basin Standards

Non-contributing Basins are basins designed to retain the full 100-year stormwater volume and can be excluded from calculations to determine post-development peak discharges. Non-contributing Basins shall be designed to meet the following standards:

1. The maximum water storage depth shall be 9 inches.

2. A minimum of 3 inches of freeboard shall be provided for Non-contributing Basins.

3. Non-contributing Basins shall be located where they do not pose a safety hazard or create an adverse impact to adjacent properties and structures.

4. Basin bottoms shall provide for uniform ponding.

5. Side slopes shall be 3:1 or flatter.

6. For Expanded Area Non-contributing Basins, the ratio of the upstream drainage area to the pervious basin bottom shall not exceed 2:1.

7. The use of parking and access lane areas for retention and freeboard is allowed for Expanded Area Non-contributing Basins.

Figure 5.3 illustrates a concept for Expanded Area Non-contributing Basins, capturing the full volume from adjacent parking areas, which have drainage areas meeting the upstream drainage area ratio of 2:1.

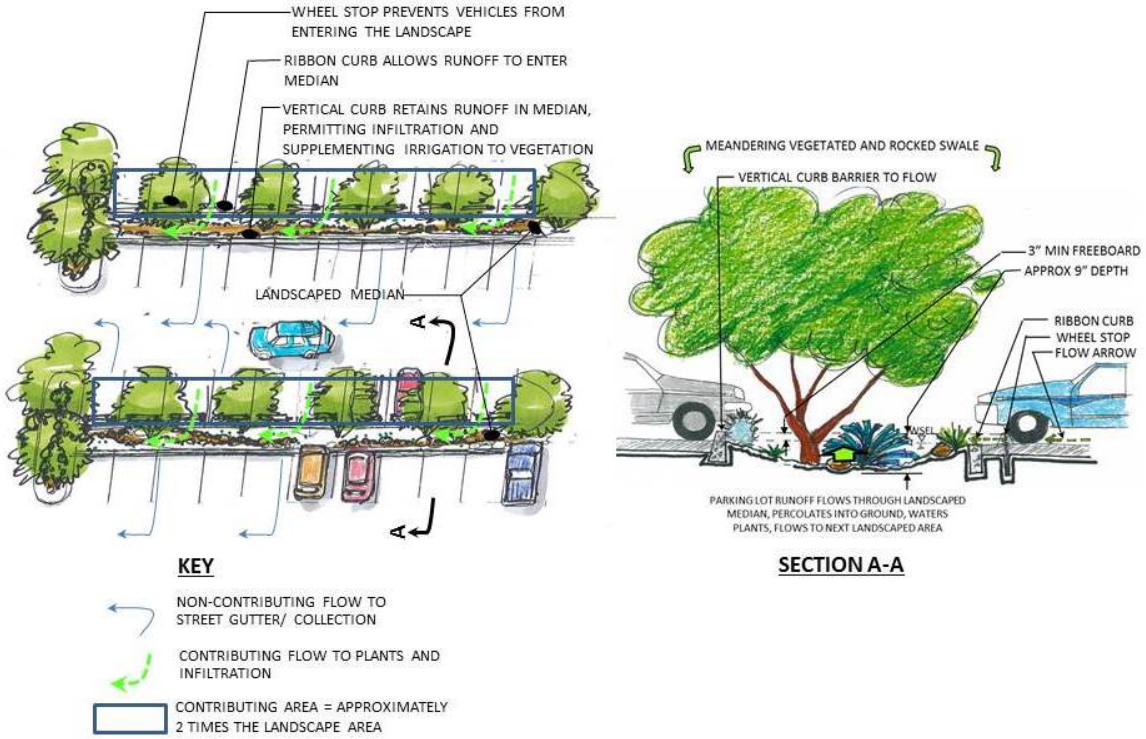


Figure 5.3 Expanded Area Non-contributing Basin in a Parking Lot Median

5.7 Bioretention Basin

Bioretention basins are engineered basins consisting of an over-excavated area that is replaced with a constructed soil medium to aid in runoff storage and infiltration.

1. The bioretention basin shall consist of:
   a. A subbase of a 6-inch to 24-inch layer of coarse aggregate (gravel) that is washed to remove fine material; and
   b. A soil media barrier placed between the subbase and a constructed soil medium. The Floodplain Administrator may approve use of a filter fabric or other subbase containment if conveyance requirements must be met.
   c. A constructed soil medium that is a mixture of sand (85% ASTM C-33 sand by volume) and organic material (15%) such as peat, top soil, mulch, or compost which has been mixed in a drum mixer. The constructed soil medium shall be 16 inches to 36 inches deep. Alternative soil media require prior approval by the Floodplain Administrator.

2. The bioretention basin shall have a flat-topped surface that is depressed a minimum of 6 inches and a maximum of 12 inches below adjacent finished grade. Side slopes shall be 3:1 or flatter.

3. Because soil bearing capacity within a potential zone of saturation may be reduced, bioretention basins shall be set back horizontally from a structure a minimum of 5 feet, unless an appropriate alternative setback is justified by a geotechnical engineer registered in the State of Arizona prior to approval of the tentative plat or development plan.

4. Bioretention basins shall include a sediment trap located at the downstream end of the inlet, as shown in Figure 5.1.

5. A vertical inspection pipe shall be provided in order to assess the effectiveness of the bioretention basin. The pipe shall be perforated 4-inch PVC or equivalent and shall extend from the bottom of the gravel sub-base to the top of the constructed soil medium with a removable cap. See Figure 5.4.

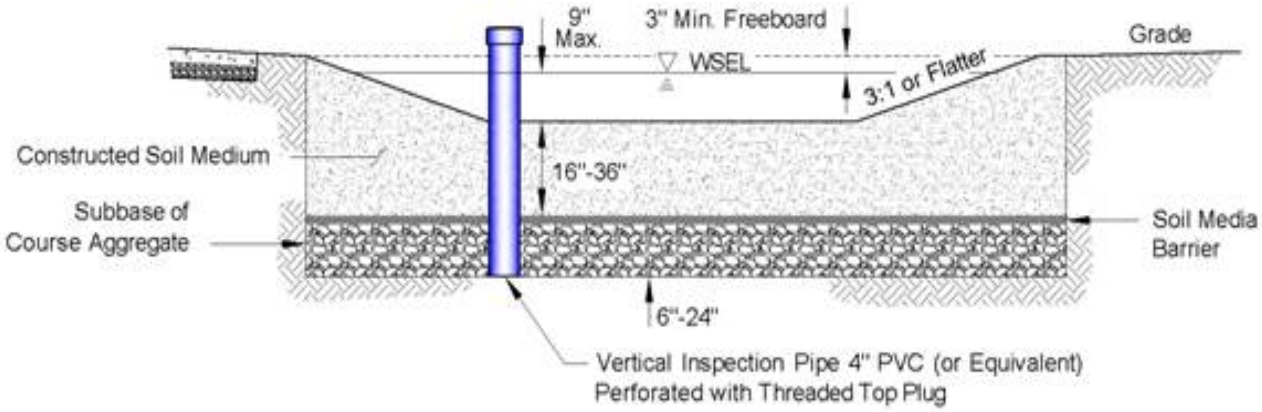


Figure 5.4 Bioretention Basin

5.8 Retention within a Detention Basin

A retention area for first-flush retention or stormwater harvesting may be constructed within a detention basin. Areas not designated for retention may be used for landscaping or riparian habitat mitigation. The following standards, illustrated in Figure 5.5, apply:

1. A maximum of 9 inches of retention is allowed. The depth is measured from the lowest elevation on the basin floor to the lowest outlet invert elevation.

2. The retention area shall connect the basin inlet to the outlet, and meet the following criteria:
   a. The width of the retention bottom area shall be a minimum of 4 feet to allow for maintenance of this area;
   b. Any plantings or invasive vegetation in the retention area are prohibited and shall not obstruct maintenance activities or compromise the design volume.
   c. The use of check dams in the retention area in order to create cells of uniform depth is allowed.
   d. The retention area floor shall provide for uniform ponding.
   e. Retention areas shall have 3:1 or flatter earthen side slopes.

3. If vegetated areas on terraces above the retention area are proposed, the following apply:
   a. Berms to harvest stormwater are allowed on the terraces.
   b. If bermed, terraces shall provide for uniform ponding. Planting terraces shall be elevated to the top of the retention area.

3. A maximum of 9 inches of retention is allowed, unless designed as described below. The depth is measured from the lowest elevation on the basin floor to the lowest outlet invert elevation
a. A retention depth of greater than 9 inches may be allowed if the following conditions are met. See Figure 5.5

iv. The remaining 50% of the basin shall meet the construction requirements of Part 1 of this section

