

Pima County Transportation
and Flood Control District
Charles Huckelberry, Director

Guidelines
for the
Development
of Regional
Multiple-Use
Detention/Retention
Basins in
Pima County
Arizona

Prepared by:

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INTRODUCTION

INTRODUCTION

BACKGROUND:

The Pima County Department of Transportation and Flood Control District is currently evaluating the principal drainage basins within eastern Pima County. These studies will ultimately result in storm water management plans for each major drainage area.

In the context of these studies, the Pima County Flood Control District is considering the development of regional detention/retention facilities.

These basins, typically larger than 20 acres, would be developed and maintained by Pima County. The development of these regional basins may be funded in part by fees assessed to developers in lieu of the construction of smaller scale basins within individual development projects.

The Flood Control District recognizes that there is an opportunity to develop regional facilities that serve or accommodate uses other than flood control. This report has been developed to establish guidelines for the development of regional detention/retention basins for multiple use.

SCOPE OF GUIDELINES:

These guidelines have been developed as a tool to be used in the planning, programming, and design of regional, multiple use, detention/retention basins. These guidelines must be used in conjunction with appropriate hydrologic, hydraulic, and engineering design.

When applied to this data, these guidelines should enable the development of multiple use detention/retention basins that are not only functional storm water control facilities but also valued neighborhood amenities.

APPLICABILITY:

These are general guidelines to be applied to various, as yet unidentified, sites in Pima County. Their successful use will require the input of planning, design, and engineering professionals.

An effort has been made to develop guidelines that are appropriate for Pima County and the Tucson metropolitan area. Towards this end the specific physical, demographic, and social characteristics of eastern Pima County have been carefully considered. The resultant guidelines deal with conditions that are possible and likely to occur in Pima County.

ANTICIPATED USERS:

The principal users of these guidelines will be the staff of the Pima County Flood Control District and consultants working for the District on regional detention/retention basin projects. These guidelines, however, are intended to be of value and use to other groups. Included among these other groups are:

- The Pima County Parks and Recreation Department
- Pima County Planning and Development Services
- Neighborhood Groups and Homeowners Associations, and
- A variety of community organizations that could potentially use and benefit from regional basin development.

An attempt has been made to include herein, information that will be useful to each of these anticipated users.

UPDATES:

Very few multiple use, regional detention/retention basins have been constructed in Pima County. These guidelines have been prepared to aid in the initial development of basins of this type. To remain useful it is recommended that these guidelines be reviewed and updated after the construction of two or three such basins. A great deal can be learned from a review of the development process and from an evaluation of completed facilities. New and updated approaches can and should be incorporated into these guidelines so that they will continue to be a useful tool in the detention/retention basin development process.

DEFINITIONS:

Several terms are used within these guidelines to identify and describe different types of flood control basins. For purposes of this report these terms are defined as follows.

Detention Basin: A flood control facility that collects and detains storm water runoff, releasing it at a controlled rate.

Retention Basin: A flood control facility that collects and retains storm water runoff. The dissipation of collected water is accomplished by infiltration and evaporation.

Regional Basin: A detention or retention basin that collects storm water runoff from a large area, typically several hundred acres. Frequently the drainage area will include several development projects.

Regional basins fulfill the storm water management function of several smaller detention/retention basins within a drainage area.

Multiple Use Basin: A retention or detention basin that is designed to accommodate activities and uses in addition to flood control.

Infiltration Basin: A type of retention basin designed to dispose of storm water runoff through infiltration.

Recharge Basin: A type of detention or retention basin designed to recharge ground water aquifers with storm water runoff.

**CHARACTERISTICS
OF PIMA COUNTY**

CHARACTERISTICS OF PIMA COUNTY

INTRODUCTION:

This chapter provides an overview of the physical and demographic characteristics of Pima County. These characteristics create a unique set of conditions that are different from other states and other areas within Arizona. These conditions could influence multiple use, regional detention/retention basin development and must be considered in the planning and design process. The following is a summary of local conditions and their probable impact on basin development.

PHYSICAL CHARACTERISTICS:

Slopes and Topography:

Characteristics:

- Average Slope in County = 3%
- Average Slope in foothills areas = 10%
- The Tucson valley slopes from southeast to northwest at approximately 20' per mile.

Impacts on Basin Development:

- Stepped basins or basins with deep excavation at upper end may be necessary to achieve required capacity.

Geology and Soils: (See Illustration)

Characteristics:

- Depth to bedrock varies from 0-5' in foothill areas to much greater depths along major washes.
- Soils are typically thermic arid and torric.
- Soils fall into 5 major associations; Grabe-Gila-Pima, Anthony-Sonoita, Mohave-Tres Hermanos-Anway, Pinaleno-Nickel-Palos Verdes, and Rillino-Latene-Cave.
- Soil conditions in the Tucson valley are fairly homogeneous.

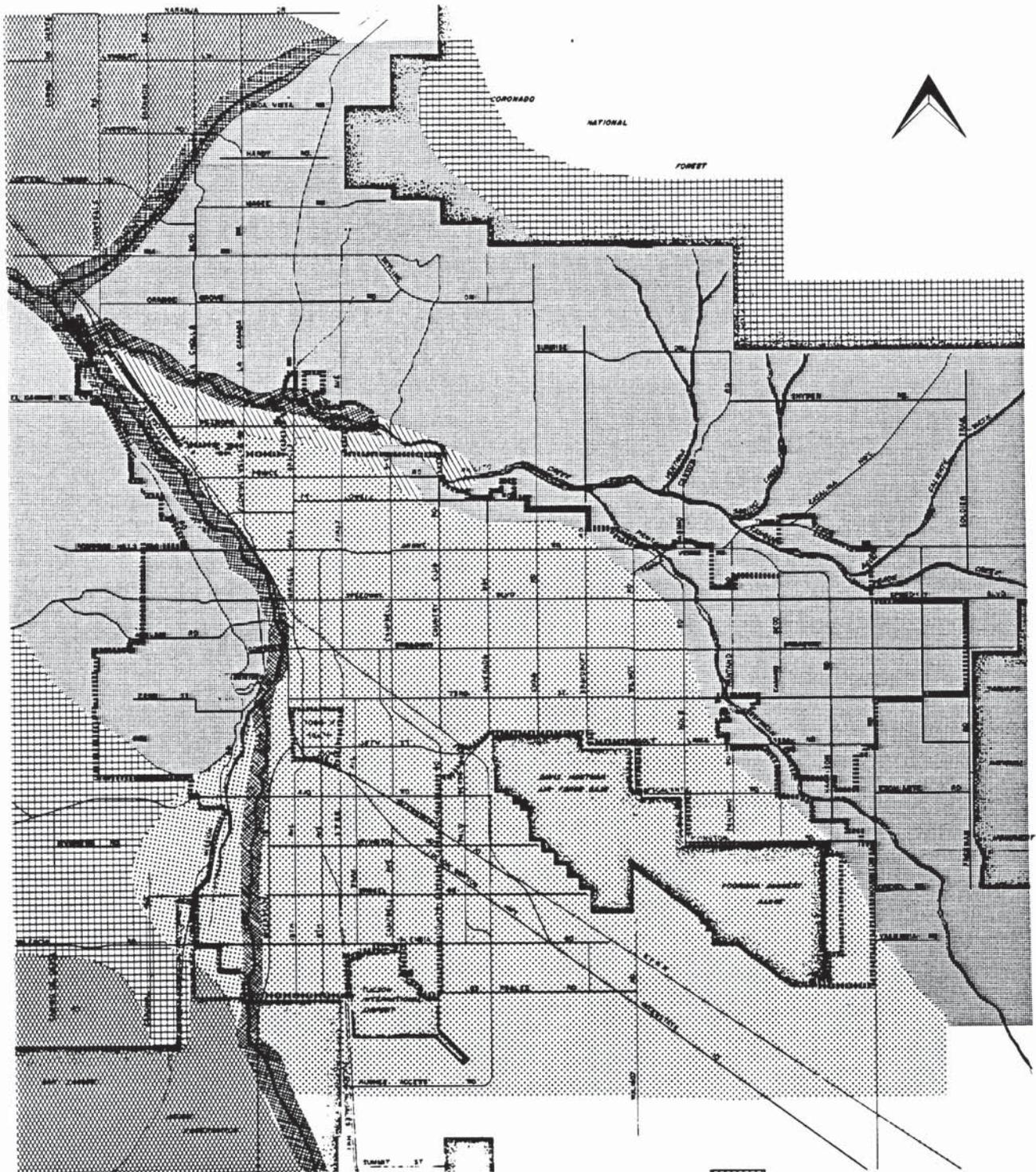
Impact on Basin Development:

- Soil depth and soil characteristics are typically suitable for detention/retention basin development.

Drainage Patterns: (See Illustration)

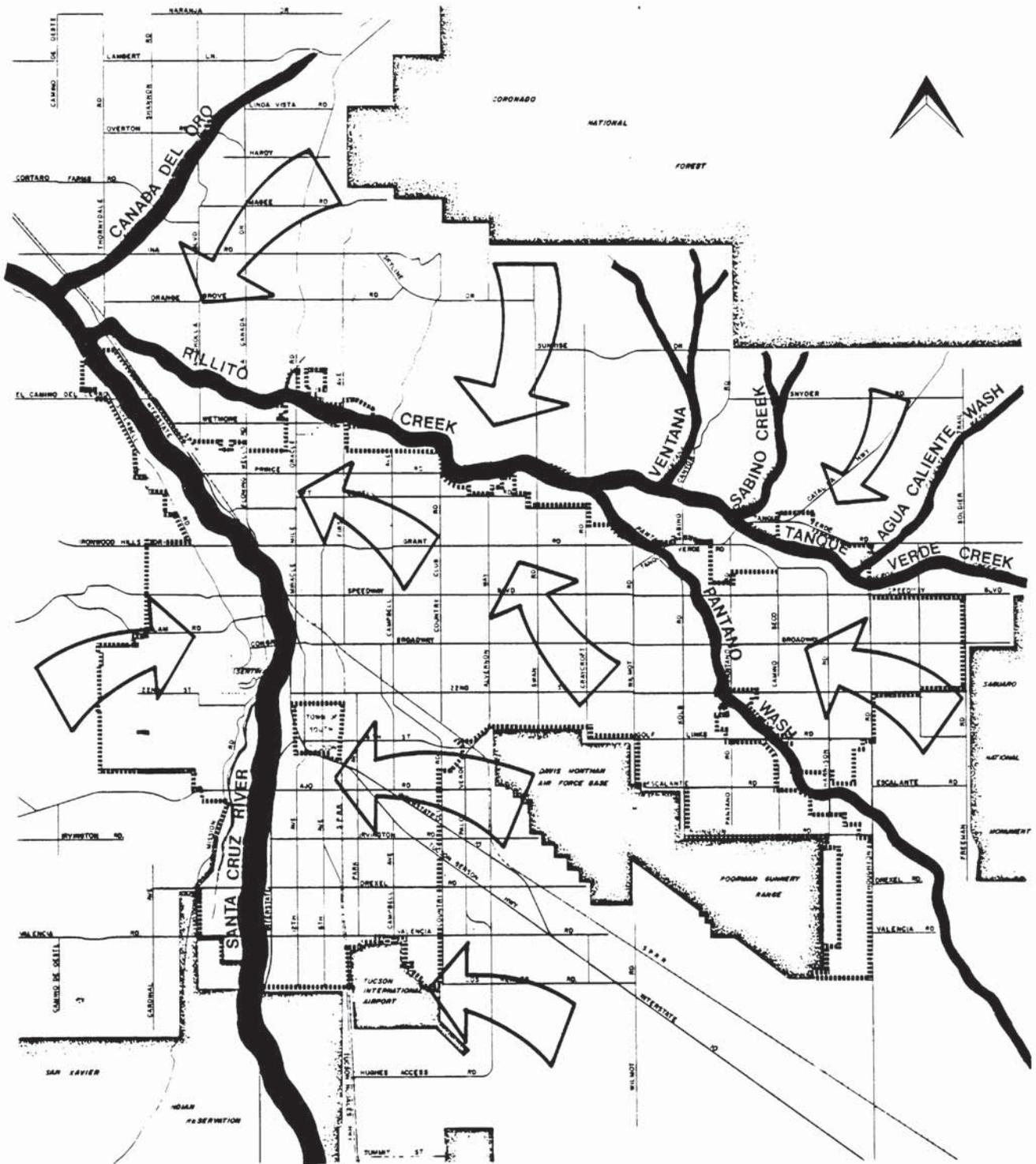
Characteristics:

- The principal drainage channel is the Santa Cruz River, which collects runoff from much of the City of Tucson and from the east slopes of the Tucson Mountains.
- The Rillito River is a major tributary, collecting runoff from the south slopes of the Catalina Mountains.



-  RILLINO-LATENE-CAVE
-  PINALENO-NICKEL-PALOS VERDES
-  GRABE-GILA-PIMA
-  ANTHONY-SONOITA
-  ROCK OUTCROP-LAMPSHIRE-CELLAR
-  MOJAVE-TRES HERMANOS-ANWAY

Soils



Drainage

-  DRAINAGE CHANNELS
-  DIRECTION OF DRAINAGE

- The Canada del Oro Wash is a major tributary, collecting runoff from the west slopes of the Catalina Mountains.
- The Pantano Wash is a major tributary, collecting runoff from the east side of the Rincon Mountains and flows into the Rillito.
- Much of eastern Pima County is covered by a braided network of washes and small channels.

