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I. Introduction

Water conservation is essential for the sustainability of the community. In 2008, the per capita drinking water use in Bernalillo County was 161 gallons a day. Of that amount, it is estimated that 40% was used for landscape purposes. Reducing the amount of water used for landscaping is one of the primary goals for both Bernalillo County and the Albuquerque Bernalillo County Water Utility Authority. The Water Conservation Plan for Bernalillo County (2006) and the Water Resources Management Strategy (2007), a long-range water supply plan for the metropolitan area, both emphasize reducing in the amount of drinking water used for landscape as a viable strategy for water conservation.

Taking a water-conserving approach to every development project can exert a great influence on the future sustainability of Bernalillo County. These Standards and Guidelines illustrate how to do this for each major type of development. They have been organized into separate chapters that reference the Bernalillo County Zoning Code for ease in use. The first chapter describes the physical environment of Bernalillo County, which can be divided into five biozones with similar conditions. The following three chapters detail water conservation standards and guidelines for Single Family Residential development (Chapter II); Commercial, Office, Institutional, Multi-Family Residential, Small Subdivision and Industrial development (Chapter III); and Master Planned Communities, Larger Subdivisions, and Land Planning (Chapter IV).

Photo 1. Rio Grande, Albuquerque, New Mexico

A. Purpose and Goals

The purpose of this project is to develop standards and guidelines that define the requirements of the Bernalillo County Water Conservation Ordinance and provide direction to homeowners, builders and developers so that they can meet the ordinance requirements. The goal of the Standards and Guidelines is to improve water conservation through increased compliance with the ordinance by showing how to maximize water efficiency and conservation through design. This step-by-step guide provides: 1) definitions of the requirements, 2) directions on how to analyze the site and design for minimal disturbance and maximum use of precipitation, 3) descriptions and illustrations of methods with examples, 4) a matrix of methods and environmental conditions to facilitate decision making, 5) methods for conserving water through irrigation and 6) tools such as plant lists and water savings calculation sheets. The Standards and Guidelines pertain primarily to exterior water conservation measures such as the following::

- Site design that considers and integrates existing factors both on and off the site
- Best Management Practices for grading and stormwater management
- Application of water-harvesting methods
- Indirect ways to conserve water through site and landscape design
- Selection of appropriate plants from a user-friendly list that corresponds to terms used in the ordinance
- Specialized plant lists for golf courses and public recreation areas
- Water-saving irrigation techniques
- Use of graywater
- Water-conserving maintenance of landscape, water-harvesting systems, and irrigation

The Standards and Guidelines have been developed in accordance with existing regulations and by researching references developed by professional organizations and state and federal agencies involved in energy and water conservation. Standards and practices created and maintained by other municipalities and local governing bodies concerned with resource conservation have also been reviewed.

A protocol document/summary of ordinance requirements has been developed as a companion to this Standards and Guidelines to help the homeowner/builder/developer to prepare for processing plans through the County. This document is included in the Appendix. Together with the Standards and Guidelines, the protocol will enable both applicants and County staff to easily determine whether or not the requirements of the Water Conservation Ordinance have been met by using the checklists developed for applicants. The easy-to-understand checklists will increase compliance with the ordinance by clearly listing the requirements and the steps employed to meet them. County staff will be able to verify compliance by conducting a field inspection and subsequently approving the checklist.

B. How to Use this Document

Start with Your Bioregion and Site Conditions

Bioregion and site conditions are key considerations in determining the type, number and placement of water conservation devices to be used on a site. The Bioregion map (see Map 1 on page 9) shows that Bernalillo County is divided into five distinct bioregions based on environmental characteristics typically found within that area. Knowing the general conditions in a particular bioregion can help property owners and developers predict how various water conservation measures are likely to perform on a particular parcel or site. For example, harvesting water from downspouts or canales from a building in the West Mesa Bioregion where there are well-drained, sandy soils on a slope would be handled very differently from a harvesting water on a site in the Rio Grande Valley that has flat terrain and soils with high clay content. While general assumptions can be made based on the dominant characteristics of each bioregion, ultimately it is the evaluation of the specific site that will determine which water conservation methods and devices would be most appropriate.

The steps to using this document are:

1) Identify your bioregion.
   a) Refer to the Bioregion Map (Map 1) and locate your parcel.
   b) Review the Bioregion Soils (Map 2), Precipitation (Map 3) and Vegetation (Map 4) Maps for general characteristics that are likely to prevail on your site. Note any characteristics particular to your site that may differ from characteristics dominant in the bioregion that impact microclimate, soil or drainage, such as prior uses of the land, patterns of erosion or solar exposure (south- versus north-facing).
2) Identify the property's development category.
   a) The Standards and Guidelines have been organized into separate chapters for different types of development: Single-Family Residential (A-1, A-2, R-1), Commercial/Office, and Industrial, Multi-family residential, and residential subdivision with fewer than five units (R-2, MH, O-1, C-N, C-2, C-L1, M-1, M-2) and Master Planned Communities, Campuses, Land Planning and Residential Subdivisions with five or more units (R-1, R-2, C-N, C-1). Refer to the Bernalillo County Zoning and Drainage Code for specific requirements applicable to each land use zone. Site design, approaches to grading and drainage, irrigation practices, graywater systems, water-harvesting strategies and plant selection are all influenced by the type and scale of the development.
3) Review the Water Conservation Standards and Guidelines for the development category in which you are working.
   a) Refer to the Water Conservation Device Matrix for a list of potential water-harvesting techniques and best management practices (page 40, page 116 and page 194). Based on site conditions, determine which devices could be used on your site.
   b) Read the additional details in the accompanying text for each of the techniques, following the matrix to confirm which methods are best suited for your needs.
4) Design
   a) Refer to "Appendix J. Bernalillo County Protocol Document/Summary of Ordinance Requirements" to determine which Water Conservation ordinance requirements apply to your site. The full ordinance is included in this document as "Appendix A. Bernalillo County: Applicable Plans, Regulations and Ordinance"
   b) Develop site, building and landscape plans that include the selected water conservation methods. An outline of appropriate design process steps is included in the guidelines section for each development type. Additional resources are included in the appendices such as the ABCWUA plant list, which provides information on vegetation appropriate to each bioregion, as well as the particular water and sun needs of individual plants.
   c) Refer to calculation worksheets in "Appendix B. Pre- and Post-Development Calculation Worksheets" recognizing when professional consultation may be advisable.

Please note that the design recommendations and information provided in these guidelines are for explanation and illustration of key water conservation concepts only. Not all design or construction details and information are shown, and adjustment to accommodate site-specific conditions will be needed. In addition, some of the techniques and best management practices may require permits or design by a registered professional, so be sure to verify current permit and other requirements with the relevant County or State agencies.

C. Bioregions

Located in the northernmost reach of the Chihuahuan Desert, Bernalillo County lies in the Rio Grande Valley between the escarpment on the west and the Sandia Mountains on the east. Due to its relatively high elevation and location on the continental interior, the area experiences hot summers and cold winters, with nighttime temperatures dipping below freezing around 108 times per year on average. Annual precipitation averages slightly below 9 inches, an amount far exceeded by the average evapotranspiration rate. Prevailing winds for much of the county are out of the north from October through March, from the west in April and May, and from the east from June through September. The winds significantly contribute to erosion and increased evapotranspiration rates.

Given the county's scant precipitation and dwindling groundwater supplies, water is a critical resource. Water resource management and planning is best done on a regional level due to the many variables involved such as water supply and demand, climate, and legal and institutional constraints. The Office of the State Engineer has therefore defined New Mexico's water planning areas by basin designations. The majority of Bernalillo County lies within the Middle Rio Grande Basin, with the exception of the easternmost portion, which is within the Estancia Basin. Bernalillo County is the most populous in New Mexico and therefore can have a significant impact in terms of water conservation. The County Water Conservation Ordinance that became effective October, 2010, represents a significant step towards increased conservation for new development throughout the county. The ordinance requirements for water-conserving site design and development can be met by a range of best management practices and techniques. Variables such as soil types, elevations, climates, and vegetation must be evaluated when determining which water conservation devices to use on a particular site. As an example, the water needs for a plant on a west-facing slope in the sandy soils of the West Mesa would be much higher than those of the same plant on a flat area in the Rio Grande Valley or on a north-facing slope in the Sandia foothills.

Understanding the type of soil present on a site within the bioregion is key to appropriate design of the site and landscape. In a given bioregion within the county there may be no need to amend the soil, however some soils inhibit healthy plant growth and may need amendment. Determining the correct soil treatment and the soil amendment that might be needed begins with understanding the soil itself.

For the most part the relationship between plants, soil and water is based in the soil structure; this refers to the density of soil particles and the pore spaces between them (porosity or permeability) and the combination of soil types (texture). In general, a well-structured soil will readily accept, store, and transmit water, gases and nutrients to plants. The interrelated porosity or permeability and texture of soil if balanced can create the best conditions for low water use and plant growth. A dense structure, such as that of clayey soils, will greatly reduce the amount of air and water that can move freely through the soil. If the texture of the soil is too dense water can pond. A good soil repair for this problem can be adding gypsum to soil to open the pores. Water moves more readily through coarser-texture soils, such as those with a high percentage of sand. If water moves too freely through soils, as is the case with sands, it may be appropriate to add a percentage of clay or humus to the soil to increase water holding capacity and decrease permeability. Soil texture can effect plant growth and health; it is determined by the relative percentages of sand, silt, and clay. Loam, which has good texture, is considered a great gardening soil, it generally has percentages of 40% clay, 40% sand and 20% silt. Bioregions within Bernalillo County can be well drained or impermeable; they can have very simple textures as is the case in the sand of the west mesa or the clay in the valley. To understand how to amend or treat these various soil types for the best plant growth conditions consult with a green industry professional like a nursery person, landscape architect or designer, or the NMSU Cooperative Extension Service or other like agencies.

Based on topographic and biological features such as elevation, climate, average temperature range, soils, geology, and vegetation types, Bernalillo County can be divided into five distinct areas or bioregions: West Mesa, Rio Grande Valley, East Mesa, Foothills and Mountains, and East Mountains (see Figure 1 and Map 1).

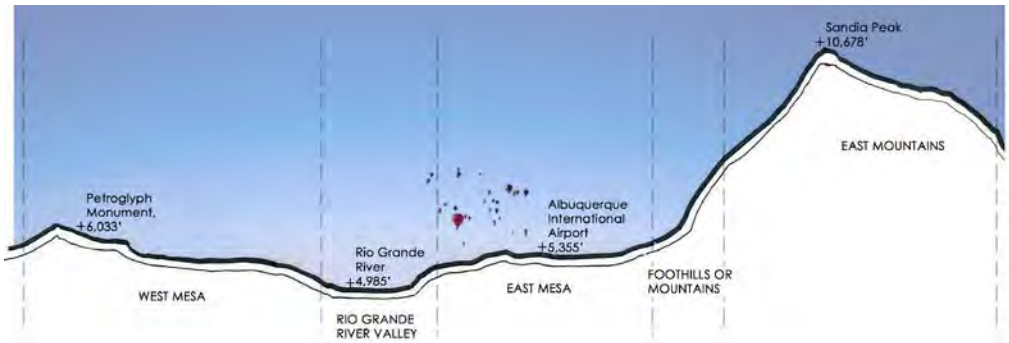


Figure 1. Diagrammatic Cross Section - Bernalillo County Bioregions

West Mesa - The West Mesa Bioregion reaches from the western edge of Bernalillo County to the western edge of the Rio Grande Valley. The zone is characterized by the hardy vegetation of desert grasslands, sand scrub and montane scrub/juniper savanna. Some of the plants found in this zone are prairie grasses, sand-sage, broom and feather dalea, punctuated with numerous wildflowers. These resilient plants are supported by average annual precipitation in the range of 7 to 9 inches. The soils in this bioregion are typically classified by the Natural Resources Conservation Services' (formally the Soil Conservation Service) system however for the purposes of this Guide we will use simpler and more user friendly descriptions (see "Map 2. Bernalillo County Soils" at the end of this section for the NRCS system). The West Mesa bioregion consists of well drained, deep soils composed of sandy or gravelly loams. Loam can be defined as sand (40%), Silt (40%) and clay (20%), these soils generally contain more nutrients and humus than sandy soils, have better infiltration and drainage than silty soils, and are easier to till than clay soils. Loams are more desirable for growing crops and landscaping and are considered ideal for gardening and agricultural uses because they retain nutrients well and retain water while still allowing the water to flow freely. West Mesa soils drain quickly with the exception of patches of finer clay that occur in some locations. In the far western part of the county the soils might be shallower than the immediate urbanized West Mesa, with layers of sand and gravel over sandstone, shale and basalt; these soils are excessively to well-draining but have widely varying depths to bedrock, which affects drainage and can cause low permeability.

Photo 2. West Mesa

Winds frequently sweep across the West Mesa bioregion, at times with sustained gusts over 40 miles per hour. The wind has a desiccating effect and sculpts the surface topography. The West Mesa exists in an area known as a thermal belt, which is an area between higher elevations and a valley into which cold air drains. The main implication is that there are fewer occurrences of freezing temperatures in the West Mesa bioregion than in the valley or the foothills and mountains. Average temperatures range from lows of 24°F to highs in the low 90s..

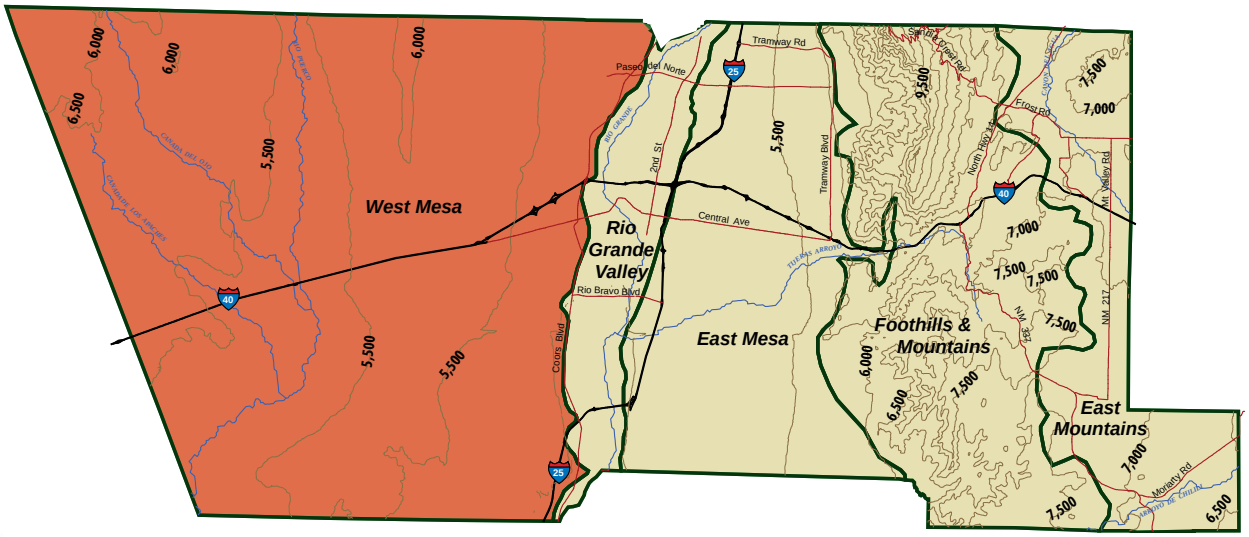


Figure 2. West Mesa Bioregion

Rio Grande Valley - The Rio Grande Bioregion runs north-south roughly through the middle of the county. For thousands of years people have settled and farmed along the river, and consequently, the vegetation in the Rio Grande Valley bioregion is a mix of urban and agricultural plants with a bosque of woodland meadow, cottonwoods, New Mexico olive, sumac, forbs and meadow grasses between the river levees. Soils in this bioregion were deposited by the river and are deep soils on alluvial fans, foothills and mesas. They are well-drained loamy soils for the most part; however, there are areas with a significant percentage of clay in the and sand as well as sandy soils with scatterings of clay deposits. In areas where the clay content is higher, the capacity to hold water is increased and may result in ponding and poor percolation. The areas that are predominated with sand or loam are well drained. Average annual precipitation is approximately 6 to 8 inches. Temperatures in the Rio Grande Valley Bioregion tend to be lower in evenings and mornings and drop below freezing more frequently than in the thermal belt zones due to cold air drainage from the mountains. Average lows in the valley hover around 20°F. Paradoxically, temperatures during the summer can be higher in the valley bioregion than in either of the mesa bioregions, averaging about 92°F. Ambient humidity also tends to be higher in the valley than in the other bioregions due to the presence of the river, irrigation canals, flooded fields and denser tree canopy.

Photo 3. Rio Grande Valley

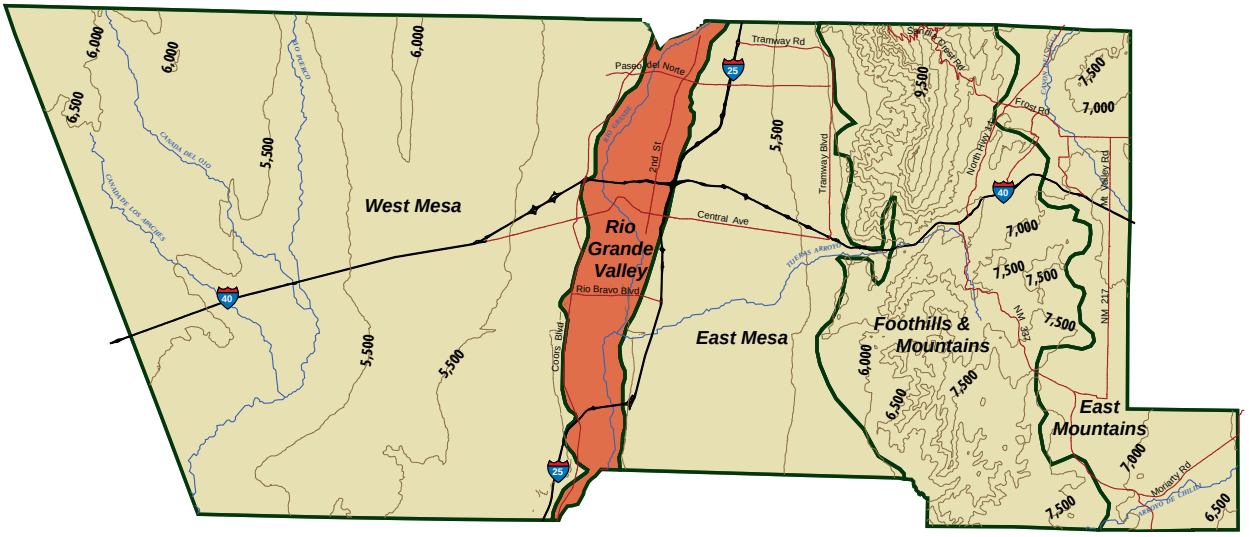


Figure 3. Rio Grande Valley Bioregion

East Mesa - The East Mesa Bioregion is the area commonly referred to as the Heights; it lies between the valley and the foothills of the Sandia Mountains. This zone has been highly urbanized so urban exotic landscape plants are most commonly seen. The native vegetation varies greatly from sand scrub to desert grassland to coniferous and mixed woodland of chamisa, sages, prairie grasses, piñon, juniper, oak and other deciduous trees. Annual precipitation averages around 7 to 9 inches, with the higher amounts falling at the higher elevations. Soils found in the East Mesa bioregion are deep and found on alluvial fans and mesas. They are made up of decomposed granite, sand, gravels and silty loam. These coarse-textured soils tend to drain well for the most part. The soils in the foothills are characterized by deep well drained loamy and stony soils and rock outcroppings. This bioregion is also in a thermal belt with temperatures averaging from lows of 24°F to highs in the low 90s.

Photo 4. The East Mesa

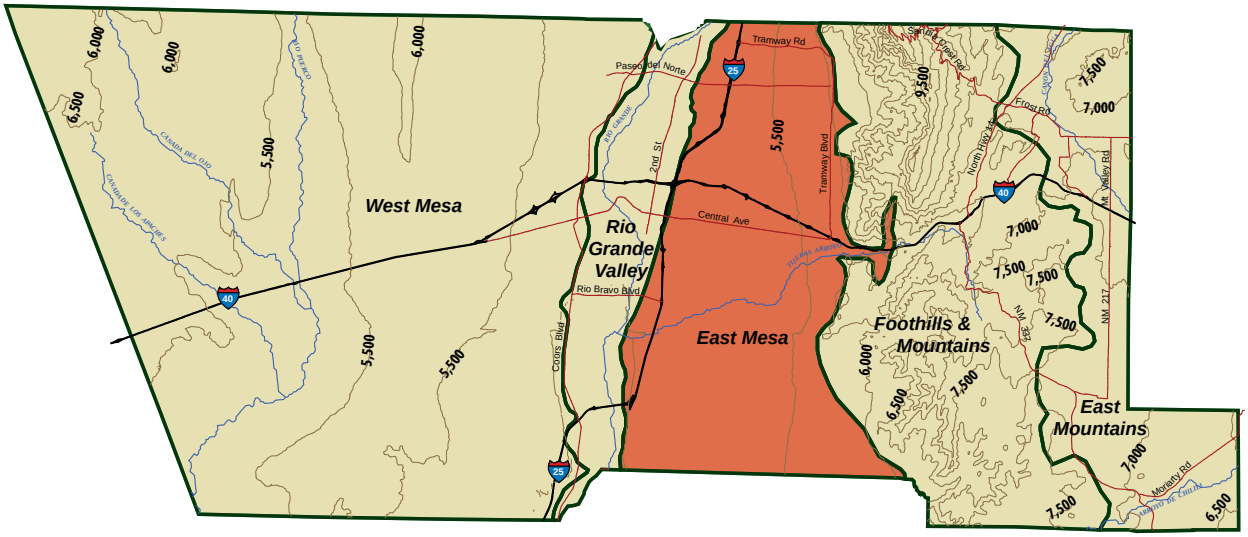


Figure 4. East Mesa Bioregion

Foothills and Mountains - The Foothills and Mountains bioregion begins at the foothills on the west side of the Sandia Mountains and ends at the toe slope on the east side of the Mountains. Vegetation in this bioregion includes coniferous and mixed woodland/montane scrub and juniper savanna, or montane and sub-alpine coniferous forest, depending upon elevation and slope orientation, which influence rainfall amounts and sun exposure. Ponderosa pine and fir mixed with aspen trees make up the main vegetation at the highest elevations (10,500-7,500 ft.) with piñon and juniper dominating at the next highest elevations (7,500-5,000 ft.). Below 5,000 feet junipers mingle with shrubs and eventually give way to shrubs and grasses at lower elevations. Precipitation averages range between 11 to 23 inches annually, again varying with elevation and slope orientation. Precipitation is usually dropped on the east side of the mountains so the east and northern slopes tend to be greener than the less shaded western and southern slopes. Soils in this bioregion are shallow with rock underlain to deep on mountains and foothills, they tend to be cobbly, stony and very stony loamy soils. Given their predominantly loose and gravelly texture, these soil associations tend to drain well. Rocky outcroppings are also common in this bioregion. This bioregion has changes in elevation of 3,000 feet, so the relative drop in temperature between the crest at 10,678 feet and the lower elevations at around 6,000 feet can be more than 22°F.

Photo 5. Typical Foothill Scene at Sunset

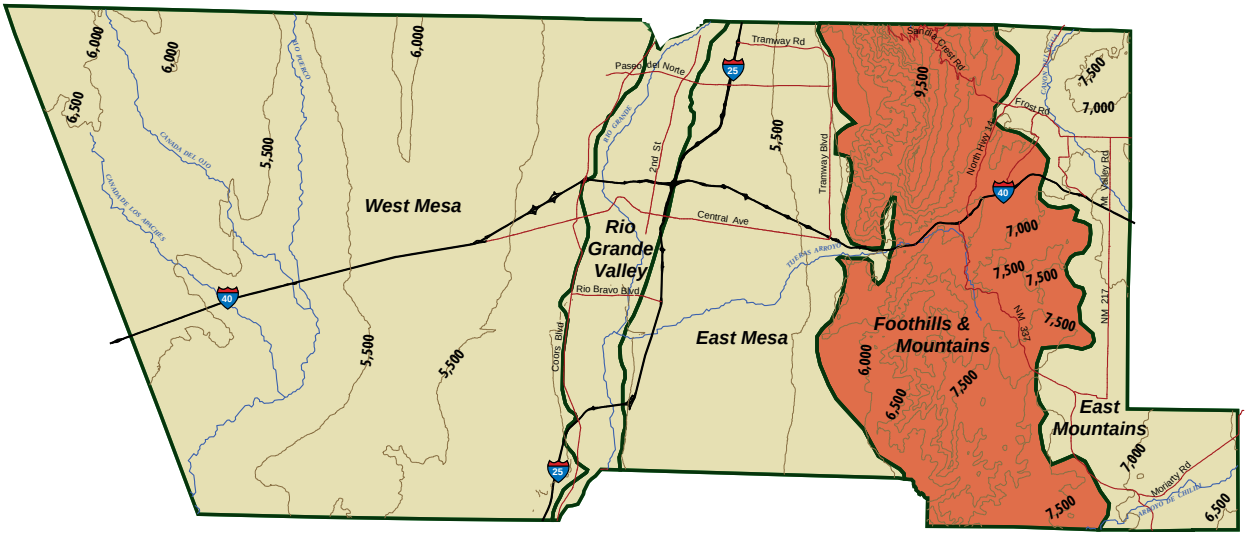


Figure 5. Foothills & Mountains Bioregion

East Mountain - The East Mountain Bioregion begins at the toe of the eastern slope of the Sandia Mountains and encompasses some of the Manzano and the San Pedro Mountains. Annual precipitation averages between 13 to 14 inches. The increased precipitation supports the coniferous and mixed woodland/montane scrub and juniper savanna vegetation types found in this bioregion. Vegetation on the eastern slope is denser, and the grasses in the savanna are more robust due to higher precipitation levels. There are pockets of farmland and rangeland in the far southeast and toward the northeast corner of the county. Soils in this bioregion can be deep in the uplands or very shallow with rock underlain, dependent on location. The soils are generally well drained and loamy. The soils are loamier than some bioregions and have a higher organic content due to the increased vegetative cover. The elevation changes from about 7,500 to 6,500 feet, but winds are common and produce a chilling as well as desiccating effect.

Photo 6. Geology, and Vegetation Typical in East Mountain Biozone

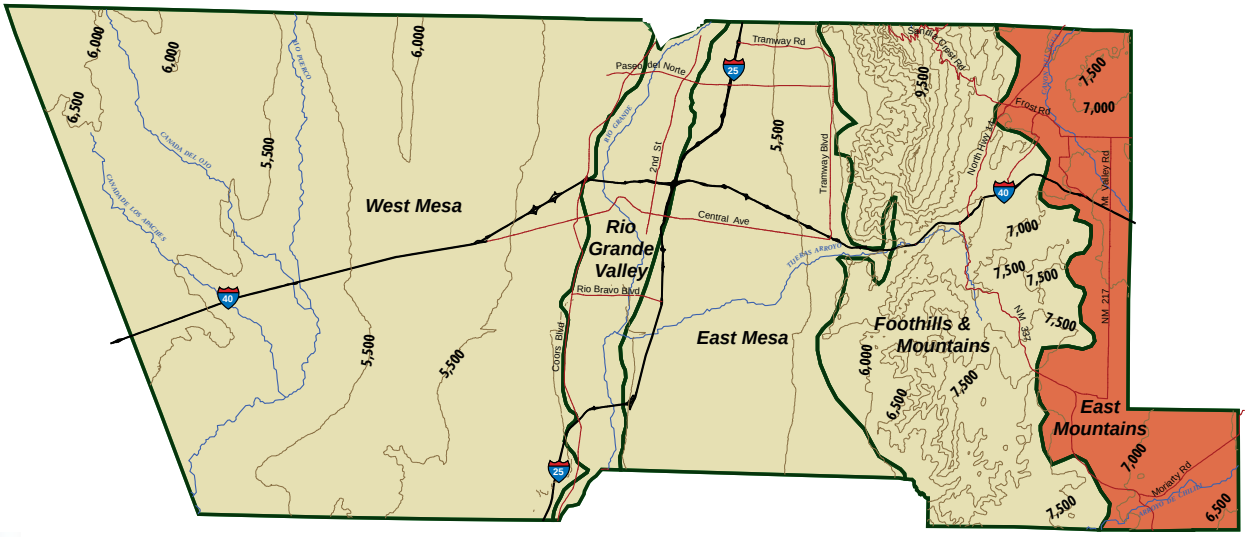
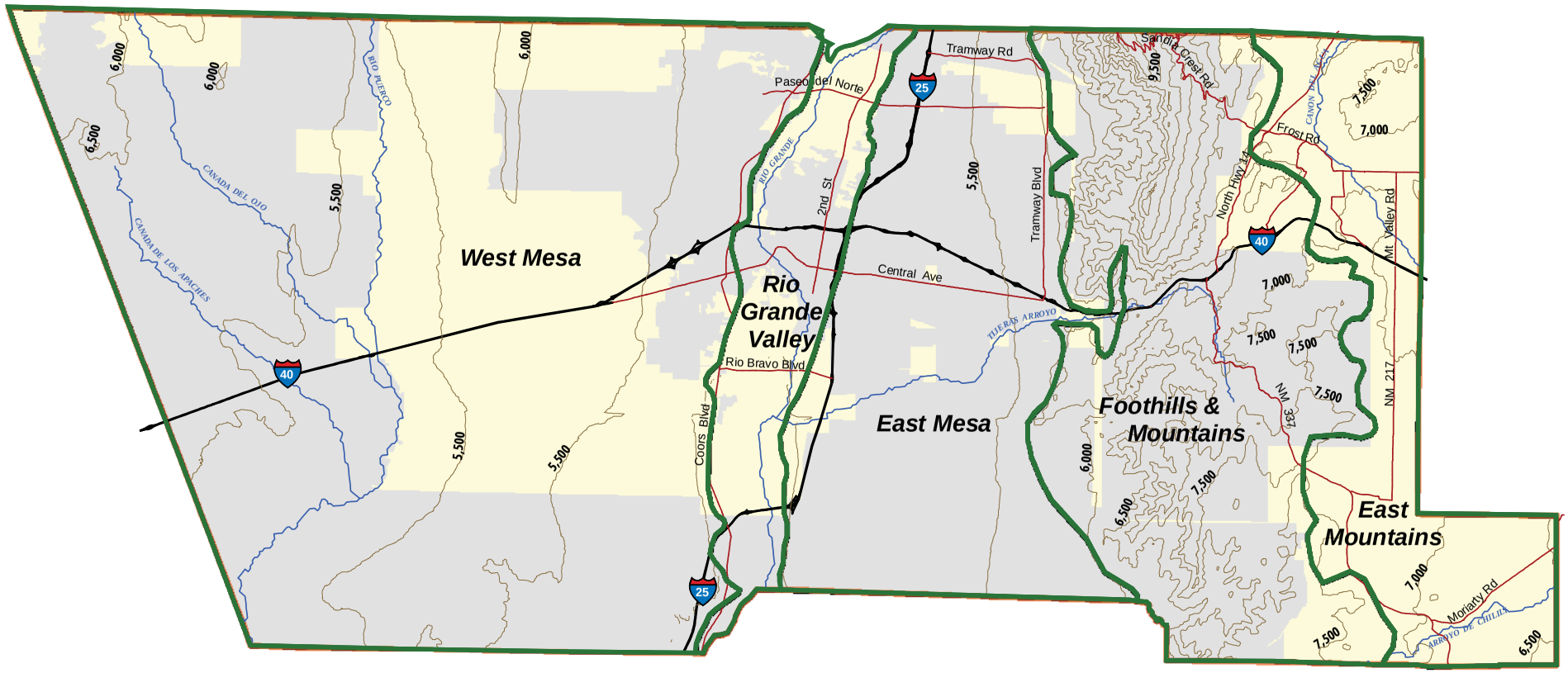


Figure 6. East Mountains Bioregion



Map 1. Bernalillo County Biozregions

Legend

- Bioregion Boundary
- 500 Foot Contours
- Non - County Lands (Native American Tribes, Federal Lands, State Lands)
- Streets

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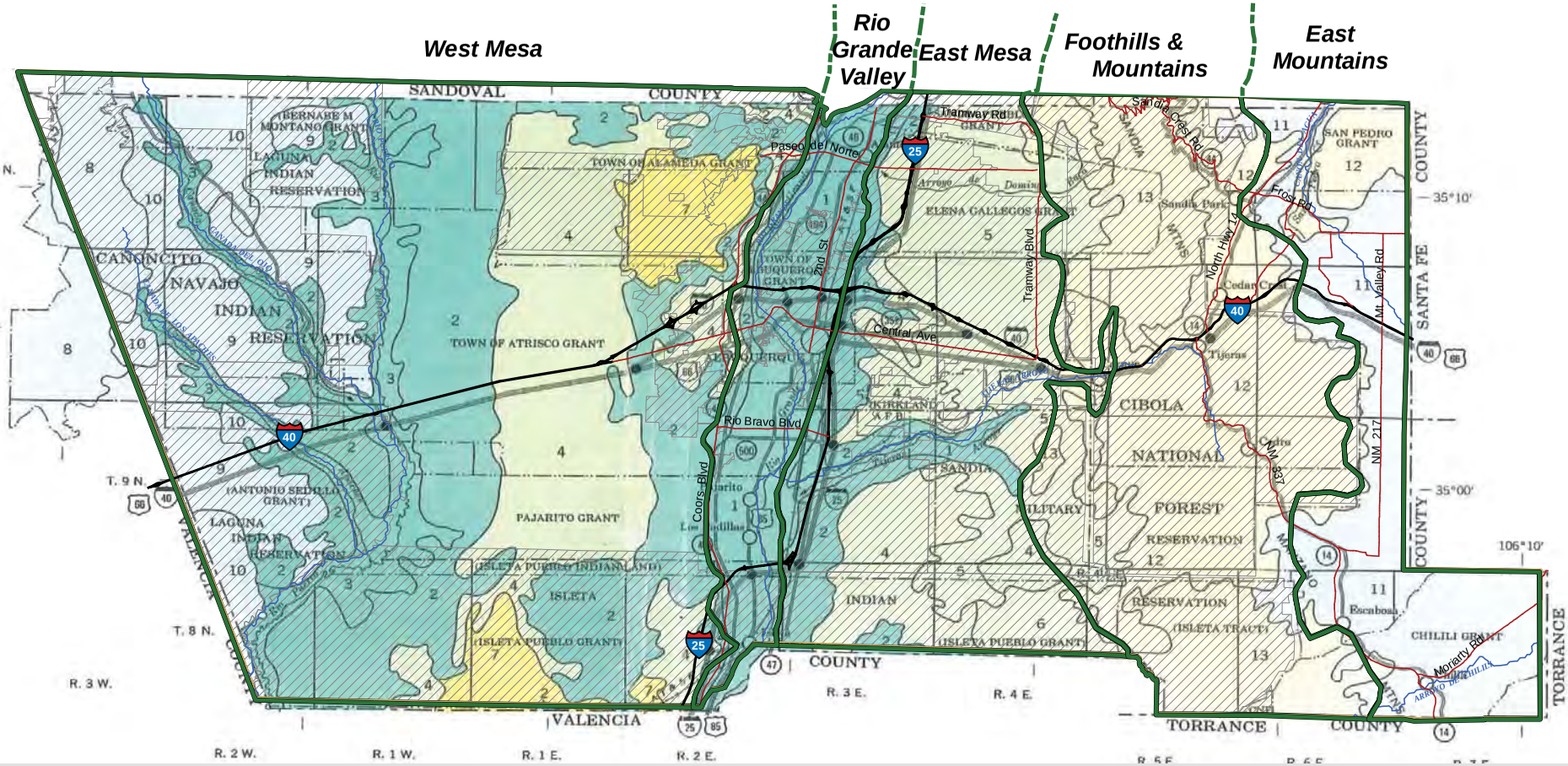

Map 2 produced by the Natural Resources Conservation Service, shows the major soils in the areas as illustrated by the different colors. Average annual precipitation as presented by: (Precipitation: 'precip_a_nm.shp', New Mexico Resource GIS Program, University of New Mexico, originator: Chris Daly of Oregon State University and George Taylor of the Oregon Climate Service at Oregon State University, http://rgisedac.unm.edu/climate/nmprecipshp.zip; 1998) is depicted on Map 3.Vegetation commonly found in the five Bioregions is shown in Map 4, this information came from (Vegetation: 'veg0001.shp', New Mexico Resource GIS Program, University of New Mexico, http://rgisedac.unm.edu/vegetaion/veg1shp.zip; 1997).

Map 2. Bernalillo County Soils

SOIL ASSOCIATIONS*

DEEP SOILS ON FLOOD PLAINS AND DISSECTED TERRACES

1. Gila-Vinton-Brazito association; Level or nearly level, well drained loamy soils mainly on the flood plain along the Rio Grande
2. Bluepoint-Kokan association: Nearly level to steep, somewhat excessively drained or excessively drained sandy and gravelly soils on dissected terraces and alluvial fans
3. Hantz-Gila association: Level or nearly level, well drained loamy soils mainly on the flood plain along the Rio Puerco

DEEP SOILS ON ALLUVIAL FANS, MESAS, AND PIEDMONTS

4. Madurez-Wink association: Level to moderately sloping, well drained loamy soils on piedmonts
5. Tijeras-Embudo association: Level to moderately sloping, well drained loamy and gravelly soils on alluvial fans
6. Latene-Nickel association: Nearly level to moderately steep, well drained loamy and gravelly soils on mesas and fans

MODERATELY DEEP OR SHALLOW SOILS ON BASALT FLOWS

7. Alameda-Akela association: Level to gently rolling, well drained loamy and cobbly soils

VERY SHALLOW TO DEEP SOILS oIN UPLANDS

8. Penistaja-Travessilla-Bond association: Deep to very shallow, nearly level to strongly sloping, well drained loamy soils over sandstone
9. Penistaja-Otero association: Deep, nearly level to moderately sloping, well drained loamy soils underlain in places by sandstone
10. Shingle-Kim association: Deep to very shallow, level to gently rolling, well drained loamy soils over shale and sandstone
11. Silver-Witt-Laporte association: Deep to very shallow, level to moderately steep, well drained loamy soils underlain in places by limestone

SHALLOW TO DEEP SOILS ON MOUNTAINS AND FOOT SLOPES

12. Seis-Orthids association: Shallow or moderately deep, level to very steep, well drained, very cobbly, stony, and very stony loamy soils
13. Kolob-Rock outcrop association: Deep, moderately steep to very steep, well drained loamy and stony soils and Rock outcrop

Terms for texture in the titles of associations refer to the texture of the surface layer of the major soils in the associations.

Legend

- Bioregion Boundary
- Non - County Lands

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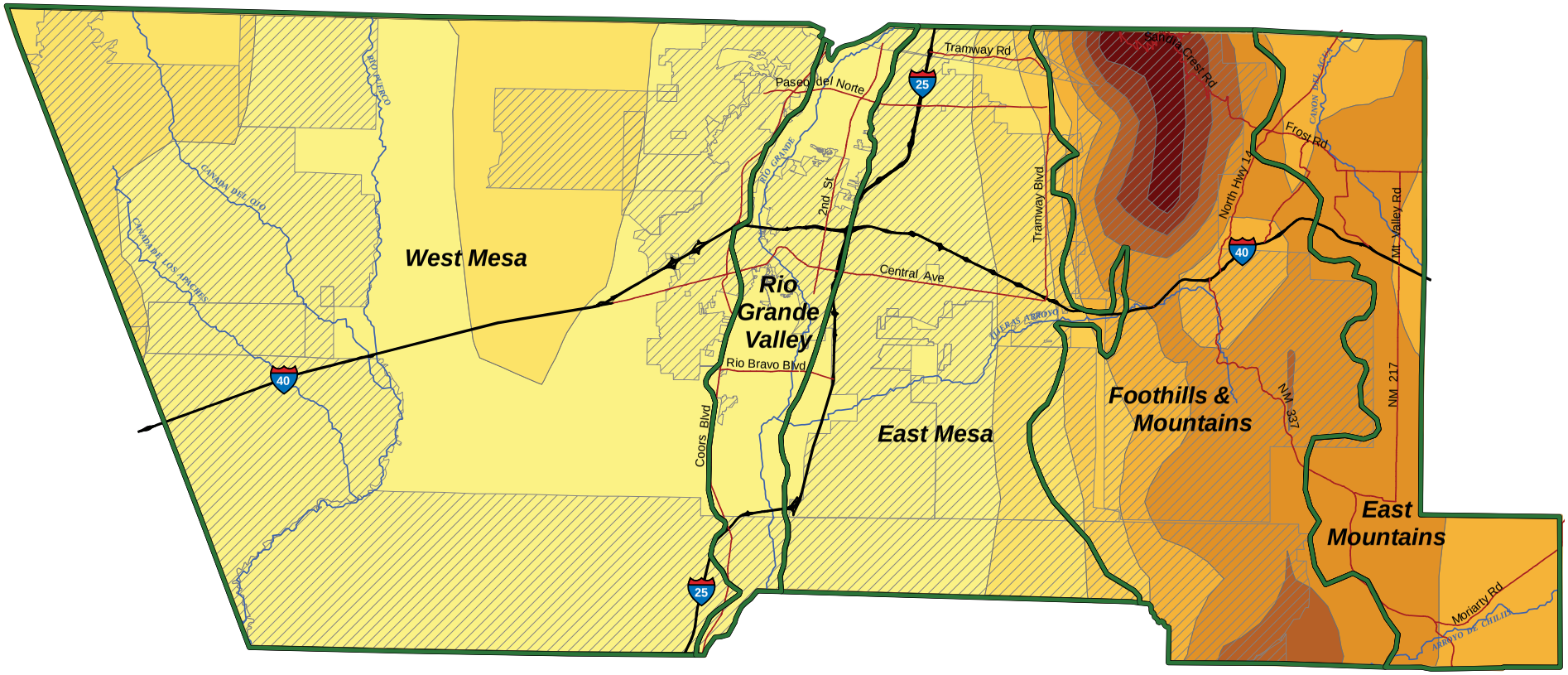

Map 2 produced by the Natural Resources Conservation Service, shows the major soils in the areas as illustrated by the different colors. Average annual precipitation as presented by: (Precipitation: 'precip_a_nm.shp', New Mexico Resource GIS Program, University of New Mexico, originator: Chris Daly of Oregon State University and George Taylor of the Oregon Climate Service at Oregon State University, http://rgisedac.unm.edu/climate/nmprecipshp.zip; 1998) is depicted on Map 3. Vegetation commonly found in the five Bioregions is shown in Map 4, this information came from (Vegetation: 'veg0001.shp', New Mexico Resource GIS Program, University of New Mexico, http://rgisedac.unm.edu/vegetaion/veg1shp.zip; 1997).

Map 3. Bernalillo County Precipitation with Bioregions

Legend

- Bioregion Boundary
- Non - County Lands
- Less than 9 inches
- 9 - 11 inches
- 11 - 13 inches
- 13 - 15 inches
- 15 - 17 inches
- 17 - 19 inches
- 19 - 21 inches
- 21 - 23 inches

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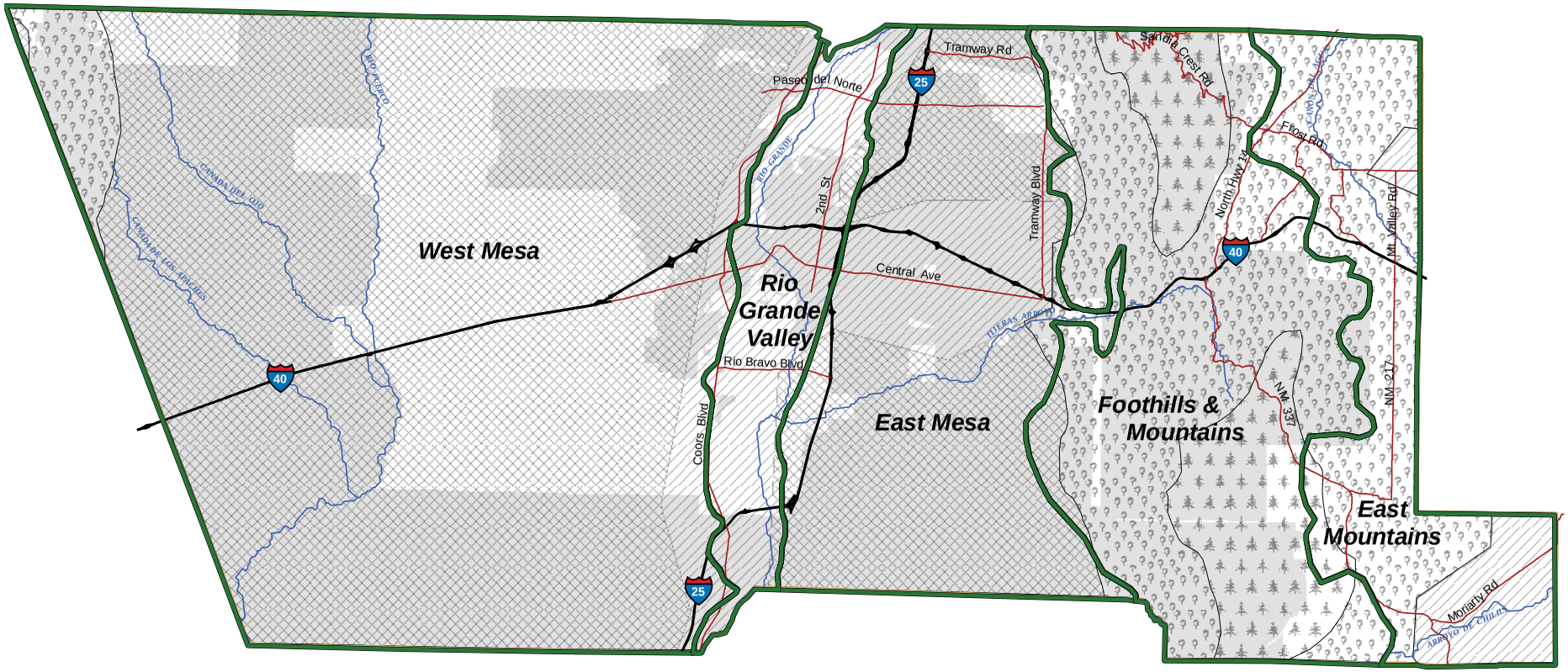

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Map 4. Bernalillo County Vegetation Map with Bioregions

Legend

- Bioregion Boundary
- Non - County Lands
- Montane or Sub-Alpine Coniferous Forest
- Urban, Farmland or Open Water
- Coniferous and Mixed Woodland / Montane Scrub / Juniper Savanna
- Desert Grassland / Great Basin Desert Scrub / Plains-Mesa Sand Scrub

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D. Glossary

100-YEAR DESIGN STORM. That storm whose precipitation within a six-hour period and resulting runoff has a one percent chance of being equaled or exceeded in any given year. A special condition may require/allow use of storms of longer duration.

ALBUQUERQUE BERNALILLO COUNTY WATER UTILITY AUTHORITY. (ABCWUA). The Albuquerque Bernalillo County Water Utility Authority or its authorized agent. It includes the water and wastewater facilities and all operations and management of such facilities necessary to provide water and wastewater service.

AMAFCA. The Albuquerque Metropolitan Arroyo Flood Control Authority.

ATHLETIC FIELD. Turf area which is used to hold athletic events or practices. Parks that have substantial areas used for athletic events or practices will be considered Athletic Fields.

BMP. Best management practice. Best management practices are schedules of activities, prohibitions or practices, maintenance procedures and other management practices to prevent or reduce the pollution of waters of the United States. BMPs also include treatment requirements, operating procedures, and practices to control runoff, spillage or leaks, sludge or waste disposal or drainage from raw material storage. With regard to construction these practices may include structural devices or nonstructural practices that are designed to prevent pollutants from entering water or to direct the flow of water.

BUBBLERS. Irrigation heads which deliver water directly to the soil adjacent to the heads.

CHANNEL STABILITY. A condition in which a channel neither degrades to the degree that structures, utilities or private property are endangered, nor aggrades to the degree that flow capacity is significantly diminished as a result of one or more storm runoff events or moves laterally to the degree that adjacent property is endangered.

CHANNEL. Any arroyo, stream, swale, ditch, diversion or watercourse that conveys storm runoff, including manmade facilities.

CITY. The City of Albuquerque.

COMPREHENSIVE PLAN. The Albuquerque/Bernalillo County Comprehensive Plan and amendments thereto.

CONCEPTUAL GRADING AND DRAINAGE PLAN. A plan prepared in graphical format showing existing and proposed grading, drainage, control, flood control and erosion control information in sufficient detail to determine project feasibility.

COUNTY ENGINEER. The engineering manager of the engineering division of the County Public Works division or his designee.

DESIGN STORM. A storm which deposits a stated amount of precipitation within a stated period over a defined area and which is used in calculating storm runoff and in designing drainage control, flood control and erosion control measures.

DETENTION POND. (see also water catchment basin and retention pond). Refers to a depressed area or basin that has been constructed for the purpose of holding stormwater on a site for a period of time and then releasing it into a conveyance system to where it can be used or returned to the river. The length of time and size of the basin is subject to regulations set forth by the Office of the State Engineer and the Department of Environmental Health.

DEVELOPED LAND. Any lot or parcel of land occupied by any structure intended for human occupation, including structures intended for commercial enterprise.

DEVELOPER. Any individual, estate, trust, receiver, cooperative association, club, corporation, company, firm, partnership, joint venture, syndicate or other entity engaging in the platting, subdivision, filling, grading, excavating or construction of structures or facilities.

DOWNSTREAM CAPACITY. The ability of downstream major facilities to accept and safely convey runoff generated upstream from the 100-year design storm.

DRAINAGE COVENANT. A legal document executed between a real property owner and the county and, in general, identifies, addresses and defines a drainage facility or facilities, maintenance, county's right of entry, demand for removal or repair, failure to perform by owner and emergency work by county, liability of county, indemnification, cancellation of agreement and release of covenant, assessments, notification, term, binding of property, changes and severability. The drainage covenant shall be in a form provided by the county.

DRAINAGE MAINTENANCE. The cleaning, shaping, grading, repair and minor replacement of drainage, flood control and erosion control facilities, but not including the cost of power consumed in the normal operation of pump stations.

DRAINAGE MANAGEMENT OR TREATMENT. The treatment and/or management of surface runoff from all storms up to and including a ten-year design storm.

DRAINAGE MANAGEMENT PLAN. A plan prepared and adopted by the county, city or AMAFCA which details the drainage controls required within a particular watershed, arroyo corridor or other designated drainage district. The drainage management plan shall comply with an arroyo corridor plan if one has been adopted.

DRAINAGE PLAN. A short, detailed plan prepared in graphical format with or on a detailed grading plan addressing onsite and off-site drainage control, flood control and erosion control issues for lots or parcels of less than five acres.

DRAINAGE REPORT. A comprehensive analysis of the drainage; flood control and erosion control constraints on and impact resulting from a proposed platting, development or construction project.

DRAINAGE RIGHT-OF-WAY. A public right-of-way acquired whether in fee or in easement, by the city, county, AMAFCA, the MRGCD, or the state for the primary purpose of handling storm drainage.

DRAINAGE. Storm drainage.

DRIP IRRIGATION. Low pressure, low volume irrigation applied slowly, near or at ground level to minimize runoff and loss to evaporation.

DROUGHT STATUS. Level of drought as defined by the New Mexico Drought Monitoring Committee. Four drought levels include; Drought Advisory, Drought Watch, Drought Warning, and Drought Emergency.
(1) Drought Advisory
(2) Drought Watch
(3) Drought Warning
(4) Drought Emergency

DROUGHT. An extended period of low precipitation in an area which occurs in sufficient length or magnitude to cause water shortages and/or crop damage.

ENERGY STAR. A United States government-backed program that provides an energy performance rating system for household appliances. Appliances with the Energy Star label attached have met energy efficiency guidelines set by the United States Environmental Protection Agency and the United States Department of Energy.

EPA. United States Environmental Protection Agency.

EROSION CONTROL PLAN. A plan for the mitigation of damages due to soil erosion and to deposition.

EROSION CONTROL. Treatment measures for the prevention of damages due to soil movement and to deposition.

FLOOD CONTROL. The treatment measures necessary to protect life and property from the 100-year design storm runoff.

FLOOD HAZARD AREA. An area subject to inundation from the 100-year design storm runoff.

FLOODWAY. The channel of a river, arroyo or other watercourse and adjacent land areas that must be reserved in order to safely discharge the 100-year design storm runoff.

FUGITIVE WATER. The flow or release of any water from any activity or process onto adjacent property or the public right-of-way. Fugitive water does not include runoff from natural precipitation.

FULLY DEVELOPED WATERSHED. A hydrologic condition in which all areas upstream and downstream of a point in question are assumed completely developed, including any undeveloped areas which are assumed to be developed in accordance with mid-range development densities as established by the comprehensive plan, appropriate area plans or sector plans, adopted facilities master plans and the hydraulic and hydrologic standards established by this article.

GRADING PLAN. A plan describing the existing topography and proposed grading, including retaining wall locations and details, interfaces with adjacent properties, streets, alleys and channels, referenced to mean sea level (1929 or 1988 datum) such as city benchmark or NMSHTD benchmark, and showing sufficient contours, spot elevations and cross sections to allow a clear understanding by reviewers, contractors and inspectors.

GRAYWATER. Wastewater from bathroom sinks, bathtubs, showers , and laundry which is not used to wash diapers or other similarly soiled or infectious garments.

HAND WATERING. The application of water for irrigation purposes through a hand held hose, including hoses moved into position by hand and left to flow freely or through a shut-off nozzle.

HIGH EFFICIENCY TOILET. A toilet fixture that flushes a maximum volume of 1.3 gallons (4.9 Liters) per flush or less and meets minimum performance standards from a list approved by Bernalillo County. High Efficiency Toilets may include dual-flush toilets. Dual Flush toilets must not exceed 1.1 gallons (4.2 Liters)per flush for liquids and 1.6 gallons (6.0 Liters) per flush for solids.

HIGH-WATER-USE PLANTS. Plants that are classified as high-water-use on a list approved by Bernalillo County.

HIGH-WATER-USE TURF. Turf grass that is classified as high-water-use on a list approved by Bernalillo County.

INFILTRATION RATE. The amount of water absorbed by the soil per unit of time, usually expressed in inches per hour.

LANDSCAPE AREA. The entire parcel minus any undisturbed un-irrigated natural areas, building footprints, driveways, non-irrigated portions of parking lots, decks, patios or other non-porous areas.

LOW IMPACT DEVELOPMENT. A planning and design approach to development that emphasizes the integration of site design and planning techniques that conserve natural systems and hydrologic functions with a goal of maintaining the natural hydrologic characteristics of developing watersheds. Many of the approaches involve individual site design for stormwater management to prevent runoff where it can be used to supplement landscape irrigation requirements, improve water quality and recharge groundwater supplies.

LOW-WATER-USE PLANTS. Plants that are classified as low-water-use on a list approved by Bernalillo County.

MAJOR ARROYO. Any channel whose watershed exceeds 320 acres in a 100-year design storm, whether such watershed is in its natural or unaltered state or has been altered by development, runoff diversions or detention facilities.

MAJOR FACILITY. Any facility, including a street or alley, which would collect, divert or convey a peak discharge of more than 50 cubic feet per second (50 cfs) or store two acre-feet or more of runoff in the event of a 100-year design storm.

MASTER PLANNED FACILITY. Any drainage control, flood control or erosion control facility recommended in the Albuquerque Master Drainage Plan (1981), amendments thereto, or any voter approved general obligation bond financed drainage control, flood control or erosion control facility.

MEDIUM-WATER-USE PLANTS. Plants that are classified as medium-water-use on a list approved by Bernalillo County.

MINOR FACILITY. Any facility which would collect, divert or convey a peak discharge of 50 cubic feet per second (50 cfs) or less, or store less than two acre-feet of runoff in the event of the 100-year design storm.

MRGCD. The Middle Rio Grande Conservancy District.

MULTIPLE USE FACILITY. A drainage control, flood control or erosion control facility in which other secondary uses are planned or allowed including, but not limited to, recreation, open space, transportation and utility location.

NEW DEVELOPMENT. Any subdivision application or building permit issued for new construction. New Development does not include additions to existing single family residential buildings. A stand-alone structure with water and waste water service is considered New Development.

NEWLY SEEDED. Seed planted in a prepared area with the intent of establishing a turf area.

NPDES PHASE II. National Pollution Discharge Elimination System, Phase II.

NUISANCE WATERS. Those waters leaving a site and entering a public street, which do not result from precipitation, such as landscape overwatering or car washing.

PARK. An area of land set aside for public use including permanently maintained cemeteries.

PROJECT DESIGN SWALE (DRAINAGE DITCH, BORROW DITCH OR BAR DITCH). A swale or ditch parallel to the driving surface to convey stormwater runoff from the street right-of-way.

PRUDENT LINE (EROSION LIMIT LINE). That line which will not be disturbed by erosion, scour or meandering of a natural (unlined) arroyo, channel or watercourse over a period of 30 years and which will not be disturbed by a 100-year storm occurring at any time during the 30-year period. The prudent line shall be so located as to include all freeboard required to contain the wave action of the 100-year design storm.

PUBLIC RIGHT-OF-WAY. The area of land acquired or obtained by the city, county, or state primarily for the use of the public for the movement of people, goods, vehicles, or stormwater. For the purposes of this ordinance the public right-of-way shall include sidewalks, curbs, streets, and stormwater drainage inlets.

RESPONSIBLE PARTY. The owner, tenant, manager, supervisor, or person in charge of the property, facility, or operation during the period of time the violation(s) is observed.

RESTRICTED PLANTS. Plants that are classified as restricted on a list approved by Bernalillo County.

RETENTION POND. (See also water catchment basin and detention pond). Refers to a depressed area or basin that has been constructed for the purpose of holding stormwater on a site until it infiltrates. The length of time and size of the basin is subject to regulations set forth by the NM Office of the State Engineer and the NM Department of Environmental Health.

RUNOFF. Precipitation, snowmelt, or irrigation water that is not absorbed by the soil and moves across ground surfaces.

SPRAY IRRIGATION. The application of water to landscaping by means of a device that projects water through the air in the form of small particles or droplets.

STORM DRAINAGE SYSTEM. Arroyos, storm drains, roadways, culverts, bar ditches, ponds, pump stations, dams, detention ponds, retention ponds, inlets and appurtenant structures and other facilities which convey stormwater.

STORMWATER POLLUTION PREVENTION PLAN. The information and program required by EPA, NMED and/or the county for construction phase stormwater management.