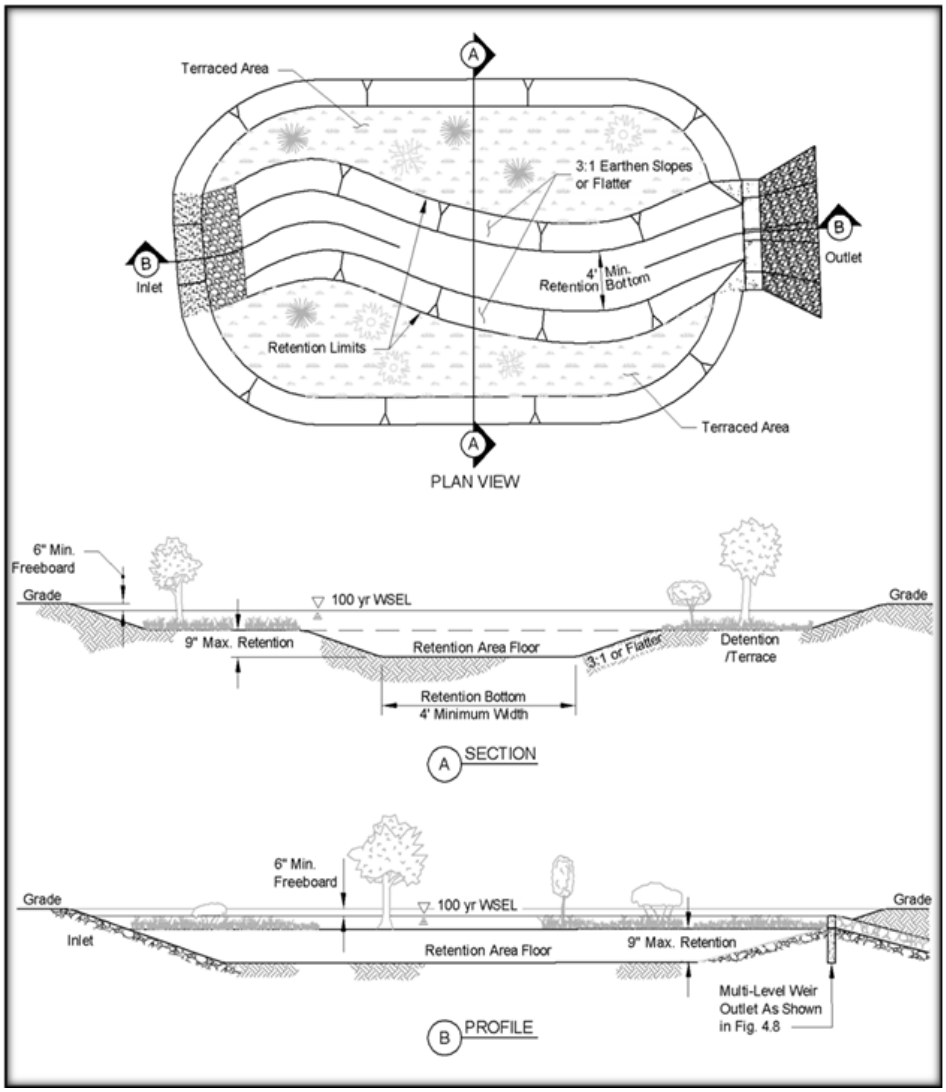


Figure 5.5 Terraced Detention Basin with Retention

5. 9 Pervious Pavements

Pervious pavements can be used to infiltrate or store water. Because pervious pavement systems include a permeable paving surface and a subsurface material that can hold water, they can reduce runoff peak and volume. Use of pervious pavements for commercial and residential projects may require a variance from the transportation department of the governing jurisdiction. Pavement design should be performed when pervious pavements are proposed for areas of vehicular use. Acceptable types of pervious pavement installations are provided below.

5.9.1 Porous Gravel

Porous gravel is well-suited for industrial applications that do not pose a risk to groundwater and rural, low-traffic uses. A low-traffic commercial parking area is shown in Photo 5.1, and a gravel cross section is shown in Figure 5.6.

Photo 5.1 Porous Gravel Installation

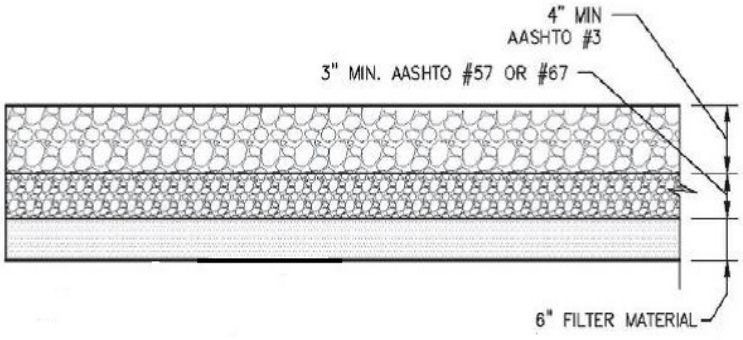


Figure 5.6 Porous Gravel Cross Section

5.9.2 Concrete Grid Pavement

Concrete grid pavement consists of a concrete matrix with a minimum of 20% of free-draining surface area. A concrete grid installation is shown in Photo 5.2, and a grid cross section is shown in Figure 5.7.

Photo 5.2 Concrete Grid Pavement Installation

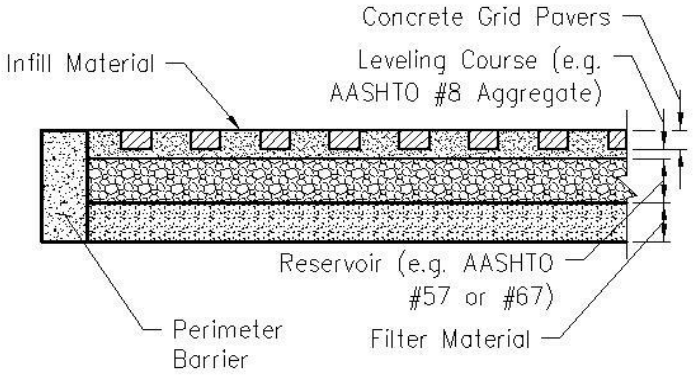


Figure 5.7 Concrete Grid Cross Section

5.9.3 Permeable Interlocking Concrete Pavement

Permeable interlocking concrete pavement (PICP) consists of impervious concrete blocks placed to allow a minimum of 5% of open surface area. A PICP installation for parking adjacent to a street is shown in Photo 5.3, and a paver cross section is shown in Figure 5.8.

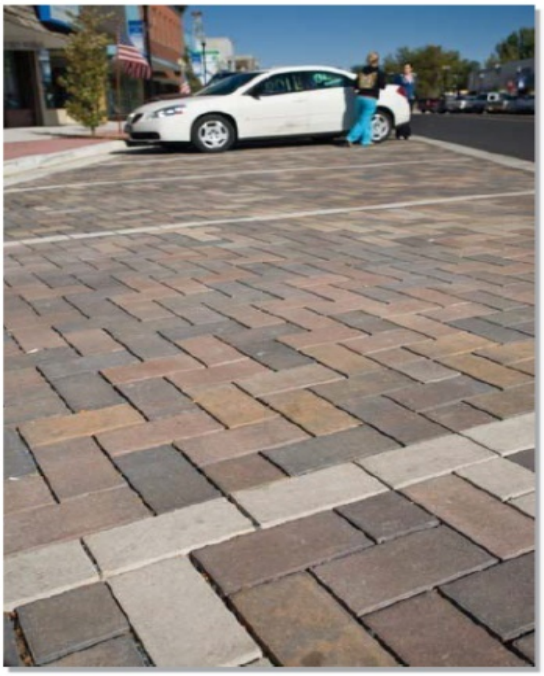


Photo 5.3 PICP Installation

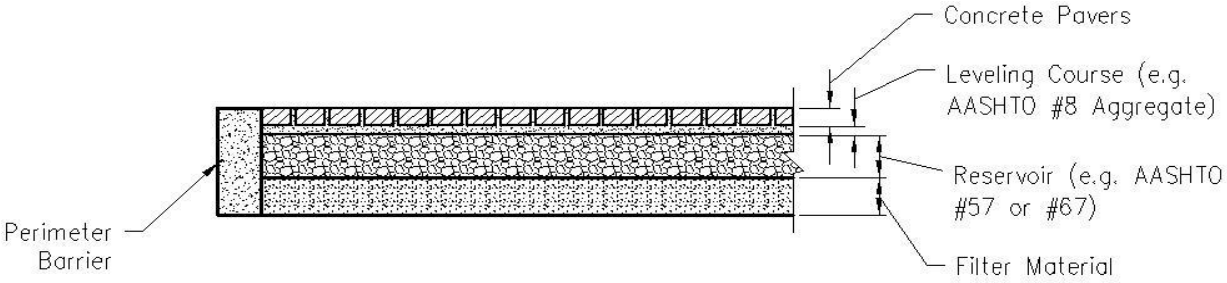


Figure 5.8 PICP Cross Section

5.9.4 Pervious Concrete

Pervious concrete allows water to infiltrate because it does not contain fine aggregate. A pervious concrete installation is shown in Photo 5.4, and a concrete cross section is shown in Figure 5.9.

Photo 5.4 Pervious Concrete Installation

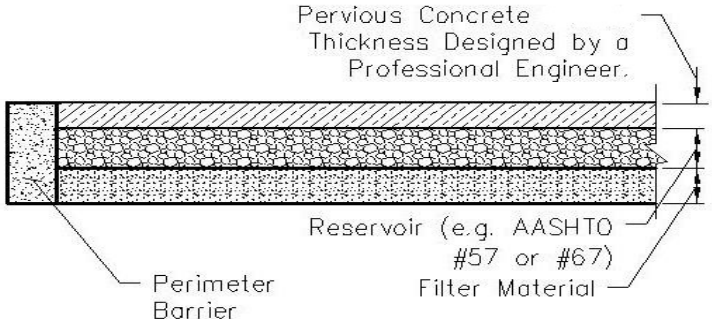


Figure 5.9 Pervious Concrete Cross Section

Specifications for other types of pervious pavement installations may be approved by the Floodplain Administrator.

5.9.5 General Standards for Pervious Pavements

Pervious pavements are suitable for low speed vehicular use areas, such as parking lots, as well as sidewalks and other pedestrian use areas. To date, most pervious pavements are not as well suited for higher speed moving live loads such as traffic on roadways.

The following standards apply to pervious pavements:

1. Pervious pavements shall be protected from materials that can clog interstices, such as oil, grease and sediment during construction and during the life of the project.

2. A geotechnical report by a registered Arizona civil engineer shall specify appropriate setbacks from structures and foundations, bedding materials and other structural site elements and affirm that the soil under the pervious pavement is suitable for infiltration.

3. The primary components of a pervious pavement system shall include a permeable paving surface, a reservoir material, such as crushed rock, and a filter material. A leveling course is required for concrete grid and PICP systems.

4. The leveling course shall consist of American Association of State Highway and Transportation Officials (AASHTO) #8 aggregate or approved equal.

5. Aggregate that forms the reservoir layer shall be uniformly graded and shall conform to the AASHTO material size standard #67 or #57, or other size standard which may be approved by the Floodplain Administrator. AASHTO #57 or #67 materials can be assumed to have a reservoir porosity of 0.4. The reservoir volume should be considered for design of pavement drainage areas, but the volume shall not be counted toward detention or retention requirements because imperfect maintenance can result in blockage of infiltration.