Impact on Basin Development:

- The siting and configuration of regional detention/retention basins will be influenced by the availability of suitable land adjacent to major or tributary washes.

Ground Water: (See Illustration)

Characteristics:

- Ground water is currently being withdrawn at twice the rate of replenishment.
- Aquifer recharge occurs most extensively along streambeds, along mountain fronts, and through alluvial fans.
- Recharge is greatest where stream channels are underlain by deposits of coarse sand and gravel.
- Depth to ground water varies from 75-100' along major washes to several hundred feet in other locations.

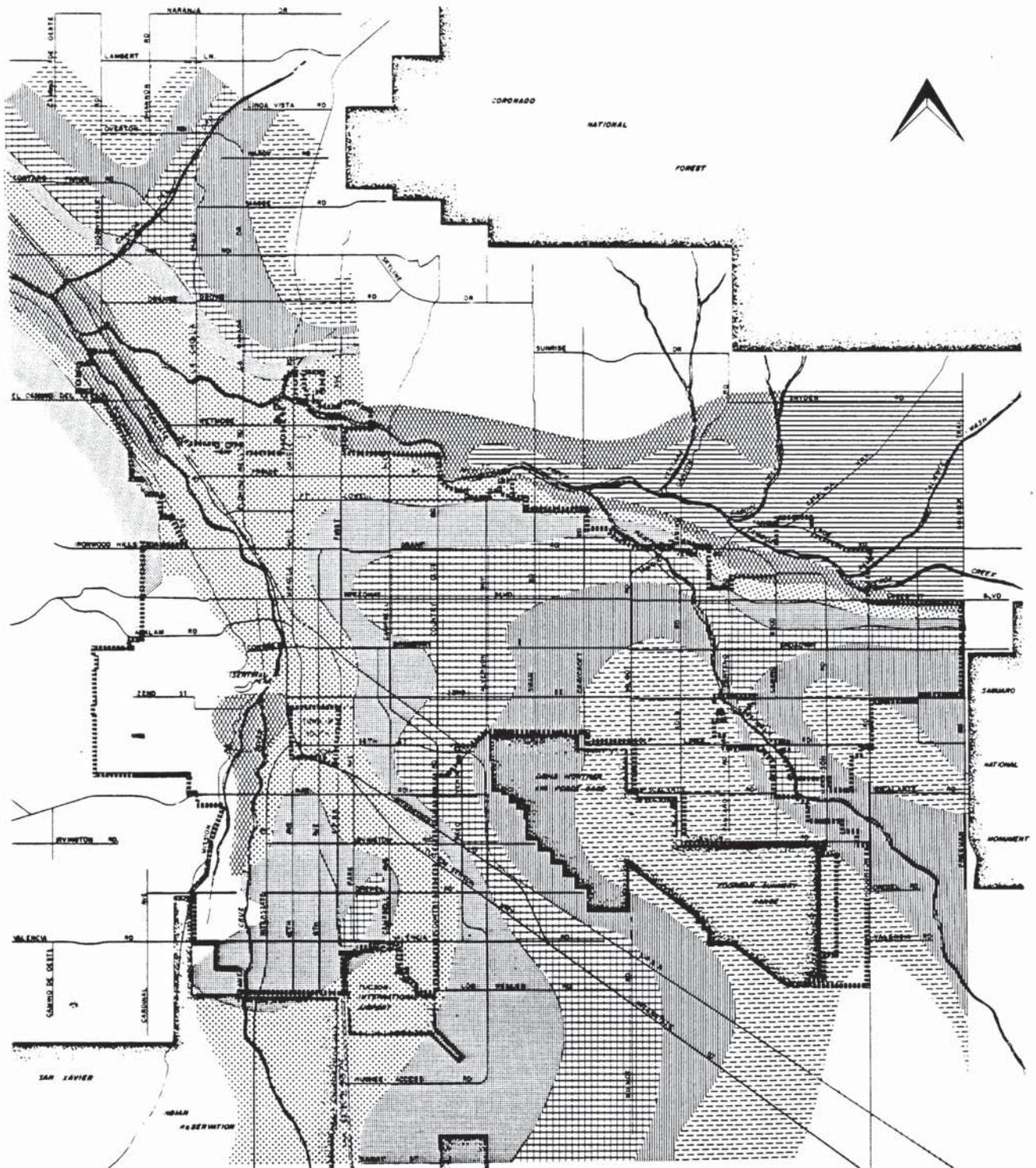
Impact on Basin Development:

- There are opportunities for achieving ground water recharge with basins. A model recharge basin should be developed and the impact of urban runoff on ground water quality monitored.
- Soil conditions and depth to ground water will determine if a basin site is appropriate for ground water recharge.

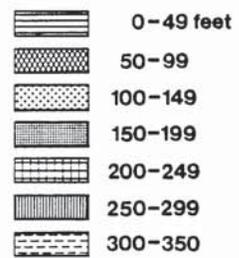
Precipitation:

Characteristics:

- 55% of the precipitation occurs between July and September.
- Summer precipitation is derived from intense intermittent storms which cover a small area.
- 28% of the precipitation occurs between December and March.
- Winter precipitation results from large cyclonic storms and are characterized by gentle rainfall over large areas.
- Severe flooding occurs most frequently in early autumn when tropical storms become stalled over the area.



Depth to Water



Impact on Basin Development:

- Most basins will be dry for the greatest part of the year.
- Intense storms have potential to fill basins in a very short period of time.

Vegetation: (See Illustration)

Characteristics:

- Four plant communities characterize the native vegetation in eastern Pima County. These communities are:
 - Palo Verde-Saguaro Community
 - Creosote Community
 - Saltbush Community
 - Riparian Community
- Most non-urbanized areas within the County have a native plant cover that effectively checks soil erosion.
- Much of the native riparian plant community has been destroyed. Only small areas remain in the county.
- Plants are indicators of soil and climatic conditions.

Impact on Basin Development:

- Native species should be utilized in revegetation of basin sites, where appropriate, to integrate basins into surrounding environment.
- Native riparian plant communities should be maintained wherever possible.
- Vegetation in heavily urbanized areas provides physical and psychological relief.

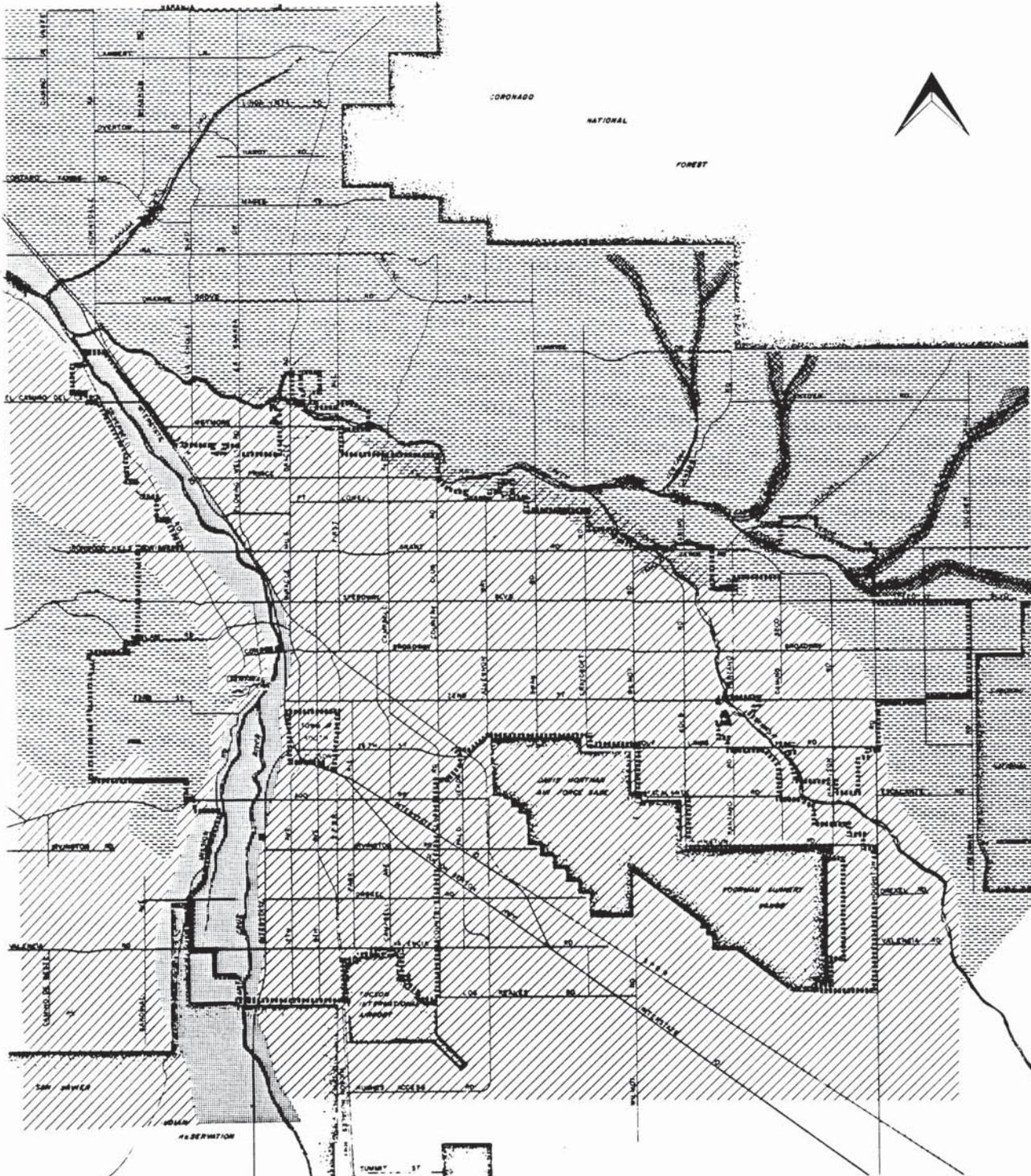
Urban Development:

Characteristics:

- Urban development now covers much of Eastern Pima County.
- Rapid urbanization is projected to continue for the next several decades.
- Increased urbanization increases the impermeable surface areas.
- Average annual runoff is estimated to be four times as much as that of a comparable undeveloped desert area and may be ten times as much in some individual years.

Impact on Basin Development:

- Increased urbanization increases the need for detention/retention basins.
- Detention/retention basins are necessary to reduce downstream flooding.
- Land for large scale regional basins will become less available as additional urban development occurs.



-  CREOSOTE
-  PALOVERDE-SAGUARO
-  SALT BUSH
-  RIPARIAN

Vegetation

DEMOGRAPHIC CHARACTERISTICS:

Population:

Characteristics:

- 1980 Population of Pima County = 531,443.
- 1985 Population of Pima County (estimated) = 602,109.
- 2000 Population of Pima County (projected) = 935,900.

Impact on Basin Development:

- Increased urban development will occur in conjunction with population growth resulting in increased storm water runoff.
- Increased urbanization and runoff will necessitate the development of flood control facilities including detention/retention basins.

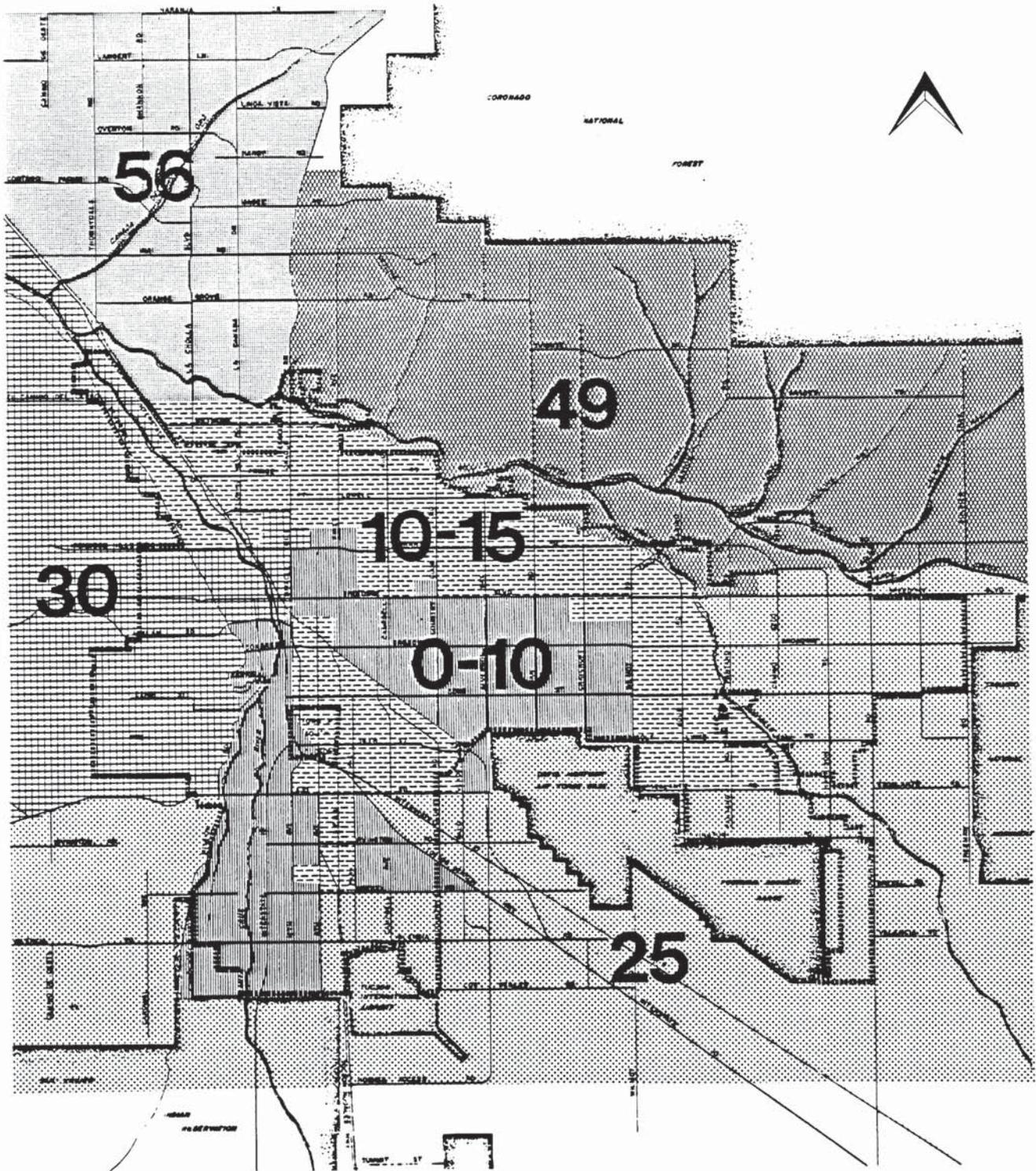
Population Growth by Regions: (See Illustration)

Characteristics:

- Population growth within sub regions of the Tucson metropolitan area between 1975 and 1985 has been as follows:
 - Northwest: +56%
 - North/Northeast: +49%
 - West: +30%
 - Southwest: +25%
 - Central Areas: 0 to +10%

Impact on Basin Development:

- Increased urban development and runoff in nearly all parts of the Tucson metropolitan area will result in a need for additional detention/retention basins for flood control.



