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(Reserved for future use)

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 new development in Pima County. This manual is a supplement to, and has the same regulatory authority as, the Pima County Floodplain Management Ordinance, Title 16 of the Pima County Code.

Since 1987, the Regional Flood Control District (the District), through the Stormwater Detention/Retention Manual, has required runoff detention systems to:

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

This manual will continue to require protection of adjacent properties and preservation of pre-developed peak discharges but will incorporate revisions that:

1. Replace the 2-year or 5-year threshold retention requirement with first flush retention that may be located throughout the development. The retained volume may 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.

1.2 ORDINANCE OVERVIEW AND DETENTION REQUIREMENTS

The broad goals of the Floodplain Management Ordinance (the Ordinance) 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 Ordinance requires 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 Ordinance requirements in Chapter 16.48, RUNOFF DETENTION SYSTEMS, support the overall goals of the Ordinance by mandating that post-development runoff rates be reduced to pre-development rates. In Section 16.36.030, Grading, storm water, and drainage improvement, the Ordinance stipulates that improvements be compatible with the existing upstream and downstream drainage conditions and that any proposed grading and/or grade change not have an adverse impact on surrounding properties. These sections of the Ordinance form the foundation for the requirements presented in this manual.

With a general requirement for assuring no adverse impact arising from Section 16.36.030, the standards also rely on the more specific requirements in Chapter 16.48, including:

1. All new developments will provide some method of peak discharge or volume reduction of runoff.

2. Watershed basins within Pima County have been designated as Critical Basins or Balanced Basins, as shown on the Critical and Balanced Basin Map available at: http://rfcd.pima.gov/rules/pdfs/critical_basins.pdf. 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. 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.

3. A fee may be paid to the District in-lieu of construction of detention facilities when the parcel to be developed is less than one acre in size; when the parcel is located within close proximity to a major watercourse; when the proposed development is of low residential density (less than 2 residences per acre) and maintains the natural drainage patterns; or when other engineering justification acceptable to the Chief Engineer can be demonstrated. Detention Waiver Request forms are available on the District website: http://rfcd.pima.gov//pdd/guidelines/pdfs/det_ret_waiver.pdf
and more information is provided in Chapter 8, Detention Waiver Request and Payment of In-Lieu Fee.

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 District does not

allow 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.

1.4 CONFLICTING REQUIREMENTS AND VARIANCES

If any of the requirements of this manual conflict with one another, the Ordinance or other District policies; the more restrictive requirement shall apply.

Requests to provide designs, analyses or reporting which is different from the requirements stated in this manual shall be made in writing to the District a minimum of 20 working days prior to submittal. A response shall be provided in writing to the applicant making the request within 20 working days.

1.5 LOW IMPACT DEVELOPMENT PRACTICES

This manual introduces requirements for 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, while reducing both peak discharge rate and runoff volume.

The use of LID practices accomplishes multiple goals including responding to the frequent complaints from downstream neighbors about the increased amount of run-off from new development during even the smallest storms, satisfying State and Federal regulations requiring jurisdictions to reduce the contribution of pollutants from urbanized areas to our watercourses, and providing a mechanism to provide runoff to landscape, bufferyards, and riparian areas in a way that also satisfies some flood control requirements.

Site design which incorporates LID concepts will include elements such as catchments immediately downstream of impervious surfaces and grading and interconnected curvilinear flow paths which reduce the velocity of surface flow. An example of a site design incorporating LID concepts is the Lester Street site at the University of Arizona and is illustrated below.

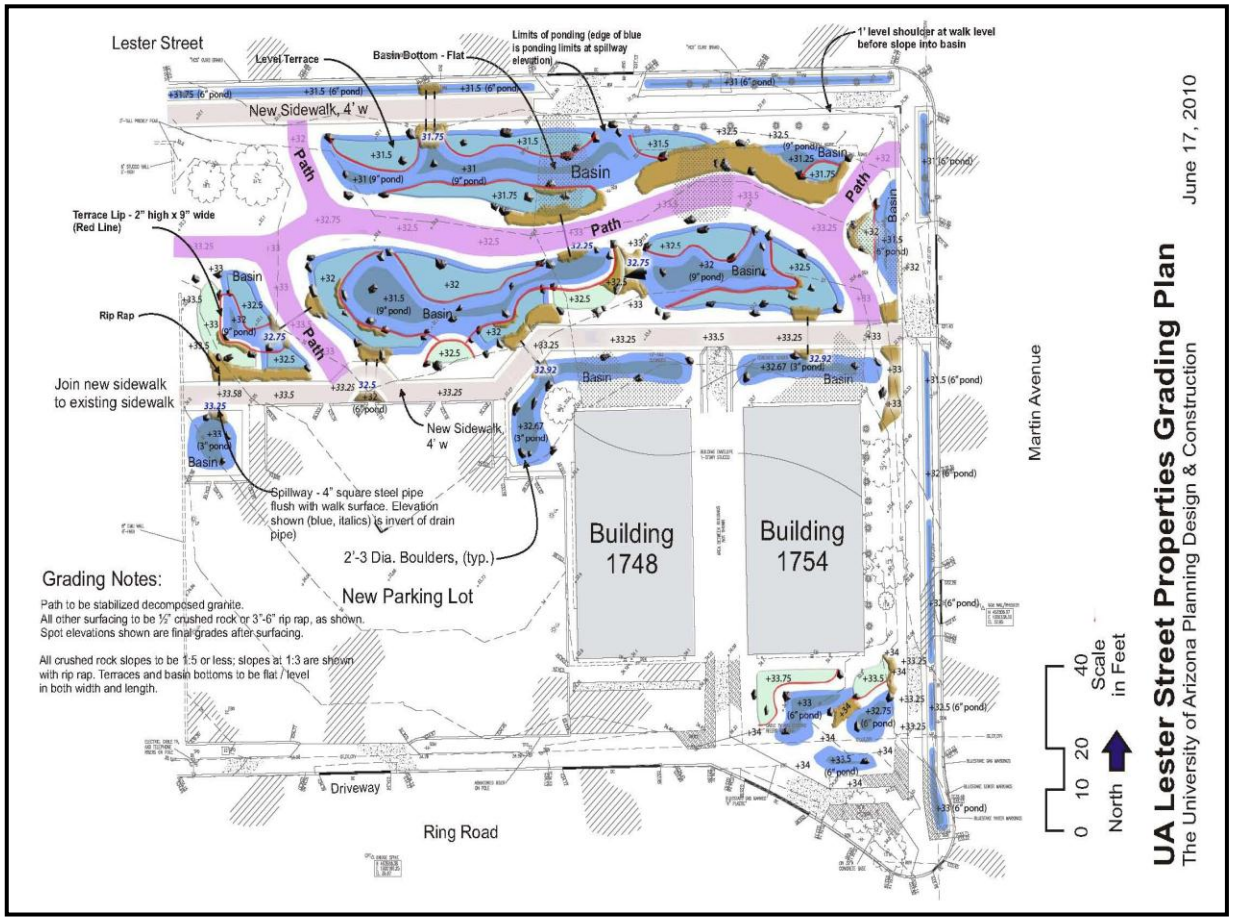


Figure 1.1 An Example of LID site design (Source).

Runoff from roofs and parking areas is directed to a series of shallow basins which are interconnected by pipes or berm spillways so that the amount and rate of flow at the downstream boundary of the project are reduced.

Appropriate landscaping creates aesthetically pleasing runoff paths and increases evapotranspiration. The landscape concept for the Lester Street project is shown below.

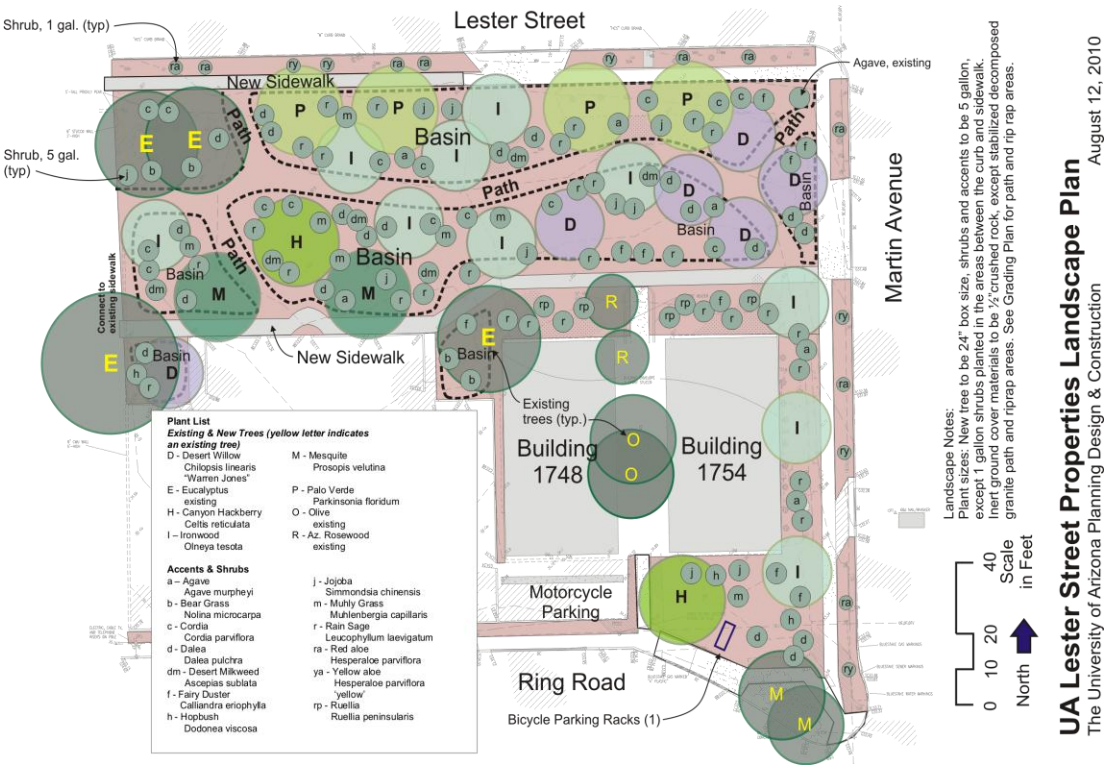


Figure 1.2 An Example LID Landscape Concept Plan

In lieu of 2-year or 5-year threshold retention, the District will require the use of LID practices to capture and retain the first flush, or the first 0.5 inches of rain that falls on impervious or disturbed areas. This requirement will not apply to those portions of the project site that are left undisturbed.

To incentivize the use of LID practices, the District will allow a reduction in the required volume of detention facilities in addition to mitigation of the first flush retention requirements, when quantifiable flood control benefits can be measured, these practices include:

1. Minimization of disturbed, compacted and impervious surfaces,
2. Protection and maintenance of riparian habitat and drainage patterns,
3. Use of stormwater harvesting in depressed earthen areas.
4. Decentralization of these basins throughout the development
5. Disconnection of impervious surfaces
6. Maximization of time of concentration through the use of swales, site design and increased lengths of flow paths, and

7. Use of conveyance systems which mimic natural conditions.

In order to facilitate the use of LID practices, the District encourages applicants to satisfy other requirements within LID practices. Examples include incorporating LID practices when meeting landscaping, native plant, and riparian requirements. The location of mitigation areas may maximize the effect of proposed LID practices. Other regulatory requirements that could be met include open space set aside, bufferyard, and park requirements.

Details and design standards for authorized LID practices will be 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 District. While this manual provides standards and guidelines for designing, constructing and maintaining detention basins, it also promotes use of alternatives to excavated basins or a combination of detention basins and alternative practices to achieve required levels of stormwater detention and retention.

Site planning during re-zoning 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 Planning and Development Division of the District 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 District prior to submittal of the detention analysis.

The District intends to review this manual periodically and to update the manual if appropriate. As new construction methods and materials, environmental regulations and sustainable development practices evolve, new design standards may be incorporated into the manual.

1.8 BACKGROUND RESEARCH

The publication of this manual follows a thorough literature review, modeling of the proposed practices, compilation of recognized design standards and procedures, and public comment.

The background research supporting the results appearing in this manual is available at: http://rfcd.pima.gov/pdd/.

2 FIRST FLUSH RUNOFF VOLUME REDUCTION

Capturing and retaining stormwater throughout the project results in a reduction of the size of the 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 in order to address water quality protection goals, reduce downstream adverse impacts related to the increased frequency of runoff from the development, and encourage the development to mimic natural features which allows for the beneficial re-use of stormwater on a development.

2.1 FIRST FLUSH RUNOFF VOLUME REDUCTION REQUIREMENTS

All new development shall provide the retention volume necessary to retain the first flush volume of runoff.

2.2 FIRST FLUSH RETENTION REQUIREMENT DETERMINATION

The calculation for first flush retention shall be in accordance with the following table:

	Non-Riparian Area	Riparian Area
Proposed Impervious Areas	1440 ft^3/ac	1815 ft^3/ac
Additional Disturbed Areas	140 ft^3/ac	245 ft^3/ac

These values were determined using Curve Numbers from the PC-Hydro manual with a 0.5 inch rainfall event and assuming B soils for Riparian areas and C soils for other areas. The first flush retention volumes for impervious areas were determined as the runoff from a 0.5 inch rainfall event using a Curve Number of 99 for impervious surfaces on non-riparian areas, and 0.5 inches of runoff (Curve Number = 100) for impervious surfaces on riparian areas. The first flush retention volume for disturbed areas was determined as the increase in runoff volume from a B or C hydrologic soil group to a D hydrologic soil group for riparian and non-riparian areas, respectively.

Appendix H presents support for the use of the 0.5-inch standard.

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 lay out the site to mitigate

the impacts of the disturbance from the developed area using practices that reduce runoff rates by minimizing the impervious and disturbed surface area and promoting infiltration through preservation and enhancement of riparian areas and regulatory floodplains and through judicious layout of impervious areas.

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 retention required.

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

2.3.1 Minimize Disturbed, Compacted and Connected Impervious Surfaces

Fundamental elements of low impact development are reducing a development's impervious footprint and limiting construction disturbance. At the site planning stage, by incorporating these elements, an applicant has the opportunity to reduce the amount of required first flush retention by minimizing the amount of impervious surface and by minimizing the grading/disturbance envelope. Table 1 summarizes acceptable practices to minimize imperviousness and disturbance.

Table 2.1 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 permeable paving materials.

In addition, 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.

2.3.2 Protect/Enhance Riparian Habitat and Regulatory Floodplains and Other High Permeability Areas

Riparian habitat areas and regulatory floodplains 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.

Table 2.2 Acceptable Techniques to Protect/Enhance Mapped Riparian Habitat and Regulatory Floodplains

Phase	**Techniques**
Planning	Avoid mapped riparian habitat and regulatory floodplains. Identify available planting sites adjacent to mapped riparian habitat and regulatory floodplains. Identify mapped riparian habitat sites where vegetation has been degraded and propose appropriate plantings.
Design	Follow the site layout proposed during planning. Provide limits of mapped 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 riparian habitat area and regulatory floodplains will reduce the required first flush retention requirements, provide increased roughness to attenuate flows, and reduce or negate the requirement for habitat mitigation. In addition, retention basins could be located immediately adjacent to existing riparian habitat in order to enhance this environment by providing supplemental irrigation through stormwater harvesting.

2.4 USE OF LID PRACTICES TO MITIGATE THE FIRST FLUSH RETENTION REQUIREMENT

The required first flush retention volume shall be calculated for each watershed using the first flush retention volumes in Section 2.2. The total retention volume in each watershed must equal or exceed the required first flush retention volume for the watershed. Retention areas that are counted towards the first flush requirement must be located downstream of an impervious area.

2.4.1 Stormwater Harvesting Basins

Stormwater Harvesting Basins are depressed earthen areas in native soils that are located and designed to collect and retain runoff from on-site impervious or disturbed areas, such as parking lots or rooftops for irrigation of vegetation. In order to most effectively capture and retain the first flush, the stormwater harvesting basins should be designed to collect runoff, and once full, all additional runoff should flow out through an overflow weir. These basins should have an inlet but may or may not have an outlet, with water elevation controlling how much water is collected and retained. If the basin is sloped, the depressed area may contain internal berms to pond water in multiple cells with planting areas on the upstream side of the berm.