6. Filter materials remove pollutants and are required for pervious pavement systems. A granular filter without a geotextile is required, unless an alternate design is approved by the Floodplain Administrator. A 6-inch thick filter layer consisting of materials conforming to the gradation presented in Table 5.1 below shall be installed as the bottom layer of pervious pavement systems.

Table 5.1 Pervious Pavement System Filter Material Gradation

Sieve Size	Mass Percent Passing Square Mesh Sieves
19.0 mm (3/4")	100
4.75 mm (No. 4)	60 – 100
300 µm (No. 50)	10 – 30
150 µm (No. 100)	0 – 10
75 µm (No. 200)	0 - 3

5.10 Practices that Increase the Time of Concentration

Peak discharge rates may be reduced through the use of site design which allows for increased infiltration. This can be accomplished by increasing the length of the flow path, by flattening slopes, and by roughening the surface. When these practices are proposed, the following standards apply.

5.10.1 Lengthened Flow Path Standards

Lengthened flow paths shall occur in swales or channels which meet the following criteria. A channel or swale qualifies as a conveyance designed to lengthen flow path when it provides a longer flow path than the shortest, most linear, most direct route between upper and lower portions of a site watershed.

1. Swales and channels shall meet current channel design standards, including freeboard.

2. When 100-year flow velocities are 3 feet per second or less, earthen swales are allowed. Earthen swales may be allowed for higher 100-year velocities when a project site soils sieve analysis prepared by a geotechnical engineer registered in the State of Arizona is submitted, along with acceptable engineering justification of a higher value based on acceptable methods such as those provided in the Federal Highway Administration's Highways in the River Environment or those adopted by the Natural Resources Conservation Service.

3. When 100-year flow velocities are greater than 3 feet per second, swales shall be rock lined unless an engineering analysis justifies that no erosion protection is necessary.

4. Swales may be lined with angular rock with a D_{50} of at least 4 inches to roughen the flow path.

6. MULTIPLE-USE CONCEPTS

With appropriate site planning, detention basins and stormwater harvesting basins can serve other practical purposes in addition to being a vegetated amenity. Other acceptable uses and/or benefits include passive and active recreation, habitat enhancement and landscaped bufferyards. These are more fully described below.

6.1 Multiple Benefit Concepts

6.1.1 Resource Benefits of Shaded Basins

1. Energy Reduction**:** Shade-producing vegetation planted in stormwater harvesting basins on the east, west and north sides of a building can be used to capture runoff from the building and adjacent impervious areas to irrigate vegetation that can shade the building and reduce the cooling costs.

2. Potable Water Reduction**:** Watering of vegetation accounts for a substantial portion of the potable water used in our region. The use of water harvesting can reduce amount of the potable water used for irrigation. When new landscaping is required, or if augmentation of the urban canopy is desired, these new plantings require irrigation. After an initial establishment period, the use of water harvesting basins can result in viable plants that do not need additional irrigation from potable water.

6.1.2 Public Health Benefits of Shaded Basins

1. Heat Reduction**:** Vegetation planted in basins produces shade that can reduce overall ambient air temperature which has a health benefit to the community. This benefit is particularly important if an impervious unshaded area can be replaced with a pervious shaded area. The overall reduction in temperature can also reduce energy demand for cooling.

2. Air Quality Improvements**:** Air quality improvements come in the form of reduction in dust from wind breaks provided by vegetation in basins, and mitigation of harmful gasses.

3. Water Quality Improvements**:** Basins can capture water that contains contaminants that might impact water quality. In addition, soil and plant processes can break down organic constituents like oil. Utilizing organic mulch such as wood chips in stormwater collection basins enhances the ability of soil and microbes to break down pollutants while maintain and improving soil infiltration capacity.

6.1.3 Transportation Benefits of Shaded Basins

1. Traffic Safety: Stormwater harvesting basins in curb-extensions and street intersections can slow traffic and increase safety in residential areas. Known areas of problematic speeding may be made safer with these traffic-calming features.

2. Extended Pavement Life: Shaded pavement has been shown to have a longer life in desert environments which can reduce the long-term expenditure for pavement maintenance.

3. Improved Pedestrian Accessibility: Shaded walking areas are more conducive to pedestrians and bicyclists and are an element of the Complete Street design. The placement of detention and stormwater harvesting basins adjacent to roadways and parking lots or within medians and islands can be used to capture runoff from the street or parking lot to irrigate vegetation that can shade streets or parking lots.

4. Reduced Street Noise: Vegetation planted in stormwater harvesting basins next to roadways reduces street noise.

6.1.4 Benefits of Basins to Habitat

1. Enhance Wildlife Corridors**:** The placement of basins adjacent to watercourses, riparian habitat or other existing vegetated areas creates a larger corridor for wildlife, and a bigger buffer from adjacent improvements. Utilization of native, multi-story canopies (e.g. a combination of ground covers, shrubs, and trees) further enhances structural habitat for wildlife.

6.1.5 Property Value Benefits

1. Increased Property Value: Creating a landscaped amenity of the stormwater features for the benefit of the site and/or public rights-of-way is encouraged. Greater abundance of trees and other vegetation has been shown to be associated with increased property values. This is the result of aesthetic improvements as well as some of the other benefits described above (e.g. reduced energy and water costs) which have a direct economic benefit.

2. Property Screening: Frequently, new development is required to provide bufferyards so that the intensity of development is not too severe, and that appropriate screening of the new

development occurs. By placing stormwater harvesting basins within the bufferyard, landscaping will receive increased amounts of runoff which can be removed from supplemental irrigation more quickly. In addition, due to the expected density of this vegetation, additional requirements for screening with walls or fences may be waived.

6.2 Multiple Use Concepts

6.2.1 Human Activity Zones

If the detention basin also is intended for human activity, the following additional design standards apply:

1. A basin designed with human activity zones shall contain a minimum of 1 pedestrian access slope of 8:1 or flatter and a maximum of 100 feet either to the base of an access slope or to a 4:1 or flatter basin side slope.

2. All facilities and furnishings placed below the elevation of the 100-year water surface shall be waterproof and not floatable.

6.2.2 Basins Containing Landscape Bufferyards

If the detention basin or stormwater harvesting basin is also intended to support bufferyard landscaping, the following additional design standards apply:

1. The drainage report must demonstrate that the multiple uses of the bufferyard for both landscaping and detention are compatible.

2. The project landscape plan must be submitted to the Floodplain Administrator for review prior to final approval of the development plan or plat.

3. The Floodplain Administrator will review for requirements of the applicable floodplain ordinances and policies. Landscape requirements shall be reviewed by the Development Services Department.

7. INSPECTION AND MAINTENANCE REQUIREMENTS

7.1 Inspection and Maintenance General Requirements

1. Inspection and maintenance are required for all basins. An inspection and maintenance protocol including frequency of inspection, a checklist of items to be inspected and recommended maintenance when an inspection identifies a maintenance requirement shall be prepared by an Arizona registrant. The protocol may be included in the project drainage report or prepared as a separate document. The protocol shall be reviewed and approved by the Floodplain Administrator prior to approval of the tentative plat or development plan. The protocol shall be delivered to the entity responsible for inspection and maintenance. An example of a detention basin inspection and maintenance checklist is provided in Appendix F.

2. Upon completion of construction of all basins, an As-built Certification shall be prepared by an Arizona registrant and submitted to the Floodplain Administrator and entity responsible for basin maintenance. The plan associated with the As-built Certification shall be used by the responsible party when performing periodic inspections and when restoring the basin to design specifications, if required. The Floodplain Administrator may utilize the certification during enforcement actions.

3. The periodic maintenance described in this chapter does not require a Floodplain Use Permit.

4. Periodic inspections shall occur a minimum of once per year. If significant storm events occur between annual inspections, additional inspections are required following each of the significant events.

5. Inspections shall include examination of the design components described in Chapters 4 and 5 which are incorporated in the project site being inspected. During an inspection, conditions shall be checked for proper functioning and compared to design specifications. If function impairment or deviation from design specifications is observed, maintenance shall be performed as described below or as directed by the inspector.

7.2 Inspection and Maintenance Requirements for All Basins

7.2.1 Basin Location and Collection

1. Basins shall be maintained to perform as designed for the life of the project. Flow paths and structures delivering flow to basins shall not be altered. Obstruction of flow paths or structures, alteration of basin location or modification of flow direction shall be remedied, and the basin functioning shall be restored to design specifications.

2. Conveyances to the basins shall be maintained free of leaves, debris, or other obstructions.

3. Inlet and outlet locations shall be maintained free of obstructions.

7.2.2 Basin Depth and Freeboard

1. The depth of the basin shall be inspected to ensure the design volume, depth and freeboard are maintained.

2. For detention basins, the design depth shall be restored when the depth of sediment exceeds 6 inches above the lowest bottom floor elevation shown on the basin as-built plans. For stormwater harvesting basins, the design depth shall be restored when the design depth of the basin is reduced by more than 1 inch.

3. Slopes shall be maintained to the original design configuration.

4. Trash and debris shall be removed.

7.2.3 Basin Storage Time

1. Basin bottoms shall be inspected for evidence of ponding lasting longer than the limits in Section 4.5.1 for Detention Basins and longer than 24 hours for stormwater harvesting basins.

2. If an inspection identifies evidence of ponding exceeding these limits, the following maintenance shall be performed:
   a. Areas of ponding shall be graded to drain to the outlet for basins with no retention;
   b. Compacted soil shall be scarified to promote infiltration;
   c. Basin outlets shall be maintained to function as designed; and
   d. Obstructions at the outlet shall be removed.
   e. Additional design remedies may be required, if problems persist.

7.2.4 Basin Floor

1. The basin floor shall be inspected to ensure that the design slope is maintained, that infiltration has not been significantly reduced and that vegetation or other obstructions do not alter slope, infiltration or basin volume.

2. Maintenance shall be performed when accumulated sediment and debris alter the design slope to the basin outlet or infiltration potential.
3. Invasive non-native plants shall be removed. A list of invasive non-native plants can be found in Appendix E of the Pima County Regulated Riparian Habitat Mitigation Standards

and Implementation Requirements available on the Rules and Procedures Page of the District's web page.