Population

0-10 PERCENT INCREASE IN POPULATION SINCE 1975

LAND USE AND OPEN SPACE CHARACTERISTICS:

Land Use:

Characteristics:

- Single Family Residential use is the predominant land use in the Tucson Metropolitan area.
- The trend in the future will be toward higher density development.
- Dispersed development in the Tucson Metropolitan area during the past several decades resulted in significant tracts of land that appeared to be 'open space'.
- In-fill development is now occurring and eliminating these 'open spaces'.

Impact on Basin Development:

- Land for the development of regional detention/retention basin sites is becoming less available.
- The need for open space, such as that provided by regional detention/retention sites is increasing.

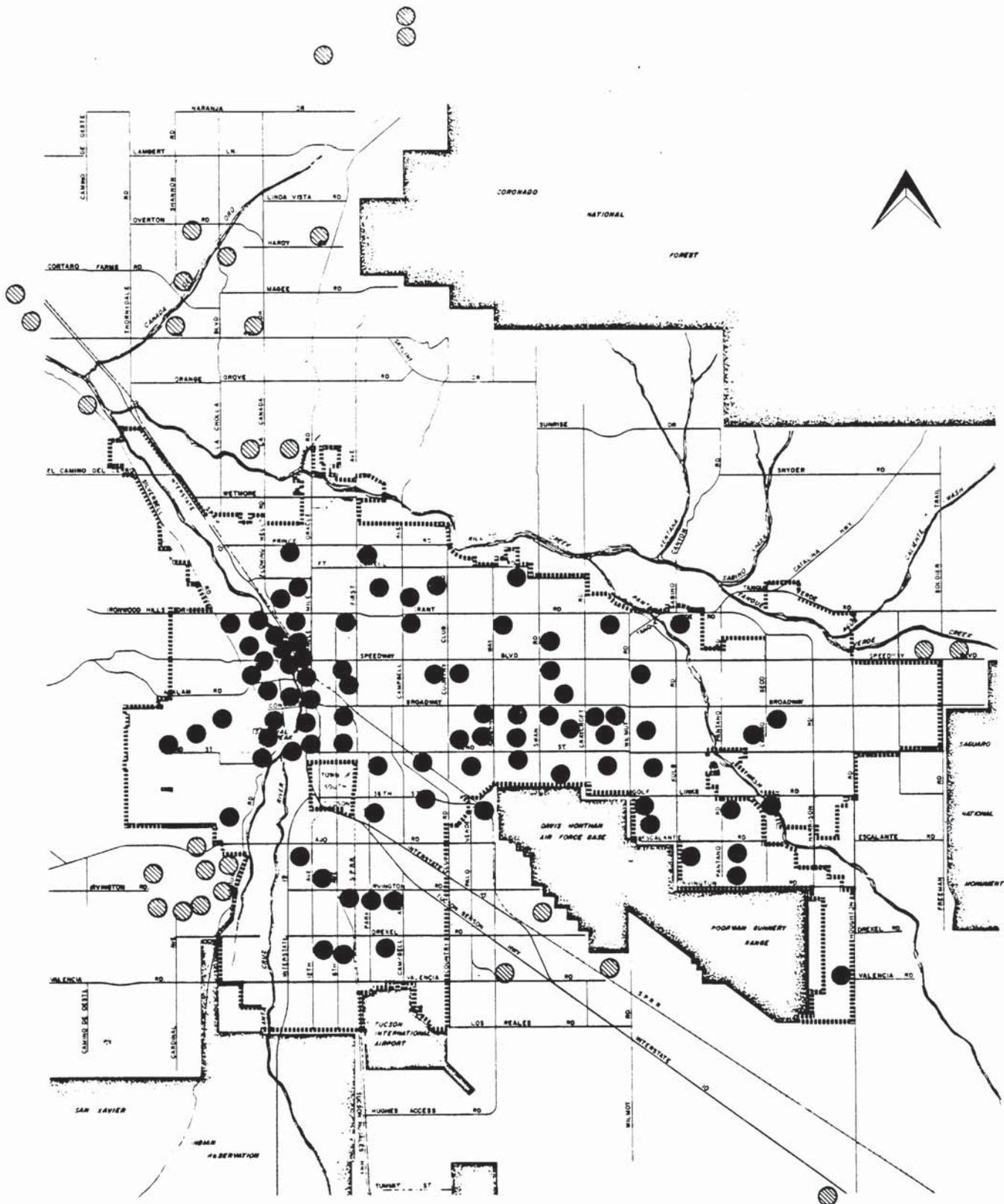
Parks and Open Space: (See Illustration)

Characteristics:

- City and County parks constitute most of the public open space within the Tucson Metropolitan area.
- The City of Tucson and Pima County park systems encompass approximately 5200 acres (excluding Tucson Mountain Park, Old Tucson, and the Desert Museum).
- The greatest number of developed parks are located in areas with the lowest population growth.
- In the past, park land acquisition and development increased with the population growth.
- Current population growth in outlying areas, combined with budget cuts, have severely limited the Parks Department's ability to meet recreation demands in these areas.

Impact on Basin Development:

- Development of regional detention/retention basins as recreation sites can help meet some of the increasing demand for recreation facilities in Pima County.



Parks and Recreation Facilities

- CITY PARK
- ▨ COUNTY PARK

MULTIPLE-USE CONCEPT

MULTIPLE USE OF DETENTION/RETENTION BASINS

INTRODUCTION:

Pima County's rapid growth has created needs and demands of every type, including the need for improved flood control facilities. Urban expansion has resulted in increased volumes of stormwater runoff. This has significantly increased the hazard of downstream flooding.

The Pima County Floodplain Management Ordinance, enacted in 1974, includes requirements for detention/retention basins to reduce stormwater runoff peak flows. In the past, the primary, if not exclusive, function of detention/retention basins was flood control. Recently ideas regarding the dual and multiple use of these basins have come to light. Pima County is now actively considering the combined uses of flood control and ground water recharge. Intergovernmental plans for a demonstration project at the confluence of the Alamo Wash and Rillito River are being developed. In addition to flood control and ground water recharge, the Flood Control District is considering other potential uses of detention/retention basin sites.

FLOOD CONTROL DISTRICT GOALS:

The Pima County Flood Control District has identified eight specific goals which relate to the health, safety, and welfare of the community-at-large. These goals include; the integration of recreation and flood control, the protection and preservation of natural flood storage areas, and the preservation of unique riverine environments. The multiple-use concept for detention/retention basins is consistent with, and will help achieve, realization of these goals.

RATIONALE:

The rationale for multiple-use detention/retention basin development includes decreased costs and increased community acceptance. The combination of flood water storage and other community facilities on a single site significantly decreases total costs for land acquisition and site development. These savings will allow for the construction of a greater number of more fully developed public facilities.

The development of detention/retention basins as parks or urban green space increases their acceptance by area residents. A basin that resembles an abandoned sand and gravel pit may not be accepted by the community even though it is necessary for flood control. One that is developed as a visually attractive "park", however, will likely be considered a neighborhood amenity.

On a county wide basis, development has had a negative impact on the visual character of our community. Residential development, shopping malls, and industrial parks have replaced the natural, undulating desert ambiance. Multiple-use detention/retention basins that are also open green spaces can help mitigate this negative aspect of urban growth.

COMPATIBILITY; FLOOD CONTROL AND OTHER USES:

Flood control functions and other uses in detention/retention basins are generally compatible. If appropriately designed, use conflict is a minor concern. Flooding of detention/retention basins will typically occur during and immediately following local storm events. These are generally periods when people are least likely to engage in outdoor activities. During the balance of the year flooding will not be a problem and these public spaces can be used for other purposes.

POTENTIAL USES:

Uses appropriate for Pima County detention/retention basins include the broad categories of:

- active recreation
- passive recreation
- water based recreation
- wildlife habitat
- native plant communities/preserved 'desert zones'
- urban green space
- water harvesting and/or recharge
- nursery/research
- environmental art

Uses of detention/retention basins should be determined before the basin is designed. Uses that address specific community needs should be incorporated whenever possible.

In terms of spatial needs, uses fall within the spectrum of specific to non-specific. Specific configurations are necessary for some uses. Other activities can be conducted in a wide variety of spaces. Spatial characteristics which can influence potential uses include; linearity, size, openness, steepness, cover, etc.

Selected uses should also reflect the age and abilities of the potential users; infants, toddlers, children, teens, adults, and the elderly. An assessment should be made of the age distribution and the nature of special populations within the area.

DESCRIPTION OF POTENTIAL USES:

The following is a more detailed look at use categories appropriate for Pima County detention/retention facilities. Included is a description of each general category. This is followed by a list of specific uses and activities that fall within that category.

The specific uses and activities noted are appropriate for regional scale detention/retention basins. Many are also appropriate for small, project scale basins. Those appropriate for small basins have been identified.

Also provided with each major use category is an outline of design requirements. These requirements are quite broad and must be evaluated in conjunction with the opportunities and constraints at each site. Programmed uses, basin configuration, and site surroundings must be considered.

A list of agencies and groups that may be involved for a specific use is included under each category. Additional organizations and groups should be added as appropriate.

ACTIVE RECREATION



INTRODUCTION:

Active recreation includes a wide range of organized and unstructured activities that involve some type of physical movement.

The Pima County 1983 Outdoor Recreation Needs Assessment lists a number of recreational facilities which are needed in the community. Regional detention/retention basins, because of their size, will provide opportunities for many large scale recreational developments. Active recreation is for both individuals and groups and generally requires larger areas than passive recreation.

ACTIVITIES AND USES:

- fly kite (s)
- swimming pool (s)
- climb (s)
- swing (s)
- slide (s)
- jump-rope/hopscotch (s)
- parcourse/work-out (s)**
- equestrian activities **
- skateboard (s)
- climb/roll down a hill (s)
- rollerskate (s)
- ride bike (s)**
- jog (s)**
- walk dog (s)**
- field sports *
- basketball (s)*
- frisbee (s)
- lawn bowl (s)*
- volleyball (s)*
- croquet (s)*
- boccee (s)*
- handball (s)*
- racketball (s)*
- badmitton (s)*
- horseshoe (s)*
- tennis (s)*
- archery (s)*
- outdoor concerts (s)*
- campsite *
- shuffleboard (s)*
- wrestle (s)
- driving range *
- mini-golf
- target shooting **
- trail biking **
- off-road vehicles **
- ultra-light landing strip **

(s) appropriate for small basins
* non-linear spatial need
** linear spatial need

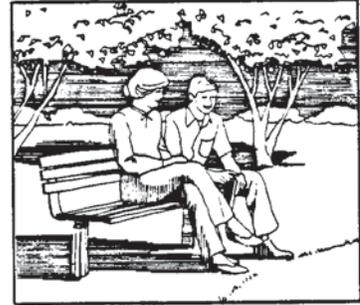
GENERAL DESIGN REQUIREMENTS:

- Provide adequate space, orientation and surface covers for selected recreation uses
- Site to minimize conflict with neighborhood and/or other programmed uses when appropriate
- Group like activities together (ie. active and group, passive and individual)
- Consider multiple use of linear activities which do not conflict (ie. inundation v. no inundation)
- Use berming and grading when appropriate to separate conflicting uses
- Provide adequate lighting and parking
- Control pedestrian access and travel throughout the site by clearly defined and maintained trails which accommodate walkers and bicyclers
- Provide sun and wind protection: use shrubs and trees planted in groups near trails or picnic areas
- Provide an aesthetically pleasing environment by screening parking areas, maintenance buildings and facilities with vegetation and/or landforms
- Link on-site trails with existing trails that extend off-site into neighboring residential areas, natural areas or bike paths
- Provide an interesting trail experience by having trail meander through areas of dense plantings and through open areas with longer views

AGENCIES OR GROUPS INVOLVED IN PLANNING FOR THIS ACTIVITY:

- Arizona Outdoor Recreation Coordination Committee
- State Parks Board
- County Parks and Recreation
- County Planning and Development Services
- Recreational associations (leagues)
- Concessionaire
- School Districts

PASSIVE RECREATION



INTRODUCTION:

Passive recreation generally involves individuals or small groups and a minimal amount of physical activity. Typically, passive recreation does not require large open spaces. Variations in spatial character, however, can enhance the appropriateness of an area for a specific passive recreational activity.