2.4.2 Road-side Stormwater Harvesting Basins

Road-side basins in native soils collect and retain runoff from impervious areas such as roadways or parking lots. Road-side basins should be located in appropriate areas after considering other factors such as driveway and sidewalk locations, site triangles, and catchment area. They may be located either in medians or on the developed side. When road-side basins are proposed, they should be able to collect and retain the first flush, while allowing the continued conveyance of runoff once full. These basins should have an inlet but no outlet, with water elevation controlling how much water is collected and retained. Safety of pedestrians and vehicles shall be considered when locating road-side basins.

2.4.3 Non-contributing Area Basin

A Non-contributing Area Basin is a stormwater harvesting basin designed to collect the full volume of stormwater which falls on or immediately adjacent to the basin.

The bottom of a Non-contributing Area Basin shall be flat and designed for uniform ponding over the permeable bottom.

Non-contributing Area Basins may be of two types. The first type is designed to collect only the stormwater which falls on it, with no contribution from adjacent areas. An example of this type of Non-contributing Area Basin is a landscape bufferyard with no inlet from adjacent drainage areas. This type of Non-contributing Area Basin must be

12" in depth to allow 9" of water storage below the top, with a freeboard of 3". The maximum depth for stormwater harvesting basins is 12", and designs for Non-contributing Area Basins with no inflow from adjacent areas shall comply with this maximum depth. When this type of basin is proposed and designed to the required depth, the area of the basins are not included in any peak discharge calculations.

A second type of Non-Contributing Area Basin is located at a low point of a project site, such as within a paved or disturbed area of the site. When this type of Non-contributing Area Basin is proposed, the ratio of the immediately adjacent drainage area to the pervious basin bottom area must not exceed 2:1. This type of basin shall be a minimum of 9" in depth, and a freeboard of 6" from the top of the basin to the top of the adjacent drainage area shall be provided. The 12" maximum depth of stormwater harvesting basins is exceeded for this type of basin to provide an additional factor of safety for adjacent vehicular or pedestrian areas.

A Non-contributing Area Basin meeting the above criteria and the area draining to it are not included in any peak discharge calculations.

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 road-side basins, but contain a soil medium that encourages infiltration, soil moisture storage and plant growth. Bioretention basins may include perforated drainage pipe risers and subsurface drains to collect stormwater and move it to the subsurface. Bioretention basins enhance infiltration characteristics, which mean that the same surface planting area may collect more water, or the areal extent of road-side and stormwater harvesting basins may be reduced.

The volume captured by a biorentention feature includes both the surface capture volume and the void space (assumed to be 40%) of the engineered medium.

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

2.4.5 Retention Within Detention Basins

A detention basin can also be designed to accommodate some retention in order to meet the first flush retention requirement.

Detention basins with uniform side slopes and no terraces may incorporate retention within an area a maximum of 6" below a low-flow or primary outlet. The volume provided below the outlet can be counted as retention volume.

When terraces are proposed within a detention basin in order to meet riparian habitat or native plant requirements, the volume lost to the terrace can be made up by deepening the remainder of the basin below the positive drainage pipe or primary outlet. The volume of the retention area within the detention basin can be used to meet the first flush retention requirement. The vegetation on the terraces should benefit from this water. No vegetation is allowed within the retention area, as this area also serves as a sediment trap and is subject to periodic maintenance requirements.

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 90% of pre-developed peak discharge rates at the project boundary.

A Critical Basin map is available at: http://rfcd.pima.gov/rules/pdfs/critical_basins.pdf. All areas of 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 ($Q_{pre\text{-}rp}$) shall be established using the 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 developed to assist with model parameterization. The District's Technical Policies are available at: http://rfcd.pima.gov/rules/#techpolicies.

3.2.2 Post-Developed Conditions

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

3.3 IMPACT OF STORMWATER HARVESTING BASINS ON DETENTION REQUIREMENTS

3.3.1 Peak Discharge Rate Reduction

The use of stormwater harvesting basins throughout a project site can reduce the size of downstream detention basins. By retaining stormwater throughout the site, the volume of runoff flowing to a detention basin is reduced and the time of concentration for these flows may increase.

Where it is proposed to reduce the size of a detention basin due to the use of stormwater harvesting basins, the following method shall be used to quantify the peak rate reduction for each return period: (See Appendix D for details on how the stormwater harvesting factor was developed.)

1. Calculate the post-development runoff volumes ($V_{post\text{-}rp}$) and peak discharge rates ($Q_{post\text{-}rp}$) for the 2, 10, and 100 year events (e.g $V_{post\text{-}2}$, $V_{post\text{-}10}$, $V_{post\text{-}100}$) for each watershed.

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).

3. Calculate the ratio (X_{rp}) of the basin volume (V_{bas}) to the post-development runoff volume ($V_{post\text{-}rp}$) for each return period (e.g. $X_2 = V_{bas} / V_{post\text{-}2}$)

4. Find the Stormwater Harvesting Factor (H_{rp}) for each return period from the following table:

Table 3.1 Stormwater Harvesting Factors (H_{rp}) for Peak Discharge Reduction

X_{rp}	H_{rp}	X_{rp}	H_{rp}	X_{rp}	H_{rp}
< 0.10	0.000	0.40	0.378	0.71	0.753
0.10	0.009	0.41	0.392	0.72	0.762
0.11	0.015	0.42	0.407	0.73	0.771
0.12	0.021	0.43	0.422	0.74	0.779
0.13	0.029	0.44	0.436	0.75	0.788
0.14	0.037	0.45	0.450	0.76	0.796
0.15	0.046	0.46	0.464	0.77	0.805
0.16	0.055	0.47	0.478	0.78	0.813
0.17	0.065	0.48	0.492	0.79	0.821
0.18	0.075	0.49	0.506	0.80	0.829
0.19	0.086	0.50	0.519	0.81	0.837
0.20	0.098	0.51	0.532	0.82	0.845
0.21	0.109	0.52	0.546	0.83	0.853
0.22	0.122	0.53	0.558	0.84	0.861
0.23	0.134	0.54	0.571	0.85	0.869
0.24	0.147	0.55	0.584	0.86	0.877
0.25	0.160	0.56	0.596	0.87	0.886
0.26	0.174	0.57	0.608	0.88	0.894
0.27	0.188	0.58	0.620	0.89	0.903
0.28	0.202	0.59	0.631	0.90	0.911
0.29	0.216	0.60	0.642	0.91	0.920
0.30	0.230	0.61	0.654	0.92	0.929
0.31	0.245	0.62	0.665	0.93	0.938
0.32	0.259	0.63	0.675	0.94	0.948
0.33	0.274	0.64	0.686	0.95	0.958
0.34	0.289	0.65	0.696	0.96	0.968
0.35	0.304	0.66	0.706	0.97	0.979
0.36	0.319	0.67	0.716	0.98	0.989
0.37	0.333	0.68	0.725	≥0.99	1.000
0.38	0.348	0.69	0.735		
0.39	0.363	0.70	0.744		

5. Determine the area of the watershed that will flow to or through stormwater harvesting basins (A_s) and the total watershed area (A_t), and calculate the ratio $\eta_A = A_s / A_t$.

6. Use this information to determine the post-development peak discharge rate for each return period after accounting for the presence of the stormwater harvesting basins using the equation:

$$Q_{swh\text{-}rp} = Q_{post\text{-}rp} (1 - \eta_A H_{rp})$$

7. If $Q_{swh\text{-}rp}$ is equal to or less than $Q_{pre\text{-}rp}$ (or 90% of $Q_{pre\text{-}rp}$ for critical basins) for all three return periods then additional detention is not required.

   If $Q_{swh\text{-}rp}$ is still greater than $Q_{pre\text{-}rp}$ (or 90% of $Q_{pre\text{-}rp}$ for critical basins) for each return period then additional detention is required. See Section 3.4

3.3.2 Volume Reduction

The inflow hydrograph to a detention basin may be generated from PC-Hydro. When stormwater harvesting basins are used, the inflow hydrograph can be adjusted to account for the storage volume and attenuation that these basins provide.

In addition to the attenuated peak for each return period ($Q_{swh\text{-}rp}$) that was calculated in 3.3.1, the stormwater harvesting basins' impact on the post development runoff volume ($V_{swh\text{-}rp}$) can be calculated for each return period with the following equation:

$$V_{swh\text{-}rp} = V_{post\text{-}rp} - V_{bas}$$

The "*Stormwater Harvesting Hydrograph Spreadsheet*" shall be used with the parameters determined here and in Section 3.3.1 to convert the detention basin inflow hydrographs without stormwater harvesting into detention basin inflow hydrographs with stormwater harvesting. The stormwater harvesting hydrograph may be used as the inflow hydrograph to a detention basin or another point from a site with stormwater harvesting basins.

See Appendix E for the spreadsheet.

3.4 PEAK DISCHARGE RATE REDUCTION USING DETENTION

Project designs shall maximize LID practices and site layout practices to minimize detention volume. When detention is proposed, the following methods shall be used to determine peak discharge rate reduction.

3.4.1 Methods to Calculate the Peak Discharge Rate Reduction of Detention Basins

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 the following relationship:

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

Where:

I_{t+1} = inflow at time t + 1
I_t = inflow at time t
O_{t+1} = outflow at time t + 1
O_t = outflow at time t
Δt = length of time step
S_{t+1} = storage volume at time t + 1
S_t = storage volume at time t

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% of the pre-developed peak discharge for Critical Basins.

The District's PC-Route.xls spreadsheet is recommended for basin routing. Appendix I includes the spreadsheet, information about its development, instructions and an example.

HEC-HMS or HEC-1 are also acceptable software for basin routing. Other programs in the public domain may be considered on a case-by-case basis. Permission to utilize software other than the District's spreadsheet, HEC-HMS or HEC-1 must be obtained in writing from the District 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 size of outlet pipes and/or heights of weirs or other outlet types are assumed. A trial run gives results which may reach the target for all or none of the three design storms. By adjusting the volume of the basin or the design of the outlet, the designer can successively approximate the design needed to reach regulatory criteria for all three design storms.

4 DETENTION BASIN DESIGN STANDARDS

The following design standards apply when detention basins are proposed to offset increased peak discharge rates and volumes from a development. Deviation from these standards requires written approval of the Chief Engineer. Additional standards to address specific site conditions may apply.

Requirements for drainage report content are provided in Chapter 9, Drainage Report Requirements, and the required content for plans, plats and as-built plans is found in Chapter 10, Requirements for Plats and Development Plans. Typical details required on plans are provided in Appendix C.

4.1 DETENTION BASIN GENERAL REQUIREMENTS

1. Projects shall maximize the use of LID practices, detailed in Chapter 5, to reduce the required detention volume.

2. Inspection and Maintenance Plans are required for all basins. The Maintenance and Inspection Plans shall be reviewed and approved by the District prior to approval of the Tentative Plat or Development Plan. An example of a detention basin inspection and maintenance checklist can be found in Appendix C.

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

4. Upon completion of construction of all basins, an as-built plan of the basin shall be prepared and submitted to the District. The as-built plan shall be used by the responsible party when performing periodic inspections and when restoring the basin to design specifications, if required.

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 Plan and As-Built Plan.

4.2 DETENTION BASIN GENERAL PROHIBITIONS

1. Although the use of single-lot water harvesting facilities is encouraged, the volume provided shall not reduce the required detention volume for residential projects.

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

3. On-line detention for regulatory flows is prohibited.

4. The use of parking and access lanes to provide detention volume is prohibited.

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 and immediately downstream of new development.

2. Basins shall be located a sufficient distance upstream of the project boundary 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 10-foot setback from basins and appurtenances, including basin outlets, positive drainage pipes and outer toes of embankments, to the project boundary shall be provided. An example is shown in Figure 4.1.

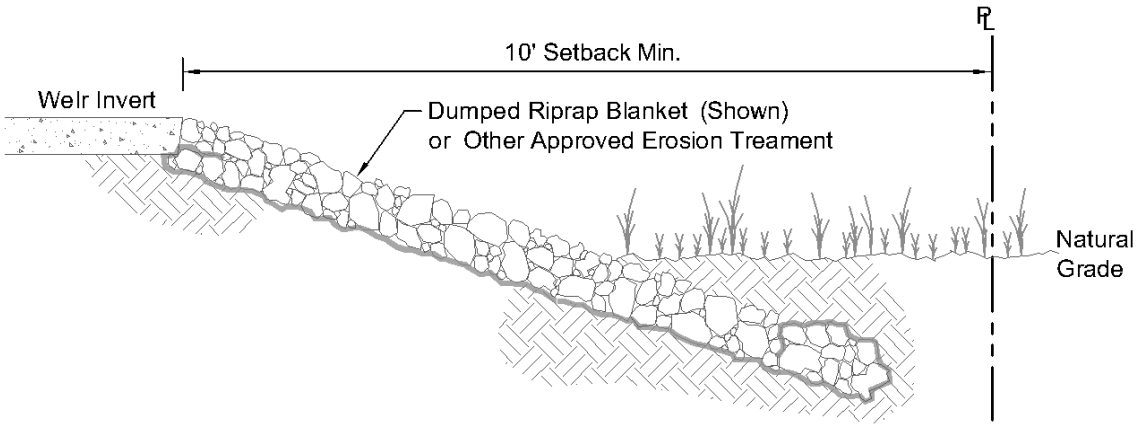


Figure 4.1 Minimum Setback from Property Line

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

Basins shall be located to avoid the use of embankments, if possible. Serta Perfect Day Queen Mattress Set with Memory Foam

4.3.2 Detention Basin Location and Collection Maintenance Requirements

1. Basins shall be maintained to perform as designed for the life of the project and shall not be converted to a different use without written review and approval of the District.

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

4.3.3 Detention Basin Location and Collection Prohibitions

1. Basins shall not be located within a regulatory floodplain, except when an entire project site is located within a regulatory sheet flooding area.

2. Inlets or outlets shall not direct flow over a sidewalk.

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

4. Post-development alterations that affect the function or design of drainage infrastructure are prohibited; including but not limited to, alteration of drainage structures, construction of new improvements and post-development site grading which increases flows to 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.

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.

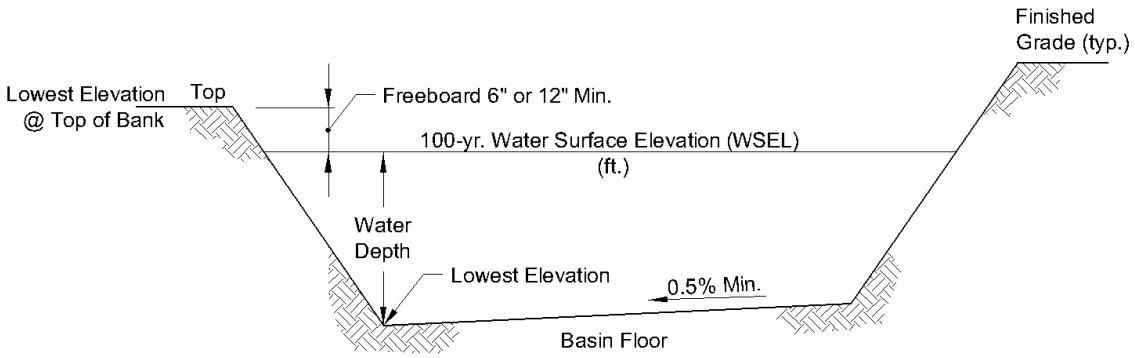


Figure 4.2 Basin Depth and Freeboard Requirements

4. Basins shall have a minimum of 1 sediment level determination 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 at least 2 feet and with side slopes steeper than 8:1 shall have a security barrier at all locations where side slopes are steeper then 8:1. Security barriers shall meet the requirements found in Section 4.12.

4.4.2 Detention Basin Depth and Freeboard Maintenance Requirements

1. The depth of the basin shall be inspected annually to ensure the design volume is maintained.

2. Design volume shall be restored when the depth of sediment exceeds 10% of the design 100-year water depth.

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

4.4.3 Detention Basin Depth and Freeboard Prohibition

1. 100-year water depth shall not exceed 6 feet.

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.

2. The maximum storage time for a basin that intercepts runoff from a watershed greater than 10 acres in size is 24 hours.