4. Soil with evidence of oil, grease or other chemicals shall be removed and disposed of properly.

5. Debris and trash shall be removed.

7.2.5 Basin Side Slope

1. Inspections shall occur to ensure that slope treatment has not been damaged by settling, vegetation, erosion, or other causes.

2. Should damage be observed, basin side slopes shall be restored to design specifications.

3. When slope treatment is dumped riprap, the treatment shall be repaired when foundation soil is lost or filter fabric is exposed.

4. Filter fabric that has migrated under a dumped rock riprap layer or has tears or holes shall be restored to design specifications.

5. Grouted riprap side slopes shall be restored to design specifications when foundation soil is lost or grout beds become damaged.

6. Retaining walls shall be restored to design specifications when signs of tipping, clogged weep holes or soil subsidence are observed.

7.2.6 Basin Inlet Structure

1. Inspections shall occur to ensure the inlet is free of obstructions and not damaged.

2. Should obstructions or damage be observed, inlets shall be restored to design specifications.

3. When an inlet includes a sediment trap, sediment shall be removed to the design elevation.

7.2.7 Basin Outlet Structure

1. Inspections shall occur to ensure the outlet and all components are free of obstructions and not damaged.

2. Should obstructions or damage be observed, outlets shall be restored to design specifications.

7.2.8 Basin Maintenance Access

1. Inspections shall be conducted to ensure access to the basin is not compromised.
2. Conditions which compromise the design access shall be repaired.

7.2.9 Basin Landscaping

1. Inspections shall occur to ensure that landscaping has not impacted basin function.
2. If damage is observed, the basin shall be restored to design specifications.
3. Invasive non-native plants shall be removed. A list of the invasive non-native plants can be found in Appendix E of the Pima County Regulated Riparian Habitat Mitigation Standards and Implementation Requirements available on the Rules and Procedures Page of the District's web page.
4. Any vegetation or debris within the 20-foot radius described in Section 4.17.1 shall be removed.

7.3 Additional Inspection and Maintenance Requirements for Detention Basins

7.3.1 Detention Basin Embankment

1. Inspections shall be conducted to ensure the embankment is not damaged due to erosion, piping, sliding, settling or other causes.
2. If damage to an embankment is observed, the embankment shall be restored to design specifications.

7.3.2 Detention Basin Security Barrier

1. Inspections shall be conducted to ensure the security barrier and surrounding grade are not damaged to the extent that the security of the basin is compromised.
2. If compromising damage is observed, the security barrier shall be restored to design specifications.

7.3.3 Detention Basin Perimeter Wall

1. Inspections shall occur to ensure the perimeter wall and/or erosion at wall openings are not adversely impacting the basin.

2. If adverse impacts are identified, the basin and/or wall shall be restored to the design specifications.

7.3.4 Detention Basin Underground Storage System

1. Inspections shall occur to ensure the underground storage system is not damaged and is functioning as designed.

2. Design specifications shall be restored when an inspection reveals any of the following:
   a. Seepage, settlement, cracking, signs of improper joint alignment or displacement of joints;
   b. Sediment accumulation; or
   c. Damage to or malfunction of pumps, valves, sumps, piping, manifolds or appurtenances.

7.3.5 Detention Basin Equipment Elevation

1. Electrical equipment shall be inspected to ensure that it is elevated a minimum of 1 foot above the 100-year water surface elevation.

2. Foundations shall be inspected for stability and material damage.

3. Conditions which compromise the design height of the equipment shall be repaired.

7.3.6 Detention Basin Pump

1. Inspections shall be conducted after alarm system activation as well as annually and after significant storm events to ensure the pump is not damaged and is functioning as designed.

2. Prior to the summer and winter rainy seasons, the pump, back-up system and alarm system shall be operated to ensure the system is functioning as designed.

3. If damage/malfunction is observed, the system shall be restored to design specifications.

4. Trash and debris shall be removed from the pump system and properly disposed.

7.3.7 Detention Basin Dry Well(s)

1. Inspections shall be conducted to ensure the dry well(s) and settling chamber(s) are functioning as designed.
2. If an inspection identifies that a dry well is not infiltrating within the storage limits outlined in Section 4.5.1, or other damage or maintenance requirements are identified, maintenance shall be performed to restore the dry well to design specifications.
3. Accumulated debris, weeds and trash shall be removed from the surface.
4. Sediment shall be removed from the settling chamber when approximately 15 to 20% of the original volume of the chamber is filled.
5. All sediment removed from a settling chamber shall be disposed of at an authorized sanitary landfill.

7.4 Additional Inspection and Maintenance Requirements for Bioretention Basins

1. All other applicable stormwater harvesting basin inspection and maintenance requirements in this chapter shall be met.
2. Access to the vertical inspection pipe shall be maintained.
3. An inspection of the vertical inspection pipe shall occur to ensure infiltration is occurring. If standing water is observed in the inspection pipe, replacement of the medium or other method of retention is required.
4. Sediment shall be removed from the sediment trap.
5. The surface depression shall be inspected to ensure that the design depth is maintained. If reduced depression depth is observed, the design depth shall be restored.

7.5 Additional Inspection and Maintenance Requirements for Detention Basins with Retention

1. Retention areas shall be inspected to ensure the retention areas are performing as designed. If ponding lasting longer than 24 hours is observed, the soil in the basin bottom shall be loosened to promote infiltration.
2. The retention area floor shall be maintained free of vegetation, debris and other obstructions.

3. The depth of the retention area shall be inspected to ensure the design volume is maintained. Sediment and other deposits shall be removed when the design depth of the retention area has been reduced by more than 1 inch.

4. Slopes shall be maintained to the original design configuration.

5. Soil with evidence of oil, grease or other chemicals shall be removed and disposed of properly and the basin returned to the original design specifications.

7.6 Additional Inspection and Maintenance Requirements for Multi-Use Basins

1. All other applicable inspection and maintenance requirements for detention basins in this chapter shall be met.

2. All equipment, hardscape, furnishings, and electrical equipment shall be maintained to the original design standards.

8. COVENANTS

8.1 General Requirements

1. Covenants will be required when any of the following stormwater practices are proposed:
   a. LID practices, as described in Section 1.5;
   b. Embankments;
   c. Underground storage;
   d. Pumps; and
   e. Dry wells.

   Appendix G contains example covenants and exhibits for commercial projects. For residential subdivisions, covenants shall be recorded with the applicable Conditions, Covenants and Restrictions.

2. Covenants shall comply with the requirements of Chapter 16.38 of the Floodplain and Erosion Hazard Management Ordinance, or other applicable sections of the Ordinances.

3. For corporate covenants, the signer shall provide sufficient documentation to demonstrate authorization to sign for the corporation. Sufficient documents include:
   a. Articles of Incorporation;
   b. A corporate resolution demonstrating the individual's authority to represent the corporation; or
   c. A notarized letter on corporate letterhead that indicates that the person is allowed to represent the corporation.

4. The covenants must specify inspection and maintenance responsibilities of the property owner(s). It shall be the responsibility of the property owner(s) to perform maintenance as necessary to ensure the integrity of the stormwater detention and retention facilities.

9. DETENTION WAIVER REQUEST AND PAYMENT OF IN-LIEU FEE

Section 9 DETENTION/RETENTION WAIVER REQUEST AND PAYMENT OF IN-LIEU FEE

Collection of a fee in lieu of a detention system may be allowed when certain structural flood control measures are provided or it can be demonstrated that detention at the site does not provide offsite flood relief due to parcel size, location within the drainage basin, or other factors.

9.1 Waiver Request Requirements

1. At least one of the following shall be demonstrated when a detention waiver is requested:
   a. Structural flood control measures are proposed in place of detention systems.
   b. The project site is 1 acre or less.
   c. The project is located adjacent to a major watercourse. For the purpose of this manual a major watercourse has a 100-year peak discharge of 10,000 cfs or greater. Approval to classify another watercourse as a major watercourse may be granted by the Floodplain Administrator if engineering justification demonstrates adequate downstream capacity within the watercourse to convey the 100-year flood peak to a logical downstream conclusion under conditions of ultimate watershed urbanization.
   d. The project is located on a secondary tributary of a primary tributary, draining a watershed of no more than ten square miles, of a major watercourse and the relationship between the travel time of the discharge from the project and the rise times of the hydrographs of the project flows and the primary tributary satisfy Equation 9.1; it can be demonstrated that the natural watercourses and drainage infrastructure within the secondary tributary watershed have adequate capacity to convey the future 100-year flood peak emanating from the watershed under conditions of ultimate watershed urbanization; and it can be demonstrated that the primary tributary peak discharge is not affected by the future 100-year flood peak from the secondary tributary or, if it is affected, the primary tributary and all drainage infrastructure downstream of the confluence of the secondary and primary tributaries have adequate capacity to convey the future 100-year flood peak under conditions of ultimate watershed urbanization.
   e. The development has a density that is less than 2 units to the acre and preserves natural drainage patterns. The development shall not rely on constructed drainage facilities, such as constructed channels and storm drains to convey stormwater runoff.
   f. The project site is eligible for a waiver due to other engineering justification acceptable to the Floodplain Administrator.

2. Demonstration of the criteria in this section does not guarantee approval of a detention waiver request.

A waiver for retention may be requested for situations where the volume of retention cannot be contained within the development property or where tests show that the soils have poor infiltration. The waiver may request a reduction in retention volume or the transference of design consideration from retention to detention with a maximum discharge rate of 1-cfs for sites in critical basins or 3-cfs for sites in balanced basins. These maximum discharge rates may be achieved by using a bleed pipe or weir in which the invert of the bleed pipe or weir is a maximum of 6 inches above the basin floor. The waiver may be granted by the engineering reviewer as part of the development review process. The approved waiver request will be included in the Drainage Report or Drainage Statement for the project.