Passive recreational activities are appropriate for both large and small scale basins.

ACTIVITIES AND USES:

- sunbathe (s)
 - sit (s)
 - listen (s)
 - write (s)
 - art (s)
 - talk (s)
 - play board/card game (s)
 - play instrument (s)
 - look/watch (s)
 - listen to concert/music (s)
 - listen to speech (s)
 - nap (s)
 - daydream (s)
 - picnic (s)
 - nature study (s)
 - star gazing (s)
 - meditation (s)
 - gardening (s)
- (s) suitable for small basins

GENERAL DESIGN REQUIREMENTS:

- Provide adequate space, orientation and surface covers for selected recreation uses
- Site to minimize conflict with neighborhood and/or other programmed uses
- Group like activities together
- Consider multiple use of linear activities which do not conflict
- Use appropriate vegetation depending on location within basin (ie. inundation v. no inundation)

- Use berming and grading to separate conflicting uses
- Provide adequate lighting and parking
- Control pedestrian access and travel throughout the site by clearly defined and maintained trails which accommodate walkers and bicyclers
- Provide sun and wind protection, use shrubs and trees planted in groups near trails or picnic areas
- Screen parking areas, maintenance buildings and facilities with vegetation and/or landforms
- Link on-site trails with existing trails that extend off-site into neighboring residential areas, natural areas, or bike paths
- Provide adequate seating throughout basin - comfortable, variety of locations, orientations
- Provide numerous shaded areas
- Provide seating and tables, some with playing boards
- Provide for privacy and solitude by using vegetation to screen

AGENCIES OR GROUPS INVOLVED IN PLANNING FOR THIS ACTIVITY:

- Arizona Outdoor Recreation Coordination Committee
- Arizona State Parks Board
- Pima County Parks and Recreation
- Pima County Planning and Development Services
- Recreational associations (leagues)
- Concessionaire
- School Districts

WATER BASED RECREATION



INTRODUCTION:

Water based recreation includes those activities that are conducted in or around a permanent body of water.

Water based recreation is in high demand in Pima County. Water features can provide physical and psychological relief from the hot desert environment. In the public setting, permanent water features provide an opportunity to use a scarce resource for maximum public benefit.

There are three types of water based recreational facilities that might be developed at Pima County detention/retention basins. They include;

- swimming pools and fountains
- permanent lakes and ponds that have a source of water to augment stormwater runoff
- Wetlands or temporary lakes and ponds which have water only during and immediately following rainy seasons

Any of these three types might be appropriate for specific sites in Pima County.

Three principal concerns related to the development of permanent water features include; consumptive water use, maintenance, and safety. These issues must be addressed in the development of any permanent water feature.

ACTIVITIES AND USES:

- swimming pool (s)
- viewing (s)
- listening (s)
- cooling (s)
- fishing (s)
- boating (Paddle, canoe, sailing, sail-surfing, rowing)
- model boating (s)
- duck feeding (s)
- wildlife habitat (see wildlife section) (s)
- wading (s)

(s) suitable for small basins

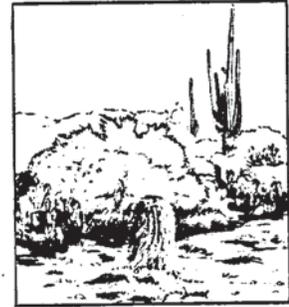
GENERAL DESIGN REQUIREMENTS:

- Create interesting, varied shoreline
- Install sensitively designed dock structures (where appropriate)
- Create aesthetic yet maintainable 'edges'
- Provide adequate entrance and exit for wildlife
- Provide adequate cover for wildlife
- Provide wildlife viewing areas for public
- Provide linkages with other appropriate uses
- Water within 8 to 10 feet of shoreline should not exceed two feet in depth
- Aeration should be maintained within acceptable ranges by using fountains, jets, cascades, or pumps
- Bottom material should be appropriate for type of programmed useage (chemical, plastic, etc.)

AGENCIES OR GROUPS INVOLVED IN PLANNING FOR THIS ACTIVITY:

- Arizona Water Commission
- Arizona Water Quality Council
- Arizona Game and Fish Commission
- Arizona Outdoor Recreation Coordination Committee
- Arizona State Parks Board
- Arizona Groundwater Management Study Commission
- Arizona Department of Water Resources
- Pima County Parks and Recreation
- Pima County Planning and Development Services

NATIVE PLANT COMMUNITIES



INTRODUCTION:

Preserved native plant communities or desert zones will help maintain the Sonoran Desert character of eastern Pima County. Preserved or reestablished stands of native vegetation even in relatively small areas, will help to offset the impacts of urban development. Native plant communities, preserved or reestablished, are an appropriate "use" at regional detention/retention basin sites.

GENERAL DESIGN REQUIREMENTS:

- Maintain as much natural integrity of the site as possible
- Minimize disturbance during construction
- Minimize number of roads transecting the site
- Allow maximum linkage of on-site plant communities with any existing native plant communities adjacent to the site
- If natural drainage exists, minimize disturbance to and loss of native riparian trees
- Restrict vegetation maintenance to that necessary for roadway and facility maintenance
- Control motor vehicle access
- Provide public parking at periphery of the site
- Maintain a well defined trail system for recreational uses to prevent random travel through the site
- Provide educational information regarding native plant communities (signage, pamphlets)
- If revegetating, use native plant species similar to pre-existing conditions
- Provide seating where appropriate within or on edge of area

AGENCIES OR GROUPS INVOLVED IN PLANNING FOR THIS USE:

- Arizona State Parks Board
- Pima County Parks and Recreation
- Pima County Planning and Development Services
- Research Institutions
- Botanical Gardens and Horticulture Groups



INTRODUCTION:

Urban wildlife has recently been shown to be of great benefit to the population of growing cities. Almost any area with vegetation will attract some wildlife species. The goal of this particular use is to provide an appropriate environment to lure and maintain a mix of desirable species. Diverse wildlife must be provided with food, water, escape cover and the appropriate spatial configuration. As well as attracting the species, opportunities for observation must be provided in areas which will not disturb the inhabitants.

GENERAL DESIGN REQUIREMENTS:

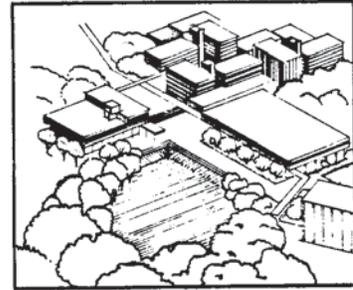
- Provide a diverse predominantly native plant community to encourage use of the site by native wildlife
- Preserve as many trees, shrubs and ground cover plants existing on-site prior to construction as possible
- Diversity of plant form and species should be encouraged
- Multi-layered diverse species are more stable and attract more wildlife than monocultures of tall trees or grasses.
- Select species mix native to the area
- Prevent pollution and overenrichment of water bodies being used by wildlife
- Make water more available to wildlife by planting shrubby plants and ground cover adjacent to its edge - this will furnish escape cover
- Prohibit free roaming dogs
- Control human use of the area by having a clearly defined trail system which leads people through areas least likely to disturb wildlife
- Trails should provide a variety of opportunities for viewing wildlife (access to high points at the edge of ponds or channels)
- Do not surround bodies of water by a trail, some water edge should be inaccessible to humans
- Provide islands in water bodies for nesting and refuge

- Provide adequate entry and exit points
- Have a water control structure to allow change in water levels
- Pond should have gently sloping edges (3:1 maximum) to three feet in depth, leveling off and extending for several feet before getting deeper - this will encourage the growth of emergent vegetation providing food and habitat for waterfowl and a variety of reptiles and amphibians
- Provide continuous vegetated corridors across the site which connect with vegetated areas off-site
- Link the vegetation corridors with water bodies on and off-site
- Keep roads to periphery of site
- Provide adequate buffer strips of vegetation between roads and ponds/lakes
- Leave some dead plants standing or fallen on the ground
- Provide rocks and boulders for wildlife to rest upon, where appropriate
- Select species types for enhancement of wildlife. Provide foliage height diversity, group plantings in aesthetic arrangements, and provide various levels of shading.

AGENCIES OR GROUPS INVOLVED IN PLANNING FOR THIS ACTIVITY:

- Arizona Game and Fish Commission
- Pima County Parks and Recreation
- Pima County Planning and Development Services
- Audobon Society
- Arizona Wildlife Federation
- Educational/Research Institutions

URBAN GREEN SPACE



INTRODUCTION:

Urban green space provides a visual resource within the community. An amenity that may not be physically 'used' but one that provides numerous psychological benefits.

As the city develops, urban green space will become more and more valuable. Green spaces provide refreshing visual breaks from the built environment. The vegetation also works as a filter, cleansing the air we breath. It reduces erosion by slowing the impact of rain and holding the soil together with it's roots. It may be useful as a buffer to screen unsightly views and as a means of orienting and directing pedestrian flow.

Urban green space in detention/retention basins has the potential to be a multi-faceted amenity, solving functional, aesthetic and environmental problems simultaneously. It will most likely be one of the most enjoyed of the suggested basin uses.

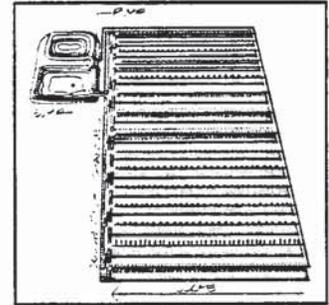
GENERAL DESIGN REQUIREMENTS:

- Provide a variety of shapes, sizes and locations
- Provide a variety of visual sequences, both from within the site (if access is allowed) and from outside the basin
- Plant with native or low maintenance vegetation appropriate to the location and other programmed uses (if any)
- Plants should include a variety of types, species and sizes for interest, color, etc.
- Provide shaded and unshaded seating niches to view open areas
- If basin is deep (over 5 feet), planted terraces are imperative so the vegetation will be seen from off site
- Provide trail system (if access is allowed) to meander through open space

AGENCIES OR GROUPS INVOLVED IN PLANNING FOR THIS ACTIVITY:

- Pima County Parks and Recreation
- Pima County Planning and Development Services
- Pima County Urban Design Commission

WATER HARVESTING AND RECHARGE



INTRODUCTION:

Water harvesting requires three components: collection, storage and dispersion. Its uses are many: providing water for on-site landscape irrigation use, as a component of a research project, or as a striking portion of an environmental art piece. Harvesting water on-site will need special study to design systems compatible with the primary use of the basin, flood control.

Groundwater recharge is a use already being considered by Pima County. Generally, multiple shallow basins or 'zig-zag' configurations have been suggested. Maximizing surface area contact between water and soil is imperative. This use has numerous benefits to augment ground water and could provide for passive, water-based recreational activities.

Although both water harvesting and groundwater recharge will necessitate more detailed planning to mitigate potential siltation problems, both uses are appropriate for detention/retention basin sites.

GENERAL DESIGN REQUIREMENTS:

WATER HARVESTING:

- Treat soil to increase impermeability (parafin, sodium chloride, etc.)
- Grading of site should optimize runoff to storage facility
- Provide storage facility - above or below ground
- If pond storage, utilize evaporation control mechanism
- Large basin area, single or multiple, minimum 10 acres

RECHARGE

- Settling basins to filter out suspended sediments
- Provide berms placed parallel and perpendicular to flow, to slow and increase contact with soil surface or utilize linear basins with ratio of 1:3 (width to length)
- Provide visual and trail linkages to promote passive water use
- Utilize 'non-barriers' when needed (ie. vegetative buffer, ha,ha's, etc.)
- Design basins to decrease impermeability.

AGENCIES OR GROUPS INVOLVED IN PLANNING FOR THIS ACTIVITY:

- Arizona Water Commission
- Arizona Water Quality Council
- Arizona Department of Water Resources
- Arizona Groundwater Management Study Commission
- Pima County Parks and Recreation
- Pima County Planning and Development Services
- Education/Research Institutions

NURSERY AND RESEARCH SITES



INTRODUCTION:

Detention/retention basins developed as nurseries could provide space for propagation and growing of plant materials for various County agencies. These nurseries could be designed for permanent or temporary use. In either case adequate access control must be provided to minimize theft and vandalism.

Nurseries might also be developed with demonstration areas for; erosion control, edible landscaping, and drought tolerant planting design.

In terms of research, detention/retention basins would be appropriate for a wide variety of non-consumptive research projects. Non-consumptive research projects are those that monitor and document rather than those which actively "take" from the site. Testing of new plant strains for drought tolerance, hardiness, and rate of growth would be an example of non-consumptive research.

Research could be coordinated by; County agencies, educational institutions, extension services, or other local groups.

Both nurseries and research sites, if sensitively planned could contribute to the area both aesthetically and educationally.