STORMWATER QUALITY CONTROL. The treatment methods necessary to protect and enhance the quality of stormwater.

STORMWATER. Stormwater runoff, which is flow on the surface or in the subsurface that percolates from the ground resulting from precipitation.

TEMPORARY DRAINAGE FACILITY. A nonpermanent drainage control, flood control or erosion control facility constructed as part of a phased project or to serve until such time that a permanent facility is in place including, but not limited to, desilting ponds, berms, diversions, channels, detention ponds, retention ponds, bank protection and channel stabilization measures.

TEN-YEAR DESIGN STORM. That storm whose precipitation within a six-hour period and resulting runoff has a ten percent chance of being equaled or exceeded in any given year. A special condition may require/allow use of storms of longer duration.

URBANIZED AREA. That area identified in the most current US Census as having a population in excess of 50,000 persons, or a density of 1,000 persons per acre or greater.

WATER UTILITY AUTHORITY CUSTOMER. Any person, association, corporation or other entity receiving Albuquerque Bernalillo County Water Utility Authority water service.

WATER WASTE. The nonbeneficial use of water. Nonbeneficial uses include but are not restricted to:

1. Landscape irrigation water applied in such a manner, rate and/or quantity that it causes runoff onto adjacent property or public right-of-way;
2. Landscape irrigation water which leaves a sprinkler, sprinkler system, or other application device in such a manner or direction as to spray onto adjacent property or public right-of-way;
3. Water provided through the Middle Rio Grande Conservancy District or community acequia systems for irrigation purposes applied in such a manner, rate and/or quantity that it overflows the area being watered and runs onto adjacent property or public right-of-way.

WATERCOURSE. Any river, creek, arroyo, canyon, draw or wash or any other channel having definite banks and bed with visible evidence of the occasional flow of water.

ZONING ADMINISTRATOR. The official designated to enforce the County Comprehensive Zoning Ordinance, as may be amended from time to time.

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II. Water Conservation Standards and Guidelines for Single-Family Residential Land Uses

The water conservation information and methods in this chapter apply to a single-family lot with one dwelling unit. Corresponding zoning categories are A-1 Rural Agricultural Zone, A-2 Rural Agricultural Zone, R-1 Single-Family Residential Zone, and special use permits for similar uses. The descriptions that follow mention some of the requirements for each zone. In most cases a grading & drainage plan prepared by a New Mexico licensed engineer is required. For a full listing see the Bernalillo County Zoning Code (Appendix A of the Bernalillo County Code of Ordinances).

Corresponding Zones:

A-1. Rural Agricultural Zone - Restricted to one single-family dwelling or HUD Zone Code II manufactured home per lot of record.

a. Minimum lot area is one acre with a minimum width of 150 feet.
b. If lot is located in Residential Area 2 of the Southwest Area Plan, minimum lot area is one acre if municipal water and sewer services are available and one and one-fourth acres if they are not.

A-2 Rural Agricultural Zone - Restricted to one single-family dwelling, HUD Zone Code II manufactured home or a mobile home allowed in the area designated in the East Mountain Area Plan per two acre-lot.

a. Minimum width is 150 feet.

R-1 Single Family Residential Zone - Restricted to one single-family home on a lot not less than three quarters of an acre in size. Where community water and sewer services are made available, the lot size may be reduced according to development densities in the Albuquerque/Bernalillo County Comprehensive Plan.

a. Minimum lot width of 60 feet. With community water and sewer services, lot size may be decreased to 8,000 square feet if located in the Developing, Established or Central Urban Areas of the Comprehensive Plan and 14,520 feet if located in the Semi-Urban Area.

A. Introduction

A typical US household uses 5,000 gallons of water per week for landscape irrigation based on a 10,000 square foot lot. Landscape irrigation accounts for 40% of the potable water used by customers of the Albuquerque Bernalillo County Water Utility Authority (ABCWUA). As part of the County's water conservation efforts, Bernalillo County has enacted a Water Conservation Ordinance that requires inclusion of water conservation measures for new residential development, additions and remodels. Employing water conservation measures can save billions of gallons of potable water. This chapter provides information and methods appropriate for water conservation on single-family residential lots.

Landscape Types

For the sake of simplicity, landscapes can be categorized as ornamental or functional. Ornamental landscapes exist mainly for aesthetic value and can be formal or informal, elaborate or simple. Functional landscapes have a primary purpose other than aesthetics and include uses such as athletic fields, playgrounds and agriculture. A residential landscape may include both ornamental and functional landscapes for example, such as when vegetable gardens or fruit trees are present, or when the turf area includes a soccer net, putting green or volleyball court.

An additional method of classifying landscapes is by the design and the selection of plants. Using this method, the five landscape types described below are commonly found in Bernalillo County. This list is ordered from the lowest to highest water-use.

- **Natural or Reclaimed Landscape** - This landscape type emphasizes protection of the native landscape and reclamation or restoration of disturbed areas with native or adapted plants. Re-contouring the land and correcting a disrupted watershed are required, and construction techniques and products specifically developed for restoration are commonly used. Mulches are generally applied only in connection with reseeding. Temporary irrigation may be used or plantings may rely solely on natural precipitation for sustenance.

- **Precipitation-Supported Landscape** - Also known as precip, precipitation-only, or rainwater supported, this landscape is extremely water conservative and uses native and adapted xeric plants, usually mulched with gravel or bark chips. Reclamation areas may also be included in this landscape type. It differs from the xeric landscape type in that it relies exclusively on natural precipitation to sustain the plants after they are established. Prior to establishment either natural precipitation or temporary irrigation may be utilized. If used, the irrigation system may be a mix of high efficiency spray and bubblers and/or drip irrigation.

- **Xeric Landscape** - The word "xeric" is derived from the Greek word "xeros", or dry, and a xeric landscape or "xeriscape" is a water-efficient, low maintenance landscape that is appropriate to the natural environment. Xeriscaping refers to using plants that have low water needs, but also to a site-specific approach to the landscaping plan. Xeriscapes typically use native or adapted drought-tolerant plants in beds mulched with gravel or bark chips but can also include areas of low-water-use turf and wildflowers. This landscape type is typically irrigated with bubblers, drip irrigation systems and high efficiency spray and can significantly reduce water use compared to a traditional high-water-use landscape.

- **Traditional/Xeric Mix Landscape** - This landscape mixes traditional high-water-use landscape with xeric planting areas. In this type of landscape the higher water uses such as grass, trees and shrub beds are typically concentrated in heavy use areas, while xeric landscape areas are located along perimeters and less used areas of the residence. It is typically irrigated with a mix of high efficiency spray and bubblers as well as drip irrigation. Shifting all or part of a landscape that consists of high-water-use plantings or turf areas to traditional/xeric or xeric landscape can reduce water use significantly, generally by one third to one half.

- **Agricultural Landscape Uses** - This landscape type is focused on agricultural or food-producing uses and can be part of any of the other types of landscapes. Agricultural landscapes normally require irrigation, but depending on plant or crop type, irrigation could be precipitation-only. Bubblers, drip systems or flood irrigation with conservancy water are commonly used for agricultural landscapes.

Shifting from a landscape that consists of high-water-use turf areas and high-to-moderate water use shrubs and trees to a xeric landscape, or a combination of traditional and xeric landscape can reduce consumptive water use by one third to one half. An integrated site design links the site's water, energy and aesthetic requirements with its available resources such as runoff, shade and vegetation. An integrated site design with xeriscaping not only saves water, but also respects the environment and region. Regardless of the style or level of complexity, the following basic steps apply when developing an integrated design to achieve water conservation.

Benefits of Xeric Landscapes

- Water savings: Using drought tolerant plants can reduce water consumption by 50% or more.
- Reduced maintenance: Reducing the amount of high-water-use plants and turf areas reduces the amount of time and money spent on fertilizing and mowing.
- Habitat creation: Provides a source of food and other necessities for birds, insects and animals.

B. Recommended Steps for Water-Conserving Landscape Design for Single-Family Residential Uses

Integrated site design uses a multi-step approach to create a water-conserving site plan that matches requirements such as aesthetics and water conservation with the site's resources, such as runoff and existing topographic features. Integrated site design goals include retaining rainwater on-site, minimizing disturbance of existing vegetation and soils, retaining existing grading and topographic features to the extent possible, and taking advantage of wind and solar patterns to increase heating and cooling efficiency. The process steps for developing an integrated site design are listed below.

1. **Analyze the site**. A detailed site analysis is the foundation for an integrated site design. The first step is creating a base plan of the lot. Whether you are starting with a completely undeveloped or a partially developed site, draw the entire site and all the existing elements on it to scale. A scale drawing is a drawing that represents a real object, with the scale of the drawing being the ratio of the size of the drawing to the actual size of the object. In other words, each element in the drawing has the same relative proportions as it does in reality. The smaller the ratio, the larger the area you can represent on a single sheet of paper.

   Mark locations, sizes, types or species, and health of existing vegetation to determine which should be preserved during development. It is also helpful to note views to be preserved or screened, as well as adjacent property uses such as common areas and roads.

   The plan should note site characteristics such as topography (the surface features of the site) including high points such as hills, peaks, ridges, and mesas; low points such as valleys or basins, and slopes. Important views, both good and bad, and the locations of existing vegetation, utilities and structures should also be noted.

   Look at and note surface water drainage flow patterns such as where runoff from roofs and other impervious surfaces enters the landscape and where it collects, such as in natural depressions or ponding areas, as these areas present water-harvesting opportunities. Observing the property during or immediately following a storm can be helpful in assessing stormwater flows. Show the direction of the water flow with arrows. Note any existing areas that would collect and convey stormwater, such as hard surfaces (paving, bare earth and roof surfaces) and where the water collected would flow. Your site is part of the larger drainage system of its watershed, and it is important to note how drainage patterns at adjacent sites work relative to your site. Check with your governing agency to see if there is an existing Grading & Drainage Plan that might restrict what you can do on your property. See additional information in the "Key Concepts of Water-Conserving Landscape Design"on page 31.

   Places showing evidence of erosion should also be noted and considered when designing the layout of the development in order to mitigate the erosion. Erosion is a sign that water is moving too fast to infiltrate.

   Exposure to wind and sun should also be evaluated as both can increase water loss through higher evaporation and evapotranspiration rates. Mark the property orientation (north arrow) to help determine the amount of sun and shad each area receives throughout the day. Map the sunlight's path over the area as well as seasonal solar changes that might influences plant placement. Note any microclimate area created by protection from or higher exposure to sunlight or wind. Plants can be positioned to take advantage of the shade and protection provided by buildings and other site structures, reducing irrigation needs.

   Think about the level of maintenance that will be supported as this will influence site landscape design choices.

2. **Assess the site's soil.** Soils and the underlying geology greatly influence infiltration and runoff rates. Variations in them should be considered when determining where to place built structures, hardened and non-hardened areas, and water-harvesting and infiltration devices. Refer to the soil descriptions for the relevant biozone listed in Chapter I. In general, Bernalillo County soils are deficient in organic matter and tend to be alkaline (moderately high pH). West Mesa Biozone soils are predominantly sandy, whereas the soils in the Rio Grande Valley Biozone have high clay content. Soils in the East Mesa, Foothills and Mountain and East Mountains are gravelly with some loam and silt. Soil maps for some areas can be downloaded from the National Resource Conservation Service website (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm).

Soil testing can also help to assess the type and health of the soil. Soil test kits are available at County Cooperative Extension Offices and most garden centers. Soil testing kits come with instructions, and the steps are basically similar: 1) Remove the top layer of debris or turf, 2) With a clean small narrow shovel or auger, take 4 or 5 samples of the soil by digging 6" to 8" deep at different locations within the area you are testing, 3) Remove a 1/2-inch slice from the side of each hole and place it in a clean bucket, 4) Mix the soil sample together thoroughly, spread the mixed soil out on a newspaper to dry and collect a pint for testing, 5) Send to the address on the kit or follow the kit self-test instructions. Soil should not be wet as wet soil can give false readings; however, soil should also not be too dry to dig into and take a slice. A good soil assessment is necessary to determine whether amendments are needed. Most tests include analysis of soil pH (percent hydrogen ion; an indicator of soil acid-base level), the amount of organic matter, the soil's drainage potential and amounts of basic nutrients present such as nitrogen (N), phosphorous (P) and potassium (K). Once basic information about the soil is known, decisions about how to prepare the soil for planting can be made. Choosing native or adapted plants that prefer the existing soil conditions and local climate can eliminate the need to amend the soil and generally achieves a higher level of water efficiency. Soil amendments can be added to address deficiencies or issues such as compacted soils. For example, the addition of organic matter such as composts, peat, and manure can loosen compacted soil, lower the pH, and provide food for beneficial soil microorganisms. Also available are products that increase the water-holding capacity of soil such as super-absorbents, which are commonly polymers of various origins, mineral-based products like Zeolite, or organic by-products from manufacturing such as coir. (See "Soil and Soil Amendments" on page 72.)

Simple Soil Type Testing

- Soak a patch of soil, then allow it to dry out for 24 hrs. Scoop up a handful and firmly squeeze it. If a tight, slippery ball forms the soil is probably high in clay. If the soil crumbles and feels gritty when you open your hand it is sandy soil. If it holds a loose ball but crumbles slightly the soil is a loam combination.

3. **Plan areas for different functions and uses.** Consider which areas are public and which are private, which are for active play, passive enjoyment, entertaining, outdoor living and service areas. Other potential functions include water conservation, stormwater management and harvesting, climate moderation to protect your home from summer sun or winter winds, and privacy and security. Decisions should be guided by the amount of water and maintenance required by each. It is important to spend some time on the site to understand how to best take advantage of what the site has to offer.

Place a piece of tracing paper on top of the base plan created in Step 1 and sketch out a "bubble" diagram that outlines all the uses you would like to include in your landscape design. Organize the desired uses by drawing freeform bubbles that show the rough size and shape of the area for that use, keeping scale and proportion in mind. Consider the relationships and circulation among the various use areas and existing features. Refine the diagram until you achieve a level that depicts the best division of uses, spaces and circulation.

4. **Use the concept of hydrozoning when designing the landscape.** Hydrozoning, or designing the landscape to group together plants with similar water requirements, provides the foundation for an efficient irrigation system. Each hydrozone contains plants that share similar water needs such as High, Moderate, Low and Very Low. Typically three general hydrozones are used; the highest water use or greatest density plantings are placed closer to the building(s) in areas that are highly visible or most heavily used. These areas may also include turf grass. These higher water-use areas require supplemental irrigation and are sometimes called "oasis" zones. Shady areas and places where water tends to collect can also be appropriate for higher water-use plantings.

Farther away from buildings, or in areas where the level of human use is lower, the landscape can be less dense and incorporate plants with intermediate to low water requirements. The water needs of this "transition" zone will therefore be lower than that of the "oasis" zone.

The outermost zone is generally the lowest water use or "arid" zone and has the lowest density of plantings, often composed exclusively of drought tolerant or native plant material laid out in a more naturalistic planting scheme. Larger lots may have multiple zones, while smaller lots may have smaller or fewer zones. (See Figure 7 and Figure 8.)

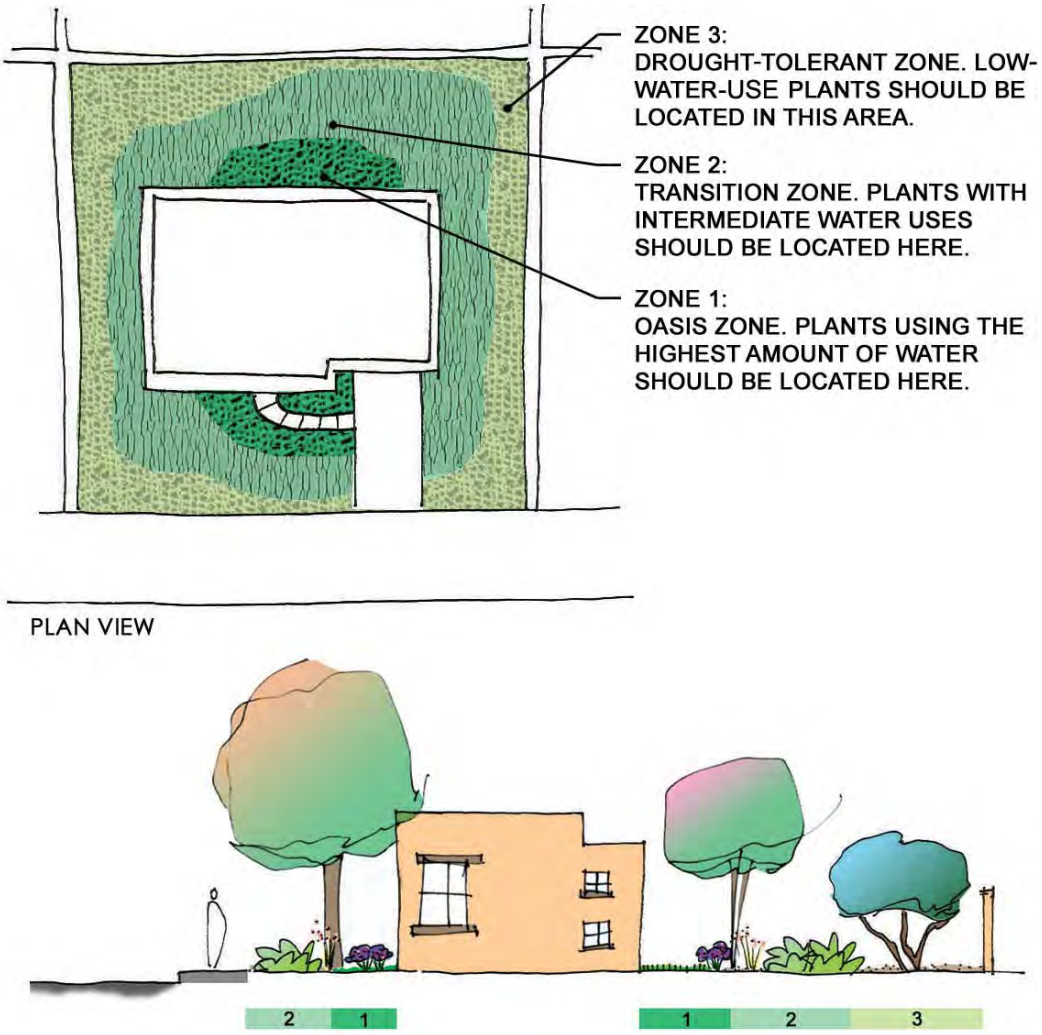


Figure 7. Hydrozones for A-1 Landscape

An efficient irrigation system is critical for water-conserving landscapes. An irrigation system based on hydrozones can significantly reduce landscape water use by providing irrigation system zones that match hydrozone plant group water requirements and allowing the groups to be watered separately.

In order to achieve maximum water efficiency, the appropriate type of irrigation must be used for each hydrozone. Lower-water-use plant groups may be drip irrigated, whereas higher-water-use turf areas may use sprinklers. The irrigation system should be designed to apply water efficiently, have the flexibility to change with needs of the plants, be easily operated by the owner or maintenance crew and be properly installed. For more information regarding irrigation systems and strategies refer to the "Water-Conserving Irrigation" Section on page 74 in this document.

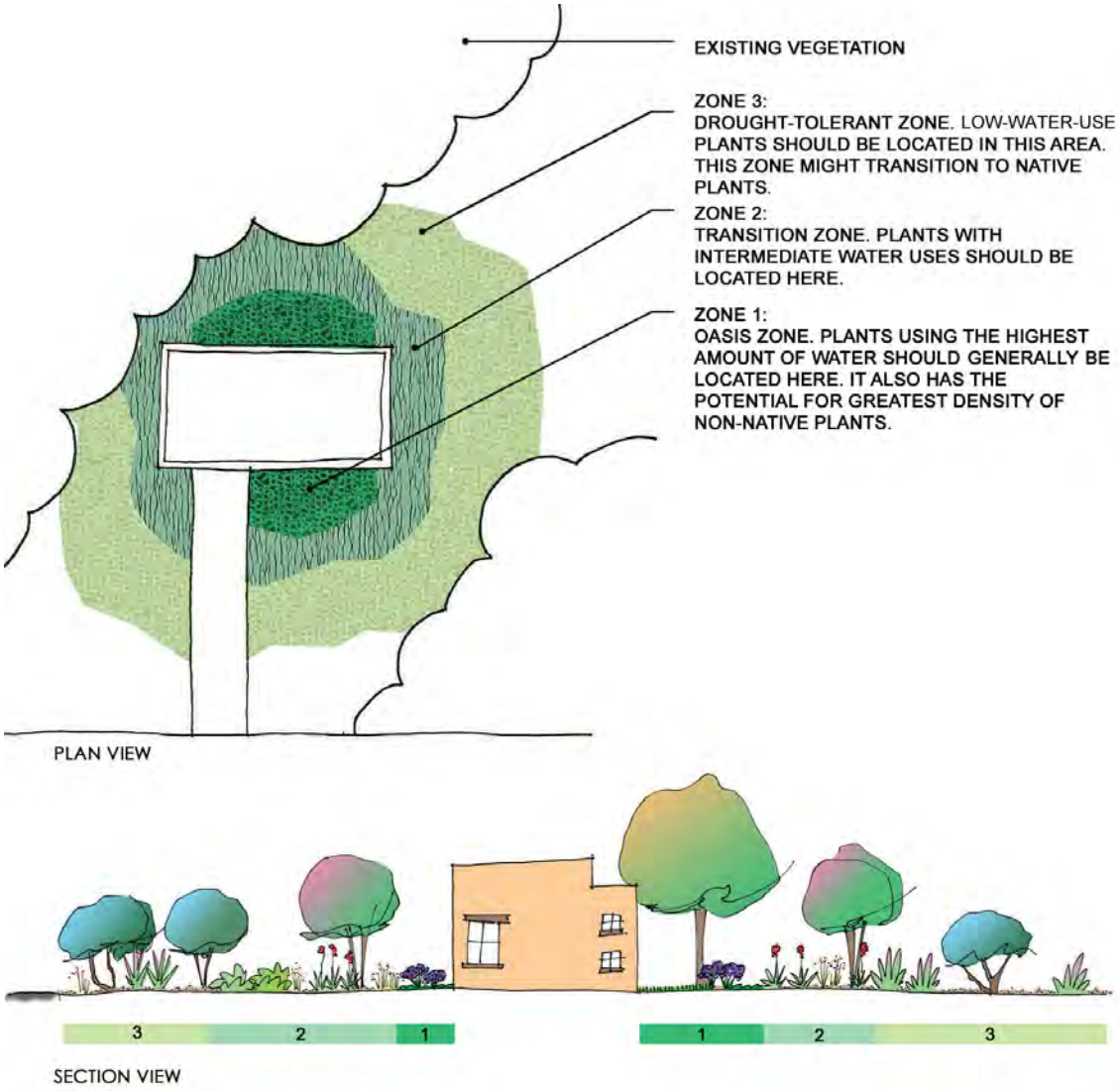


Figure 8. Hydrozones for R-1 Landscape

5. **Include Water-Harvesting Features.** Capturing rainwater that falls on the property and storing or diverting it to planted areas is another way to increase the water efficiency of your site. It can save thousands of gallons of potable water per year. Strive to design your site so that there will be no stormwater or irrigation runoff from your property. Information on a wide range of water-harvesting options is provided in the "Water-Conserving Landscape Devices and Best Management Practices" section of this chapter.

6. **Select Plants.** Considerations when selecting plants include function, water, sun and shade requirements, frost tolerance, maintenance needs and pollen potential, as well as aesthetic considerations like color, texture, and size. Selecting the proper plant and then placing it where it will thrive requires understanding both the average climatic conditions of the area, as well as microclimates created by particular features of the site and climate. Check the USDA cold hardiness zone for your specific area by consulting with the local Cooperative Extension Office books or on-line resources. Also useful is the Sunset climate zones map, available online and in the Sunset Western Garden Book, which provides information based on a 24-zone system that considers a number of climatic factors including length of growing season, timing and amount of rainfall, winter lows, summer highs, wind, and humidity.

   Microclimate conditions to consider include length and direction of sun exposure, reflected heat, wind exposure and frost. Selecting plants that prefer the soils and environmental conditions of the site will help to ensure that they are water-efficient and thrive once planted.

   Native plants are the most water-efficient and generally do not require fertilizers or soil amendments as they are adapted to local soils and climatic conditions. Non-native drought-tolerant or low-water-use plants can also be excellent options. There are many lush, colorful water-efficient plants to choose from. Nursery staff, on-line resources and reference books are good information sources to assist with plant selection.

   - Use the base plan created during the site analysis (Step one) to draw a to-scale diagram of the landscape area.
   - Using data gathered during site analysis, consider the amount and type of sun exposure for the areas to be planted and select plants that prefer those conditions, taking into account the impact of shading from trees and shrubs that have not yet reached maturity. Other factors that create microclimate impacts include reflected heat from walls or buildings, and northern exposures, which create increased cold and shade conditions. Plants are rated for their cold hardiness based on the USDA-designated zones discussed above. Group plants according to their water requirements.
   - Use the placement of plantings to mitigate extremes of heat, cold and wind. For more information see "Thermal Effects of Landscape" later in this Chapter.
   - Develop the planting plan to accommodate the mature plant size (both height and width) to avoid future maintenance issues such as overcrowding or blocked views. Keep in mind the need for clear views at roadway corners, property entries and other traffic entry and exit locations.
   - Consider other features that are important to you: color, fragrance, texture, different heights and blooming times and the type of wildlife you wish to attract (or discourage).
   - When selecting and purchasing plants use the botanical (Latin) name to ensure that you get the plant with the desired characteristics, as different plants can go by the same common name.

   The Albuquerque Bernalillo County Water Utility Authority (ABCWUA) has developed an extensive plant list that provides information on a wide range of plants appropriate for use in the county's various biozones, including their water requirements, mature size, light needs, pollen potential and landscape use. Copies of the plant list are available at local libraries, nurseries, home garden centers, and community centers as well as through the ABCWUA and Bernalillo County.

Limiting the size of turf areas and using lower water-use grasses will help to achieve a water-efficient landscape. In light of increasing pressure on potable water supplies and frequent droughts, more water-conservative options are becoming increasingly popular. A range of low-water-use, low maintenance turf grasses and ground covers that do not require constant fertilization are now available and present excellent alternatives to traditional high-water-use turf. Several types of turf grass that meet the criteria for low or moderate water-use plant material are listed in "Appendix C. Albuquerque Bernalillo County Water Authority Xeriscape Plant List 2010"

Lastly, install the plants themselves with water conservation in mind. Generally speaking plants, whether trees, shrubs, or ground covers should be installed at an elevation lower than the ambient land around them or with basins. This is done to ensure that irrigation that is applied to the plant will remain where it is needed at the plants roots. As the plant grows the basin will need to be graded to maintain its water holding capacity and potentially widened to accommodate the plants growing root system. In "Appendix K. Plant and Turf Grass Installation Details" we have included a range of diagrams showing how plants should be installed in Bernalillo County and the desert southwest for a reference.

Turfgrasses too should be planned for water conservation. They should be installed a low points on the site if possible to capture water from landscapes and drainage at higher elevations. Turfgrass areas should not be bermed for water conservation. Also, planting grasses on slopes should be avoided. When installing turfgrasses the finished grade should always about 1" lower than adjacent surfaces such as sidewalks, drivepads, mulches and other surfaces to allow for drainage. See "Appendix K. Plant and Turf Grass Installation Details" for details on installation.

7. **Create a master plan.** Use the information gathered in the steps above to create the new landscape design. You may decide to hire a professional to draw the plan for you (see "Hiring a Professional"), or you can develop the plan yourself. Regardless of which method you use, the plan will help you to create a water-efficient, functional landscape that can be developed in phases, if desired.

To create a landscape master plan, draw any new structural elements such as walkways or patios on a piece of tracing paper placed over the base plan. If the house has not yet been built you can increase the water efficiency of your site by placing it based on the principles outlined in the "Siting" section. Add water harvesting devices, then draw the plantings, using the plants' mature sizes and environmental needs to ensure correct placement and grouping them according to the hydrozone concept discussed previously. The irrigation system can then be designed as an overlay to the landscape master plan.

Developing a good plan before you install a new landscape will help to ensure that the landscape is functional and water-efficient as well as beautiful. If you have difficulty drawing the plan, you can mock up the landscape using objects to substitute for the actual plants and areas. For example, tall stakes can represent trees and garden hoses can mark the outline of planting beds and patios, pathways and other paving can be outlined with outdoor marker paint or even flour. This can be a good visual check of your plan and your plan spacing

8. **Use mulches.** Mulching is simply covering the soil. Mulches minimize evaporation of soil moisture by covering and cooling the soil, They also reduce weed growth and help to prevent soil erosion. Mulches are classified as organic or inorganic. Typical organic mulches are bark, wood chips, straw, leaves, hulls, compost, peat moss, pine needles, and grass clippings. These materials improve soil texture and fertility as they decompose. Organic mulches tend to float and may not be the best choice for water-harvesting areas. Inorganic mulches include crushed rock, stones, gravels, glass, and synthetic materials and generally deplete more slowly than organic mulches. Cobble, larger gravels and decorative rock help stabilize swales, spillways and berms, reducing erosion and evaporation. Mulching with either type increases infiltration by slowing water movement and absorption. It also slows evaporation of infiltrated moisture by covering and cooling the soil. Mulch should not be placed directly against trunks of shrubs and trees as it can cause rot or fungi. Both organic and inorganic mulches should be periodically replaced as they break down and deplete over time. Do not use black plastic or other impermeable coverings under mulches. Impermeable coverings prevent water and air from circulating into the soil and trap condensation, creating ideal conditions for mold, cockroaches and other pests. If black plastic is present and cannot be removed, poke holes through it around the full root zone area of plantings. If an underlay is desired, use landscape or filter fabric under mulch. This allows water and air to infiltrate while initially preventing weed growth. For additional information on mulch types and application see "Mulches" in the "Water-Conserving Devices and Best Management Practices" section of this chapter.

9. **Plan for and practice proper maintenance.** The amount of maintenance required depends upon plant selection, mulch type and factors related to features such as water-harvesting devices included in the landscape. Decide how much maintenance you are willing to support – either by doing it yourself or hiring a landscape service. Budget limitations should also be considered. New landscapes will generally have a higher number of weeds during the first three years following installation due to soil disturbance. Mulching will help to control weed germination levels, and removing weeds prior to setting seed will save on maintenance time in the following growing season. In general, a well-designed and constructed xeric landscape requires only minimal upkeep that includes regular inspection of irrigation and water-harvesting devices, litter clean-up, weed elimination, and timely pruning and mowing.

C. Key Concepts of Water-Conserving Landscape Design

The core concepts for designing a water-conserving landscape are:

1. Retain and infiltrate water as close to where it falls as possible.
2. Maximize the amount of permeable surface and prevent soil erosion.
3. Prevent soil erosion.

1. Retain and infiltrate water as close to where it falls as possible

When designing a new landscape or modifying an existing one, strive to use land characteristics to create opportunities for water to infiltrate wherever possible. This can be done by using or enhancing existing site features, such as depressions, or by creating new site features through land forming or grading. Below are a few of the basic site-related features and techniques used for watershed management and drainage based on the underlying principle of catching rain where it falls.

Slope

The slope, or degree to which land rises or falls, is a basic element of land forming and is fundamental to water- conserving site design. Slope influences how fast water travels over the soil surface, affecting the rate at which water infiltrates into the soil. Slope also indicates which direction water will travel once it hits the ground. In addition to the site being developed, the slope of adjacent land should be analyzed for potential stormwater flows entering or exiting the site.

Grading and Drainage

Conventional site design strives to direct stormwater off the site and into the storm drain system as quickly as possible. Water-conserving site design tries to imitate or replicate the predevelopment flow patterns, allowing rainwater to collect and infiltrate as close as possible to where it falls. Where possible, natural arroyos and drainage ways should be retained and integrated into the site design. If not possible, the site should be graded so that stormwater is directed to swales or ponding areas to prevent it from flowing onto adjacent lots, as illustrated in Figure 9. Check with your governing agency to see if there is an existing Grading & Drainage Plan that might restrict what you can do on your property or if your plans require the submittal of a Grading & Drainage Plan.

An integrated site design also includes multiple approaches for stormwater management to capture and direct runoff to where it can be used to supplement landscape irrigation requirements, improve water quality and recharge groundwater supplies. Keeping stormwater on site provides free water for landscaping and also reduces the amount of stormwater flowing into the storm sewer system and the need for costly infrastructure.

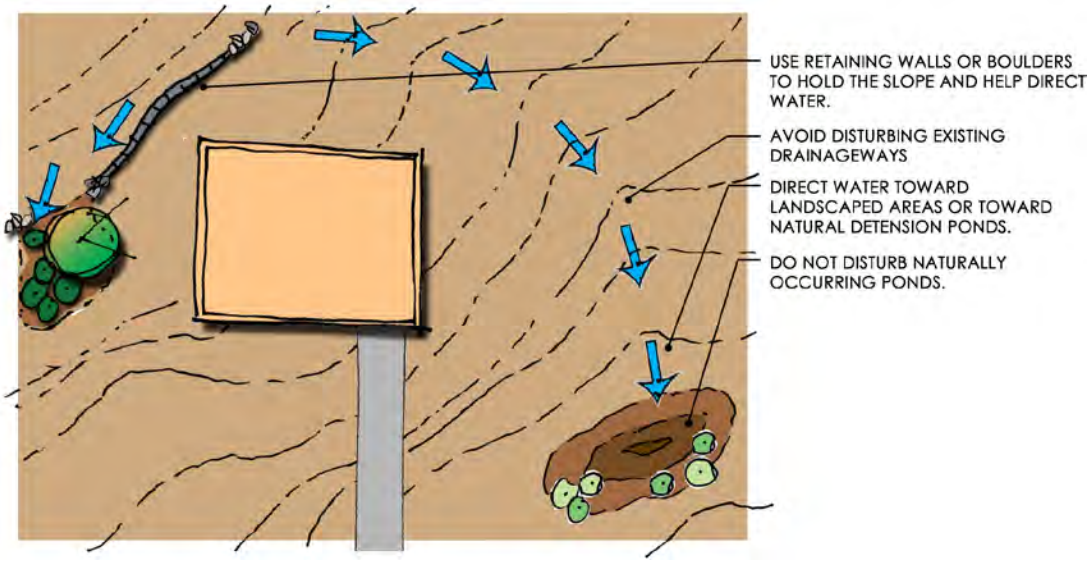
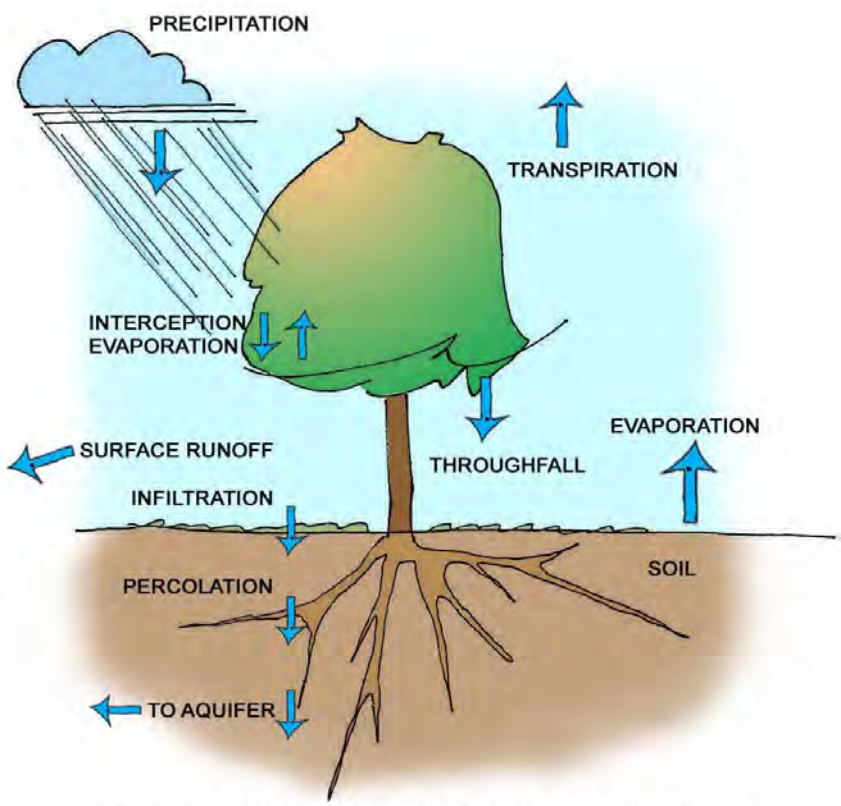


Figure 9. Directing Stormwater through Grading Techniques

Grading depressions in the landscape create opportunities for water to collect and infiltrate, which are very beneficial when used for planting areas. Shallow depressions can be sufficient; the larger the area they encompass, the more water they will retain. One inch of water can penetrate the soil to a depth of about one foot, so a very shallow one-inch depression would allow a one-inch rain to permeate the entire root zone of a groundcover, which has a root zone depth of about one foot. For larger plantings such as shrubs whose root zones are two feet deep, and tree root zones at three feet, shallow depressions that are a minimum of two and three inches deep, respectively, would suffice for complete penetration if the basin is filled. Increasing the depth of depressions will allow rain from larger precipitation events to pool and infiltrate and helps to decrease the amount of runoff. The depressions also assist irrigation efficiency by retaining water at the right place relative to the plantings until it infiltrates.

Dry washes or shallow swales can help to slow and direct runoff to desired locations in the landscape. They should be winding and lined with irregularly sized stones to slow the water and allow it to infiltrate. Areas with poor drainage, such as those with clay or caliche lenses, can benefit from the creation of drainage chimneys. A drainage chimney is simply a deep hole that either pierces the hard soil layer,or provides a place for subsurface water to drain. Fill the hole with gravel and mulch the top consistent with the rest of the landscape area. Plants placed around the edge of the chimney can use the water held there.

The diagram in Figure 10 illustrates the water cycle. Understanding this cycle and putting this knowledge to work in the landscape can help to maximize water conservation. Allowing rainwater to infiltrate the soil as close as possible to where it falls is the most efficient water conservation method of all. Retaining and infiltrating stormwater on site feeds excellent quality water to vegetation at no cost while minimizing runoff. This helps to reduce the amount of infrastructure required for flooding and erosion prevention. Moreover, allowing infiltration of rainwater has the potential to re-charge groundwater and in some instances the aquifer. The "Water-Conserving Landscape Devices and Best Management Practices" section



THE RAIN INFILTRATION CYCLE SHOWS RAINFALL STARTING WITH PRECIPITATION FROM STORM EVENTS. WATER THEN EITHER EVAPORATES BACK INTO THE AIR OR INFILTRATES INTO THE SOIL. AFTER THE WATER INFILTRATES THE FIRST LAYER OF SOIL, IT THEN PERCOLATES INTO NEARBY PLANT ROOTS AND EVENTUALLY INTO THE AQUIFER.

Figure 10. The Water Cycle

of this chapter contains information on a variety of ways to capture and infiltrate water on your site.

Siting

With a vacant lot, you have the opportunity to locate your house and other built elements such as sidewalks and driveways to take best advantage of conditions for water harvesting and increasing the environmental efficiency of your home. Figure 11 and Figure 12 show ideal home placement on a typical lot in A-1, A-2 and R-1 zones. The homes have been sited to minimize the disturbance on the land, preserve existing vegetation and take advantage of water flow patterns and natural wind protection from trees and shrubs. Preserving existing vegetation helps to minimize negative impacts of development on the site's water. Grade changes, either natural or man-made, should be taken into account when deciding where to place new buildings to direct water away from the structures and toward useful purposes such as landscaping. Rainwater is managed by multiple methods

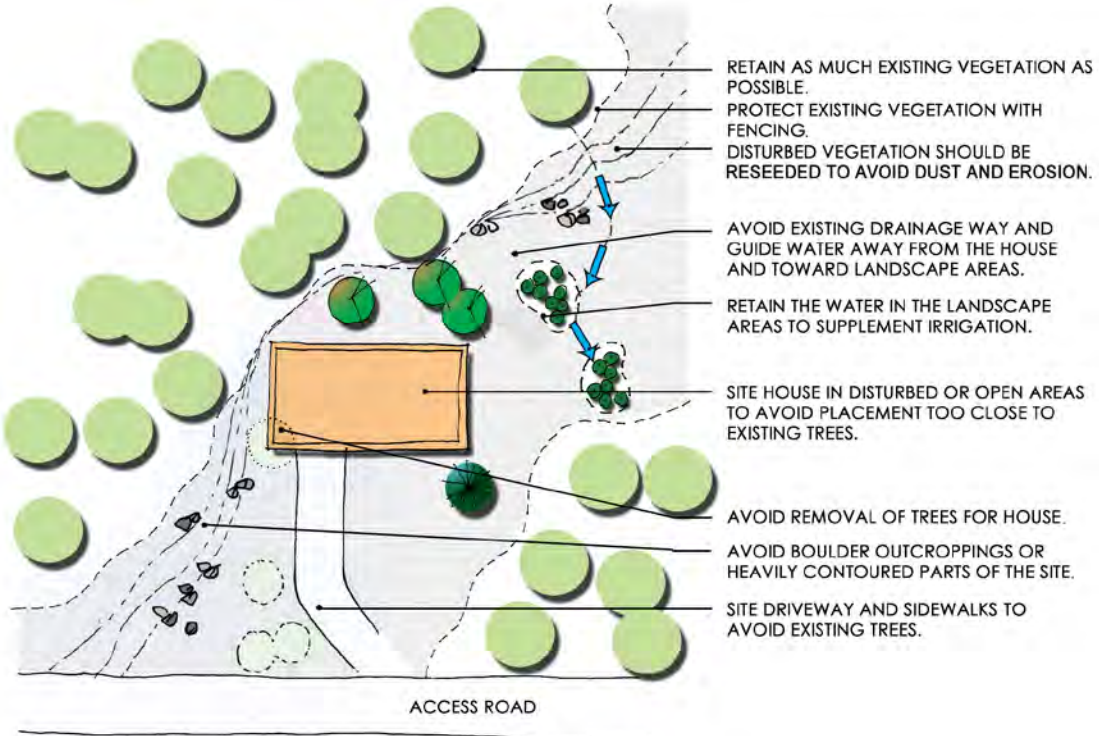


Figure 11. Ideal Home Placement for A-1 or A-2 Larger Lots

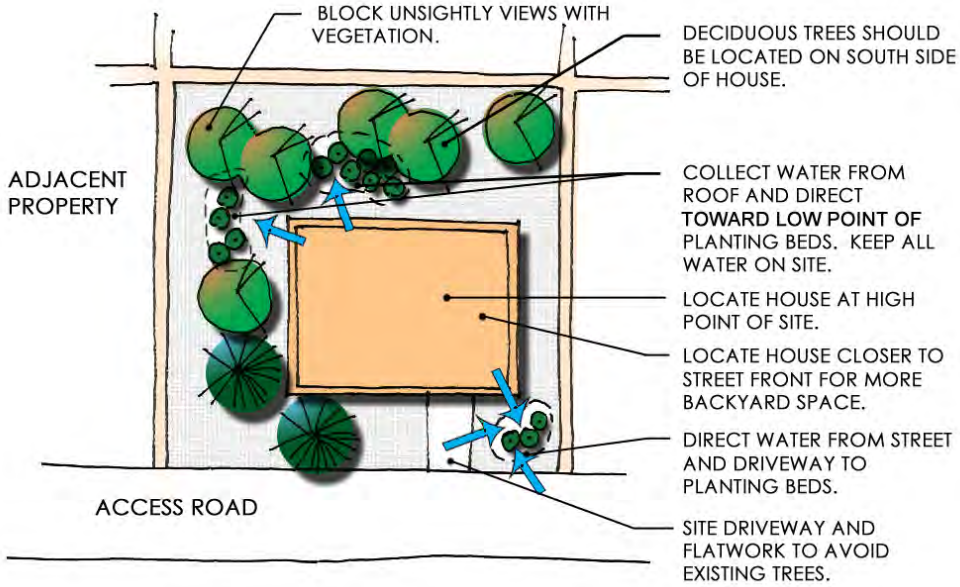


Figure 12. Ideal Home Placement for R-1 Lot

that minimize the amount of impervious surfaces and collect rainwater and direct it to landscape areas on site.

2. Maximize Permeability

Reduce Impervious Surface

It has been said that we are "paving our way to drought." This statement points to two results of covering the earth with impervious surfacing. First, when impermeable surfaces prevent stormwater from infiltrating the ground, the opportunity to recharge groundwater or the aquifer is lost. Second, impermeable surfaces increase the absorption of heat from the sun and reflect it to surrounding vegetation and the atmosphere, which in turn requires more water for plant growth and to cool structures and people. When designing your site try to minimize the amount of impermeable surface area through efficient organization and layout of site elements that deal with circulation and vehicle access. Another way to decrease the amount of impermeable surface is by breaking up the total area using pavers, brick, flagstone or other paving materials that allow water to infiltrate between the individual pieces. Permeable concrete and asphalt can be used in place of their traditionally non-permeable predecessors for most residential paving purposes, and graveled surfaces or crusher fines offer additional alternatives.

Non-porous paving

Other than rooftops, the majority of non-porous surfaces on a residential lot are paved patios, driveways and walkways that are typically built of concrete, stone or asphalt. Many outdoor surfaces such as sidewalks, driveways and patios don't necessarily have to be waterproof, as noted above, or can be designed to shed runoff into landscape and water-harvesting areas as shown in Figure 13. The best way to accomplish this is by orienting paved surfaces to slope away from structures during initial grading and

Figure 13. Porous vs. Non-porous Surfaces

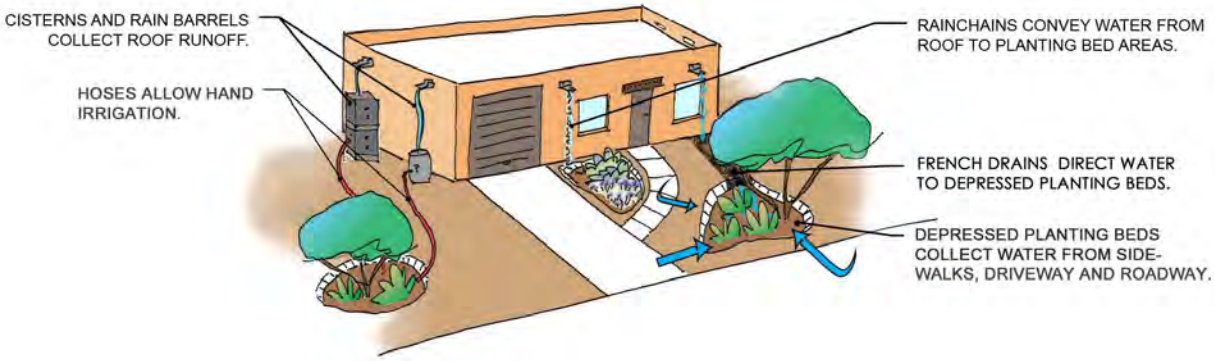


Figure 14. Utilizing Stormwater from Non-Porous Surfaces in Landscape

construction. Low points should be located where the flow can be utilized by landscaping without causing erosion problems. See Figure 14 for an example of utilizing stormwater from non-porous surfaces.

3. Prevent Erosion

A properly graded site spreads and slows stormwater runoff by lengthening and reducing slopes and directing the runoff to areas designated for capture and infiltration. Preventing water erosion helps to protect soils and vegetation, which are key contributors to the site's water efficiency level.

Additional Landscape Design Considerations

Thermal Effects of Landscaping - Strategically placing trees and other plantings can mitigate extremes of heat, cold and wind reducing home energy costs and water use while providing aesthetic benefits.

- Plant deciduous trees on the south, west and east sides of the home to provide shade from harsh western sun, cool the home in summers and allow exposure to warming rays of the sun in the winter. The eastern exposure might have smaller leafed trees for dappled shade. Simple measures like these can reduce the use of swamp coolers and air conditioners by more than 30 percent, as well as reduce the amount of water consumed by their operation. Swamp coolers typically use between four and eight gallons of water per hour.
- Trees planted along the north exposure of homes can have an insulating effect in winter and summer by adding a layer of living matter between the exterior walls of the home and temperature extremes. Evergreen trees and shrubs can block wind and screen wanted views. Water demand can be reduced by grouping trees together so that they shade each other, creating a cooler temperature and higher humidity microclimate.
- Shading paved areas helps to reduce heat build-up. The evapotranspiration of "oasis" hydrozone plantings placed close to the house can help cool the building as well as patio or other outdoor living spaces.
- Buffer garden areas from the effects of drying winds by planting rows of tall shrubs or trees. Figure 15 illustrates several of these principles.

Chapter 1 of this document provides information regarding dominant environmental conditions for each

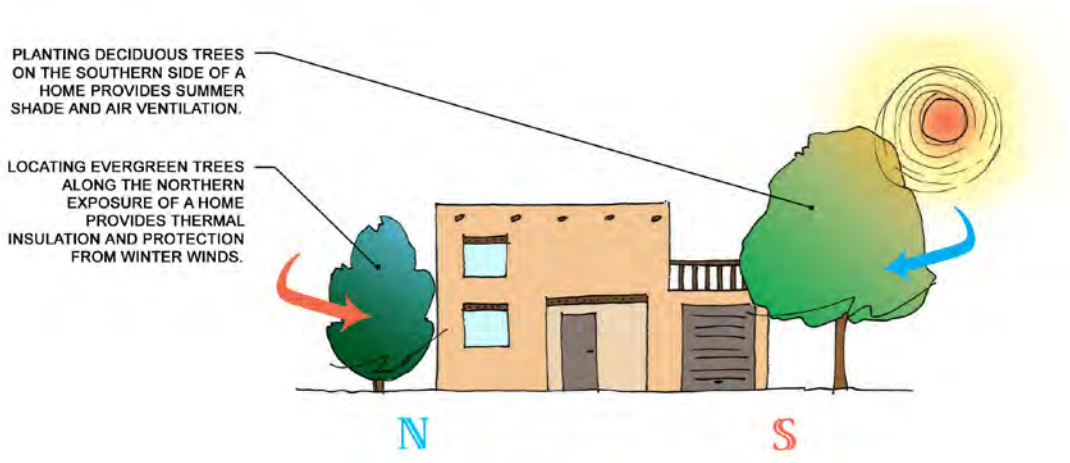


Figure 15. Climate Mitigation through Landscape Plantings

of the Bernalillo County Biozones. This can supplement information gathered during site analysis to determine the optimal placement of plantings for thermal mitigation.

Evolution of the Landscape - The various elements of a landscape including plants, soils and topographic features are not static and will change over time. This evolution should be taken into account in landscape planning and design.

Ample space must be given for plants to grow without crowding. Given the smaller initial size of most plants when first placed in the landscape, there is a natural tendency to plant too many plants or to plant them too close together. It is important, however, to allow space for the growth and mature sizes that plants will ultimately achieve. For example, trees canopies will spread and so will the area they shade, so plants underneath should be tolerant of both sun and shade. Otherwise sun-loving plants can be relocated as the canopy extends. The water needs of plants under trees may also change due to decreasing evaporation and establishment; be prepared to make adjustments to account for changing water demands. The placement of trees should always be based on their mature size so that they are planted far enough away from buildings, structures and utilities to avoid drastic pruning or removal.

Measuring irrigation water applied

There are two easy ways to measure the amount of water being applied during irrigation

- After the irrigation run is completed, push a shovel into the dirt and then push it back such that you can see how deep the moistened soil goes. Alternately you can use a metal rod as described in the Water-Conserving Irrigation section.
- For measuring sprinkler irrigation place 3-5 straight-sided empty cans at even intervals being sure to place a can near the edge of the area being irrigated. Run the sprinklers for thirty minutes, then measure the depth of water in each of the cans. Add up the depth of water in all of the cans, then divide that total by the number of cans and multiply by 2. The result is inches of water applied per hour.

Landscape Rehabilitation (retrofits vs. new landscapes) - It is not necessary to completely change an existing high-water-use landscape in order to conserve water. One relatively simple way to improve the landscape's water efficiency is to verify that the irrigation schedule is appropriate to the plant needs and the soil type. Adjustments can be made to the irrigation system or schedule based on the test results (see "Measuring Irrigation Water Applied"). Retrofitting or revamping an existing irrigation system to include newer water-conservation technologies and equipment can also greatly reduce water waste (see the "Water-Conserving Irrigation" section for more information). Increasing the drought-tolerance of plantings by gradually reducing the amount of water currently being used is another option. For example, if plants are being watered every day for 15 minutes, determine whether that amount of irrigation time is soaking the entire root zone depth. If so, the schedule may be reduced to every other day for 30 minutes for several weeks, and then further reduced to every three days and so on until you achieve the watering frequencies recommended in "Appendix I. Recommended Watering Schedules" Remember to monitor the plants for signs of stress and adjust the actual duration and frequency accordingly.

The first step in rehabilitation and retrofitting is to evaluate the existing landscape:

- How much water does it require for good health? How much water is it getting? How is it delivered?
- Does the landscape serve its function?
- Is there room for improvement (plants past their prime, overgrown their location, causing other problems)?
- Is water running off turf grass that is growing on slopes?

Based on the answers, determine what changes you would like to make (new function, other desired changes) and follow the "Recommended Steps for Water-Conserving Landscape Design" noted above with the addition of these considerations:

- Avoid drastic changes in irrigation to plants that are to remain. If a turf area is going to be changed by replacing it with a low-water-use turf or with other plants, care should be taken to account for any trees or shrubs that may have been benefitting from the turf irrigation. The irrigation system may require adjustment to ensure that these plantings continue to receive sufficient water. It is often unnecessary to replace an entire irrigation system, as kits are available to convert spray irrigation

systems to shrub spray or drip systems. Consultation with an irrigation specialist can help to ensure a successful transition to reduced water use.

- Xeriscaping creates a landscape that exists in harmony with the surrounding dry environment, such as replacing turf with colorful, low-water-use plants and mulching with inorganic or organic materials. Replacing turf grass with gravel is not xeriscaping, as it raises reflected heat levels, increasing the water needs of existing plants and use of air conditioning.
- Select the appropriate turf for your biozone and function. For example, Buffalograss thrives in heavy clay soils, but struggles in sandy soils and does not tolerate heavy foot traffic. It is not the best choice for a backyard in the West Mesa Biozone, whereas a fescue blend is better adapted to the soil and use conditions.

Photo 7. Alternatives to Bluegrass Turf

TURF-TYPE TALL FESCUE:

Uses approximately 50% less irrigation than Kentucky Bluegrass. Turf-type Tall Fescue looks like Kentucky Bluegrass but grows in a much wider range of conditions.

TURF-TYPE BUFFALOGRASS:

Uses 75 to 100% less irrigation than Kentucky Bluegrass Turf-type Buffalograss makes a beautiful soft lawn and needs little or no irrigation.

Reclamation and Revegetation - Vegetation helps to prevent water and wind erosion, and plant roots help to keep soil porous and increase its infiltration capacity. In addition to retaining existing vegetation to the extent possible, plant cover should also be maximized on the site. Reseeding or revegetating disturbed, degraded and bare areas generally results in a more water-conservative landscape.

The need for reclamation can be reduced or eliminated if care is taken during the construction process, reducing cost and time required to achieve a water-conserving site. The key steps include:

- Minimizing the area of disturbance - Mass grading and plowing expose the soil to the sun and wind, increasing evaporation. These practices also destroy existing vegetation that holds the soil, preventing it from being blown or washed away. Restricting construction activity to the minimum possible area limits the total adverse impact to the site.
- Periodic spraying of water or the addition of commercially available dust control substances over disturbed soil reduces the amount of dust generated and helps to maintain a minimal level of soil moisture that improves the germination rate of reclamation seeding. The need for dust control measures can be reduced by keeping the disturbed area to a minimum.
- Revegetating with native grasses and plants helps to protect the soil and reduce runoff and evaporation of water. Native dryland seed mixes generally include a combination of warm and cool season grasses. The warm season grasses, such as galleta, sideoats and blue grama, germinate during warmer weather, usually after the summer monsoons. Cool season grasses, such as Indian ricegrass, sprout in early spring. A mix of both types takes advantage of opportunities presented by seasonal precipitation and provides a diverse mix of species. Wildflower seeds can be added to native grass mixes to help bind the soil, add diversity and provide food for insects, birds and other wildlife.
- When seeding with native grasses, sufficient moisture at the right time is critical. Planning for supplemental irrigation if natural precipitation is insufficient will help to improve germination and survival rates.
- Applying crimped straw or mulching with compost or small-sized aggregate over seeding areas can

help to retain soil moisture and prevent seed and soil from being blown away, increasing successful germination.

Maintenance Practices - Landscape and site maintenance practices can also be adjusted to conserve water; for example, sweeping sidewalks, patios and driveways instead of washing them off. A hose can deliver five gallons of water per minute, so even five minutes of washing can use 25 gallons of water.

Ornamental Water Features and Amenities - Water use can be conserved through careful design and selection of ornamental water features, amenities and swimming pools. The Bernalillo County Water Conservation ordinance limits ornamental ponds to a maximum surface area of 500 square feet, and ornamental fountains to 250 square feet of surface area. If multiple water features are used, the total combined surface area must not exceed those limits. Water must be recirculated in fountains, waterfalls and similar features. It is possible to further make ornamental water features more water conservative by taking a few simple measures such as reducing evaporation loss. The sketch below (Figure 16) illustrates how evaporation can be minimized by covering the reservoir with attractive cobble. Locating water features where they will not be exposed to western sun in the summer and providing shade over ponds and open water fountains also reduce evaporation. Periodic inspection and appropriate maintenance to identify and eliminate leaks are also important. Using harvested rainwater to supply ornamental water

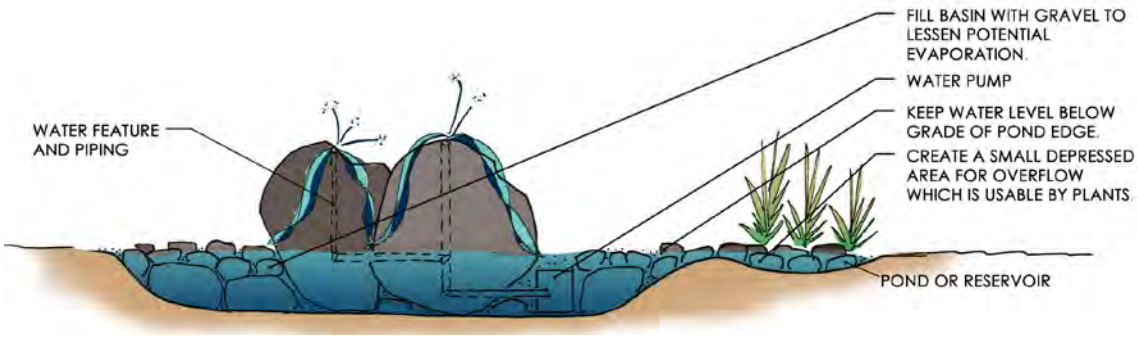


Figure 16. Water Feature with Minimal Evaporation

features conserves water and has the added benefit of avoiding mineral build-up, which can reduce maintenance and cleaning requirements.