4.5.2 Storage Time Maintenance Requirements

1. Basin bottoms shall be inspected annually and after storm events for evidence of ponding lasting longer than the limits in Section 4.5.1.

2. If an inspection identifies evidence of ponding lasting longer than the limits in Section 4.5.1, the following maintenance shall be performed:

   a. Areas of ponding shall be graded to drain to the outlet,
   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.

4.6 BASIN FLOOR

4.6.1 Basin Floor Standards

1. The basin floor shall be graded to a slope of 0.5% or steeper to provide positive drainage to the basin outlet.

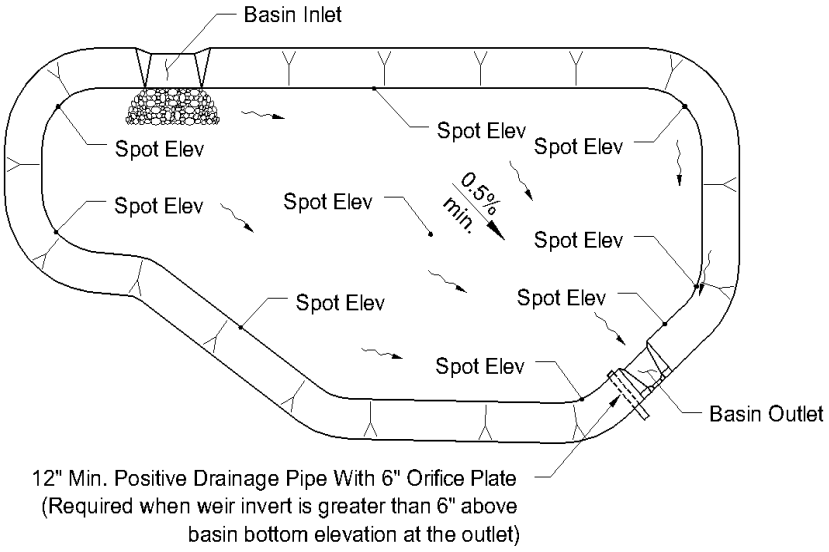


Figure 4.3 Basin Floor Minimum Slope for Positive Drainage

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 at: http://rfcd.pima.gov/wrd/riparian/pdfs/revised_guidelines_jan2010.pdf.

3. Other types of vegetation shall comply with Section 4.19.

4.6.2 Basin Floor Maintenance Requirements

1. The basin floor shall be inspected annually and after storm events to ensure that positive drainage is maintained.

2. Maintenance shall be performed when accumulated sediment and debris alter the design slope to the basin outlet.

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 Guidelines available at: http://rfcd.pima.gov/wrd/riparian/pdfs/revised_guidelines_jan2010.pdf.

4. Compacted soil shall be scarified to avoid areas of ponding and promote infiltration.

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

6. Debris and trash shall be removed from the basin at least annually.

4.6.3 Basin Floor Prohibitions

1. 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.

4.7 POSITIVE DRAINAGE PIPES

4.7.1 Positive Drainage Pipe Standards

1. When the outlet invert of the basin is more than 9 inches above the lowest elevation of the basin floor, a positive drainage pipe with an inlet invert no greater than 9 inches above the lowest elevation of the basin floor shall be installed. An example is shown in Figure 4.4. The positive drainage pipe shall be:

   a. At least 12 inches in diameter for pipes less than 50 feet long,
   b. At least 18 inches in diameter for pipes between 50 and 100 feet long, and

c. At least 24 inches in diameter for pipes longer than 100 feet long.

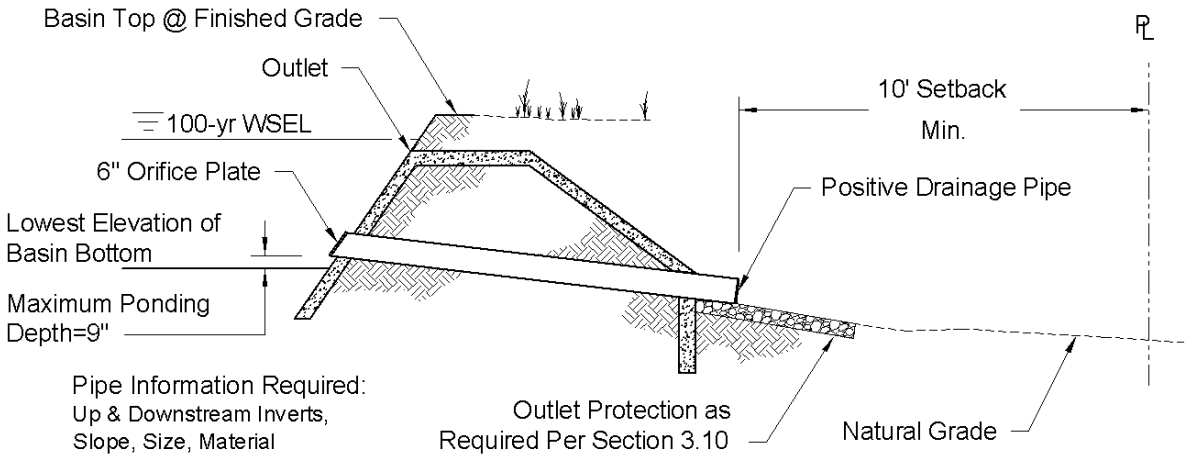


Figure 4.4 Positive Drainage Pipe Schematic

2. All positive drainage pipes shall be fitted with a 6-inch orifice plate on the upstream end.

3. Positive drainage pipes shall have a minimum slope of 0.5%.

4. The following pipe materials are acceptable:

   a. Corrugated Metal Pipe (CMP),
   b. High Density Polyethylene Pipe (HDPE),
   c. Spiral Rib Pipe (SRP), and
   d. Reinforced Concrete Pipe (RCP).

5. Positive drainage pipes shall not cause an adverse impact to surrounding properties.

6. A minimum 10-foot setback from the downstream end of positive drainage pipes to the property line shall be provided.

7. The inlet of positive drainage pipes shall be located adjacent to the lowest elevation of the basin floor.

8. Detail B.2 provided in Appendix B presents specifications for positive drainage pipes.

4.7.2 Positive Drainage Pipe Maintenance Requirements

1. Positive drainage pipes shall be inspected annually and after storm events to ensure the pipes are free from obstruction, intact and not causing erosion.

2. Pipe obstructions shall be removed.

3. Damaged pipes shall be repaired or replaced to the design specifications.

4. Erosion surrounding the area of an inlet or an outlet shall be repaired to the finished grade elevations provided on the as-built plan.

5. Basin elevations which result in ponded water in excess of 100-year design depth shall be corrected to provide positive drainage.

4.7.3. Positive Drainage Pipe Prohibitions

1. Polyvinyl chloride (PVC) pipe is prohibited.

2. Pipes smaller than 12 inches in diameter are prohibited.

3. Varying pipe slope is prohibited.

4. Pipe bends are prohibited.

4.8 SIDE SLOPES

4.8.1 Side Slope Standards

1. Slope treatment shall be provided as described in Table 4.1 below:

Table 4.1 Slope Treatment

Slope	Minimum Treatment/Materials Allowed
3:1	Approved Hydroseed Dumped Riprap with Fabric Filter
2:1	Hand Placed Riprap with Filter Fabric Reno or Gabion Mattress
1:1	Grouted Riprap or Concrete Lining with Welded Wire Fabric Articulated Revetment Units Gabions
Vertical	Retaining Wall

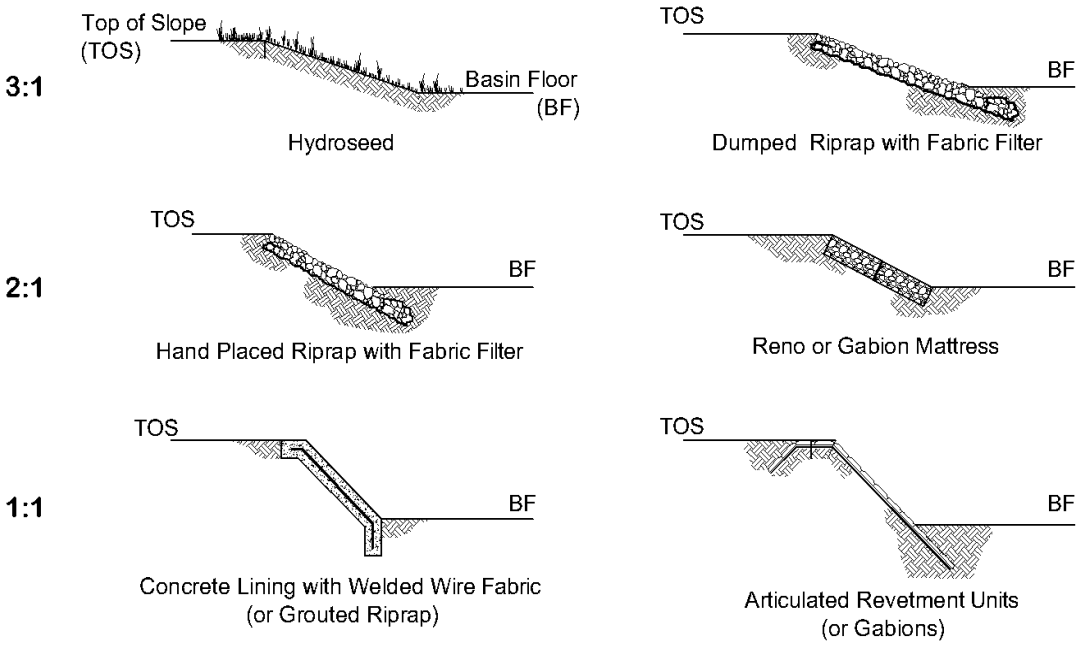


Figure 4.5 Typical Slope Treatment Profiles

2. Dumped riprap, when required, shall have a D_{50} of at least 6 inches and be placed with a blanket thickness of 2 times the D_{50}.

3. Hand placed or dumped riprap shall consist of hard, durable angular stone. 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}

4. 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. An example is shown in Figure 4.6.

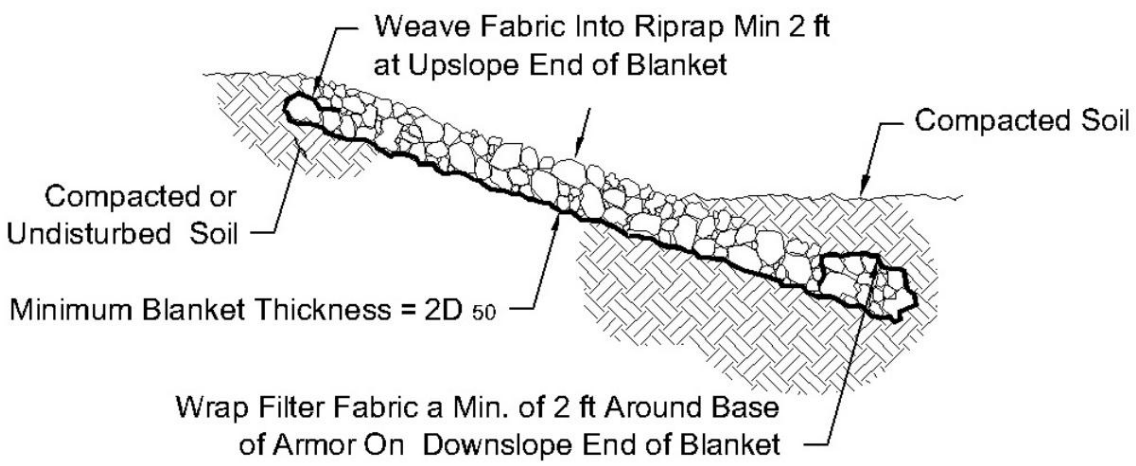


Figure 4.6 Riprap Blanket with Filter Fabric End Treatment

5. 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.

6. Vertical basin sides shall be designed as a retaining wall.

7. 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 a structural engineer registered in the State of Arizona.

8. When hydroseed is used as slope treatment 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 at: http://rfcd.pima.gov/wrd/riparian/pdfs/revised_guidelines_jan2010.pdf.

4.8.2 Side Slope Maintenance Requirements

1. Inspections shall occur annually and after storm events 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 the 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.

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

4.8.3 Side Slope Prohibitions

1. Free-standing walls are not allowed as a basin side.

2. Retaining walls greater than 4 feet measured from the bottom of the footing are not allowed as a basin side.

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 at: http://rfcd.pima.gov/wrd/riparian/pdfs/revised_guidelines_jan2010.pdf.

4.9 INLET STRUCTURES

4.9.1 Inlet Structure Standards

1. Inlets shall be placed immediately downstream of development to collect the increased stormwater runoff from post-developed conditions.

2. 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 District, such as, Bentley CulvertMaster or FlowMaster.

3. When flow crosses a sidewalk, a scupper shall be used. The sidewalk scupper shall meet the design standards outlined in the latest edition of the *City of Tucson/Pima County Standard Details for Public Improvements*.

4. When pipes are used as an inlet, the minimum size allowed is 18 inches.

5. Inlets shall have downstream 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. *Federal Highway Administration, Hydraulic Engineer Circular No. 14; HEC-14*, or
   c. Other methods accepted by the District.

6. The erosion protection shall extend below the finished grade of the basin floor and/or side slope. The surface of the erosion protection shall be level with the finished grade. An example is shown in Figure 4.7.

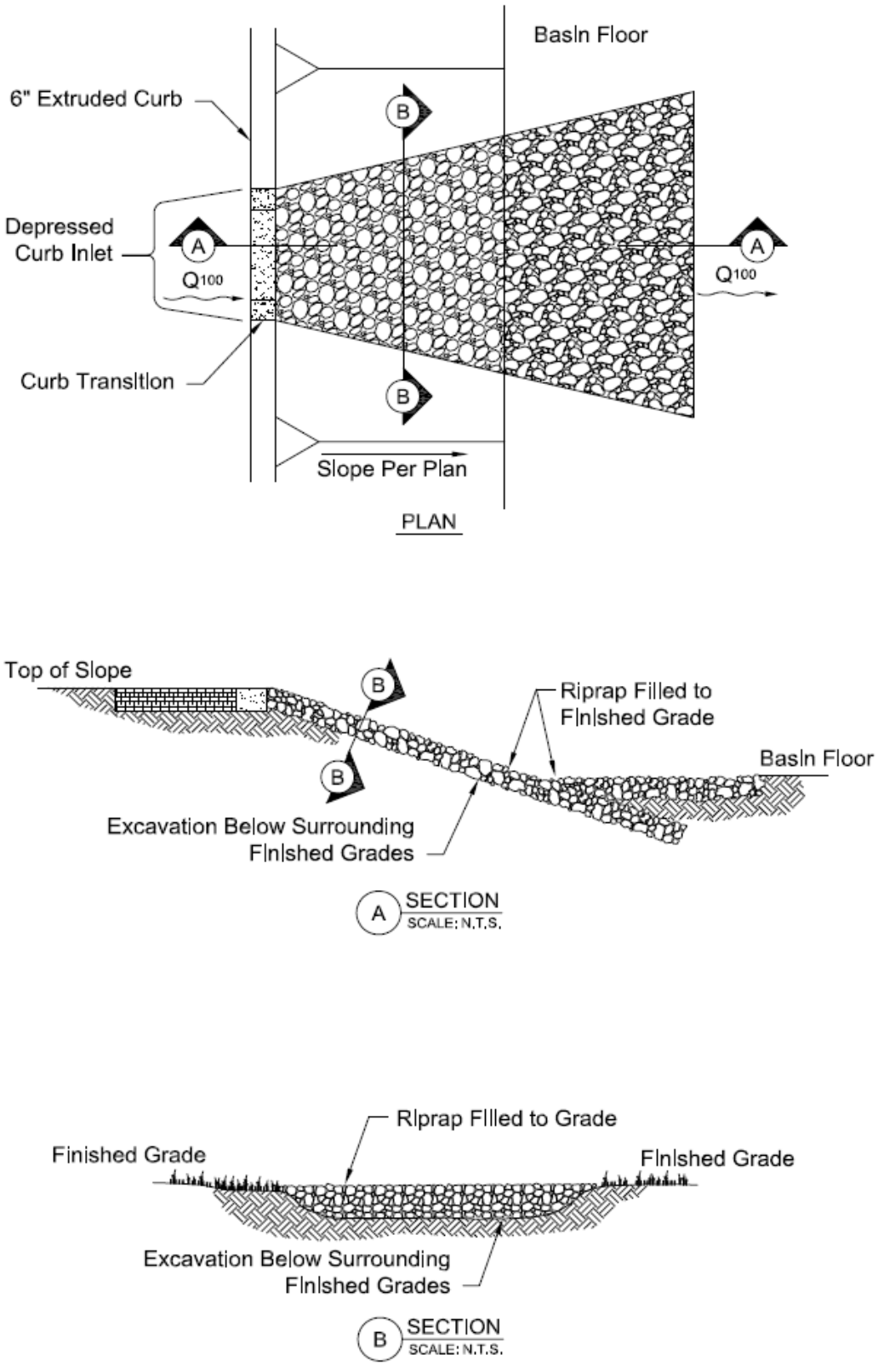


Figure 4.7 Erosion Protection below Finish Grade

7. 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. An example is shown in Figure 4.6.