9.1.1 Tributary Location

1. If the project site is located on a secondary tributary of the major watercourse (e. g., Channel 2 of Figure 9.1) then it must be demonstrated that the secondary tributary and all drainage infrastructure within the sub-watershed have adequate capacity to convey the future 100-year flood peak emanating, under conditions of ultimate urbanization, from that portion of the sub-watershed which contains not only the proposed development, but also all areas upstream of the development. For instance, segment BC of Channel 2 in Figure 9.1 and any associated drainage infrastructure must have adequate capacity to convey the 100-year flood peak emanating from the areas draining into Channel 2 upstream of Point C, based upon conditions of ultimate watershed urbanization. In this example, if Equation 9.1 is met, it would not be required to demonstrate that segment AB of Channel 1 and associated drainage infrastructure have adequate capacity, since flood peaks would not be increased on this primary tributary as a result of the proposed development.

2. Peak discharges and times of concentration used in this analysis shall be calculated by the Pima County Hydrology method, or other method specified by the Floodplain Administrator. Hydrograph rise times shall be calculated by the methods presented in Appendix H.

$$Equation\ 9.1 \qquad \frac{T + T_r{}'}{T_r{}''} \leq 0.40$$

Where:

T = 100-year flow travel time between the downstream point of the project site and the confluence with a major watercourse, as defined in Section 9.1, paragraph 1.c. T shall be calculated by the incremental time of concentration illustrated in Example 9.1 below.

$T_r{}'$ = Rise time of the 100-year synthetic flood hydrograph for on-site drainage emanating from the project site under developed conditions.

$T_r{}''$ = Rise time of the 100-year synthetic flood hydrograph at its confluence with the major watercourse for drainage emanating from the entire watershed. $T_r{}''$ shall be determined using the assumption that the entire watershed is fully developed with no stormwater detention facilities.

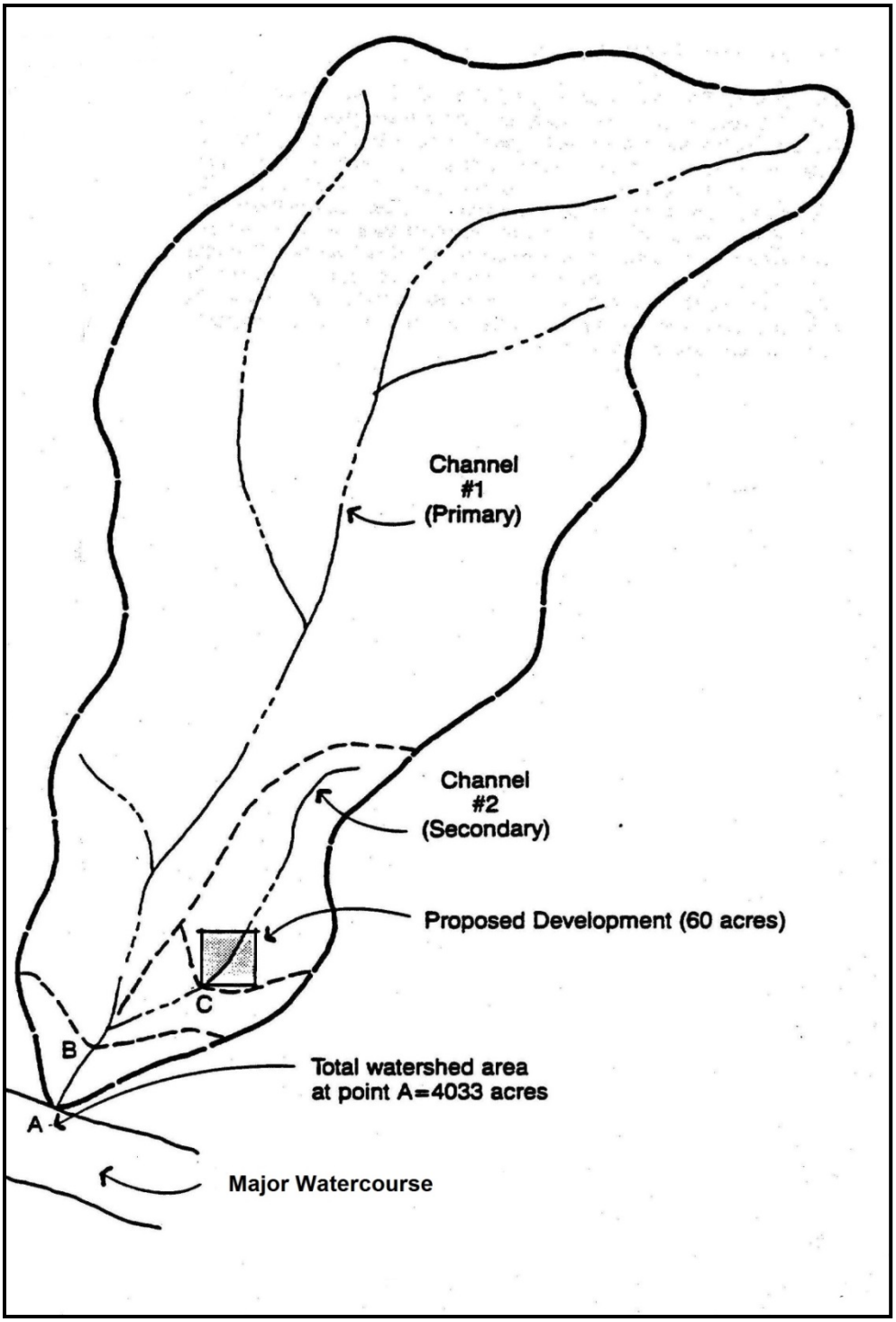


Figure 9.1. Sample Watershed for Example 9.1
(Stormwater Detention/Retention Manual, Pima County Department of Transportation and Flood Control District, City of Tucson)

Example 9.1

A 60-acre parcel proposed for high-density urban development is located in the extreme lower portion of a 4033-acre sub-watershed of the Rillito Creek. The watershed locations are illustrated in Figure 9.1

The purpose of the example is to illustrate the method for determining if it can be demonstrated that the project is eligible for a detention waiver under the requirements of Section 9.1, paragraph 1.d.

Times of concentration, determined by PC-Hydro, for points along the channels of interest are:

Channel 1, Point A t_c = 61 minutes
Channel 1, Point B t_c = 57 minutes

Channel 2, Point B t_c = 25 minutes
Channel 2, Point C t_c = 17 minutes

The travel time through the reach of Channel 1 between Points A and B,

T_{AB} = 61 minutes – 57 minutes = 4 minutes

The travel time through the reach of Channel 1 between Points B and C,

T_{BC} = 25 minutes – 17 minutes = 8 minutes

The total travel time $T = T_{AB} + T_{BC}$ = 4 minutes + 8 minutes = 12 minutes

Incremental travel times are calculated for each channel segment located between the major watercourse and the project site. The total travel time, T, is the sum of the incremental travel times.

Determine T_r':

The time of concentration for the on-site developed conditions runoff from the 60-acre parcel is obtained from PC-Hydro and is 6 minutes. The rise time, T_r', obtained from the table in Appendix H is 14 minutes.

Determine T_r'':

For Channel 1, Point A, the time of concentration is 61 minutes. T_r'' = 53 minutes is calculated by Equation H.1 in Appendix H.

From these values, Equation 9.1 is evaluated:

$$\frac{T + T_r'}{T_r"} = \frac{12 + 14}{53} = 0.49$$

The value of the solution is 0.49 which is greater than the limiting value of 0.40; therefore, it has not been demonstrated that the location of the project site relative to the primary tributary meets the criterion for a waiver stated in Section 9.1, 1.d. Furthermore, even if the solution is less than the limiting value, downstream channel and drainage infrastructure adequate capacity must also be demonstrated.

9.2 Waiver Application Requirements

For requirements, contact the Floodplain Administrator.

9.2.1 Waiver Request Response and Approval

1. The Floodplain Administrator will provide a response letter to the Applicant within 10 working days following the waiver request submittal.

2. If the request is approved, a fee calculation sheet with the required fee will be provided with the response letter.

3. If the request is approved, the applicant shall provide an electronic copy of the approved application and all attachments specified by applicable policies prior to approval of the development plan or plat.

4. A copy of the response letter granting approval of the waiver request shall be provided in the drainage report.

5. The fee shall be paid, according to the instructions in the response letter, prior to final approval of the development plan or plat.

6. If the waiver request is denied for incompleteness, the Applicant shall provide additional information as requested in the response letter and re-submit the waiver request for an additional review.

7. If the waiver request is denied because the project does not meet any of the criteria found in Section 9.1, detention must be provided.

8. Approval of a detention waiver request does not impact the requirement for first-flush retention.

10. DRAINAGE REPORT CONTENT

The drainage report shall contain a separate section entitled Stormwater Detention and Retention. This section shall contain sufficient analyses and information to demonstrate that the applicable requirements of this manual will be met for the project.

10.1 Content for an Approved Detention Waiver

1. If a waiver has been approved by the Floodplain Administrator, the Stormwater Detention and Retention Section shall contain the following:
   a. A short discussion of the justification for the waiver; and
   b. Copy of the Detention Waiver approval.

10.2 Content for LID Practices

1. Provide a description of stormwater harvesting basinsd and the analysis of the first-flush retention requirement using the methodology found in Section 2.2.

2. Provide a discussion of use of additional LID practices, including:
   a. Minimized disturbed and impervious surfaces;
   b. Protection/enhancement of riparian habitat and regulatory floodplains and other higher permeability areas, such as natural areas;
   c. Disconnected impervious surfaces;
   d. Lengthened flow paths;
   e. Use of conveyance systems which mimic natural conditions;
   f. Decentralization of detention basins; and
   g. Pervious pavements.

3. When stormwater harvesting basins are proposed, provide the analysis of the peak discharge rate reduction for each return period using the methodology presented in Section 3.3.