- ***Swimming Pools*** - When appropriately managed, the water efficiency of swimming pools can be increased. Measures pool owners can take to conserve water include:
  - Keeping the pool covered when not in use. Evaporation can cause losses of up to 40 gallons per square foot of open water, which translates to 16,000 gallons for a 400-square-foot pool.
  - Provide windbreaks around the pool such as fencing or landscaping. Windbreaks can help to reduce evaporation as well as heat loss.
  - Refrain from keeping the pool water level high to reduce losses from splashing and overflow.
  - Install newer water-saving pool filters; older models can use 180 to 250 gallons of water in a single back wash.
  - Clean the pool filter often to reduce the frequency at which you have to replace the pool water.

  A typical residential pool (16' x 32') holds approximately 20,000 gallons of water. If it is necessary to drain the pool, the water can be used to water landscaping with a few simple steps.

  Draining an In-ground Pool
  - Stop adding chemicals to the water. Wait 72 hours or longer if pool is highly chlorinated. Chlorine levels of three parts per million (ppm) or lower are safe for most plant material.
  - Find the drain line in the filter pump; it should be located near the pump motor.
  - Attach a long hose to the drain line and take the open end out to a landscaped area.
  - Run the pump until the landscape appears unable to take in any more water and move the hose to another landscaped area. If there are no other landscaped areas to drain onto, turn off the pump.

- Wait several hours.
- Repeat the steps until the pool is empty.

Draining an Above-ground Pool

- Stop adding chemicals to the pool. Wait 72 hours or longer if the pool is highly chlorinated. Chlorine levels 3 ppm or lower are safe for most plant material.
- Rent an electric pump if necessary.
- Place the intake hose in the pool and the outlet hose in a landscaped area.
- Plug in and turn on the pump, priming per the manufacturer's recommendations.
- Run until the landscape appears unable to take in any more water and move the outlet hose to another landscaped area. If there are no other landscaped areas to drain onto, turn off the pump.
- Wait several hours.
- Repeat if necessary.

- ***Hot Tubs*** - Hot tubs, when properly maintained and covered, do not need to be emptied and refilled often. Filling them with fresh water once or twice per year is more than adequate for most residential use. Water loss from hot tubs can be reduced by inspecting for and repairing leaks and by minimizing evaporation through use of a correctly fitting cover. When emptying a hot tub, the water may be used to water the landscape if the concentration of sanitizing chemicals is low. Acids should be neutralized, chlorine levels should be 3 ppm or lower, and no new chemicals should be added to the hot tub for 48 to 72 hours prior to draining.

- ***Outdoor Showers*** - Outdoor showers should use low-flow showerheads and can be plumbed for graywater harvesting or designed to allow used shower water to flow into planted areas, providing supplemental irrigation. Selection of soaps and shampoos should be appropriate for the soil conditions on the site. Any technique used to reuse shower water must comply with the New Mexico Department of Health regulations, standards, and requirements.

- ***Misting Systems*** - Water misting systems have become popular with people seeking relief from New Mexico's hot dry summers. A typical misting system uses two gallons of water per minute to cool a 1,000-square-foot space. This translates to 480 gallons over a four-hour period. Due to this large water use, misting systems are discouraged by the Standards and Guidelines. Shade trees and other

landscaping provide efficient alternatives to misting systems to help cool outdoor living spaces.

D. Water-Conserving Landscape Devices and Best Management Practices

In this section, methods for conserving water in the landscape are described and illustrated. These devices and best management practices can be used to help meet Bernalillo County Water Conservation Ordinance requirements and enable the developer, builder or home owner to conserve water while creating a beautiful and thriving landscape that improves the environment and enhances property value. A complete copy of the Water Conservation Requirement (Ch. 30. Art. VII, Sec. 241-251) can be found in Appendix A.

Water Harvesting

Water harvesting generally refers to capturing stormwater drainage from impermeable surfaces such as driveways, rooftops, sidewalks, patios and other surfaces and directing it into the landscape or into a storage system for future use. It also refers to capturing, redirecting and infiltrating stormwater within the landscape. Using a combination of devices or techniques can maximize the amount of stormwater harvested and used. Figure 14 demonstrates several methods commonly used to direct and distribute captured stormwater.

Water harvesting offers multiple benefits such as reducing the amount of irrigation required, improving water quality, and reducing erosion and the amount of site discharge into the storm sewer system. Water harvesting devices can be used individually or in systems called "treatment trains" to collect and distribute water to the landscape efficiently. The devices can be as simple and small as rain chains and rain barrels, or as large and complex as ponds or constructed wetlands.

Basic Principles for Water Harvesting

- Plan for use of harvested water to support landscape needs.
- Look for water harvesting opportunities throughout the site. Providing opportunities for stormwater to slow and infiltrate as close as possible to where it enters the site or reaches the ground will decrease the need for larger scale interventions downstream.
- Collect, slow and enable stormwater to infiltrate the ground using a variety of water-harvesting devices based on the site conditions and constraints.
- Plan for overflow from all water-harvesting and storage devices used and direct the overflow into the landscape.
- Plan for water quality. Stormwater washes the surfaces it runs over, collecting and conveying pollutants and sediment that have accumulated. The potential amount and type of materials conveyed in first flush runoff should be considered when selecting and designing water-harvesting devices and systems for a site.
- Maintain water-harvesting devices and systems. Plan for and provide appropriate maintenance in order to maximize device and system performance and longevity.
- Make sure that your drainage project does not negatively impact anyone else's property.

General Construction Notes
Check with utility companies about buried cables or gas lines BEFORE BEGINNING TO DIG.

Water-Conserving Landscape Device Matrix

The following matrix lists a range of potential water-harvesting techniques along with information regarding their use. More detailed information on each technique is available in the text following the matrix.

To use the matrix, locate the desired primary water conservation function, then follow the rows across to see which devices perform that function. Review the ideal conditions, counter-indications and constraints regarding use and siting for each device to determine whether it is appropriate for your site conditions. If a particular technique is not appropriate for your site, review the other devices listed for the desired function to find other options. A summary of maintenance considerations is also provided to assist in preliminary decision making. After determining which devices are most likely to perform well for your site, review the

Device	Primary Water Conservation Function	Additional Functions	Ideal Site Conditions	Counter indications/ Constraints	Configuration / Design Options	Maintenance Considerations / Issues	Detailed Information
Swale	Drainage water conveyance.	Infiltration/ landscape sustainability, flow reduction, flow diversion.	Slopes of 0.5% to 1.5%.	Minimum 0.5 % slope on paved surface, minimum 1.0 % slope on vegetated surface, rip-rap or vegetative armoring may be necessary for high water velocities.	On-contour swales/berms, off contour swales, armored or vegetatively reinforced. Erosion control blankets necessary on slopes of >5:1.	Visual inspection and cleaning after significant rainfall event, landscape maintenance.	page 45
Check Dam	Erosion control along drainageways/ water harvesting.	Decreases water velocity, water quality improvement/ desedimentation, infiltration for landscaping.	Drainage area <10 acres - for every one foot drop in elevation or a minimum of 50- feet separation.	Do not place in live streams (only useful for intermittent drainageways).	Boulder/cobble weirs, wicker weirs, earthen checkdams, concrete.	Visual Inspection for damage, sediment removal, landscape maintenance; drainage should allow slow infiltration but not ponding (to avoid mosquito problems).	page 48
Gabion Structures	Erosion control. Retaining wall.	Decrease water velocity, water quality improvement, infiltration.	Hillsides and drainageways.	Landscaping needs to be carefully chosen, and proper anchorage of base should be designed by engineer to prevent failure of gabion wall.	Terraces, in drainageways.	Visual inspection and cleaning of gabion wire after significant rainfall events.	page 50
Curb Cuts (for Water Harvesting)	Parking lot and street conveyance.	Flow diversion/ water harvesting for parking and streets.	Parking lots and streets adjacent to vegetation and landscaped areas.	Should be installed per the applicable regulating agency standards and methods of construction (Bernalillo County, NMDOT).	Parking medians, streetscape rain gardens.	Because these devices are accepting drainage from streets, they need visual inspection and cleaning.	page 51
Rain Chain	Water conveyance for low rooftop flows.	Aesthetics.	Rooftops with canales or gutters.	Large rooftop drainage basins may produce too much water.	Many, constricted only by style.	Sediment cleaning necessary in individual baskets.	page 52
Microbasin	Infiltration devices / water harvesting.	Water quality improvement, small infiltration basins, landscape sustainability.	Parking lots, open landscapes, gentle slopes (slopes less than 5%).	Not suitable for steep slopes, not suitable along swales or major drainageways, may need spillways.	Localized depressions, crescent depressions (for hillsides), parking islands.	Visual inspection and cleaning after significant rainfall event, landscape maintenance, drainage should allow slow infiltration but not ponding (to avoid mosquito problems).	page 53

Device	Primary Water Conservation Function	Additional Functions	Ideal Site Conditions	Counter indications/ Constraints	Configuration / Design Options	Maintenance Considerations / Issues	Detailed Information
Soil Imprinting	Slow infiltration.	Erosion control / water harvesting.	Open land unobstructed with impervious surfaces.	Steep slopes of > than 2%.	Open landscape areas, ideal for reclamation.	During establishment of seed erosion must be abated. After establishment no maintenance should be necessary.	page 55
Waffle (or Grid) Gardens and Terraces	Infiltration, reclamation.	Erosion control, flow reduction.	Steep hillsides (terraces), flat surfaces where cross migration of subsurface water needs abatement.	Extremely sandy or erosive soils.	Terraces and flat surfaces, berms surrounding may need armoring.	Rebuilding may be necessary upon large storm events.	page 55
Permeable Paving	Infiltration from parking and pedestrian areas.	Water quality improvement, groundwater recharge, pollution prevention.	Parking lots and pedestrian areas surrounded by vegetation.	Sand and silt from desert areas can clog openings in pavement.	Asphalt, concrete, or open celled pavers with underlying gravel. Permeable pavement should be sloped a minimum of 0.5% To prevent ponding. If underlying gravel is used as storage area, it must be sized per the design storm.	Periodic flushing, power blowing or vacuuming may be necessary to facilitate drainage, landscape materials should not be stored on surface.	page 55
Bioretention Cell or Basin	Water quality improvement.	Infiltration / aesthetics.	Parking lot (for runoff pollution protection).	Some plants may require irrigation.	Parking lot islands, filter strips on parking lot end points. Design so that a maximum of 6 inches of water is present at design flow to prevent inundation of vegetation.	Landscape maintenance is specialized; irrigation may be necessary, landscape may need replacement periodically to retain functionality.	page 59
Constructed Wetland	Water quality improvement.	Infiltration, water quality improvement.	Sewage treatment, landscape water quality improvement.	Maintain a minimum of 20 feet from any structure. A geotechnical report should be completed to address slope stability of pond embankments. Avoid soils with high infiltration rates (sandy soils). Water inflow should be greater than the site release rate, infiltration rate, and evapotranspiration rate.	Unlined, using soils with high water retention, lined using soils with high infiltration rates.	Routine management of vegetation (replacing dead plants and removal of plant material) and routine removal of sediment. Wetlands should be designed with vehicular access points for proper maintenance.	page 61

Device	Primary Water Conservation Function	Additional Functions	Ideal Site Conditions	Counter indications/ Constraints	Configuration / Design Options	Maintenance Considerations / Issues	Detailed Information
Detention Pond	To detain water in a pond with a stormwater outlet (shorter term storage and infiltration).	Infiltration/landscape sustainability, groundwater storage, water quality improvement.	Large open areas, sandy soils preferred. See configuration column.	Maintain a minimum of 20 feet from any structure. A geotechnical report should be completed to address slope stability of pond embankments.	Size per design storm. Pond should be sized for a minimum 100-yr 24-hr storm and have at least one foot of free board at peak volume. Outlet culvert should be sized to allow the pond to completely drain design volume within 72 hrs. Pond should have a minimum of a 2% bottom slope to allow complete drainage. Pond should be designed with an overflow structure to prevent failure of embankments during extreme storm events.	Visual inspection and cleaning of pond bottom, outfall structure, and overflow structure after significant rainfall events.	page 62
Retention Pond	To retain water in a pond with no outlet (storage and infiltration).	Infiltration/landscape sustainability, groundwater storage, water quality improvement.	Large open areas, sandy soils preferred. See configuration column.	Evapotranspiration calculations must be done to ensure the water in the pond will empty between significant storm events. Mass balace analysis should be done by a licensed engineer. Maintain a minimum of 20 feet from any structure. A geotechnical report should be completed to address slope stability of pond embankments.	Pond should be sized for a minimum 100-yr 24-hr storm and have at least one foot of free board at peak volume. Surface area of pond should be sized to allow for complete evaporation of water volume between significant storm events. Pond should be designed with an overflow structure to prevent failure of embankments during extreme storm events.	Visual inspection and cleaning of pond bottom and outfall structure after significant rainfall events.	page 65
French Drain	Below grade infiltration, flood protection.	Temporary shallow groundwater storage, conveyance, infiltration/landscape sustainability, pollution prevention.	Rooftops with canales, land slopes of 0.5% To 1.5%.	Non-porous / clayey soils (poor drainage), below grade use only, steep slopes. Size according to target flow/velocity (should not drop below 2 ft/s, not greater than 7 ft/s).	Perforated pipe, w/wo gravel bed and filter fabric surrounding, gravel bed with filter fabric (gravel grain size distribution should be such that geomenbrane & perforated pipe do not clog).	Due to below grade installation difficult to clean; if installed with landscape adjacent, difficult to replace/clean.	page 65

Device	Primary Water Conservation Function	Additional Functions	Ideal Site Conditions	Counter indications/ Constraints	Configuration / Design Options	Maintenance Considerations / Issues	Detailed Information
Wicking Systems	Below grade infiltration/ passive irrigation for individual plants.	Minimal drainage protection.	Landscape plantings with minimal irrigation, on-contour swales.	Non-porous/clayey soils (poor drainage).	Must be located near root system of plant.	Due to below grade installation difficult to clean; if installed with landscape adjacent, difficult to replace/clean.	page 69
Mulches (gravel, wood, other)	Reduce evaporation in landscape areas.	Aesthetics.	Landscape areas.	When place adjacent to hard surfaces depth of mulch must be considered.	Matches landscaping.	Most mulches must be periodically replaced, blowing sand and dirt can inundate mulches.	page 70
Rain Barrel	Minor water storage.	Water quality improvement, landscape irrigation.	Rooftops with canales or gutters.	Minimal water storage possible.	Single barrels, multiple barrels installed in series.	Sediment collection or filtering may be necessary, overflow devices necessary.	page 82
Cisterns	Water storage.	Water quality improvement, landscape irrigation.	Availability of non-porous surfaces (i.e, roofs and parking lots).	Cannot collect water from turf grass or graveled surfaces (porous surfaces).	Above and below ground.	Sediment collection or filtering may be necessary, overflow devices necessary.	page 83

detailed device descriptions in the section following the matrix to further assist your decision making process.

Conveyance Devices

These methods are designed to collect, slow, and deliver captured storm runoff to the desired location. They also allow some water to infiltrate into soils as it passes along the conveyance channel.

Swales

Function: A swale is a depressed open channel designed to capture sheet flow runoff and convey it slowly in broad, shallow flow to where it can be stored or used for landscaping. Swales are designed to slow and spread the water to allow pollutants to settle and filter out as the water infiltrates the ground. Swales can be lined with hard materials such as rip-rap or cobble, or planted with a range of plant materials to enhance their function. Swales can be built to depths of between one and three feet and with widths of from one to four feet or more, with a roughly equally dimensioned berm on the downslope side. This can be constructed with soil excavated from the swale. Swales can be designed as single channels or connected in a series to increase their water distribution and infiltration capacities. The addition of check dams for swales on sloping sites can further enhance their infiltration capacity. Swales slow stormwater while diminishing its volume, simultaneously improving water quality through vegetative and soil filtration.

There are two basic types of swales, **on-contour** swales and **off-contour** swales. Detailed descriptions and applications for each type are listed below.

- ***On-Contour Swale*** - On-contour swales are constructed parallel to the site elevation contours as depicted in Figure 17.

  Siting: On-contour swales are suited to small and large drainage areas with gentle to steep slopes, such as open spaces, parks and landscaped areas. Swales should be constructed at least 10 feet away and downslope from building foundations. They are not appropriate for use in drainage channels, on fill areas or on sites with extremely sandy soils that may erode even at low-water-flow velocities.

  Construction: Swales should be sized to convey both smaller flows at speeds that facilitate stormwater cleaning and infiltration functions as well as peak flows without damage to the berms and spillways. Swales should be as long as possible to increase the time water is held, maximizing water quality improvement and infiltration. Water travelling in the swale should move at speeds less than or equal to 1.5 feet per second for the water quality design storm level, and less than 5 feet per second (or the erosive velocity of the channel) for the peak flow design storm level. The swale's water storage volume should be based on the amount of runoff coming from watershed above the swale and the slope at the swale location (see "Appendix B. Pre- and Post-Development Calculation

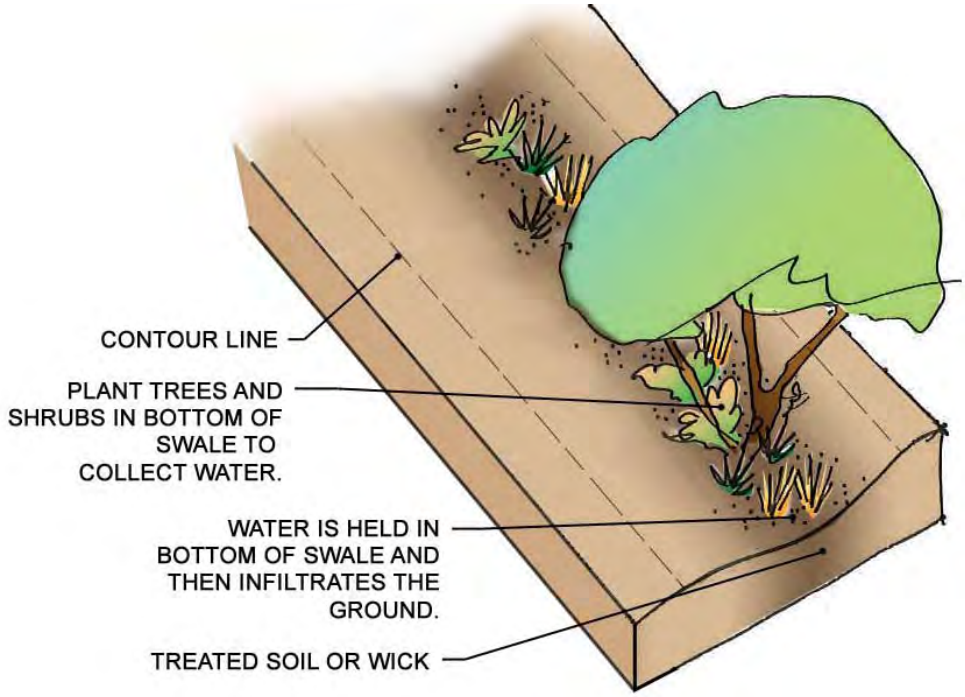


Figure 17. On-Contour Swale

Worksheets").

- To construct a swale, dig a curvilinear depression parallel to the selected line of elevation (contour), placing the excavated dirt on the downhill side of the swale to create a berm. The top of the berm should be roughly level, except for spillway areas, which should be the lowest point in the berm and armored with cobblestone or other hard material. The bottom of the swale can be uneven as long as it is lower than the spillway and should be mulched and vegetated. Swales should be a minimum of 6 inches deeper than the maximum design-flow-depth to prevent overflow onto adjacent area if runoff exceeds the design size or the swale is obstructed. The swale bottom should be less than 8-feet wide to avoid erosion issues such as rilling and gullying, and should be at least 2 feet wide if the swale will be mowed.
- Smooth the swale and berm and only compact the berm soil to maintain permeability of the swale bottom. Reinforce the berm with rip-rap or vegetation as needed, depending upon water velocity and soil types. Native vegetation that is tolerant of both drought and periodic inundation is an appropriate choice for planting in and near swales. Plants requiring more moisture should be planted on the swale sides and bottom where the soil moisture level is higher. The plants' root systems will help to stabilize the structure, and plants with an upright form will help to help slow stormwater in the swale. Plants should be placed so they do not block flows at spillway locations, and selected plants should have root structures that will enable them to withstand swale water flows. Wicks can be used to further augment the water-retaining capacity of the swales to provide for plant water needs (see additional information in the "Wicking Systems" section).
- Swales should have an internal longitudinal slope of 2% in order to convey stormwater at rates that facilitate infiltration and avoid standing water, which can create mosquito problems. Installing check dams can help to slow the movement of water within the swale to prevent erosion and to mitigate slopes in excess of 2% and up to 6% (see additional information in the "Check Dams" section).

Alternate Configurations:

- It is generally preferable to construct multiple swales at several points in the watershed versus a single large swale. On-contour swales can be built in linked series with spillways that allow overflow from one swale to flow into swales at lower elevation levels (see Figure 18). Spillways should be positioned so that the water is forced to move along the swale for as long as possible before flowing to subsequent swales. The top of the berm should be level except for spillway areas. The spillway should be lined with stone or other non-erosive material. A rock apron or splash pad should be installed on the downstream side to absorb the erosive impact of water exiting the spillway.

Maintenance: Maintenance tasks include checking for signs of overflow following heavy rains and periodically removing sediment. Sediment can be removed with shovels or machinery. Reseeding or replanting may be necessary after sediment is removed.

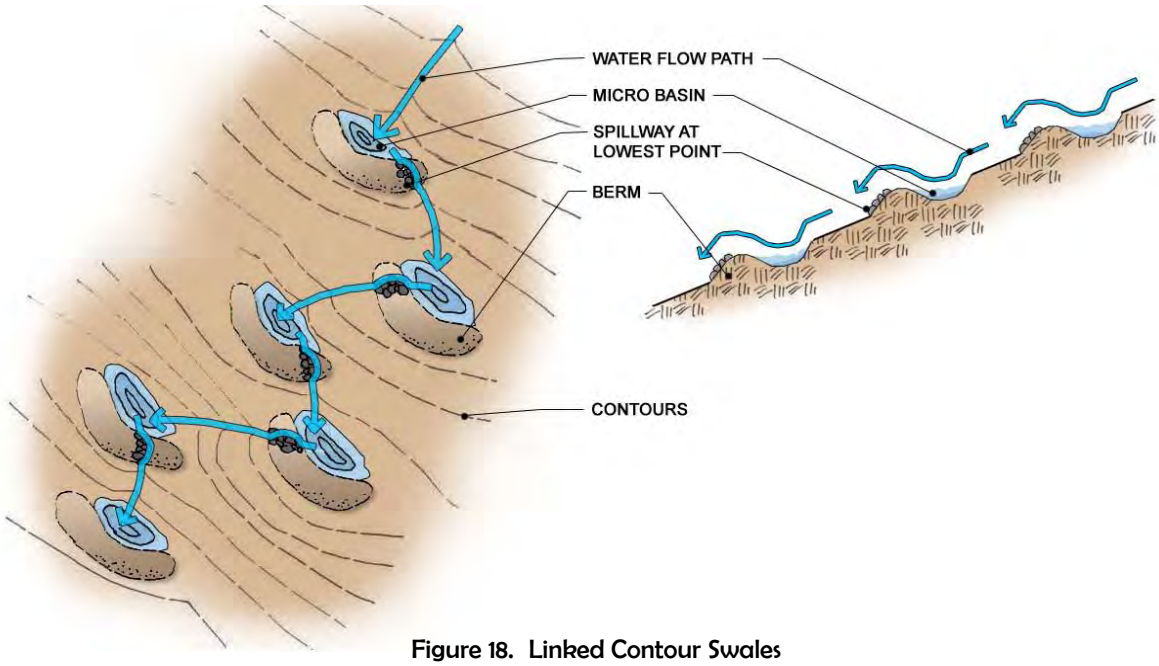


Figure 18. Linked Contour Swales

- ***Off-Contour Swale -*** Off-contour swales are constructed so that the swale and berm are at an angle to the contour line.

  Siting: Off-contour swales and berms are appropriate for moderate-sized drainage areas with gentle slopes, large landscaped areas and open spaces. Setting the swales at a slight angle to the contour elevation allows stormwater to move downhill slowly in a controlled manner to maximize infiltration and eventually discharge at the desired location as illustrated in Figure 19. Swales should be constructed at least 10 feet away and downslope from building foundations, and are not appropriate for use in drainage channels, on fill area or on sites with extremely sandy soils that may erode even at low water flow velocities.

  Construction: Determine the storage volume needed for the water harvesting swale (see Water Harvesting Calculations in Appendix B) based upon the watershed area above the swale, the slope at the swale location and the runoff from impervious surfaces on the site.

  - Construct a curved swale so that it is at a slight angle to the contour, with one end a little higher and the other a little lower as it follows the curve of the land. Deposit the excavated dirt on the downhill side to create a berm (Variation: series of swales can be constructed, using a spillway to connect and allow overflow from the swale placed at higher elevations to spill into the swale at the next lower elevation. Spillways should be placed so that the water is forced to move along the contour for some distance before flowing to subsequent and downhill swales.
  - Smooth the swale and the berm, compacting only the soil of the berm. The top of the berm should be level except for spillway areas.
  - Reinforce the berm with materials as necessary (depends upon soils and velocity) using rockwork such as rip-rap. Vegetation can also be used to reinforce berms but may require the use of other reinforcement strategies as interim measures until the vegetation is established.
  - Native, drought-tolerant vegetation with massive and fibrous root systems is appropriate choice for planting in and near swales as it will hold the soil, reducing sediment problems. Root systems help to stabilize the structure but should be placed so they do not block spillways flows. Plants requiring more moisture should be planted in the swale on the sides and bottom where the soil moisture level is likely to be higher. Trees and large shrubs can be planted in the swale, on the berm and immediately downstream as the roots can seek moist soils. Maintenance tasks include checking for signs of overflow following heavy rain events, and periodic removal of sediment.

  Maintenance: Maintenance tasks include checking for signs of overflow following heavy rain and periodically removing sediment and debris. Sediment can be removed with shovels or machinery.

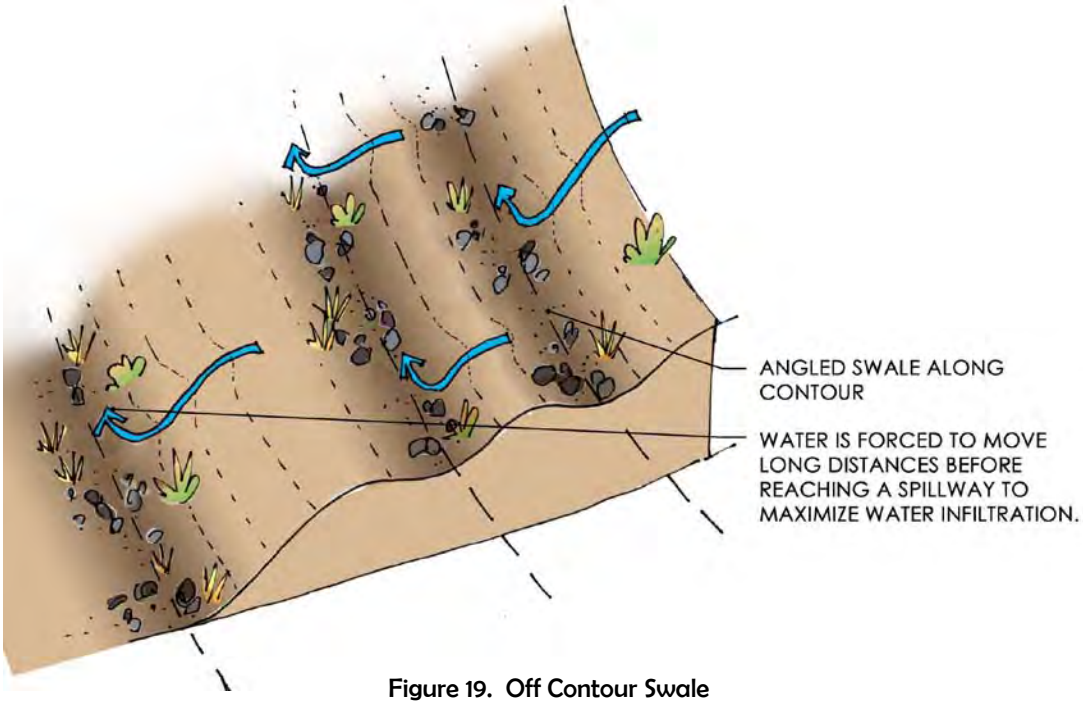


Figure 19. Off Contour Swale

Reseeding may be necessary after sediment removal.

Check Dams

Function: Check dams are small barriers or weirs that decrease the velocity of concentrated stormwater flows by creating small ponded areas that help to prevent channel erosion and allow suspended sediment to settle out. An added benefit is that they create excellent areas for landscaping as the harvested water can be well utilized. By slowing the water, the dams also promote water infiltration within the channel. Check dams also aerate runoff as it flows over the dam crest (Figure 20).

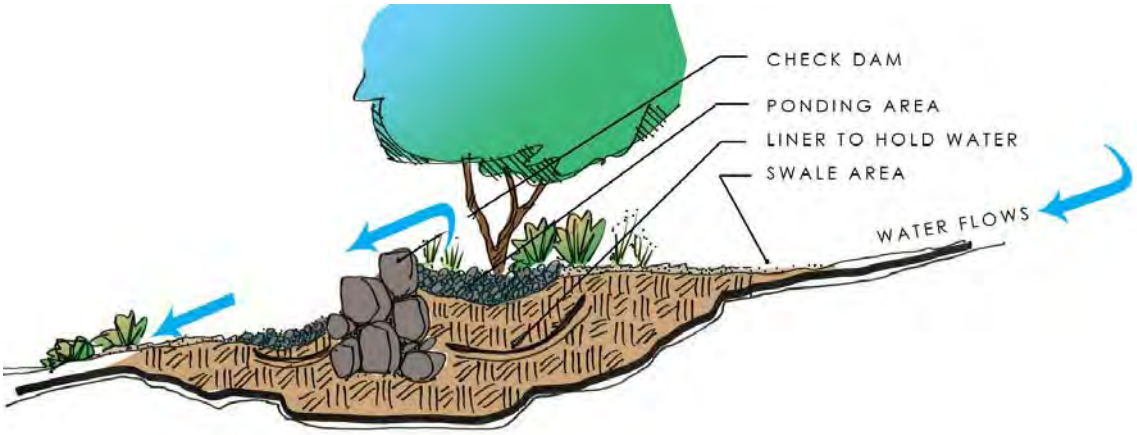


Figure 20. Check Dam

Siting: Check dams can be constructed across swales, small channels or drainage ditches. They are particularly useful for steeply sloped swales and channels and those where vegetation is difficult to establish to hold the channel banks. The total drainage area should not exceed 10 acres. However, consultation with a professional engineer is advised. Check dams should not be constructed in live streams as they will disrupt movement of fish and other aquatic fauna (Figure 21).

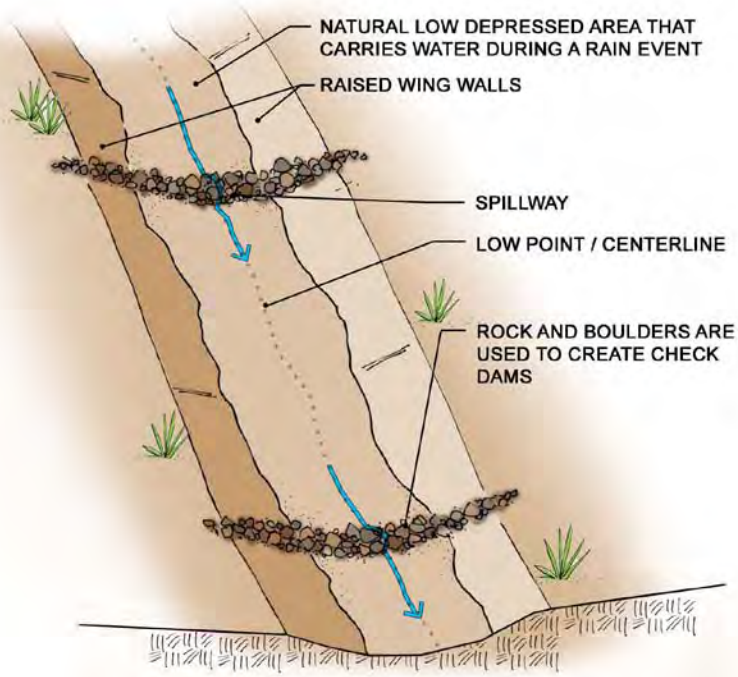


Figure 21. Check Dam Series

Construction: Check dams can be constructed from a variety of materials including logs, lumber, gravel bags, brick, concrete blocks, cast-in-place concrete, fiber rolls, boulders, cobblestone or rip-rap, all constructed in conjunction with earthen dams. The materials should be non-toxic and durable. Check dams can also be made from rock-filled gabion baskets (see "Gabion Structures" later in the chapter).

Check dams should span the swale or channel completely to avoid erosion at dam edges. The materials used should be anchored or heavy enough to resist the pressure of heavy flows. In general, cobble or rocks should be a minimum of 8 to 12 inches in size. Rock or stone can be encased in geotextile to prevent shifting during high flows. The geotextile can also be extended up and downstream of the dam to help prevent erosion on the front and rear aprons of the dam.

Logs should be four to six inches in diameter and embedded at least 18 inches into the soil or secured to vertical support logs that have been buried to that depth.

The center of the dam should be lower than the sloped ends of the check dam edges to ensure that water flows over rather than around the dam.

It is possible to use erosion control blankets, which are biodegradable open-weave blankets, in conjunction with check dams to facilitate vegetation growth on channel slopes and bottoms.

Check dams should be installed at heights and distances apart to allow small pools to form in the widened channel behind them, taking into account the length of time standing water will remain if the channel does not run between storm events. Standing water provides mosquito habitat and can kill vegetation in the channel if it remains for an extended period. In general check dams should be a minimum of 12 inches thick, as wide as the swale, and a minimum of three to six inches high. Check dams should be placed at every one foot drop in elevation or a minimum of 50 feet apart. For channels with steep slopes running their length, check dams should be spaced so the crest of each dam is at least as high as the toe of the next dam upstream, creating continuous ponding along the length of the channel or swale and preventing erosive flows (see Figure 22).

Maintenance: Look for evidence of scouring, channel erosion or damage on the dam front, rear apron, or at the outer ends of the dam and repair or adjust the dam layout accordingly. Periodic excavation of built-up sediment behind the dams may be required when sediment depth reaches half the dam height. If dam materials have been removed or misplaced by high flows, replace them and consider whether the dam design should be augmented to address similar volumes and velocities in future.

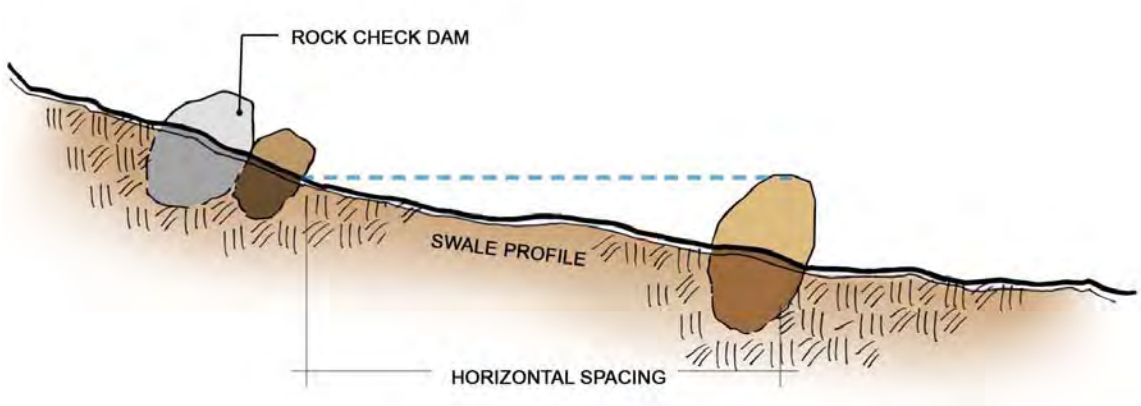


Figure 22. Check Dam Spacing

Gabion Structures

Photo 8. Gabion

Function: Gabions are semi-permeable structures that can be used to construct check dams to slow flows within water channels, or for retaining walls or channel revetment to stabilize highly erosive or steep slopes along channels. The resulting decreased water velocity helps to prevent erosion, allows sediment to settle out and facilitates water penetration into the channel and adjacent soils.

Siting: It is advisable to consult a qualified professional regarding appropriate siting and design. Gabion structures incorrectly constructed or placed can create or aggravate erosion problems and pose safety risks. Gabion walls are sometimes placed at or around curves to prevent erosion during large storm events. Erosion problems at the base and edges of the gabion wall can be lessened by providing a rip-rap apron. In smaller water channels that drain areas less than four acres, several smaller gabions constructed at frequent intervals are more effective than a single gabion greater than 3 feet in height. Channel banks at gabion locations should be firm or rocky and not sandy.

Construction: Gabions are large, multi-chambered, welded wire or wire mesh cages or baskets filled with 4-inch to 8-inch stones or other similar material that is appropriately sized to stay within the baskets. The cages are then wired together to construct flexible and permeable larger blocks which are then set in courses to build various structures. Gabion construction is simple and does not require skilled labor. Pre-fabricated gabion baskets can be purchased, or they can be custom-built. The baskets can be lined with geotextile to prevent buildup of sediment within the void spaces between fill stones; however, soil deposition and subsequent plant establishment can be desirable as it further stabilizes and naturalizes the structure. If the structure is being used as a check dam, it is important to include a downstream rock apron with a length double-to-triple the height of the gabion as shown in Figure 23. The depth of the structure should be double the diameter of the rock used in the rock apron. A minimum depth of 1 to 2 feet or a depth equal to twice the diameter of rock, whichever is greater, should be used. The apron should also span the entire width of the gabion. The apron should be encased in wire mesh and tied to the gabion in several places to prevent shifting.

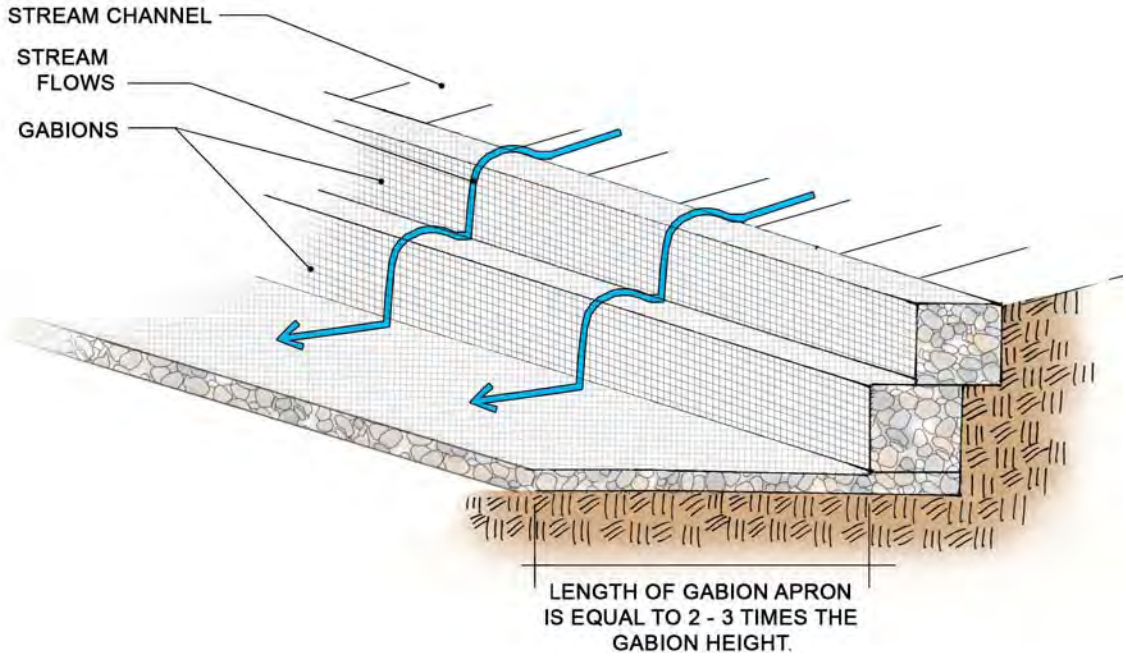


Figure 23. Gabion Structure

The wire mesh baskets are galvanized and can also be coated with PVC to prevent corrosion of the metal. Site conditions that could contribute to excessive corrosion, such as poor water quality and acidic soils, should be considered when determining whether coating is needed.

It is important that foundation surfaces are smooth and reasonably level and that the gabions are securely tied into them as well as into abutting surfaces. The baskets can be filled mechanically or manually.

Gabions should be placed perpendicular to the channel so that the water flows straight into the gabion rather than at an angle. Gabions can be placed at angle or parallel to the flow path to prevent erosion or slope stabilization problems at the banks of the channel. The gabion should be sunk 12 inches to 18 inches into the channel bottom and banks to hold it in position. The top of the gabion structure should be lower in the middle than at its edges at the channel banks to ensure that water flows in the center of the channel. It is advisable to consult a qualified professional regarding appropriate siting and design for gabion structures.

Maintenance: Properly constructed gabions are very robust structures as their permeable structure allows them to dissipate the energy embodied in stormwater flows. The porosity of gabions is useful in retaining wall applications as the voids allow evaporation and drainage to remove excess moisture from the backfill. When correctly built and sited they require very little maintenance. Periodic inspection is advisable to confirm baskets are intact and to look for evidence of undercutting or excessive erosion at transition areas. If such evidence is found adjust the gabion or apron dimensions to correct the problem.

Curb Cuts

Function: Divert stormwater from paved surface and direct it into landscape areas or conveyance devices.

Siting: Can be used to divert stormwater into parking lot islands or other adjacent landscape areas and to direct water into medians or landscape areas along roadway edges.

Construction: There are several types of curb cuts, such as a simple openings in a standard concrete curb (Photo 9), or one with additional features designed to facilitate, slow and direct flows (Photo 10). In some cases it is also possible to eliminate curbs by sinking parking island areas and installing car stops with perforations (Photo 11). In all instances, inflow areas should be protected from erosion by installing boulders, rip-rap, cobble, landscape fabric or similar materials.

Maintenance: Monitor openings to remove trash and debris. After storm events check for evidence of erosion and, if present, add materials to prevent further degradation.

Photo 9. Curb Cut

Photo 10. Modified Curb Cut

Photo 11. Curbless Option

Roof Drainage

Roofs are designed to shed rain in order to protect buildings from damage. In conventional designs, the water that falls on roofs is conveyed away from building foundations, then flows to the storm drain. Roof drainage can be captured and used on site through a variety of water-harvesting systems. The first components in such a system are the gutters and downspouts that collect and move the water down to the next component. As a general guideline, gutters should be at least five inches wide and should be composed of galvanized steel, aluminum or other non-corroding material. The front of gutters should be 1/2-inch lower than the back. Gutters should slope along their length at rates of 1/16-inch per foot for sectional gutters and 1/16 inch per 10 feet for seamless gutters. Consulting a company that specializes in gutter design and installation is advisable to ensure gutters are appropriate for the roof type, potential snow load and other factors.

Photo 12. Rain Chain with Rain Barrel

Downspouts should be spaced 20 feet to 50 feet apart and should be provided at a rate of one square inch of downspout area for every 100 square feet of roof area. Downspouts should direct water into the landscape or water storage devices such as rainbarrels or cisterns.

Rain chains or open canales can be used in place of downspouts to direct water to storage devices (Photo 12), or to conveyance devices such as gutter extenders or swales that divert it to landscaped areas. The various devices can be used alone or in combination; for example, rain chains and rain barrels could be used for individual units of an office complex or small apartment units. Large structures with vast areas of impermeable surfaces will require more complex site drainage systems with greater storage and infiltration capacity.

Photo 13. Roof Drainage using Canale Beams

Photo 14. Interior Crickets for Canale

Infiltration Devices

The water-harvesting methods described below are all types and scales of basins designed to collect, slow, and allow storm runoff to infiltrate into soils on the site. Water catchments and infiltration devices should be located at least ten feet away from building foundations and can be integrated into the landscape design.

Microbasins

Function: Collects and retains stormwater in localized basins.

Siting and Water Volume: Microbasins can be used to collect runoff from smaller areas with gentle slopes or from relatively flat land with low volumes of stormwater runoff. They can be built in a variety of sizes to support the differing water needs of single or multiple plants. In parking lots, planter areas can be designed to harvest runoff that comes through curb cuts (Photo 15). Microbasins are not appropriate for use in locations with heavy stormwater flow such as arroyos or washes. The scale of the basin must be based on site-specific conditions and potential stormwater flows. A series of basins with spillways connecting them can be constructed to address areas with more concentrated runoff; however, this approach requires consulting an engineer. Microbasins should be designed and constructed to capture and infiltrate stormwater quickly enough to avoid mosquito problems. Bernalillo County Ordinance, Chapter 38. Article III. Division 3 Design Standards require that retention ponds drain in 24 hours or less, with some exceptions.

Photo 15. Parking Island Microbasin

Construction: Microbasins can be constructed in a variety sizes and configurations, individually or in a series. Type and configuration options include:

- ***Localized Depression*** - This is the simplest form of microbasin, comprising a depression without berms (Figure 24). A variation of this type of basin would be depressing the interior of a parking island within a curb. Water collection potential could be further augmented by curb cuts.

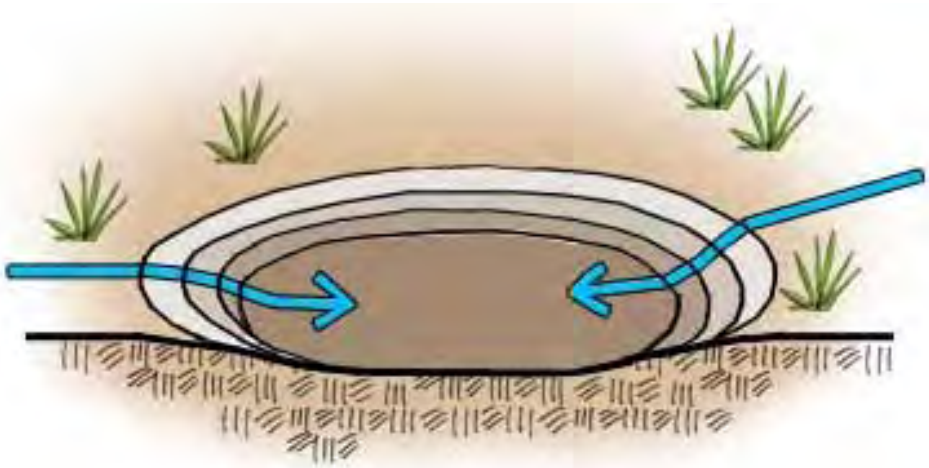


Figure 24. Localized Depression

- ***Eyebrow*** - Dig out a depression (basin) and deposit the excavated dirt downhill and on the sides of the basin to create a thick, gently sloped berm in the shape of a crescent pointing away from the water entry point as shown in Figure 25, A spillway to direct overflow can be created with an armored depression at the desired point along the berm. Compact the berm to help prevent it from eroding. The berm can also be armored with rip-rap or cobble or planted to further prevent erosion. Planting selections should consider conditions in the basins, such as the potential for temporary flooding in the bottom. The bottom of the basin can be flat or concave to concentrate water at the desired location or to provide even more infiltration across an area. Flatten the bottom of the basin without compacting. Microbasins should also be mulched and planted to facilitate rapid water infiltration.

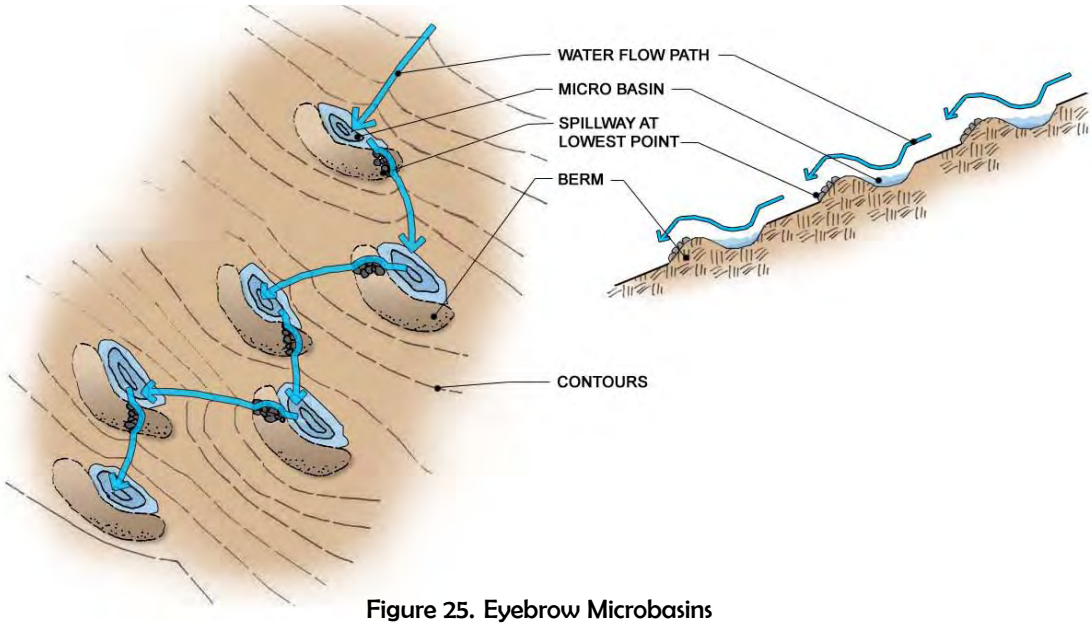


Figure 25. Eyebrow Microbasins

- ***Series*** - Microbasins can be constructed in a series to address moderate flows. Placing them in an offset path relative to each other lengthens the flow path and affords additional opportunity for infiltration. Spillways should be constructed as noted previously to direct overflow from one basin to the next.

- ***On-contour Series*** - Microbasins can be constructed in series along one or both sides of a ridge or elevated area to capture and infiltrate runoff. The basins should be placed to follow the contour line around the ridge, with their upslope ends at the same elevation. The same principle can be applied to collect runoff from elevated surfaces such as sidewalks (Figure 26).

Maintenance: Monitoring is critical. Microbasins should be checked following large rain events for evidence of overflow, which can indicate the need for adding or adjusting a spillway. If the basin is appropriately sized, sited, and constructed, overflow should rarely occur, with the exception of series basins that are designed to overflow into one another.

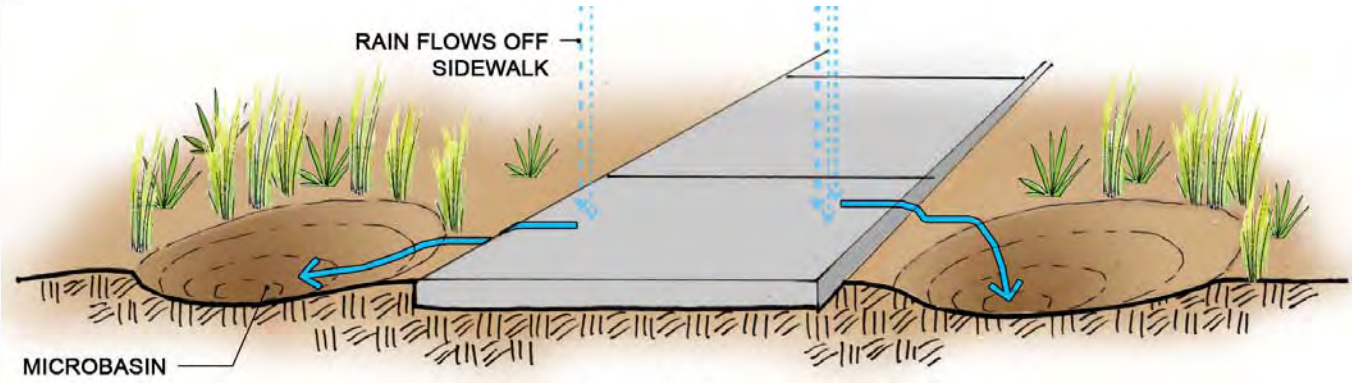


Figure 26. Microbasins along Sidewalk

Soil Imprinting

Photo 16. Soil Imprinting

Function: Imprinting roughens the land surface to increase its water-holding capacity, which facilitates increased infiltration of precipitation. The imprints funnel water into depressions. Water, seed, plant litter and topsoil mix together at the bottom where they help to germinate seeds and establish seedlings. Seedlings in the imprints are protected from drying winds and sunlight, providing increased germination and survival rates.

Siting: Imprinting is appropriate for reseeding areas that have compacted or degraded soils. It can be used on flat or sloping areas.

Construction: Imprints are formed by running a roller with angular steel teeth over the target soil surface. The steel teeth form troughs or indentations by compressing and shearing the soil, as well as crests or ridges that are lifted between the troughs. A well-designed imprinter produces these two interacting features with minimal soil disturbance or compaction.

Maintenance: Depending on the site conditions, imprinting and seeding may need to be repeated over a period of several years to achieve the required revegetation density.

Waffle (or Grid) Gardens

Function: Creates a series of square or rectangular depressions laid out in a grid (similar to a waffle) which collect and infiltrate water to support plant material requirements.

Siting: Waffle gardens can be used on flat or sloping terrain so long as the waffle basin bottoms are relatively level. This distributes water evenly and prevents it from accumulating in one area of the waffle or eroding the waffle wall.

Construction: Create small depressions either by excavation or by building up small berm walls between waffle basins. To work well, the waffle depressions should extend at least partially below grade to abate subsurface migration of water. Once they are planted, mulch the basins to increase moisture retention.

Maintenance: Re-excavate waffle basins as needed to ensure sufficient depth for water collection. If basin bottoms become compacted, amend soil or aerate to increase permeability.

Permeable Paving

Function: Porous, pervious or permeable pavings allow stormwater and air to filter through them and infiltrate the soil below, reducing stormwater runoff. Some pollutants are also removed. Permeable pavings can be used alone or in conjunction with sub-surface storage or water treatment devices such as vault reservoirs. Permeable pavings come in a variety of materials and can be used for a range of applications including parking lots, sidewalks, driveways, plazas and courtyards, tennis and basketball courts, bicycle trails, fire lanes and low-traffic roadways. The use of pervious paving can save money by reducing stormwater impact fees and the amount of land dedicated to stormwater retention or detention areas. Paved surfaces play a major role in transporting stormwater runoff and contaminants to receiving waters. Permeable paving can be used to infiltrate stormwater and reduce the amount of runoff leaving the site, helping to improve runoff quality and decrease downstream flooding. Using permeable paving materials reduces the effective imperviousness of the site while maximizing land use. Permeable paving also has the potential to reduce or eliminate the requirement for conventional stormwater retention/detention systems and sewer pipes.

There are several types of commonly available permeable pavings:

- ***Permeable concrete and asphalt*** are similar to standard concrete and asphalt, but are open-graded, meaning the aggregate is of a consistent size with no fines, or small particle, content. A special binder is frequently included in the material mixture as well. The open-graded aggregate creates void spaces throughout the paving material which allow water and air to pass through it and into the ground below. Methods for installing permeable pavements differ from the standard, impervious types. Most permeable paving systems have an aggregate base to provide structural support, act as a base reservoir to provide runoff storage, remove pollutants through filtering and adsorption. Well-constructed porous pavements have the capacity to meet or exceed a site's pre-development infiltration level.

  When properly installed, **permeable concrete** contains 15 to 30 percent void space throughout its entire volume which allows water to drain through to the soil below (Photo 17). The void spaces increase in size from top to bottom of the concrete's cross section, reducing the chance of clogging. Potential flow rates through pervious concrete range from 140 inches per hour to more than 1,000 inches per hour. An additional benefit of pervious concrete is its performance during precipitation and freezing events. The moisture does not remain on the surface but instead moves down into the voids and base course reservoir, providing a safer driving surface. As an example, a 1-inch by 1-inch by 6-inch deep column of permeable concrete can store 1.5 inches of stormwater. The voids also harbor beneficial bacteria, which help to break down pollutants such as hydrocarbons. The cement-based concrete does not leach harmful chemicals, though it can slightly impact the pH of soil it contacts. Pervious concrete can also reduce the heat island effect as it can be as much as 12 degrees cooler than conventional pavement. Porous concrete can be constructed to a range of load-bearing strengths but when used for roads is generally restricted to lower and lighter traffic loads.

Photo 17. Permeable Concrete

  Porous asphalt surfaces are used on highways and other roads to improve driving safety by removing water from the surface. It can also be used for jogging paths, bike trails and similar applications. Porous asphalt does present some potential issues that should be taken into account, however. Asphalt is oil-based and can leach toxins, which can be carried into the receiving soils along with infiltrating stormwater. Healthy soils can remediate some of these toxins, but care should be taken to ensure adequate remediation capacity exists to prevent problems. Another consideration is the potential for "drain-down" that can occur when porous asphalt is exposed to higher temperatures such as during New Mexico summers. Drain-down happens when the asphalt binder migrates downward through the asphalt's void spaces due to heat and gravity. As the softened binder flows downward, it carries particulate matter such as sand and dust from the surface until it encounters a cooler area. The binder then fills the void spaces at that level and hardens. Over time drain-down can greatly reduce or eliminate the asphalt's permeability. At the time of this writing, the only solution is to replace the asphalt.

- ***Open-jointed pavers*** can be made of concrete or stone and are laid with open, permeable spaces between the pavers. The built-in drainage spaces can be filled with rounded gravel or a well-draining soil mix and planted with grass or groundcover. These pavers are not as structurally stable as interlocking pavers and so are appropriate for slower speed and lower weight traffic-related applications (Photo 18).