Photo 4.1 Basin Inlet with Adequate Length of Riprap and Sufficient Height of Riprap at the Transition from the Spillway to Avoid Undermining

Photo 4.2 Basin Inlet with Inadequate Transition Riprap Placement

Photo 4.3 Erosion at a Basin Inlet Lacking Riprap Placement

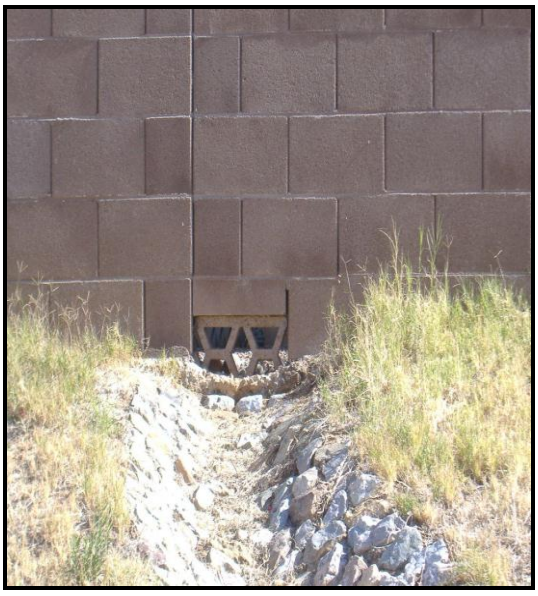


Photo 4.4 Adequate Riprap Placement Prevents Erosion

4.9.2 Inlet Structure Maintenance Requirements

1. Inspections shall occur annually and after storm events 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.

4.9.3 Inlet Structure Prohibitions

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

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

4.10 OUTLET STRUCTURES

4.10.1 Outlet Structure Standards

1. Outlets shall not cause an adverse impact to surrounding properties.

2. 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.

3. 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 of this manual. Examples of outlet structures are shown in Figures 4.8 and 4.9.

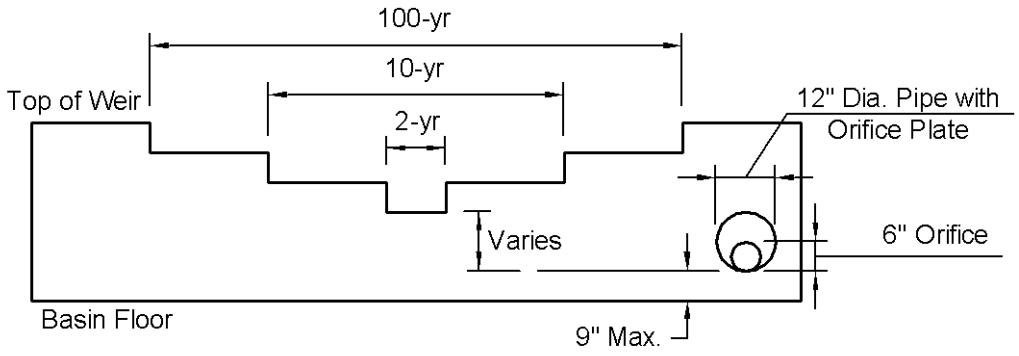
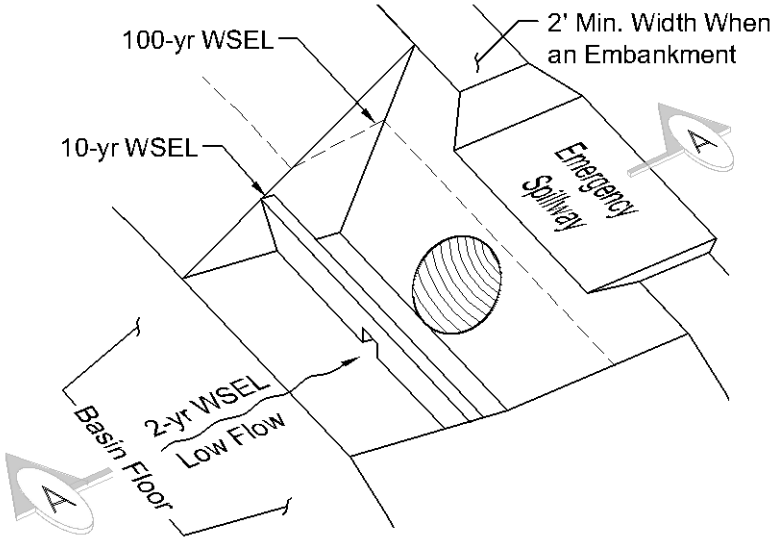
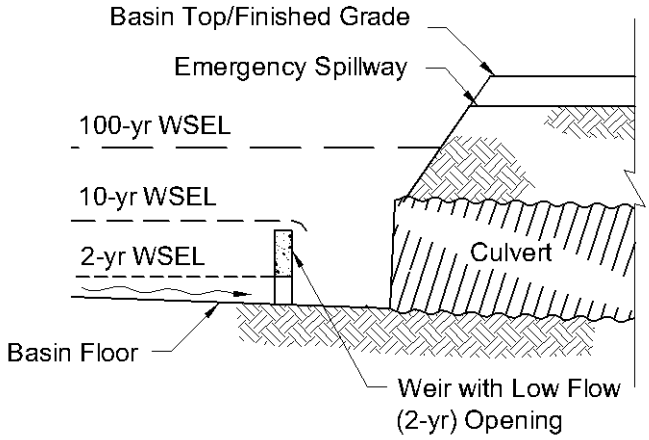


Figure 4.8 Multi-Level Weir Outlet for the 2-, 10-, and 100-year Storm





Cross Section A-A

Figure 4.9 Combination Weir – Culvert Outlet

Photo 4.5 Combination Weir Box

4. 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 District, such as, Bentley CulvertMaster or FlowMaster.

5. Outlets shall have downstream 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. *Federal Highway Administration, Hydraulic Engineer Circular No. 14; HEC-14, or*
   c. Other methods accepted by the District.

6. The erosion protection shall be placed beneath the finished grade of the downstream side of the outlet. Soil shall be excavated and removed beneath the erosion protection so that the top of the erosion protection is coincident with the finished grade. An example is shown in Figure 4.7.

7. Unless grouted, rock riprap shall be underlain with filter fabric. The filter fabric shall be woven 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. An example is shown in Figure 4.6.

4.10.2 Outlet Structure Maintenance Requirements

1. Inspections shall occur annually and after storm events 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.

4.10.3 Outlet Structure Prohibition

1. Outlets shall not direct flow over a sidewalk or through a handicap accessible ramp or parking space.

4.11 EMBANKMENTS

Photo 4.6 Embankment in a Residential Subdivision Basin

4.11.1 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. Embankments shall have a top width of at least 2 feet.

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

4. Embankments shall be compacted to at least 95% of the maximum Modified Proctor density.

5. The embankment shall be set back at least 10 feet from the project boundary. The setback shall be measured from the toe of the outer embankment slope to project boundary. An example is shown in Figure 4.10.

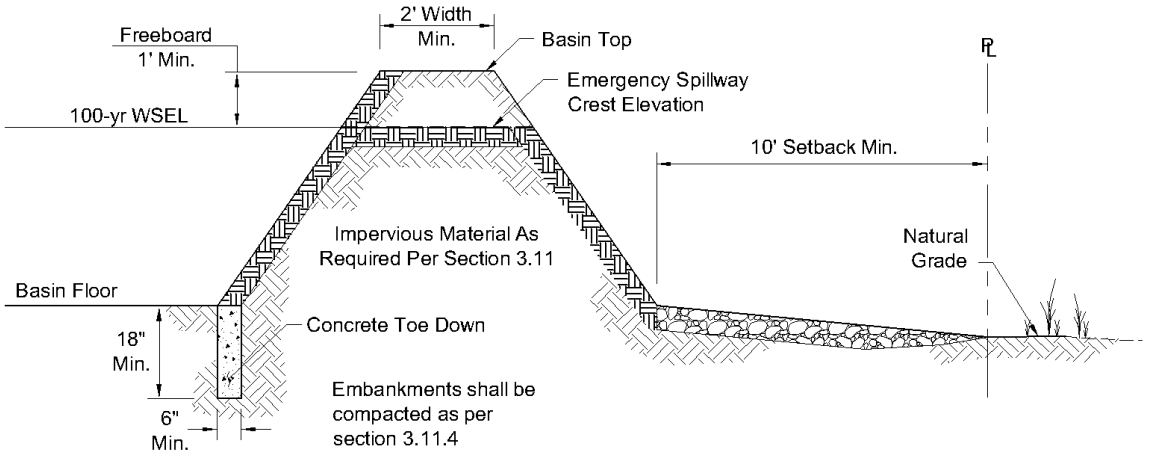


Figure 4.10 Embankment Requirements

6. 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 crest and the downstream side of the emergency spillway, as shown in Figure 4.10, shall be constructed of impervious material,
   d. The design capacity of the emergency spillway shall be the post-developed 100-year peak discharge at a depth of 6 inches,

e. The location of the emergency spillway shall not create any adverse impact to surrounding properties,
f. Impervious treatment shall be provided on the interior slope of the embankments, and
g. Impervious treatment shall include a toe down which extends 18 inches below the toe of the embankment and shall be at least 6 inches thick, as shown in Figure 4.10.

Photo 4.7 Low Embankment Stabilized Without Impervious Treatment

7. When an embankment is located within an erosion hazard setback, an engineering analysis shall be provided to determine erosion protection requirements which will protect the embankment from lateral migration of the watercourse.

8. A recorded covenant which specifies inspection and maintenance responsibilities is required when a basin includes an embankment. An example covenant can be found in Appendix A. The covenant shall be recorded prior to approval of the Development Plan or Final Plat, and the Sequence No. shall be provided on the Development Plan or Plat adjacent to the embankment location on the plan view.

4.11.2 Embankment Maintenance Requirements

1. Inspections shall be conducted annually and after storm events 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 the design specifications.

4.11.3 Embankment Prohibition

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

4.12 SECURITY BARRIER

4.12.1 Security Barrier Standards

1. Basins designed for 100-year water depths of at least 2 feet and with side slopes steeper than 8:1 shall have a security barrier at all locations where side slopes are steeper then 8:1.

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. A security barrier shall be constructed wherever pedestrian circulation occurs within 5 feet of the top of a basin. 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.

4.12.2 Security Barrier Maintenance Requirements

1. Inspections shall be conducted annually and after storm events 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.

4.12.3 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.

Photo 4.8 Security Barrier at a Basin Inlet

4.13 SIGNS

4.13.1 Sign Standards

1. Signs shall be provided to inform the public of the basin purpose, depth and the potential hazard resulting from collection of runoff during a storm event. An example is shown in Figure 4.11.

Figure 4.11 Example Sign Which Meets Requirements

2. Signs shall be visible from pedestrian and vehicular access.

4.13.2 Sign Maintenance Requirements

1. Inspections shall occur annually to ensure the sign is present and not damaged.

2. Evidence of damage or vandalism that obstructs visibility of the words on the sign shall be corrected.

4.14 PERIMETER WALLS

4.14.1 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 4.9 shall be provided.

2. When a wall is proposed within 5 feet of the top of a basin slope, a report from a structural engineer registered in the State of Arizona shall be provided prior to approval of the Improvement Plan that contains at least the following:

    a. The appropriate minimum setback from the top of slope, and
    b. Specific structural design requirements with details.

4.14.2 Perimeter Wall Maintenance Requirements

1. Inspections shall occur annually and after storm events 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.

4.14.3 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.

4.15 UNDERGROUND STORAGE

4.15.1 Underground Storage Standards

1. When site constraints prevent a basin from being constructed, underground storage may be allowed.

2. Where underground storage is proposed, failure or blockage of the system shall not pose a hazard to public safety or property. Design considerations include underground storage location and emergency flow conveyance.

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

4. Underground storage shall have inlets and outlets which meet the design standards found in Sections 4.9, 4.10 and 4.18.

5. Underground storage volume shall be 1.5 times the design volume of an above-ground basin.

6. The top of any exterior foundation shall extend above the inlet a minimum of 12 inches plus 2 percent for a minimum of 25 feet away from the foundation.

7. Pumps shall meet the design requirements of Section 4.20.

8. A recorded covenant which specifies inspection and maintenance responsibilities is required for an underground storage system. An example covenant can be found in Appendix A. The covenant shall be recorded prior to approval of the Development Plan or Final Plat, and the Sequence No. shall be provided on the Development Plan or Plat adjacent to the underground storage location on the plan view.

9. 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 by a geotechnical engineer 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.

4.15.2 Underground Storage Maintenance Requirements

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

2. When an inspection reveals any of the following, the underground storage system shall be restored to design specifications:

   a. Seepage, settlement, cracking, signs of improper joint alignment or displacement of joints,
   b. Sediment accumulation, and
   c. Damage to or malfunction of pumps, valves, sumps, piping, manifolds or appurtenances.

4.16 SETBACKS

4.16.1 Setback Standards

1. For maintenance access, a minimum 10-foot setback from basins and appurtenances, including basin outlets, positive drainage pipes and outer toes of embankments, to the project boundary shall be provided. An example is shown in Figure 4.1.

2. Because soil bearing capacity within a potential zone of saturation may be reduced, structures shall be setback at least 15 feet from a basin, 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.

3. If a structure is proposed within 25 feet of a basin inlet, the minimum setback from the basin shall be 25 feet, as shown in Figure 4.12.

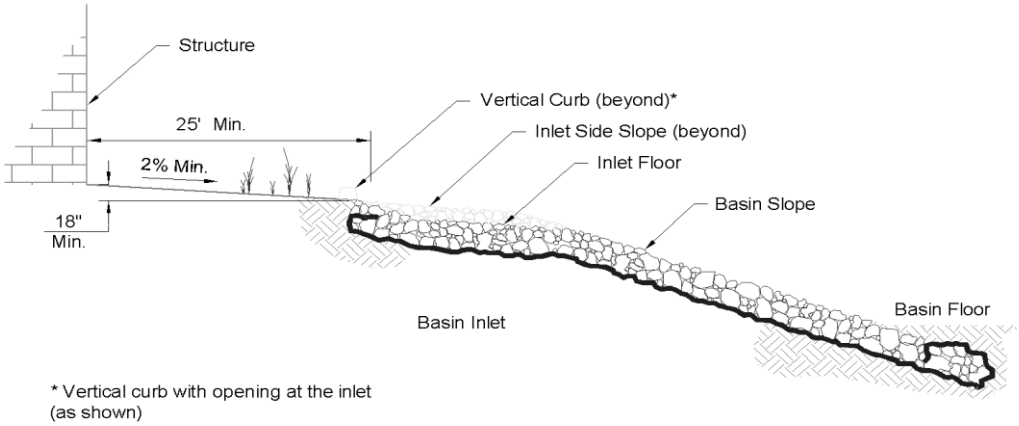


Figure 4.12 Setback and Elevation Requirements for Structures Adjacent to Inlets

4. When a wall is proposed within 5 feet of the top of a basin slope, a report from a structural engineer registered in the State of Arizona shall be provided prior to approval of the Improvement Plan that contains at least the following:

    a. The appropriate setback from the top of slope, and
    b. Specific structural design requirements with details.