GENERAL DESIGN REQUIREMENTS:

- Relatively flat slopes
- Easy access for both individual workers and for maintenance crews
- Provide irrigation water
- Consider need for screening and/or limiting access
- Provide adequate circulation system
- Provide shade structures for lectures, work, etc.
- Provide storage areas

AGENCIES OR GROUPS INVOLVED IN PLANNING FOR THIS ACTIVITY:

- Pima County Parks and Recreation
- Pima County Planning and Development Services
- Educational/Research Institutions
- University of Arizona - Cooperative Extension
- Local horticultural groups
- Professional groups (nurserymen, contractors, horticulturists, landscape architects)

ENVIRONMENTAL ART



INTRODUCTION:

The landscape has been a concern of artists for a long time. In the mid-sixties, artists became more involved with the landscape. Some used it as a canvas, recording their works verbally or photographically. Other artists actually alter the landscape, their pieces are generally called 'earthworks' or 'land projects'. These artists are manipulating the land, their works are bound to the site. The artists deal with a character which is revealed or extended by changing conditions of light, weather, seasons or solar, lunar or celestial cycles.

Land projects are complex and fascinating areas of modern art. This art has been utilized in mining reclamation, reuse of quarries and other disturbed landscapes as well as pristine sites.

Earthworks lend themselves well to the concept of detention/retention basin multi-use. The forms can sometimes be viewed, played upon, walked through and around, and could be appropriately integrated with the hydraulics and engineering needs of the basin.

Robert Smithson's 'Spiral Jetty in the Great Salt Lake and the 'Amarillo Ramp' were created to counter desolate sites and to address notions of entropy. The Spiral Jetty is exposed and submerged as the water level rises and falls over the years.

Environmental art as a detention/retention use could also give Pima County national recognition. Quite possibly it would be the first time a land project was developed within a flood control facility.

GENERAL REQUIREMENTS:

- As per artist's specifications

AGENCIES OR GROUPS INVOLVED IN PLANNING FOR THIS ACTIVITY:

- National Endowment for the Arts
- Non-profit art foundations (ie. Skystone, Dia, etc.)
- Pima County Parks and Recreation
- Pima County Planning and Development Services
- Tucson Museum of Art
- Tucson/Pima County Arts Council

USE COMPATIBILITY MATRIX

	ACTIVE RECREATION	PASSIVE RECREATION	WATER-BASED RECREATION	NATIVE PLANT COMMUNITY	WILDLIFE HABITAT	URBAN GREEN SPACE	WATER HARVESTING/RECHARGE	NURSERY/RESEARCH SITE	ENVIRONMENTAL ART
ACTIVE RECREATION									
PASSIVE RECREATION	M								
WATER-BASED RECREATION	S	S							
NATIVE PLANT COMMUNITY	M	S	M						
WILDLIFE HABITAT	U	S	S	S					
URBAN GREEN SPACE	S	S	S	S	S				
WATER HARVESTING/RECHARGE	S	S	S	M	U	M			
NURSERY/RESEARCH SITE	M	M	M	S	U	S	M		
ENVIRONMENTAL ART	M	S	S	S	M	S	M	S	

S = Suitable
 M = Moderately Suitable
 U = Unsuitable

BASIN CONFIGURATION

BASIN CONFIGURATION

INTRODUCTION:

Most of the detention/retention basins developed to date in Pima County have been geometrically regular excavations. Required volumetric capacity has been the principal, if not exclusive, design criterion for these basins. This has been sufficient for project scale basins used exclusively for flood control. It will not, however, be adequate for regional, multiple use detention/retention facilities.

DESIGN CONSIDERATIONS:

Items that must be considered in determining the most appropriate configuration for regional, multiple use detention/retention basins are as follows:

- Characteristics of the Site

An effort must be made to minimize the apparent disturbance to the site. Significant site features such as unique land forms and mature stands of vegetation should be preserved whenever feasible. Site slopes and soil infiltration conditions must also be considered.

- Programmed Uses

The intended uses (uses in addition to flood control) must be considered in determining appropriate basin configuration. Spatial requirements, acceptable frequency of flooding, and other considerations must be established for each intended use.

- Safety

When public access is allowed and encouraged, basin configuration must give thorough consideration to user safety. Basin configuration must be responsive to the potential hazard of flooding. Unobstructed routes out of the basin must be provided for all users. Other potential safety hazard such as steep slopes or abrupt grade changes must be avoided. (See "Safety" page 64.)

- Availability and Cost of Land

Accommodating various uses and preserving site features are critically important considerations in determining basin configuration. They must, however, be evaluated in the context of land availability and cost.

- Hydrologic and Hydraulic Characteristics

Basin hydrology and the hydraulic characteristics of inlet and outlet structures will be principal determinants of basin configuration. Procedures and criteria for evaluating these issues are addressed in the Pima County Stormwater Detention/Retention Design Manual.

- Neighborhood Context/Adjacent Land Use

Adjacent land uses should be considered when determining appropriate basin configuration. Public use areas within the basin should be developed in proximity to existing parks and open space. Potentially hazardous areas should be kept as far away from residential areas as possible.

- Visual Character

The visual character of the completed facility is of extreme importance when basins are constructed within developed or developing residential neighborhoods. Basins that are visually attractive are likely to be considered neighborhood amenities and accepted by the area residents.

- Access for Maintenance

All detention/retention basins require some maintenance. These requirements increase with the introduction of multiple uses. Safe access for maintenance equipment is essential.

All of the above items must be considered in determining the appropriate configuration for safe, attractive, multiple-use detention/retention facilities. They must be given the same consideration as other design criteria such as required volumetric capacity and inlet/outlet locations. If this is done, the configuration that is most appropriate for a specific site can be determined.

VARIABLES

There are several variables related to basin configuration. These variables, and considerations related to each, are outlined below.

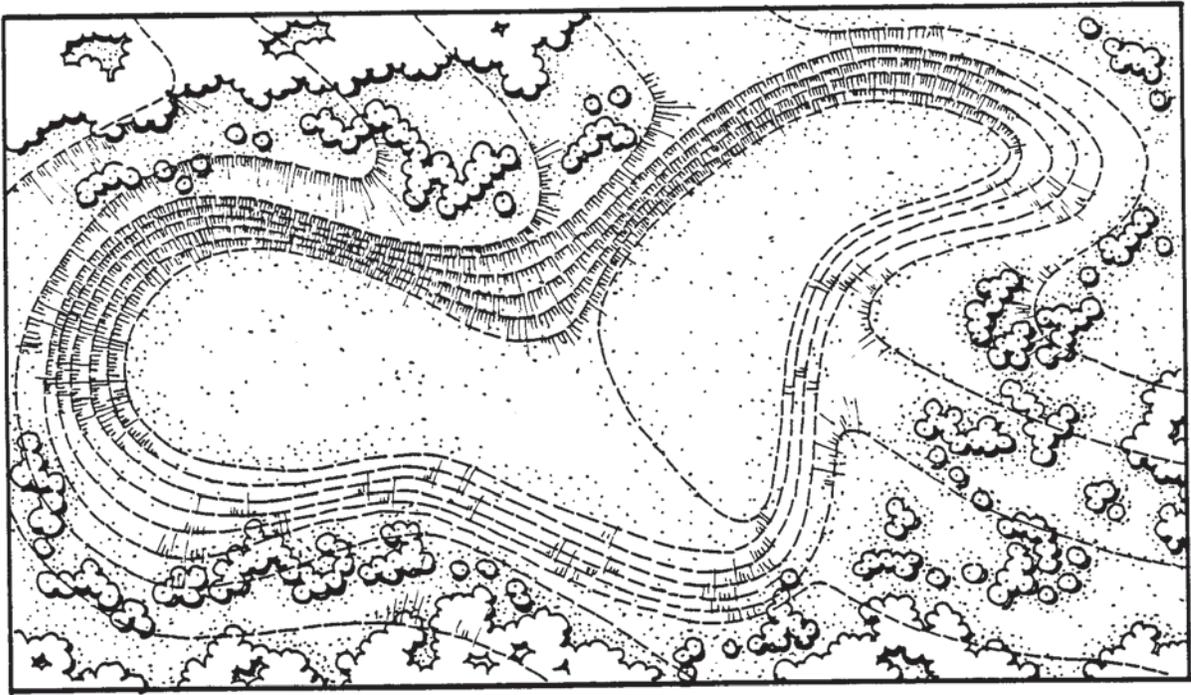
● Basin Shape

The planimetric shape of a basin has very little impact on its ability to function as a flood control facility. Consequently a wide range of shapes can be considered and utilized.

As a general rule curvilinear, irregularly shaped basins will have the most natural character. To maximize the integration of basin to site and to enhance the visual quality of the facility irregularly shaped curvilinear basins are recommended.

More rigid geometric shapes can also be utilized. If utilized, however, basin shapes should have some variety and interest.

In all cases the shape of the basin site should be considered. A basin that articulates the shape of the site is more likely to be visually attractive than one that does not.



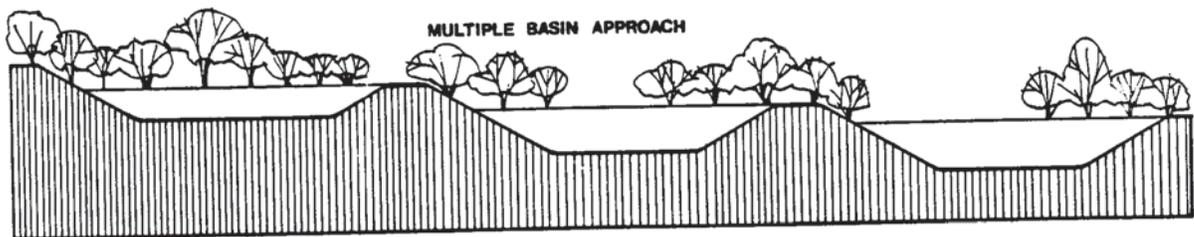
● Basin Depth

Basin depth will significantly impact the visual character and safety of a detention/retention basin. Large, abrupt, grade changes are not typical of sites in Pima County where regional basins are likely to be constructed. To maximize the natural character and appearance of the facility, deep basins should be avoided if possible.

Basin depth also impacts safety. A potential water depth of 10 to 15 feet represents a significantly greater hazard than a depth of 2 to 3 feet. A maximum potential water depth of approximately 3 feet is recommended.

Independent of flooding, the height of side slopes can be a safety issue. The greater the height, the greater the potential for falls and injury. Minimizing the depth of basins can reduce this potential safety hazard.

The required depth of a basin is directly related to the slope of a site. With a single basin deep cuts may be required at the upper end to achieve required basin capacity. An alternative configuration, one that can minimize depth of cut, involves the use of multiple or stepped basins. In combination, the volumetric capacity of a series of basins can be equal to the capacity of the single large basin. The maximum depth of cut, however, is significantly reduced.



● Side Slopes

As with basin depth, side slopes represent a major safety concern in the context of multiple use detention/retention facilities.

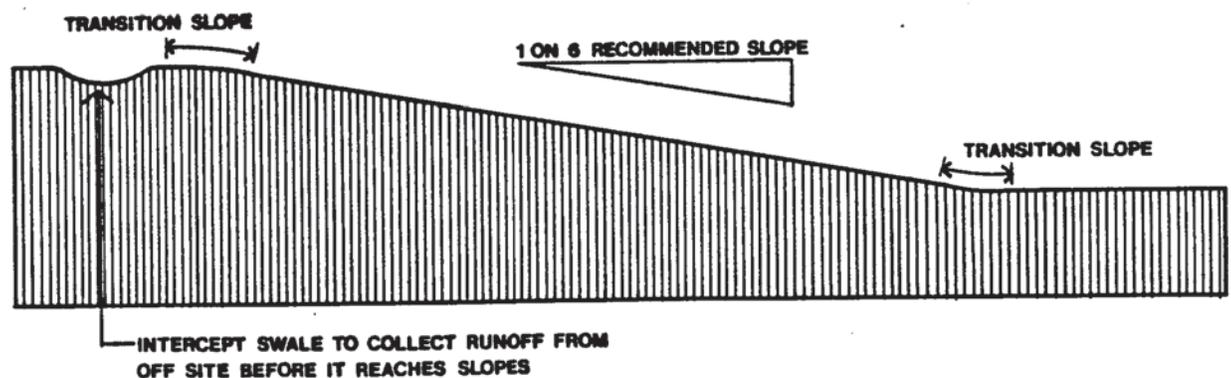
From the perspective of potential falls, the flatter the slope the better. A 1 on 6 side slope is recommended. It is also recommended that the bottom and top of slopes be tapered so that the inattentive, or physically impaired, user will be warned that they are approaching a grade change.

In situations where slope heights of 8 to 10 feet or greater cannot be avoided, a benched slope should be considered. A benched slope can limit a potential fall and significantly improve safety.

The maintenance of slopes must also be addressed. In general, flatter slopes are less subject to erosion and will require less maintenance. In almost all cases slopes must be designed to allow for safe operation of maintenance equipment. An absolute limit in terms of equipment operation is a 1 on 3 slope. Slopes within a range of 1 on 4 to 1 on 6, however, are much more desirable.

The design of basin side slopes should be done with the visual character of the completed facility in mind. In nature, slopes vary considerably even within a given locale. Variation in basin side slopes can improve the natural character of the site and should be utilized whenever possible.

From a variety of standpoints, flatter slopes are more desirable than steeper ones. It must be recognized, however, that flatter side slopes require greater area to achieve a given capacity. A balance must be found that keeps basin slopes to a minimum without unnecessarily increasing the area required for basin construction.