4. Provide a stormwater harvesting basin summary table which uses the same basin labels as shown on the proposed conditions drainage exhibit and the project plan with the following:
   a. Total stormwater harvesting basin retention volume, cubic feet or acre feet;
   b. First-flush retention volume, cubic feet or acre feet;
   c. Bottom elevation, feet;
   d. If applicable, invert elevations for inlet and overflow, feet;
   e. If applicable, dimensions of inlets and overflow, feet;
   f. The contributing area to each basin or group of basins, square feet or acres;

g. The post-developed peak discharge directed to each basin or group of basins, cubic feet per second;
h. The reduced peak discharge rates attributable to stormwater harvesting for 2-, 10- and 100-year return periods, cubic feet per second; and
i. The pre-developed peak discharge rates, cubic feet per second, and indication if additional detention is required.

5. Provide a cross section of each stormwater harvesting basin showing and labeling the following information, as applicable:
   a. Side slope with surface treatment and the horizontal-to-vertical ratio indicated;
   b. 100-year water surface elevation, feet;
   c. If applicable, inlet and overflow structures with dimensions, feet, material type and elevations, feet; and
   d. Inlet and overflow protection, toe down, feet, rock riprap (length, feet, thickness, feet, or relative rock diameter, treatment, rock size, inches).

6. Provide a cross section of each bioretention basin, showing and labeling material layers and surface depression, inches, and side slopes.

7. On the proposed conditions drainage exhibit, show the location of all LID practices.

10.3 Content for Detention Basins

1. A brief summary of the applicable detention requirements relevant to the development including a statement about the project's location within a Balanced or Critical Basin.

2. A description of the detention proposed to achieve the required post-development peak discharge or runoff volume reduction for the project.

3. A description of inlet and outlet structures, with supporting design calculations, including:
   a. Hydraulic calculations for all inlet and outlet structures;
   b. Calculations for erosion protection dimensions and rock sizing; and
   c. Calculations demonstrating that flows exiting the project boundary approximate flow characteristics of pre-developed conditions.

4. Stage-storage-discharge table.

5. The analysis of the storage-indication method to determine amount of peak discharge rate reduction by a basin along with supporting documentation shall be provided.

The following storage-indication methods can be used to determine the peak discharge rate reduction:

a. The PC-ROUTE spreadsheet with supporting documentation.
b. HEC-HMS Version 3.3, or higher, with supporting documentation, including:
    i. HEC-HMS model summary output, and
    ii. A CD of the modeling.

6. A basin summary table with the following basin design parameters:
    a. Detention volume, cubic feet or acre feet;
    b. If applicable, retention depth, inches, and volume, cubic feet;
    c. Top and bottom elevations, feet;
    d. 100-year water surface elevations, feet;
    e. Invert elevations for inlets and outlets, feet;
    f. Dimensions of inlets and outlets, feet;
    g. 2-, 10- and 100-year inflows, cubic feet per second; and
    h. 2-, 10- and 100-year outflows, cubic feet per second.

7. A cross section of the basin showing and labeling the following information as applicable:
    a. Bottom slope (0.5% minimum unless retention is provided);
    b. Side slope with surface treatment and the horizontal-to-vertical ratio indicated;
    c. 100-year water surface elevation, feet;
    d. Inlet and outlet structures with dimensions, feet, material type and elevations, feet;
    e. Outlet protection, toe down, feet, rock riprap (length, feet, thickness, feet, or relative rock diameter, treatment, rock size, inches); and
    f. If applicable, security barrier.

8. Cross sections perpendicular and parallel to the basin inlet and outlet structures, with dimensions, feet.

9. When a basin is located to accept flows from predominantly natural areas, supporting calculations for sediment basin design shall be provided by an engineer registered in the State of Arizona.

10. When a basin is proposed less than 15 feet away from a structure, the recommended minimum separation between a basin and a structure shall be provided by a geotechnical engineer registered in the State of Arizona.

11. When an embankment is proposed, the following shall be provided:
    a. Site conditions specified in Section 4.10.1.2;
    b. For embankments designed to impound greater than 1 foot of water, the calculations for the emergency spillway design capacity as outlined in Section 4.10.1.9.; and

c. Engineering analysis for erosion protection if the embankment is located within an erosion hazard setback or regulatory sheet flood area; and

12. When an underground storage system is proposed the following shall be provided:
    a. A storage volume analysis documenting 1.5 times the design volume of an above ground basin;
    b. The drainage path to deliver flows in a reasonable and safe manner in the event the system cannot accept flow; and
    c. A copy of the report specified in Section 4.13.1.8.

13. When a pump is proposed, the following shall be provided:
    a. The Floodplain Administrator's written acceptance to use the pump;
    b. Analysis demonstrating that the pump can accommodate the entire volume of the 100-year post-developed hydrograph emanating from the contributing drainage area or a statement indicating that a back-up pump with an emergency power source will be utilized;
    c. Demonstration that the pump's discharge rate does not exceed the pre-developed conditions 2-year peak discharge rate;
    d. Trash rack/screen design calculations using a 2.0 clogging factor;
    e. Emergency back-up plan;
    f. Drainage exhibit showing drainage flow under clogged conditions; and
    g. Inspection and maintenance protocol with, at minimum, the following:
        i. Maintenance schedule;
        ii. Type of maintenance activities; and
        iii. Exhibit showing the location of the pump, alarm systems and other equipment.
    h. A copy of the pump system analysis as outlined in Section 4.18.1.15.

10.4 Content for Dry Wells

1. When a dry well is used as a method of disposal, the following shall be provided:
    a. Justification for the use of a dry well;
    b. The Floodplain Administrator's written approval of the dry well;
    c. A copy of the percolation test that determines the stabilized infiltration rate;
    d. Dry well system design by a licensed professional;
    e. Calculations and supporting documentation for the dry well disposal rate;
    f. Dry well specifications and cross section of a typical well;
    g. Depth to groundwater information;
    h. Documentation that the disposal rate meets the storage time standards found in Section 4.5; and
    i. A plan for stormwater disposal in the event the dry well(s) cease(s) to function.
    j. Inspection and maintenance protocol with at minimum the following:
        i. Maintenance schedule;

ii. Type of maintenance activities;
iii. Exhibit showing the location(s) of the dry well(s); and
iv. Contact information of the driller or authorized maintenance professional.

10.5 Required Summary Table for All Projects

1. A table of the 2-, 10- and 100-year peak discharges for pre-developed, post-developed without detention/retention and post-developed with detention/retention at all concentration points where flows exit the project site shall be provided in the main body of the report.
   a. The table shall demonstrate that the post-developed with detention/retention peak discharges do not exceed the pre-developed peak discharges or are reduced, as required.
   b. If developed conditions watersheds have a different configuration than pre-developed conditions watersheds, the table shall correlate the post-developed concentration points with the pre-developed concentration points. The location of post-developed concentration points at the downstream property boundary must approximate the location of the pre-developed concentration points at the downstream property boundary.

11. REQUIREMENTS FOR PLATS, DEVELOPMENT PLANS AND CONSTRUCTION PLANS

The following information shall be placed on or submitted with plats and development plans.

11.1 Required Content for Tentative Plats and Development Plans

11.1.1 Detention Waiver

1. If a Detention Waiver has been granted for the project, provide a General Note:

   "*A waiver of detention requirements has been granted for this project by the Floodplain Administrator. The owner has paid a fee in lieu of providing stormwater detention facilities.*"

11.1.2 General Notes and Permitting Notes

1. If Detention and/or Retention is provided, provide the following General Note, with the relevant volumes:

   "This project is required to provide stormwater detention and/or retention. The total volume of detention provided is _____ cubic feet. The total volume of retention provided is _____ cubic feet.

2. When a project includes LID practices, embankments, an underground storage system, pumps or a dry well, provide the following General Note:

   "This project includes _____ [LID practices, embankments, underground storage system, pumps or drywell(s)]. An inspection and maintenance protocol has been provided to the entity responsible for maintenance. An inspection and maintenance covenant has been recorded in the Public Records of Pima County."

3. When a project has drainage and grading improvements that are required to mitigate off-site adverse impacts to the proposed development, an As-Built Certification or plan shall be prepared and submitted to the Floodplain Administrator.

   Provide the following Permitting Note to disclose this requirement:

"An As-Built Certification (Plan) of the drainage and grading improvements that are required to mitigate off-site adverse impacts to the project shall be prepared and submitted to the Floodplain Administrator."

4. When a project has drainage and grading improvements that are required to mitigate off-site adverse impacts to adjacent properties, an As-Built Certification or plan shall be prepared and submitted to the Floodplain Administrator. The As-Built Certification requires approval prior to the Certificate of Occupancy for development plans and prior to the final Release of Assurances for plats. Provide the following Permitting Note for development plans and General Note for tentative plats to disclose this requirement:

   "Prior to issuance of the [Certificate of Occupancy/final Release of Assurances] an As-Built Certification(Plan) of the drainage and grading improvements that are required to mitigate off-site adverse impacts to adjacent properties shall be prepared and submitted to the Floodplain Administrator. Upon approval of the as-built plan by the Floodplain Administrator, the hold to issuance of [Certificate of Occupancy/final Release of Assurances] can be removed."

11.1.3 Required Descriptions for Detention Basins and Stormwater Harvesting Basins

1. Provide a descriptor box adjacent to each basin. Include a leader arrow to the basin or provide a label for the basin and reference the label on the top of the descriptor box. Include the following applicable information in the descriptor box:
   a. Total volume, cubic feet or acre feet;
   b. If applicable, detention volume, cubic feet or acre feet;
   c. If applicable, retention volume, cubic feet;
   d. If applicable, first-flush retention volume, cubic feet;
   e. If applicable, Q_{100} in, cubic feet per second;
   f. If applicable, Q_{100} out, cubic feet per second;
   g. Basin top elevation, feet;
   h. 100-year water surface elevation, feet; and
   i. 100-year ponding depth, (measured from the lowest elevation of the basin), feet.

2. For tentative plats, the basin(s) shall be shown within a Common Area, and the plat shall indicate in the title block that the Common Area includes drainage.

3. Label each basin as a Private Detention or Stormwater Harvesting Basin.

4. Show conceptual grading for each basin and include the following information:

   For detention and stormwater harvesting basins include:
   a. Location of maintenance access;
   b. Conceptual grade contours;
   c. Side-slope horizontal-to-vertical ratio with slope treatment;
   d. Location and dimensions, feet, of outlet or slope protection; and
   e. For drainage infrastructure requiring a covenant, provide the Sequence Number adjacent to the applicable structure and/or basin or a note indicating that the covenant has been recorded in the Public Records of Pima County.