4.16.2 Setback Prohibition

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

4.17 ELEVATION REQUIREMENTS

1. When a structure is proposed within 25 feet of a basin inlet, the top of any exterior foundation shall be elevated a minimum of 18" above the inlet elevation, and a minimum 2% slope shall be provided between the basin inlet and the edge of the foundation. Figure 4.12 illustrates this elevation requirement.

2. 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 electrical engineer registered in the State of Arizona certifies that the electrical equipment does not pose any hazard to public health or safety when inundated.

4.17.1 Elevation Maintenance Requirements

1. Electrical equipment shall be inspected annually and maintained to ensure it remains waterproof.

4.18 MAINTENANCE ACCESS

4.18.1 Maintenance Access Standards

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

2. In order to provide maintenance access, a minimum 10-foot setback from basins and appurtenances, including basin outlets, positive drainage pipes and outer toes of embankments, to the project boundary shall be provided. An example is shown in Figure 4.1.

3. When a basin maintenance access ramp is proposed and a security barrier is not required, removable bollards shall be provided at the entrance of the ramp to restrict unauthorized vehicle access. Bollards shall meet the design standards outlined in the latest edition of the *City of Tucson/Pima County Standard Details for Public Improvements*.

4.18.2 Maintenance Access Maintenance Requirements

1. Inspections shall be conducted annually and after storm events to ensure access to the basin is not compromised.

4.18.3 Maintenance Access Prohibition

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

4.19 LANDSCAPING OTHER THAN RIPARIAN HABITAT MITIGATION

4.19.1 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.

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

3. 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.

4. 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 at: http://rfcd.pima.gov/wrd/riparian/pdfs/revised_guidelines_jan2010.pdf.

4.19.2 Landscaping Maintenance Requirements

1. Inspections shall occur annually and after storm events 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 Guidelines available at: http://rfcd.pima.gov/wrd/riparian/pdfs/revised_guidelines_jan2010.pdf.

4. Any vegetation or debris within the 20-foot radius described in Section 4.19.1. shall be removed.

4.19.3 Landscaping Prohibitions

1. Any vegetation within the 20-foot radius described in Section 4.19.1. is prohibited.

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

3. The use of decomposed granite or rock less then 4 inches in diameter on the basin floor is prohibited.

4. Invasive non-native plants located within a basin are not allowed.

4.20 PUMPS

4.20.1 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 District 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 4.10.

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

8. 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.

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

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

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

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

13. 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 District recommendations if appropriate.

14. A recorded covenant which specifies inspection and maintenance responsibilities is required when a pump is used as a method of stormwater disposal. An example covenant can be found in Appendix A. The covenant shall be recorded prior to approval of the Development Plan or Final Plat, and the Sequence No. shall be provided on the Development Plan or Plat adjacent to the pump location on the plan view.

15. The project's Drainage Report shall provide the following information:

a. Emergency back-up plan,
b. Drainage exhibit showing drainage flow under clogged conditions,
c. Maintenance Plan with at minimum the following:
    i. Maintenance schedule,
    ii. Type of maintenance activities,
    iii. Exhibit showing the location of the pump, alarm systems and other equipment, and
    iv. Copy of the covenant.

16. A pump system analysis shall be submitted for District 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.

4.20.2 Pump Maintenance Requirements

1. Inspections shall be conducted annually, after storm events and after the alarm system is activated 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.

5. The site layout shall consider adequate access for maintenance vehicles and removal of equipment for repair.

4.21 DRY WELLS

4.21.1 Dry Well Standards

1. When site constraints prevent the construction of a basin, the use of a dry well may be allowed. Approval to use a dry well shall be obtained from the District prior to the first submittal of the Tentative Plat or Development Plan. When requesting the approval, the engineer must submit the 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 dry wells, and
        iii. A percolation testing report by a Geotechnical Engineer registered in the State of Arizona. 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 the proposed structure(s) with the building footprint,
        iii. Parking lot layout including pedestrian circulation, and
        iv. The general drainage scheme.

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

3. 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.

4. 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.

5. Test results shall be de-rated, using Equation 4.1, based on the in-situ soil conditions. 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.

    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, and
    c. The maximum allowable rate, after application of the de-rating factor, is not recommended to exceed 1.0 cfs per drywell for design purposes.
    d. 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.

Equation 4.1

$$P_d = \frac{P_r}{D_r}$$

Where:

P_d is the design percolation rate in inches/hour,
P_r is the measured stabilized percolation rate in inches/hour, and
D_r is the de-rating factor.

6. 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.

7. The dry well location shall be in an accessible location for routine maintenance and inspection and shall be protected from damage by vehicles.

8. The infiltration/percolation rate of the dry well shall meet the storage time standards found in Section 4.5. Dry wells that do not meet this standard shall be replaced or refurbished by the owner or a representative.

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

10. 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.

11. During site development, all dry wells shall be securely covered with filter cloth or other material to prevent the introduction of excessive sediment into the settling chamber.

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

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

14. A recorded covenant which specifies inspection and maintenance responsibilities is required when a dry well is used as a method of stormwater disposal. An example covenant can be found in Appendix A. The covenant shall be recorded prior to approval of the Development Plan or Final Plat, and the Sequence No. shall be provided on the Development Plan or Plat adjacent to the dry well location on the plan view.

15. A typical drywell installation is shown in Figure 4.13.

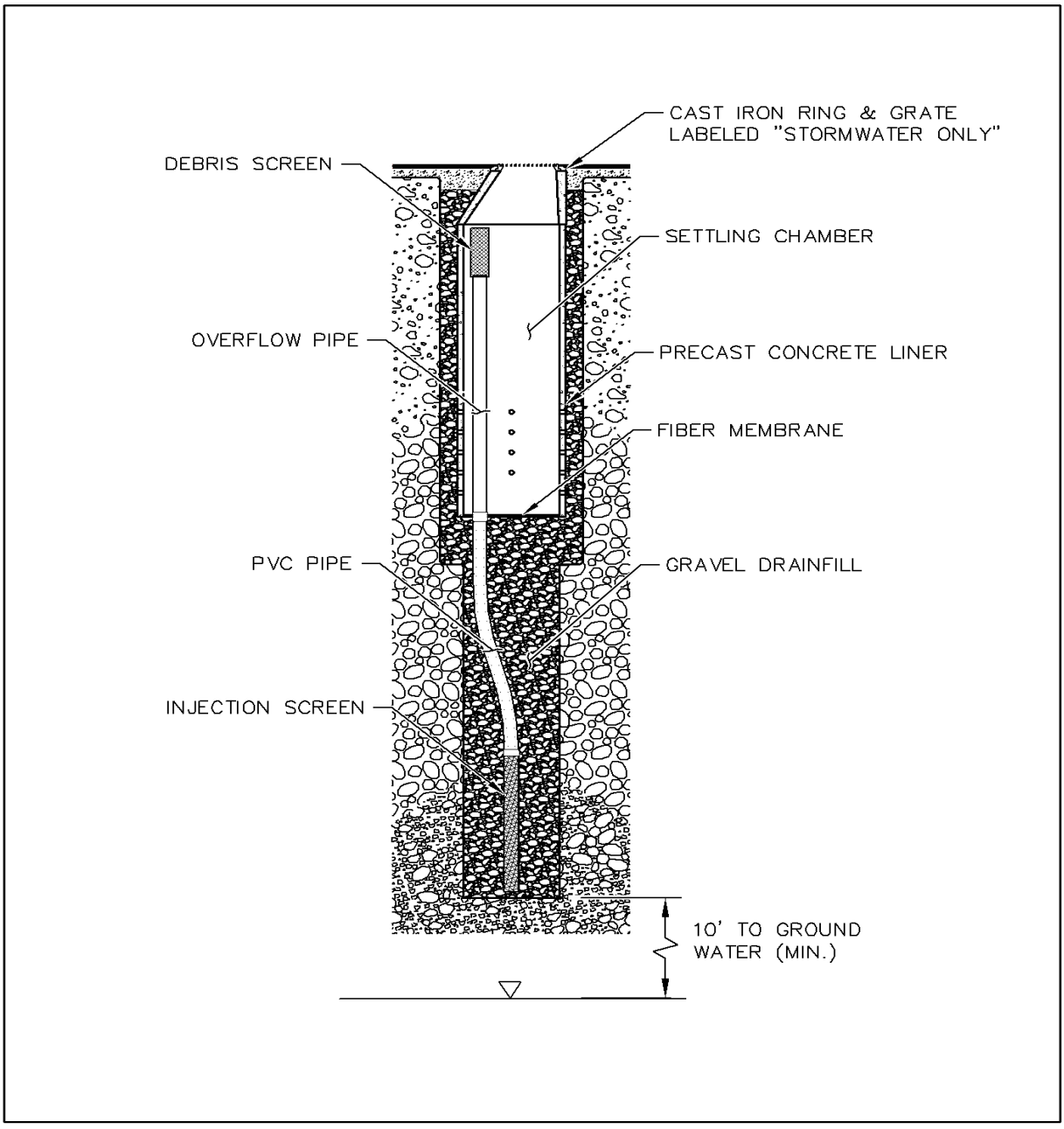


Figure 4.13 Typical Dry Well Installation

16. The project's Drainage Report shall provide the following information:

    a. Design by a licensed professional,
    b. Plan for stormwater disposal in the event the drywell(s) cease(s) to function,
    c. Maintenance Plan with at minimum the following:
        i. Maintenance schedule,

ii. Type of maintenance activities,
iii. Exhibit showing the location(s) of the drywell(s),
iv. Contact information of the driller or authorized maintenance professional, and
v. A copy of the covenant.

4.21.2 Dry Well Maintenance Requirements

1. Inspections shall be conducted annually and after storm events to ensure the dry well and settling chamber are functioning as designed.

2. If an inspection identifies that the dry well is not infiltrating within the storage limits outlined in Section 4.5.1, or other damage or maintenance requirements are identified, the maintenance shall be performed to restore the drywell(s) 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.

6. Maintenance requirements shall be provided in the restrictive covenants for subdivisions where dry wells are used.

4.21.3 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. Drywells are prohibited for industrial developments.

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

4. Landscaping shall not impair drywell 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 retention, to 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 also consider the site's natural hydrology when locating proposed improvements. The planner should identify hydrologic features including existing flow paths, areas with high permeability soils, riparian areas and other areas with high biological resource value. 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 planning 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. Maximum use of LID practices is required for all projects.

5.1 LOW IMPACT DEVELOPMENT GENERAL REQUIREMENTS

1. Projects shall retain the first 0.5 inches of rainfall that flows off of impervious and disturbed surfaces (first flush retention).

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

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

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

5. Inspection and Maintenance Plans are required for all projects using LID practices. The Inspection and Maintenance Plans shall be reviewed and approved by the District 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 plan shall be prepared and submitted to the District. The as-built plan shall be used by the responsible party when performing periodic inspections and maintenance when restoring the LID practices to design specifications, if required.

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 Plan and As-Built Plan.

5.2 LOW IMPACT DEVELOPMENT GENERAL PROHIBITIONS

1. Although the use of single-lot water harvesting facilities is encouraged, the volume provided by such facilities shall not be used to satisfy 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 then 9 inches of stormwater. The depth is measured from the lowest elevation on the basin floor to the lowest overflow of the basin.

3. Basin floor shall allow for uniform ponding across the entire basin.

4. 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.

5. Stormwater harvesting basins shall be constructed entirely below finished grade with 3 inches of freeboard provided above the overflow of the basin.

6. All side slopes of a stormwater harvesting basin shall be 3:1 or flatter unless the side slope is rock lined.
7. The maximum storage time within a stormwater harvesting basin is 12 hours.

8. Stormwater harvesting basins shall be designed with an inlet. The inlet shall meet the following criteria:

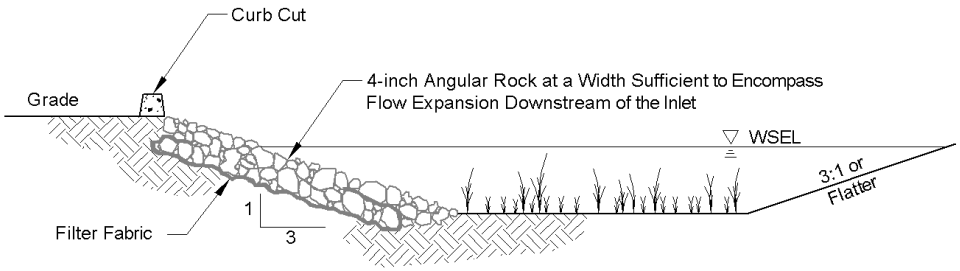
    a. The inlet shall be located to accept flow from the contributing watershed.
    b. Inlet erosion protection shall consist of either:

        i. 4-inch angular rock at a width sufficient to encompass flow expansion downstream of the inlet. Hand-placed non-grouted rock shall be placed in two layers on filter fabric. Hand placed grouted rock shall be embedded in the concrete a minimum of ½ the rock diameter; or
        ii. A 4" thick concrete cut-off wall extending to the basin floor. See Figure 5.1.

9. When an overflow is proposed, the overflow shall meet the following criteria:

    a. The overflow shall be located where it does not pose a hazard to pedestrian circulation or create an adverse impact to structures, infrastructure or adjacent properties.
    b. Overflow erosion protection shall consist of either:

        i. If discharging onto earthen surface, 4-inch angular rock at a width sufficient to encompass flow expansion downstream of the overflow. Hand-placed non-grouted rock shall be placed in two layers on filter fabric. Hand placed grouted rock shall be embedded in the concrete a minimum of ½ the rock diameter; or
        ii. If discharging onto pavement, a 4" thick concrete cut-off wall extending to the basin floor. See Figure 5.1

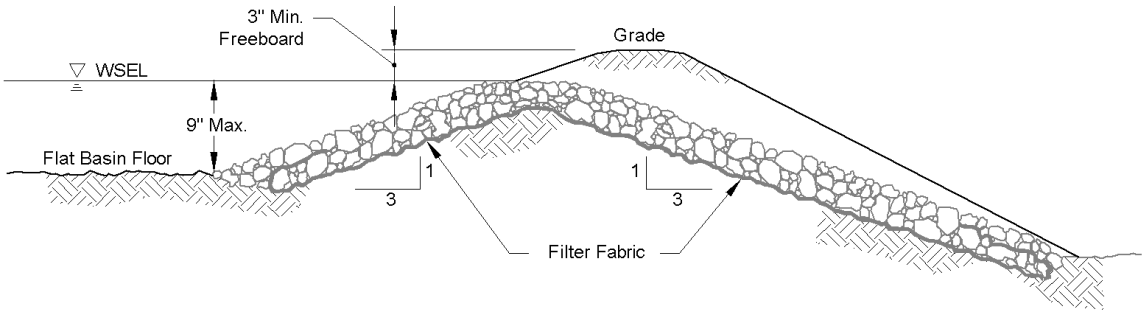


STORMWATER HARVESTING BASIN

(1) INLET EROSION PROTECTION

SCALE: N.T.S.

- Hand placed, non-grouted rock shall be placed in two layers on filter Fabric.
- Hand placed, grouted rock shall be imbedded into the concrete a minimum of $\frac{1}{2}$ the rock diameter.



STORMWATER HARVESTING BASIN

(2) OUTLET EROSION PROTECTION

SCALE: N.T.S.

Figure 5.1 Stormwater Harvesting Basin Inlet and Outlet Erosion Protection

10. When stormwater harvesting basins with terraced cells are proposed, internal check dams to pond water shall be provided.

    a. The minimum freeboard of 3 inches shall be measured from the top of the check dam to the lowest finished grade adjacent to each cell.
    b. The check dams shall consist of:

        i. An earthen berm with 3:1 slopes or flatter that extends the length of the cell,
        ii. A layer of 4” minimum angular rock over filter fabric that extends to the floor of the upstream and downstream cell.

c. All rock on 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 of flat surface between a sidewalk or pedestrian circulation area,
    b. Minimum 10 feet from structures, or minimum setback specified in a geotechnical report for the project.
    c. Minimum 5 feet from the property boundary for maintenance access, and
    d. Minimum 18 inches from the back of curb when located adjacent to a street.