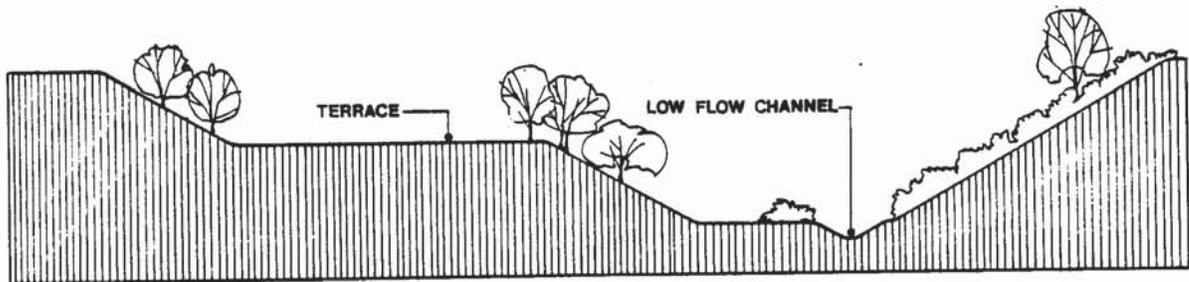


● Terracing

When basins are developed for multiple use, inundation of constructed facilities is an acknowledged possibility. Facilities need not be inundated by every storm however. Terracing, or the creation of areas with different elevations within a basin can be used to create zones with different potentials for flooding.

A basin can be created with a deep area that has a volumetric capacity adequate for run off from all events up to a five or ten year storm. Terraced areas, within the basin but above a specific elevation will not be flooded during these frequent storms and will be available for public use. Only when storms of greater severity are encountered will these areas be flooded and their use by the public precluded.

Terracing of basins to limit frequency of flooding can play a key role in the development of multiple use detention/retention basins.



● Low Flow Channels

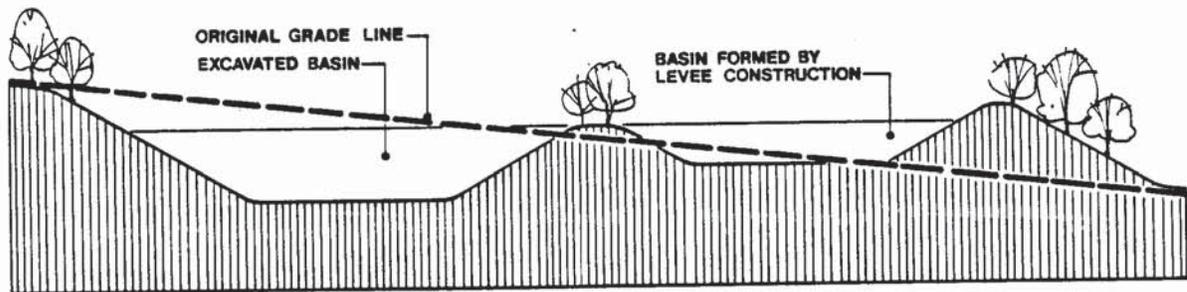
A variation of the terracing concept is the construction of low flow channels through a basin. "Nuisance" flows resulting from frequent low intensity storms can be accommodated in a small channel through the basin. This channel keeps flooded areas to a minimum during normal rainfall periods. During more severe storms, water is allowed to enter and fill up other areas of the basin.

● Excavation / Levee Construction

The vertical configuration of a detention/retention facility can be accomplished by excavation, levee construction or a combination of the two. Under various circumstances all of these methods are appropriate. Site conditions such as slope and soil characteristics will typically determine the approach that should be used.

When levees are utilized, extreme caution must be used in their design to insure structural integrity. One of several factors that must be evaluated is resistance to sliding. Typically if levee side slopes are flatter than 1 on 3 the levee will have adequate resistance to sliding. This is presented as a guide to developing a preliminary basin configuration. It must, however, be thoroughly reviewed along with several other factors that will influence the levees structural integrity.

Drainage behind a constructed levee or berm must also be given careful attention. If natural drainage patterns are interrupted or blocked, adequate channels around the obstruction must be provided to prevent flooding of adjacent property.



● Volumetric Capacity

The required volumetric capacity of a regional basin will typically be established by the Pima County Flood Control District prior to the commencement of detailed basin design. As such it will be a "given" rather than a variable in basin configuration. It is mentioned here, however, in that it can impact the regulations that apply to a specific basin.

If the depth of impounded water exceeds 10' or the volume of impounded water exceeds 50 acre feet the facility is considered a jurisdictional dam and regulations established by the Arizona Department of Water Resources apply. In some instances this may be necessary or desirable, in others it may not.

In instances where it is preferable not to construct a jurisdictional dam consideration should be given to a series of stepped basins that limit the height and volume of water impounded at any one location.

COMPUTER MODELING

There are computer programs available that can model and plot perspective sketches of proposed basin designs from preliminary contour sketches. Alternative configurations can be developed and drawn quickly for evaluation by the design team. The perspective sketches can be particularly effective in presenting proposed plans to area residents and potential users.

SUMMARY OF RECOMMENDATIONS RELATED TO BASIN CONFIGURATION:

- Utilize irregularly shaped curvilinear basins whenever possible to create a natural character.
- Minimize basin depth. Keep potential water depth to less than 3 feet whenever possible.
- Minimize height of slopes using benches as needed.
- Use slopes that are as flat as possible. Keep slopes to 1 on 6 whenever possible and do not exceed 1 on 3 except where absolutely necessary.
- Vary degree of slope within range noted above to give basin a natural character.
- Use terracing to create areas for public use with minimum likelihood of inundation.
- Provide low flow channels to convey frequent "nuisance" flows.
- Consider alternatives such as multiple basins when single basin height exceeds 10 feet or when single basin capacity exceeds 50 acre feet.

ACCEPTABLE FREQUENCY OF INUNDATION FOR VARIOUS FACILITIES:

Some facilities that might be developed within detention/retention basins will not be damaged by periodic inundation. It is acceptable to site these facilities in areas that will be frequently flooded.

Other facilities may be extensively damaged or destroyed by flooding. The high cost of repairing or replacing these facilities dictates that they be sited where the potential for flooding is remote or non-existent. Appropriate basin configurations must be developed to protect these developments.

The following chart is a general recommendation regarding the frequency with which various facilities might be flooded.

PROTECTION OF FACILITIES FROM FLOODS RESULTING FROM VARIOUS STORM EVENTS

	ANY STORM GENERATING RUN-OFF FLOWS	AVERAGE ANNUAL STORM	5 YEAR STORM	10 YEAR STORM	25 YEAR STORM	50 YEAR STORM
FIELDS						
Football/Soccer (Turf)	○	○	●	●	●	●
Baseball/Softball (Turf)	○	○	●	●	●	●
Open Plan Fields (Turf)	○	●	●	●	●	●
Model Airplane (Turf)	○	●	●	●	●	●
COURTS						
Basketball (Asphalt)	○	○	●	●	●	●
Tennis (Asphalt)	○	○	●	●	●	●
Handball/Racquetball (All concrete)	○	○	●	●	●	●
Handball/Racquetball (Wood floor)	○	○	○	○	○	●
Volleyball (Turf of sand)	○	○	●	●	●	●
Shuffleboard (Concrete)	○	○	●	●	●	●
Horseshoe pits (Clay)	○	○	●	●	●	●
TRAILS						
Pedestrian (Paved-Handicapped accessible)	○	○	●	●	●	●
Pedestrian (Natural-Unpaved)	○	●	●	●	●	●
Bicycle (Asphalt)	○	○	●	●	●	●
Equestrian Trails	○	●	●	●	●	●
Exercise course/trail	○	●	●	●	●	●
AMPHITHEATERS						
Amphitheaters	○	○	○	○	●	●
Outdoor classrooms	○	○	○	○	●	●
OTHER ACTIVE RECREATION FACILITIES						
Tot Lots/Playstructures	○	○	○	○	●	●
Golf driving range	○	●	●	●	●	●
Roller skating slabs (concrete)	○	○	●	●	●	●
Bicycle moto-cross hill	○	●	●	●	●	●
Picnic/Barbeque areas	○	○	●	●	●	●
WATER BASED RECREATION FACILITIES						
Swimming pools	○	○	○	○	○	●
Fishing ponds	●	●	●	●	●	●
Small boat lakes	●	●	●	●	●	●
Waterfowl ponds/wetlands	●	●	●	●	●	●

- May be constructed in areas inundated by designated storm event
- Should not be constructed in areas inundated by designated storm event

	ANY STORM GENERATING RUN-OFF FLOWS	AVERAGE ANNUAL STORM	5 YEAR STORM	10 YEAR STORM	25 YEAR STORM	50 YEAR STORM
PLANT/ANIMAL ENVIRONMENTS						
Wildlife Habitat-Wetland	●	●	●	●	●	●
Wildlife Habitat-Sonoran Desert	○	●	●	●	●	●
Native Plant Communities Riparian	●	●	●	●	●	●
Native Plant Communities Upland-Sonoran Desert	○	●	●	●	●	●
ENVIRONMENTAL ART						
With potential damage by inundation	○	○	○	○	●	●
Resistant to damage by inundation	○	●	●	●	●	●
BUILDINGS						
Picnic Ramadas	○	○	●	●	●	●
Rest Rooms	○	○	○	○	●	●
Concession	○	○	○	○	●	●
Equipment Storage	○	○	○	○	●	●
Maintenance Garage	○	○	○	○	●	●
Recreation Hall/Meeting Room	○	○	○	○	○	●
Nursery Shade Houses	○	○	●	●	●	●
Propagation/Greenhouses	○	○	●	●	●	●
Stables/Barns	○	○	○	○	○	●
SERVICE/SUPPORT FACILITIES						
Parking Lots	○	○	●	●	●	●
Maintenance/Equipment Yards	○	○	●	●	●	●
PLANT NURSERIES						
Container growing areas	○	○	●	●	●	●
Field growing areas	○	●	●	●	●	●
RESEARCH FACILITIES (will depend on nature of research)						
Permanent Facilities	○	○	○	○	●	●
Temporary Facilities	○	○	●	●	●	●
UTILITIES						
Septic system/tile field	○	○	●	●	●	●
Sewage lift station	○	○	○	○	●	●
Pad mounted electric transformers	○	○	○	○	○	●
Electric distribution panels	○	○	○	○	○	●
Light fixtures	○	○	●	●	●	●
Irrigation pumps/pressure tanks	○	○	○	○	●	●
Water pumps/pressure tanks	○	○	○	○	●	●

TECHNICAL ISSUES

EROSION CONTROL AND REVEGETATION

INTRODUCTION:

The construction of a retention basin will invariably result in the disturbance or complete removal of all existing vegetation. The exposed soils, often of slopes steeper than what might naturally occur, are subject to the erosive forces of water, wind, and in some cases pedestrian or vehicular traffic. Controlling erosion to maintain the integrity of the basin, to prevent loss of valuable soil, and to prevent sediment deposition down gradient is extremely important.

Control of erosion can be accomplished by developing a vegetative soil cover or through use of inert materials. Both the vegetative and inert approach have application at retention basin sites. The severity of erosive forces, cost, intended uses, and visual character must all be considered in determining the most appropriate erosion control technique.

EROSION CONTROL TECHNIQUES USING VEGETATION:

On most undisturbed sites in Pima County, a vegetative cover provides a natural protection against erosion. This natural protection is the result of foliage and branching which break the impact of precipitation and from extensive root systems which "reinforce" and hold the soil in place.

This natural erosion protection can be developed on disturbed sites such as detention/retention basins through revegetation. Revegetation can be accomplished through the planting of individual tree and shrub plants. While the planting of individual trees and shrubs is desirable and even necessary in some locations, it may be impractical for achieving revegetation over large sites.

A more practical way of revegetating large areas is through seeding. The application of seed to the soil surface, however, is but one step in the overall revegetation process. A description of revegetation techniques and materials is as follows.

COMPONENTS OF THE REVEGETATION PROCESS:

There are several steps in the revegetation process. Each of these are critical to the success of the overall revegetation program. These steps and the issues related to each are as outlined below.

● Seed Selection

Selection of seed from appropriate plant species is the single most important factor in the cost and success of a revegetation effort. Species used in the seed mix must be appropriate for the physical environment and for the uses planned in the basin. Soil test results should also be considered when developing a seed mix. Species used must be appropriate for soil conditions on site.

The rate at which the seed of each species is sown is also extremely important. An insufficient rate will not result in adequate plant cover. Excessive rates dramatically increase costs without increasing the density of resultant plant cover. The use of large amounts of wildflower seed, while desirable in many instances, can in other instances, unnecessarily increase the cost without improving the functional characteristics of the resultant planting. Careful consideration must be given to seed mix selection.

- Soil Preparation

The condition of the soil is important to the success of a revegetation effort. Generally some type of tillage is recommended prior to seeding. This will facilitate root penetration after seed germination.

There are possible conditions, however, where tillage is not recommended. An example of this might be steep slopes where the tillage operation would be an impetus to erosion during the period between tillage and plant establishment. In such cases soil penetration should be kept to a minimum.

In some instances, it may be desirable to place a layer of soil and gravel on the surface of the area to be seeded. As the gravel in the mix becomes exposed, it begins to form a type of "desert pavement" similar to that which occurs naturally in the desert environment. This "desert pavement" can prevent soil erosion while seeds are germinating and plants are becoming established.

- Fertilization:

Plant growth can be facilitated by the application of fertilizer on soils to be revegetated. Typically soil tests are conducted to determine the appropriate analysis and application rate for fertilizers. Fertilizer is broadcast over the area and incorporated into the soil during soil preparation.

An alternative technique for application of fertilizer is possible when hydroseeding is utilized. In this case fertilizer can be included with the seed-water slurry and applied as part of the seeding operation.