Photo 18. Open-jointed Pavers

- ***Interlocking concrete or brick pavers*** are precast with spacers that automatically provide a consistent drainage space around each paver. The drainage spaces can be filled with gravel or a well-draining soil mix and planted with grass or groundcover to allow stormwater to filter through to the underlying soils. Interlocking pavers are very durable, require minimal maintenance and have heavy weight-bearing capability. Interlocking pavers may in some cases be placed over a stone reservoir base to increase water detention and infiltration capacity. An additional advantage of pavers is their ability to be reused.

Photo 19. Interlocking Pavers

- **Grass paving grids** (also called reinforced turf) are composed of a flexible grid of plastic rings placed over a base course that is usually a blend of gravel, sand and topsoil when topped with turf. The ring grid is filled with topsoil and planted with grass or a groundcover. Grass paving grids are appropriate for low-speed, low-traffic-frequency areas such as overflow parking, residential driveways and fire and maintenance access lanes.

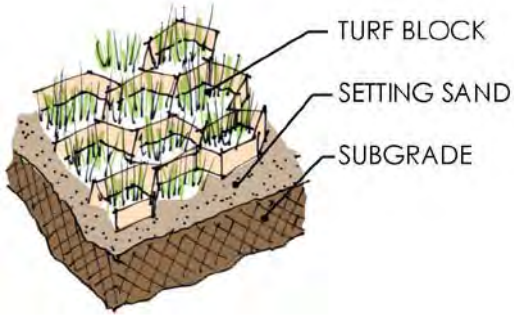


Figure 27. Grass Paving Grid

- **Gravel pavers** are based on the same flexible plastic ring grid as grass pavers but are placed over a geotextile and filled with gravel, which provides increased load-bearing capacity compared with grass pavers. Potential uses for gravel pavers include any low-speed, high-frequency traffic areas such as parking lots and vehicle storage yards, service yards or outdoor bulk storage areas. The ring grid structure of grass and gravel paver systems, along with the base course layer, distributes loads and help to prevent soil compaction and erosion. These paving solutions also help to reduce heat island impacts. In addition, the ring grid system is frequently manufactured from post-consumer recycled plastic.

- **Crusher fines** are a mixture of aggregate and small stone particles, typically 3/8-inch or less, and are available in a range of colors. Fines with no binder added are appropriate for low-use walkways or trails. With the addition of binding agents such as polymers, resins or plant-based binders such as psyllium, **stabilized fines** can be used for higher-use walkways and trails, as well as areas such as outdoor break rooms or recreation areas. An advantage of fines is ease of maintenance; they require only raking and compaction and periodic replacement of displaced or degraded material. Fines also contain no oils or toxins that could leach out, and depending on color, can have a lower heat reflectivity level than other regular concrete or asphalt. Fines provide a more cushioned surface for running and mountain biking than concrete or asphalt and are less expensive than those materials.

- **Single-sized aggregate** such as loose gravel or stone-chips without any binder, is a highly permeable and relatively inexpensive paving option appropriate for low-speed, low-traffic settings such as car-parks and driveways.

Siting: Generally, permeable pavings should be placed at least 3 feet to 4 feet above the level of the seasonal high-water table to avoid water pooling within the paving or base course material and potentially causing damage. Permeable pavings also generally require either well-draining subsoil (sandy soil or sub-grade treatment) to provide sufficient temporary storage space to allow water to infiltrate the receiving soil. The infiltration capacity of the underlying native soil is a critical design consideration for determining the necessary base course depth for stormwater storage and for determining whether an under-drain system will be required. The paving design should infiltrate the design storm runoff into the underlying soil within 24 to 48 hours. If the subsoil is composed predominantly of clay, silt or other expansive soils, care should be taken to ensure the paving design will drain and infiltrate water effectively

within the required time frame. If the underlying soil type does not allow for complete infiltration within that time frame, modifications such as an overflow drainage pipe, increased subbase storage capacity, or water draining to alternative temporary storage and infiltration devices may be required. **Fines and aggregate pavings** should be applied on slopes greater than 6% to avoid loss due to surface runoff erosion. When placing fines on expansive or hydric soils such as clay, use of filter fabric is advisable to avoid saturation and surface-cracking. **Permeable concrete, asphalt and some pavers** are laid over a rock base course that has large void, or pore, spaces. The base course supports the pavement and acts as a reservoir, holding stormwater until it can infiltrate the native soil below, or in systems with under-drains, by slowly release to the storm drain system. Highly permeable soils, such as sandy soils, have the greatest load-bearing capacities. The lower capacities of other soil types can be offset by the design of the base course underlying the permeable pavement. Care should be taken to avoid placing permeable pavings in locations where they will be subjected to large amounts of sediment being deposited by wind or water onto the paving surface. This can clog the pore spaces and inhibit drainage and infiltration over time. Such issues can be mitigated through use of other water quality devices such as filter strips, which help to reduce the amount of sediment in stormwater flowing onto the paving. Always follow manufacturers' recommendations for siting and installing manufactured paving materials.

Construction: The general construction steps for permeable pavings are listed below. Detailed design and construction specifications are commonly available for manufactured pavers and paving systems.

Permeable pavings are composed of the surface material, either permeable paving or pavers, laid over a storage layer, which is usually a coarse stone aggregate topped by a layer of smaller aggregate. This acts as a choker course, separating the surface material from the storage layer. The aggregate layer may be wrapped in non-woven geotextile. The geotextile keeps soil from clogging the storage layer.

The depth of the rock or gravel subbase should be based on the weights, frequency and speeds of the traffic it will carry, the infiltrative speed and capacity of the underlying native soils, and the amount of stormwater to be handled. An under-drain system can also be used to connect to the storm drain system to address runoff in excess of the soil infiltration and storage reservoir capacities.

Additional factors for consideration include winter conditions, such as numerous freeze-thaw cycles that may dictate increased base thickness to protect the permeable paving from heave damage.
The basic steps of the construction process are excavation, subbase installation, and finally overlay of the selected permeable paving. If a turf or gravel paving system is being used, the voids in the paver grid are filled with the relevant material (topsoil and turf, loamy sand, pea gravel, larger-sized washed gravel, etc.) depending on the system's purpose and use. Permeable pavers are placed on a layer of sand that is spread over permeable geotextile fabric laid on top of the base course. The pavers are then leveled with a vibrating plate compactor, and the joints filled with sand or the appropriate permeable fill material. Whereas most paver systems can be used immediately after installation, permeable concrete or asphalt should be allowed to cure according to the installer recommendation (usually a few days). Grass-pave systems require sufficient time for the plant material to establish before receiving significant traffic.

Crusher Fines pavings should be compacted in moist (not wet) fines in 3-inch to 4-inch lifts with a vibrating plate. It is possible to add a subbase of 3/4-inch rock wrapped in filter fabric (like a burrito) in areas with drainage issues. Use of a geo-web product in addition to commercially available binders will further stabilize the fines. The surface of the pathway or trail should be sloped or crowned 3% to 5% to ensure positive drainage.

Maintenance:

- **Grass and gravel pavers.** Minimal maintenance is required to ensure good infiltration. Keep the paver surface clear of organic materials (leaves, grass clippings, etc.). Periodic vacuuming or low-pressure washing should be used to clear out voids. The required frequency should be based on site conditions. Gravel fill may also need to be added after cleaning gravel pavers. Grass pavers require watering and mowing like any turf system. If the paver area will be subject to snow removal, care should be taken to lift the plow blade to clear the grass or gravel surface. Avoid using sand, salt, ash or other chemical de-icers as they may clog the paving pore spaces.

- **Permeable concrete and asphalt.** The surface should be kept clear of sediment, dirt, sand and organic debris to avoid clogging the pore spaces. With New Mexico's high winds and sandy soils, also include a minimum cleaning frequency. The maintenance considerations for permeable pavers are similar to other permeable pavements but care must be taken when vacuuming the space between pavers so that small drainage aggregate is not removed,;this can cause clogging problems downstream. Periodic vacuuming is recommended to clear out voids and extend the functional life of the paving, with the frequency based on site conditions. During winter avoid using sand, salt, ash or other chemical de-icers as they may clog the paving pore spaces.

- **Crusher fines.** Surface repairs should be done as-needed based on compaction and wear, generally every couple of years. Edges of paths or trails may also require weed removal, and hardeners should be reapplied to **stabilized fines** on an as-needed basis.

- **Single-sized aggregate.** Simply requires replenishment as needed.

Water Quality Improvement Devices

Bioretention Cell or Basin

Function: Bioretention basins are shallow landscaped depressions or basins used to slow and treat on-site stormwater runoff. Stormwater is directed into the basin and filtered through the basin soil and plants. The cleaned water then infiltrates underlying native soils or can also be used with conveyance or storage devices as part of a stormwater treatment and infiltration system. In addition to stormwater control and filtering functions, bioretention cells can help to address on-site erosion issues and provide habitat for birds and insects.

Siting: Bioretention basins are appropriate for residential, commercial and industrial sites. Potential locations include median strips, plazas and parking lots as well as other areas on the site. The drainage area feeding the basin should not exceed two acres in size and should not contain significant sediment. If surrounding areas will contribute significant amounts of sediment, the basin should be designed with water quality improvement devices such as vegetated swales or filter strips for pretreatment to reduce sediment loads to acceptable levels. The pretreatment devices should be selected based on site conditions and constraints. Areas feeding the basin should have a minimum slope of 0.5% for paved areas, and 1.0% for vegetated areas in order to maintain positive flow into the basin.

Construction: Bioretention basins typically include several key components: the contributing drainage area, any pretreatment devices; the ponding zone; a layer of mulch, vegetation, engineered basin soils; a storage layer and an underdrain system to address excess runoff that cannot be infiltrated as quickly as needed. The ponding zone should be 12 inches or less in depth with side slopes of 2:1 or less, and should drain within 24 to 48 hours. If the infiltration rate of the underlying native soils is less than 3.6 inches per hour, a 3-inch layer of sand mixed to a depth of 2 to 4 inches with the native soil, topped by a storage layer of uniformly-sized, washed gravel or stone should be added to facilitate infiltration. For locations with extremely dense, low-permeability soils such as caliche, greater measures may be necessary. The depth of the storage layer should be based on needed storage capacity to address runoff and should not exceed 48 inches. An under-drain pipe with a 6-inch minimum diameter should be installed at the top of the storage layer and should include a clean-out for maintenance. The under-drain should be wrapped

in a filter sock to prevent clogging and should discharge into a stable infiltration outlet such as a swale, or into the storm sewer system. Compacting basin soils during construction should be avoided in order to achieve maximum infiltration rates. The engineered basin soil mixture can be structural soil or a mixture of sand, compost and topsoil. This should be premixed and placed in 12-inch-deep lifts. A layer of permeable geotextile or a 2- to 4-inch layer of pea gravel should be placed below the engineered soils mixture to prevent it from permeating and clogging the storage layer. Plants should be selected for their ability to deal with basin drought and flood conditions. The mulch should be permeable but large enough to avoid excessive floating and should be installed in a 2- to 3-inch layer after planting is completed.

Maintenance: Bioretention basins should be regularly inspected to insure infiltration is occurring at the desired rate and that water is not ponding in the basin longer than 48 hours. Any eroded areas should be repaired following storm events, and the drain structure should be checked for clogging. Debris and accumulated sediment should be removed annually and plant material replaced if needed. The mulch layer should also be replenished annually.

Tree box filters are a variation of bioretention cells placed in sub-grade containers containing trees. They are used in urban streetscapes and parking lots to capture and treat runoff by removing pollutants as the runoff filters through the box soil media. The runoff also provides irrigation to the tree or other plant material in the box filter system. The basic components of a box filter system are a container filled with a highly permeable bioretention soil mixture over a layer of gravel or crushed stone with an under-drain system that discharges either into surrounding soil or the storm system. Stormwater runoff drains directly from impervious surfaces through a filter media. Because of their relatively small individual capacity, use of multiple box filters in a stormwater drainage area are needed to significantly reduce peak flow rates. Tree box filters provide a space-efficient stormwater management solution with high pollutant removal rates while providing a beneficial environment for street trees.

Proprietary tree box filter systems are also available for purchase and can offer cost-effective and high-performing runoff reduction and water quality improvement capability.

Filter or Buffer Strip

Function: Filter strips are used to slow runoff, allowing pollutants and sediment coming from large or significantly polluted impervious surface areas to filter out before the runoff reaches other water harvesting and treatment measures or receiving areas. Filter strips also help to prevent sheet and rill erosion. Rill erosion results from overland flow that is focused by the soil surface roughness and creates narrow, shallow incisions into the soil. They are best suited to provide water quality improvement and infiltration of runoff from roadways and parking lots generated by lower intensity rain events. Most higher velocity runoff from intense rain events is generally only conveyed by the filter strip, so they are often used in conjunction with other water-harvesting devices. There are a variety of filter strip types including sand, gravel, turf or grass, and vegetated filter strips. In the arid Southwest, sand or gravel filter strips are generally more viable than vegetated strips. Filter strips located adjacent to bodies of water are called buffers. In general, filter strips have a uniform mild slope stretching downward from the surface contributing the runoff.

- **Sand or gravel filters** - To achieve maximum reduction of peak flow and stormwater runoff, it is important to locate filters in soils that accommodate infiltration and to minimize ponding depth. Careful site analysis is required to design an effective, integrated network of these systems throughout a landscape.

  Design depends largely on the drainage area's characteristics. Underground sand filters are suited to urban areas with limited open space and a high percentage of impervious surface. Above-ground systems are suited to large drainage areas with adequate open space, such as highway interchanges, that have soils suitable for infiltration. Diatomaceous earth can also be used for filter strips. As with any infiltration/filtration system, when sand, gravel or diatomaceous earth filters are used in pollution hotspots or in poorly draining soils, they should be lined and outfitted with sub-drains that discharge to the surface.

Siting: Generally filter strips are most effective on slopes greater than 1% and less than 5%. They should be at least 2 to 4 feet above the groundwater level to avoid permanently wet conditions that can breed mosquitoes and other disease vectors. Typical filter strip configurations are long and narrow, with a minimum flow path length of 15 feet to provide adequate area for water infiltration. The width of the strip should be equal to that of the contributing surface. Filter strips should not be used as paths or roadways. Additional considerations include use of de-icers or sand on the runoff-contributing surface. The former can impact health of grass or vegetated filter strips, whereas large amounts of sand can diminish the useful life of the filter strip, requiring increased maintenance.

Construction: The filter strip should be uniformly graded with a slope between 1% and 5%, with the toe and top of slope as flat as possible to ensure even sheet flow and avoid ponding and erosion issues. If flows from the contributing area above the strip are concentrated, a level spreader may be needed to ensure even sheet flow, which is critical for correct filter strip performance. A range of level spreaders can be used, including concrete curbing, or a 1-foot by 2-foot deep gravel filled trench can be constructed to deliver even sheet flow to the filter trench area.

For vegetated filter strips, grasses or a range of native xeric, low-growing plants are appropriate. If vegetation will be started from seed, erosion control measures should be used to protect seed and seedlings until they are sufficiently established to withstand erosive flows moving across the filter strip area. Supplemental irrigation may be required during the establishment period of vegetated strips. Adding a low permeable berm at the downstream end of the strip can reduce the required strip width by lengthening the time runoff is in contact with the strip. The berm should be one foot or less in height and made of permeable material such as a mixture of gravel and sand. Generally filter strips are designed to address flows from smaller, higher frequency storm events, usually one- to two-year storms. If flows from larger storm events have the potential to damage the strip, include a bypass mechanism to move those flows into other stormwater devices.

Maintenance: Check for and repair any eroded areas, such as channels formed by concentrated flows, to facilitate even flow over the filter strip area. If large amounts of sediment have unevenly accumulated, they should be removed to avoid disrupting sheet flow over the strip. Periodic re-grading and refurbishment of the upslope filter strip edge may be needed, depending on sediment deposition rates. Weed and invasive species removal, mowing, and trimming is appropriate for vegetation health. Reseeding or replanting may be needed for grass or turf filter strips if concentrated flows have eroded vegetation away. Use of erosion-control blankets for repair areas can aid re-establishment. Turf strips should be mowed regularly to maintain a 3- to 4-inch grass height. Mowing should be done when the soil is dry to avoid compaction and tracking damage which can disrupt even sheet flow and filter strip function. If vegetation is sparse or grass has not established appropriately, consider replacement with alternate species. If the filter strip design includes a gravel trench level spreader, periodic removal of sediment will be needed.

Constructed Wetlands

Function: A constructed shallow vegetated basin or series of linked basins that are permanently or seasonally flooded, constructed wetlands are extremely effective for water quality improvement. They remove pollutants and also perform varying degrees of infiltration function depending on underlying soil types.

Siting: Constructed wetlands are generally more appropriate for larger sites. They require a relatively large amount of space as well as sufficient base flow to maintain the water level for wetland vegetation health and appropriate pollutant removal – a key consideration in the desert Southwest. Safety is a critical concern when siting and designing wetlands, and public access should be addressed with care. Constructed wetlands are especially useful for mitigating high nutrient loads in runoff from areas such as golf courses. Constructed wetlands are not appropriate for areas with steep or unstable slopes, and untreated runoff should never be directed into existing natural wetlands. Depending on the depth, volume and discharge amounts of the ponding areas, approval from the New Mexico Environment Department may be required.

Construction: Given the complexity of constructed wetland design, utilizing the services of a professional for siting, design and construction is highly advisable to ensure appropriate water quality function and to avoid potential nuisance and disease vector issues. A few construction considerations include the potential use of an impermeable liner to maintain adequate ponding levels in areas with high porosity soils and ensuring that pipes and outlet structures are appropriately designed and constructed to prevent structural failure from water erosion of the berm or dam fill.

Storage Systems

Detention Pond

Function: Detention ponds are reservoirs designed to reduce peak flow associated with large storm events by temporarily detaining a set amount of stormwater runoff while it infiltrates or is slowly discharged to another location. The ponds improve runoff water quality by removing sediment particles and the pollutants that cling to them by allowing them to settle out in still water. During storm events, runoff enters the pond's upstream inlet, and the heavier sediment-laden stormwater displaces cleaner, lighter water held in the pond by moving it up and out through the discharge outlet. The recently added stormwater then remains in the pond, allowing the sediment and pollutant load to settle out. Detention ponds can also help to prevent channel erosion. Recent studies indicate that designs that provide detention for a period of 12 to 24 hours and are based on smaller design storms, such as a one-year storm, are more effective for this particular purpose.

Detention ponds can take the form of dry or wet ponds or constructed wetlands. Detention ponds allow sediment particles and pollutants to settle out of detained stormwater. Dry detention ponds do not have a permanent pool and are often designed with small pools at the inlet and outlet of the pond. Detention ponds can be used to provide flood control capacity by including additional detention storage beyond the extended detention level.

Dry detention ponds can serve multiple purposes in addition to their stormwater management functions, such as being used as plazas, sports areas and park-like spaces during the dry season. They can also be designed with multiple levels to keep low-frequency storm events segregated to allow use of the majority of the pond area. In other situations they can be small oases of lush plants that can take advantage of the additional water (see Figure 28).

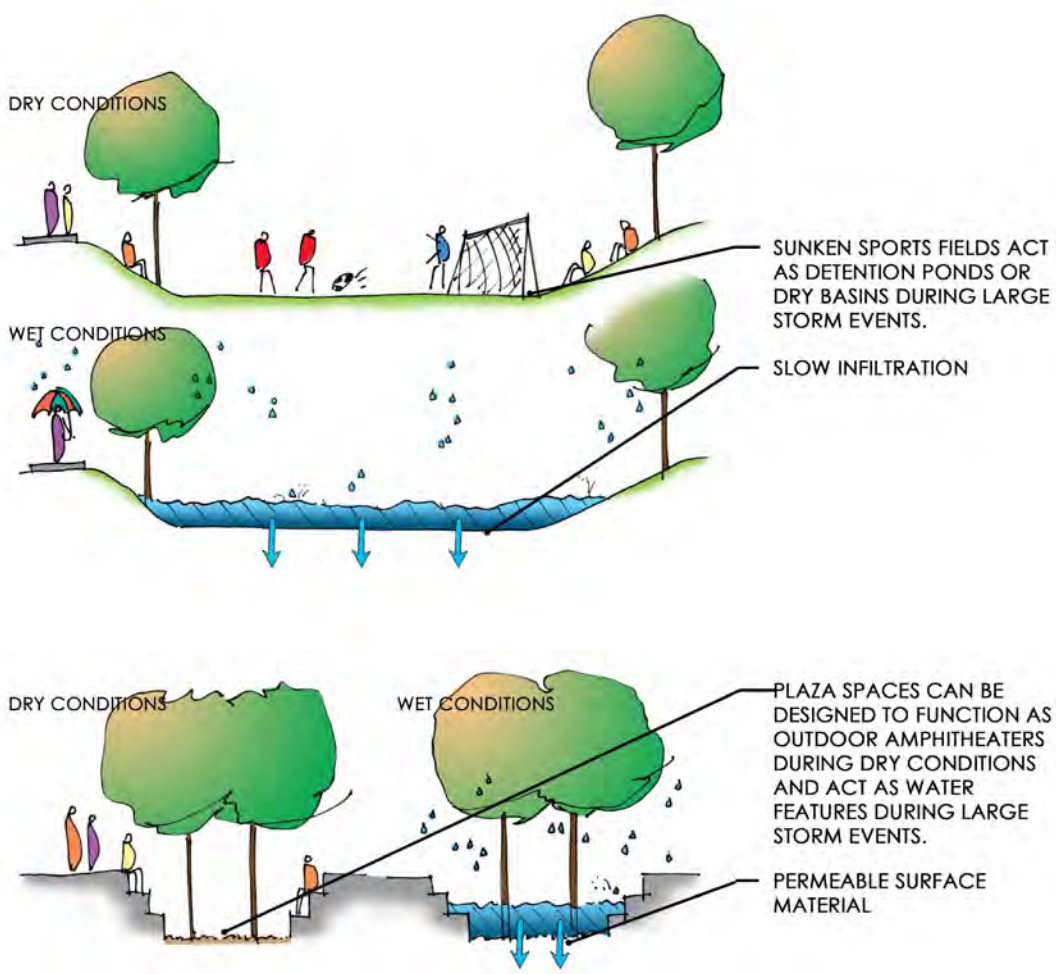


Figure 28. Multipurpose Detention Pond Areas

Detention ponds can be designed to address multiple stormwater control and quality objectives as shown in Figure 29. Detention pond outlets can be any type of conveyance device that allows water to flow out at a controlled rate. Multiple outlets can be used to address different flows from various-design storm levels.

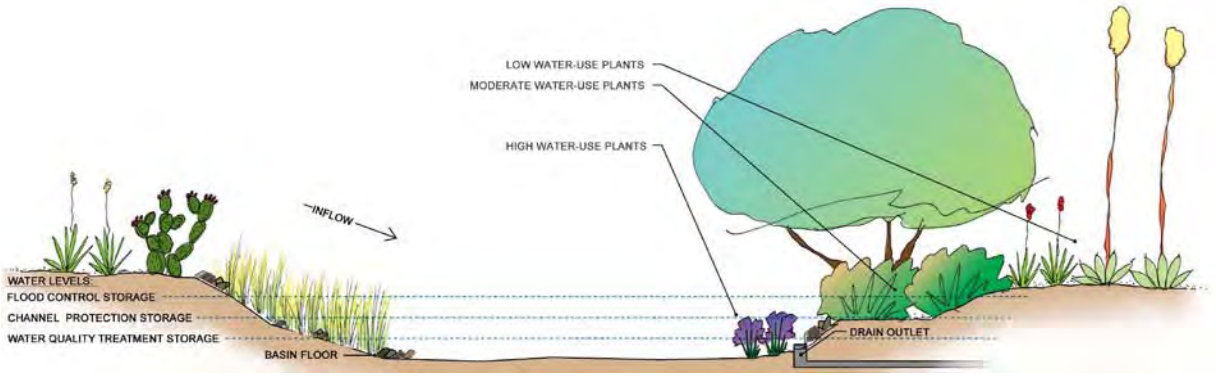


Figure 29. Detention Pond Storage Levels

Siting: Dry, extended detention ponds can be constructed on sites with stable slopes up to 15% as long as the basin bottom is relatively level. Pond drainage can be problematic in low-relief terrain areas, however. A minimum drainage area of ten acres is generally advisable for dry, extended detention ponds due to pond construction costs and the potential for outlet orifice clogging. It is important to ensure that the elevation drop from the pond inlet to the pond outlet is sufficient to enable water to flow through the system. The slope of the area upon which the pond will be built should be relatively flat, and side slopes of the pond should not exceed 3:1. A minimum separation of three feet between the water table and pond bottom is recommended.

Detention ponds can be used on any soil type, with minor design adjustments needed for quick-draining soils. Dry, extended detention ponds should be a sufficient vertical distance above the groundwater table to avoid permanent wetness in the pond bottoms which can lead to mosquito issues. If the pond will receive highly contaminated runoff from point-pollution sources, increased separation distance from groundwater will be required.

If the pond will be located on rapidly draining soils such as sand, an impermeable liner may be needed to prevent possible sinkholes or groundwater contamination.

Construction: It is advisable to consult a qualified professional when designing and constructing detention or retention pond facilities in order to ensure a safe, appropriately functioning pond that meets the requirements of applicable engineering standards. Detention and retention ponds used to control stormwater runoff are required to be certified by a New Mexico licensed engineer. Pond size is driven by the desired outflow water quality level and rate and based on a chosen design-storm level. The design capacity of stormwater ponds is frequently based on 200-year, 100-year, 5- to 10-year or 1- to 2-year storms. In addition to the design-storm level, determination of the water storage volume needed for a detention/retention pond is based upon the area of the contributing watershed, amount of impermeable surface within that area, soil type, and vegetative cover (see "Appendix B. Pre- and Post-Development Calculation Worksheets"). The required pond size can be reduced by maximizing the number of on-site infiltration areas. In general the pond's length should be greater than its width. This prolongs total detention time by maximizing the flow path, increasing filtration and infiltration. Remember, detention and retention ponds used to control stormwater runoff are required to be certified by a New Mexico licensed engineer.

A range of features can be included in the detention pond design, but basic pond design should include runoff pretreatment, treatment and conveyance, as well as maintenance reduction and vegetation features. Pretreatment removes larger sediment particles in a small pool called a sediment forebay before the water moves into the treatment area or main body of the pond. In the arid Southwest, a dry sediment chamber may be used in place of a wet forebay. Plants used in detention areas should be selected based on their ability to tolerate drought and flood conditions that will prevail in the ponding area. Pond design can also address periodic high runoff volumes created by snowmelt. Vegetation for ponds handling snowmelt runoff from roads may need to be salt-tolerant. Combination retention-detention ponds have outlets that are installed at a higher elevation than the bottom of the pond so that some stormwater can be retained and the remainder can be directed to landscaping or stormwater facilities.

Conveyance features to move water into and out of the pond should be designed to prevent erosion from occurring along them.

In order to maximize land use extended dry detention ponds can be designed to serve multiple functions, such as providing a recreation or playing field area during dry periods.

Wet detention ponds generally have a primary function of improving stormwater runoff quality because they can provide significant pollutant reduction. Wet ponds must be properly designed and maintained to achieve their stormwater quality functions; it can take from three to six years to reach the ecological balance necessary to do so. During that initial establishment period, issues such as excessive algal growth and nuisance odors may be experienced. The design of wet ponds requires a few additional considerations to ensure appropriate function. The pond length should be three to five times its width and simply shaped to promote adequate water circulation. The permanent ponding depth should be a minimum of 3 feet—ideally 6 feet—to decrease light penetration and prevent sediment scouring. The sides of the pond should be designed with slopes that help to promote safety, minimize mosquito habitat and prevent excessive rooted aquatic plant growth, such as those noted in Figure 30. An underwater planted shelf around the pond perimeter can help to improve pollutant removal and prevent physical access to the deeper pond areas.

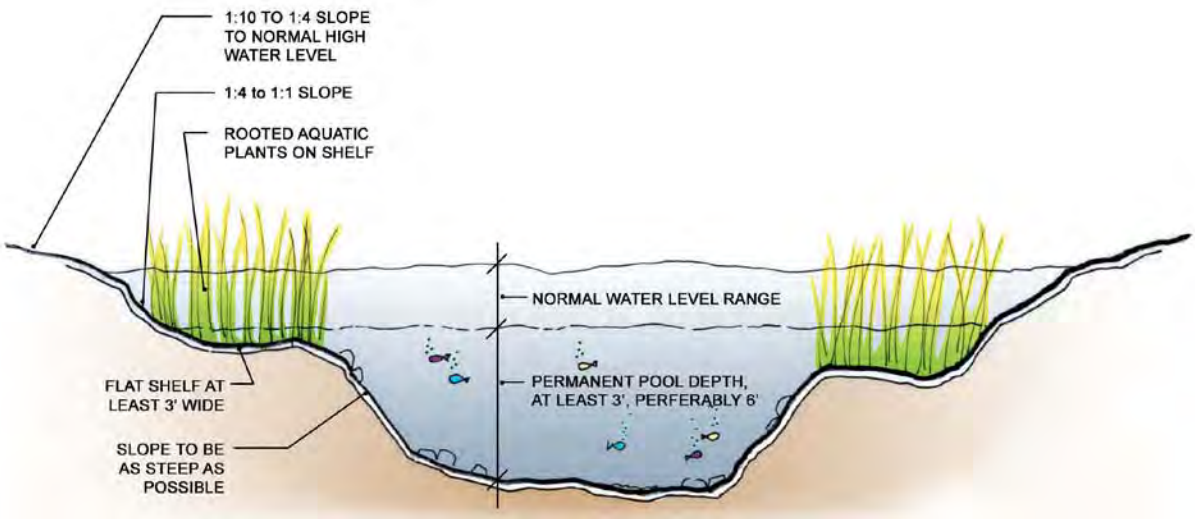


Figure 30. Wet Detention Pond

Pond inlets and outlets should be spaced well apart to avoid malfunction and designed to prevent erosion due to scouring. Outlet design should maximize sediment retention during periods of low pond depth through low outflow volume. Inlets and outlets should be designed to prevent safety issues, and an appropriately-sized emergency spillway should be included. The emergency spillway allows extreme-storm-event flows that exceed the pond design capacity to safely exit the pond without causing structural damage.

If the water sources flowing into the pond are contaminated or highly polluted, inclusion of preliminary water treatment devices may be needed to avoid exceeding the pond's pollutant-bearing capacity. A drain to facilitate pond maintenance and access routes for maintenance equipment should also be included.

Maintenance: Periodic inspection—at least twice annually—is advisable. Inspection should include checking for signs of bank or bottom erosion and damage to embankments, verification that inlets and outlets are functioning and free of debris, and monitoring of sediment build-up in the pond and forebay area. If runoff feeding into the pond is high in sediment, the latter two inspections may need to be performed more frequently. Sediment should be removed when total pond volume has been reduced by one quarter. Accumulated debris or litter should be removed, dead vegetation replaced, and any erosion or undercutting damage repaired.

Wet detention ponds require periodic dredging to remove contaminated sediment. Dredging frequency can be reduced through pond design that includes excess or sacrificial volume.

Retention Pond

Function: Retention ponds are designed to hold stormwater and allow it to infiltrate; therefore, do not incorporate outlets. These ponds can be used in conjunction with a variety of water-harvesting techniques such as swales and other conveyance devices, or can receive stormwater directly as it is diverted from a paved surface. The design considerations listed above for wet and dry detention ponds are applicable to retention ponds, with the exception of outlets; however, the design should account for emergency overflow.

Siting: Retention ponds can be constructed on sites with slopes up to 15% as long as the basin bottom is relatively level. The slope of the area upon which the pond will be built should be relatively flat, as side slopes of the pond should not exceed 3:1. A minimum separation of 3 feet between the water table and pond bottom is recommended unless the pond is designed as a wet pond.

Construction: Key objectives of retention pond design include safety (due to the potential hazard represented by standing water), disease vector prevention (such as mosquitoes) and appropriate and excess capacity management. Generally pond depth should not exceed 8 feet. It is advisable to consult a qualified professional when designing and constructing detention or retention ponds in order to ensure a safe, appropriately functioning pond.

Maintenance: Periodic inspection, at least twice annually, is advisable. Inspection should include checking for signs of bank or bottom erosion and monitoring of sediment build-up in the pond and forebay area (if applicable). If runoff feeding into the pond is high in sediment, the latter two inspections may need to be performed more frequently. Sediment should be removed when total pond volume has been reduced by one quarter. Accumulated debris or litter should also be removed, dead vegetation replaced and erosion or other damage repaired. Verification that mosquitoes and other disease vectors are not present should also be performed, and any issues addressed.

In-ground Temporary Storage and Infiltration Systems

These comprise a variety of methods devised to temporarily hold stormwater in the ground and allow it to infiltrate. They usually employ minimal technology and can be easily installed by a landscape contractor or homeowner.

French Drains

Function: French drains are rock-filled trenches designed to facilitate infiltration of stormwater. The concept is to allow the water to infiltrate surrounding soils through the trench sides, ends and bottom. French drains can be constructed independently, as shown in Figure 31, or as part of a more complex water-harvesting network.

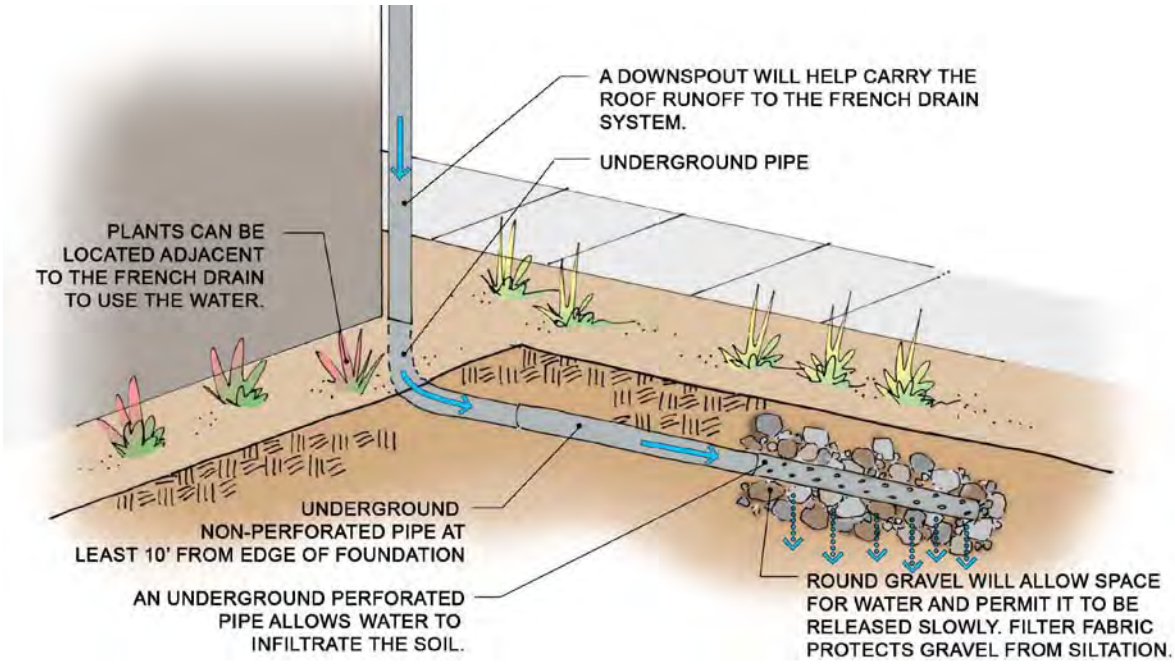


Figure 31. French Drain

Figure 32 illustrates the incorporation of French drains, swales, and microbasins in a residential landscape. When these techniques are used in conjunction with devices such as rainchains and rain barrels, they can provide 30% to 80% of the water needs for the landscape.

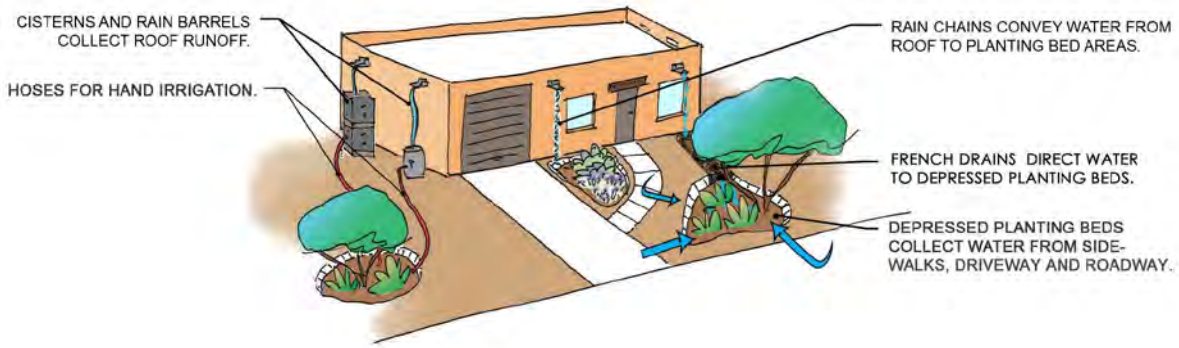


Figure 32. Water Harvesting Using French Drain, Swales and Microbasins

Siting: French drains are appropriate for low to moderate flows on flat to moderately-sloped areas and can be used in steeply sloped areas to provide greater storage volume than would be possible with surface basins. The soil surrounding the drain determines how quickly water will be able to infiltrate. Sandy or gravelly soils drain fastest, whereas heavier, clay soils drain more slowly. Thus, the soil type should be taken into account when determining the size of and location for the drain. French drains have about one-third the water-holding capacity of an open trench due to the space consumed by their rock fill.

French drains can be placed either on or across contours; either configuration can help to prevent erosion by capturing and slowing water, allowing it to infiltrate.

To avoid diminished infiltration over time, the runoff feeding into French drains should be low in sediment. If some sediment will be present, wrapping the rock fill in filter fabric, or placing the drain in conjunction with filtering devices such as filter strips or microbasins can help prevent clogging. French drains should not be placed in watercourses due to the high sediment potential.

Try to avoid placing French drains within the root zones of existing trees as the excavation will destroy roots and could compromise the tree's health. If placing the drain within an existing tree root zone is the only or best option, orienting the drain to run radially towards the tree trunk will minimize root destruction (see Figure 33).

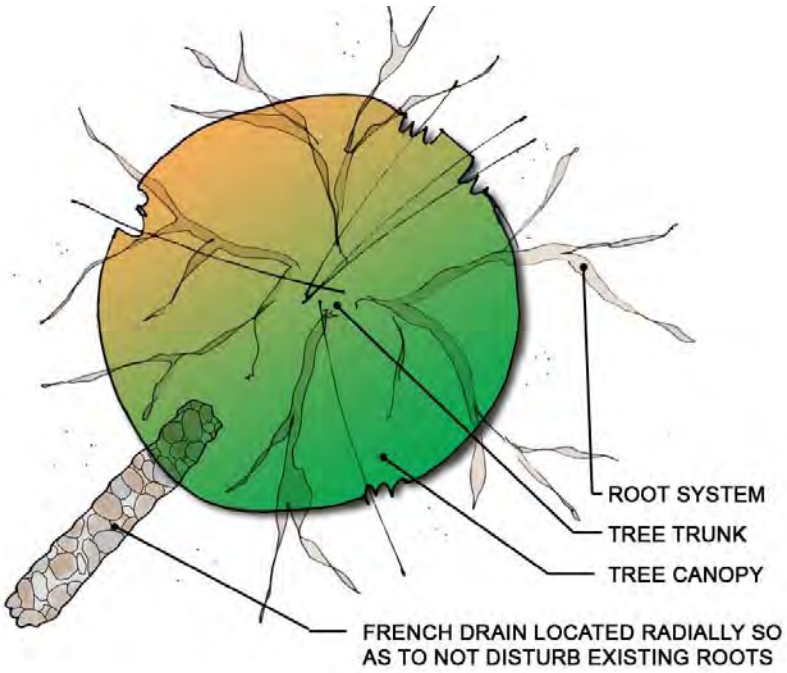


Figure 33. Placement of French Drain within Tree Root Zone

French drains should not be placed underneath driveways or other drivable surfaces as they are not structurally appropriate for heavy load-bearing; however, they can be used to move water under sidewalks or pathways.

French drains should not be located within 10 feet of building foundations. In order to harvest roof drainage from building downspouts and maintain the minimum 10-foot distance, it is possible to use non-perforated pipe to link the downspout to the French drain. Install the non-perforated pipe run from the downspout to the edge of the French drain, where it will connect to a perforated pipe that runs the length of the drain basin. The perforated pipe should be placed so that the basin rock or cobble fill does not crush it. Be sure to install a screen at the top of the downspout to prevent debris from entering and clogging the pipes or French drain.

If there is potential for the drain to contribute to slope destabilization, it is advisable to engage a qualified professional to assist with design and placement.

Construction: As with all drainage projects, check with utility companies to verify locations of buried cables or gas lines BEFORE BEGINNING TO DIG, and make sure that the drain will not negatively impact adjacent properties.

French drains should have a minimum 1% grade (a drop in elevation of one foot per every 100 feet of length) to ensure water movement through the structure. Grading should be plotted out before you begin digging. Trench size depends on how much water needs to be managed. For French drains that are not completely buried, dig the trench and fill with washed small-diameter rock, cobble or gravel until the surface is even with the adjacent ground level. Rounded rock, while not as stable as interlocking angular rock, is preferable as it provides greater void space. Depending on the surrounding soil type, it may be advisable to line the trench with filter fabric prior to filling it with rock to prevent soil from gradually filling the void spaces within the French drain. If the length of the French drain exceeds 20 feet, include a perforated pipe to facilitate even flow and release of the harvested water within the drain area. The trench should be a minimum of 5 or 6 inches wide and three to four times as deep as the pipe diameter. For drains containing perforated pipe, lay a 2-inch layer of coarse, washed gravel in the bottom of the trench. Then place landscape fabric on the gravel, ensuring there is enough fabric to wrap up and around the pipe and additional fill gravel, creating a fabric tube. Lay the pipe in the trench on the gravel layer with the drainage holes facing down, if they are only on one side of the pipe. Shovel more washed gravel over and around the pipe to the required depth. Wrap the ends of the landscape fabric over the top of the gravel layer. Place a layer of coarse sand and topsoil over the top of the drain and then either an additional layer of filter fabric and mulch, plants or sod according to the location within your overall landscape. Plantings can be located at the end or along the sides of French drains to take advantage of the captured water.

Maintenance: Preventing silt or sediment from entering or building up in the French drain is important to ensure good continued infiltration function over time. If sediments build up in french drain and de-sedimentation becomes necessary it may warrant excavation and rebuilding french drain. If the top surface of the drain is not completely buried, keep it free from debris and ensure it is draining within 24 hours to prevent mosquito issues.

Alternate French Drain Configurations: French drains can be constructed in a branching pattern with a large one branching into smaller side French drains to make better use of a large amount of runoff (Figure 34). The bottom of the entire system must be sloped away from the building to direct the water toward particular locations such as planting areas.

French drains can also be installed vertically to create infiltration columns as illustrated in Figure 35. These can be particularly effective for improving water and oxygen availability around the perimeter of trees. Depending on the surrounding soil type, the columns may fill with silt over time but will still provide better infiltration and aeration to tree roots than the unaltered native soil. Pre-fabricated versions of tree-root watering systems, both stand-alone and linked to irrigation, are available from some manufacturers.

Dry wells are another alternate configuration, consisting of pits filled with gravel or aggregate used to address runoff from smaller impermeable areas.

Siting: Not appropriate for areas with high sediment loads that would clog the well. An advantage of dry wells is their potential use on steep slopes that preclude other infiltration devices.

Construction: Dry well size should be based on the desired capacity and runoff amount from the contributing area.

Maintenance: Keep surface free of debris and check for sediment buildup, which should be removed if well function is significantly diminished.

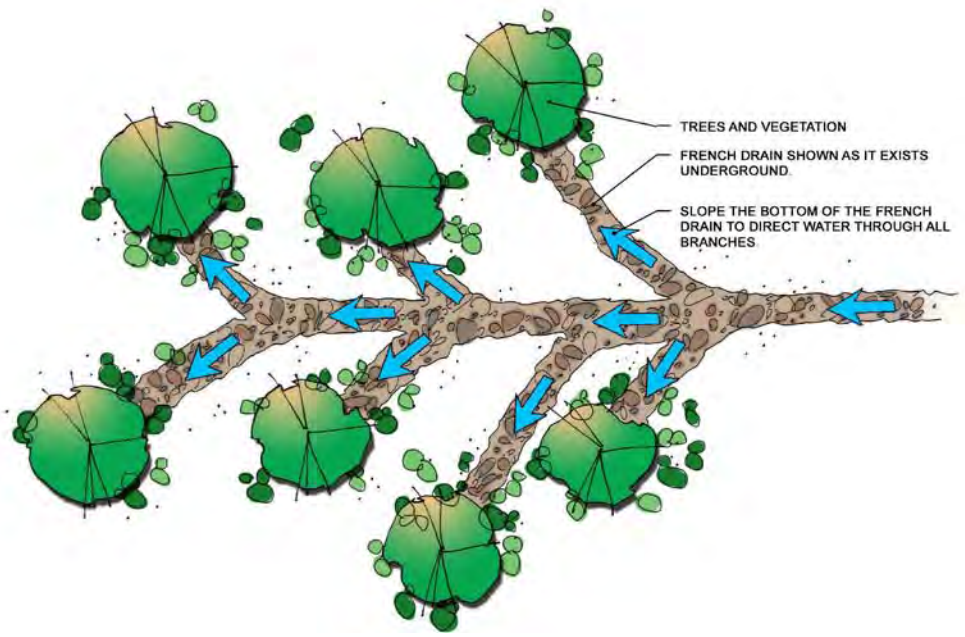


Figure 34. French Drain in Branching Series

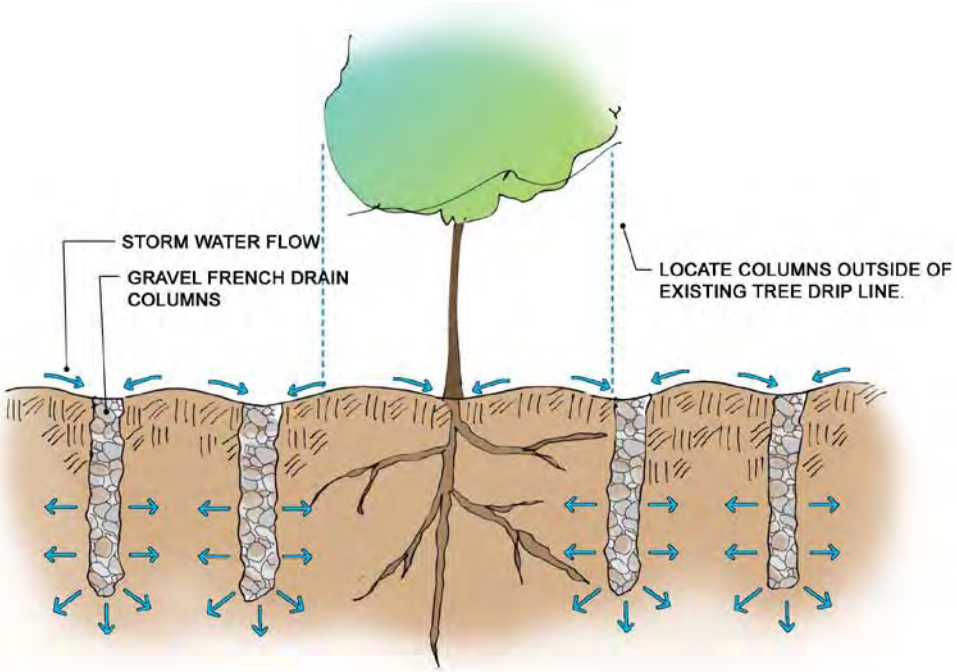


Figure 35. Vertical French Drains

Wicking Systems

Function: Wicks act like sponges, collecting stormwater runoff via a swale or other landform, storing the water, and making it available to the root systems of plants over time. Depending upon the amount of water, soil type, and plant water needs, wicks can provide water for an extended period of time and act like a shallow aquifer (see Figure 36 and Figure 37). Wicks have a secondary function of erosion control as they help to reduce the amount and velocity of runoff. This secondary function can be useful when mitigating eroding slopes. Wicks can be constructed from gravel, pumice stones, straw bales or other organic material and installed like a column or "curtain" in depressions between large plants such as shrubs or trees. When plants are placed on either side of the wick, they are given a supply of moisture at their root zones for weeks or even months after rain events. The basic idea behind wicks is to harvest runoff from the surface and direct it to a wick. The wick slowly releases the water into the soil where it can be absorbed by plant roots. Wicks can also be used in conjunction with regular and perforated piping to collect and move water from downspouts or canales away from building foundations and out into the landscape.

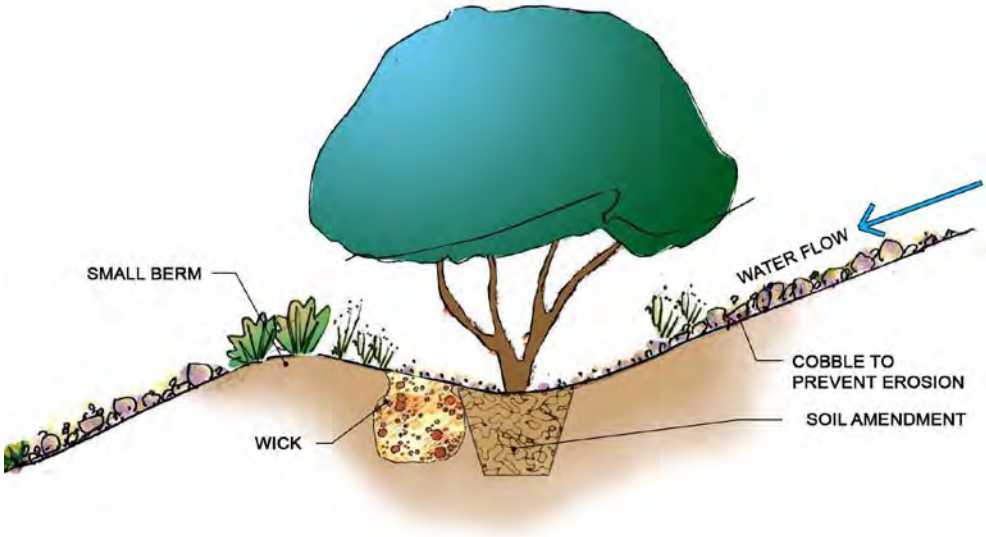


Figure 36. Wick System

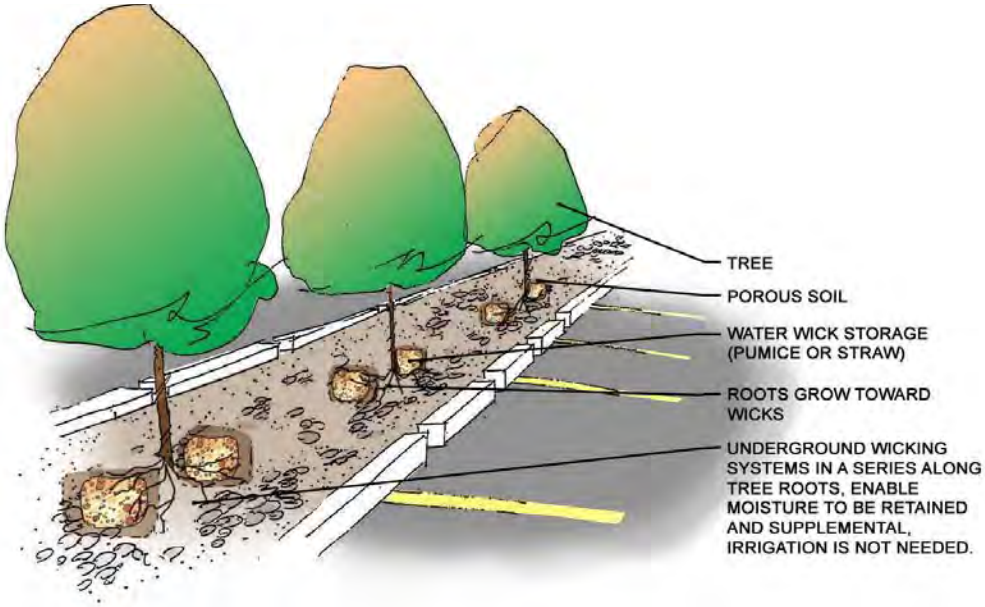


Figure 37. Wicks in Parking Island

Siting: Wicks can be positioned in a variety of locations in the landscape, preferably a minimum of 10 feet from building foundations. One option is to locate the low points near where you will be planting and simply excavate them to accommodate the wick. Another alternative is to grade the site so there is a low point, or simply dig a trench to the appropriate depth where the wick is needed. Plants can be placed along either or both sides of a wick. Locations that are cut off from adjacent stormwater flows, such as parking lot islands, are ideal locations for wicks. Wicks can also be useful for providing a supplemental water source to trees or plantings in precipitation-only landscapes, or plantings that would benefit from an additional water source. When placing wicks near existing vegetation, care should be taken to avoid damaging the plants' root zones.

Construction: Dig a hole large enough to contain a straw bale or a large amount (8 to 9 cubic feet) of water-absorbing material such as pumice. Pea gravel or similarly-sized pumice stone particles work very well. Cover the wick with a layer of filter fabric, or several (20 to 25) layers of newspaper, which will help to prevent dirt from clogging it, and then with a 3- to 4-inch layer of cobble or other mulch.

To connect roof downspouts to wicks located at least 10 feet away from the building foundation, excavate a 3-foot diameter hole at the bottom of the downspout and then dig a trench sufficiently wide to accommodate a 4-inch pipe from the hole to the wick location. The trench should slope between 0.5 to 1% to facilitate drainage to the wick. Fill the 3-foot hole with pea gravel to a depth of 1 foot and then place a 12-inch box drain on top of the gravel. Connect the 4-inch pipe from the drain box outflow opening to the wick area. If the length of the wick itself exceeds 20 feet include a perforated pipe to facilitate even flow and release of the harvested water within the wick. Fill the remainder of space around the drain box with gravel and then fill and cover the wick as noted above. In case the wick becomes completely saturated the design should also accommodate excess water by allowing any overflow to feed an adjacent water-harvesting device such as a French drain or bioretention area.

Maintenance: When properly constructed, wicks require little to no maintenance, If runoff coming into the wick is high in sediment, however, the wick can become clogged over time, requiring sediment removal or wick replacement. Preventative maintenance includes checking and clearing downspout debris screens which keep material from entering and potentially blocking the pipe.

Evaporation-Loss-Reduction Devices

Mulches

Function: Some parts of Bernalillo County receive only about 8 inches of precipitation per year, while potential evaporation may exceed 100 inches annually. By covering and cooling the soil, mulches can significantly reduce surface evaporation water loss, as well as weed growth and erosion. Mulches improve water and air penetration and protect shallow-rooted plants from soil temperature fluctuations and freeze damage. Over time, as they decompose, mulches also improve soil structure and nutrient availability. Mulches also provide an aesthetic benefit. There are two basic categories of mulches: inorganic, such as gravel, cobble, decomposed granite/crusher fines or other stone material, and organic, such as pecan shells, shredded bark, pine needles, straw, leaves, grass clippings, oyster shells and the like. Inorganic mulches can also be used to help prevent erosion from slopes and berms.

Siting: Mulches can be applied over bare soils, either alone or over landscape fabric. Mulching planted areas provides the benefits noted above, and mulching water-harvesting basins, depressions and swales improves their performance. Mulch particles should be appropriately-sized to address potential loss due to wind or water flow erosion. Organic mulches tend to be lighter and are best in low-flow areas, while inorganic mulches such as cobble are more appropriate for areas that will experience higher velocity flows.

Construction: Inorganic mulches should be applied 2 to 3 inches deep and can be applied over filter fabric. Extremely fine-grained mulch can inhibit infiltration and clog soil pore spaces. When using decomposed granite crusher fines as a mulch, it is important to wash off fine sediments first.

Organic mulches should be applied 3 to 4 inches deep directly on the soil surface. Leave several inches of space between the tree trunks or the base of plants and the mulch edge. This helps to avoid rot or mold issues.

Maintenance: Both organic and inorganic mulches deplete over time. They should be periodically replenished to maintain optimal depths for soil cooling and evaporation loss reduction. If any areas show evidence of erosion, determine and address the root cause of the issue.

Some of the soil nitrogen in contact with mulch is consumed as organic mulches decompose. This can potentially result in nitrogen deficiency, which is indicated by yellowing, primarily of lower leaves. This can be rectified by nitrogen fertilizers, applied at a rate of 2 pounds of a complete fertilizer, preferably organic, or 1/4 pound of ammonium sulfate for every 100 square feet of mulched area. Do not use "weed-and-feed" fertilizers in mulched areas.

Area and Coverage Depth of One Cubic Yard of Mulch	
Area (sq. ft.)	Depth of mulch (inches)
80	4
100	3
160	2
325	1

Advantages and Disadvantages of Mulch Types			
Mulch type	**Advantages**	**Disadvantages**	**General Comments**
Inorganic, inert mulches			
Filter fabric	Initially reduces weeds. Allows air and water penetration. Long-lasting if covered with mulch. Relatively easy to apply.	Can be costly. Degrades if exposed to sunlight or direct wear.	Preferable and better performing than black plastic. Allows water and air to infiltrate.
Decomposed granite/ crusher fines, gravel, stone, pea gravel, pebbles	Available in colors to match or complement the architecture. Relatively inexpensive.	Will not prevent growth of some weedy grasses.	Extremely fine-grained mulch can inhibit infiltration and clog soil pore spaces. Inorganic mulches can add heat load to areas lacking overstory of vegetation.
Cobble, rip-rap	Available in colors to match or complement the architecture.	Will not prevent weed growth. More labor intensive to install.	Supplementing with smaller diameter gravel or fines to fill in crevices can help prevent erosion between cobbles.
Organic Mulches			
Cocoa-bean hulls	Long-lasting, dark brown color.	Poisonous to many animals including dogs and cats. Compact; forms a crusty surface. Expensive.	Molds may form on surface. Harmless if stirred to break crust.
Crushed corncobs	Uniform in color.	May retain too much moisture at surface or compact if kept wet.	Availability limited in some areas.
Grass clippings	Readily available. Nutrient recycling.	Must be applied loosely, in thin layers to reduce matting. Herbicide residues may harm plants. Some potential to be nitrogen-robbing.	To prevent matting, allow to dry prior to application.
Leaves (composted)	Readily available. Nutrient recycling.	Not very attractive. May become matted.	
Leaves (fresh dried)	Readily available. Nutrient recycling.	Not very attractive. May blow away. Can be a fire hazard. Wet leaves compact into slimy mats.	Most appropriate in naturalized gardens or shrub masses.
Newspaper	Readily available. Good for preventing soil splashing (disease) on lower leaves or vegetables.	Don't use color inserts or red ink. Not very attractive unless covered.	Use 3 to 6 sheets thick and cover with organic mulches.
Pine needles	Do not compact.	Difficult to obtain in quantity. Can be a fire hazard.	Best for winter protection of fall-transplanted material.
Shredded bark, bark chips, chunk bark	Long-lasting, attractive. Somewhat resistant to wind erosion.	Cost relatively high. Shredded bark may compact. Large bark chunks may impede spreading perennials.	
Straw	Readily available. Inexpensive.	Blows easily. Highly flammable. Weed seeds often present.	Best used as a temporary mulch around plants needing protection in winter. Anchor with wire mesh.
Wood chips, shavings, recycled shingles	Long-lasting. Readily available. Does not blow away.	Texture and color not uniform. Can cause nitrogen deficiencies in plants if incorporated into the soil.	Rustic but usually attractive. Will not compact readily.
Pecan shells	Attractive red-brown color, which weathers to a silvery grey.	Can blow away, can be scattered somewhat after installation by birds picking out remaining nut meat.	Will not compact readily.