12. Landscaping within stormwater harvesting basins is encouraged.

    a. All areas within a stormwater harvesting basin except for check dams may be used for planting area, and
    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 at: http://rfcd.pima.gov/wrd/riparian/pdfs/revised_guidelines_jan2010.pdf.

13. Except for road-side stormwater harvesting basins, LID practices in subdivisions shall be located in a Common Area designated for Drainage.

5.3.2 Road-side Stormwater Harvesting Basin

The following additional standards apply to stormwater harvesting basins that are located adjacent to a curbed roadway.

1. Stormwater harvesting basins proposed within a Right of Way (ROW) and designed to receive runoff from a curbed street shall be located between the back of curb and the front of sidewalk.

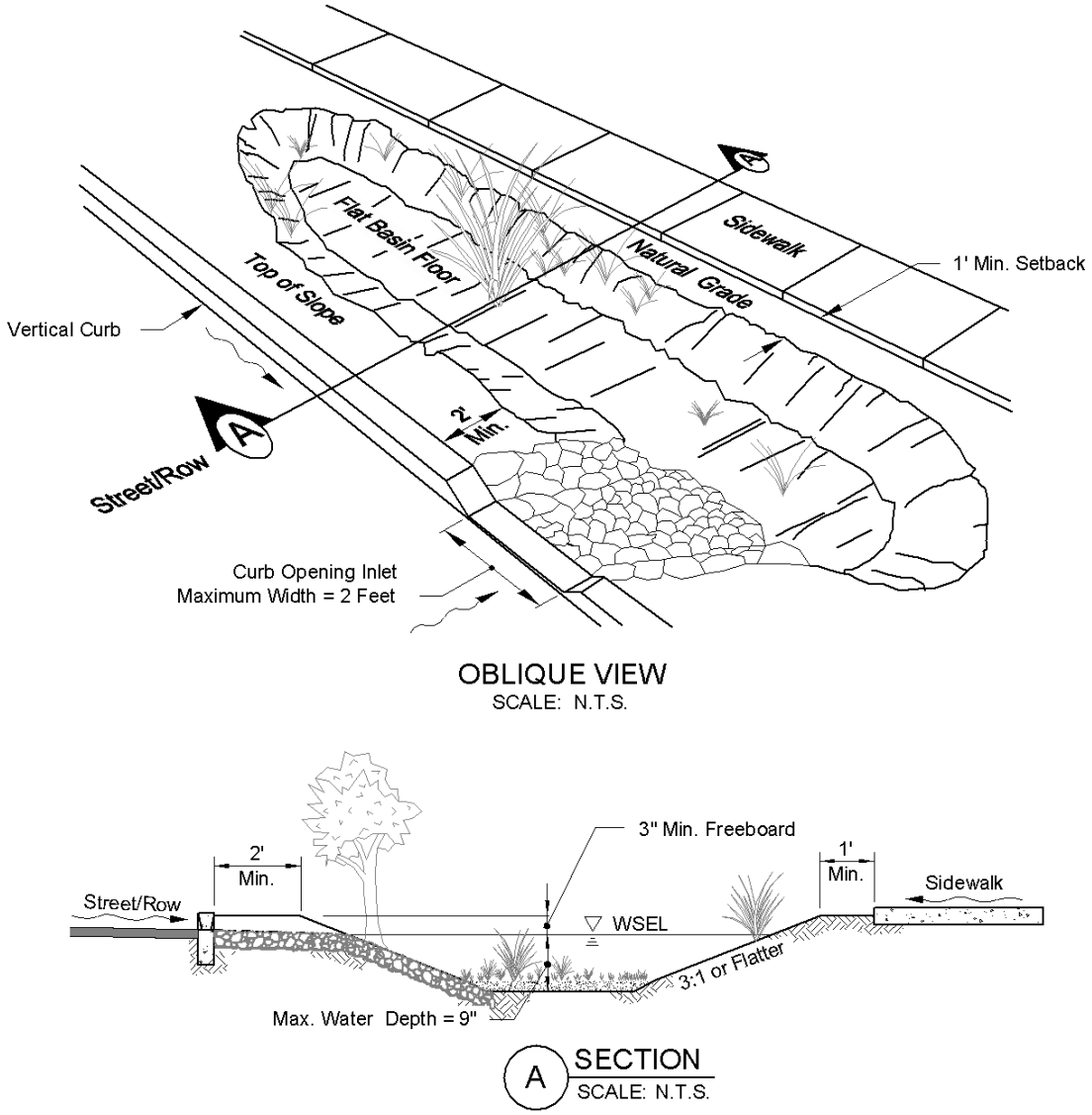
2. Curb openings for road-side stormwater harvesting basins shall meet the following criteria:

    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. An example is shown in Figure 5.2.

3. Adjacent to the roadway or sidewalk, basin side slopes shall be 3:1 or flatter. An example is shown in Figure 5.2.

4. Adjacent to sidewalk, the top of the basin shall be a minimum of 1 foot from the edge of sidewalk.



ROAD-SIDE STORMWATER HARVESTING BASIN

- Curb openings shall be separated from driveway aprons and other curb openings by a minimum distance of 10 feet.
- Curb openings shall be located a minimum of 20 feet from an end of a curb return (corner).
- Curb openings proposed on existing curbs retrofit shall be made by a saw cut method.
- Side slopes, bottom of basin may be riprapped; maximum water depth measured from general top of riprap.

Figure 5.2 Road-side Stormwater Harvesting Basin

5.3.3 Stormwater Harvesting Basins Adjacent to Parking Areas

The following additional standards apply to stormwater harvesting basins that are located adjacent to a parking area.

1. Adjacent to parking areas, the top of the basin shall be set back a minimum of 2 feet from any parking space in order to provide a safe pedestrian area. The setback shall be measured from the parking line to the basin as shown in Figure 5.3.

2. Basin side slopes adjacent to parking areas shall be 3:1 or flatter.

3. If curb is proposed, curb openings shall be either 2 feet or sized to convey the 100-year peak discharge from the upstream contributing area without creating ponding in excess of 1 foot within the parking area.

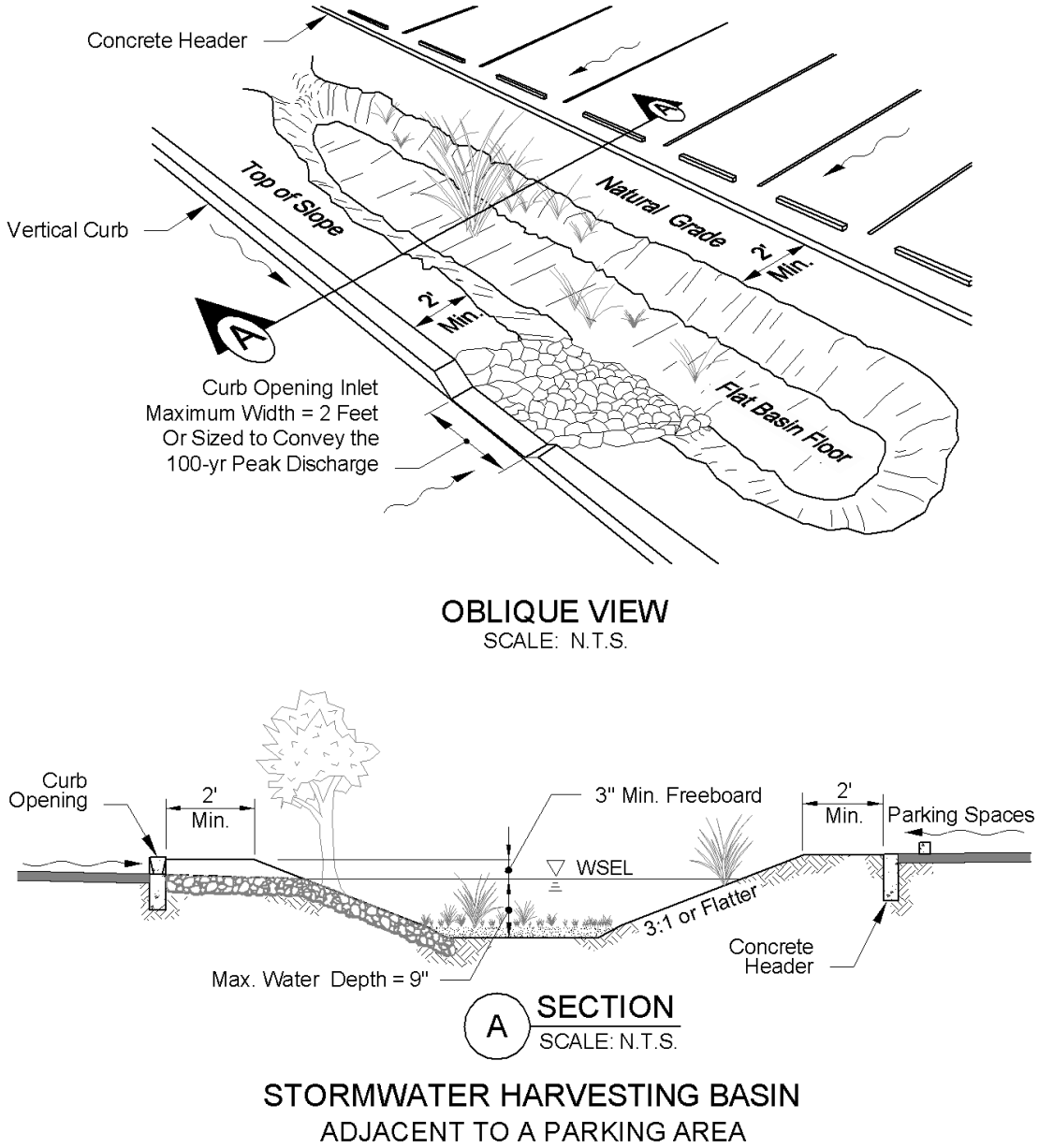


Figure 5.3 Stormwater Harvesting Basin Adjacent to a Parking Area

5.3.4 Non-contributing Area Basin Standards

Non-contributing area basins are basins designed to retain the full 100-year runoff volume and can be excluded from adjacent watersheds when determining post-development hydrology. Non-contributing area basins shall be designed to meet the following standards:

1. The minimum depth shall be 6 inches.

2. A minimum of 3 inches of freeboard shall be provided.

3. Non-contributing basins shall be located in an area that does not pose a safety hazard or create an adverse impact to adjacent properties and structures.

4. Non-contributing basin bottoms shall be flat.

5. Side slopes are 3:1 or flatter.

6. The impervious to pervious ratio for the non-contributing basin must not exceed 2:1.

7. The use of parking and access lane areas to retain extra runoff is allowed.

The standards are illustrated in the following figure.

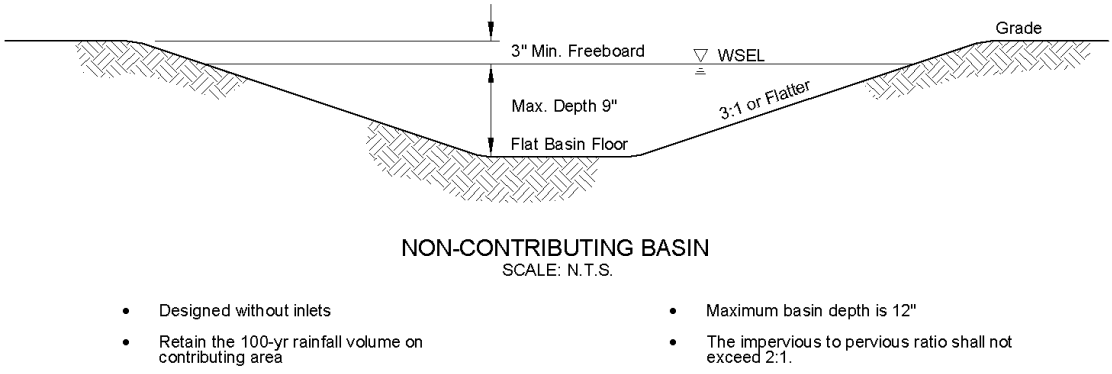


Figure 5.4 Non-Contributing Area Basin

5.3.5 Bio-retention Basin

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

1. The bio-retention basin shall consist of:

   a. A sub-base consisting of an 8 inch bottom layer of coarse aggregate (gravel) that is washed to be free of fine material,
   b. A woven geo-textile fabric, installed per the manufacturers specifications, placed between the sub-base and the constructed soil medium, and

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 and shall be fully mixed in a drum mixer. The constructed soil medium shall not be more than 24 inches thick. Alternative soil media require prior approval by the District.

The bio-retention 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.

2. Because soil bearing capacity within a potential zone of saturation may be reduced, bioretention basins shall be setback horizontally from a structure a minimum of 5 feet or twice the depth of the constructed soil medium, whichever is greater, 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.

3. Bio-retention basins shall provide a sediment trap located at the downstream end of the inlet.

4. A vertical inspection pipe shall be provided in order to assess the effectiveness of the bio-retention 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.

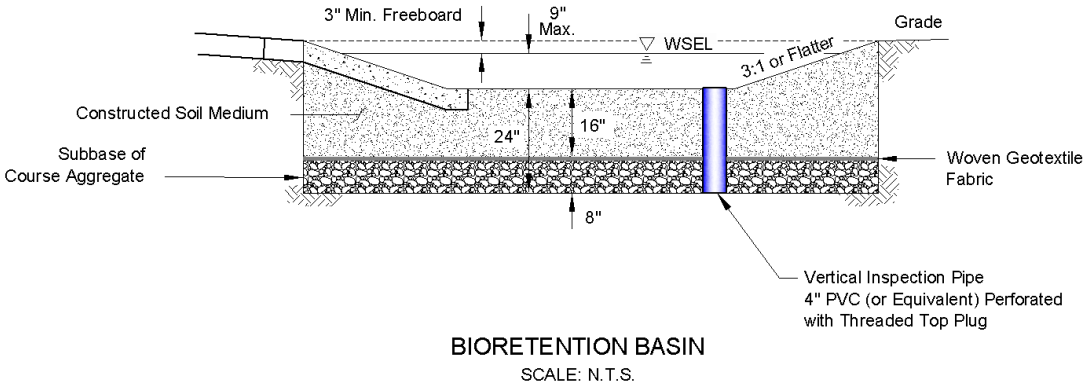


Figure 5.5 Bioretention Basin

5.3.6 Retention within a Detention Basin

A retention area may be constructed within a detention basin. The remaining area may be used for the planting of riparian vegetation. The following additional standards apply:

1. A maximum of 9 inches of first flush retention is allowed.

2. The positive drain pipe or the lowest invert of the weir shall not be more than 9 inches above the lowest elevation of the basin floor.