- Application

There are several techniques that can be used to apply seed for revegetation. These include drill seeding, broadcast seeding and hydroseeding. Site conditions will dictate the most appropriate technique to use. The following is a description of these seeding techniques.

- Drill Seeding

Drill seeding uses agricultural type seeding equipment which places the seeds of selected plant species in small furrows and then covers the seed and lightly compacts the soil. The advantages of this seeding technique are low cost and excellent seed soil contact which is important for germination and establishment. The disadvantage of this technique is that the required equipment cannot be used on slopes that are 1 on 3 or steeper.

- Broadcast Seeding

Broadcast seeding uses equipment that "sprays" seed of selected species above the surface of the soil. It is an inexpensive means of distributing seed. To prevent seed from being blown away or eaten by wildlife, however, it must be raked or dragged to incorporate the seed into the soil. The advantage of this seeding technique is cost. The disadvantages are; the need to rake after seeding and the inability of tractor mounted broadcast seeders to operate on slopes of 1 on 3 or steeper.

- Hydroseeding

Hydroseeding involves the mixing of seed and water and the pumping of the slurry onto the soil surface. The advantage of the technique is that it allows for seeding of steep slopes and other areas that are not accessible by other seeding equipment. The disadvantage of this technique is a relatively high cost.

- Mulching

Mulch is a material that is applied over newly seeded areas to protect the seed and soil surface until individual plants have been established. The mulch material functions to break the impact and erosive force of precipitation. It also serves to reduce the loss of soil moisture from the seed bed.

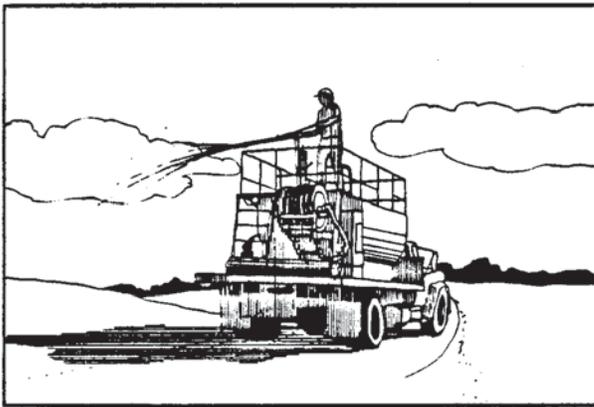
There are two mulch materials that are typically used in Pima County. They are straw and processed wood fiber.

Straw is typically spread over the soil surface using a mechanical blower. The applied straw should be "crimped" or "punched" into the soil surface to prevent it from being blown away.

Wood fiber is designed for application as a slurry or "hydromulch". It can be mixed with the seed slurry or applied over the seed as a second application.

- Tacking

Tacking involves the application of a tackifier or compound to hold the mulch in place. With straw mulch the tackifier is applied over the mulch. With wood fiber mulch it is generally included in mulch slurry. The material is non-toxic and designed to break down after several months, when plants have germinated and become established. Tacking of mulch is extremely important on areas where seeding has been done on steep slopes.



RECOMMENDATIONS FOR THE DEVELOPMENT OF A REVEGETATION SPECIFICATION:

The chart on the following page is a summary recommendation for the development of a revegetation specification. It identifies appropriate procedures, techniques, and rates for the various components of the revegetation process.

This chart is followed by a series of recommended seed mixes. These seed mixes were developed specifically for detention/retention basins in Pima County. A description of areas where it would be appropriate to use each seed mix is included. Also included is the common/botanical name and recommended sowing rate for each species included in the various seed mixes.

The proposed seed mixes will be appropriate for most conditions that will be encountered at detention/retention facilities. Other seed mixes, however, can and should be considered. It is of critical importance in developing seed mix specification to contact suppliers to insure seed availability. Long lead times are often necessary as seed from native plants is often hand collected.

When grasses are used in the seed mix it is important to include both warm and cool season species. This will help to insure a vegetative cover at all times of the year.

REVEGETATION DATA SHEET

SOIL TYPE	SLOPE	SOIL PREPARATION	FERTILIZATION ①	PLANTING TECHNIQUE	RECOMMENDED SEED MIXES ②	RECOMMENDED MULCH TYPE - APPLICATION TECHNIQUE	MULCH APPLICATION RATE	RECOMMENDED TACKIFIER - APPLICATION TECHNIQUE	TACKIFIER APPLICATION RATE
HIGHLY ERODIBLE SOILS -	0 - 15% SLOPES	RIP OR DISC TO DEPTH OF 6"	BROADCAST AND INCORPORATE INTO SOIL DURING SOIL PREPARATION	BROADCAST AND DRAG OR DRILL SEED	A-1 A-2 A-3	STRAW-BLOWN AND CRIMPED OVER SEEDED AREA	STRAW @ 3000 LBS PER ACRE	NONE REQUIRED	----
					B-1	WOOD FIBER-HYDRAULICALLY APPLIED OVER SEEDED AREA	WOOD FIBER @ 1500 LBS/ACRE	NONE REQUIRED	----
	15 - 30% SLOPES	RIP OR DISC TO DEPTH OF 6"	BROADCAST AND INCORPORATE INTO SOIL DURING SOIL PREPARATION	BROADCAST AND DRAG OR DRILL SEED	A-4	STRAW-BLOWN AND CRIMPED OVER SEEDED AREA	STRAW @ 4000 LBS PER ACRE	AZ-TAC WITH WOOD FIBER MULCH, APPLIED OVER STRAW	60 LBS AZ-TAC W/ 300 LBS WOOD FIBER MULCH PER ACRE
MODERATELY ERODIBLE SOILS -	30% SLOPES AND STEEPER	SCARIFY	APPLY HYDRAULICALLY WITH SEED MIX	HYDROSEED	A-5	WOOD FIBER MULCH-APPLIED HYDRAULICALLY OVER SEED	300 LBS MULCH PER ACRE APPLIED WITH SEED AS TRACER PLUS 1700 LBS MULCH PER ACRE APPLIED AS SECOND STEP	AZ-TAC APPLIED HYDRAULICALLY WITH MULCH	80 LBS/ACRE
					B-3	WOOD FIBER-HYDRAULICALLY APPLIED OVER SEEDED AREA	WOOD FIBER @ 1800 LBS/ACRE	NONE REQUIRED	----
	0 - 15% SLOPES	RIP OR DISC TO DEPTH OF 6"	BROADCAST AND INCORPORATE INTO SOIL DURING SOIL PREPARATION	BROADCAST AND DRAG OR DRILL SEED	A-1 A-2 A-3	STRAW-BLOWN AND CRIMPED OVER SEEDED AREA	STRAW @ 2500 LBS PER ACRE	NONE REQUIRED	----
15 - 30% SLOPES	RIP OR DISC TO DEPTH OF 6"	RIP OR DISC TO DEPTH OF 6"	BROADCAST AND INCORPORATE INTO SOIL CURING SOIL PREPARATION	BROADCAST AND DRAG OR DRILL SEED	A-4	WOOD FIBER-HYDRAULICALLY APPLIED OVER SEEDED AREA	WOOD FIBER @ 1200 LBS/ACRE	NONE REQUIRED	----
					B-2	STRAW-BLOWN AND CRIMPED OVER SEEDED AREA	STRAW @ 3000 LBS PER ACRE	AZ-TAC WITH WOOD FIBER MULCH, APPLIED OVER STRAW	60 LBS AZ-TAC W/ 300 LBS WOOD FIBER MULCH PER ACRE
	30% SLOPES AND STEEPER	SCARIFY	APPLY HYDRAULICALLY WITH SEED MIX	HYDROSEED	A-5	WOOD FIBER MULCH-APPLIED HYDRAULICALLY OVER SEED	300 LBS MULCH PER ACRE APPLIED WITH SEED AS TRACER PLUS 1500 LBS MULCH PER ACRE APPLIED AS SECOND STEP	AZ-TAC APPLIED HYDRAULICALLY WITH MULCH	80 LBS/ACRE

① Fertilizer analysis and application rates based on soil tests.

② Type A seed mix for use in areas subject to periodic inundation. Type B seed mix for use in areas not subject to inundation.

RECOMMENDED SEED MIXES
FOR REVEGETATION

Seed Mix No. A-1	Seed Mix No. A-2	Seed Mix No. A-3	Seed Mix No. B-1	Seed Mix No. B-2	Seed Mix No. B-3																																																																																																																																			
<p>This seed mix contains only grasses and is recommended for areas with the following conditions:</p> <ul style="list-style-type: none"> ● Generally flat ● May be subject to periodic inundation (10-20 days/year) ● No permanent irrigation ● Subject to moderate foot traffic <table border="1"> <thead> <tr> <th>NAME</th> <th>RATE (Lbs. P.L.S./Acre)</th> </tr> </thead> <tbody> <tr><td>Aristida purpurea (Red three am)</td><td>2.0</td></tr> <tr><td>Schismus barbatus (Six weeks grass)</td><td>3.0</td></tr> <tr><td>Eragrostis lehmanniana (Cochise lovegrass)</td><td>2.0</td></tr> <tr><td>Eragrostis curvula (Weeping lovegrass)</td><td>1.5</td></tr> <tr><td>Plantago insularis (Indian wheat)</td><td>5.0</td></tr> <tr><td>Sporobolus cryptandrus (sand drop seed)</td><td>2.0</td></tr> </tbody> </table>	NAME	RATE (Lbs. 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Cercidium floridum (Blue Paloverde)	2.0																																																																																																																																							
Prosopis velutina (Mesquite)	2.0																																																																																																																																							
NAME	RATE (Lbs. PLS/Acre)																																																																																																																																							
Aristida purpurea (Red three am)	3.0																																																																																																																																							
Schismus barbatus (Six weeks grass)	3.0																																																																																																																																							
Plantago insularis (Indian wheat)	5.0																																																																																																																																							
Atriplex polycarpa (Desert saltbush)	2.0																																																																																																																																							
Encelia farinosa (Brittle bush)	2.5																																																																																																																																							
Ercella farinosa (Triangle leaf bursage)	2.0																																																																																																																																							
Franseria deltoides (Bursage)	2.0																																																																																																																																							
Dodonea viscosa (Hopseed bush)	3.0																																																																																																																																							
Cercidium microphyllum (Foothills palo verde)	3.0																																																																																																																																							

ADDITIONAL SEED MIXES:

Seed mixes, in addition to those presented above may be developed and used in conjunction with regional detention/retention basins. Mixes which include wildflowers, though expensive, may be appropriate for highly visible areas. Other mixes may be necessary for special locations and conditions. Intended uses of the basin, such as wildlife habitat may also influence the species of plants used for revegetation.

IRRIGATION OF REVEGETATED AREAS:

The species utilized in the seed mixes above have been selected to survive without supplemental irrigation. A temporary irrigation system, however, is strongly recommended to aid in seed germination and plant establishment within revegetated areas. A more thorough discussion of this subject is included in the IRRIGATION chapter of this report.

SOIL TESTING:

The testing of soils on sites to be revegetated is strongly recommended. Testing should occur before the revegetation specification has been finalized. Adjustments to proposed seed mixes and fertilizer/mulch/tackifier application rates may be appropriate for local soil conditions.

EROSION CONTROL TECHNIQUES USING INERT MATERIALS:

Inert materials will typically be used where the potential for erosion is severe, such as along inlet/outlet channels where turbulent flows and high velocities are likely. Inert materials and techniques that are appropriate for erosion control in detention/retention facilities include; rock rip-rap, boulder placement, stone gabions, soil cement, interlocking modular units, and concrete channels. Woven or interlocking "fabric-mats" can also be used and are particularly effective when used in conjunction with vegetative erosion control techniques.

● Rock Rip-Rap

Rip-Rap involves the placement of large (6"-12"Ø) rocks on a soil embankment. It is usually adequate when the potential for erosion is moderate.

● Boulder Placement

Boulder placement is a type of rip-rap which utilizes large rocks, rocks with a minimum dimension of approximately 24". These boulders are not easily displaced even by high velocity, turbulent runoff flows. Boulder placement can effectively control erosion in even severe conditions.

A potential source of boulders are the various copper mines surrounding the Tucson metropolitan area. These boulders are part of the overburden and can be obtained for the cost of hauling them to the site.

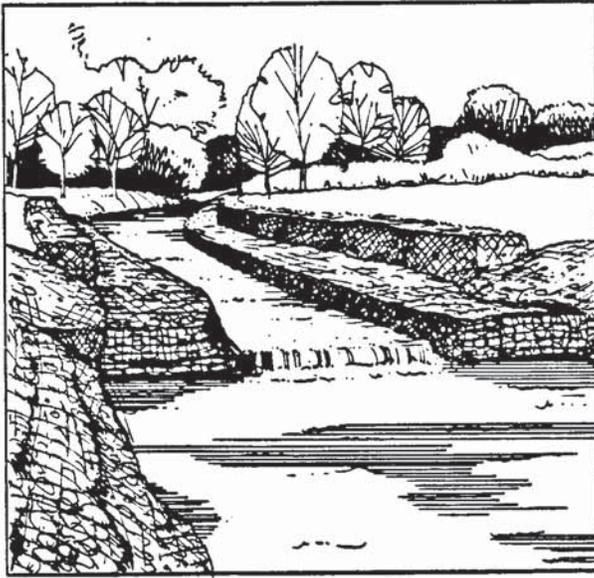
● Gabions

Gabions can be utilized to control erosion under severe conditions. They can be used to create stable, near vertical walls. They can also be used in the construction of hydraulic structures where shape and configuration are important, such as spillways and outlet channels.