Source: Derived from J.E. Klett, Colorado State University Extension landscape horticulturist, and professor, department of horticulture and landscape architecture. Revised from original fact sheet authored by J.R. Feucht, retired. 11/97. Revised 1/07.

E. Soil and Soil Amendments

Determining the type of soil present on a given site in a Bernalillo County bioregion and how it might need to be modified to improve the sites water holding capacity is also an important consideration for appropriate design for water conservation and management. The soil type will determine modifications which might be needed such as de-compaction or amendment. Soil type is also a key consideration for plant selection. The first step in determining any possible soil modifications which might be warranted is soil analysis testing, this can provide valuable information to guide decision making for these potential soil modifications and it is the most accurate means of determining a site's soil modification needs. Soil analysis can also determine whether amendment is needed and help to tailor soil amendments to the site design.

The relationship between soil and water use is based on soil structure (texture and porosity). Soil structure refers to the arrangement of solid particles of soil types and the pore spaces between them. In general, a well-structured soil will readily accept, store, and transmit water, gases and nutrients and provide a positive horticultural medium for plant growth and health. Soil texture is determined by the relative percentages of sand, silt, and clay present. Soil porosity or permeability is determined by the combination of soil structure and texture. A dense structure, such as that of clayey soils, will greatly reduce the amount of air and water that can move freely through the soil. Water moves quickly through coarser-texture soils, such as those with a high percentage of sand, and slowly through fine-texture soil with a high percentage of clay. Photo 20 shows the soil types which are the most common in Bernalillo County. A soil analysis will help determine what to do with this information. For instance, if sandy soils are predominant on a given site and the occupant would like to grow plants that require more water than the ambient landscape of sand sages and desert willow, then soil amendments of loam or humus would be important to increase the soils water holding capacity. If the occupants were in the valley and clayey soils are predominant, loosening up the soil texture with sand may be appropriate. However, the most water conservative landscape design is one that fits its soils and ecologic niche. It is always recommended for the resident or site developer to seek the assistance of green industry professionals (i.e. nursery-people, landscape architects and designers, contractors) to determine the best course of action.

Below we provide more general information about amendment and soil de-compaction.

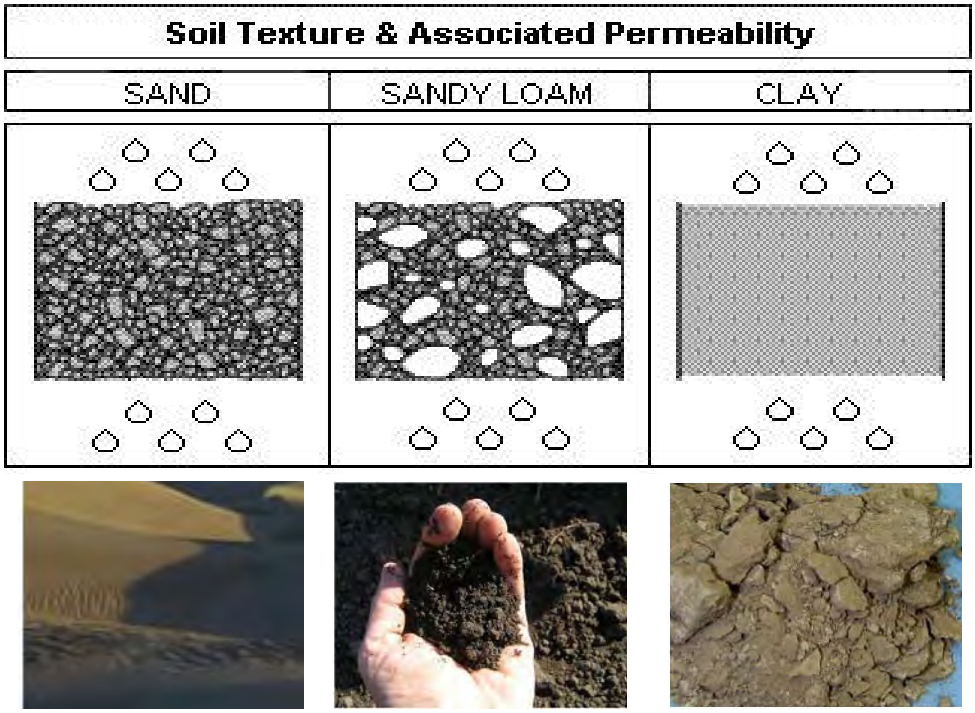


Photo 20. Soil Permeability

Soil Amendments

Soil amendments or conditioners are substances that improve the physical properties of soil and promote plant growth. Soil amendments can increase a soil's water retention qualities or increase permeability (for clayey soils). The composition of soil plays an important role in determining its water-holding capacity. Most soils in the arid Southwest lack organic matter and are limited in their water-holding capability. Organic amendments, such as composts, peat, diatomaceous earth and manure, and organic by-products from manufacturing such as coir, can improve a soil's water-retention capacity, loosen compacted soil, lower soil pH, and provide food for beneficial soil microorganisms. Inorganic materials such as gypsum, perlite, vermiculite, super-absorbent polymers, porous ceramics, and mineral-based products such as Zeolite can also be useful for improving soil texture and porosity.

The decision to use amendments should be based on the condition and type of existing soil, recommendations from soil test results, plant types that will be used, and the project budget. Choosing plants that are adapted to local soil and environmental conditions can reduce or eliminate the need for soil amendment. If amendment is required, best results are obtained by applying amendment materials in amounts based on results of soil structure and texture analysis. Generally speaking, increasing the water-holding capacity of soil is desirable. Clay soils, which already hold onto water, can benefit from amendments that increase porosity or permeability such as gypsum or sand. The benefits of improving soil to support plant and water-retention needs can offset amendment costs and can also decrease the use of fertilizers, herbicides and pesticides.

Compacted Soils and Construction Activities

Compacted soils occur when the weight of heavy machinery, vehicles, built structures or persistent foot traffic compress soil, reducing soil structure and pore space and creating a hard, solid mass. The amount and impact of compression varies depending on the soil type. Soils high in clay content, such as those in the Rio Grande Valley bioregion, compact very easily. Water infiltration into densely packed soils is greatly reduced and slowed, and much of the water can simply flow across them. The end result is that the volume and frequency of runoff from the site is increased, as is the amount of sediment and pollutants such as pesticides, fertilizers and oils carried by the runoff. The sediment and pollutants are ultimately deposited in waterways such as the Rio Grande.

Topsoil, even the small amounts in desert regions, are a valuable water conservation resource, and efforts should be made to preserve it during construction. Site preparation prior to construction should include removing and stockpiling existing topsoil. After construction, a thin layer of the stockpiled topsoil can be spread over the subsoil, which has been compacted by construction activities, and then the area can be landscaped. Because the subsoil is compacted, water does not easily infiltrate, and issues with erosion and poor plant health are common. Preventing soils from becoming compacted helps to conserve water and saves money by protecting the investment in landscape plantings, minimizing the need for dust control during construction and for post-construction reclamation efforts.

To prevent unnecessary soil compaction and destruction of existing vegetation construction activities, vehicles, equipment and materials should be kept within a prescribed area and away from the dripline of a tree. During the demolition and construction periods, existing trees and other vegetation to be retained should be surrounded with protective fencing at least out to the canopy dripline as shown in Figure 38 to prevent compaction of soils within the root zone.

Compacted soils can also occur on sites after construction due to high volumes of foot traffic. Thoughtful design and planning for pedestrian circulation keeps people on walkways and avoids soil compaction.

Pre-existing compacted areas can be mitigated through selective tilling or deep plowing to break up the compacted soil and enable the movement of water and air through the soil. Deep plowing should be performed prior to the application of salvaged topsoil. The addition of soil amendments can also help to restore soil infiltration capacity and fertility.

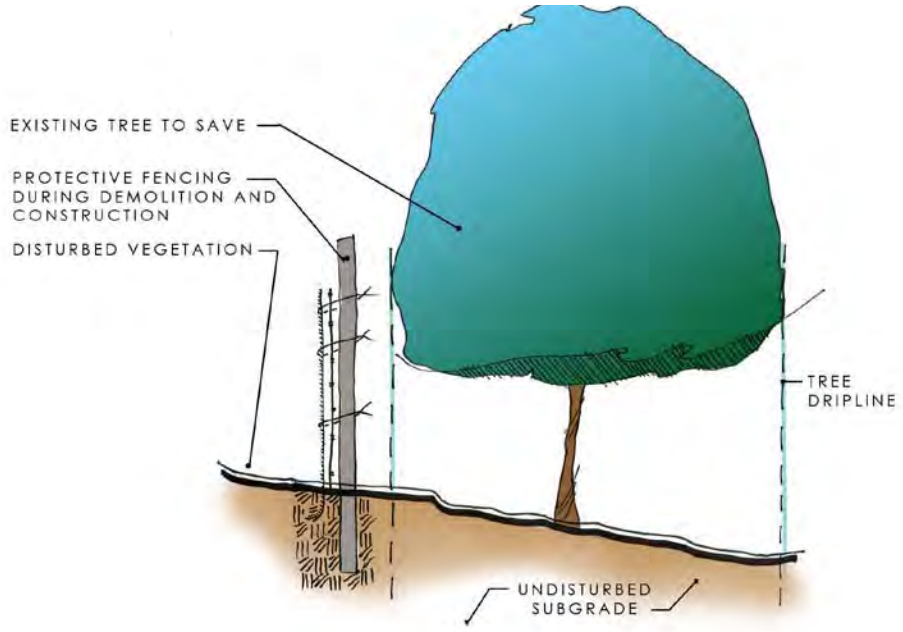


Figure 38. Tree Protection Zone

F. Water-Conserving Irrigation

Introduction

A well-designed and maintained irrigation system is essential to achieving a beautiful, healthy and water-conservative site and landscape. This section of the guidelines provides basic descriptions of the different types of irrigation systems, issues to consider when determining how to irrigate, and recommended best practices for designing and maintaining an irrigation system. Additional information is available through the online resources listed at the end of this section.

It has been estimated that between 40% and 60% of municipal water consumption is used for landscape irrigation and that more than 50% of that irrigation water is wasted due to evaporation or runoff caused by overwatering. A water-conserving irrigation system applies water by the most efficient method possible, only when and where it is needed. A good rule of thumb is to water deeply but less frequently in order to encourage deeper root growth. This in turn enables plants to draw moisture from a larger area of soil, increasing their ability to tolerate drought. It is important to account for the soil type of the site when planning irrigation watering durations and frequencies. As an example, water travels more quickly through sandy soils, so more frequent watering may be needed than for a site with higher clayey soils, which drain more slowly.

As noted in the section, Recommended Steps for Water-Conserving Landscape Design, an irrigation system based on hydrozones is fundamental to reducing landscape water use. A hydrozone-based landscape design groups together plants with similar water requirements. The irrigation system can then be designed to align the most appropriate and efficient type of irrigation to each hydrozone and allows each zone to be watered separately. For example, lower water-use plant groups may be drip-irrigated, whereas higher water-use turf areas may use sprinklers, dependent on landscape type.

There are basically two major approaches to irrigation, passive and active. Passive irrigation systems are "low technology" solutions that use gravity to deliver water to targeted areas in the landscape via channels, hoses or other conveyance devices. Active irrigation systems are mechanized and move water under pressure through the delivery network of pipes or hoses and out to the targeted landscape areas. Additional information on passive irrigation and water-harvesting devices is available in the Water-Conserving Landscape Devices and Best Management Practices section of this document.

Irrigation System Components

The basic components of most irrigation systems are:

Controller – The clock or brain of the irrigation system, determining when and for how long each irrigation zone (with an automatic valve) will be watered. Photo 21 shows a typical residential controller. Care should be taken in programming basic controllers to ensure watering schedules are based on the irrigation needs of each hydrozone, as well as on soil and slope conditions.

Photo 21. Irrigation Controller

Smart controllers enable irrigation to occur when it is actually needed rather than on a preset schedule. They utilize data from sensors and weather stations to determine when and how much irrigation is needed, offering the greatest potential for water-efficient irrigation. A range of sensor and weather station data types can be included such as rain, wind, evapotranspiration, flow and soil moisture. Researching current product offerings is essential as irrigation technology is constantly evolving, providing an ever-increasing range of cost-effective options for improving the irrigation system water efficiency.

There are many additional controller features that can help promote water-conserving irrigation including:

- Cycle-and-soak or interval programming options, which help reduce runoff by accommodating site conditions such as hard, compacted or clay soils or slopes that require watering in increments to allow the soil adequate time for absorption, enabling deeper penetration of subsequent irrigation.
- Percentage increase/decrease or water budgeting features, which allow quick uniform adjustment of watering periods for all zones on a system. These are useful when adjusting irrigation schedules up or down to accommodate seasonal or monthly changes in plant water needs.
- Rain-delay features, which adjust irrigation schedules to avoid watering during or immediately after rain.
- Soil moisture sensors measure the amount of water in the soil and let the controller know when it is dry enough and the plants need water.
- Weather-based controls (Smart Controllers) rely on data gathered from nearby weather stations. This information is relayed to the controller via a pager signal and automatically adjusts the programmed watering schedule.
- Multiple programming allows the flexibility to water plants of varying microclimates or water needs.
- Non-volatile memory retains the programs in the controller's memory in the event of a power outage.

Backflow preventer - Required by ordinance and keeps irrigation water from being siphoned back into the potable water supply and potentially contaminating it. There are several types of backflow preventers: reduced pressure, pressure vacuum breaker, anti-siphon valve and double check type. Be sure to verify local requirements when selecting a backflow prevention device.

Pressure regulator - Used to reduce system water pressure. They are often needed to deliver the lower pressure required for optimal operation of a drip system.

Photo 22. Pressure Regulator

Automatic control valves - Activated by a signal from the controller to control the flow of water into the designated irrigation zone, allowing you to water different parts of the landscape at different times and for different periods. Installing separate valves based on the concept of hydrozoning is a cornerstone of a water-efficient irrigation system. An irrigation system based on hydrozones can significantly reduce landscape water use by providing irrigation system zones that match the water requirements of the various plant groups and allow them to be watered separately. Also, lower-water-use plant groups may be drip irrigated, whereas higher-water-use turf areas may use sprinklers. It is necessary to select the proper type of irrigation for each hydrozone.

Irrigation System Types

An irrigation system is composed of a set of components that generally includes a water source (meter or well), a water distribution network and water delivery devices. Irrigation systems can typically be classified into five types: Drip and low-flow, bubbler, sprinkler, flood and hand-watering. Flood irrigation will not be discussed in detail as it is subject to regulations by irrigation organizations such as the Middle Rio Grande Conservancy District and Acequia Associations; however it should be noted that this irrigation method loses significant amounts of water to evaporation.

Drip and Low-Flow Systems

Drip irrigation systems are a highly efficient for providing water to plants in the landscape and are ideal for xeric landscapes. A properly designed system using low-flow drip irrigation can achieve efficiency levels of more than 90% and virtually eliminate water waste. Drip systems provide a slow, steady amount of water directly to the root zone of the plant, minimizing loss due to evaporation and application in areas that are not planted. They also reduce loss due to runoff and overspray.

Drip irrigation systems are typically operated at a lower water pressure than sprinklers, and pressure regulation is needed to maintain this lower pressure. The water pressure needed for drip systems is typically in the range of 10 to 20 pounds per square inch (psi). A wide variety of products are available for drip irrigating, including individual emitters, multi-outlet emitter devices, dripline and microsprays. The components of drip systems are described below (See also Figure 39).

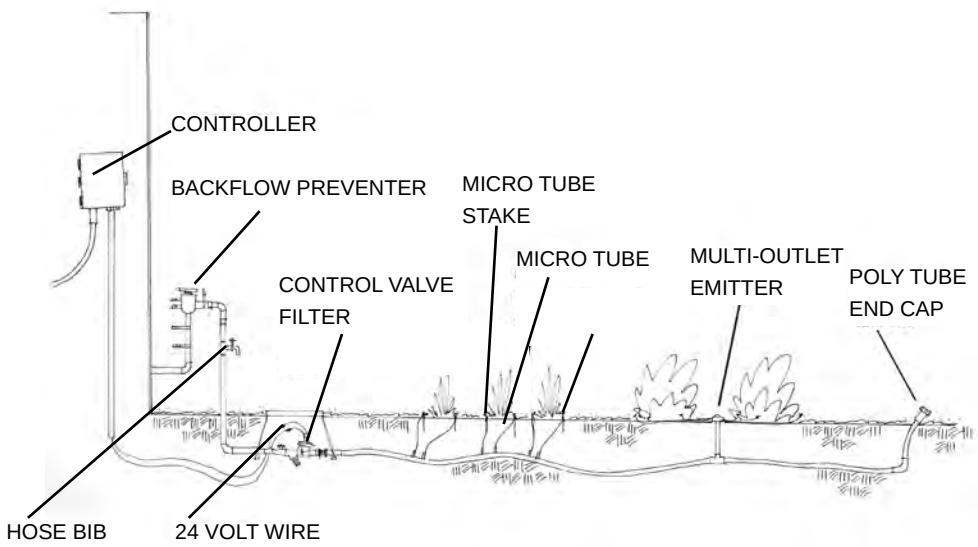


Figure 39. Drip Irrigation System Components

- **Filters** – Are often included in drip systems upstream from all control valves to prevent particulate matter in the water such as sand or silt from building up and clogging any part of the system. Some filters can be removed and washed while others are self-cleaning.

- **Micro-tubing** – Is flexible polyethylene distribution tubing that connects to individual drip emitters. It is generally available in 1/4-inch or 1/2-inch diameter sizes, is relatively inexpensive, easy to install and repair, and is resistant to ultraviolet light damage.

- **Drip emitters** – Are small watering devices that deliver water at very low pressure and rates that are measured in gallons per hour (gph). They are available in a variety of types and forms, including self-cleaning, pressure-compensating, and micro-spray emitters. Output from "non-compensating" emitters increases or decreases as tube line pressure increases or decreases, whereas emitters categorized as "pressure-compensating" are designed to deliver the same amount of water over a fairly wide range of tubing line pressures. Depending on the design of the drip irrigation system, this can be an important consideration.

Photo 23. Drip Emitter

The number of emitters should be based on the plant type and size, the soil type, and be sufficient to deliver the maximum daily water requirement for the mature plant size. Emitter flow rates should be proportional to the plant type and size.

Higher-water-use plants may need more emitters than native or drought-tolerant plants of the same size.

Suggested Drip Emitter Quantities			
Plant Type	**Mature Canopy Size in Feet**	**Number of Emitters**	**Emitter Flow Rate (gallons per hour)**
Groundcover/Small Shrub/Ornamental Grass	1-3	1	.5 - 1
Large Shrubs	4-6	2	2
Small Trees	7-10	3	2
Trees	11-14 15-20 21+	4-6 6-12 12+	2-4 2-4 4

Emitters should be placed uphill from the plant. For plants located on steep slopes, create mini-basins or a depression around the base of the plant to receive water from the emitters while preventing erosion and runoff.

For new plantings, install emitters halfway between the base of the plant and the outer edge of the rootball. This is termed the dripline. As plants grow and mature, emitters should be moved to water the root zone (the soil area that surrounds the plant's roots) (see Figure 40).

Most roots spread 1.5 to 4 times the plant's canopy and penetrate 2 to 3 feet deep. For existing or mature plants, place emitters to deliver water at the edge of the mature root zone, (see Figure 41).

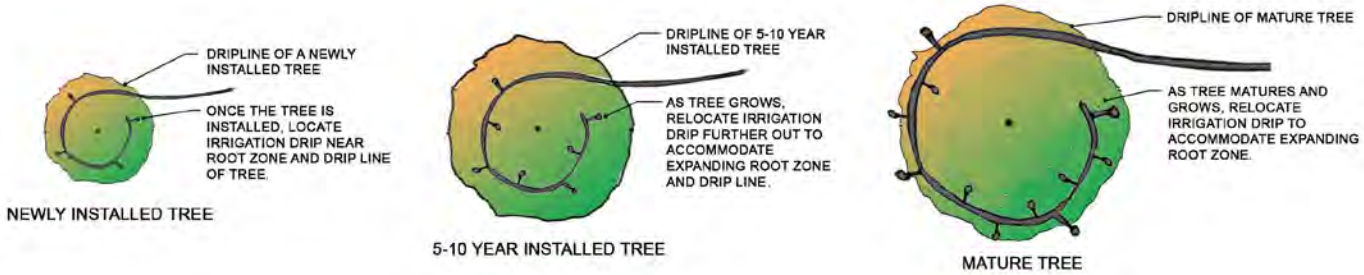


Figure 40. Adjusted Emitter Placement Over Time

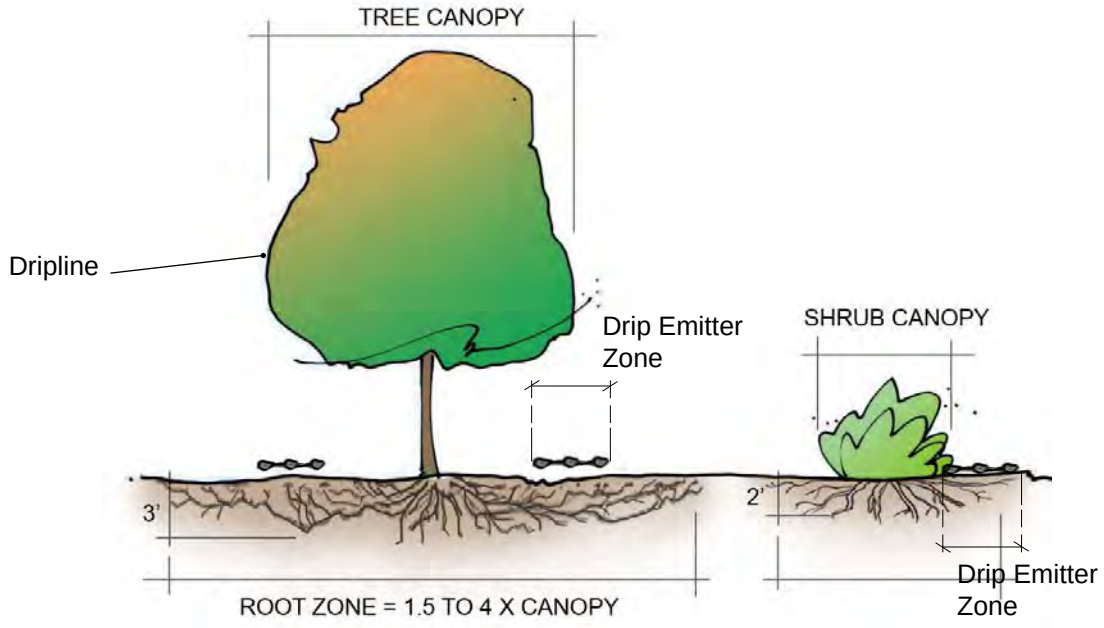


Figure 41. Approximate Sizes of Mature Root Zones

- **Dripline** - Is plastic tubing that has been pre-drilled with regularly spaced holes or in-line emitters that deliver water at a consistent rate and can be used for watering containers or narrow planting areas. Another type of dripline is made of porous tubing similar to soaker hose that allows water to seep through the entire tube wall.

Photo 24. In-line Emitter

Photo 25. Soaker Hose

- **Multi-outlet emitters** (also known as multi-emitter hydrants) - Deliver water from one central riser pipe to multiple independent outlets. Each outlet's flow rate can be connected to micro-tubing with drip emitters to deliver different amounts of water to the landscape. Multi-outlet emitters with pressure-reducing components can be used to replace existing sprinkler heads when converting turf areas to xeriscape.

Photo 26. Multi-outlet Emitter

Bubblers

Bubblers are most effective when deep watering is desired, such as for trees or shrubs. They are simple to install and provide water in an "umbrella" pattern over a small area, usually at higher gallon-per-hour (gph) rates than drip emitters. They can be installed on pop-up heads or fixed risers. Pop-up heads are an additional expense; however, they are preferable when the bubblers will be located in areas subject to foot traffic, as they can prevent damage to the bubblers.

Photo 27. Bubbler

Bubblers are also available as part of pre-fabricated Root Watering Systems that apply irrigation water to trees or shrubs directly in the root zone. These systems also increase oxygen supply to the root zone and can be especially beneficial in situations involving compacted soils. An illustration of this system is shown in Figure 42.

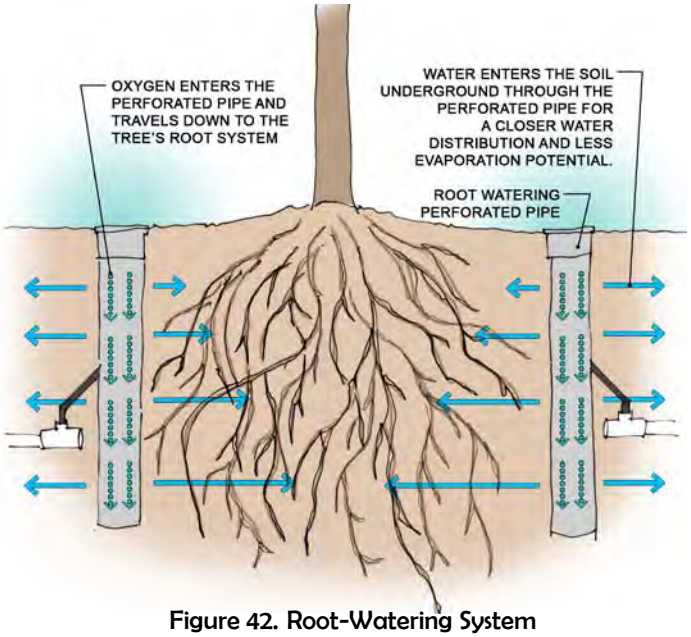


Figure 42. Root-Watering System

Stream bubblers can be used when irrigating densely planted shrub or ground cover areas. They provide a consistent stream of water with a variety of choices for the radius of throw (Photo 28).

Photo 28. Stream Bubbler

Spray Systems

Spray systems are most commonly used for turf grass or large areas of other groundcovers and are generally viewed as the most efficient irrigation method for lawns. Spray systems apply water in gallons per minute and lose significant amounts of water due to evaporation, so they must be carefully designed, installed and maintained to avoid additional loss due to overspray issues (application of water to adjacent areas that do not require irrigation such as sidewalks, walls or driveways). Pressure regulation is particularly important to avoid producing overspray or mists that waste water. Another key design and maintenance objective for water-efficient spray irrigation is uniform application of water. Poor uniformity of irrigation application can result in some areas being drier than others. Often the irrigation being supplied by the entire system is increased in an effort to address the dry areas, which results in some areas being over-watered and water being wasted. Verifying and adjusting heads to ensure that they are positioned and operating correctly is an important maintenance task. The efficiency of older systems can be improved by replacing old sprinkler heads with newer, more efficient models.

There are several types of sprinklers available:

Photo 29. Pop Up Sprinklers

- **Pop-up sprinklers** - Are activated by water pressure when the control valve is opened and retract when the valve is shut off. This is useful in situations where the sprinklers may be walked on, or where there is potential for vandalism. They are available in a variety of pop-up heights, heads and nozzle-types that allow the irrigation system to be tailored to the site. Sprinklers emit a fixed spray in a 5- to 15-foot radius and so are generally appropriate for smaller areas.

- **Fixed-spray heads** - Deliver a fan small water droplets and are appropriate for watering smaller areas.

- **Matched precipitation rate sprinklers** - Also called rotary nozzles, these provide more uniform coverage by allowing a variety of spray arcs and radii to be used on the same irrigation zone while still achieving consistent spray distance and application rates. They can be installed onto pop-up spray heads and are more water efficient than conventional spray heads as they apply water at lower speeds and lower precipitation rates allowing the soil to absorb more of the water received.

- **Nozzles** - Are an interchangeable part of a sprinkler head and create the spray pattern such as full, half- or quarter-circle. They determine the radius of throw and the rate of water application for the head.

Photo 30. Full Radius

Photo 31. Half Radius

Photo 32. Quarter Radius

- **Rotors -** Can be gear-driven or impact types. Rotors are appropriate for larger watering areas such as playing fields or parks, with coverage ranging up to a 45-foot radius. Rotors rotate slowly as they distribute single or multiple streams of water. Rotors are less likely to cause runoff, as they apply water at a slower rate than spray heads. Like spray heads, rotors are available on fixed or pop-up risers.
  - **Gear driven rotors** efficiently project water in a single stream in circular or part-circular pattern. The water is projected by a drive gear that transmits the water through a single orifice.
  - **Impact (rotor) sprinklers** project water in a circular or part-circular pattern by a spring loaded arm that is pushed back by the water stream to create the pattern. They are less efficient than either gear driven rotors or pop-up sprinklers.
  - **Stream rotors** have multiple rotating streams of water and are appropriate for watering medium-sized areas.
  - **Micro-rotors** and **low-pressure rotary heads** are now available and provide a more efficient alternative to the spray head for smaller areas.

Photo 33. Gear Driven Rotor

Photo 34. Rain Sensor

- **Rain-shutoff devices or rain sensors** - Prevent the irrigation system from running if it has rained recently. These relatively inexpensive devices generally allow the user to specify the amount of precipitation that will trigger the shutoff. Irrigation resumes when the sensor has dried out and returned to the baseline condition.

Photo 35. Soil Moisture Sensor

- **Soil moisture sensors** - Measure the level of moisture in the soil and trigger the irrigation system to run when the conditions are sufficiently dry, preventing it from operating when the soil is saturated. Many soil sensors allow the user to program the moisture level that triggers the system.

Photo 36. Soaker Hose

- **Soaker hoses** - Are made of black, porous rubber that slowly "weep" water, allowing it to penetrate to the root zone while causing minimal surface wetting, minimizing surface evaporation and runoff, and reducing water use by 60 percent or more versus using a standard hose. They can be a useful alternative to drip irrigation for areas that dry out quickly, such as borders and foundation plantings, or for temporary watering of non-irrigated xeric plantings during periods of extreme drought.

- **Hand-watering** - The efficiency is highly dependent on the person doing the watering and can easily result in over- or under-watering. When hand-watering, care should be taken to apply water deeply but less frequently to encourage deeper root growth and create a healthy root zone. The depth to which water is penetrating can be verified by pushing a 1/4-inch or 3/8-inch metal rod into the ground after watering. The rod will stop when it hits dry soil, indicating the water penetration depth. Ideally the water should percolate down only to the bottom or slightly below the bottom of the plant root zone, as water beyond this level is not usable by the plant. Attaching a spray head or nozzle with a shutoff valve at the dispensing end can increase the efficiency of hand watering by allowing the user to cut off water quickly whenever necessary. Installing a faucet timer that automatically shuts off the water or using a timer as a reminder can help to avoid over-watering.

WATER-CONSERVING STRATEGIES FOR SPRINKLERS

- Sprinklers are designed to irrigate with "head to head" coverage. Improperly spaced sprinklers will have poor uniformity in their coverage, leading to over- or under-watering.
- Use sprinkler heads with built-in pressure regulators that allow the system to operate at lower pressures, saving water that can be lost due to misting. For every 5 psi that the system pressure is lowered, water use is lowered from six to eight percent.
- Nozzles control the amount of water flowing from a sprinkler and the distance the water will travel. High-efficiency nozzles save water by creating larger water droplets, which in turn produce a more uniform spray pattern.

Irrigation Water Supply Options

The supply options listed below should be considered, as they can reduce or eliminate reliance on municipal, county or other potable water sources. The use of natural precipitation should be also maximized by thoughtful site design for water harvesting to supplement artificial irrigation systems and lessen demand on other water supply sources.

Recycled and Reclaimed Water

- ***Graywater*** - Non-potable water is an excellent alternative irrigation supply and offers the opportunity to reduce use of potable water.

  The New Mexico Environment Department defines graywater as "untreated household wastewater that has not come in contact with toilet waste and includes wastewater from bathtubs, showers, washbasins, clothes washing machines and laundry tubs, but does not include wastewater from kitchen sinks or dishwashers or laundry water from the washing of material soiled with human excreta, such as diapers." NMED notes that, "Graywater is distinguished from 'black water,' which is wastewater from toilets, kitchen sinks and dishwashers."

  A permit is not required to use graywater for **residential** irrigation if the daily amount of graywater discharged does not exceed 250 gallons. Other uses may require permits. For current information and more detail on current graywater use requirements and restrictions see the New Mexico Environment Department website at http://www.nmenv.state.nm.us and search on the term "graywater."

  In a typical graywater system, water that would normally be discharged for sewage treatment is collected, treated to remove suspended solids and contaminants, and then reused. At a minimum, graywater systems normally include the following components:
  - storage tank(s)
  - filter(s)
  - pump
  - valves
  - purple PVC piping (purple designates the water being piped as non-potable)
  - irrigation heads with protected openings or purple non-potable marker

  It is important to use valves and filters designed for gray or reclaimed water as they are designed to address potential issues such as clogging and wear caused by impurities in non-potable water.

  Graywater systems must be installed in accordance with local plumbing codes. Appropriate design, installation and maintenance of a graywater system are critical to ensuring a safe and reliable supply of graywater.

  Graywater Use
  - Graywater should not be used for irrigation if there is not more than five vertical feet between your landscape and the water table below.
  - Graywater should never be discharged into a lake, stream or arroyo.
  - Graywater must be discharged using a hose, drip system or bubblers and should never be sprayed.
  - Any piping used for discharge of graywater should be marked as non-potable.
  - Be sure that the water used cannot run off your site.
  - Take measures to reduce contact with humans or pets.
  - Graywater should not be permitted to pond.
  - Overflow from the graywater distribution system should be directed into the sanitary sewer.

The amount of graywater available for irrigation is a function of the amount of wastewater produced by the users of the site's building(s). Water-conserving fixtures and appliances will also impact the amount of wastewater produced. When designing graywater irrigation systems it is important to calculate the amount of waste water available and to match that to the landscape irrigation needs. If graywater supply is not sufficient to meet total demand, supplemental water sources may be needed. It may be necessary to divert some or all graywater to the sewer or septic system if year-round demand does not match supply. Outdoor irrigation needs are largely seasonal, but including evergreen plant materials can help boost non-growing season demand.

Graywater contributes nutrients which are beneficial to plant and soil health. Gray or reclaimed water can also be more conducive to plant health than treated potable water that contains chlorine and other chemicals which can adversely impact plant health. Graywater is generally alkaline and typically contains more salts than potable water. Native plants adapted to local conditions are less likely to be impacted by the additional alkalinity and salts, but plants that are not alkaline and salt-tolerant may be impacted. Combining reclaimed water with potable water, or rotation of irrigation with fresh water can help to address this issue, and is recommended if irrigation system monitoring of indicates evidence of salt buildup.

- ***Other recycled and reclaimed water sources*** - Condensate from central air systems is another potential source of supplemental irrigation water supply. Condensate is essentially equivalent to distilled water as it is mineral-free and has a total dissolved solids (TDS) level near zero. It should be noted that the lack of minerals in the water makes it corrosive to metals such as steel and iron and can also inhibit plants' nutrient uptake ability. The latter issue can be addressed by including a fertilizer injection system to add nutrients to the condensate before applying it to the planting areas or by simply fertilizing plants. Because it might contain heavy metals from contact with cooling coils and other HVAC equipment, condensate should not be used for human consumption. Condensate can be used for landscape irrigation and since condensate is simply water collected from HVAC coils it is also usable for fruits and vegetables. However, be careful to watch for potential for contamination from the HVAC unit. Depending on the amount of condensate available, combining rainwater harvesting and recovered condensate for irrigation can deliver a more consistent amount of harvested water. Mixing supply in this manner can also help to dilute heavy metal content.

  Another potential source of reclaimed water is the Albuquerque Bernalillo County Water Utility Authority. For more information contact the ABCWUA http://www.abcwua.org.

Storage Systems

Storing harvested rainwater under or above ground is a viable option for many sites. Most ground-storage methods are simple enough to be installed by a landscape contractor, although the calculations for sizing them may require professional services. Regulations for ground-storage systems exist for particular areas within each of the biozones identified in this document due to flood plain designation, as in the Rio Grande Valley, or other factors. Contact Bernalillo County Public Works for applicable requirements for your site.

- ***Rain barrels*** - Rain barrels are tanks that hold roof runoff until it can be used either for hand watering or by an irrigation system. It is important to consider the capacity of the tank versus the potential volumes of water coming off the roof. Rain barrels typically range in size from 20 to 150 gallons and can be purchased in a variety of materials such as heavy plastic or wood. They can also be linked together to increase capacity. The barrel should also have an overflow mechanism to handle excess water. A good rule of thumb is to plan for at least one gallon of storage capacity for each square foot of roof or collection surface. Most rain barrels include a spigot or hose attachment near the bottom so the collected water can be drained for use. Both the overflow mechanism and hose attachment should be oriented so they drain excess water away from the building to avoid potential foundation damage. A screen cover is required to keep out debris and prevent mosquito breeding. The barrel cover should also be designed to prevent animals or children from climbing into the barrel. Rain barrels should be placed on a secure, level base as they can weigh over 500 pounds when full. Elevating the bottom of the barrel one foot above grade can make it easier to maintain and fill watering buckets. Photo 37 shows a typical rain barrel.

Photo 37. Rain Barrel

  Maintenance: Check that lids and hoses are attached and properly placed and the spigot or other hardware is functioning properly, and that water is being dispersed in expected locations. Check and clear screens and downspouts feeding barrels.

- ***Cisterns*** - Cisterns are water storage tanks and can be used to store harvested stormwater above or below ground, as shown in Photo 38 and Photo 39. Relatively common in some parts of the US in the first half of the 20th century, the popularity of cisterns is increasing once again as water conservation is being encouraged. Present-day cisterns are predominantly used for irrigation due to concerns over water quality; however, modern cisterns can be outfitted with filters or other water purification methods when the water is meant for human or animal consumption.

Photo 38. Above-ground Cistern

Photo 39. Below-ground Cistern

Cisterns come in a wide range of sizes, materials and shapes, and can be constructed individually or in a connected series where the overflow from one cistern flows into the next. A number of manufacturers offer modular cistern systems which provide highly flexible configuration and capacity options. Some manufacturers also offer turn-key cistern design and installation services.

The appropriate tank volume is based on average rainfall amounts and the total square footage of area that will collect stormwater. Groups of residential units, such as apartments and commercial and office buildings, offer significant opportunities for collecting rainwater using cisterns. Cost and space required for the tank are additional considerations.

A cistern should be placed on a level surface or pad. Potential damage to adjacent features be taken into account when determining where to locate the tank. Cisterns should be located for ease of maintenance or replacement. The locations of downspouts feeding into the cistern are also a factor. If the water stored in the tank will be accessed via a gravity-feed system, the height of the tank location relative to the landscape areas that will use the stored water is also a

Roof Water Harvesting Capacity

Roof Area (sqft)	Total Water Harvested (cuft)	(gal)
1000	633	4737
2000	1267	9475
3000	1900	14212
4000	2533	18949
5000	3167	23687
6000	3800	28424
7000	4433	33161
8000	5067	37899
9000	5700	42636
10000	6333	47373
11000	6967	52111
12000	7600	56848
13000	8233	61585
14000	8867	66323
15000	9500	71060
16000	10133	75797
17000	10767	80535
18000	11400	85272
19000	12033	90009
20000	12667	94747
25000	15833	118433
30000	19000	142120
35000	22167	165807
40000	25333	189493
45000	28500	213180
50000	31667	236867

Note: Harvesting calculations based upon a 9.5 in/yr annual rainfall and an 80% collection efficiency

consideration. Water from the cistern can also be discharged using a pump connected to an irrigation system, hose, perforated pipe or surface channel that conveys water to the landscape (see Figure 43).

Cisterns have a removable lid or entry port for maintenance access. Cisterns can be left open to catch rain or connected to more elaborate systems that collect water from several locations and direct it into the cistern. Open systems should be designed to minimize water loss due to evaporation and to prevent algae growth. Outlet pipes should be positioned a few inches above the bottom of the tank to avoid sucking out sediment settled on the tank bottom. The tank should have an overflow pipe that does not require a pump to function with a capacity equal or greater than the inlet pipe. All inlets and outlets should be screened to keep mosquitoes, animals and debris out of the tank. In addition cistern water should be filtered prior to entering the irrigation system to avoid potential clogging issues.

Maintenance: The tank, screens on inlet and outlet pipes, and any gutters feeding into the cistern should be cleaned periodically to remove accumulated debris. The interior of the tank should also be checked periodically and maintained in accordance with manufacturer's requirements or according to best practices for the tank material. Performance of the overflow pipe should also be verified following significant storm events.

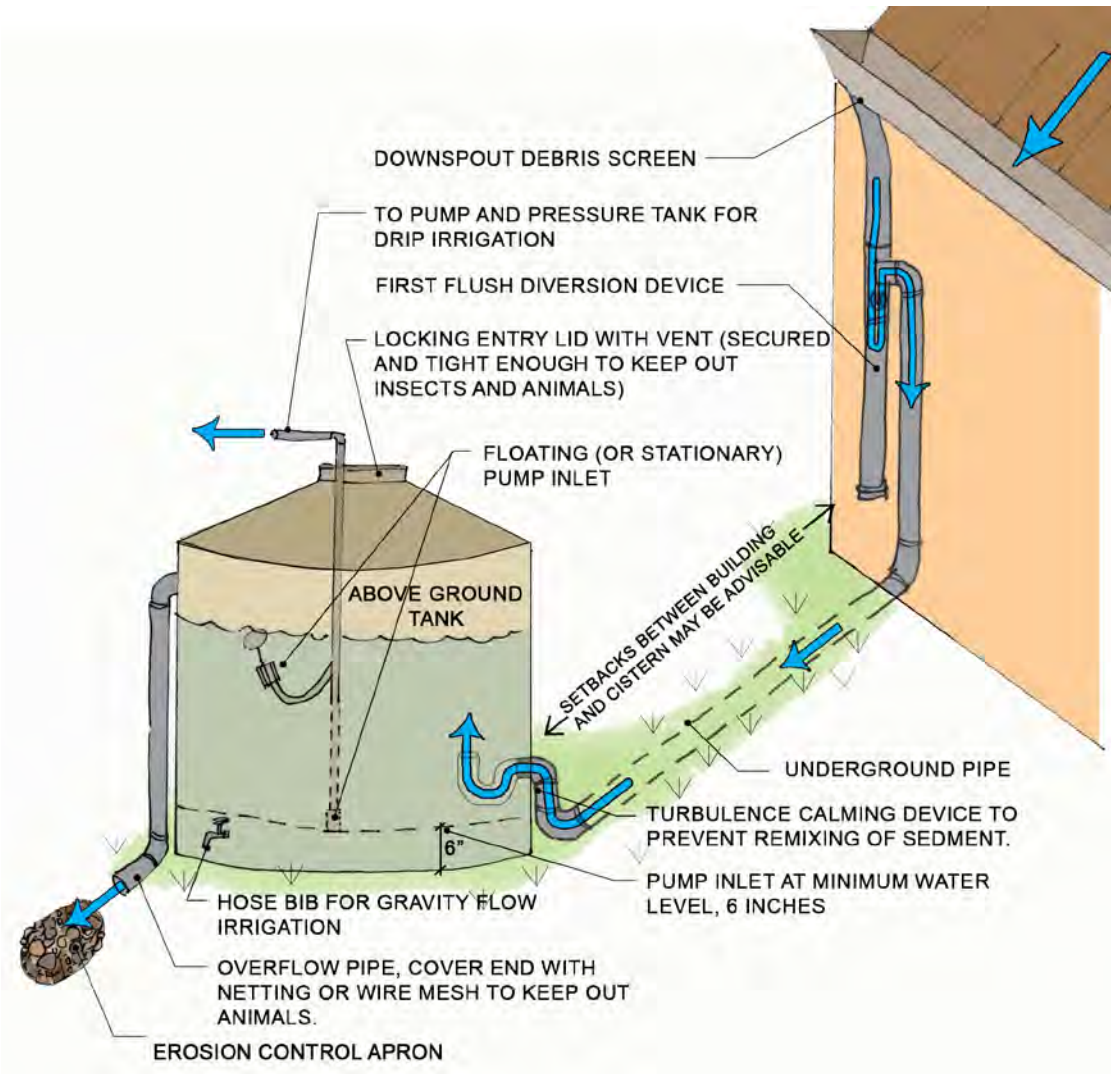


Figure 43. Cistern System

Irrigation System Design, Installation and Management

Designing your own irrigation system requires an understanding of how the various elements of the landscape work together. These elements include site grading, microclimates, soil types and infiltration rates. A basic understanding of hydraulics is also needed to calculate pipe sizes and system pressure losses. In order to develop an effective watering schedule, you will need a basic working knowledge of plant types and evapotranspiration rates. In addition, local plumbing codes and ordinances need to be followed. Most manufacturers of irrigation equipment can provide some help to the homeowner, providing instruction manuals and videos for those interested in doing it themselves. Some will even provide a design for you, or you may consider hiring a professional (for additional information see the "Hiring a Professional" section that follows later in this chapter).

Basic Irrigation System Design Tips

1. Use a landscape plan or make a scaled drawing of your property's existing landscape to use as a base for your irrigation plan.

2. Determine your hydrozones. As discussed in the "Landscape Design" section of this document, grouping plants by their water needs provides the foundation for a water-efficient landscape design. Separate irrigation system zones can be designated by hydrozone in order to tailor the watering schedule to plant group requirements. The same type of water delivery device should be used for all plants on a particular zone, such as drip emitters for a shrub hydrozone, bubblers for a tree hydrozone, or spray heads for a turf hydrozone.

3. Calculate the available water capacity and water pressure. Water capacity is the maximum flow of water available, expressed in gallons per minute (gpm). Water capacity determines the maximum number of emitters, sprinklers or bubblers you can have in a single irrigation zone. If the site water capacity is 25 gpm, the maximum number of a one-gpm sprinkler per zone would be 25.

   Heads are labeled with their optimal operating pressure. As noted earlier, exceeding that pressure will waste water by creating mist, while operating at lower pressures will result in uneven coverage. Water pressure and flow rate can be verified by attaching a combination flow and pressure gauge to an outside faucet.

4. When using sprinklers:
   - Be sure to match sprinkler radius to the size and shape of the area to be watered. Don't use spray heads in areas less than 10 feet wide to avoid overspray and runoff. In small areas, drip emitters, micro-sprays, or bubblers are appropriate options.
   - Use low-precipitation-rate (low-volume) sprinkler heads, as they deliver water at a lower rate, allowing the soil to absorb more efficiently and reducing runoff. These are particularly useful for soils with slower infiltration rates, such as clay or silt, and for slopes.
   - Use matched-precipitation-rate heads which apply the same amount of water regardless of the head dispersal shape, providing uniform coverage.
   - Heads should be laid out so that the water throw from one sprinkler head reaches the next adjacent head (head-to-head coverage). Uniform coverage promotes turf health and helps to avoid the temptation to over-water in an attempt to address dry spots.
   - Use check valves to eliminate drainage from low heads in the system.

5. Include water-saving irrigation devices in your system design. Information on rain and soil moisture sensors, smart controllers, drip systems and other options can be found in the Irrigation System Type section above.

Irrigation System Renovation

Renovating an existing irrigation system is a lot like renovating any other part of a home as you are dealing with the conditions left by the last homeowner. If the problems with your existing system are too severe, starting from scratch may be the best approach. If the irrigation system is basically sound, however, all that may be needed is an irrigation system audit to show you ways the system can be improved for better performance. For additional information regarding audits, see "Best Management Practices for Irrigation System Maintenance" on page 91.

Hiring a Professional

Irrigation designers are trained to evaluate specific site conditions and develop irrigation plans tailored to the needs of the plants and the site. They should be well-versed in the latest technology available for maximizing irrigation water efficiency. They should also be able to provide installation oversight to ensure the project is built according to their specifications. As-built or record drawings should be provided to document any variations in the installation of the system design. The end user should be provided with all product warranties and operating instructions. Some irrigation supply companies provide system design services or design assistance resources for homeowners.

If your site will have a landscape maintenance manager, consider hiring a Landscape Irrigation Auditor certified by the Irrigation Association. Certified Landscape Irrigation Auditors are trained in exterior water management and can help to ensure that water efficiency is maximized in your landscape.

- ***Qualifications -*** When searching for a professional irrigation designer or contractor to design or install an irrigation system, there are certain qualifications you should consider. The tips below can be used to help you make an informed choice for your irrigation project.

  - **Certification and Licensing** - New Mexico state law requires anyone who contracts to do work to be licensed according to the Construction Industries Licensing Act. Licensed contractors are regulated by laws designed to protect the public, and hiring a licensed contractor is highly advisable. When hiring a contractor ask for their state license number and call the State License Board to verify that it is issued for the appropriate discipline, is current, and is in good standing.

    The Irrigation Association Certification Board manages industry certifications for irrigation designers and contractors. These require that the contractor achieve certain levels of irrigation experience and education, pass a series of examinations, agree to abide by the Association's code of ethics, and receive ongoing education yearly. The designations include Certified Irrigation Designer (CID), Certified Irrigation Contractor (CIC), Certified Landscape Water Manager (CLWM) and Certified Landscape Irrigation Auditor (CLIA).

  - **References** - Ask for and check references and request a list of similar jobs the contractor has recently completed in your area. If possible, look at the work and talk to the owners about their experience with the contractor.

  - **Water Management** - Ensure that your contractor will design your system with water efficiency in mind and use appropriate irrigation methods such as drip irrigation to achieve that efficiency.

  - **Written proposals** - A professional contractor should provide a written proposal that includes a detailed list of every task to be performed, along with the dollar amount.

  - **Insurance** - Reputable professionals will carry appropriate insurance policies to protect you and your property. Ask if the contractor has liability and workers' compensation insurance and request certificates in writing.

  - **Contract** - Insist on a written contract for your protection, regardless of the amount of the contract. After the contract is signed, any changes you and the contractor agree to make in the work or the materials to be used must be in writing. This written "change order" must also include any additions or reductions in the total job price. Here is a list of basic elements you will find in most irrigation contracts:
    - Specific costs of materials to be installed
    - Specified start date and an estimated completion date
    - Statement regarding payment arrangements such as down payment, progress payment and balance due
    - The name, street address and telephone number of the contractor
    - Complete description of the work to be done and materials to be used (including quantities, sizes, models and brands of irrigation equipment)
    - Warranties covering materials and workmanship

- Statement that the contractor will do any necessary cleanup and removal of debris after the job is completed
- "Notice to Owner" explaining the state's mechanic's lien laws and the ways to protect yourself and your property
- "Notice of Cancellation" informing you how long you have after signing the contract to cancel
- Statement requiring the contractor to provide proper lien releases for suppliers
- Statement of contractor's obligation to obtain all permits
- Validation of any required license and certificates of insurance, not just copies
- Statement that the work will meet the standards specified in the contract
- Statement that contractor will be responsible for all cleanup.

- **Customer Service -** The contractor you hire should be available if you have questions or if a problem arises in the future. In addition, ask questions about how to reset the controller once your new turf is established.

- **Key Inspection Points and Testing -** The contractor's work should be inspected when the locations of all the piping have been laid out on the project site. A pressure test should be performed to verify that all piping has been installed properly and that there are no leaks in the system.

- **Final Walkthrough -** A final walkthrough should be conducted to inspect and verify that all work is complete and satisfactory. During the walkthrough, the contractor should demonstrate all of the capabilities of the irrigation controller and that the controller has been properly programmed for all irrigation zones. The locations of all sprinklers, bubblers, drip emitters, etc., should follow the original plans. All heads should be installed at the proper height. Any deviations from the original plans should be documented for future reference.

Reducing Water Use

When initially installed, most plant materials will require more frequent deep watering in order to establish a healthy root zone. Once established, plants should be irrigated on an evapotranspiration (ET) watering schedule as recommended by Irrigation Association guidelines. When adjustments in the watering schedule are needed, these should be done monthly based on historical ET rates.

Some native and very-low-water-use plants may be weaned off irrigation over time, especially if they have been planted in water-harvesting swales or water catchments. This process should be carried out very slowly. Careful monitoring is necessary to delay irrigation until the maximum allowable depletion of soil moisture has occurred. This will vary based on soil type and the depth of the root system. Plants with shallow root zones will likely wilt more rapidly than those with deeper root zones.

It also may be possible to reduce irrigation to higher-water-use plants by watering less frequently but longer to encourage deeper root growth. It is important, however, to consider the soil type; faster-draining, sandy soils will require more frequent watering than those with higher clay content. Extra care should be taken when reducing or eliminating irrigation to trees. Even native, drought-tolerant trees will require some supplemental irrigation in times of drought. Trees can take several years to die, and regular observation to monitor for change is the best method for determining when a plant is experiencing stress.

An efficient landscape irrigation system should have a watering schedule that delivers the proper amount of water for the root depth of the plants. Water should be applied at the outer edge of the plant canopy, and to the depth of the root zone as shown in the table below.

Efficient Watering Depth	
flowers and turf lawns	8-10 inches
shrub and groundcovers	2 feet
established trees	6-8 feet (once a month)

Source: ABCWUA

Use a soil probe (smooth metal 1/4-inch to 3/8-inch rod) to inspect root depth and check for proper soil moisture and irrigation penetration depth as shown in the Moisture Probe Depth Chart below.

Moisture Probe Depth Chart				
Plant Type	**Root Zone Depth (in inches)**	**Depth of Probe**		
		Water	**Wait to Water**	**Overwatered**
Groundcover / turf	6-12"	0-4"	4-12"	>12"
Shrub	12-24"	0-4"	4-18"	>24"
Tree	18-36"	0-4"	4-36"	>36"

Large shrubs and trees require that the irrigation zone be expanded as the roots and canopy reach farther and farther out from the original placement of the water source as illustrated in the graphic below. As this occurs, additional bubblers or drip emitters should be moved to or added at the drip line of the tree. Figure 44 demonstrates the evolution of a bubbler system to accommodate increasing plant size. Figure 45 shows modification of drip emitters over time to account for plant growth.

Watch for signs or over- or under-watering, and adjust the irrigation schedule accordingly. Plant root systems need both water and air. Overwatering deprives the root system of air and can cause root rot, indicated by dried green leaves on the plant. Soil that is consistently damp or has mushrooms or other fungus growth can also indicate excessive irrigation. Over-watering wastes water by allowing it to infiltrate to below or beyond the root zone, where the plant cannot access the water. Under-watering causes plants to develop shallow, more fragile root systems that inhibit robust growth and long-term plant health. The appearance of tree roots running on top of or near the soil surface can indicate watering that is too shallow.

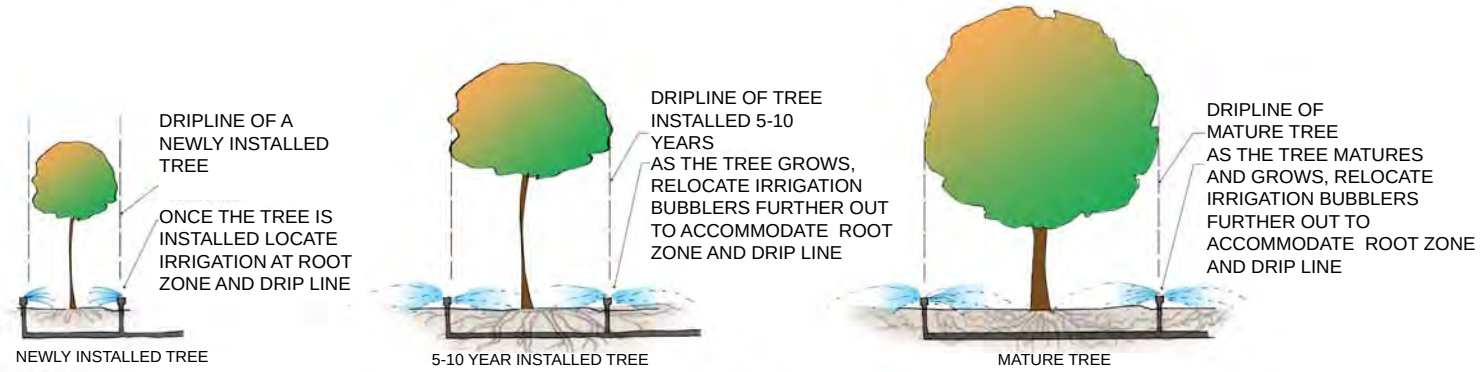


Figure 44. Bubbler Placement Modification Over Time

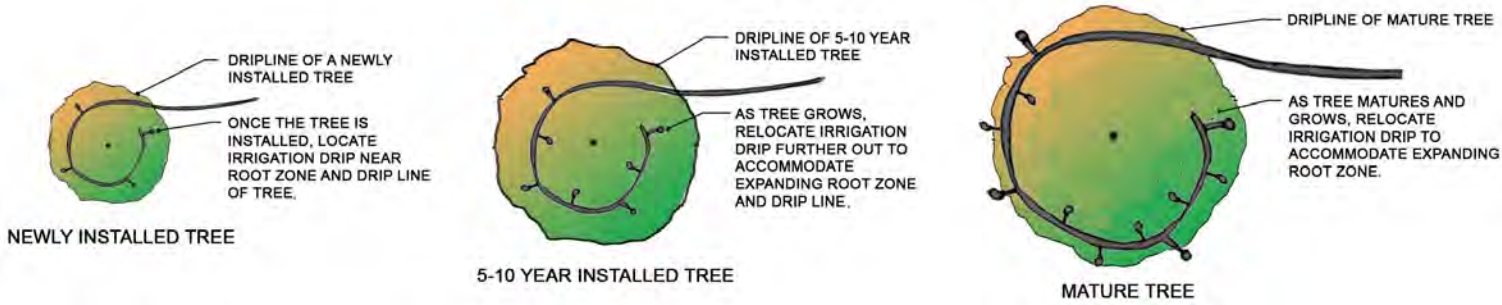


Figure 45. Drip Emitter Placement Modification Over Time

For all plantings, water slowly to the depth of the root zone, and only after the soil has dried to within the top four inches. Drip irrigation can do this automatically, applying water slowly and directly to the soil. Using an evapotranspiration-based watering schedule based on Irrigation Association guidelines will help to ensure that irrigation is applied at appropriate levels. Irrigation frequency and duration should take into account both the needs of the plant species in the landscape as well as the soil type. Sandy soils drain rapidly, whereas clay soils hold moisture for longer periods, leading to over-watering. Watering should be less frequent for clay soils in order to allow time for the soils to dry out between irrigation sessions. Soils around newly constructed buildings are often compacted which also inhibits moisture penetration. In some cases irrigating in a "cycle and soak" mode where water is applied for a shorter length of time, then allowed to completely soaked in before additional water is applied, may be the best method to achieve root zone depth penetration without incurring runoff. Again, the key is to ensure that water is penetrating to the appropriate root zone depth for each plant type and watering only when it is necessary.