   For detention basins also include:
   f. Location of the sediment level device;
   g. Security barriers, if applicable, with height (minimum of 42 inches high) and material type indicated;
   h. If no retention is proposed within the detention basin, positive drainage to the outlet structure, minimum 0.5% slope; and
   i. Location of inlet and outlet structures with inverts or other inlet and outlet elevations. Call out dimensions and materials. Call out the Q_{100}, cubic feet per second, for all structures.

5. When a retaining wall is utilized as a basin side, a preliminary structural design detail for the retaining wall must be provided. The preliminary design shall include at a minimum the wall and footing dimensions. The intent is to demonstrate that the foundation of the wall will not negatively impact property setbacks or easements and to provide assurance that soil saturation has been considered. The preliminary design detail may be marked preliminary and should be attributed to the design engineer, if the design engineer is different from the project engineer. Complete structural design and construction drawings will be submitted as required by development services during the construction permitting process.

6. When an underground storage system is proposed, show the following on the tentative plat or development plan:
   a. Location of the underground storage system;
   b. Appropriate building setbacks from the underground storage system related to structural integrity, feet;
   c. Locations of inlets and outlets with Q_{100}s and location of emergency overflows.

7. When the project includes a pump(s), the following information shall be included on the plan view:
   a. Location of the service equipment;
   b. Location of the sump with dimensions shown; and
   c. Q_{100} discharge, cubic feet per second.

8. When the project includes a dry well(s):
   a. The location of the drywell(s);
   b. Slope to the dry well(s); and
   c. Elevation of the dry well inlet(s), feet.

9. When Non-contributing Basins or Bioretention Basins are proposed, the following shall be shown:
   a. The location of the basin(s);
   b. If applicable, location of sediment trap;
   c. Retention volume, cubic feet.

11.1.4 Requirements for LID Practices other than Stormwater Harvesting Basins

1. When LID Practices other than Stormwater Harvesting Basins are proposed, the following shall be shown:
   a. The location and dimensions of swales and other constructable site features, with proposed surface treatment called out.

2. It is optional to call out site planning techniques, such as reduced disturbance or disconnected impervious surfaces.

11.2 Required Detention Basin and LID Practices Content for Final Plats

11.2.1 Detention Waiver

1. If a Detention Waiver has been granted for the project, provide a General Note:

   "A *waiver of detention requirements has been granted for this project by the Floodplain Administrator. The owner has paid a fee in lieu of providing stormwater detention facilities."*

11.2.2 General and Permitting Notes

1. If Detention and/or Retention is provided, provide the following General Note, with the relevant volumes:

   "This project is required to provide stormwater detention and/or retention. The total volume of detention provided is _____ cubic feet. The total volume of retention provided is _____ cubic feet.

2. If applicable, provide the General Note:

   "This project includes _____ [LID practices, embankments, an underground storage system, pumps or dry well(s)]. An inspection and maintenance protocol has been provided to the entity homeowners association. The inspection and maintenance requirements are included in the Conditions, Covenants and Restrictions which have been recorded in the Public Records of Pima County."

3. When a project has drainage and grading improvements that are required to mitigate off-site adverse impacts to the proposed development, an As-Built Certification or plan shall be prepared and submitted to the Floodplain Administrator. The As-Built Certification or plan requires approval prior to the issuance of any building permits, except for model home permits and any permits necessary to build drainage infrastructure.

   Provide the following Permitting Note to disclose this requirement:

   "Prior to issuance of any building permits an As-Built Certification(Plan) of the drainage and grading improvements that are required to mitigate off-site adverse impacts to the project shall be prepared and submitted to the Floodplain Administrator. Upon approval of the as-built plan by the Floodplain Administrator, the hold to issuance of building permits can be removed."

4. When a project has drainage and grading improvements that are required to mitigate off-site adverse impacts to adjacent properties, an As-Built Certification or plan shall be prepared and submitted to the Floodplain Administrator. The As-Built Certification requires approval prior to the final Release of Assurances.

   Provide the following Permitting Note to disclose this requirement:

   "Prior to the final Release of Assurances, an As-built Certification(Plan) of the drainage and grading improvements that are required to mitigate off-site adverse impacts to adjacent properties shall be prepared and submitted to the Floodplain

Administrator. Upon approval of the as-built plan by the Floodplain Administrator, the hold to the final Release of Assurances can be removed."

11.2.3 Requirements for Detention Basins and Stormwater Harvesting Basins

1. Show the areas where basins are located as Common Area, and indicate in the title block that the Common Area includes drainage features.

11.3 Required Detention Basin and LID Practices Content for Construction Plans

1. Show all basins and other LID practices on the plan view, calling out applicable setbacks. Label all basins as private.

2. On detail sheets, show cross sections of basins, including detention basins, stormwater harvesting basins, and bioretention basins, with the following information as applicable:
   a. For detention and stormwater harvesting basins include:
      i. Dimensions of top and bottom areas, feet;
      ii. Top and bottom elevation, feet;
      iii. Freeboard elevation, feet;
      iv. 100-year water surface elevation, feet;
      v. Side-slope horizontal-to-vertical ratio with slope treatment;
      vi. Setbacks from property boundaries or other suitable access area (4-foot minimum);
      vii. Weir or other outlet structure elevation(s), feet;
      viii. Location and dimensions of inlets; and
      ix. Dimensions, rock sizing, fabric filter placement, and/or cutoff walls for any proposed erosion protection. The erosion protection shall be shown extended below finished grade.
   b. For detention basins only include:
      i. Security barriers, if applicable, with material type and height; and
      ii. For embankment conditions indicate the following:
         1. Freeboard elevation, feet, (1 foot minimum);
         2. 95% compaction; and
         3. For embankments designed to impound more than 1 foot of water, the following shall be included:
            a. Emergency spillway location; and
            b. Impervious treatment with toe down (minimum depth of 18 inches).

   Typical cross sections are provided in Appendix E.

   c. For bioretention basins include:
      i. Depth and length, feet;

ii. Depression depth, inches;
iii. Base layer depth, inches, and material type;
iv. Depth of soil medium, inches, and material type; and
v. Dimensions of sediment trap.

3. On a detail sheet, show cross sections perpendicular and parallel to inlet and/or outlet structures with the following information:
   a. Dimensions, feet;
   b. Material type;
   c. Invert elevations, feet; and
   d. 100-year peak discharge, cubic feet per second.

   A typical detail is provided in Appendix E.

4. When an underground storage system is proposed, show the following, at a minimum:
   a. Location of the underground storage system;
   b. Appropriate building setbacks from the underground storage system related to structural integrity;
   c. Locations of inlets and outlets with Q_{100}'s and locations of emergency overflows;
   d. Dimensions and material; and
   e. Any recommended compaction or bedding material.

5. When the project includes a pump, the following information shall be included on the plan view:
   a. Location of the service equipment;
   b. Location of the sump with dimensions shown;
   c. Q100 discharge, cubic feet per second;
   d. Manufacturer's specifications; and
   e. Elevations of pump components.

6. When the project includes a dry well, the following shall be shown on the plan view:
   a. The location of the drywell;
   b. Slope to the dry well;
   c. Elevation of the dry well inlet;
   d. A detail showing the typical dry well installation; and
   e. A detail showing the words "Stormwater Only" stamped in raised letters on the drywell grate.

11.3.1 Requirements for LID Practices other than Stormwater Harvesting Basins

1. When LID Practices other than stormwater harvesting basins are proposed, the following shall be shown:

a. The location and dimensions of swales and other constructible site features, with proposed surface treatment called out.

2. It is optional to call out site planning techniques, such as reduced disturbance or disconnected impervious surfaces.

12. REQUIRED CONTENT FOR AS-BUILT CERTIFICATION AND PLANS

12.1 General Requirements

1. Drainage and grading improvements required by the Floodplain Administrator shall be inspected by a Professional Engineer registered in the State of Arizona. The Engineer shall certify that the improvements were built in substantial conformance with the approved plans.

2. When the improvements have been constructed in substantial conformance with the approved construction plans, an As-Built Certification is sufficient. When construction is not in substantial conformance, an as-built plan shall be submitted for review and approval along with the certification document. The as-built plan may be the original plan sheets with exceptions noted on the plan or new plan sheets. The submitted plan sheets shall be stamped or labeled As-Built and signed and sealed by the certifying Engineer.

12.1.1 Detention Basins

1. The following, at minimum, shall be certified;
   a. Top and bottom elevation, feet;
   b. Side-slope horizontal-to-vertical ratio;
   c. Inlet and outlet locations, dimensions and elevations, feet;
   d. Setbacks from property boundaries and, if applicable, structures, feet;
   e. Maintenance access;
   f. 0.5% slope along basin bottom for positive drainage to the outlet structure when retention is not provided within the detention basin;
   g. Erosion protection, including material and dimensions, feet;
   h. Slope treatment;
   i. Sediment level device;
   j. If applicable security barrier material and location;
   k. When the basin includes embankment conditions, the following:
      i. Toe-down dimensions, feet; and
      ii. For embankments designed to impound more than 1 foot of water:
         1. Emergency spillway location and dimensions; and
         2. 95% compaction of the embankment materials.
   p. When the basin includes a retaining wall, the following:
      i. Dimensions, feet; and
      ii. Setbacks, feet.
   q. For underground storage, the following;
      i. Building setbacks, feet;
      ii. Type of material;
      iii. Bedding material;

iv. System dimensions, feet; and
v. Inlets, outlets, and overflows.

r. When the basin includes a pump:
i. Pump sump dimensions and location;
ii. Pump specifications;
iii. Inlets, outlets, and overflows; and
iv. Alarm system.

s. When a project includes a dry well:
i. Drywell grate with the words "Stormwater Only;"
ii. Drywell specifications and location; and
v. Verification of ADEQ drywell registration.