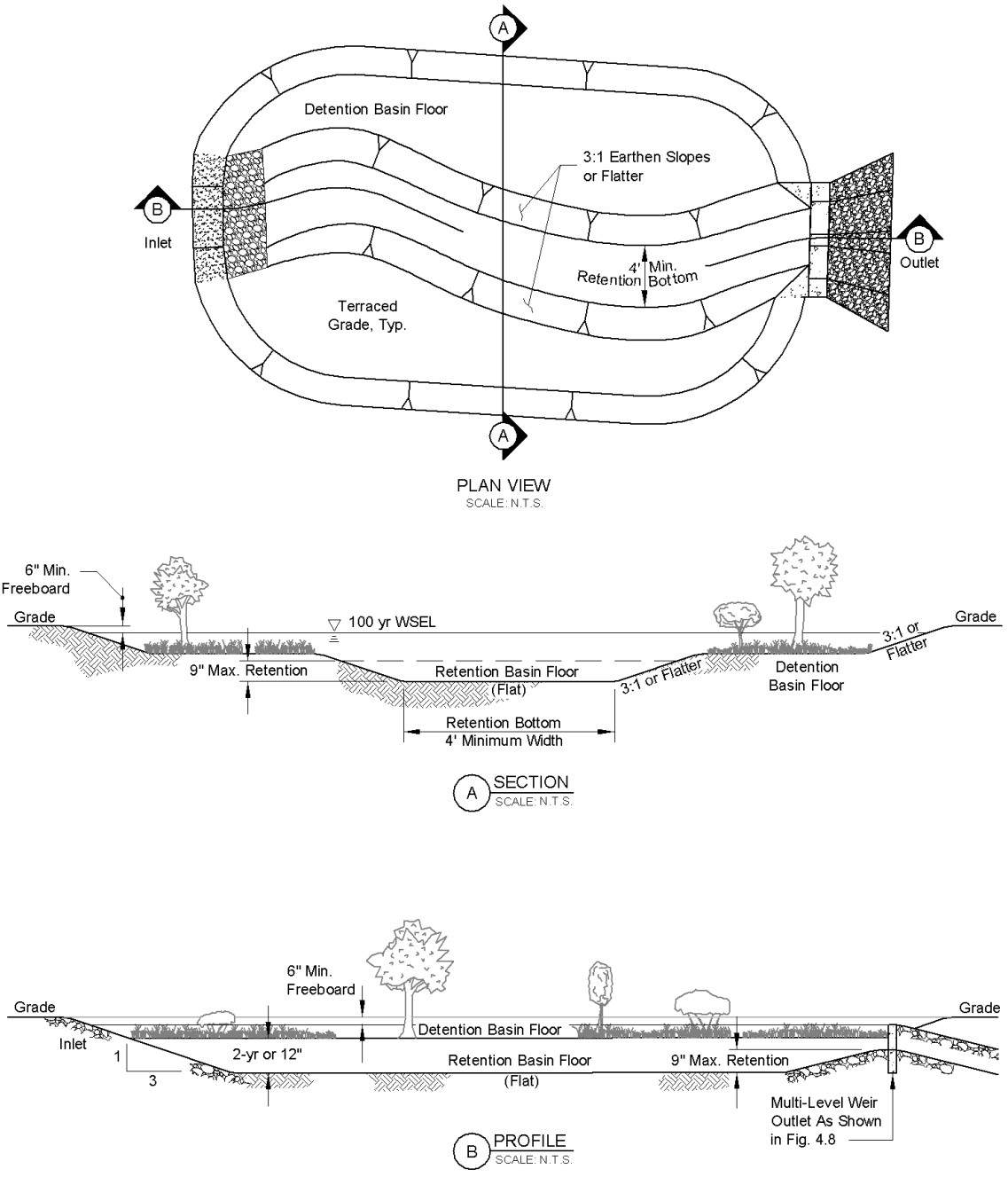
3. The retention area shall connect the basin inlet to the outlet, and meet the following criteria:

    a. The width of the retention bottom area shall be a minimum of 4 feet to allow for maintenance of this area,
    b. Planting of vegetation in the retention area is prohibited,
    c. The use of check dams in the retention area in order to create cells of uniform depth is allowed, and
    d. Retention areas shall have 3:1 or flatter earthen side slopes.

4. The vegetated areas shall meet the following criteria:

    a. Berms to harvest rainwater are allowed in these areas, and
    b. These areas shall otherwise have a flat bottom surface for uniform ponding.

Figure 5.5 illustrates the layout of a retention area within a detention basin which has terraced planting areas.



TERRACED DETENTION BASIN WITH RETENTION

- Planting within the retention area is prohibited
- Terrace shall be elevated at or above the 2-year wsel, but not more than 9"

Figure 5.6 Terraced Detention Basin with Retention

5.4 STORMWATER HARVESTING BASIN MAINTENANCE

1. Stormwater harvesting basins shall be maintained to perform as designed for the life of the project and shall not be converted to a different use without the review and approval by the District.

2. Stormwater harvesting basins shall be inspected annually and after storm events to ensure the basins are performing as designed.

3. Inlets and outlets shall be maintained free of obstructions.

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

5. The depth of the stormwater harvesting basin shall be inspected annually to ensure the design volume is maintained.

6. The basin shall be restored to design specifications when the depth of sediment exceeds 1 inch.
7. Slopes shall be maintained to the original design configuration.

8. 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.

5.4.1 Bio-retention Basin Maintenance

In addition to the maintenance requirements provided above, these additional maintenance requirements apply to bio-retention basins.

1. Access to the vertical inspection pipe shall be maintained in order to determine if there is standing water in the constructed soil medium or if infiltration is occurring. If infiltration rates are declining or not occurring, replacement of the medium or other method of retention is required.

2. Debris and litter in the detention area shall be removed to minimize clogging of the sand media.

5.5 STORMWATER HARVESTING BASIN PROHIBITIONS

The following prohibitions apply to stormwater harvesting basins.

Invasive non-native plants located with 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 at: http://rfcd.pima.gov/wrd/riparian/pdfs/revised_guidelines_jan2010.pdf.

5.6 PRACTICES THAT INCREASE THE TIME OF CONCENTRATION

Peak discharge rates may be reduced through the use of a 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:

5.6.1 Lengthened Flow Path Standards

Lengthened flow paths shall occur in swales or channels which meet the following criteria.

1. Swales and channels shall meet current channel design standards, including freeboard.
2. When 100-year flow velocities are 2 feet per second or less, earthen swales are allowed.
3. When 100-year flow velocities are greater then 2 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 D50 of at least 4 inches to roughen the flow path.

6 MULTIPLE-USE CONCEPTS

Use of a detention basin for multiple purposes is practical and feasible in many locations. Acceptable uses are human activity, such as passive and active recreation, and landscape buffer yards. The following requirements apply when a detention basin provides for uses other than detention.

6.1 BASINS DESIGNED WITH HUMAN ACTIVITY ZONES

6.1.1 General 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 electrical engineer registered in the State of Arizona certifies that the electrical equipment does not pose any hazard to public health or safety when inundated;

    a. Improvement Plans must show the location of electrical equipment, the design elevation and the 100-year water surface elevation, and;
    b. A Registered Electrical Contractor must certify that all electrical installations meet all standards for placement in or near ponded water.

2. One or more signs are required for basins designed with human activity zones to inform the public of the basin purpose and potential hazard resulting from collection of stormwater. Signage must be visible from the activity area, pedestrian access and vehicular access. Signs shall comply with the standards of Section 3.13.

3. When drainage crosses a pedestrian access, scuppers shall be provided. The scupper capacity shall be the 100-year peak discharge at the crossing.

4. A basin designed with human activity zones shall contain a minimum of one 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.

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

6.1.2 Maintenance Requirements

1. All applicable maintenance requirements from Chapter 4, Detention Basin Design Standards, shall be met.

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

3. Inspections shall occur after storm events. If damage to materials or furnishings is apparent, the basin configuration shall be restored to the original design configuration.

6.1.3 Prohibitions

1. 100-year water depths greater than 3 feet are prohibited.

2. Electrical equipment without certified waterproofing below the 100-year water depth is prohibited.

3. Hardscape, seating and tables, sports equipment and any other materials which float or are not waterproof are prohibited.

4. Obstruction of inlets or outlets is prohibited.

6.2 BASINS CONTAINING LANDSCAPE BUFFER YARDS

6.2.1 General Requirements

1. When landscape buffer yards are required by the Pima County Zoning Code, Chapter 18.72, and detention containing a landscape buffer yard is proposed, an engineering analysis of the detention requirements met by the buffer yards is required as part of the project drainage report.

2. The drainage report must demonstrate that the multiple-uses of buffer yards for both landscaping and detention are compatible.

3. The project landscape plan must be submitted to the District for review prior to final approval of the Development Plan or Final Plat.

4. The District will review for requirements of the Floodplain Ordinance. Landscape requirements shall be reviewed by the Development Services Department.

5. All applicable requirements of Chapter 4, Detention Basin Design Standards, and Chapter 5, LID Practices Design Standards shall be met.

6.2.2 Landscape Buffer Yards Maintenance Requirements

1. All applicable maintenance requirements from Chapter 4, Detention Basin Design Standards, shall be met.

6.2.3 Landscape Buffer Yards General Prohibitions

1. Landscaping shall not obstruct flow conveyance, inlets or outlets.

7 COVENANTS

7.1 GENERAL REQUIREMENTS

1. The District requires covenants to be recorded with the Pima County Recorder's Office for when any of the following stormwater detention practices are proposed:

   a. Low Impact Development Practices,
   b. Embankments,
   c. Underground Storage,
   d. Pumps, and
   e. Dry wells.

   Appendix B contains example covenants and exhibits.

2. Covenants shall comply with the requirements of Chapter 16.38 of the Floodplain and Erosion Hazard Management Ordinance.

3. For corporate covenants, the signer shall provide sufficient documentation to demonstrate authorization to sign for the company. Sufficient documents include:

   a. Articles of Incorporation,
   b. A corporate resolution demonstrating the individual's ability to represent the company, or
   c. A notarized letter on company letterhead that indicates that the person is allowed to represent the company.

4. Covenants shall be recorded prior to approval of the Development Plan or Final Plat, and the Sequence No. shall be provided on the Development Plan or Plat in a General Note on the Cover Sheet of the Plan or Plat.

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

8 DETENTION WAIVER REQUEST AND PAYMENT OF IN-LIEU FEE

Sections 16.48.030 and 16.48.040 of the Ordinance allow collection of a fee in lieu of a detention system 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.

8.1 WAIVER REQUEST REQUIREMENTS

1. At least one of the following shall be demonstrated when a detention waiver is applied for:

    a. Structural flood control measures, conforming to the requirements of Section 16.48.30, are proposed in place of detention systems,
    b. The project site is one 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,
    d. 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, or
    e. The project site is eligible for a waiver due to other engineering justification acceptable to the District.

2. When removing a detention system projects shall maximize the use of LID practices to reduce the required detention volume.

3. Demonstration of the criteria in this section does not guarantee Approval of a detention waiver request.

8.2 WAIVER APPLICATION REQUIREMENTS

8.2.1 Waiver Request Form

1. To apply for a waiver, the owner or owner's representative shall obtain a Detention Waiver Request Form from www.rfcd.pima.gov/pdd/guidelines/pdfs/det_waiver.pdf, complete all sections and submit directly to the District.

8.2.2 Waiver Request Submittal Procedure

1. The Request Form and Attachments shall be submitted to the Division Manager of the Planning and Development Division of the District.

2. The submittal should be made as early in the site planning process as possible.

3. The submittal shall be a stand-alone document, separate from any Drainage Report prepared for the project.

8.2.3 Waiver Request Attachments

1. The following attachments must be provided with the waiver request:

    a. An exhibit, to scale, with the following information;
        i. The project boundaries,
        ii. Adjacent major streets,
        iii. Nearby watercourses, if applicable,
        iv. The location of existing and developed conditions concentration points with 100-year peak discharges,
        v. Proposed LID practices and
        vi. If structural flood control measures are proposed in accordance with Section 16.48.030 they shall be shown.

    An example is provided with the waiver request form and found at: http://rfcd.pima.gov/district/forms.htm.

    b. Aerial photo with the project area outlined, showing surrounding adjacent properties,
    c. PC Hydro output data sheets for on-site existing and developed conditions concentration points and for concentration points where flows exit the project,
    d. PC Hydro output data sheets for the entire site area; one data sheet with a basin factor for existing conditions and one data sheet with a basin factor for developed conditions,
    e. PC Hydro hydrographs for existing and developed conditions runoff for the entire site area (the hydrographs associated with the data sheets in Item d), and
    f. The estimated required detention volume calculated from the difference between the two hydrograph volumes from Item e.

8.2.4 Waiver Request Response and Approval

1. The District 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 District approved application and all the attachments outlined in Section 8.2.3 prior to approval of the Development Plan or Final Plat.

4. A copy of the District's response letter granting approval of the waiver request shall be provided in the Drainage Report.

5. The fee shall be paid to the District, according to the instructions in the response letter, prior to final approval of the Development Plan or Final 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 8.1.1, detention must be provided.

9 DRAINAGE REPORT CONTENT

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

9.1 CONTENT FOR AN APPROVED DETENTION WAIVER

1. If a waiver has been approved by the District, the Stormwater Detention Section shall contain the following:

    a. A short discussion of the justification for the waiver.
    b. Copy of the Detention Waiver approval letter.

9.2 CONTENT FOR LID PRACTICES

1. Provide a description of stormwater harvesting basins used and the analysis that meets 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, compacted and connected impervious surfaces,
    b. Protection/enhancement of riparian habitat and regulatory floodplains and other high permeability areas, and
    c. Lengthened flow paths.

3. When stormwater harvesting basins provide detention volume, provide the analysis for the peak discharge rate reduction for each return period using the methodology is found in Section 3.3.

4. Provide a stormwater harvesting basin summary table with the following:

    a. First Flush Retention volume, if applicable (cubic feet or acre feet)
    b. Bottom elevation (feet),
    c. Invert elevations for inlet and overflow (feet),
    d. Dimensions of inlets and overflow, if applicable,
    e. Detention Volume, if applicable (cubic feet or acre feet),
    f. The contributing area to each basin or group of basins (square feet or acres)
    g. When stormwater harvesting basins provide detention volume, the peak discharge rate reduction, as a result of the basins for all return periods.

5. Provide a cross-section of each stormwater harvesting basin showing and labeling the following information, as applicable. Examples can be found in Chapter 5 of each different type of basin:

    a. Side slope with surface treatment and ratio indicated,
    b. 100-year water surface elevation,
    c. If applicable, inlet and overflow structures with dimensions, material type and elevations specified, and
    d. Inlet and overflow protection, toe down, rock rip rap (length, thickness, treatment, rock size).

Provide a cross-section of each bio-retention basin, showing and labeling material layers and surface depression and side slopes.

Provide hydraulic cross-sections of LID swales with dimensions, velocity, and 100-year water surface elevation.

On the Proposed Conditions Drainage Exhibit, show the location of all LID practices.

9.3 CONTENT FOR DETENTION BASINS

1. A brief summary of the applicable detention requirements relevant to the development including a statement whether the project site is located in a Balanced or Critical Basin.

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

3. Stage-storage-discharge table.

4. 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.

5. The analysis of the storage-indication method to determine amount of peak discharge rate reduction by a basin and supporting documentation shall be provided. The following storage-indication methods can be used to determine the reduction peak discharge rate:

    a. The District's PC Route.xls spreadsheet.

i. Supporting documentation for this method shall include:
   1. Worksheets from the RFCD Basin Routing spreadsheet.

b. HEC-HMS Version 3.3 or higher, or
   i. Supporting documentation for this method shall include:
      1. HEC-HMS model summary output (as shown in example 1), and
      2. A CD of the modeling.

6. A basin summary table with the following basin design parameters:

   a. Size (square feet or acres),
   b. Volume (cubic feet or acre 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,
   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),
   b. Side slope with surface treatment and ratio indicated,
   c. 100-year water surface elevation,
   d. Inlet and outlet structures with dimensions, material type and elevations specified
   e. Outlet protection, toe down, rock rip rap (length, thickness, treatment, rock size),
   f. Positive drainage pipe with size indicated, and
   g. Impervious interior surface treatment shall be specified when embankment conditions impounding more than 1 foot of water are proposed.

8. Cross-sections perpendicular and parallel to the basin inlet and outlet structures.

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

10. When an embankment is proposed, the following shall be provided:

    a. Justification for the use of the embankment(s),
    b. For embankments designed to impound greater than 1 foot of water, the calculations for the emergency spillway design capacity as outlined in Section 4.11.1, No. 6,

c. Engineering analysis for erosion protection if the embankment is located within an erosion hazard setback, and
d. A copy of the covenant to be recorded. The covenant shall be recorded prior to approval of the project.

11. When an underground storage system is proposed the following shall be provided:

    a. Justification for the use of underground storage,
    b. A storage volume analysis 1.5 times the design volume of an above ground basin,
    c. When underground detention storage is proposed, a path to deliver flows in a reasonable and safe manner in the event the system cannot accept flow shall be shown
    d. A copy of the covenant to be recorded. The covenant shall recorded prior to authorization of the project, and
    e. A copy of the report specified in Section 4.15.1, No. 9.

12. When a pump is proposed, the following shall be provided:

    a. Justification for the use of the pump,
    b. The District's written acceptance to use the pump,
    c. Analysis demonstrating the entire volume of the 100-year post-developed hydrograph from the contributing drainage area will be provided or a statement that a back-up pump with an emergency power source will be utilized,
    d. Demonstration that the pump's discharge rate does not exceed the pre-developed conditions 2-year peak discharge rate,
    e. Trash rack/screen design calculations using the 2.0 clogging factor,
    f. Emergency back-up plan,
    g. Drainage exhibit showing drainage flow under clogged conditions,
    h. 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,
    i. A copy of the covenant to be recorded, The covenant shall recorded prior to authorization of the project, and
    j. A copy of the pump system analysis as outlined in Section 4.20.1, No. 15.