Watering Guidelines for Establishing Xeric Plantings

Week	Cool Season	Hot Season
1 - 2	Every 3-4 days	Every 1-2 days
3 – 4	Every 6-7 days	Every 3-4 days
5 – 6	Every 7-10 days	Every 4-6 days
7 – 8	Every 10 days to 2 weeks	Once a week
9+	Gradually increase time between watering until plants are fully established. Establishment generally takes 1 year for smaller plants, 2 years for larger plants and 2-3 years for trees.	

Note: Watering needs change depending on weather, soil type and other factors. Visually inspect plantings daily and modify the schedule if needed.

- ***Turf Grass Irrigation***

  Wherever possible, it is best to choose low-water-use plants or turf grass. Turfgrasses typically employed for lawns and landscaping in Bernalillo County are either cool season or warm season grasses. Cool season grasses include Bluegrasses (Poa species) and its cultivars, and many varieties of Tall-Type Fescue (festuca species). These grasses generally grow in the cooler months of the year typically in March/April and September/October; they are dormant in the winter and in the summer. However irrigation of these grasses should continue in the summer months as they are not drought tolerant grasses. Warm season turfgrasses include Bermuda (cynodon species), buffalograss (Bouteloua syn. Buchloe dactyloides), and sometimes Grama Grass (Bouteloua gracilis) or others. These grasses generally grow from April/May through August/September. During the summer months it is important that they be irrigated; however they are generally more able to withstand the heat with less water than cool season grasses and can therefore be categorized as drought tolerant grasses. Grama grass for instance should need very little irrigation once established in all of Bernalillo County; buffalograss on the other hand will require some irrigation in the West Mesa, Rio Grande Valley and East Mesa bioregions. When turf grass is used, be sure to:

Photo 40. Turf grass thatch

  - Let the grass grow taller (to 3 inches) to promote water retention in the soil. The longer grass blades make the grass more water-efficient by shading the root zone and promoting deeper root growth.
  - Follow the Bernalillo County Water Conservation Ordinance regarding turf areas sizes and do not plant turf grass areas that are less than 10 feet wide in any dimension, as they are extremely difficult to water efficiently.
  - Water turf grass areas in the evening or early morning to avoid evaporation losses.
  - Do not operate sprinklers when it is windy or raining.
  - Install and maintain sprinkler head heights per the manufacturer's recommendation to avoid water waste from spray being blocked by plants.
  - Aerate turf grass areas and de-thatch to allow for proper infiltration of irrigation water. Photo 40 shows turf grass thatch. Thatch is the fibrous area between the soil and the grass.
  - Water only when necessary, generally every three or four days. Watering less frequently promotes deeper root growth which increases the lawn's water efficiency. It takes 660 gallons of water to supply 1,000 square feet of lawn with one inch of water.
    - A good way to check whether your lawn needs watering is to step on the grass. If it springs back up when you move, it doesn't need water. If it remains flat, the lawn is ready for watering.

- ***Irrigating Trees***
  - Provide gaps in your watering schedule to allow soils to dry. This permits needed aeration for tree roots.
  - Proper irrigation will result in healthier trees that are less prone to insect damage and disease. The depth of soil infiltration after watering should be checked to be sure trees are not being under- or over-watered. Deeper irrigating encourages deeper root growth. Deeper roots are less apt to be stressed by higher soil temperatures closer to the surface.

- ***Irrigating on Slopes***

  In Bernalillo County (and the arid southwest in general) it is important to minimize the use of irrigation on slopes as much as possible because irrigation of sloped landscapes can cause soil erosion and water waste. However, for very specific cases, irrigation may be necessary and should follow the general guidelines below. It should also be noted that spray irrigation should be avoided on slopes greater than 1:5 (1 foot of vertical rise to 5 feet of horizontal distance).
  - Place bubblers on the uphill side of plants. See Figure 46 for an example of this type of installation.
  - Provide a well or depression around the base of the plant or plant grouping to hold water and allow it to infiltrate the plant root zone.
  - Program your controller to irrigate slopes over several cycles, allowing water to infiltrate while preventing excess runoff.

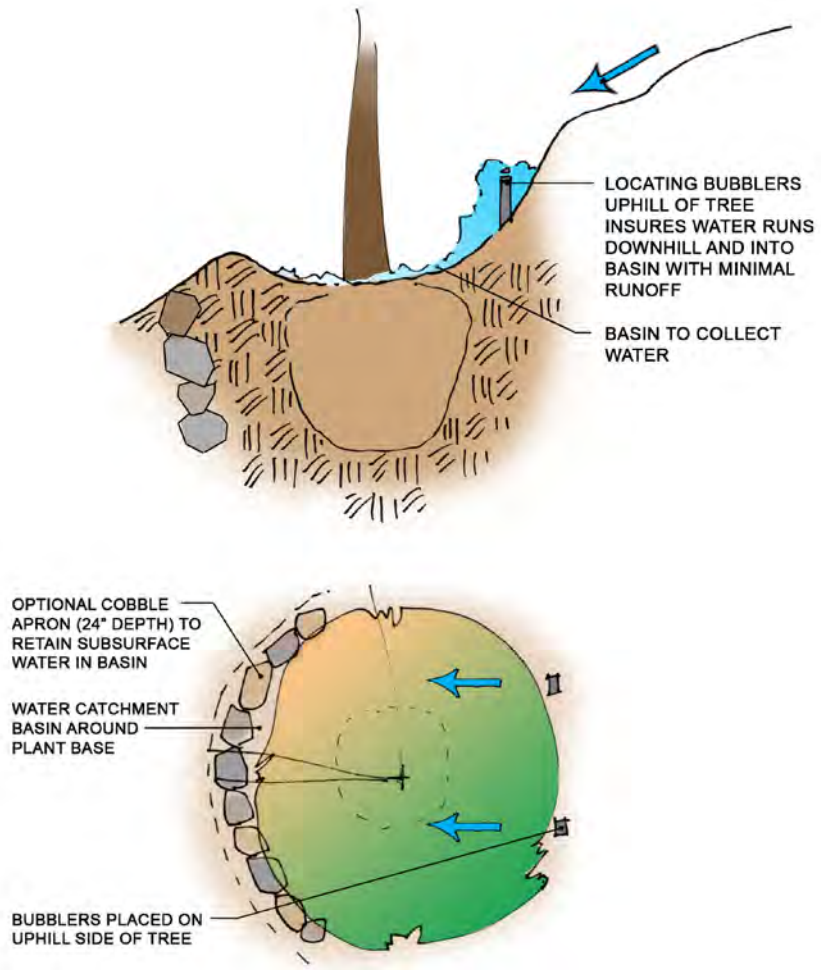


Figure 46. Bubbler Placement on Slopes

Best Management Practices for Irrigation System Maintenance

Residential irrigation systems should be inspected, adjusted and repaired on a monthly basis. Inspection should include adjusting valves, heads, checking nozzles and verifying the operation of sensors. Drip irrigation filters and emitters should also be checked monthly and cleaned or replaced as needed. Turn on the irrigation system and visually make sure that all emitters are operating properly.

Performing an annual water audit is strongly recommended for maximum water savings. The audit helps the homeowner to verify the system's efficiency and to determine whether modification to the irrigation water schedule is needed. The following issues are typically checked for during an irrigation system audit and provide a good initial starting point for improving water efficiency:

- Improper operating pressure – Operating at the wrong pressure causes inefficient system operation, wasting water and potentially damaging equipment.
- Tilted sprinkler heads (should be straightened).
- Broken heads or pipes.
- Obstructed spray patterns.
- Low head drainage - The loss of the water that remains in the pipe after the system turns off. Gravity will cause the water to flow through the pipe to the lowest point, where it leaks out into the landscape. By using sprinklers with built-in check valves, this water will stay inside the pipe.
- Clogged nozzles or emitters.
- Improperly mixed equipment - Never mix different types, brands or models of sprinklers or different nozzles in the same irrigation zone as this will contribute to water loss due to inefficiencies.
- Sprinklers not installed at the proper height - Sunken sprinklers will often not pop up high enough to spray over the height of the grass, disrupting the proper spray pattern of the water.
- Improper arc adjustment of sprinkler heads.
- Rotary heads that no longer rotate.
- Use of non-pressure-compensating emitters.
- Leaking pipes and equipment.
- Compaction and excessive turf thatch.
- Backflow prevention devices - Inspect periodically, at a minimum as determined by local ordinance.
- Hidden leaks - Use your water meter to check for hidden leaks. Read the meter at the beginning and end of a two-hour period when no water is being used in the house or landscape. If the meter reading isn't exactly the same, there is a leak somewhere in the system.
    - Check for leaks in hose bibs as they can lose more than 73 gallons per day depending on the size of the leak.
- Freeze damage - Winterize systems in areas (such as sites in the East Mountain biozone) where freeze damage is a real threat. In warmer areas the system should be maintained and operated to compensate for typical winter drought times.

Drip irrigation systems require regular inspection and maintenance to ensure peak performance and water conservation:

- Flush the system, at a minimum annually. Open the line end caps and run the system for one minute, turn off and close the end cap.
- Locate and check emitters while the system is running to verify performance. Replace clogged or missing emitters and close off any emitters that are no longer necessary. Replace unmatched emitters, the same emitter should be used throughout a drip irrigation zone.
- Verify that emitters are placed appropriately and that each plant is receiving water. Move emitters out from the dripline of trees and shrubs as they mature. In general the root zone extends 11/2 to 4 times the canopy width. Add emitters as appropriate to accommodate mature plant needs.

Additional information on designing and installing irrigation systems, designers, and irrigation technologies is available through the websites listed below.

City of Albuquerque--Do It Yourself

http://www.abcwua.org/pdfs/irrigationmanual.pdf
City of Albuquerque "Rainwater Harvesting"

Albuquerque/Bernalillo County Water Authority free residential water audit
http://www.abcwua.org/content/view/75/65/

Rainbird homeowner's irrigation information
http://www.rainbird.com/diy/index.htm

Hunter Irrigation Homeowner's Irrigation Information
http://www.hunterindustries.com/homeowners.html

Toro Homeowner's Irrigation Information
http://www.toro.com/sprinklers/guides.html

EPA
http://www.epa.gov/watersense/docs/home_draft_spec508.pdf
Single family homes guidelines

Bureau of Reclamation- Smart technology
http://www.usbr.gov/waterconservation/docs/SmartController.pdf

Hiring a Professional
http://www.irrigation.org/hirecertified/
http://findalandscapepro.pbwiki.com/How+to+Hire+a+Pro

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Garden Design www.gardendesign.com
Horticulture www.hortmag.com
Organic Gardening www.organicgardening.com
Sunset Magazine www.sunset.com

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Forgotten Rain, *Rediscovering Rainwater Harvesting,* Heather Kinkade-Levario, 2003
www.forgottenrain.com

Suzy Banks & Richard Heinichen, *Rainwater Collection for the Mechanically Challenged*,

Brad Lancaster, *Rainwater Harvesting for Drylands*, . www.harvestingrainwater.com

Stormwater as a Resource, How to Harvest and Protect a Dryland Treasure
http://www.nmenv.state.nm.us/swqb/Storm_Water_as_a_Resource.pdf

Wendy Price Todd & Gail Vittori. *Texas Guide to Rainwater Harvesting., 2nd Ed.*
http://www.twdb.state.tx.us/publications/reports/RainwaterHarvestingManual_3rdedition.pdf

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Art Ludwig, *Create an Oasis with Greywater, Your Complete Guide to Choosing, Building and Using Greywater Systems*, 4th Ed., Oasis Design, 2000. http://www.oasisdesign.net

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V. Appendices

"Appendix A. Bernalillo County: Applicable Plans, Regulations and Ordinance"

Included in this document:

"Bernalillo County Board of Commissioners, Water Ordinance Conservation Requirements. Ch. 30. Art. VII, Sec. 241-231, Amend. 5-25-2010" - http://www.bernco.gov/upload/images/public_works/water/waterconservord.pdf

Reference only; plan and ordinances not included in this document:

Bernalillo County Water Conservation Plan. April, 2006 - http://www.bernco.gov/water-conservation-plan-for-bernalillo-county/

Bernalillo County Zoning Ordinances - http://library.municode.com/index.aspx?clientID=13071&stateID=31&statename=New%20Mexico

Bernalillo County Storm Drainage Article III of the Flood Ordinance No. 2008-15 - http://library.municode.com/HTML/13071/level3/BECOCO_CH38FL_ARTIIISTDR.html#TOPTITLE

"Appendix B. Pre- and Post-Development Calculation Worksheets"

Included in this document:

"Pre- and Post-development Flow Example Calculations"
"Table 1. Precipitation Zones"
"Table 2. Land Treatments"
"Table 3. Excess Precipitation"
"Table 4. Peak Intensity"
"Table 5. Rational Method, Co-Efficient, C"
"Treatment Train Example Calculations"

"Appendix C. Albuquerque Bernalillo County Water Authority Xeriscape Plant List 2010"

Included in this document:

"Xeriscape Plant List" - http://www.abcwua.org/pdfs/xeriplantlist.pdf

"Appendix D. State of New Mexico: Plans, Regulations and Guides"

Reference only; regulations and guides not Included in this document:

New Mexico Environment Department Graywater Discharges (NMAC 20.7.810) - http://www.nmenv.state.nm.us/fod/LiquidWaste/20%207%203%20NMAC%20-%20filed%202-21-2007%20with%20toc.pdf

New Mexico Environment Department Graywater Systems (NMAC 20.7.811) - - http://www.nmenv.state.nm.us/fod/LiquidWaste/20%207%203%20NMAC%20-%20filed%202-21-2007%20with%20toc.pdf

New Mexico Environment Department Graywater Irrigation Guide - http://www.nmenv.state.nm.us/OOTS/GRAY%20WATER%20IRRIGATION%20GUIDE1.pdf

New Mexico Office of the State Engineer: Water Use and Conservation Program - http://www.ose.state.nm.us/conservation_index.html

"Appendix E. United States Environmental Protection Agency: Water Conservation Plan Guidelines"

Reference only; guidelines not included in this document:

United States Environmental Protection Agency: Water Conservation Plan Guidelines - http://www.epa.gov/greeningepa/water/index.htm

"Appendix F. Annotated Bibliography"

Included in this document

"Appendix G. Water Features and Amenities"

Included in this document

"Appendix H. Structural Soils"

Included in this document

"Appendix I. Recommended Watering Schedules"

Included in this document

"Appendix J. Bernalillo County Protocol Document/Summary of Ordinance Requirements"

Included in this document

"Appendix K. Plant and Turf Grass Installation Details"

Included in this document

Appendix A. Bernalillo County: Applicable Plans, Regulations and Ordinance

BERNALILLO COUNTY

BOARD OF COUNTY COMMISSIONERS

ORDINANCE NO. _____

AMENDING AND REPEALING CERTAIN SECTIONS OF WATER CONSERVATION REQUIREMENTS SECTIONS 30-241 THOUGH SECTIONS 30-251

Section 1. PURPOSE AND INTENT

To implement portions of the Bernalillo County Water Conservation Plan in order to: reduce per capita water use; encourage responsible use of water; reduce water waste; require conservation measures for new development and preserve water supplies within Bernalillo County for the health safety and welfare of County residents. It is the intent of Bernalillo County to follow the specifications of this ordinance when designing, building, operating, and maintaining its own facilities.

Bernalillo County public policy is to encourage, support and protect xeriscaping, efficient irrigation systems, and water conservation by property owners and lessees. Restrictive covenants which require turf grass or other high water use plants, or otherwise restrict, limit or increase the cost for xeriscaping, efficient irrigation systems or water conservation by property owners or lessees in any manner shall be considered contrary to public policy.

Section 2. APPLICABILITY

This ordinance applies to all persons, entities, and properties within unincorporated Bernalillo County. Where a conflict exists between any of the regulations or limitations prescribed in this ordinance and any other regulations applicable to the same area, the more stringent limitation or requirement shall govern and prevail.

Section 3. PENALTY FOR VIOLATION OF ORDINANCE

Violations of this ordinance are punishable as provided in section 1-6 of this Bernalillo County Code.

Section 4. ENFORCEMENT

(A) The County Manager or his/her designee shall be responsible for the enforcement of this ordinance. The County Manager may prescribe policies, rules, or regulations to carry out the intent and purposes of this ordinance.

(B) Water Customers of the Albuquerque Bernalillo County Water Utility Authority (ABCWUA) shall not be subject to enforcement of the same violation by both Bernalillo County and the ABCWUA.

Section 5. ADMINISTRATION

The Bernalillo County Manager is responsible for the administration of this ordinance. Powers assigned to the County Manager may be delegated by the County Manager to other appropriate County divisions and departments as deemed necessary to carry out the requirements of this ordinance. The County Manager or his/her designee is hereby authorized and directed to enforce all of the provisions of this ordinance. The County Manager or his/her designee shall have the power to render interpretations of this ordinance and to adopt and enforce rules and supplemental regulations to clarify the application of its provisions. Such interpretations, rules and regulations shall be in conformity with the intent and purpose of this ordinance. The County Manager or his/her designee shall establish administrative procedures to carry out the intent and purpose of this ordinance.

Section 6. DEFINITIONS

For the purpose of this ordinance, the following definitions shall apply unless the context clearly indicates or requires a different meaning.

ACTIVE RAINWATER HARVESTING. The use of collection systems, storage containers or cisterns to capture and store rainwater runoff for later use on the property.

ALBUQUERQUE BERNALILLO COUNTY WATER UTILITY AUTHORITY (ABCWUA). The Albuquerque Bernalillo County Water Utility Authority or its authorized agent. It includes the water and wastewater facilities and all operations and management of such facilities necessary to provide water and wastewater service.

ATHLETIC FIELD. Turf area which is used to hold athletic events or practices. Parks that have substantial areas used for athletic events or practices will be considered Athletic Fields.

BUBBLERS. Irrigation heads which deliver water directly to the soil adjacent to the heads.

BUILD GREEN NEW MEXICO PROGRAM (BGNM). A voluntary program to encourage homebuilders to use technologies, products and practices that will: provide greater energy efficiency, reduce pollution, provide healthier indoor air, preserve natural resources, improve durability, reduce maintenance and reduce water usage in new homes.

BUILD GREEN NEW MEXICO CERTIFICATION. Certification by the Build Green New Mexico program that all of BGNM current standards, documentation, and inspections have been met to achieve the water and energy conservation goals for the specified level.

COMMERCIAL DEVELOPMENT. Any retail, office, industrial, mixed use, institutional, service or other non-residential building, facility or activity allowed as a permissive or conditional use or by special use permit in accordance with the provisions of the county zoning ordinance.

DRIP IRRIGATION. Low pressure, low volume irrigation applied slowly, near or at ground level to minimize runoff and loss to evaporation.

DROUGHT. An extended period of low precipitation in an area which occurs in sufficient length or magnitude to cause water shortages and/or crop damage.

DROUGHT STATUS. Level of drought as defined by the New Mexico Drought Monitoring Committee. Four drought levels include; Drought Advisory, Drought Watch, Drought Warning, and Drought Emergency.

(1) Drought Advisory
(2) Drought Watch
(3) Drought Warning
(4) Drought Emergency

DWELLING UNIT. A room or suite of rooms with kitchen and bath facilities designed as a unit for occupancy by one family.

ENERGY STAR. A United States government-backed program that provides an energy performance rating system for household appliances. Appliances with the Energy Star label attached have met energy efficiency guidelines set by the United States Environmental Protection Agency and the United States Department of Energy.

EPA WATERSENSE. A partnership program sponsored by the U.S. Environmental Protection Agency (EPA) that helps consumers identify water-efficient products and programs through independent testing and certification.

EPA WATERSENSE LABEL. Label that indicates a product and programs met all of the water efficiency and performance criteria established by the EPA WATERSENSE program.

EXTERIOR MANAGEMENT PLAN (EMP). A two-year plan to employ site best management practices that significantly reduce water use, and chemical use.

GRAYWATER. Wastewater from bathroom sinks, bathtubs, showers, and laundry which is not used to wash diapers or other similarly soiled or infectious garments.

HAND WATERING. The application of water for irrigation purposes through a hand-held hose, including hoses moved into position by hand and left to flow freely or through a shut-off nozzle.

HIGH-WATER-USE PLANTS. Plants that are classified as high-water-use on the plant list maintained by the ABCWUA.

HIGH-WATER-USE TURF. Turfgrass that is classified as high-water-use on a list approved by Bernalillo County.

INFILTRATION RATE. The amount of water absorbed by the soil per unit of time, usually expressed in inches per hour.

LANDSCAPE AREA. The entire parcel minus any undisturbed un-irrigated natural areas, building footprints, driveways, non-irrigated portions of parking lots, decks, patios or other non-porous areas.

LARGE MULTI FAMILY DEVELOPMENT. Residential developments with 8 or more dwelling units on the same parcel.

LOW-WATER-USE PLANTS. Plants that are classified as low-water-use on the plant list maintained by the ABCWUA.

MEDIUM-WATER-USE PLANTS. Plants that are classified as medium-water-use on the plant list maintained by the ABCWUA.

NEW DEVELOPMENT**.** Any development that requires a building permit including remodels and additions.

NEWLY SEEDED. Seed planted in a prepared area with the intent of establishing a turf area.

ORNAMENTAL LANDSCAPE AREA. Landscapes that are designed strictly for decorative and aesthetic value and have no functional area for activities.

PARK. An area of land set aside for public use that is permanently maintained for community recreational and quality of life enhancement purposes.

PASSIVE WATER HARVESTING. The use of earthworks and contouring such as berms, swales, terracing, and depressions to direct and control rainwater runoff where it can infiltrate into soil to be used by vegetation.

PRIVATE PARK. A Park which is permanently maintained by the owner or Property Holders Association, not a local government.

PUBLIC RIGHT-OF-WAY. The area of land acquired or obtained by the city, county, or state primarily for the use of the public for the movement of people, goods, vehicles, or storm water. For the purposes of this ordinance the public right-of-way shall include sidewalks, curbs, streets, and storm water drainage inlets.

RESPONSIBLE PARTY. The owner, tenant, manager, supervisor, or person in charge of the property, facility, or operation during the period of time the violation is observed.

PRECIPITATION SUPPORTED PLANTS. Plants that are classified as precipitation only the plant list maintained by the ABCWUA. Additional plants may be approved if they have demonstrated survivability in the local environment under precipitation only conditions.

RAINWATER HARVESTING. The use of active or passive methods to capture and use rainwater runoff on the property.

RUNOFF. Precipitation, snowmelt, or irrigation water that is not absorbed by the soil and moves across ground surfaces.

SINGLE FAMILY DEVELOPMENT. A building designed to be occupied by one family and containing one kitchen.

SMALL MULTI FAMILY DEVELOPMENT. Properties that contain more than 1 and less than 8 dwelling units.

SMART IRRIGATION CONTROLLER. Irrigation controller that uses site specific and local information such as soil moisture, rain, wind, slope, soil types, plant type, etc. to apply the proper amount of water to meet the plant water requirements.

SOIL AMENDMENT PROGRAM. A program approved by Bernalillo County to incorporate compost or other approved material into the soils in the Landscape Area to improve the nutrient and water holding capacity of the soil.

SPRAY IRRIGATION. The application of water to landscaping by means of a device that projects water through the air in the form of small particles or droplets.

WATER UTILITY AUTHORITY CUSTOMER. Any person, association, corporation or other entity receiving Albuquerque Bernalillo County Water Utility Authority water service.

WATER WASTE. The nonbeneficial use of water. Nonbeneficial uses include but are not restricted to:

(1) Landscape irrigation water applied in such a manner, rate and/or quantity that it causes runoff onto adjacent property or public right-of-way;
(2) Landscape irrigation water which leaves a sprinkler, sprinkler system, or other application device in such a manner or direction as to spray onto adjacent property or public right-of-way;
(3) Water provided through the Middle Rio Grande Conservancy District or community acequia systems for irrigation purposes applied in such a manner, rate and/or quantity that it overflows the area being watered and runs onto adjacent property or public right-of-way.

(4) Flow resulting from temporary failures or malfunctions of water supply system when the failure or malfunction is not repaired within 48 hours.

Section 7. OUTDOOR WATERING RESTRICTIONS

The restrictions in this section apply to all properties within unincorporated Bernalillo County not provided water service by the ABCWUA.

(A) All spray irrigation during the period beginning on April 1 and ending on October 31 of each year must occur between 7:00 p.m. and 11:00 a.m. This restriction shall not apply to drip irrigation and low precipitation bubblers, hand watering, or watering of containerized plants and plant stock.

(B) During periods when the New Mexico Drought Monitoring Committee determines the drought status as either a drought watch, drought warning or drought emergency the Board of County Commissioners, may impose additional increasingly stringent mandatory watering restrictions such as, but not limited to:

1. Restrictions on planting new sod or turfgrass seed;
2. Restrictions on vehicle washing at residences;
3. Restrictions on the use of ornamental fountains;
4. Further restrictions on outdoor watering.

Or

Additional restrictions as defined in a Drought Management Plan adopted by the Bernalillo County Board of County Commissioners.

(C) Restrictions in divisions (A) and (B) above do not apply to the following:

1. Irrigation necessary for one day only where treatment with an application of chemicals requires immediate watering to preserve an existing landscape or to establish a new landscape;
2. Water used to control dust or compact soil;
3. Attended watering systems that have one or more repair or maintenance personnel present at the irrigated zone being serviced for purposes of inspecting system condition and function and/or repairing or maintaining the watering system;
4. Water provided through the Middle Rio Grande Conservancy District or community acequia systems for irrigation purposes.

(D) Guidelines for Parks, Athletic Fields and Golf Courses.

1. Parks and golf courses shall use medium and low water use plants as much as possible. High water use turf or other restricted plants shall be allowed only in those areas with heavy usage or foot traffic, such as athletic fields, playgrounds, golf course tees, greens, and fairways.

2. All parks in the unincorporated area of Bernalillo County should use less than 35 inches of water per acre of landscape area per year. Usage will be calculated on a per individual park basis and shall include all water supplies except reclaimed wastewater or other non-potable water sources.

3. Athletic fields and golf courses in the unincorporated area of Bernalillo County should use less than 45 inches of water per acre of landscape area per year. Usage will be calculated on a per individual athletic field basis and shall include all water supplies except reclaimed wastewater or other non-potable water sources.

4. All Parks, Golf Courses, and Athletic Fields shall use effective water conservation measures and best management practices that are feasible and reasonable for given local conditions, such as but not limited to:

a. Evapotranspiration or soil moisture irrigation control;
b. High water-use turf removal or replacement;
c. Leak detection and repair systems or programs;
d. Irrigation system efficiency improvements.

Section 8. WATER WASTE

The restrictions in this section apply to all properties within unincorporated Bernalillo County. Operators of public or private utilities shall not be responsible for violations of this section incurred by their customers.

(A) No person, entities or properties shall cause or permit water waste.

(B) The restrictions in paragraph (A) of this section do not apply to the following:

1. Storm runoff allowed under provisions of the City of Albuquerque or Bernalillo County drainage ordinances as currently adopted or subsequently amended;
2. Flow resulting from temporary water supply system failures or malfunctions. These failures or malfunctions shall be repaired within 48 hours of notification or the system shut off until repair can be completed;
3. Flow resulting from temporary irrigation ditch failures or malfunctions. These failures or malfunctions shall be repaired immediately and the irrigation ditch shut off until repair can be completed;
4. Flow resulting from firefighting or routine inspection of fire hydrants or from fire training activities;
5. Water applied as a dust control measure;
6. Water applied to abate spills of flammable or otherwise hazardous materials; where water is the appropriate methodology;
7. Water applied to prevent or abate health, safety, or accident hazards when alternate methods are not available;
8. Flow resulting from routine inspection, operation, or maintenance of a utility water supply system;

9. Flow resulting from well testing, sampling, or monitoring conducted as part of a hydrologic study or well test;
10. Water used in the course of installation or maintenance of traffic flow control devices;
11. Water used for construction or maintenance activities where the application of water is the appropriate methodology and where no other practical alternative exists.

Section 9. DESIGN AND CONSTRUCTION REGULATIONS FOR NEW DEVELOPMENT

This section applies to all New Development.

(A) Single Family and Small Multi-Family Development Requirements.

All New Single Family and Small Multi-Family Development shall use one of the three alternatives listed to select water conservation measures that will be incorporated into the design and construction of the new dwelling.

1. Alternative Number 1. Bernalillo County Water Conservation Measures Worksheet.

    a. Building permit applications for all Single Family and Small Multi-Family Development using Alternative Number 1 shall include a fully and properly completed Water Conservation Measures Worksheet certifying that:

        (i) Measures selected on the worksheet will reduce indoor water use by at least 20% using plumbing fixtures which are more water efficient than those required in the 2006 Uniform Plumbing Code; and,

        (ii) All of the selected measures shall be incorporated into the design and construction of the new dwelling; and,

    b. All new Single Family and Small Multi-Family Development using Alternative Number 1. shall comply with the Planting Restrictions in Section 9 Subsection (D); and,

    c. Before obtaining a Certificate of Occupancy, all Single Family and Small Multi-Family Development using Alternative Number 1 may be subject to inspection and approval by a Water Conservation Compliance Officer or other designated staff.

2. Alternative Number 2. Build Green New Mexico Bronze Certification.

    a. Building permit applications for all Single Family and Small Multi-Family Development using Alternative Number 2 shall submit a copy of a fully and

properly completed Build Green New Mexico Property Registration form and Applicant's Affidavit; and,

b. All new Single Family development using Alternative Number 2 shall comply with the Planting Restrictions in Section 9 Subsection (D) or any subsequent modifications to the outdoor requirements of the Build Green New Mexico Program whichever are more stringent; and,

c. Before obtaining a Certificate of Occupancy all Single Family and Small Multi-Family Development using Alternative Number 2 must submit certification from Build Green New Mexico which shows that the dwelling meets a minimum of the Build Green New Mexico Bronze Certification and provide independent verifiers name and address.

3. Alternative Number 3. EPA Watersense Fixtures.

a. Building permit applications for all Single Family and Small Multi-Family Development using Alternative Number 3 shall include a fully and properly completed Water Conservation Measures Form certifying that:

(i) All Toilets installed shall meet EPA Watersense specifications; and,

(ii) All Bathroom Faucets installed shall meet EPA Watersense specifications; and,

(iii) If a Dishwasher is installed by the home builder, it shall be Energy Star qualified; and,

(iv) If a Clothes Washer is installed by the home builder, it shall be Energy Star qualified; and,

(v) Hot water distribution systems should be designed and built to minimize the volume of water between the plumbing fixture and hot water source. This may be accomplished by minimizing pipe runs and reducing diameter of hot water pipes, using demand initiated hot water systems, or other efficient system designs.

b. All new Single Family and Small Multi-Family Development using Alternative Number 3 shall comply with the Planting Restrictions in Section 9 Subsection (D); and,.

c. Before obtaining a Certificate of Occupancy all Single Family and Small Multi-Family Development using Alternative Number 3 will be subject to inspection and approval by a Water Conservation Compliance Officer or other designated staff.

(B) Requirements for Commercial and Large Multi-Family Development.

1. Building permit applications for all new Commercial, Large Multi-Family and Institutional Development shall include a fully and properly completed Commercial Indoor Water Conservation Measures Worksheet certifying that:

   a. Indoor water use will be reduced by at least 20% using plumbing fixtures which are more water efficient than those required in the 2006 Uniform Plumbing Code; and,

   b. All of the measures selected on the Commercial Indoor Water Conservation Measures Worksheet shall be incorporated into the design and construction of the new building.

2. Building permit applications for all new Commercial and Large Multi-Family Development on more than 1 acre shall include a fully and properly completed Commercial Outdoor Water Conservation Plan and Site Plan that includes three (3) of the following seven (7) outdoor water conservation measures related to landscaping. One of the three (3) options completed must include option i, ii, or iii. After January 1, 2016 all New Development shall comply with four (4) of the following seven (7) water conservation measures. One of the four (4) options completed must include option i, ii or iii. All New Development shall comply with the Planting Restrictions in subsection (D) of this section. The Commercial Outdoor Water Conservation Plan shall be reviewed for approval by the County Geohydrologist or other designated County official. Approval of Commercial Outdoor Water Conservation Plan and Site Plan by the County will be based on the Water Conservation Plan Criteria below unless the applicant proposes alternative methods that provide equivalent or greater water conservation.

   a. Water Conservation Plan Criteria

      The plan shall include three (3) of the following seven (7) outdoor water conservation measures related to landscaping. One of the three (3) options completed must include option i, ii, or iii. After January 1, 2016 all New Development shall comply with four (4) of the following seven (7) water conservation measures. One of the four (4) options completed must include option i, ii or iii. All New Development shall comply with the Planting Restrictions in subsection (D) of this section.

         (i) At least 25% of the Landscape Area shall be Precipitation Supported Plant Material. Irrigation may be used for establishment of the precipitation supported plant material, but the area shall be zoned separately from any other landscaped area. If this option is chosen, then option vii. must also be completed and the irrigation to the area should be shut-off within 2 years and identified in the EMP. After January 1, 2013 35 % of the Landscape Area shall be

provided by Precipitation Supported Plant Material. After January 1, 2016 45 % of the Landscape Area shall be provided by precipitation supported plant material.

(ii) Passive water harvesting shall occur on at least 25% of the landscape area. The irrigation system shall be designed so that the water harvesting areas are zoned separately from non-water harvesting areas. After January 1, 2013 Passive Water Harvesting shall occur on 35 % of the landscape area. After January 1, 2016 Passive Water Harvesting shall occur on 45 % of the landscape area.

(iii) 100% of the irrigation water supply shall be from a non-potable municipal, private or well source. Non-potable water supplies will need to be officially documented and confirmed.

(iv) A smart irrigation controller (Smart Controller) shall be designed and installed to control all of the irrigation system for the Landscape Area. The smart controller must be from a list approved by Bernalillo County.

(v) An approved Soil Amendment Program is used during installation of the landscape to improve the nutrient and water holding capacity of the soil.

(vi) Non-potable water shall be collected and stored for use as the primary water source for landscape irrigation. Storage capacity shall be a minimum of 50% of the peak month landscape demand for the property.

(vii) An Exterior Management Plan (EMP) shall be developed and submitted to the County with other project documents. The EMP is a 2-year commitment to employ best management practices that significantly reduce water use, chemical use, and water runoff as compared with standard practices.

3. All New Commercial Development less than 1 acre may follow the guidelines for outdoor water use in B. 2. above, or use a smart controller for all landscape areas, use only low and medium use plants, and have no spray irrigation.

4. All new Large Multi Family residential development including mobile home parks with more than 8 units shall have separate meters or sub-metering for water service to all dwelling units.

(C) Remodels and Additions

1. All remodels and additions for Single Family and Small Multi Family Development shall use EPA Watersense labeled fixtures for any new plumbing fixture installed. Existing plumbing fixtures not included in the remodel shall be evaluated for replacement using incentive programs from Bernalillo County or the ABCWUA.

2. All remodels on Commercial and Large Multi Family Development shall use EPA Watersense labeled fixtures for any new plumbing fixture installed. All remodels on Commercial and Large Multi Family Development which affect more than 50% of the existing plumbing fixtures shall use EPA Watersense labeled plumbing fixtures for any new fixture installed and upgrade any existing fixtures using EPA Watersense labeled fixtures. All additions on Commercial Large Multi Family Development which increase the floor area of the existing building by more than 50% of the existing square footage shall use EPA Water sense labeled plumbing fixtures for any new fixture installed and upgrade any existing fixtures using EPA Watersense labeled fixtures.

3. All landscaping plantings that are added or replaced as part of a remodel or addition on Commercial Large Multi Family Development shall be from the low-water-use approved plant list. Any existing landscaping may remain.

(D) Restrictions on Landscape Planting, Ponds, and Irrigation Systems.

1. All properties other than County owned parks, golf courses and athletic fields shall not be designed and constructed to use high water use turf or plants on more than 10% the landscape area, except;

a. For Single Family and Small Multi-Family Development, the use of high water use plants shall not exceed 1,500 square feet of the landscape area;
b. In the event that 10% of the landscape area is less than 300 square feet, high water use turf and other high water use plants may be used on up to 300 square feet of the landscape area;
c. Large Multifamily Development may use high water use turf on up to 30% of the Landscape Area as long as no dimension of the turf area is less than ten (10) feet. Swimming pools will be considered the same as high water use turf for the purposes of this limitation;
d. Properties zoned A-1 Agricultural with access to water provided through the Middle Rio Grande Conservancy District or community acequia systems for irrigation purposes may use high water use turf or other high-water-use plants in the Landscape Area supplied by irrigation water;
e. Private Parks may have up to 10% of the Landscape Area in high water use turf or other high water use plants. If grading and drainage plan details demonstrate that water harvesting will support up to 30% high

water use turf or plants then up 30% of the Landscape Area may be high water use turf or plants;

f. Private Parks which are supplied by 100% utility-provided non-potable water may have up to 30% of the Landscape Area in high water use turf or plants.

2. Street medians, streetscapes, Ornamental Landscapes and common areas of subdivisions shall not be designed and constructed with high-water use turf and other high-water use plants. Street medians, streetscapes, Ornamental Landscapes and common areas of subdivisions that are included in a grading and drainage plan shall be evaluated for water harvesting opportunities during the grading and drainage plan review.

3. Ornamental ponds shall not be designed and constructed to exceed 500 square feet of surface area. Ornamental fountains shall not be designed and constructed to exceed 250 square feet of surface area. Multiple water features on the same property will be considered together to determine surface area. Flowing water used in fountains, waterfalls and similar features shall be re-circulated. Ponds and fountains shall be designed to be consistent with the requirements of all applicable local and state regulations.

4. The List of Low, Medium, and High Water Use Plants maintained by the ABCWUA will be the approved plant list for landscape planting. Exceptions and additions to this list may be approved if documented proof of water use can be demonstrated for the area of intended use.

5. The List of Precipitation Only Plants maintained by the ABCWUA will be the approved plant list for Precipitation Supported landscape planting. Exceptions and additions to Precipitation Only Plant List may be approved if documented proof of water use can be demonstrated for the area of intended use.

(E) Irrigation Systems.

1. All irrigation systems shall be designed and installed to meet all minimum standards established by the current editions of uniform plumbing code and uniform mechanical code. All irrigation systems should use currently accepted water conservation design principals to maximize efficiency of the irrigation system.

2. Spray irrigation systems shall not be designed and constructed for use on slopes greater than four feet of horizontal distance per one foot vertical change (4:1).

3. Spray irrigation systems shall not be designed and constructed to apply water to any area within eight feet of a street curb or storm sewer inlet. These areas may be irrigated by drip, bubbler, soaker or sub-surface irrigation systems.

4. Spray irrigation systems shall not be designed and constructed using sprinkler heads that are closer than eight inches to impermeable surfaces.

5. Spray irrigation systems shall not be designed and constructed to be used in areas less than ten feet in any dimension excepting within back or side yards of residential properties, or where such an area is contiguous with adjacent property so that the dimension totals ten feet minimum. Spray irrigation systems shall not be designed and constructed to be used on any area less than 15 feet in any dimension within parking lots. These areas may be irrigated by drip, bubbler, soaker or sub-surface irrigation systems.

Section 10. EXEMPTIONS

(A) An application for an exemption shall be filed with the County Manager or his/her designee on a form and accompanied by such data and information as may be prescribed.

(B) The request for exemption shall contain the following information:

(1) Specific exemption, or exemptions requested;
(2) Duration of time for requested exemption;
(3) Address of location where exemption is requested;
(4) Proposed location on premises of the exemption is requested;
(5) Previous temporary exemptions;
(6) Physical size and dimensions of area where exemption is requested;
(7) Other data and information to support the need for the exemption request.

(C) Exemptions to Section 7 (Outdoor Watering Restrictions) and Section 9 (Design and Construction Regulation for New Development (D) Planting Restrictions) may be issued for agricultural purposes for properties with wells and associated water rights permitted for agricultural irrigation by the office of the State Engineer of New Mexico until such agricultural use ceases.

(D) Exemptions to Section 7 (Outdoor Watering Restrictions) may be issued for a period not to exceed 60 days to establish a Newly Seeded turf area on Properly Prepared Ground which has been cultivated and prepared to sow turfgrass seed to establish a new turf area.

(E) Exemptions to Section 7 (Outdoor Watering Restrictions) may be issued for a period not to exceed 30 days to establish newly sodded turf and/or landscape.

(F) Exemptions to Section 7 (Outdoor Watering Restriction) may be issued for a period not to exceed 45 days to establish inter-seeded areas within an established turf area.

(G) Exemptions to Section 9 Subsection (A), 2. Alternative Number 2 may be issued if the Single Family and Small Multi-Family Development fails the energy

certification of BGNM requirements but the water conservation requirements in this ordinance are met.

(H) An exemption for alternate methods for compliance with the specific requirements or the technical specifications of this ordinance may be approved if the applicant: 1) shows that compliance with requirements would pose an unreasonable burden; 2) proposes alternative methods that would provide equivalent or greater water conservation than those required in this ordinance.

In order to be considered, the exemption application shall describe the specific requirement(s) for which an alternate requirement is requested, justify the request by explaining the site specific circumstances that make compliance with the requirements unreasonably burdensome, and propose specific alternate solutions with verifiable documentation that the alternate solution will provide equivalent or greater water conservation than those required in this ordinance.

(I) Exemptions to Section 9 (Design and Construction Regulation for New Development Subsection (D) Planting Restrictions) may be issued for new Commercial Development for properties with access to water provided through the Middle Rio Grande Conservancy District or other community surface water systems with associated water rights permitted for agricultural irrigation by the office of the State Engineer of New Mexico. The exemption shall apply only to the areas of the landscape which are used for agricultural purposes.

Section 11. APPEALS

(A) Appeal of Section 10 (Exemptions), A responsible party may appeal exemption application decisions to the Zoning Administrator by filing an appeal within 15 days of receiving an exemption decision. The exemption decision shall provide information on the right to appeal and the procedures to follow.

(B) The appeal shall identify the property and state the grounds of appeal together with all material facts in support thereof. When a hearing is requested, the Zoning Administrator shall send written notice by certified mail, return receipt requested, to the appellant of the time and place of the hearing.

(C) If an appeal is received within the 15 business day time limit, the Zoning Administrator shall hold a hearing within 15 business days after receipt of the request. The County shall, in writing, notify the person who requested the hearing of the date, time, and place of the hearing. The County shall, in writing, notify all persons who were sent notice of the exemption decision of the date, time and place of the hearing. In the hearing, the burden of proof shall be upon the person who requested the appeal.

(D) Hearings shall be held at the offices of the County or at another public facility.

(E) The hearings shall be conducted so that all relevant views, arguments and testimony are fairly presented without undue repetition. The Zoning Administrator shall allow the County, the applicant and the person who requested the hearing to call and examine witnesses, to submit written and oral evidence and arguments, to introduce exhibits, and to cross-examine persons who testify. The rules of civil procedure and the rules of evidence shall not apply.

(F) Based upon the evidence presented at the hearing, the Zoning Administrator shall affirm, modify, or reverse the exemption application decision. The Zoning Administrator decision shall be in writing, and a copy of the decision shall be mailed to the applicant and the person who requested the hearing within 7 working days.

Section 12. EFFECTIVE DATE

The effective date of this article shall be October 1, 2010.

DONE this _____ day of _____, 2010.

APPROVED AS TO FORM	**BOARD OF COUNTY COMMISSIONERS**
_____	_____
County Legal	Art De La Cruz, Chair
	_____
	Maggie Hart Stebbins, Vice Chair
	_____
	Alan B. Armijo, Member
	_____
ATTEST:	Michael C. Wiener, Member
_____	_____
Maggie Toulouse, County Clerk	Michael Brasher, Member

Pre- and Post-development Flow Example Calculations

Purpose/Objective

The following example calculation is used to determine the pre- and post-development volumetric runoff and peak flows from a small ½-acre single family development.

Procedure

1) Determine the area of the watershed
2) Determine the precipitation zone
3) Determine the design storm type
4) Determine the land treatment for the pre- and post-developed site
5) Determine abstractions and excess precipitation and volumetric runoff from the pre- and post-developed site
6) Determine the peak discharge rate from the pre- and post-developed site

References/Data Sources

The example calculation presented herein is based upon: *The City of Albuquerque Development Process Manual (DPM), Chapter 22 Drainage, Flow Control and Erosion Control, Section 2, Part A - Procedure for 40 Acre and Smaller Basins.*
The tables used in this example calculation have been adapted from the *DPM*.

Assumptions and Limitations

This procedure was developed for watersheds smaller than 40 acres using the Rational Method procedures as described in the DPM.

Calculations

1) Determine the area of the watershed:
   The single family development is on a 1/2 acre site

2) Determine the precipitation zone: (Table 1)
   Bernalillo County has four precipitation zones
   The example 1/2 acre site is located in precipitation zone 4

3) Determine the design storm:
   This example calculation uses a 100-year, 6-hour storm event

4) Determine the land treatment for the pre- and post-developed site: (Table 2)
   Land treatment types A, B, C, D are defined in the tables included with this example calculation

   The percentage of each land treatment type for the example ½-acre pre-developed site is as follows:

Type A	100	*percent*	*(0.5 acres)*
Type B	0	*percent*	
Type C	0	*percent*	
Type D	0	*percent*	

   The percentage of each land treatment type for the example ½-acre post-developed site is as follows:

Type A	13	*percent*	*(0.065 acres)*
Type B	7	*percent*	*(0.035 acres)*
Type C	45	*percent*	*(0.225 acres)*
Type D	35	*percent*	*(0.175 acres)*

5) Determine excess precipitation and volumetric runoff from the pre- and post-developed site: (Table 3)
Excess precipitation is the depth of precipitation as determined by the design storm less the amount of losses due to initial abstractions and infiltration. Each land treatment type has a corresponding excess precipitation as found in the attached tables. The total volumetric runoff is the sum of excess precipitation multiplied by the percentage of each land treatment.

Pre-developed (100-year, 6-hour storm)
*Volumetric runoff = [(100-percent Type A) * (0.80 inches Excess Type A)] * 1/2 acres * 1/12 feet/inches = 0.0333 acre-ft*

Post-developed (100-year, 6-hour storm)
*Volumetric runoff = [(13-percent Type A) * (0.80 inches Excess Type A) + (7-percent Type B) * (1.08 inches Excess Type B) + (45-percent Type C) * (1.46 inches Excess Type C) + (35-percent Type D) * (2.64 inches Excess Type D)] * 1/2 acres * 1/12 feet/inches = 0.0734 acre-ft*

Total volumetric runoff from a 100-year, 6-hour storm event has increased 0.0401 acre-ft after development of the 1/2 acre site.

6) Determine the peak discharge rate from the pre- and post-developed site: (Table 4), (Table 5)
This example calculation uses a 0.2-hour (12-minute) peak intensity. The rational method coefficients and peak intensities are taken from the tables included in this calculation.
*Q = C*I*A (where Q is the sum of C*I*A for each land type)*
where:
Q = peak discharge, cfs
C = rational method coefficient (specific to each land treatment)
I = peak intensity, in/hr
A = area (area of each land treatment), acres

Pre-developed
*Peak Flow = (0.39 * 5.61 * 0.5) = 1.09 cfs*

Post-Developed
*Peak Flow = [(0.39 * 5.61 * 0.065) + (0.52 * 5.61 * 0.035) + (0.66 * 5.61 * 0.225) + (0.94 * 5.61 * 0.175)] = 2.00 cfs*

The pre-developed peak flow is 1.09 cfs and the post-developed peak flow is 2.00 cfs.

Tables

Table 1. Precipitation Zones	
Zone	**Location**
1	West of the Rio Grande
2	Between the Rio Grande and San Mateo
3	Between San Mateo and Eubank, North of Interstate 40; and between San Mateo and the East boundary of Range 4 East, South of Interstate 40
4	East of Eubank, North of Interstate 40; and East of the East boundary of Range 4 East, South of Interstate 40

Table 2. Land Treatments	
Treatment	**Land Condition**
A	Soil uncompacted by human activity with 0 to 10 percent slopes.
	Native grasses, weeds and shrubs in typical densities with minimal disturbance to grading, ground cover and infiltration capacity.
B	Irrigated lawns, parks and golf courses with 0 to 10 percent slopes.
	Native grasses, weeds and shrubs, and soil uncompacted by human activity with slopes greater than 10 percent and less than 20 percent.
C	Soil compacted by human activity. Minimal vegetation. Unpaved parking, roads, trails. Most vacant lots. Gravel or rock on plastic (desert landscaping). Irrigated lawns and parks with slopes greater than 10 percent. Native grasses, weeds and shrubs, and soil uncompacted by human activity with slopes at 20 percent or greater. Native grass, weed and shrub areas with clay or clay loam soils and other soils of very low permeability as classified by SCS Hydrologic Soil Group D.
D	Impervious areas, pavement and roofs.
Most watersheds contain a mix of land treatments. To determine proportional treatments, measure respective subareas.	

Table 3. Excess Precipitation	E (INCHES) – 6-HOUR STORM			
Zone	100-YR..			
	[2-YR., 10-YR.]			
	Land Treatment Type			
	A	B	C	D
1	0.44	0.67	0.99	1.97
	[0.00, 0.08]	[0.01, 0.22]	[0.12, 0.44]	[0.72, 1.24]
2	0.53	0.78	1.13	2.12
	[0.00, 0.13]	[0.02, 0.28]	[0.15, 0.52]	[0.79, 1.34]
3	0.66	0.92	1.29	2.36
	[0.00, 0.19]	[0.06, 0.36]	[0.20, 0.62]	[0.89, 1.50]
4	0.8	1.08	1.46	2.64
	[0.02, 0.28]	[0.11, 0.46]	[0.27, 0.73]	[1.01, 1.69]

Table 4. Peak Intensity	(IN/HR at t_c = 0.2 hour)
Zone	100-YR. [2-YR., 10-YR.] Intensity
1	4.7 [1.84, 3.14]
2	5.05 [2.04, 3.41]
3	5.38 [2.21, 3.65]
4	5.61 [2.34, 3.83]

Table 5. Rational Method, Co-Efficient, C				
Zone	100-YR.			
	[2-YR., 10-YR.]			
	Land Treatment Type			
	A	B	C	D
1	0.27 [0.00, 0.08]	0.43 [0.02, 0.24]	0.61 [0.26, 0.47]	0.93 [0.92, 0.92]
2	0.31 [0.00, 0.11]	0.45 [0.04, 0.28]	0.62 [0.29, 0.50]	0.93 [0.91, 0.92]
3	0.35 [0.00, 0.16]	0.48 [0.10, 0.33]	0.64 [0.35, 0.55]	0.93 [0.92, 0.93]
4	0.39 [0.02, 0.23]	0.52 [0.16, 0.38]	0.66 [0.43, 0.59]	0.94 [0.93, 0.93]

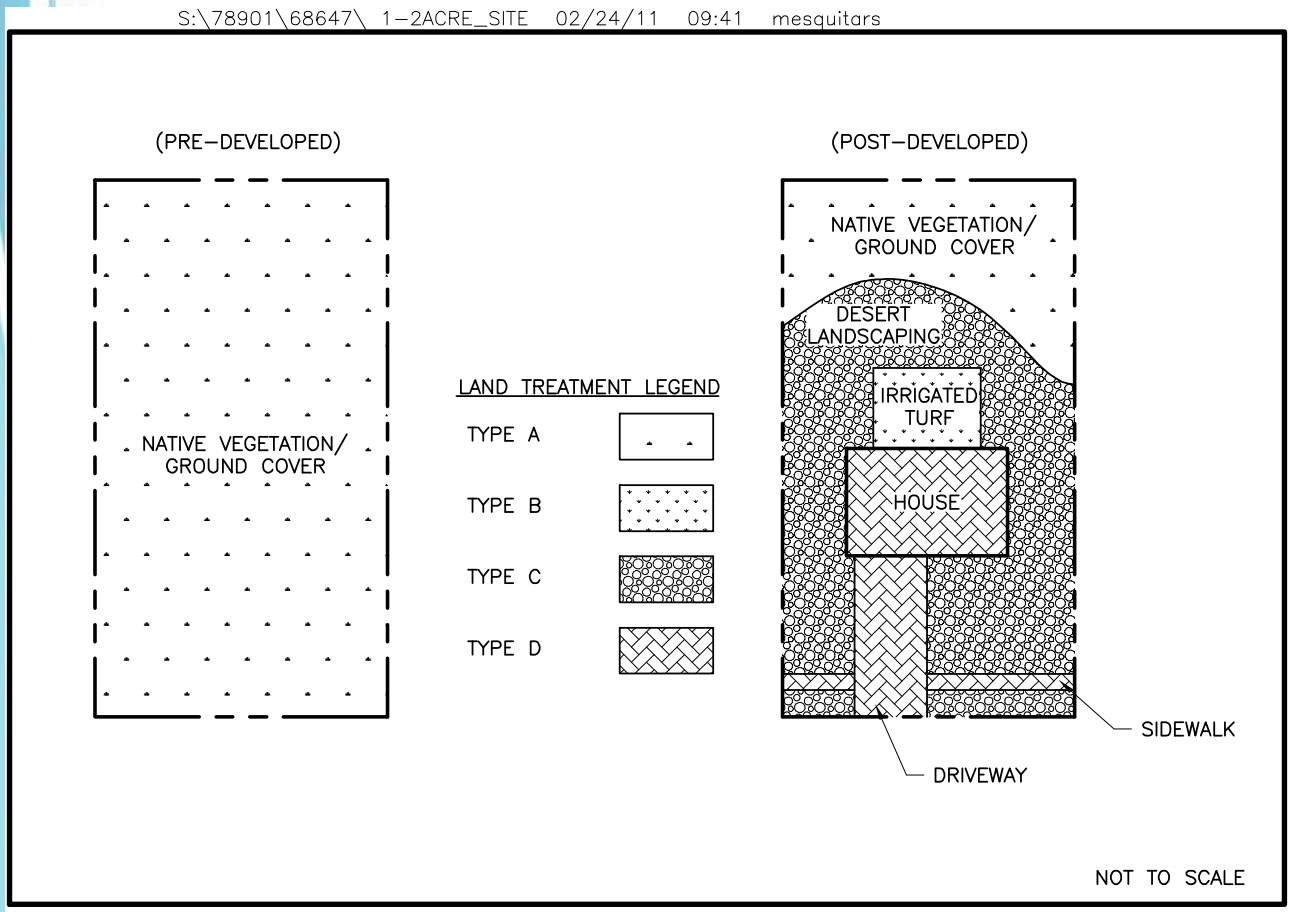

Figure No. ---
PRE AND POST DEVELOPED
EXAMPLE 1/2 ACRE SITE

Treatment Train Example Calculations

Purpose/Objective

The following example calculation is used to size three water harvesting devices for a developed 2-acre commercial site.

Procedure

1) Determine water-harvesting devices to be used onsite and provide a description of how each device will function.
2) Determine collection area for each water-harvesting device.
3) Size each water-harvesting device based on design storm volume and collection area.

References/Data Sources

For Design-Storm data refer to: *The City of Albuquerque Development Process Manual (DPM), Chapter 22 Drainage, Flow Control and Erosion Control, Section 2, Part A - Procedure for 40 Acre and Smaller Basins.*

Assumptions and Limitations

The commercial site has the following characteristics

Size: 2 acres

Design Storm/Precipitation Zone for 100-year, 6-hour (Precipitation Zone 1): 2.2 inches (Determined from DPM).
Rainwater is collected in three separate zones of the example developed commercial site (permeable pavement parking lot, unpaved areas draining to swales, and rooftop harvesting using rain barrels). Rainwater collected in each of these zones is handled by each respective water harvesting device.

Calculations

Permeable Pavement

The parking lot will be constructed of permeable pavement which will be used to collect and store any rainwater that falls onto the pavement. The parking lot will be sloped in such a manner that stormwater does not run off the pavement onto surrounding areas. All stormwater that is collected within the pavement will then infiltrate through the pavement subgrade in a period no greater than 48 hours. After the maximum 48-hour period, the permeable pavement will again have full capacity for the next rain event. The purpose of the calculation is to assure that the pavement is sized to store the entire volume of rain which falls onto the pavement during stormwater event and to drain within a 48-hour time span after the storm has ended.

Permeable pavement collection area: 0.5 acres (assumes 100% collection efficiency)
Pavement void space: 30 percent
Depth of pavement: 8 inches
*Permeable pavement storage volume (total void space): 0.5 acres * (43,560 sf/acre) * 0.30 * 8 inches * (1 ft/12 inch) = 4356 cf*
Stormwater volume (Volume of rainwater from 6-hour event that falls onto the pavement collection area):
*2.2 inches * (1 ft/12 inch) * 0.5 acres * (43,560 cf/acre) = 3993 cf*
Check #1: Pavement storage volume should be greater than stormwater volume
4356 cf > 3993 cf
Measured subgrade infiltration rate: 0.1 ft/hr (rate at which rainwater stored in pavement infiltrates into the soils below)
Infiltration Rate Safety Factor: 4
Effective Infiltration Rate = (0.1 ft /hr) / 4 = 0.025 ft/hr
Drawdown time: (Amount of time for collected stormwater to drain from void spaces in pavement into soils below)
*3993 cf / (0.025 ft/hr * 0.5 acres * (43,560 cf/acre)) = 7.3 hrs*
Check #2: Infiltration time is less than 48 hrs:
7.3 hrs < 48 hrs

Swale

The swale will be used to collect and convey stormwater that does not fall onto paved surfaces or the roof of the building. The swale provides some infiltration during conveyance. The remaining volume of water that does not infiltrate into the soils beneath the swale will be conveyed off site. The purpose of this calculation is to determine swale depth based upon selected swale widths and sideslopes. The swale depth shall be deep enough to hold all rainwater collected during the storm event.