12.2 Stormwater Harvesting Basins

1. The following at minimum, shall be certified:
   a. Location as proposed;
   b. Dimensions of top and bottom areas, feet;
   c. Top and bottom elevation, feet;
   d. Side slope ratio;
   e. Setbacks, feet;
   f. Maintenance access;
   g. Slope treatment;
   h. Location of the sediment trap.

2. When bioretention basins are used, the following shall be certified:
   a. Depth, inches or feet;
   b. Top dimensions, feet;
   c. Location of the sediment trap;
   d. Vertical inspection pipe; and
   e. Material types.

12.3 Other LID Practices

1. The following, at minimum, shall be certified:
   a. Location of LID Practice(s);
   b. If disconnection of impervious surfaces or pervious pavement is being claimed as a LID practice, construction as designed; and
   c. If lengthened flow paths are incorporated as a LID practice, site layout as designed, dimensions of swale and surface treatment of swale.

13. GLOSSARY OF TERMS

The following terms are in addition to the terms defined by the Ordinances of jurisdictions within incorporated and unincorporated Pima County.

Adverse Impact – A change in flow conditions as a result of a development that creates a violation of an applicable floodplain ordinance, a safety issue or property damage.

Approval – Written notice by the Floodplain Administrator approving a submittal including development plans; plats; drainage reports; waivers; proposed pumps, drywells, or underground stormwater storage; and requests to provide designs, analyses or reporting which is different from the requirements stated in this manual

Approved Plan – The most current development plan, plat or construction permit which bears the authorized signature of approval.

Arizona Department of Water Resources (ADWR) - The state agency assigned with oversight of flood control as provided in Title 48 Chapter 21 of the A.R.S.

Attenuation – The collective effect of peak discharge or volume reductions achieved by routing flood waters through a detention basin or approved Low Impact Development Practices.

Concentration Point – A hydrologic term which describes any specific point within a watershed where surface drainage is to be analyzed.

Construction Permit - An engineering document which shows the site layout for a proposed project overlaid on a map of the site and the surrounding area. The plan shows the proposed building locations and footprints, parking lot layout, access, drainage facilities, construction details, site grading and utilities locations for conformance review with applicable regulations.

Covenant – Written agreements that impose responsibilities on the land owners and restrictions upon the use of land.

Dams – The Arizona Department of Water Resources (ADWR), Surface Water Division, has legal jurisdiction over all dams which exceed certain height and storage limits.

> Arizona State Statutes, article 45-1201., defines a dam as any artificial barrier, including appurtenant works for the impounding or diversion of water, twenty-five feet or more in height or the storage capacity of which will be more than fifty acre-feet but does not include:
>
> - Any barrier that is or will be less than 6 feet in height, regardless of storage capacity.

- Any barrier that has or will have a storage capacity of 15 acre-feet or less, regardless of height.
- Any barrier for the purpose of controlling liquid-borne material.
- Any barrier that is a release-contained barrier.
- Any barrier that is owned, controlled, operated, maintained or managed by the United States government or its agents or instrumentalities if a safety program that is at least as stringent as the state safety program applies and is enforced against the agent or instrumentality.

Development Plan – An engineering document which shows the site layout for a proposed project overlaid on a map of the site and the surrounding area. The plan shows the proposed building locations and footprints, parking lot layout, access, drainage facilities and utilities for conformance review with applicable regulations.

Disposal Time – The time period during which standing water must be eliminated from a detention basin or Low Impact Development Practice.

Disturbance – The condition of land areas that have been graded, compacted, or significantly altered.

Drainage Report – A report that provides a description of existing and future site conditions supporting hydraulic and hydrologic data, a delineation of the flood prone areas, and a detailed description of the proposed manner in which drainage shall be handled.

Embankment – A linear, usually trapezoidal in cross section, compacted soil feature which is constructed along 1 or more sides of a detention basin. The linear extent of the embankment is constructed above the predominant finished grade. The embankment may be constructed of in-situ or imported soils. Incidental fills to restore predominant natural grade or mass-grading to establish project overall grades are not considered to be embankments.

Emergency Spillway – An outflow spillway from a detention basin which is provided to allow for the safe overflow of floodwaters.

Filter Fabric – Fabric, typically non-woven, used for soil stabilization to prevent soil shifts and movements.

Final Plat – A survey document suitable for recordation of all or part of a subdivision conforming to an approved tentative plat.

First-flush – The delivery of a highly concentrated pollutant loading during the early stages of a storm due to the washing effect of runoff on pollutants that have accumulated on drainage surfaces.

Flood Control – The control of flood waters by employing methods of containment such as a detention system that stops and slows down the downstream progress of flood waters.

Freeboard – The distance measured from the top of an impoundment to the 100-year water surface elevation.

Finished Grade – Any ground elevation which has been cut to or built to the design elevation.

Hard Durable Stones – Stones highly resistant to deterioration by natural processes.

HEC-HMS – Hydrologic Modeling System (HEC-HMS) designed to simulate the precipitation-runoff processes of dendritic drainage basins.

Human Activity Zones – Areas used within a basin for multiple purposes other than detention where human recreational activities are involved.

Hydrograph – A graph showing changes over time in the stormwater runoff from a drainage area.

Hydroseed – A mixture of seed, mulch and soil ameliorants applied by spraying or other mechanical means.

Impervious – Not allowing entrance or passage by water.

Impervious Treatment – A process that renders a surface impervious to water.

Inflow – Runoff which flows into a stormwater storage facility from the upstream watershed.

Inlet – Structural element that serves as the entrance where stormwater is directed into a basin.

Inspection – Examination of the conditions of drainage structures to ensure their proper functioning.

Invasive Plants – Plants that invade ecosystems beyond their historical range. Dependent on these ecosystems, invasive plants can threaten native ecosystems or commercial, agricultural, or recreational activities dependent on these ecosystems costing the economy billions of dollars on an annual basis.

Landscape Bufferyard – A strip of land used for landscaping to separate one type of land use/zoning from another.

Length of Watercourse – The length of the flow path taken by water runoff from a surface.

Low Impact Development (LID) – Practices that utilize basic principles modeled after the natural environment by managing runoff and urban water use at the source using uniformly distributed small-scale controls.

Maintenance – The upkeep of drainage structures to assure conformance with approved design and storage volume over time.

Maintenance and Inspection Protocol – A document describing items to be inspected to assure proper functioning of drainage structures over the life of a project and the maintenance activities, if any, to be completed to resolve issues noted during an inspection.

Major Watercourse – For the purposes of this manual, a natural channel which conveys a 100-year peak discharge of 10,000 cfs or more, or a watercourse which has been designated as a major watercourse for an individual instance based on engineering justification accepted by the Floodplain Administrator.

Multiple-Use Concepts – Concepts employed in an engineered basin that provide benefits in addition to the primary function of flood control. Such benefits may include recreation, water harvesting, or visual buffers.

Outflow – The discharge which exits a stormwater storage facility by means of an outlet structure.

Outlet – The point at which stormwater runoff flows out of an engineered basin.

PC-Hydro – A semi-empirical rainfall-runoff model accepted in Pima County for predicting flood peaks from ungaged watersheds under natural and developed hydrologic conditions.

Peak Discharge – The maximum flow rate, in terms of volume per time, passing a particular location during a storm event.

Pima County – The incorporated, as well as the unincorporated areas of Pima County, including public lands, but excluding tribal and military reservations and those incorporated areas of cities or towns which have elected to assume separate floodplain management powers and duties pursuant to Section 48-3610 of the Arizona Revised Statutes.

Pre-Developed Conditions – Site conditions related to drainage prior to land development.

Primary Tributary – A channel which flows directly into a major watercourse.

Project Boundary – The boundary that sets the limits of the project site.

Post-Developed Conditions – Site conditions related to drainage after land development.

Positive Drainage – The drainage condition which provides for removal of stormwater from a site within the required disposal time and prevention of ponding of water for periods exceeding the required disposal time.

Rainwater – Liquid water that has precipitated from atmospheric water vapor but has not yet landed on the earth's surface or any protrusions on the earth's surface.

Recorded – Placed into the public record by the Pima County Recorder.

Regional Detention Basin – A detention basin which collects stormwater runoff from a relatively large area, and has been designed to use storage as a means of reducing downstream flood peaks, reducing possible flood damage, or reducing downstream channel construction costs. Regional facilities are usually multi-purpose, and normally are the responsibility of a public entity.

Riprap – A rock layer combination of large stone, cobbles and boulders that protects earthen surfaces from erosion.

Routing – A mathematical procedure for predicting the changing magnitude, speed, and shape of a flood wave as it travels through a detention basin.

Runoff – Stormwater flowing over a surface.

Secondary Tributary – A natural channel which discharges into a primary tributary.

Setback – The horizontal distance between an object of interest and perimeter of a basin or property boundary or public access limit.

Sediment – An earthen material that is carried and deposited by water.

Site – Area where a project is located including improved areas, open space, floodplains and other regulatory development areas.

Storage – Volumetric measurement of the water stored in the detention basin.

Stormwater – Rainwater that has landed on a surface.

Stormwater Harvesting – The process of intercepting stormwater from a surface such as a roof, parking area, or land surface, and putting it to beneficial use.

Subdivision – Improved or unimproved land or lands divided or proposed to be divided for the purpose of sale, lease, or for cemetery purposes, whether immediate or future, into 6 or more lots, parcels or fractional interests.

Subsoil – The layer of soil under the topsoil.

Sustainability Principles – The development and construction principles that support a sustainable future.

Swale – A depression that is cut into the soil for the purpose of conveying stormwater.

Technical Policy (Policies) – Publications by the District which clarify the permitting requirements of the Pima County Floodplain and Erosion Hazard Management Ordinance.

Tentative Plat – A tentative plat is a map showing the existing conditions of the property and surrounding area on which proposed development is overlaid, which can include topography, infrastructure improvements, and existing structures.

Time of Concentration – The time required for storm runoff to flow from the hydraulically most remote point of a catchment or drainage area to the outlet or point under consideration.

Watershed – The contributing drainage area located upstream of a specific point along a watercourse.

Weir – A structure placed at the basin outlet to control the volume of outflow.

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