9.4 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 District's written approval/acceptance to the dry well,
    c. A copy of the percolation test that determines the stabilized infiltration rate,
    d. Drywell system design by a licensed professional,
    e. Calculations and supporting documentation for the drywell 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,
    i. A plan for stormwater disposal in the event the drywell(s) cease(s) to function,
    j. Maintenance Plan with at minimum the following:
        i. Maintenance schedule,
        ii. Type of maintenance activities,
        iii. Exhibit showing the location(s) of the drywell(s), and
        iv. Contact information of the driller or authorized maintenance professional, and
    k. A copy of the covenant to be recorded. The covenant shall recorded prior to authorization of the project.

9.5 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 and post-developed with detention at all concentration points where flows exit the project site.

    a. The table shall demonstrate that the post-developed with detention 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 developed concentration points with the pre-developed concentration points.

10 REQUIREMENTS FOR PLATS AND DEVELOPMENT PLANS

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

10.1 REQUIRED DETENTION BASIN CONTENT FOR TENTATIVE PLATS AND DEVELOPMENT PLANS

10.1.1 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 Regional Flood Control District. The Owner Has Paid A Fee In-Lieu Of Providing Stormwater Detention Facilities."*

10.1.2 General and Permitting Notes

1. If Detention is provided, provide the following General Note, with the relevant volumes. If detention is not provided by a certain practice, enter zero cubic feet for that practice:

   "This project is required to provide Stormwater Detention. The total volume of detention provided is _____ cubic feet.

   The total volume is provided by the following practices:

   Below Grade Excavated Basin(s) _____ *cubic feet*
   Engineered Basin Side _____ *cubic feet*
   Stormwater Harvesting Basin(s) _____ *cubic feet*
   Underground Storage _____ *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 Dry Well(s)]. An Inspection and Maintenance Plan Has Been Provided to the Homeowner's Or Property Owner's Association. An Inspection And Maintenance Covenant Has Been Recorded At Sequence No. _____, Of The Public Records Of Pima County."

Provide the recording information prior to Tentative Plat or Development Plan approval.

3. When a project has drainage and grading improvements that are required to mitigate off-site adverse impacts of the proposed development an as-built plan shall be prepared and submitted to the District. The as-built plans require District 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 for Development Plans and General Note for Tentative Plats to disclose this requirement:

   "Prior To Issuance Of Any Building Permits Pursuant To Section 16.36.030.D. Of The Floodplain Ordinance, An As-Built Plan Of The Drainage And Grading Improvements That Are Required To Mitigate Off-Site Adverse Impacts Shall Be Prepared And Submitted To The District. Upon Approval Of The As-Built Plan By The District, The Hold To Issuance Of Building Permits Can Be Removed."

10.1.3 Requirements for Detention Basins and Stormwater Harvesting Basins

1. Provide a descriptor box adjacent to the 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. Detention volume (cubic or acre feet),
   b. Q100 in (cubic feet per second),
   c. Q100 out (cubic feet per second), if applicable,
   d. Basin top elevation (feet),
   e. 100-year water surface elevation (feet), and
   f. 100-year ponding depth (feet) (measured from the lowest elevation of the basin).

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

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

4. In plan view, show conceptual grading for the basin(s) and include the following information,

For detention and stormwater harvesting basins include:

a. Maintenance access,
b. Location of maintenance ramp (10-foot minimum), if applicable,
c. Location of sign(s), if applicable,
d. Conceptual grade contours,
e. Side slope ratio with slope treatment, and
f. For drainage infrastructure requiring a covenant, provide the Sequence Number adjacent to the applicable structure and/or basin.
g. Location and dimensions of outlet or slope protection. Call out rock size, type of placement or other material.

For detention basins only include:

h. Location of the sedimentation device,
i. Security barriers, if applicable, with height (minimum of 42 inches high) and material type indicated,
j. Positive drainage to the outlet structure, minimum 0.5% slope, and
k. Location of the positive drainage pipe. Call out material and orifice plate.
l. Location of inlet and outlet structures with inverts or other inlet and outlet elevations. Call out dimensions and materials. Call out the Q_{100} for all structures except the positive drainage pipe.

5. On a detail sheet, show a cross-section of the basin, with the following information:

For detention and stormwater harvesting basins include:

a. Dimensions (feet),
b. Top and bottom elevation (feet),
c. Freeboard elevation (feet),
d. 100-year water surface elevation (feet),
e. Side slope ratio with slope treatment, and
f. Setbacks from property boundaries (10 foot minimum).
g. Weir or other outlet structure elevation(s) (feet),

For detention basins only include:

h. Positive drainage pipe(s) with a 6-inch orifice plate; indicate diameter (inches) and material type,
i. Security barriers, if applicable, with material type and height, and
j. For embankment conditions indicate the following:
    i. Freeboard elevation (feet) (1 foot minimum),
    ii. 95% compaction, and

iii. For embankments designed to impound more than 1 foot of water, the following shall be included,
    1. Emergency spillway location, and
    2. Impervious treatment with toe down (minimum depth of 18 inches).

Typical cross-sections are provided in Appendix B, Details.

6. On a detail sheet, show cross-sections perpendicular and parallel to the inlet and/or outlet structures with the following information:

    a. Dimensions (inches or 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 C, Detail _____

7. On a detail sheet, show 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.

8. On a detail sheet, provide a detail for the positive drainage pipe with the orifice plate. An example detail is provided in Appendix C.

9. When a retaining wall is utilized as a basin side a preliminary structural design detail for the retaining wall must be provided with a Geotechnical Report sealed by a structural engineer registered in the State of Arizona with the first review submittal.

10. When an underground storage system is proposed 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:

    e. Appropriate building setbacks from the underground storage system related to structural integrity,
    f. Certification by a geotechnical engineer that the load bearing capacity of the soils underlying the underground storage structure is adequate and the soil complex is appropriate bed material,
    g. Structural design details, and
    h. Other design recommendations if appropriate.

11. When a pump is proposed as a method of disposal, the following applies:

a. District approval to use the pump is required prior to the first submittal of the Tentative Plat or Development Plan.
b. If the District allows the use of a pump, a pump system analysis shall be provided with the first review submittal. The analysis shall include the information outlined in Section 3.20.
c. When the project includes a pump(s), the following information shall be included on the plan view:
   i. Location of the service equipment, and
   ii. Location of the sump with dimensions shown.

12. When a dry well is used as a method of disposal, the following apply:

    a. District approval to use a dry well is required prior to the first review submittal. When requesting the approval, the engineer must submit the field investigation results and a preliminary site plan as outlined in Section 3.21,
    b. When the project includes a drywell(s), the following information shall be included on the plan view:
       i. A detail showing the typical dry well installation,
       ii. A detail showing the words "Stormwater Only" stamped in raised letters on the drywell grate, and
       iii. On the plan view the location of the drywell(s).

10.1.4 Requirements for LID Practices other than Stormwater *Harvesting Basins*

1. When Non-Contributing Area Basins or Bio-Retention Basins are proposed, the following apply:

   a. When the project includes a non-contributing area basin(s) or bio-retention basin(s), the location of the basin(s) shall be called out on the plan view.
   b. On a detail sheet, cross-sections perpendicular and parallel to the basin(s) shall be provided.

10.2 REQUIRED DETENTION BASIN CONTENT FOR FINAL PLATS

10.2.1 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 Regional Flood Control District. The Owner Has Paid A Fee In-Lieu Of Providing Stormwater Detention Facilities.*

10.2.2 General and Permitting Notes

1. If detention is provided, provide the following General Note, with the relevant volumes. If detention is not provided by a certain practice, enter zero cubic feet for that practice:

   "This project is required to provide Stormwater Detention. The total volume of detention provided is _____ cubic feet.

   The total volume is provided by the following practices:

   Below Grade Excavated Basin(s) _____ cubic feet
   Engineered Basin Side _____ cubic feet
   Stormwater Harvesting Basin(s) _____ cubic feet
   Underground Storage _____ cubic feet"

2. If applicable, provide the General Note:

   "This Project Includes _____ [LID Practices, Embankments, Underground Storage System, Pumps Or Dry Well(s)]. An Inspection And Maintenance Plan Has Been Provided To The Homeowner's Or Property Owner's Association. An Inspection And Maintenance Covenant Has Been Recorded At Sequence No. _____, Of The Public Records Of Pima County."

3. Provide the Permitting Note:

   "Prior To The Release of Assurances Pursuant To Section 16.36.030.E. Of The Floodplain Ordinance, An As-Built Plan Of The Drainage And Grading Improvements That Are Required To Mitigate Off-Site Adverse Impacts Shall Be Prepared And Submitted To The District. Upon Approval Of The As-Built Plan By The District, The Hold To The Release of Assurances Can Be Removed."

10.2.3 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 is intended for drainage.

11 REQUIRED CONTENT FOR AS-BUILT CERTIFICATION AND PLANS

11.1 GENERAL REQUIREMENTS

1. Drainage and grading improvements that mitigate for offsite impacts shall be inspected by a Professional Engineer registered in the State of Arizona. The Engineer shall certify that the improvements were built in conformance to the approved plans. The District's As-Built Certification Document shall be used as the certification. The document is available at: http://rfcd.pima.gov/district/forms.htm

2. When the drainage and grading improvements are built per the approved plan set, the certification document may be submitted without plan sheet attachments.

3. When the drainage and grading improvements are not built to the approved plan, an as-built plan shall be submitted to the District 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.

11.1.1 Detention Basins

1. The following at minimum, shall be certified;

    a. Dimensions (feet),
    b. Top and bottom elevation (feet),
    c. Freeboard elevation (feet),
    d. Side slope ratio,
    e. Setbacks from property boundaries,
    f. Maintenance access (10 foot minimum),
    g. 0.5% slope along basin bottom for positive drainage to the outlet structure,
    h. Weir or other outlet structure elevation(s) (feet),
    i. Erosion protection, including rock sizing and dimensions,
    j. Cut off wall elevations, if applicable,
    k. When the basin includes embankment conditions, the following;
        i. Freeboard elevation (feet) (1 foot minimum),
        ii. Toe down dimensions,
        iii. 95% compaction, and
        iv. Embankments designed to impound more than 1 foot of water; emergency spillway and impervious treatment with toe down.
    l. When the basin includes a retaining wall, the following:

   i. Dimensions,
   ii. Structural design details,
m. For underground storage, the following;
   i. Building setbacks,
   ii. Structural design details,
n. When the basin includes a pump;
   i. pump sump dimensions, and
   ii. pump specifications
o. Maintenance ramp, if applicable,
p. Sign(s),
q. Slope treatment,
r. Sedimentation device,
s. Security barriers, if applicable,
t. Positive drainage pipe(s) with a 6-inch orifice plate,
u. When a project includes a dry well; Drywell grate with the words "Stormwater Only," drywell specifications and location.

11.1.2 Stormwater Harvesting Basins

1. The following at minimum, shall be certified;

   a. Location as proposed,
   b. Dimensions (feet),
   c. Top and bottom elevation (feet),
   d. Side slope ratio,
   e. Setbacks (feet),
   f. Maintenance access,
   g. Slope treatment.

2. When bioretention basins are used, the following shall be certified

   a. Depth (inches or feet),
   b. Location of the sediment trap,
   c. Vertical inspection pipe,
   d. Material type, and
   e. Soil matrix.

11.1.3 Other LID Practices

1. The following at minimum, shall be certified;

   a. Location of LID Practice(s),
   b. If disconnection of impervious surfaces is being claimed as a LID practice, construction as designed,

c. If lengthened flow paths are incorporated as a LID practice, site layout as designed, dimensions of swale and surface treatment of swale.

12 GLOSSARY OF TERMS

Adverse Impact – A change in flow conditions as a result of a development that creates a violation of the Floodplain Ordinance, a safety issue or property damage.

Approval – Written notice by the District approving a submittal including Development Plans; Plats; Drainage Reports; waivers; proposed pumps, drywells, or underground stormwater storage; or variances.

Approved Plan – The most current Development Plan or Plat 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.

Balanced Basins – A drainage basin or watershed which contains flood water channels, natural or manmade, and/or flood control structures that are adequate to contain existing runoff from the base flood produced by the basin or watershed, but in which additional runoff may not be safely contained by said channels or structures. All drainage basins shall be considered to be balanced basins unless a basin has been designated as a critical drainage basin.

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

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

Critical Basin – A drainage basin or watershed that contains flood water channels, natural or manmade, and/or flood control structures that cannot convey existing runoff during a base flood produced by the basin or watershed, and which has a documented history of severe hazards.

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 six feet in height, regardless of storage capacity.
- Any barrier that has or will have a storage capacity of fifteen 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.

Detention Basin – A type of flood control system that delays the downstream progress of flood waters in a controlled manner, generally through the combined use of a temporary storage area and a metered outlet device, which causes a lengthening of the duration of flow and thereby reduces downstream flood peaks.

Development – Any manmade change to improved or unimproved real estate, including, but not limited to, buildings or other structures, mining, dredging, filling, grading, paving, fencing, excavating or drilling or storage of equipment or materials.

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 Practices.

District – The County Flood Control District, as established by Title 48, Chapter 21 of the A.R.S., which is named in Pima County as the Pima County Regional Flood Control District.

Disturbance – The condition of land areas that have been damaged, demolished or eliminated.

Drainage Area – The upstream contributing watershed area measured at a single point of drainage concentration and is expressed in units of area. Other terms for this are catchment area, watershed, and river basin.

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.

Dry Well – A deep hole covered and designed in such a manner so as to hold storm water runoff until it infiltrates into the ground.

Embankment – Compacted earth which impounds water.

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

Erosion – The physical process where flowing flood water removes sediment and earthen material causing land to wear away and degrade over time.

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

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.

Floodplain – Any areas within a watercourse which have been or may be covered partially or wholly by flood waters from the 100-year flood including land that have been, or may be, subject to flooding from storm water runoff, overflow of flood waters from a watercourse, alluvial fans, sheet flood zones, or other property subject to flooding. The floodplain includes the stream channel, the floodway, and the floodway fringe area.

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 (e.g. limestone, sandstone can be eroded away by storm water).

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 of a detention basin where water is directed into the basin.

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

Invasive Plants – A species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

Landscape Buffer Yard – A strip of land used for landscaping to separate one type of land use/zoning from another. Landscape buffer yards are a requirement of Pima County Zoning Code, Chapter 18.72.

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 small-scale controls uniformly distributed.

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

Maintenance and Inspection Plan – A plan to upkeep and examine drainage structures over the life of the project.

Multiple-Use Concepts – A basin which provides benefits in addition to the primary function of flood control. Such benefits may include recreation, water harvesting, or visual buffers.

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 volume flow rate 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 Indian 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.

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.

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 a detention basin. Outlets may consist of culverts, weirs, orifices, or any combination thereof.

Rainwater – Liquid precipitation falling from the sky before it has hit a solid surface.

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

Regional Detention Basin – The basin collects 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 either the City of Tucson or the Pima County Department of Transportation and Flood Control District.

Riparian Habitat – Plant communities occurring in association with any spring, cienega, lake, watercourse, river, stream, creek, wash, arroyo, or other surface body of water, either surface or subsurface, or channel having banks and bed through which water flows at least periodically.

Regulatory Floodplain – that portion of the geologic floodplain associated with a watercourse, including its channel, or any other floodplain or floodprone area that would be inundated by the base flood, including all base floods where the base flood peak discharge is 100 cfs or greater, those areas that are subject to sheet flooding except when the maximum potential contributing watershed area is less than 20 acres, those areas identified on subdivision plats or development plans, those areas designated by FEMA, including areas designated as Shaded Zone X as well as those areas that the Chief Engineer, using the best available data, has determined is subject to a flood hazard during the base flood.

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

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

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 once it 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 six or more lots, parcels or fractional interests.

Subsoil – The layer of soil under the topsoil on the surface of the ground.

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

Swale – A ditch or depression that is cut into the soil.

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. It is reviewed for compliance with applicable regulations.

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.

Variance – A request to provide designs, analyses or reporting which is different from the requirements stated in this manual.

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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