Swale collection area: 1.0 acres (assumes 100 % collection of unpaved ground surfaces)
*Stormwater volume: 2.2 inches * (1 ft/12 inch) * 1.0 acres * (43,560 cf/acre) = 7986 cf (this is the volume of stormwater that falls onto the area that drains to the swale)*
Swale bottom width: 2-ft wide (mowed, use a wider swale width if not mowed)
Swale longitudinal slope: 2-percent

(set longitudinal slope to minimize velocities < 5 fps during design storm and < 1.5 fps during water quality event, slower velocities allow greater time for infiltration)

Sideslopes: 4:1 (horizontal : vertical)
Swale length: 200 ft (as determined by the layout of the site)
Determine swale volume: (Set swale storage volume equal to stormwater volume)

*7986 cf = 200 ft * (2-ft + 4*depth)*depth => depth = 2.9 ft (depth of swale)*

Add 1/2 ft free board => total swale depth = 3.4 ft (depth of swale with added freeboard)

Rooftop Harvesting

Runoff from the building rooftop will be collected and stored in rain barrels for on-site water needs. An assumed collection efficiency of 80 percent is used due to losses of from evaporation and initial abstractions. This calculation is used to size the volume of rain barrels. The rain barrels will be sized to store the volume of water collected from the rooftop during the design-storm event.

Rooftop collection area: 0.5 acres (area of rooftop)
*Design storm volume: 2.2 inches * (1 ft/12 inch) * 0.5 acres * (43,560 cf/acre) = 3993 cf (volume of water that falls onto rooftop during the design-storm event)*
Required rain barrel volume: (Assume 80 percent collection efficiency of design-storm volume)

Number of rain barrels: 4

*Required volume of each barrel: 3993 cf * 0.8 / 4 barrels= 800 cf per barrel*

Individual rain barrel dimensions:

diameter: 10 ft

*height = 800 cf / (3.14 * (10-ft / 2)^2) = 10 ft*

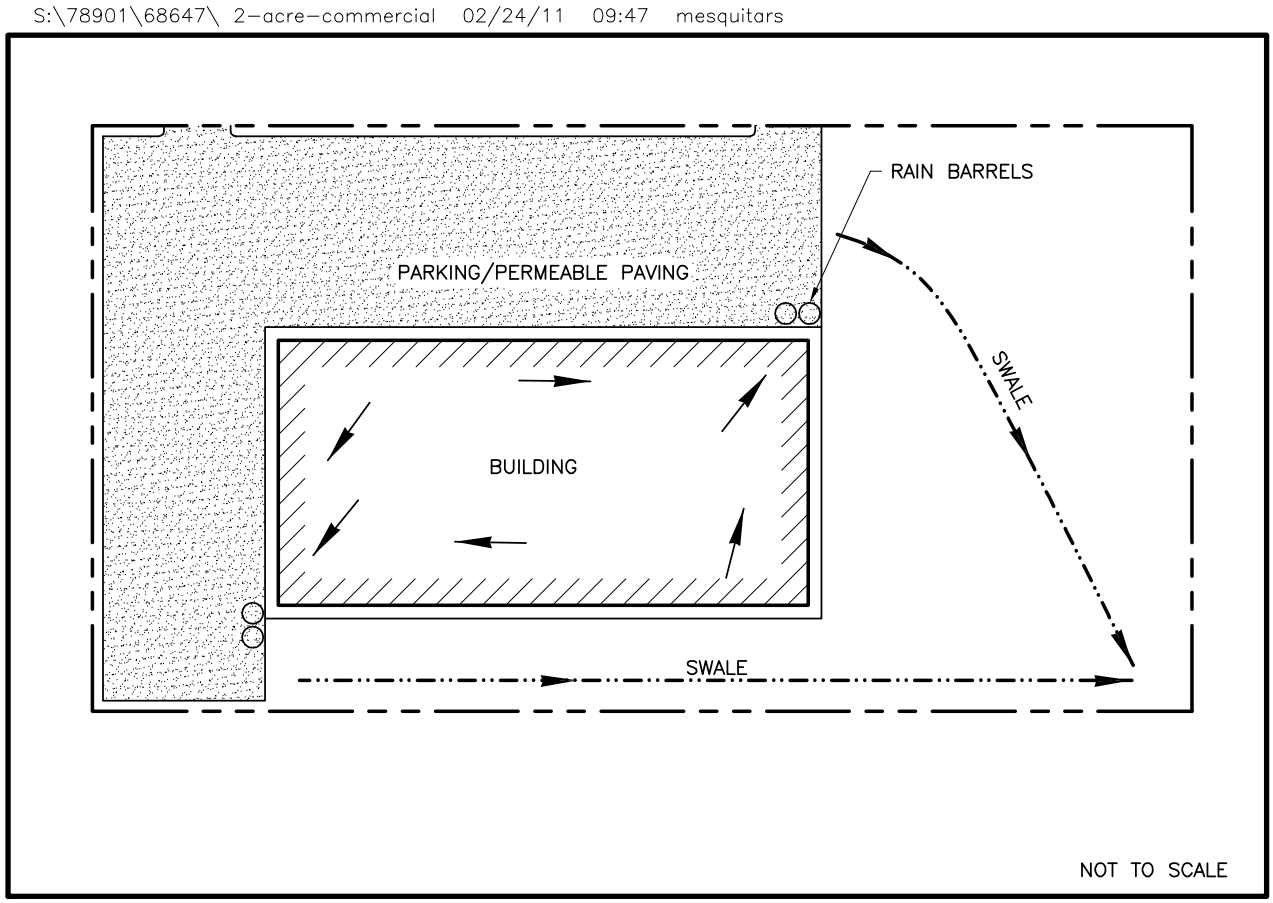

Figure No. ---
TREATMENT TRAIN EXAMPLE CALCULATION FIGURE
2-ACRE COMMERCIAL SITE

Xeriscape Plant List

http://www.abcwua.org/pdfs/xeriplantlist.pdf

PLANT LIST

How to Use the Plant List

The Albuquerque Plant List includes hundreds of plants suited to central New Mexico, but many are adaptable elsewhere in the state. We strongly recommend that you consult additional references for more detailed information, and check your neighborhood's landscape covenants, before you design your landscape.

The City of Albuquerque has a pollen control ordinance that prohibits the planting of cypress, mulberry and elm trees. Juniper is limited to female plants only, and Populus varieties are prohibited (except for Rio Grande cottonwood, lanceleaf cottonwood and quaking aspen).

Water Authority
Xeriscape Rebates

Water Authority customers may qualify for rebates for the replacement of high-water-use landscaping with xeriscaping. A Water Authority inspector must approve your rebate application and your landscape plan ahead of time and the project itself after completion. Xeriscapes employing drip irrigation can qualify for a $.75-per-square-foot rebate; rainwater harvesting xeriscapes can qualify for $1.50 per square foot. Participants in the xeriscape rebate program can also earn a 25-percent rebate (up to $100) for compost, and a 25-percent rebate (up to $50) for rental of sod removal equipment.

The rebate area of your new xeriscape must have 50 percent coverage (at maturity) of qualifying low- to medium-water-use plants, and the soil between and beneath all plants must be covered with at least two inches of mulch (gravel, decorative bark, etc.).

Ready to get started on your xeriscape project? Rebate application forms and instructions are available online at **www.abcwua.org/waterconservation** or call **768-3655.**

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L E G E N D

Region Description

UA is **URBAN ALBUQUERQUE,** the most heavily paved and therefore warmest area; soils vary greatly.

WM&RR is the **WEST MESA & RIO RANCHO,** also highly residential and nearly as consistently warm as UA; soils vary from sand to clay loam and may be shallow above underlying volcanic rock.

CV is the **CENTRAL VALLEY,** where the low-lying topography often results in colder winter temperatures; the soils are often clay loam which holds moisture well.

AF is the **ALBUQUERQUE FOOTHILLS.** Cooler than the urban center and west side, but not as cold as the valley or east side of the mountains, the soil here is decomposed granite, which is well-drained but holds moisture.

EM is the **EAST MOUNTAINS** and Estancia Valley. The coldest areas, they potentially receive the most rain and snow; the soils vary but unless mostly rock, hold moisture well.

Rebate Allowance

This refers to the mature plant square footage, used for calculating Water Authority xeriscape rebates.

Scientific Name	Common Name	Approx. Size Height x Width	Deciduous or Evergreen	Light Exposure	Water Use	Rebate Allowance	Region
DESERT ACCENTS							
Agave americana	Century Plant	6′ x 6′	Evergreen	Full Sun	RW	35	UA / WM&RR
Agave chrysantha	Golden-Flowered Agave	3′ X 4′	Evergreen	Full Sun	RW	25	UA / WM&RR
Agave havardiana	Harvard Agave	4′ X 4′	Evergreen	Full Sun	RW	25	All except EM
Agave lechuguilla	Lechuguilla	1′ X 5′	Evergreen	Sun/Shade	RW	30	All except EM
Agave palmeri	Palmer's Agave	3′ X 4′	Evergreen	Full Sun	RW	25	All areas
Agave Parryi/ neomexicana	Parry's / Mescal Agave	2′ X 2′	Evergreen	Sun/Shade	RW	15	All areas
Agave parviflora	Dwarf Agave	6″ X 8″	Evergreen	Sun	RW	10	All except EM
Agave scabra	Rough Agave	4′ X 4′	Evergreen	Full Sun	RW	25	UA / WM&RR
Agave utahensis	Utah Agave	1′ X 2′	Evergreen	Full Sun	RW	15	All areas
Agave victoria-reginae	Queen Victoria Agave	1′ X 1′	Evergreen	Full Sun	RW	10	UA / WM&RR
Coryphantha vivipara	Clustering Pin Cushions	4″ X 6″	Evergreen	Full Sun	RW	10	All areas
Cylindropuntia imbricata	Walkingstick Cholla	8′ X 6′	Evergreen	Full Sun	RW	35	All areas
Cylindropuntia kleiniae	Candle Cholla	8′ X 6′	Evergreen	Sun/Shade	RW	25	All areas
Cylindropuntia leptocaulis	Desert / Christmas / Pencil Cholla	4′ X 6′	Evergreen	Full Sun	RW	25	All areas
Cylindropuntia spinosior	Cane Cholla	8′ X 6′	Evergreen	Full Sun	RW	35	All areas
Dasylirion leiophyllum	Green Sotol	5′ X 5′	Evergreen	Full Sun	RW	20	All except EM
Dasylirion texanum	Texas Sotol	5′ X 5′	Evergreen	Sun/Shade	RW	20	All areas
Dasylirion wheeleri	Blue Sotol / Desert Spoon	5′ X 5′	Evergreen	Sun/Shade	RW	20	All except EM
Echinocereus coccineus	Spiny Hedgehog Cactus	10″ X 15″	Evergreen	Full Sun	RW	10	All areas
Echinocereus fendleri	Strawberry Hedgehog	10″ X 12″	Evergreen	Full Sun	RW	10	All areas
Echinocereus reichenbachii	Oklahoma or Lace Hedgehog	4″ X 6″	Evergreen	Full Sun	RW	5	All areas
Echinocereus triglochidiatus	Claret Cup	12″+ X 18″	Evergreen	Full Sun	RW	15	All areas
Echinocereus viridiflorus	Green-Flowered Hedgehog	5″ X 5″	Evergreen	Full Sun	RW	5	All areas
Escobaria orcuttii	Clustering Snowball	5″ X 8″	Evergreen	Full Sun	RW	10	All areas
Fouquieria splendens	Ocotillo	15′ X 10′	Deciduous	Full Sun	RW	40	All except EM
Grusonia syn Cylindropuntia clavata	Club / Dagger-Spine Cholla	3″ X 2′	Evergreen	Full Sun	RW	15	All areas
Hesperaloe capanulata	Bell-flowered Hesperaloe	4′ X 5′	Evergreen	Sun	Low+	25	All except EM
Hesperaloe funifera	Giant / Coahuilian Hesperaloe	6′ X 5′	Evergreen	Sun	Low+	25	All except EM
Hesperaloe parviflora	Red/Yellow-Flowering Yucca	3′ X 4′	Evergreen	Sun/Shade	Low+	20	All areas
Nolina lindheimeriana	Dwarf Beargrass / Ribbongrass	3′ X 3′	Evergreen	Sun	Low+	15	All except EM
Nolina microcarpa	Beargrass	5′ X 6′	Evergreen	Sun/Shade	RW	35	All areas
Nolina nelsoni	Blue Nolina	15′ X 6′	Evergreen	Sun	Low+	35	All except EM
Nolina texana	Beargrass	4′ X 5′	Evergreen	Sun/Shade	RW	30	All areas
Opuntia ellisiana / cacanapa	Spineless Prickly Pear	4′ X 5′	Evergreen	Full Sun	RW	30	UA / WM&RR
Opuntia engelmannii	Desert or Engelmann Prickly Pear	5′ X 8′	Evergreen	Full Sun	RW	40	All areas
Opuntia macrocentra	Purple Prickly Pear	3′ X 3′	Evergreen	Full Sun	RW	20	All areas
Opuntia violacea	Santa Rita Prickly Pear	3′ X 4′	Evergreen	Full Sun	RW	25	UA / WM&RR
Opuntia phaecantha	Brownsprine Prickly Pear	3′ X 5′	Evergreen	Full Sun	RW	30	All areas
Opuntia hystricina	Porcupine Prickly Pear	1′ X 3′	Evergreen	Full Sun	RW	20	All areas
Opuntia polycantha	Starvation Prickly Pear	1′ X 3′	Evergreen	Full Sun	RW	20	All areas
Yucca aloifolia	Spanish Dagger	6′ X 3′	Evergreen	Full Sun	Low+	25	UA / WM&RR
Yucca baccata	Datil / Banana Yucca	4′ X 5′	Evergreen	Full Sun	RW	30	All areas
Yucca baileyi	Bailey Yucca	3′X 3′	Evergreen	Full Sun	RW	20	UA / WM&RR
Yucca brevifolia	Joshua Tree	15′ X 15′	Evergreen	Full Sun	RW	45	UA / WM&RR
Yucca elata	Soaptree Yucca	20′ X 5′	Evergreen	Full Sun	RW	35	All areas
Yucca faxoniana / carnerosana	Palm Yucca	15′ X 6′	Evergreen	Full Sun	RW	40	All except EM
Yucca filamentosa	Adam's Needle Yucca	3′ X 3′	Evergreen	Sun/Shade	Low+	15	All areas
Yucca glauca	Soapweed	3′ X 3′	Evergreen	Full Sun	RW	20	All areas
Yucca harrimaniae	Harriman Yucca	1′ X 2′	Evergreen	Full Sun	RW	15	All areas
Yucca neomexicana	New Mexico Yucca	2′ X 4′	Evergreen	Full Sun	RW	25	All areas
Yucca pendula syn recurvifolia	Soft-Leaf Yucca	5′ X 4′	Evergreen	Sun/Shade	Low+	20	All areas
Yucca rigida	Blue Yucca	4′ X 4′	Evergreen	Full Sun	RW	25	All except EM
Yucca rostrata	Beaked Yucca	15′ X 5′	Evergreen	Full Sun	RW	35	All except EM
Yucca schidigera	Mojave Yucca	5′ X 2′	Evergreen	Full Sun	RW	20	All except EM
Yucca schotti	Mountain Yucca	5′ X 2′	Evergreen	Sun/Shade	Low+	20	All areas
Yucca thomsoniana	Thompson Yucca	8′ X 6′	Evergreen	Full Sun	RW	40	All areas
Yucca torreyi	Torrey Yucca	15′ X 4′	Evergreen	Full Sun	RW	30	All except EM
FLOWERING BULBS							
Allium sp.	Ornamental Onions	6″-36″ X 12″-24″	Deciduous	Sun/Shade	Medium	10	All areas
Belamcanda chinensis	Blackberry Lily	2′ X 2′	Deciduous	Sun/Shade	Medium+	5	All areas
Canna	Canna Lily	4′ X 1′	Deciduous	Full Sun	High	0	All except EM
Colchicum autumnali	Autumn Crocus	6″ X 6″	Deciduous	Full Sun	Medium	3	All areas
Crocus spp.	Crocus	6″ X 6″	Deciduous	Sun/Shade	Medium	3	All areas
Hyacinthus orientalis	Hyacinth	1′ X 1′	Deciduous	Full Sun	Medium	5	All areas
Iris (rhizome-type)	Bearded Iris	2′ X 2′	Deciduous	Full Sun	Medium	10	All areas
Iris spp. (bulb-type)	Bulb Irises	2′ X 2′	Deciduous	Full Sun	Medium+	5	All areas
Muscari armeniacum	Grape Hyacinths	10″ X 10″	Winter Foliage	Sun/Shade	Low+	10	All areas
Lycoris squamigera	Pink Amaryliis	18″ X 18″	Deciduous	Sun/Shade	Medium	10	All areas
Narcissus spp.	Daffodil	1′ X 1′	Deciduous	Sun/Shade	Medium	5	All areas
Tulipa spp.	Tulips	1′ X 8′	Deciduous	Sun/Shade	Medium	5	All areas
Zephyranthes sp.	Rain Lily	6″ X 6″	Deciduous	Full Sun	Medium	3	All except EM

PLANT LIST

FLOWERING PLANTS

Scientific Name	Common Name	Approx. Size Height x Width	Deciduous or Evergreen	Light Exposure	Water Use	Rebate Allowance	Region
Abronia sp.	Sand Verbena	1′ X 2′	Deciduous	Full Sun	RW	15	All areas
Acantholimon sp	Prickly Dianthus	1′ X 2′	Evergreen	Full Sun	Low	15	All areas
Achillea ageratifolia	Greek Yarrow	6″ X 1′	Evergreen	Sun/Shade	Low	10	All areas
Achillea taygetea	Moonshine Yarrow	2′ X 2′	Evergreen	Sun/Shade	Medium	10	All areas
Aethionema sp	Persian Rockcress	6″ X 1′	Evergreen	Full sun	Low	10	All areas
Agastache cana	Giant Hyssop	2′ X 2′	Deciduous	Full Sun	Medium	10	All areas
Agastache rupestris	Sunset Hyssop	2′ X 2′	Deciduous	Full Sun	Low+	15	All areas
Alcea rosea	Hollyhock	5′ X 1′	Deciduous	Full Sun	Medium	5	All areas
Aloinopsis spathulata	Hardy Living Stones	1″ X 6″	Evergreen	Full Sun	RW	5	All areas
Alyssum montanum	Basket of Gold	1′ X 1′	Deciduous	Sun/Shade	Medium	5	All areas
Amsonia species	Sand Stars	2′ X 2′	Deciduous	Full Sun	Low+	15	All areas
Anacyclus depressus	Mat Daisy	6″ X 1′	Evergreen	Sun/Shade	Low+	10	All areas
Antennaria rosea	Pussytoes	6″ X 1′	Evergreen	Sun/Shade	Low	10	All areas
Antirrhinum hispanicum ssp roseum	Spanish Snapdragon	1′ X 1′	Deciduous	Full Sun	Medium	5	AF / EM
Anthemis tinctoria	Golden Marguerite	2′ X 2′	Deciduous	Full Sun	Medium+	5	All areas
Aquilegia chrysantha	Golden Columbine	2′ X 2′	Deciduous	Shade	Medium	10	All areas
Aquilegia sp	Columbine Species	1′+ X 1′+	Deciduous	Shade	Medium	5	EM
Argemone sp	Prickly Poppy	3′ X 2′	Deciduous	Full Sun	RW	15	All areas
Armeria maritima	Thrift	1′ X 1′	Evergreen	Full Sun	Medium	5	All areas
Artemisia abrotanum	Southernwood	3′ X 3′	Deciduous	Sun/Shade	Medium	12	All areas
Artemisia X Powis Castle	Powis Castle Artemisia	2′ X 4′	Semi-Evergreen	Sun/Shade	Low+	20	All areas
Artemisia stellariana	Beach Wormwood	1′ X 2′	Deciduous	Sun/Shade	Medium	10	All areas
Artemisia versicolor	Seafoam Artemisia	8″ X 18″	Evergreen	Sun/Shade	Low+	15	All areas
Asclepias tuberosa	Butterflyweed	2′ X 2′	Deciduous	Sun/Shade	Medium	10	All areas
Asparagus officinalis	Culinary Asparagus	4′ X 3′	Deciduous	Full Sun	Medium	12	All areas
Aster novae-angliae	Aster	4′ X 2′	Deciduous	Full Sun	High	0	All areas
Berlandiera lyrata	Chocolate Flower	1′ X 2′	Deciduous	Full Sun	RW	15	All areas
Callirhoe involucrata	Winecups	1′ X 2′	Deciduous	Full Sun	Low+	15	All areas
Calylophus species	Sundrops	1′ X 2′	Deciduous	Full Sun	Low	15	All areas
Campanula carpatica	Carpathian Harebells	8″ X 2′	Deciduous	Shade	High	0	CV / AF / EM
Campanula rotundifolia	Harebells	18″ X 2′	Deciduous	Shade	High	0	CV / AF / EM
Castilleja spp.	Indian Paintbrush	1′ X 2′	Deciduous	Sun/Shade	Low+	15	All areas
Centaurea cineraria	Dusty Miller	1′ X 2′	Evergreen	Full Sun	Low+	15	All areas
Centaurea dealbata	Persian Cornflower	1′ X 2′	Deciduous	Sun/Shade	Medium	10	All areas
Centtranthus ruber	Red Valerian	18″ X 30″	Deciduous	Sun/Shade	Medium	12	All areas
Cerastium tomentosum	Snow-In-Summer	8″ X 2′	Deciduous	Sun/Shade	Medium	10	All areas
Chasmatophyllum masculinum	Hardy Tiger Jaws	2″ X 6″	Evergreen	Full Sun	Low	5	All areas
Chrysanthemum maximum	Shasta Daisy	4′ X 2′	Deciduous	Full Sun	High	0	CV /EM
Chrysanthemum x morifolium	Chrysanthemum	3′ X 3′	Deciduous	Full Sun	High	0	All areas
Convolvulus cnoreum	Silver Bush Morning Glory	1′ X 3′	Evergreen	Full Sun	Low+	15	All except EM
Consolida ambigua	Larkspur, Annual	2′ X 1′	Deciduous	Full Sun	Medium	5	All areas
Coreopsis lanceolata	Coreopsis	3′ X 2′	Deciduous	Full Sun	Medium	10	All areas
Coreopsis verticillata	Threadleaf Coreopsis	2′ X 2′	Deciduous	Full Sun	Medium	10	All areas
Convallaria majalis	Lily of the Valley	4″ X 6″	Deciduous	Shade	High	0	CV / EM
Cynara species	Cardoon & Artichoke	4′ X 4′	Deciduous	Full Sun	Medium+	15	All except EM
Dalea purpurea	Purple Prairieclover	2′ X 2′	Deciduous	Full Sun	Low+	15	All areas
Datura wrightii	Sacred Datura	2′ X 6′	Deciduous	Full Sun	Low	30	All areas
Delosperma congestum & nubigenum	Yellow Iceplant	3″ X 2′	Evergreen	Sun/Shade	Low+	15	All areas
Delosperma cooperi	Purple Iceplant	6″ X 18″	Evergreen	Full sun	Low+	15	All areas
Delosperma floribundum	Tufted Iceplant	6″ X 12″	Evergreen	Full Sun	Low+	10	All areas
Delosperma sphalmanthoides	Dwarf Tufted Iceplant	1″ X 8″	Evergreen	Full Sun	Low	10	All areas
Dianthus barbatus	Sweet William, Biennial	20″ X 20″	Deciduous	Sun/Shade	Medium	5	All areas
Dianthus deltoides	Maiden Pink	6″ X 8″	Deciduous	Sun/Shade	Medium	5	All areas
Dianthus gratianopolitanus	Cheddar Pink	1′ X 2′	Evergreen	Sun/Shade	Medium	10	All areas
Dicentra spectabilis	Bleeding Heart	2′ X 2′	Deciduous	Shade/sun	High	0	CV / EM
Dictamnus spp.	Gas Plant	4′ X 4′	Deciduous	Sun/Shade	Medium	20	All areas
Dimorphotheca sinuata	African Daisy, Annual	1′ X 1′	Deciduous	Full Sun	Medium	5	All areas
Duchesnea indica	Mock Strawberry	8″ X 2′	Deciduous	Shade	Medium+	5	CV / EM
Echinacea purpurea	Purple Coneflower	3′ X 2′	Deciduous	Sun/Shade	Medium	10	UA / CV / AF / EM
Echinops species	Globe Thistle	4′ X 4′	Deciduous	Full Sun	Medium	20	All areas
Epilobium syn Zauschneria sp	Hummingbird Plant	2′ X 3′	Deciduous	Full Sun	Low+	15	All areas
Erigeron spp.	Fleabane Daisy	1′ X 1′	Deciduous	Full Sun	Medium	3	All areas
Eriogonum herbaceous species	Wild Buckwheat	1′ X 18″	Evergreen	Full Sun	RW	15	All areas
Erysimum hieraciifolium	Siberian Wallflower	18″ X 18″	Deciduous	Full Sun	Medium	5	All areas
Erysimum linifolium	Wallflower Bowles' Mauve	2′ X 2′	Evergreen	Full Sun	Medium	10	All areas
Euphorbia antisyphilitica	Candelilla	2′ X 3′	Evergreen	Full Sun	RW	20	UA / WM&RR
Euphorbia myrsinites	Blue Spurge	1′ X 2′	Evergreen	Sun/Shade	Low	8	All areas
Euphorbia rigida	Gopher Plant	2′ X 3′	Evergreen	Sun/Shade	Low	20	All except EM
Gaillardia x grandiflora	Gaillardia	2′ X 2′	Deciduous	Full Sun	Medium	6	All areas
Gaura lindheimeri	Gaura	3′ X 3′	Deciduous	Full Sun	Medium	15	All areas
Geum ciliatum	Prairie Smoke	18″ X 1′	Evergreen	Full Sun	High	0	CV / EM
Geranium macrorrhizium	Bigroot Geranium	4″ X 18″	Deciduous	Shade	Medium+	0	All areas
Glaucium flavum	Horned Poppy	2′ X 2′	Deciduous	Sun/Shade	Medium	10	All areas
Gypsophila paniculata	Baby's Breath	3′ X 3′	Deciduous	Sun/Shade	Medium	12	All areas
Gypsophila repens	Creeping Baby's Breath	4″ X 1′	Deciduous	Sun/Shade	Medium	5	All areas
Helianthemum spp.	Sunrose	6″ X 2′	Evergreen	Full Sun	Medium	10	All areas
Helianthus annuus	Sunflower	varies	Deciduous	Full Sun	Medium	5	All areas

Scientific Name	Common Name	Approx. Size Height x Width	Deciduous or Evergreen	Light Exposure	Water Use	Rebate Allowance	Region
Helianthus maximilianii	Maximilian Sunflower	6′ X 8′	Deciduous	Full Sun	Medium	25	All areas
Helianthus tuberosus	Jerusalem Artichoke	6′ X 6′	Deciduous	Full Sun	Medium+	20	All areas
Hemerocallis hybrids	Daylilies	2′ X 3′	Deciduous	Full Sun	High	0	UA / CV / AF / EM
Heterotheca syn Chrysopsis villosa	Golden Aster	18″ X 2′	Deciduous	Full Sun	RW	15	All areas
Heuchera sanguinea	Coral Bells	2′ X 2′	Deciduous	Sun/Shade	Medium	5	CV / AF / EM
Hosta spp.	Plantain Lily	2′ X 2′	Deciduous	Shade	Medium+	5	UA /CV / AF / EM
Hypericum calycinum	St. Johnswort	1′ X 1′	Evergreen	Shade	Medium	5	UA /CV / AF / EM
Iberis sempervirens	Candytuft	1′ X 18″	Evergreen	Shade	Medium	5	All areas
Ipomoea leptophylla	Bush Morning Glory	2′ X 3′	Deciduous	Full Sun	RW	20	All areas
Kniphofia uvaria	Red Hot Poker	3′ X 2′	Deciduous	Full Sun	Low+	15	All areas
Lamium maculatum	Spotted Nettle	6″ X 6″	Deciduous	Shade	High	0	All areas
Liatris punctata	Gayfeather	2′ X 3′	Deciduous	Full Sun	Low+	15	All areas
Liatris scariosa	Tall Gayfeather	3′ X 3′	Deciduous	Full Sun	Medium	10	All areas
Linaria spp.	Butter and Eggs/Baby Snapdragon	18″ X 18″	Deciduous	Full Sun	Medium	10	CV / EM
Linum perenne	Blue Flax	18″ X 18″	Deciduous	Sun/Shade	Medium	10	All areas
Lobelia cardinalis	Cardinal Flower	3′ X 3′	Deciduous	Shade	High	0	UA /CV / EM
Lobelia laxiflora	Mexican Lobelia	2′ X 3′	Deciduous	Sun/Shade	Medium	12	All except EM
Lupinus argenteus	Silverstem Lupine	2′ X 2′	Deciduous	Full Sun	Low	15	All areas
Lupinus hybrids	Lupine	3′ X 3′	Deciduous	Full Sun	High	0	All areas
Lupinus texensis	Texas Bluebonnet, Annual	1′ X 1′	Deciduous	Full Sun	High	0	All areas
Lychnis sp	Rose Campion, Maltese Cross	18″ X 18″	Deciduous	Sun/Shade	Medium	5	All areas
Manfreda maculosa	Texas Tuberose	3′ X 2′	Deciduous	Sun/Shade	Low+	15	All areas
Melampodium leucanthum	Blackfoot Daisy	1′ X 16″	Deciduous	Full Sun	RW	15	All areas
Mirabilis jalapa	Garden Four O'Clock	4′ X 4′	Deciduous	Full Sun	Medium	20	All areas
Monarda spp.	Beebalm / Lemon Mint	varies	Deciduous	Full Sun	High	0	All areas
Nepeta X faasseni	Catmint	8″ X 2′	Deciduous	Sun/Shade	Low+	15	All areas
Nierembergia hippomanica 'Violacea'	Cup Flower	10′ X 1′	Deciduous	Full Sun	Medium	5	All except EM
Oenothera berlandieri	Mexican Evening Primrose	1′ X 3′	Semi-Evergreen	Sun/Shade	Low+	15	All areas
Oenothera caespitosa	White Evening Primrose	1′ X 2′	Evergreen	Full Sun	RW	15	All areas
Oenothera hookerii	Hooker Primrose, Biennial	2′ X 3′	Deciduous	Full Sun	Medium	12	All areas
Oenothera macrocarpa syn missouriensis	Yellow Evening Primrose	1′ X 2′	Deciduous	Sun/Shade	Medium	10	All areas
Oenothera organensis	Organ Mountain Evening Primrose	2′ X 5′+	Deciduous	Sun/Shade	Medium	20	All areas
Oenothera pallida	Pale Evening Primrose	18″ X 18″	Evergreen	Full Sun	Low+	15	All areas
Origanum sp	Ornamental Oregano	1′ X 2′	Deciduous	Sun/Shade	Medium	10	All areas
Osteospermum barberiae	Hardy African Daisy	4″ X 1′	Deciduous	Full Sun	Medium	5	All areas
Paeonia sp	Peony	2′ X 3′	Deciduous	Sun/Shade	Medium+	10	All areas
Papaver nudicaule	Iceland Poppy	18″ X 18″	Deciduous	Sun/Shade	High	0	All areas
Papaver orientale	Oriental Poppy	18″ X 2′	Deciduous	Sun/Shade	Medium	10	All areas
Penstemon ambiguus	Bush Penstemon	2′ X 3′	Evergreen	Full Sun	RW	20	All areas
Penstemon angustifolius	Narrowleaf Penstemon	1′ X 1′	Deciduous	Full Sun	RW	10	All areas
Penstemon barbatus	Scarlet Bugler Penstemon	3′ X 1′	Deciduous	Sun/Shade	Medium	5	All areas
Penstemon cardinalis	Cardinal Penstemon	3′ X 2′	Evergreen	Full Sun	Low+	15	All areas
Penstemon clutei	Sunset Penstemon	2′ X 2′	Evergreen	Full Sun	Low	15	All areas
Penstemon jamesii	Penstemon, James	10″ X 10″	Evergreen	Full Sun	Low+	10	All areas
Penstemon palmeri	Palmer Penstemon	4′ X 2′	Evergreen	Full Sun	RW	15	All areas
Penstemon pinifolius	Pineleaf Penstemon	1″ X 20″	Evergreen	Full Sun	Low+	15	All areas
Penstemon pseudospectabilis	Desert Beardtongue	3′ X 3′	Evergreen	Sun/Shade	Low	20	All areas
Penstemon secundifloris	Sidebells	1′ X 8″	Deciduous	Full Sun	Low	10	All areas
Penstemon strictus	Rocky Mountain Penstemon	2′ X 2′	Evergreen	Sun/Shade	Low+	15	All areas
Perovskia atriplicifolia	Russian Sage	5′ X 5′	Deciduous	Full Sun	Medium	20	All areas
Phemeranthus syn Talinum calycinum	Flameflower	8″ X 8″	Deciduous	Sun/Shade	Low	10	All areas
Phlomis sp	Jerusalem Sage, Kashmir Sage	2′ X 3′	Deciduous	Full Sun	Medium	12	All areas
Phlox paniculata	Summer Phlox	3′ X 3′	Deciduous	Full Sun	High	0	All areas
Phlox subulata	Creeping Phlox	6″ X 1′	Deciduous	Full Sun	Medium	3	All areas
Phyla nodiflora	Creeping Lippia	3″ X 2′	Deciduous	Sun/Shade	Medium	10	All areas
Physalis lobata	Purple Groundcherry	4″ X 2′	Deciduous	Full Sun	Low+	15	All areas
Platycodon sp	Balloon Flower	2′ X 18″	Deciduous	Sun/Shade	Medium	5	All areas
Potentilla neumanniana syn tabernaemontani syn verna	Spring Cinquefoil	4″ X 6″	Deciduous	Shade	Medium+	0	UA / CV / AF / EM
Psilostrophe tagetina	Paperflower	16″ X 16″	Deciduous	Full Sun	RW	15	All areas
Ranunculus repens	Creeping Buttercup	1′ X 1′	Deciduous	Sun/Shade	High	0	All areas
Ratibida columnifera	Coneflower, Mexican Hat	32″ X 32″	Deciduous	Full Sun	Low+	15	All areas
Rheum sp	Rhubarb	2′ X 3′	Deciduous	Shade	High	0	UA / CV / EM
Rudbeckia fulgida	Goldsturm Rudbeckia	2′ X 2′	Deciduous	Full Sun	High	0	UA / CV / AF / EM
Ruellia humilis	Wild Petunia	6″ X 1′	Deciduous	Sun/Shade	Medium	5	All areas
Ruta graveolens	Rue	2′ X 2′	Evergreen	Full Sun	Medium	10	All areas
Salvia azurea grandiflora	Pitcher Sage	3′ X 3′	Deciduous	Sun/Shade	Medium	12	All areas
Salvia darcyi	Texas Red Sage	30″ X 2′	Deciduous	Full Sun	Low+	15	All except EM
Salvia nemerosa X sylvestris	Many named varieities	18″ X 18″	Deciduous	Sun/Shade	Medium	5	All areas
Saponaria ocymoides	Soapwort	9″ X 18″	Deciduous	Sun/Shade	Medium	5	All areas
Scabiosa columbaria	Pincushion Flower	18″ X 18″	Deciduous	Sun	Medium	10	All areas
Scutellaria resinosa & wrightii	Plains Skullcap	1′ X 1′	Deciduous	Sun/Shade	Low+	10	All areas
Sedum spectabile	Stonecrop	2′ X 2′	Evergreen	Sun/Shade	Low+	15	All areas
Sedum telephium	Autumn Joy Sedum	2′ X 2′	Evergreen	Sun/Shade	Low+	15	All areas
Sempervivum tectorum	Hen and Chicks	6″ X 6″	Evergreen	Shade	Low+	5	All areas
Senecio flaccidus syn longilobus	Silver Groundsel	2′ X 2′	Deciduous	Full Sun	RW	15	All areas
Solidago dwarf sp	Dwarf Goldenrod	18″ X 2′	Deciduous	Sun/Shade	Medium	10	All areas
Solidago hybrids	Goldenrod	3′ X 3′	Deciduous	Sun/Shade	Medium+	10	All areas

PLANT LIST

Scientific Name	Common Name	Approx. Size Height x Width	Deciduous or Evergreen	Light Exposure	Water Use	Rebate Allowance	Region
Sphaeralcea spp.	Globemallow	2′X 2′	Deciduous	Full Sun	RW	15	All areas
Stachys byzantina	Woolly Lamb's Ear	1′X 18″	Deciduous	Sun/Shade	Medium	10	All areas
Stachys coccinea	Scarlet Nettle	1′X 2′	Deciduous	Sun/Shade	Medium+	5	All areas
Stanleya pinnata	Prince's Plume	3′X 2′	Deciduous	Full Sun	Low	15	All areas
Tagetes erecta	African Marigold, Annual	3′X 3′	Deciduous	Full Sun	High	0	All areas
Tagetes lucida	Mexican Marigold	18″X 18″	Deciduous	Full Sun	Medium	10	All except EM
Tagetes patula	French Marigold, Annual	18″X 18″	Deciduous	Full Sun	High	0	All areas
Tanacetum densum-amani	Partridge Feather	8″X 18″	Evergreen	Sun/Shade	Low+	15	All areas
Tanacetum vulgare	Tansy	3′X 3′	Evergreen	Sun/Shade	Medium	12	All areas
Tetraneuris syn Hymenoxys sp	Angelita Daisy/Perky Sue	1′X 1′	Deciduous	Full Sun	Low	10	All areas
Teucrium chamaedrys	Wall Germander	1′X 2′	Evergreen	Sun/Shade	Medium	10	All areas
Teucrium chamaedrys 'Prostratum'	Creeping Germander	6″X 2′	Evergreen	Sun/Shade	Medium	10	All areas
Teucrium majoricum syn cosonii syn aroanium	Greek Germander	6″X 18″	Evergreen	Full Sun	Medium	10	All areas
Thelesperma ambigua	Rayed or Threadleaf Cota	2′X 2′	Deciduous	Full Sun	Low+	15	All areas
Thymophila syn Dyssodia acerosa	Wild Marigold	1′X 1′	Deciduous	Full Sun	RW	10	All areas
Thymus pseudolanuginosus and minus	Wooly and Dwarf Creeping Thyme	3″X 1′	Evergreen	Shade	Medium	5	All areas
Thymus serphyllum	Creeping Thyme	3″X 1′	Evergreen	Shade	High	0	UA / CV / AF / EM
Thymus vulgaris	Culinary Thyme	1′X 1′	Evergreen	Full Sun	Low+	10	All areas
Tradescantia occidentalis	Western Spiderwort	2′X 2′	Deciduous	Sun/Shade	Medium	10	All areas
Verbena spp.	Verbena	varies	Deciduous	Full Sun	Low+	10	All areas
Verbena bipinnatifida	Fern Verbena	1′X 1′	Deciduous	Full Sun	Low	10	All areas
Verbena rigida	Sandpaper Verbena	1′X 3′	Deciduous	Full Sun	Low	20	All except EM
Verbena wrightii	Western Vervain	2′X 2′	Deciduous	Full Sun	RW	15	All areas
Verbena x hybrida	Garden Verbena, Mostly Annuals	1′X 1′	Deciduous	Full Sun	Medium	5	All areas
Veronica incana	Silver Speedwell	18″X 18″	Evergreen	Sun/Shade	Medium	10	All areas
Veronica liwanensis	Turkish Speedwell	3″X 2′	Evergreen	Shade	Medium	10	All areas
Veronica pectinata	Woolly Speedwell	3″X 18″	Evergreen	Shade	Medium	10	All areas
Veronica spicata	Veronica	3′X 3′	Deciduous	Shade	High	0	All areas
Viola cornuta	Tufted Violet/Johnny Jump Up	1′X 1′	Evergreen	Shade	High	0	All areas
Viola corsica	Corsican Violet	4″X 6″	Deciduous	Shade	Medium	3	All areas
Viola odorata	Sweet Violet	8″X 8″	Evergreen	Shade	High	0	All areas
Viola x wittrockiana	Pansy, Annual	9″X 9″	Evergreen	Sun/Shade	High	0	All areas
Wyethia scabra	Desert Mule's Ear	2′X 3′	Deciduous	Full Sun	RW	20	All areas
Zinnia acerosa	White Desert Zinnia	6″X 10″	Deciduous	Full Sun	RW	10	All areas
Zinnia grandiflora	Desert Zinnia	8″X 16″	Deciduous	Full Sun	RW	15	All areas
GRASSES, TURF *Turf grasses are sprinkler-irrigated and do not qualify for any rebate.*							
Agrostis spp.	Bentgrass	Mowed	Evergreen	Full Sun	High	0	Golf Courses
Bouteloua gracilis	Blue Grama	Varies	Deciduous	Full Sun	Low+	0	All areas
Bouteloua syn. Buchloe dactyloides	Bufflalo Grass	Mowed	Deciduous	Full Sun	Medium	0	All areas
Cynodon dactylon hybrids	Hybrid Bermudagrass	Mowed	Deciduous	Full Sun	Medium	0	All except EM
Festuca elatoir and all Festuca	Turf Tall Fescue	Mowed	Evergreen	Sun/Shade	High	0	All areas
Festuca ovina 'Covar'	Covar Sheep Fescue	Unmowed	Evergreen	Sun/Shade	Medium	0	EM
Festuca ovina except Glauca	Sheep's Fescue	Mowed	Evergreen	Sun/Shade	High	0	All areas
Lolium perenne and all Lolium	Ryegrass, Perennial	Mowed	Evergreen	Sun/Shade	High	0	All areas
Poa pratensis and all Poa	Kentucky Bluegrass	Mowed	Evergreen	Sun/Shade	High	0	All areas
Zoysia spp.	Zoysia Grass	Mowed	Deciduous	Full Sun	Medium	0	All except EM
GRASSES, ORNAMENTAL							
Achnatherum syn Oryzopsis hymenoides	Indian Ricegrass	18″X 18″	Deciduous	Full Sun	RW	10	All areas
Andropogon gerardii	Big Bluestem	5′X 1′	Deciduous	Full Sun	Medium	5	All areas
Andropogon hallii	Sand Bluestem	4′X 2′	Deciduous	Full Sun	Low+	15	All areas
Aristida purpurea	Purple Threeawn	1′X 1′	Deciduous	Full Sun	RW	10	All areas
Arundo donax	Carrizo Cane	20′X 20′	Deciduous	Full Sun	Medium+	25	CV
Blepharneuron tricolepsis	Pine Dropseed/Mountain Mist	18″X 1′	Deciduous	Sun/Shade	Low+	10	All areas
Bothriochloa barbinodis	Cane Beardgrass	24″X 18″	Deciduous	Full Sun	RW	15	All areas
Bouteloua curtipendula	Sideoats Gramma	30″X 2′	Deciduous	Full Sun	Low+	15	All areas
Calamagrostis arundinacea 'Karl Foester'	Feather Reed Grass	30″X 2′	Deciduous	Sun/Shade	Medium	10	All areas
Cortaderia selloana	Pampas Grass	12′X 9′	Deciduous	Full Sun	High	0	All areas
Eragrostis tricodes	Sand Lovegrass	3′X 3′	Deciduous	Full Sun	Low+	15	All areas
Erianthus ravennae	Ravenna Grass	12′X 9′	Deciduous	Full Sun	Medium+	25	All areas
Festuca idahoensis 'Joseph' & 'Siskiyou'	Blue Idaho Fescue	2′X 1′	Evergreen	Sun/Shade	Medium	5	All areas
Festuca ovina glauca	Blue Fescue	1′X 1′	Evergreen	Sun/Shade	Medium	5	All areas
Helictotrichon sempervirens	Blue Avena Grass	2′X 2′	Evergreen	Sun/Shade	Medium	10	All except WM&RR
Koeleria macrantha	Junegrass	18″X 18″	Evergreen	Sun/Shade	Low+	18	All areas
Leymus cinereus	Great Basin Wildrye	4′X 3′	Deciduous	Sun/Shade	Low+	15	All areas
Miscanthus spp.	Maiden Grass	5′X 5′	Deciduous	Sun/Shade	Medium+	15	CV
Muhlenbergia capillaris	Gulf Muhly	3′X 3′	Deciduous	Full Sun	Medium	12	All except EM
Muhlenbergia emersleyi	Bull Muhly	3′X 3′	Deciduous	Full Sun	Low+	15	All except EM
Muhlenbergia lindheimerii	Lindheimer Muhly	5′X 5′	Deciduous	Full Sun	Low+	25	All areas
Muhlenbergia porteri	Bush Muhly	1′X 2′	Deciduous	Full Sun	RW	15	All areas
Muhlenbergia rigens	Deer Grass	4′X 4′	Deciduous	Full Sun	Low+	20	All areas

Scientific Name	Common Name	Approx. Size Height x Width	Deciduous or Evergreen	Light Exposure	Water Use	Rebate Allowance	Region
Muhlenbergia rigida	Purple Muhly	2' X 3'	Deciduous	Full Sun	Low+	15	All areas
Nassella syn. Stipa tenuissima	Threadgrass	2' X 2'	Deciduous	Full Sun	Low+	15	All areas
Ophiopogon japonicus	Mondo grass	6" X 6"	Evergreen	Sun/Shade	Medium+	0	CV / AF
Panicum virgatum	Switchgrass	4' X 3'	Deciduous	Sun/Shade	Medium	15	All areas
Pascopyrum syn.Agropyron smithii	Western Wheatgrass	2' X 2'	Deciduous	Sun/Shade	Medium	10	All areas
Pennisetum alopecuroides	Hardy Fountain Grass	30" X 30"	Deciduous	Full Sun	Medium	12	All areas
Phyllostachys aurea	Golden bamboo	15' X 15'	Evergreen	Sun/Shade	Medium+	25	CV
Pleuraphis syn. Hilaria jamesii	Galleta	14" X 14"	Deciduous	Full Sun	Low	10	All areas
Schizachyrium scoparium	Little Bluestem	2' X 2'	Deciduous	Full Sun	Low+	15	All areas
Sorghastrum nutans	Indiangrass	4' X 2'	Deciduous	Full Sun	Medium	15	All areas
Sprorobolus airoides	Alkali Sacaton	2' X 2'	Deciduous	Full Sun	Low	15	All areas
Sporobolus cryptandrus	Sand Dropseed	2' X 2'	Deciduous	Full Sun	RW	15	All areas
Sprorobolus wrightii	Giant Sacaton	5' X 5'	Deciduous	Full Sun	Medium	20	All areas
Thinopyrum ponticum syn. Elytrigia elongata	Jose' Tall Wheatgrass	4' X 2'	Deciduous	Full Sun	Medium	10	All areas

GROUNDCOVERS

Aegopodium variegatum	Variegated Bishop's Weed	1' X 2'	Deciduous	Shade	Medium+	5	All areas
Achillea Millefolium	Yarrow	2' X 2'	Evergreen	Sun/Shade	Medium	10	All areas
Anemopsis californica	Yerba de Mansa	1' X 3'+	Deciduous	Sun/Shade	Medium	15	All areas
Arctostaphylos uva-ursi	Kinnikinnick	9" X 2'	Evergreen	Shade only	Medium	10	UA / AF / EM
Artemisia frigida	Fringed Sage	18" X 18"	Deciduous	Full Sun	Low	15	All areas
Artemisia ludoviciana	Prairie Sage	18" X 3'	Evergreen	Full Sun	Low+	15	All areas
Baccaris pilularis	Dwarf Coyotebush	18" X 3'	Evergreen	Sun/Shade	Low+	15	All except EM
Baccharis X 'Centennial'	Centennial Broom	3' X 5'	Evergreen	Full Sun	Low+	25	All except EM
Baccharis X 'Starns'	Thompson Broom	2' X 5'	Evergreen	Full Sun	Low+	25	All except EM
Cerastium tomentosum	Snow-In-Summer	8" X 2'	Deciduous	Sun/Shade	Medium	10	All areas
Ceratostigma plumbaginoides	Dwarf Plumbago	1' X 2'	Deciduous	Shade	Medium	10	All areas
Chamaemelum nobilis	Chamomile	6" X 1'	Evergreen	Shade	High	0	CV / EM
Cotoneaster dammeri	Bearberry Cotoneaster	1' X 9'	Evergreen	Sun/Shade	Medium	30	All areas
Cotoneaster horizontalis 'Perpusillus'	Rock Cotoneaster	2' X 7'	Evergreen	Sun/Shade	Medium	25	All areas
Cotoneaster salicifolius 'Repens'	Willowleaf Cotoneaster	1' X 9'	Evergreen	Full Sun	Medium	30	All except EM
Delosperma congestum & nubigenum	Yellow Iceplant	3" X 2'	Evergreen	Sun/Shade	Low+	15	All areas
Delosperma cooperi	Purple Iceplant	6" X 18"	Evergreen	Full sun	Low+	15	All areas
Dichondra spp.	Dichondra	2" X 1'	Deciduous	Sun/Shade	High	0	All except EM
Duchesnea indica	Mock Strawberry	8" X 2'	Deciduous	Shade	Medium+	5	CV / EM
Ephedra minuta	Dwarf Joint Fir	1' X 1'	Evergreen	Sun/Shade	Medium	5	All areas
Erigeron flagillaris	Whiplash Daisy	8" X 3'	Evergreen	Sun/Shade	Low+	15	All areas
Euonymus fortunei 'Coloratus'	Purpleleaf Wintercreeper	1' X 4'	Evergreen	Sun/Shade	Medium+	15	All areas
Euphorbia cyparissias	Cypress Spurge	1' X 1'	Evergreen	Sun/Shade	Medium	5	All areas
Jasminum nudiflorum	Winter Jasmine	2' X 8'+	Deciduous	Sun/Shade	Low+	30	All areas
Juniperus sp	Groundcover Juniper, Female Forms Only	6"-2' X 5'+	Evergreen	Sun/Shade	Low+	25	All areas
Mahonia aquifolium 'Compacta'	Compact Mahonia	2' X 4'	Evergreen	Sun/Shade	Medium	20	All areas
Mahonia repens	Creeping Mahonia	1' X 2'	Evergreen	Shade	Medium	10	AF / EM
Marrubium rotundifolium	Roundleaf Horehound	10" X 24"	Evergreen	Sun/Shade	Low+	15	All areas
Mirabilis multiflora	Native Four O'Clock	2' X 5'	Deciduous	Full Sun	Low+	25	All areas
Paxistima myrsinites	Oregon Boxwood	2' X 3'	Evergreen	Sun/Shade	High	0	EM
Prunus besseyi 'Pawnee Buttes'	Spreading Sand Cherry	2' X 6'	Deciduous	Full Sun	Medium	25	All areas
Rhus trilobata 'Autumn Amber'	Prostrate Sumac	2' X 6'+	Deciduous	Full Sun	Low+	35	All areas
Rosmarinus officinalis 'Prostrata'	Creeping Rosemary	2' X 6'	Evergreen	Full Sun	Low+	30	All except EM
Santolina chamaecyparissus	Gray Lavender Cotton	2' X 3'	Evergreen	Full Sun	Low+	15	All areas
Santolina virens	Green Lavender Cotton	2' X 3'	Evergreen	Full Sun	Low+	15	All areas
Saponaria ocymoides	Soapwort	9" X 18"	Deciduous	Sun/Shade	Medium	10	All areas
Sedum reflexum	Blue Spruce Sedum	1' X 2'	Evergreen	Sun/Shade	Low+	15	All areas
Sedum spurium	Dragon's Blood Sedum	6" X 1'	Evergreen	Sun/Shade	Medium	5	UA / CV / AF / EM
Teucrium chamaedrys	Trailing Germander	1' X 2'	Evergreen	Sun/Shade	Medium	10	All areas
Teucrium cossonii majoricum	Greek Germander	6" X 18"	Evergreen	Sun/Shade	Medium	10	All areas
Thymus pseudolanuginosus and minus	Wooly and Dwarf Creeping Thyme	3" X 1'	Evergreen	Shade	Medium	5	All areas
Thymus serphyllum	Creeping Thyme	3" X 1'	Evergreen	Shade	High	0	UA / CV / AF / EM
Verbena peruviana	Verbena	9" X 18"	Deciduous	Full Sun	Low+	12	All except EM
Veronica prostrata	Harebell Veronica	8" X 1'	Deciduous	Sun/Shade	Medium	5	EM
Vinca major	Giant Periwinkle	1' X 4'	Evergreen	Shade	Medium+	10	All areas
Vinca minor	Periwinkle	9" X 2'	Evergreen	Shade	Medium+	5	All areas
Zinnia grandiflora	Desert or Prairie Zinnia	8" X 16"	Deciduous	Full Sun	RW	15	All areas

SHRUBS, DECIDUOUS

Acacia constricta	Whitethorn Acacia	10' X 10'	Deciduous	Full Sun	RW	40	All except EM
Acacia greggii	Catclaw Acacia	10' X 12'	Deciduous	Full Sun	RW	40	All except EM
Aloysia wrightii	Mexican Oregano or Beebrush	5' X 4'	Deciduous	Full Sun	RW	25	All areas
Amelanchier utahensis	Utah Serviceberry	8' X 8'	Deciduous	Full Sun	Low+	35	All areas
Amorpha cana	Dwarf Leadplant	2' X 3'	Deciduous	Full Sun	Medium	12	CV / AF / EM
Amorpha canescens	Leadplant	2' X 3'	Deciduous	Full Sun	Low+	15	All areas
Amorpha fruticosa	False Indigo	10' X 10'	Deciduous	Sun/Shade	Medium	30	All areas
Anisacanthus quadrifidus var wrightii	Flame Anisacanthus	4' X 4'	Deciduous	Sun/Shade	Low+	20	All except EM
Anisacanthus thurberi	Desert Honeysuckle	5' X 4'	Deciduous	Sun/Shade	Low+	20	UA / WM&RR
Berberis thunbergii	Japanese Barberry	4' X 4'	Deciduous	Sun/Shade	Medium+	15	UA / CV / EM

PLANT LIST

Scientific Name	Common Name	Approx. Size Height x Width	Deciduous or Evergreen	Light Exposure	Water Use	Rebate Allowance	Region
Berberis thunbergii 'Atropur. Nana'	Crimson Pigmy Barberry	2' X 2'	Deciduous	Full Sun	Medium+	5	All areas
Berberis thunbergii Atropurpurea	Redleaf Barberry	4' X 4'	Deciduous	Full Sun	Medium+	15	All areas
Buddleia davidii nanhoensis	Dwarf Butterfly Bush	5' X 5'	Deciduous	Sun/Shade	Medium	20	All areas
Buddleia marrubifolia	Wooly Butterfly Bush	4' X 4'	Deciduous	Full Sun	Low+	20	All except EM
Caesalpinia gilliesii	Yellow Bird of Paradise	10' X 10'	Deciduous	Full Sun	RW	40	All except EM
Caragana spp.	Peashrub	8' X 8'	Deciduous	Full Sun	Medium	25	CV / EM
Caryopteris x clandonensis	Blue Mist Spirea	3' X 3'	Deciduous	Full Sun	Low+	15	All areas
Cercocarpus montanus	Montane Mountain Mahogany	10' X 8'	Deciduous	Full Sun	Low+	35	All areas
Chaenomeles japonica	Flowering Quince	6' X 6'	Deciduous	Full Sun	Medium+	20	CV / EM
Chamaebatiaria millefolium	Fernbush	5' X 6'	Deciduous	Full Sun	Low+	30	All areas
Cornus alba	Tartarian Dogwood	10' X 10'	Deciduous	Sun/Shade	High	0	CV / EM
Cornus stolonifera	Redtwig Dogwood	7' X 7'	Deciduous	Sun/Shade	High	0	CV / EM
Cotoneaster apiculatus	Cranberry Cotoneaster	4' X 8'	Deciduous	Sun/Shade	Medium	25	All areas
Cotoneaster divaricatus	Spreading Cotoneaster	4' X 8'	Deciduous	Sun/Shade	Medium	25	All areas
Cotoneaster horizontalis	Rock Cotoneaster	2' X 9'	Deciduous	Full Sun	Medium	30	All areas
Dalea formosa	Feather Dalea	2' X 3'	Deciduous	Full Sun	RW	20	All areas
Dalea frutescens	Black Dalea	2' X 4'	Deciduous	Full Sun	Low	25	All areas
Dalea versicolor	Mountain Dalea	3' X 5'	Deciduous	Full Sun	Low+	25	UA / WM&RR
Ericameria syn Chrysothamnus nauseosus	Chamisa, Rabbitbrush	5' X 5'	Deciduous	Full Sun	RW	30	All areas
Euonymus alata Compacta	Dwarf Burning Bush	6' X 6'	Deciduous	Sun/Shade	High	0	UA / CV / EM
Fendlera rupicola	Cliff Fendlerbush	6' X 4'	Deciduous	Full Sun	Low+	20	All areas
Forsythia intermedia	Forsythia	10' X 10'	Deciduous	Full Sun	Medium+	25	CV / EM
Genista tinctoria	Summer Broom	2' X 4'	Deciduous	Full Sun	Medium	15	All areas
Hibiscus syriacus	Rose of Sharon	10' X 10'	Deciduous	Full Sun	Medium	30	All areas
Hippophae rhamnoides	Sea Buckthorn	30' X 30'	Deciduous	Full Sun	High	0	EM
Holodiscus dumosus	Rock Spirea	6' X 6'	Deciduous	Sun/Shade	Medium	25	AF / EM
Jasminum nudiflorum	Winter Jasmine	4' X 12'	Deciduous	Full Sun	Low+	35	All areas
Kolkwitzia amabilis	Beauty Bush	10' X 10'	Deciduous	Sun/Shade	Medium	30	CV / EM
Leucophyllum frutescens	Texas Ranger or Ceniza	6' X 6'	Semi-Evergreen	Full Sun	Low+	30	All except EM
Leucophyllum langmaniae	Rio Bravo Sage	5' X 5'	Deciduous	Full Sun	Low+	25	All except EM
L. frutescens 'Compactum'	Compact Ceniza	3' X 4'	Semi-Evergreen	Full Sun	Low+	20	All except EM
Ligustrum vulgare	Common Privet	8' X 6'	Deciduous	Sun/Shade	Medium+	20	All areas
Lonicera tartarica	Tartarian Honeysuckle	6' X 6'	Deciduous	Sun/Shade	High	0	All areas
Parryella filifolia	Dunebroom	3' X 3'	Deciduous	Full Sun	RW	20	All areas
Philadelphus cultivars	Mock Orange	10' X 10'	Deciduous	Sun/Shade	Medium	30	All areas
Philadelphus microphyllus	Littleleaf Mock Orange	6' X 6'	Deciduous	Sun/Shade	Medium	25	All areas
Potentilla fruticosa	Shrubby Cinquefoil	3' X 3'	Deciduous	Sun/Shade	Medium+	10	All areas
Prunus besseyi	Western Sand Cherry	4' X 4'	Deciduous	Full Sun	Medium	15	All areas
Prunus tomentosa	Nanking Cherry	6' X 6'	Deciduous	Full Sun	Medium	25	All areas
Prunus X cistena	Purpleleaf Plum Bush	6' X 6'	Deciduous	Full Sun	Medium+	20	All areas
Psorothamnus scoparius	Broom Dalea	3' X 5'	Deciduous	Full Sun	RW	30	WM&RR
Punica spp.	Pomegranate	10' X 10'	Deciduous	Full Sun	Medium	30	All except EM
Rhamnus frangula Columnaris	Tallhedge Buckthorn	10' X 4'	Deciduous	Sun/Shade	Medium+	12	All areas
Rhus glabra var. cismontana	Cutleaf Sumac	3' X 5'	Deciduous	Sun/Shade	Medium	20	All areas
Rhus microphylla	Littleleaf Sumac	8' x 9'	Deciduous	Full Sun	Low+	35	All areas
Rhus trilobata	Three-leaf Sumac	6' X 6'	Deciduous	Full Sun	Low+	30	All areas
Ribes aureum	Golden Currant	6' X 6'	Deciduous	Sun/Shade	Medium+	20	All areas
Rosa foetida	Austrian Copper Rose	10' X 10'	Deciduous	Full Sun	Medium	30	All areas
Rosa rugosa	Species Rugosa Roses	4'+ X 8'	Deciduous	Full Sun	Medium+	20	CV / AF / EM
Rosa spp.	Tea, Floribunda, Grandiflora	6' X 5'	Deciduous	Full Sun	Medium+	20	All areas
Rosa woodsii	Woods' Rose	6' X 8'	Deciduous	Sun/Shade	Medium	25	All areas
Rubus cultivars	Raspberries, Blackberries	5' X 6'	Deciduous	Shade	Medium+	20	All areas
Salvia greggii	Autumn or Cherry Sage	2' X 3'	Deciduous	Sun/Shade	Low+	15	All except EM
Sarcobatus vermiculatus	Greasewood	8' X 8'	Deciduous	Full Sun	RW	35	Reclamation only
Shepherdia argentea	Silver Buffaloberry	15' X 10'	Deciduous	Sun/Shade	Medium+	30	CV / EM
Spiraea spp.	Spirea	varies	Deciduous	Sun/Shade	High	0	All areas
Symphoricarpos albus	Snowberry	6' X 6'	Deciduous	Sun/Shade	Medium	25	CV / AF / EM
Symphoricarpos orbiculatus	Coralberry	6' X 6'	Deciduous	Sun/Shade	Medium	25	All areas
Syringa spp.	Lilac	8' X 8'	Deciduous	Full Sun	Medium+	25	All areas
Syringa laciniata	Cutleaf Persian Lilac	8' X 6'	Deciduous	Full Sun	Medium+	20	All areas
Syringa meyeri	Dwarf Korean Lilac	5' X 6'	Deciduous	Sun/Shade	Medium	25	All areas
Syringa persica	Persian Lilac	8' X 8'	Deciduous	Full Sun	Medium+	25	All areas
Syringa rothomagensis	Chinese Lilac	8' X 8'	Deciduous	Sun/Shade	Medium+	25	All areas
Syringa vulgaris	Common Lilac	15' X 15'	Deciduous	Full Sun	Medium+	30	All areas
Viburnum spp.	Viburnum	varies	Deciduous	Sun/Shade	High	0	All areas
Weigela florida	Weigela	10' X 10'	Deciduous	Full Sun	Medium+	25	All areas

SHRUBS, EVERGREEN

Abelia grandiflora	Glossy Abelia	7' X 7'	Evergreen	Sun/Shade	Medium+	25	All areas
Arctostaphylos pungens	Pointleaf Manzanita	3' X 6'	Evergreen	Sun/Shade	Low+	30	All areas
Artemisia cana	Silver Sage	3' X 5'	Evergreen	Full Sun	Low+	25	All areas
Artemisis filifolia	Sand Sage	4' X 4'	Evergreen	Full Sun	RW	25	All areas
Artemisia tridentata	Big Sage	4' X 4'	Evergreen	Full Sun	Low	25	All areas
Atriplex canescens	Fourwing Saltbrush	6' X 8'	Evergreen	Full Sun	RW	40	Reclamation
Atriplex confertifolia	Shadscale	2' X 2'	Evergreen	Full Sun	RW	15	All areas
Baccharis salicina	Broom Baccharis	8' X 8'	Semi-Evergreen	Full Sun	Medium	30	Reclamation
Baccharis sarothroides	Desert Broom	6' X 6'	Evergreen	Full Sun	Low+	30	Reclamation

Scientific Name	Common Name	Approx. Size Height x Width	Deciduous or Evergreen	Light Exposure	Water Use	Rebate Allowance	Region
Berberis gladwynensis	William Penn Barberry	6′ X 6′	Evergreen	Sun/Shade	Medium+	20	All areas
Berberis julianae	Wintergreen Barberry	5′ X 5′	Evergreen	Full Sun	Medium	20	All areas
Berberis mentorensis	Mentor Barberry	7′ X 7′	Evergreen	Sun/Shade	Medium	25	All areas
Buxus spp.	Boxwood	4′ X 4′	Evergreen	Shade	Medium	15	All areas
Cercocarpus ledifolius	Curl-leaf Mtn. Mahoghany	15′ X 15′	Evergreen	Full Sun	Low+	45	All areas
Cercocarpus breviflorus	Hairy Mountain Mahoghany	15′ X 15′	Evergreen	Full Sun	Low+	45	All areas
Chrysactinia mexicana	Damianita	2′ X 2′	Evergreen	Full Sun	Low	15	All except EM
Cistus ladanifer & X purpureus	Crimsonspot & Purple Rockrose	4′ X 5′	Evergreen	Full Sun	Low+	25	All except EM
Cotoneaster buxifolius	Grayleaf Cotoneaster	2′ X 9′	Evergreen	Full Sun	Low+	35	All areas
Cotoneaster congestus	Pyrenees Cotoneaster	3′ X 3′	Evergreen	Sun/Shade	Medium	15	All areas
Cotoneaster lacteus	Parney or Clusterberry Cotoneaster	8′ X 10′	Evergreen	Sun/Shade	Medium	30	All areas
Cotoneaster salicifolius	Willowleaf Cotoneaster	6′ X 10′	Evergreen	Sun/Shade	Medium	30	All areas
Cytisus scoparius	Scotch Broom	4′ X 6′	Evergreen	Full Sun	Medium	30	All areas
Elaegnus pungens	Silverberry	10′ X 10′	Evergreen	Full Sun	Medium	30	All areas
Ephedra species	Joint-fir or Mormon Tea	2′+ X 5′+	Evergreen	Full Sun	RW	35	All areas
Ericameria laricifolia	Turpentine Bush	3′ X 4′	Evergreen	Full Sun	Low	25	All except EM
Eriogonum fascilculatum v. poliofolium	Flattop Buckwheat	2′ X 2′	Evergreen	Full Sun	Low	15	All except EM
Euonymus japonica	Japanese Euonymus	8′ X 8′	Evergreen	Full Sun	Medium+	25	All areas
Euonymous klautschovious	Manhattan Euonymus	6′ X 6′	Evergreen	Sun/Shade	Medium+	20	All areas
Fallugia paradoxa	Apache Plume	6′ X 7′	Evergreen	Full Sun	Low	35	All areas
Garrya wrightii	Wright's Silk Tassel	5′ X 5′	Evergreen	Full Sun	Low	30	All areas
Genista hispanica	Spanish Broom	4′ X 4′	Evergreen	Full Sun	Low+	20	All except EM
Helichrysum angustifolium	Currly Plant	2′ X 3′	Evergreen	Full Sun	Low+	15	All areas
Ilex cornuta 'Burfordii'	Burford Holly	8′ X 8′	Evergreen	Shade	Medium+	20	All areas
Ilex altaclarensis 'Wilsonii'	Wilson Holly	10′ X 10′	Evergreen	Shade	Medium+	25	All areas
Juniperus shrub species female cultivars only	Female Juniper Shrubs	1′+ X 4′+	Evergreen	Full Sun	Low+	35	All areas
Krascheninnikovia syn Ceratoides syn Eurotia lanata	Winterfat	3′ X 3′	Evergreen	Full Sun	Low RW	20	All areas
Larrea tridentata	Creosote Bush	6′ X 8′	Evergreen	Full Sun	Low RW	35	All except EM
Lavandula angustifolia	English Lavender	3′ X 3′	Evergreen	Sun/Shade	Medium	12	All areas
Lavendula stoechas	Spanish Lavender	3′ X 3′	Evergreen	Full Sun	Medium	12	All except EM
Leucophyllum langmaniae	'Lynn's Legacy' Texas sage	4′ X 4′	Semi-Evergreen	Full Sun	Low+	25	All except EM
Leucophyllum zygophyllum	Cimarron Rainsage	4′ X 4′	Semi-Evergreen	Full Sun	Low+	25	All except EM
Ligustrum japonicum	Waxleaf Privet	8′ X 8′	Evergreen	Sun/Shade	High	0	All areas
Mahonia aquifolium	Oregon Grape Holly	6′ X 6′	Evergreen	Sun/Shade	Medium	30	All areas
Mahonia aquifolium 'Compacta'	Compact Oregon Grape	2′ X 4′	Evergreen	Sun/Shade	Medium	20	All areas
Mahonia syn Berberis fremontii	Blue Algerita	5′ X 7′	Evergreen	Sun/Shade	Low+	30	All areas
Mahonia syn Berberis hamaetocarpa	Algerita	8′ X 10′	Evergreen	Full Sun	Low+	35	All areas
Nandina domestica cultivars	Heavenly Bamboo	8′ X 5′	Evergreen	Sun/Shade	Medium+	20	All areas
Parthenium incanum	Mariola	2′ X 3′	Evergreen	Full Sun	RW	20	All areas
Photinia fraseri	Red Tip Photinia	8′ X 8′	Evergreen	Full Sun	Medium+	20	All areas
Photinia serrulata	Chinese Photinia	10′ X 10′	Evergreen	Full Sun	Medium+	25	All areas
Picea conica	Alberta Spruce	7′ X 3′	Evergreen	Sun/Shade	Medium	12	All areas
Prunus caroliniana	Carolina Cherry Laurel	10′ X 10′	Evergreen	Sun/Shade	High	0	All except EM
Purshia syn Cowania mexicana	Cliffrose	8′ X 8′	Evergreen	Full Sun	Low	40	All areas
Purshia tridentata	Antelope Bitterbush	6′ X 8′	Evergreen	Full Sun	Low	40	All areas
Pyracantha coccinea	Firethorn	10′ X 10′	Evergreen	Sun/Shade	Medium	35	All areas
Raphiolepis indica	India Hawthorn	3′ X 4′+	Evergreen	Sun/Shade	Medium	20	All except EM
Rhamnus californica var. ursina	Coffeeberry	6′ X 8′	Evergreen	Full Sun	Low+	35	All areas
Rhododendron spp.	Rhododendron, Azalea	3′ X 3′	Evergreen	Sun/Shade	High	0	Needs acid soil
Rhus ovata	Sugarbush	10′ X 10′	Evergreen	Full Sun	Low+	40	All except EM
Rhus virens / choriophylla	Evergreen Sumac	8′ X 8′	Evergreen	Full Sun	Low+	40	All except EM
Rosmarinus officinalis	Upright Rosemary	6′ X 6′	Evergreen	Full Sun	Low+	30	All except EM
Sabal minor	Dwarf Sabal Palm	3′ X 3′	Evergreen	Shade	Medium+	10	All except EM
Salvia chamaedryoides	Mexican Blue or Chihuahua Sage	1′ X 3′	Semi-Evergreen	Full Sun	Low+	15	All except EM
Salvia dorrii	Desert Sage	2′ X 3′	Evergreen	Full Sun	Low	20	All areas
Salvia lavandulifolia	Lavander Sage	1′ X 2′	Evergreen	Full Sun	Low+	15	All areas
Salvia officinalis	Garden Sage	2′ X 2′	Evergreen	Full Sun	Medium	10	All areas
Spartium junceum	Spanish Broom	10′ X 10′	Evergreen	Full Sun	Medium	30	All areas
Vauquelinia spp.	Rosewood	12′ X 10′	Evergreen	Full Sun	Low+	40	All areas
Virburnum X burkwoodii	Burkwood Viburnum	6′ X 5′	Evergreen	Shade	Medium	20	All areas
TREES, DECIDUOUS							
Acer X freemanii	Freeman Maple	45′ X 30′	Deciduous	Sun/Shade	Medium+	25	CV / EM
Acer negundo 'Sensation'	Sensation Box Elder	40′ X 30′	Deciduous	Full Sun	Medium	35	CV / AF / EM
Acer palmatum	Japanese Maple	20′ X 20′	Deciduous	Shade	High	0	CV / EM
Acer saccharum v grandidentatum	Bigtooth Maple	25′ X 25′	Deciduous	Full Sun	Medium	35	CV / AF / EM
Acer tataricum ginnala	Amur Maple	20′ X 20′	Deciduous	Full Sun	Medium+	25	CV / EM
Acer truncatum	Shantung Maple	25′ X 25′	Deciduous	Full Sun	Medium+	25	CV / EM
Albizia julibrissin Rosea	Mimosa	20′ X 20′	Deciduous	Full Sun	Medium	35	All except EM
Carya illinoinensis	Pecan	40′ X 40′	Deciduous	Full Sun	High	0	CV
Catalpa speciosa	Catalpa	40′ X 40′	Deciduous	Full Sun	Medium	35	All areas
Celtis occidentalis	Common Hackberry	40′ X 40′	Deciduous	Full Sun	Medium	35	All areas
Celtis reticulata	Netleaf / Canyon Hackberry	25′ X 25′	Deciduous	Full Sun	Low+	45	All areas
Cercis occidentalis	Western Redbud	10′ X 12′	Deciduous	Sun/Shade	Medium	30	All except EM
Cercis mexicana	Mexican Redbud	15′ X 12′	Deciduous	Sun/Shade	Medium	30	All except EM

PLANT LIST

Scientific Name	Common Name	Approx. Size Height x Width	Deciduous or Evergreen	Light Exposure	Water Use	Rebate Allowance	Region
Cercis reniformis	Oklahoma Redbud	15' X 12'	Deciduous	Sun/Shade	Medium	30	All except EM
Chilopsis linearis	Desert Willow	20' X 25'	Deciduous	Full Sun	RW	45	All except EM
Chilopsis X Catalpa	Chitalpa	20' X 20'	Deciduous	Full Sun	Medium	35	All areas
Cornus mas	Cornelian Cherry	15' X 20'	Deciduous	Shade	Medium+	25	EM
Cotinus coggygria	Smoketree	15' X 15'	Deciduous	Full Sun	Medium	30	All areas
Crataegus crus-galli Inermis	Thornless Cockspur Hawthorn	15' X 15'	Deciduous	Sun/Shade	Medium+	25	All areas
Crataegus laevigata	English Hawthorn	20' X 20'	Deciduous	Sun/Shade	Medium+	25	UA / CV / AF / EM
Crataegus phaenopyrum	Washington Hawthorn	20' X 20'	Deciduous	Sun/Shade	Medium+	25	UA / CV / AF / EM
Crataegus X lavallei	Carriere Hawthorn	25' X 25'	Deciduous	Full Sun	Medium+	25	UA / CV / AF / EM
Cratageus monogyna	Single-seed hawthorn	30' X 8'	Deciduous	Full Sun	Medium+	20	All areas
Crateagus ambigua	Russian Hawthorn	20' X 20'	Deciduous	Sun/Shade	Medium	35	All areas
Ficus carica	Edible Fig	12' X 15'	Deciduous	Full Sun	Medium	30	All except EM
Forestiera neomexicana	New Mexico Olive	15' X 15'	Deciduous	Sun/Shade	Medium	30	All areas
Fraxinus cuspidata	Fragrant Ash	20' X 20'	Deciduous	Full Sun	Medium	35	All areas
Fraxinus angustifolia oxycarpa	Claret or Raywood Ash	35' X 25'	Deciduous	Full Sun	Medium+	30	All areas
Fraxinus pennsylvanica X velutina	Fan West Ash	40' X 30'	Deciduous	Full Sun	Medium+	30	UA / CV / EM
Fraxinus texana	Texas Ash	25' X 25'	Deciduous	Full Sun	Medium	30	All areas
Fraxinus velutina	Arizona and Modesto Ash	40' X 35'	Deciduous	Full Sun	Medium+	30	UA / CV / EM
Fruit trees	Fruit trees (Apple, Peach Pear, Quince)	25' X 25'	Deciduous	Full Sun	Medium+	30	All areas
Gleditsia triacanthos inermis	Thornless Honey Locust	50' X 45'	Deciduous	Full Sun	Medium+	30	All areas
Gymnocladus dioica	Kentucky Coffee Tree	40' X 30'	Deciduous	Full Sun	Medium	35	All areas
Juglans major	Arizona Walnut	50' X 50'	Deciduous	Full Sun	Medium	40	UA / CV / EM
Juglans microcarpa	Little Walnut	30' X 30'	Deciduous	Full Sun	Medium	35	All areas
Juglans regia	English Walnut	60' X 60'	Deciduous	Full Sun	Medium+	30	CV / EM
Juglans regia 'Carpathian'	Carpathian Walnut	20' X 20'	Deciduous	Full Sun	Medium	35	All areas
Koelreuteria paniculata	Golden Rain Tree	25' X 25'	Deciduous	Full Sun	Medium	40	All areas
Lagerstroemia indica x fauriei	Crape Myrtle	15' X 15'	Deciduous	Full Sun	High	0	All except EM
Leucaena retusa	Golden Ball Leadtree	15' X 15'	Deciduous	Full Sun	Low+	35	UA / WM&RR
Maclura pomifera	Osage Orange	25' X 25'	Deciduous	Full Sun	Medium	40	All areas
Magnolia soulangiana	Saucer Magnolia	20' X 20'	Deciduous	Part Shade	Medium	35	UA / CV / WM&RR
Malus cultivars	Crabapple	varies	Deciduous	Full Sun	High	0	All areas
Melia azedarach	Chinaberry	25' X 20'	Deciduous	Full Sun	Low+	40	All except EM
Metasequoia glyptostroboides	Dawn Redwood	60' X 40'	Deciduous	Full Sun	Medium+	30	All areas
Parrotia persica	Persian Parrotia	25' X 25'	Deciduous	Full Sun	Medium	35	All areas
Paulownia tomentosa	Empress tree	30' X 30'	Deciduous	Sun/Shade	Medium	35	All except EM
Pistacia atlantica X integerrima	Red Push Pistache	40' X 40'	Deciduous	Full Sun	Medium	40	All except EM
Pistacia chinensis	Chinese Pistache	60' X 60'	Deciduous	Full Sun	Medium	45	All areas
Platanus acerfolia	London Plane Tree	70' X 50'	Deciduous	Full Sun	High	0	CV
Plantanus wrightii	Arizona Sycamore	60' X 70'	Deciduous	Full Sun	Medium+	35	CV
Populus acuminata	Mountain/Lanceleaf Cottonwood	50' X 50'	Deciduous	Full Sun	Medium+	35	CV / AF / EM
Populus deltoides var. wislizenii	Valley Cottonwood	50' X 60'	Deciduous	Full Sun	Medium+	35	CV / EM
Populus fremontii	Western Cottonwood	70' X 60'	Deciduous	Full Sun	Medium+	35	CV / EM
Prosopis glandulosa	Honey Mesquite	25' X 30'	Deciduous	Full Sun	RW	45	All except EM
Prosopis pubescens	Screwbean Mesquite	20' X 20'	Deciduous	Full Sun	RW	40	All except EM
Prosopis torreyana	Western Honey Mesquite	18' X 20'	Deciduous	Full Sun	RW	40	All except EM
Prosopis velutina	Velvet Mesquite	20' X 25'	Deciduous	Full Sun	RW	40	All except EM
Prunus americana	American Plum	20' X 20'	Deciduous	Sun/Shade	Medium	35	All areas
Prunus armeniaca	Apricot	20' X 20'	Deciduous	Sun/Shade	Medium	35	All areas
Prunus armeniaca mandshurica	Manchurian Apricot	10' X 12'	Deciduous	Sun/Shade	Medium	25	All areas
Prunus cerastifera	Purpleleaf Plum	20' X 20'	Deciduous	Full Sun	Medium	35	All areas
Prunus virginiana	Chokecherry	20' X 20'	Deciduous	Full Sun	Medium+	30	All areas
Ptelea trifoliata	Hoptree	20' X 20'	Deciduous	Sun/Shade	Medium	35	All areas
Pyrus sp	Ornamental Pear	25' X 15'	Deciduous	Full Sun	Medium+	20	All areas
Quercus gambelii	Gambel Oak	25' X 25'	Deciduous	Sun/Shade	Medium	40	All areas
Quercus gravesii	Chisos Red Oak	25' X 25'	Deciduous	Sun/Shade	Medium	40	All except EM
Quercus lobata	Valley Oak	45' X 30'	Deciduous	Full Sun	Medium+	35	CV
Quercus macrocarpa	Bur Oak	60' X 70'	Deciduous	Sun/Shade	Medium+	40	CV / EM
Quercus muhlenbergii	Chinquapin Oak	40' X 40'	Deciduous	Sun/Shade	Medium	40	All areas
Quercus oblongifolia/engelmannii	Mexican Blue / Mesa Oak	25' X 30'	Deciduous	Sun/Shade	Medium	40	All except EM
Quercus robur	English Oak	50' X 50'	Deciduous	Sun/Shade	Medium+	40	CV / EM
Quercus shumardii	Shumard Oak	60' X 60'	Deciduous	Sun/Shade	Medium	40	All areas
Quercus texana syn buckleyi	Texas Red Oak	40' X 40'	Deciduous	Sun/Shade	Medium	40	All areas
Rhamnus cathartica	Common Buckthorn	20' X 20'	Deciduous	Full Sun	Medium	35	AF/EM
Rhamnus frangula 'Asplenifolia'	Fernleaf Buckthorn	12' X 10'	Deciduous	Sun/Shade	Medium	25	All areas
Rhus glabra	Smooth Sumac	12' X 15'+	Deciduous	Sun/Shade	Medium	30	All areas
Rhus lanceolata	Prairie Flameleaf Sumac	25' X 20'	Deciduous	Sun/Shade	Medium	35	All except EM
Robinia neomexicana	New Mexico Locust	25' X 15'	Deciduous	Sun/Shade	Medium	30	All areas
Robinia pseudoacacia	Black Locust	40' X 25'	Deciduous	Full Sun	Medium	40	All areas
Robinia X ambigua	Idaho Locust	40' X 25'	Deciduous	Full Sun	Medium	40	All areas
Sambucus mexicana	Mexican Elder	20' X 25'	Deciduous	Full Sun	Low+	45	All except EM
Sapindus drummondii	Western Soapberry	30' X 30'	Deciduous	Full Sun	Low+	45	All areas
Sorbus aucuparia	European Mountain Ash	20' X 20'	Deciduous	Sun/Shade	High	0	EM
Styphnolobium syn Sophora japonicum	Japanese Pagoda Tree, Scholar Tree	35' X 35'	Deciduous	Sun/Shade	Medium	40	All areas
Syringa reticulata	Japanese Tree Lilac	20' X 20'	Deciduous	Full Sun	Medium+	30	CV / EM
Taxodium distichum	Bald Cypress	50' X 20'	Deciduous	Sun/Shade	Medium+	35	UA / CV
Taxodium mucronatum	Montezuma Cypress	60' X 40'	Deciduous	Sun/Shade	Medium+	35	UA / CV
Tilia cordata	Littleleaf Linden	40' X 30'	Deciduous	Sun/Shade	High	0	AF / EM
Ulmus crassifolia	Cedar Elm	40' X 40'	Deciduous	Full Sun	Medium	40	All except EM
Ulmus parvifolia	Lacebark Elm	40' X 40'	Deciduous	Full Sun	Medium	40	All except EM
Vitex agnus-castus	Chaste Tree	20' X 20'	Deciduous	Full Sun	Medium	35	All except EM
Zizyphus jujuba	Jujube or Chinese Date	25' X 25'	Deciduous	Full Sun	Low+	40	All areas

Scientific Name	Common Name	Approx. Size Height x Width	Deciduous or Evergreen	Light Exposure	Water Use	Rebate Allowance	Region
TREES, EVERGREEN							
Abies concolor	White Fir	50′ X 20′	Evergreen	Full Sun	High	0	EM
Cedrus atlantica	Atlas Cedar	75′ X 50′	Evergreen	Full Sun	Medium+	35	All areas
Cedrus deodara	Deodar Cedar	80′ X 60′	Evergreen	Full Sun	Medium+	35	All areas
Cedrus libani	Cedar of Lebanon	80′ X 50′	Evergreen	Full Sun	Medium+	35	All areas
Cercocarpus ledifolius	Curlleaf Mountain Mahogany	12′ X 8′	Evergreen	Full Sun	Low+	25	All areas
Cupressocyparis leylandii	Leyland Cypress	40′ X 20′	Evergreen	Full Sun	Medium	35	All except EM
Cupressus arizonica	Arizona Cypress	50′ X 30′	Evergreen	Full Sun	Medium	40	All except EM
Ilex vomitoria	Yaupon Holly	15′ X 15′	Evergreen	Sun/Shade	Medium	30	UA / WM&RR
Juniperus chinensis	Juniper Trees, Females Only	25′ X 20′	Evergreen	Full Sun	Low+	40	All areas
Juniperus deppeana	Alligator Juniper	60′ X 40′	Evergreen	Full Sun	Low+	45	All areas
Juniperus monosperma	Oneseed Juniper	15′ X 15′	Evergreen	Full Sun	RW	35	All areas
Juniperus scopulorum	Rocky Mountain Juniper, Females Only	40′ X 20′	Evergreen	Full Sun	Low+	40	All areas
Juniperus virginiana	Juniper Trees, Females Only	20′ X 10′	Evergreen	Full Sun	Low+	30	All areas
Magnolia grandiflora	Southern Magnolia	25′ X 25′	Evergreen	Sun/Shade	Medium+	35	UA/CV
Picea abies	Norway Spruce	50′ X 20′	Evergreen	Full Sun	Medium+	30	EM
Picea engelmani	Engelmann Spruce	50′ X 20′	Evergreen	Full Sun	Medium+	30	EM
Picea pungens	Blue Spruce	50′ X 20′	Evergreen	Full Sun	Medium+	30	UA / CV / AF / EM
Pinus aristata	Bristlecone Pine	30′ X 20′	Evergreen	Full Sun	Medium	35	All areas
Pinus edulis	Pinon Pine	30′ X 20′	Evergreen	Full Sun	Medium	35	All areas
Pinus eldarica	Afghan Pine	40′ X 18′	Evergreen	Full Sun	Medium	35	All except EM
Pinus flexilis	Limber Pine	30′ X 20′	Evergreen	Full Sun	Medium	35	AF / EM
Pinus nigra	Austrian Pine	35′ X 25′	Evergreen	Full Sun	Medium+	35	AF / EM
Pinus pinea	Italian Stone Pine	60′ X 50′	Evergreen	Full Sun	Medium	40	All except EM
Pinus ponderosa	Ponderosa Pine	40′ X 25′	Evergreen	Full Sun	Medium+	35	AF / EM
Pinus strobiformis	Southwestern White or Border Pine	30′ X 20′	Evergreen	Full Sun	Medium+	30	AF / EM
Pinus sylvestris	Scotch Pine	45′ X 25′	Evergreen	Full Sun	Medium+	35	AF / EM
Poncirus trifoliata	Trifoliate Orange	15′ X 10′	Evergreen	Full Sun	Medium	25	All areas
Pseudotsuga menziesii	Douglas Fir	50′ X 20′	Evergreen	Full Sun	Medium+	30	AF / EM
Quercus emoryi	Emory Oak	35′X 35′	Evergreen	Sun/Shade	Medium	40	All areas
Quercus fusiformis	Escarpment Live Oak	25′ X30′	Evergreen	Sun/Shade	Medium	40	All except EM
Quercus grisea	Gray Oak	30′ X 30′	Evergreen	Sun/Shade	Low+	45	All areas
Quercus suber	Cork Oak	30′ X 30′	Evergreen	Sun/Shade	Low+	45	UA / WM&RR
Quercus turbinella	Desert or Shrub Live Oak	18′ X 20′	Evergreen	Sun/Shade	Low+	40	All areas
Quercus virginiana	Southern Live Oak	35′ X 40′	Evergreen	Sun/Shade	Medium	40	UA / WM&RR
Sequoia sempervirens	Coast Redwood	50′ X 30′	Evergreen	Full Sun	Medium	40	All areas
Sequoiadendron giganteum	Giant Sequoia	75′ X30′	Evergreen	Full Sun	Medium	40	All areas
Taxus species	Yew	varies	Evergreen	Shade	High	0	UA / CV / AF / EM
Thuja or Platycladus species	Arborvitae	15′+ X 12′+	Evergreen	Full Sun	Medium	30	All areas
Trachycarpus fortunei / wagnerianus	Windmill Palm	15′ X 4′	Evergreen	Sun/Shade	Medium	15	All except EM
VINES							
Akebia quinata	Chocolate Vine	Climbing X 15′	Deciduous	Sun/Shade	Medium	25	All except EM
Campsis radicans	Trumpet Vine	Climbing X 40′	Deciduous	Full Sun	Medium	30	All areas
Clematis hybrids	Clematis	Climbing X 10′	Deciduous	Sun/Shade	High	0	All areas
Clematis ligusticifolia	Western Virginsbower	Climbing X 15′	Deciduous	Sun/Shade	Medium	30	All areas
Clematis tangutica	Golden Lanterns	Climbing X 15′	Deciduous	Sun/Shade	High	0	All areas
Euonymus fortunei colorata	Purpleleaf Wintercreeper	Climbing X 6′	Evergreen	Sun/Shade	Medium+	20	All areas
Glesemium sempervirens	Carolina Jessamine	Climbing X 10′	Evergreen	Sun/Shade	Medium+	25	All except EM
Hedera helix	English Ivy	Climbing X 12′	Evergreen	Shade	Medium	30	All areas
Humulus neomexicanus	Hops	Climbing X 6′	Deciduous	Sun/Shade	Medium+	20	All areas
Lonicera japonica ‘Purpurea’	Purpleleaf Honeysuckle	Climbing X 12′	Evergreen	Sun/Shade	Medium+	20	All areas
Lonicera japonica Halliana	Hall’s Honeysuckle	Climbing X 12′	Evergreen	Full Sun	Medium+	25	All areas
Lonicera sempervirens	Coral Honeysuckle	Climbing X 8′	Deciduous	Shade/Part Sun	Medium	25	All areas
Lonicera x heckrottii	Goldflame Honeysuckle	Climbing X 8′	Deciduous	Shade/Part Sun	Medium	25	All areas
Parthenocissus inserta	Woodbine	Climbing X 40′	Deciduous	Sun/Shade	Medium	30	All areas
Parthenocissus quinquefolia	Virginia Creeper	Climbing X 40′	Deciduous	Sun/Shade	Medium+	25	All areas
Parthenocissus tricuspidata	Boston Ivy	Climbing X 40′	Deciduous	Shade	Medium+	25	All areas
Periploca graeca	Silkvine	Climbing X 40′	Deciduous	Sun/Shade	Medium	30	All areas
Polygonum aubertii	Silver Lacevine	Climbing X 40′	Deciduous	Full Sun	Low+	45	All areas
Rosa banksiae	Rose Lady Banks	Climbing X 40′	Evergreen	Sun/Shade	Low+	45	All areas
Rosa hybrid and species climbers	Climbing Roses	Climbing X 15′	Deciduous	Sun/Shade	Medium+	25	All areas
Trachelospermum jasminoides	Star Jasmine	Climbing X 6′	Evergreen	Shade	Medium	25	UA / WM&RR
Vitis arizonica	Canyon Grape	Climbing X 20′	Deciduous	Sun/Shade	Medium	35	All areas
Vitis labrusca	American grape	Climbing X 30′	Deciduous	Full Sun	Medium+	30	All areas
Vitis vinifera	European grape	Climbing X 30′	Deciduous	Full Sun	Medium	40	All except EM
Wisteria spp.	Wisteria	Climbing X 20′	Deciduous	Sun/Shade	Medium	35	All areas

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Appendix D. State of New Mexico: Plans, Regulations and Guides

New Mexico Department of Health Graywater Discharges (NMAC 20.7.810) - http://www.nmenv.state.nm.us/fod/LiquidWaste/20%207%203%20NMAC%20-%20filed%202-21-2007%20with%20toc.pdf

New Mexico Department of Health Graywater Systems (NMAC 20.7.811) - - http://www.nmenv.state.nm.us/fod/LiquidWaste/20%207%203%20NMAC%20-%20filed%202-21-2007%20with%20toc.pdf

New Mexico Department of Health Graywater Irrigation Guide - http://www.nmenv.state.nm.us/OOTS/GRAY%20WATER%20IRRIGATION%20GUIDE1.pdf

New Mexico Office of the State Engineer:Water Use and Conservation Program - http://www.ose.state.nm.us/conservation_index.html

Appendix E. United States Environmental Protection Agency: Water Conservation Plan Guidelines

United States Environmental Protection Agency: Water Conservation Plan Guidelines - http://www.epa.gov/greeningepa/water/index.htm

Appendix F. Annotated Bibliography

Additional information on designing and installing irrigation systems, designers, and irrigation technologies is available through the websites listed below.

Albuquerque/Bernalillo County Water Authority free residential water audit
http://www.abcwua.org/content/view/75/65/

Bureau of Reclamation- Smart technology
http://www.usbr.gov/waterconservation/docs/SmartController.pdf

City of Albuquerque--Do It Yourself
http://www.abcwua.org/content/view/73/63/

City of Albuquerque "Rainwater Harvesting"
http://www.abcwua.org/pdfs/irrigationmanual.pdf

EPA
http://www.epa.gov/watersense/docs/home_draft_spec508.pdf
Single-family homes guidelines

http://www.epa.gov/watersense/docs/home_draft_spec508.pdf
Information and resources for commercial and institutional water users

Hiring a Professional
http://www.irrigation.org/hirecertified/
http://findalandscapepro.pbwiki.com/How+to+Hire+a+Pro

Hunter Irrigation Homeowner's Irrigation Information
http://www.hunterindustries.com/homeowners.html

Irrigation Association Turf and Landscape Irrigation Best Management Practices
http://www.irrigation.org/Resources/Turf___Landscape_BMPs.aspx

Rainbird homeowner's irrigation information
http://www.rainbird.com/diy/index.htm

Toro Homeowner's Irrigation Information
http://www.toro.com/sprinklers/guides.html

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Appendix G. Water Features and Amenities

Water Features

When features such as fountains, ponds or waterfalls are used, design them to be as water-efficient as possible. Key considerations include evaporation rates, feature size and function. Evaporative water loss can be reduced by limiting the size of the feature, shading it, covering it when not in use, and avoiding spray features. Features with recirculating water can provide the desired effect with minimal water consumption and waste. Ideally, water features should perform practical water quality improvement or infiltration purposes in addition to being an aesthetic amenity. For example, it is possible to use ephemeral water features to infiltrate water into the soil such as having part of the stormwater conveyance system serve as a water feature when it is functioning. If you do not want infiltration from a water feature, utilization of appropriate measures and technologies such as liners to prevent unnecessary or excessive water loss should be utilized.

- **Swimming pools** can be designed and maintained to lessen their water consumption and adverse impacts of pool chemicals on the receiving water system. There are a variety of alternatives available which minimize or replace traditional chemical management regimes and, in some cases significantly reduce the frequency at which the pool must be flushed and refilled. Among the alternatives are ultra-violet purification and the use of salt versus fresh water. Pool size should be carefully considered when designing a community pool facility in order to avoid overbuilding. A variety of other measures can be used to reduce pool water waste once the pool is in operation. These include:
  - Using a pool cover when the pool is not in use. Pool covers can reduce the amount of pool water lost to evaporation by 90 to 95% and can also reduce both the amount of chemicals required to treat the water and energy costs associated with heating the pool.
  - Manual cleaning of the pool filter versus backwashing. Backwashing can use between 250 and 1000 gallons of water. Manual cleaning can also be more effective in removing debris from the filter.
  - Maintaining lower pool water temperatures reduces the amount of evaporation as warm water evaporates more rapidly.
  - Maintaining the appropriate pH level reduces the frequency of full pool cleaning required.
  - Monitoring for any leaks.
  - Maintaining the pool water level on the low side to reduce the amount of water lost to splashing and overflow.
  - Windbreaks around pools (and other water features) such as fences, privacy barriers, and trees and shrubbery help to minimize evaporation loss due to wind and also help to maintain pool water temperature. Heat loss due to wind can be significant; for example, a 7-mph wind at the surface of the pool can increase heat loss by up to 300%.
  - Locating a pool indoors or within an enclosure can also significantly reduce water loss due to evaporation.

Appendix H. Structural Soils

"CU-Soil," a mix patented by Cornell University's Urban Horticulture Institute (UHI), is composed of 80% ¾-inch to 1 ½-inch uniformly sized stone aggregate with no fines, 20% clay loam soil (25-35% clay) and 0.03% polymer gel, which is used to hydrate and tackify the soil particles to prevent them from separating from the aggregate matrix. The stone must be angular and consistently sized in order to maximize the void space between the aggregate particles. This allows soil, water and air to be spread throughout the mixture, ensuring adequate stability under pressure. In addition to sieving for consistent size, a cone separator can be used to sort out flat stones and help to further increase void space in the mix. The moisture content of the mixture should be approximately 10%, and the mix is placed in 6-inch lifts or layers and can be compacted to 95% of dry density, which is the level used under most heavy-duty concrete and asphalt pavings. The UHI-recommended depth for CU-Soil is between 24 and 36 inches. CU-Soil has been in existence for approximately 12 years. Some experts note concerns regarding whether it provides the best solution for stormwater management, as only 6% to 8% of the total structural soil volume is available for water capture and retention or for long-term tree health given that soil comprises only 20% of the mixture volume. The CU-Soil mixture should be adapted for local conditions, and increasing the clay loam content to increase the moisture-holding capacity of the mixture is advisable for Bernalillo County's desert conditions.

Another well-known structural soil mixture is commonly called "Amsterdam tree soil." It was developed in The Netherlands in the 1970s to address the decline of street trees there. The sand-based mixture is composed of medium-sized coarse sand (~.22 mm), washed to remove any salts or other particles, and 4% to 5% organic matter with 2% to 4% clay. As with the aggregate in the CU-Soil mix, the sand particles should relatively uniformly-sized. The installed depth should not exceed 40 inches and should be placed in lifts and compacted at 85 to 90 percent. A balance between the high compaction levels normally used for paving substrates and slightly lower levels that facilitate permeability has to be achieved. It is interesting to note that in Europe 85 to 90 percent levels are commonly used for streetscape paving schemes. Some experts state that sand mixes are superior to aggregate-based mixes in terms of stormwater management function, cost-effectiveness and for promoting tree health and growth.

Structural soil mixtures based on ESCS aggregate present another option. Called air-entrained soils by Henry Arnold, the landscape architect who originally developed them, ESCS is a ceramic material produced by firing shale, clay and slate until they expand and vitrify, creating a lightweight material with internal pore structures that allow it to absorb and then release water and air. Generally the mixture consists of 50% to 65% ESCS aggregate with 5% to 10% organic matter and topsoil, and 15% clay. Various versions of this type of soil mixture have been used over the last 20 years with positive results. Advantages of this type of structural soil include its ability to support heavy and continuous pedestrian traffic, and its high volumetric proportion of soil and organic matter relative to the amount of aggregate, which translates to greater stormwater management capacity and an increased growth medium for trees.

Appendix I. Recommended Watering Schedules

Water Guidelines: Established Plant

(Establishment usually takes one year for small plants, two years for large shrubs and three years for trees.

TREES	Mar-May	May-Oct	Oct-Dec	Dec-Mar	Watering Depth (every time you water)
Desert Adapted	14-30 days	7-14 days	14-30 days	30-60 days	24-36"
High Water Use	7-12 days	4-> 10 days	7-12 days	30-60 days	24-36"
SHRUBS					
Desert Adapted	14-30 days	7-21 days	14-30 days	30-60 days	18-24"
High Water Use	7-10 days	5-7 days	7-10 days	14-30 days	18-24"
GROUNDOVER/VINES					
Desert Adapted	14-30 days	7-21 days	14-30 days	30-60 days	8-12"
High Water Use	7-10 days	2-5 days	7-10 days	14-30 days	8-12"

The above schedules are guidelines because watering frequency depends upon current weather conditions, plant type, size, soil type and plant establishment.

Water at the outer edge of the plant's canopy and to the depth indicated above. Depending on emitter output and root depth, watering times are typically one or more hours. Less time means shallower water depth. Think about your emitter quantities—they measure the amount per hour.

It is important that you check your plants to see how they perform under this schedule and modify it according to their needs.

Compliance with the Bernalillo County Water Conservation Ordinance

Summary of Ordinance Requirements by Type of Development

Bernalillo County began implementing a new Water Conservation Ordinance (the ordinance) on October 1, 2010. In addition to outdoor watering and water waste restrictions that apply to everyone, the ordinance specifies conservation measures that must be incorporated into new construction, remodels and additions in the County. Water conservation measures include both interior fixtures and exterior site features. Checklists for Commercial/Large Multi-Family and Single Family and Small Multi-Family Development list required water conservation measures and options available to each type of development for meeting the ordinance requirements. Exemptions are allowed for specific situations and must be requested in an application to Bernalillo County.

Single Family and Small Multi-Family (2-7 dwelling units) Development can meet the ordinance requirements in one of three ways:

1. Completion of a Bernalillo County Water Conservation Worksheet. Printed copies of the Water Conservation Worksheet are available online and at the Zoning, Building and Planning Department, 111 Union Square SE, Suite 100. The Worksheet may be filled out on line at www.bernco.gov/water. For assistance, contact the Bernalillo County Public Works Division at 505-848-1500.
2. Build Green New Mexico Bronze Certification, www.buildgreennm.com.
3. Installation of EPA WaterSense Fixtures, www.epa.gov/WaterSense

In addition, the development must comply with the planting restrictions of the ordinance.

Final review for compliance with the ordinance will occur prior to Certificate of Occupancy. A pre-application meeting with Public Works staff is available prior to submitting plans for review, if desired. The applicant must verify compliance through inspection and approval by designated staff. Call 505-848-1500 to schedule an inspection by the Public Works Division as soon as all fixtures are installed. If the Build Green New Mexico Bronze Certification is the selected alternative, the final certification must be provided with your building permit application, with an independent verifier's name and address.

Commercial and Large Multi-Family Development can meet the ordinance requirements through a combination of indoor and outdoor measures. Indoor measures are noted on a Commercial Indoor Water Conservation Measures Worksheet. Outdoor water conservation measures are noted in a Commercial Outdoor Water Conservation Plan and Site Plan. Applicants may choose from among seven options to meet the ordinance requirements. In addition, all new development must comply with the planting restrictions of the ordinance.

The Commercial Indoor Water Conservation Measures Worksheet and the Commercial Outdoor Conservation Measures Worksheet may be filled out on line at www.bernco.gov/water. For assistance, contact the Bernalillo County Public Works Division at 505-848-1500.

You should thoroughly review the Bernalillo County Water Conservation Ordinance before starting development plans. The ordinance is available on the County Public Works Division web site: www.bernco.gov/upload/images/public_works/water/waterconservord.pdf.

Final review for compliance with the ordinance will occur when you apply for a building permit. However, to ensure that projects consider ordinance requirements from early planning stages, information about the water conservation features of your project should be provided at each level of plan review at the County. Generally, items to be reviewed are as summarized below. A pre-application meeting with Public Works staff is recommended prior to submitting plans for review, as early in the design process as possible.

Requirements by Application Type

Master Plan

Master Plan requirements will be discussed on a case by case basis.

Special Use Permit and Planned Development Area

A fully and properly completed Commercial Outdoor Water Conservation Plan and Site Plan will be required for a building permit. However, early discussions with staff are recommended to ensure that the development is designed from inception to comply with the ordinance. The following Special Use Permit submittals will be reviewed for compliance with the ordinance.

- Conceptual grading and drainage plan – will be reviewed for approach to water harvesting and use of water to irrigate landscape.
- Landscape and buffer landscaping plan – must indicate how proposed landscaping will comply with the water conservation plan criteria proposed for the development.
- Statement of responsibility for maintenance, addressing requirements of an Exterior Management Plan, if applicable.

Subdivision, Residential

A fully and properly completed Water Conservation Measures Worksheet, Build Green NM Bronze Certification form, or proof of EPA WaterSense fixtures will be required for a residential building permit. However, early discussions with staff are recommended to ensure that the subdivision is designed to take into account ordinance requirements for outdoor water conservation. The following submittal requirements will be reviewed for compliance with the ordinance.

1. Water supply information should describe how the water conservation alternatives in the Ordinance will be incorporated into the subdivision design to ensure an adequate water supply as required by the Bernalillo County Subdivision Ordinance.
2. Required plans and reports relating to grading, erosion control, and drainage must provide general indication of intent for water harvesting on individual lots, which will be reviewed at building permit.
3. If the subdivision includes common open space and/or park areas, the terrain management plan (drainage report) must indicate how the landscaping and water harvesting alternatives in the ordinance will be employed to reduce water use and also indicate maintenance responsibility for the common open space and/or park areas.
4. If applicable, the Statement of Restrictions of Record in the draft disclosure statement must include a statement making purchasers aware of Bernalillo County water conservation requirements and any commitments made as a condition of subdivision approval.

Subdivision, Non-Residential

A fully and properly completed Commercial Outdoor Water Conservation Plan and Site Plan will be required for a building permit. However, early discussions with staff are recommended to ensure that the subdivision is designed to take into account ordinance requirements. The following submittal requirements will be reviewed for compliance with the ordinance.

- Water supply information should describe how the water conservation alternatives in the Ordinance will be incorporated into the subdivision design to ensure an adequate water supply as required by the Bernalillo County Subdivision Ordinance.
- Terrain management plan (drainage report) must provide general indication of intent for water harvesting on individual lots, which will be reviewed at building permit.
- If the subdivision includes common open space and/or park areas, the terrain management plan (drainage report) must indicate how the landscaping and water harvesting alternatives in the ordinance will be employed to reduce water use and indicate maintenance responsibility for the common open space and/or park areas.
- If applicable, the Statement of Restrictions of Record in the draft disclosure statement must include a statement making purchasers aware of Bernalillo County water conservation requirements and any commitments made as a condition of subdivision approval.

Building Permit, Residential

A single family or small multi-family building permit application must include one of the following:

1. Completion of a Bernalillo County Water Conservation Worksheet may be filled out on line at www.bernco.gov/water. For assistance, contact the Bernalillo County Public Works Division at 505-848-1500.
2. Build Green New Mexico Bronze Certification, www.buildgreennm.com.
3. Installation of EPA WaterSense Fixtures, www.epa.gov/WaterSense

Before obtaining a Certificate of Occupancy, the developer/builder/homeowner must verify compliance by inspection and approval by designated staff. If the Build Green New Mexico Bronze Certification is the selected alternative, the certification must be provided, with an independent verifier's name and address.

Building Permit, Non-Residential

A commercial or large multi-family building permit application must include a fully and properly completed Commercial Indoor Water Conservation Measures Worksheet. The worksheet may be filled out on line at www.bernco.gov/water. For assistance, contact the Bernalillo County Public Works Division at 505-848-1500.

For outdoor use, the building permit application must include a fully and properly completed Commercial Outdoor Water Conservation Plan and Site Plan that includes the outdoor water conservation measures identified on the grading and drainage and landscaping plans. A checklist of alternatives is attached.

1. Grading and drainage plan must indicate any water harvesting on site and how the grading and drainage plan will direct water to landscape areas
2. Landscape plan, if required, must identify the measures to be used, including area calculations, planting materials, water supply and irrigation information as identified in the Commercial Outdoor Water Conservation Plan.

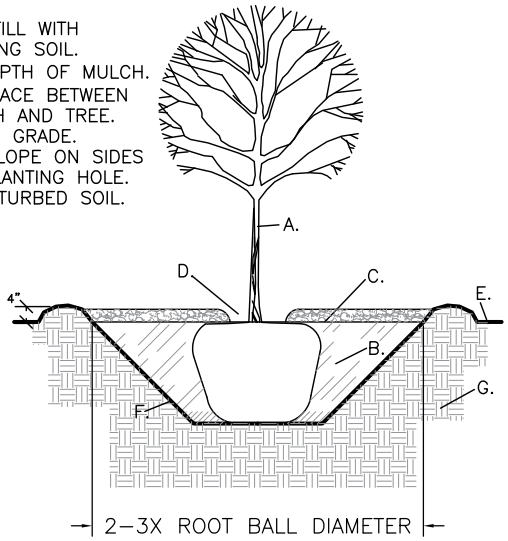
The following table indicates the required elements at each submittal that must address compliance with the ordinance.

	Required Element						
Type of Submittal	**Grading, drainage, erosion control and stormwater pollution prevention**	**Landscape and buffer landscape plan**	**Landscape Plan**	**Irrigation Plan**	**Site Plan**	**Floor Plan**	**Commercial Outdoor Water Conservation Plan**
Master Plan							
Special Use Permit/ Planned Development Area	As required by the County Storm Water Ordinance	X	May be required	May be required	X		
Subdivision	As required by the County Storm Water Ordinance						
Commercial and Large Multi-Family Building Permit	As required by the County Storm Water Ordinance		May be required	X	X	X	X
Single Family and Small Multi-Family Building Permit	As required by the County Storm Water Ordinance		Plant list and landscape and irrigation concept				

Appendix K. Plant and Turf Grass Installation Details

CONSTRUCTION NOTES:

A. TREE.
B. BACKFILL WITH EXISTING SOIL.
C. 3" DEPTH OF MULCH.
D. 4" SPACE BETWEEN MULCH AND TREE.
E. FINISH GRADE.
F. 1:1 SLOPE ON SIDES OF PLANTING HOLE.
G. UNDISTURBED SOIL.



GENERAL NOTES:

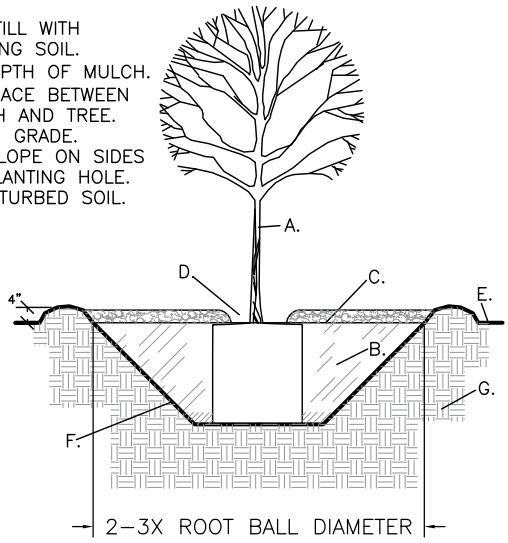
1. KEEP SOIL BELOW ROOT BALL UNDISTURBED TO PREVENT TREE FROM SETTLING.
2. REMOVE ANY EXCESS SOIL FROM TOP OF ROOTBALL TO EXPOSE ROOT FLARE (WHERE TOP MOST ROOT EMERGES FROM THE TRUNK). PLANT WITH ROOT FLARE LEVEL TO FINISH GRADE (OR 1"–2" HIGHER IN SLOWLY DRAINING SOIL).
3. TAMP SOIL FIRMLY AROUND BASE OF ROOTBALL WITH FOOT PRESSURE.
4. PRIOR TO BACKFILLING, REMOVE BURLAP, ROPE, TWINE, AND WIRE FROM ENTIRE ROOTBALL AND FROM PLANTING HOLE.
5. AT TIME OF PLANTING, ONLY PRUNE CO–DOMINANT LEADERS (DOES NOT APPLY TO MULTI–TRUNK SPECIMENS), CROSSOVER LIMBS, AND DEAD OR BROKEN BRANCHES.
6. DO NOT PLACE MULCH IN CONTACT WITH TREE, KEEP AT LEAST 4" AWAY FROM TRUNK.
7. AFTER PLANTING, THOROUGHLY WATER TO ELIMINATE AIR POCKETS.

TREE PLANTING, BALLED & BURLAP

NOT TO SCALE

CONSTRUCTION NOTES:

A. TREE.
B. BACKFILL WITH EXISTING SOIL.
C. 3" DEPTH OF MULCH.
D. 4" SPACE BETWEEN MULCH AND TREE.
E. FINISH GRADE.
F. 1:1 SLOPE ON SIDES OF PLANTING HOLE.
G. UNDISTURBED SOIL.



GENERAL NOTES:

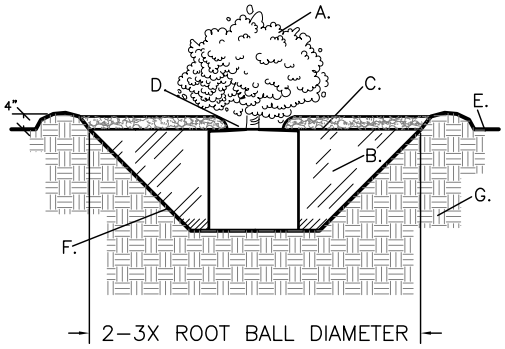
1. KEEP SOIL BELOW ROOT BALL UNDISTURBED TO PREVENT TREE FROM SETTLING.
2. REMOVE ANY EXCESS SOIL FROM TOP OF ROOTBALL TO EXPOSE ROOT FLARE (WHERE TOP MOST ROOT EMERGES FROM THE TRUNK). PLANT WITH ROOT FLARE LEVEL TO FINISH GRADE (OR 1"–2" HIGHER IN SLOWLY DRAINING SOIL).
3. REMOVE CONTAINER AND CUT ANY ROOTS THAT ARE CIRCLING THE CONTAINER.
4. TAMP SOIL FIRMLY AROUND BASE OF ROOTBALL WITH FOOT PRESSURE.
5. AT TIME OF PLANTING, ONLY PRUNE CO–DOMINANT LEADERS (DOES NOT APPLY TO MULTI–TRUNK SPECIMENS), CROSSOVER LIMBS, AND DEAD OR BROKEN BRANCHES.
6. DO NOT PLACE MULCH IN CONTACT WITH TREE, KEEP AT LEAST 4" AWAY FROM TRUNK.
7. AFTER PLANTING, THOROUGHLY WATER TO ELIMINATE AIR POCKETS.

TREE PLANTING, CONTAINER

NOT TO SCALE

CONSTRUCTION NOTES:

A. SHRUB.
B. BACKFILL WITH EXISTING SOIL.
C. 3" DEPTH OF MULCH.
D. 4" SPACE BETWEEN MULCH AND SHRUB.
E. FINISH GRADE.
F. 1:1 SLOPE ON SIDES OF PLANTING HOLE.
G. UNDISTURBED SOIL.



GENERAL NOTES:

1. KEEP SOIL BELOW ROOT BALL UNDISTURBED TO PREVENT TREE FROM SETTLING.
2. REMOVE ANY EXCESS SOIL FROM TOP OF ROOTBALL TO EXPOSE ROOT FLARE (WHERE TOP MOST ROOT EMERGES FROM THE TRUNK). PLANT WITH ROOT FLARE LEVEL TO FINISH GRADE (OR 1"-2" HIGHER IN SLOWLY DRAINING SOIL).
3. REMOVE CONTAINER AND CUT ANY ROOTS THAT ARE CIRCLING THE CONTAINER.
4. TAMP SOIL FIRMLY AROUND BASE OF ROOTBALL WITH FOOT PRESSURE.
5. AT TIME OF PLANTING, ONLY PRUNE DEAD OR BROKEN BRANCHES.
6. DO NOT PLACE MULCH IN CONTACT WITH SHRUB, KEEP AT LEAST 4" AWAY FROM TRUNK.
7. AFTER PLANTING, THOROUGHLY WATER TO ELIMINATE AIR POCKETS.

SHRUB PLANTING, CONTAINER

NOT TO SCALE

GENERAL NOTES:

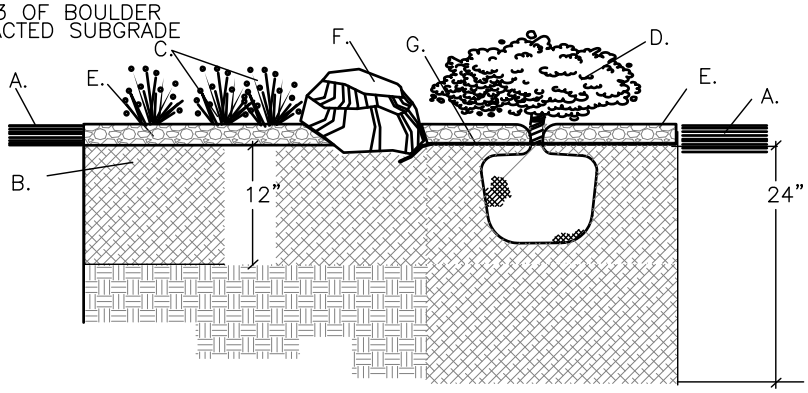
1. EXISTING SOIL WITHIN THE PLANTERS SHALL BE REMOVED AND REPLACED WITH THE SPECIFIED PLANTING SOIL MIXTURE,

SOIL MIXTURE:
60% CLEAN NATIVE SOIL
20% FINE SAND
20% ORGANIC MATERIALS
SEE SPECIFICATIONS.

2. BURY 1/3 OF BOULDER IN COMPACTED SUBGRADE

CONSTRUCTION NOTES:

A. SIDEWALK, DRIVEWAY, PLAZA, ETC.
B. PLANTING SOIL MIXTURE
C. PERENNIAL PLANTINGS
D. SHRUB PLANTINGS
E. 3" AVG. DEPTH OF MULCH
F. +12 CU. FT. LICHEN COVERED BOULDER
G. FILTER FABRIC OR WEED BARRIER



PERENNIAL & GROUNDCOVER PLANTING

NOT TO SCALE