● Soil Cement

Soil cement is a mixture of portland cement and soil placed and compacted to create a durable, impervious material. Soil cement can be an effective way to control erosion in channels where turbulent, high velocity flows are likely to occur. In areas where there are long stretches of channel to be protected, soil cement can be installed more quickly and less expensively than gabions or boulder rip-rap.

The cement content of soil cement can influence its color and appearance. The high cement content now required by Pima County Flood Control District on many of its projects results in a greyish appearance. Lower cement contents, resulting in a more natural desert color, are possible in non-critical areas. The appearance of the completed works should be considered when using soil cement.



● Interlocking Modular Units

Interlocking modular units, typically constructed of pre-cast concrete can be used to line channels or to create near vertical retaining walls. The voids in these units are designed to accommodate plant materials. When used with plant materials an attractive and very durable slope protection can be achieved. When exposed to moving water, the end of walls constructed of modular units should be toed back to prevent washout.

● Concrete Protection

Channels or structures that are subject to severe erosion potential can be poured in place or "shot" as gunite. Where concrete is used various surface treatments should be considered.

One such treatment involves the use of a stain or "desert varnish" that gives the concrete a more natural tone. When coloring agents are used it is important to match natural soil colors. Soils in Pima County are typically very light and dilution of standard coloring agents may be appropriate. Application techniques should also be considered so as to avoid uneven coloration that may look as unnatural as the untreated concrete.

● Collector Ditches

Where a basin will accept runoff, in addition to flows from inlet structures, a collector ditch or swale around the basin should be developed to intercept incoming flows. These ditches or swales should discharge the runoff at specific locations via properly designed spillways.

● Filter Fabrics

Where flows over rip-rap or gabions is substantial it may be necessary to provide a soil filter fabric below these rock structures. A filter fabric can prevent underlying fine materials from washing out or piping through the rock voids causing failure of the rip-rap or gabion.

PLANT MATERIALS AND LANDSCAPE PLANTING

INTRODUCTION:

Plant materials will be used in detention/retention basins for erosion control, other functional purposes and for aesthetic purposes. The use of native and non-native drought tolerant species is highly recommended.

PLANT ZONES:

- Channels

These are the only areas where there will be flowing water. Planting in these areas should be limited to grasses, low growing shrubs and groundcovers.

- Basin Areas

There may be inundation and standing water in these areas at some times of the year. Choice of plant materials should reflect these conditions. Trees, shrubs and grasses can be planted in these zones.

- Elevated Areas

These areas may be occasionally inundated. The choice of plant material will depend on the use assigned to the area. Trees, shrubs and grasses can be used in these zones.

USE OF NATIVE AND DROUGHT TOLERANT SPECIES:

As a general rule plant species used for landscape development and revegetation should be native to Pima County. These native species will survive and grow in the Sonoran Desert environment with a limited amount of care and without supplemental irrigation.

Other drought tolerant plants might also be considered. Many species native to the deserts of Australia and Africa have proven very successful in Pima County. These drought tolerant non-natives might be used when a particular plant feature or characteristic is needed.

ON SITE PLANTS

On site plant materials should be transplanted to the greatest extent possible. For some species this is required by state law. For many others it is an economical and ecologically sound method of acquiring mature plant materials. Plants to be transplanted shall include but not be limited to the following species:

- *Prosopis juliflora*
(Mesquite)
- *Prosopis pubescens*
(Screwbean Mesquite)
- *Olneya tesota*
(Ironwood)
- *Cercidium microphyllum*
(Little Leaf Paloverde)
- *Cercidium floridum*
(Blue Paloverde)
- *Parkinsonia aculeata*
(Mexican Paloverde)
- *Celtis reticulata*
(Hackberry)
- *Cereus giganteas*
(Saguaro)
- *Echinocerus*
(Hedgehog)
- *Opuntia* sp.
(Prickly Pear Cholla)
- *Fouquieria splendens*
(Ocotillo)
- *Ferrocactus* sp.
(Barrel Cactus)
- *Calliandra eriophylla*
(Fairy Duster)
- *Encelia farinosa*
(Brittle Bush)
- *Jatropha cardiophylla*
(Limber Bush)

- and all species not included in this list that are protected under the Arizona Native Plant Law. (A copy of the Arizona Native Plant Law is included as an appendix to this report.)

When reestablishment of native plant communities is the primary goal, as many existing plants as possible should be transplanted. The Pima County Horticulturist should be consulted for assistance in determining which plants are likely candidates for transplanting.

TURF GRASSES AND EXOTIC PLANT SPECIES:

The use of turf grasses and exotic plant species should be limited but by no means excluded from multiple-use detention/retention basins. The use of these plants should be limited because of their requirement for supplemental irrigation. Their use should be encouraged when they provide an appropriate environment for activities that can be enjoyed by the general public.

Turf grasses can be used to create play areas and ballfields that may be used by hundreds and possibly thousands of Pima County residents each week. The use of our water resources to irrigate these public spaces is appropriate and necessary.

Turf grasses can also play a role in pollution control. Turf has been found to be an effective filter removing contaminants from urban runoff before it infiltrates into the soil. In detention/retention basins where pollution control is a concern, extensive use of turf grass might be considered.

Exotic plants, or non-native species which require supplemental irrigation to survive in Pima County, can also play a role in detention/retention basin landscape development. These plants can be used in the development of mini-oases in key public spaces.

The mini-oasis concept concentrates irrigated plant material in a small zone within the overall site to create a lush local environment or oasis. This approach is an alternative to the distribution of irrigated plants over the entire site. It significantly increases the visual impact of the irrigated plant material, it creates a lush, attractive environment for a variety of uses, and typically reduces the total volume of water used for irrigation. The limited use of exotic plant species to create mini-oases within multiple-use detention/retention basins is appropriate.

PHREATOPHYTES:

Phreatophytes are plants which can survive with their roots in very wet or saturated soils. A characteristic of this type of plant is its ability to transpire significant amounts of water.

Phreatophytes might be used in detention/retention basins where it is desirable or necessary to dissipate detained water. Their use should be avoided where ground water recharge is a major objective, or where root penetration of water and sewer lines is a possibility.

Trees

Acacia sp.
(Acacia)
Bauhinia unguicularis
(Chihuahuan Butterfly)
Brachychiton populeneus
(Bottle Tree)
Casuarina stricta
(Beefwood)
Celtis reticulata
(Hackberry)
Cercidium sp.
(Paloverde)
Chamaerops humilis
(Mediterranean Fan Palm)
Cordia boissieri
(Texas Olive)
Dalea spinosa
(Smoke Tree)
Erythrina flabelliformis bidwillii
(Coral Tree)
Eucalyptus sp.
(Eucalyptus)

Ficus carica or palmeri
(Fig & Wild Fig)
Fraxinus sp.
(Ash)
Grevillea 'noellii'
Juglans major
(Walnut)
Leucaleana retusa
(Golden Lead Ball)
Olneya tesota
(Ironwood)
Parkinsonia aculeata
(Mexican Paloverde)
Pinus brutia eldarica
(Mondel Pine)
Pistacia alantica
(Pistache)
Pithecellobium flexicaule
(Texas Ebony)
Pittosporum phillyraeoides
(Willow Pittosporum)

Populus sp.
(Cottonwood)
Prosopis sp.
(Mesquite)
Quercus sp.
(Oak)
Rhus Lancea
(African Sumac)
Salix sp.
(Willow)
Schinus Molle
(California Pepper)
Sophora secundiflora
(Mescal Bean)
Sambucus mexicana
(Mexican Elderberry)
Tamarix aphylla
(Salt Cedar)
Ulmus parvifolia
(Chinese Elm)
Vitex agnus-castus
(Monk's Pepper Tree)
Xylosma congestum
(Xylosma)

Shrubs

Acacia sp.
(Acacia)
Anisacanthus thurberi
(Desert Honeysuckle)
Atriplex sp.
(Saltbush)
Baccharis sarothroides
(Desert Broom)
Caesalpinia sp.
(Birds of Paradise)
Calliandra eriophylla
(Fairy Duster)
Callistemon citrinus
(Lemon Bottlebrush)
Cassia sp.
(Cassia)
Celtis pallida
(Desert Hackberry)
Centaurea cinerari
(Dusty Miller)
Cissus sp.
(Canyon Grape)
Cordia parvifolia
(Little Leaf Cordia)
Dasylirion wheeleri
(Desert Spoon)
Dodonaea viscosa
(Hopbush)
Elaeagnus ebbingei
(Silverberry)

Encelia farinosa
(Brittlebush)
Euonymus japonica
(Euonymus)
Euphorbia rigida
(Euphorbia)
Jatropha cardiophylla
(Limber Bush)
Justicia ovata
(Justicia)
Justicia spicigera
(Justicia)
Lantana camara
(Bush Lantana)
Larrea tridentata
(Creosote)
Leucophyllum frutescens
(Texas Ranger)
Lycium berlandier
(Wolfberry)
Maythenus phyllanthoides
(Mangle Dulce)
Myrtus communis
(Myrtle)
Nerium oleander
(Oleander)
Nolina biglovii
(Bear Grass)
Olea verrucosa
(Olive Bush)

Pennisetum setaceum
(Fountain Grass)
Photinia sp.
(Photinia)
Raphiolepis indica
(Raphiolepis)
Rhus ovata
(Sugar Bush)
Rhus virens
(Evergreen Sumac)
Rosmarinus officinalis
(Bush Rosemary)
Salvia greggii
(Scarlet Sage)
Simmondsia chinensis
(Jojoba)
Tecoma stans
(Trumpet Bush)
Tecomaria capensis
(Cape Honeysuckle)
Teucrium fruticans
(Bush Germander)
Vauqueinia californica
(Arizona Rosewood)
Zauschneria latifolia
(Mexican Hummingbird Flower)

Cactus / Succulent

Agave sp. (Agave)	Ferrocactus sp. (Barrel Cactus)
Aloe sp. (Aloe)	Fouquieria splendens (Ocotillo)
Carnegiea giganteus (Saguaro)	Hesperaloe sp. (Red Yucca)
Cereus peruvianus (Night Blooming Cereus)	Opuntia sp. (Prickly Pear)
Echinocerus (Hedgehog)	Stenocercus thurberi (Organ Pipe)

Groundcovers

Acacia redolens (Acacia)	Ericameria laricifolia (Turpentine Bush)	Porophyllum gracile (Poreleaf)
Ambrosia deltoidea (Ragweed)	Gazania rigens sp. (Gazania)	Rosmarinus officinalis prostratus (Trailing Rosemary)
Atriplex semibacata (Saltbush)	Gutierrezia sarothrae (Snake Weed)	Santolina sp. (santolina)
Baileya multiradiata (Desert Marigold)	Kalstroemia grandiflora (Arizona Poppy)	Senecio cineraria (Dusty Miller)
Cassia covesii (Desert Senna)	Lantana montevidensis (Trailing Lantana)	Sphaeralcea sp. (Globe Mallow)
Convolvulus cneorum (Bush Morning Glory)	Liriope muscari (Lillyturf)	Trixis californica (Trixis)
Coultter sp. (Coultter)	Lupinus odoratus (Desert Lupine)	Verbena sp. (Trailing Verbena)
Coursetia glandulosa (Coursetia)	Nissolia shottii (Nissolia)	Verbesina enceloides (Crown Beard)
Dalea greggii (Trailing Indigo)	Oenothera berlandieri (Mexican Primrose)	Zauschneria latifolia mexicana (Mexican Hummingbird Flower)
Demophothea sinuata (African Daisy)	Osteospermum fruticosum (Trailing African Daisy)	Zinnia sp. (Zinnia)
Dyssodia pentachaeta (Dyssodia)	Penstemon sp. (Firecracker Plant)	
Erigeronum sp. (Fleabone)	Phyla nodiflora (Lippia)	

Grasses

Aristida purpurea (Purple Three Awn)	Heteropogon contortus L. Beauv. (Tanglehead)
Bouteloua barbata (Six Weeks Grama)	Muhlenbergia porteri (Bush Muhly)
Bouteloua chondrosioides (Spruce Top Grama)	Pappophorum mucronulatum (Pappusgrass)
Bouteloua filiformis (Slender Grama)	Plantago insularis (Indian Wheat)
Bouteloua gracilis (Blue Grama)	Schimus barbatus (Six Weeks Grass)
Cynodon dactylon (Bermuda Grass)	Sporobolus cryptandrus (Sand Dropseed)
Distichlis stricta (Desert Saltgrass)	Sporobolus wrightii Munro (Sacaton)
Eragrostis lehmanniana E. atheustonii (Cochise Lovegrass)	Trichachne californica (Arizona Cottongrass)
Eragrostis curvula (Weeping Lovegrass)	Tridens pulchellus (Fluffgrass)

INTRODUCTION:

An irrigation system will be a likely component of each multiple use detention/retention basin developed in Pima County. The intended uses of each basin will largely determine the type and extent of the system constructed.

In Pima County the subject of irrigation must be reviewed in the context of water conservation. Water cannot be used indiscriminately for landscape irrigation. Every effort should be made to use drought tolerant plants that do not require supplemental irrigation. There are instances, however, where extensive landscape irrigation systems can be justified.

Detention/retention basins developed as parks are such an instance. The ballfields and active recreation facilities developed may be used by hundreds and possibly thousands of individuals per week. The use of water to irrigate these necessary public amenities is an appropriate use of our water resources.

TEMPORARY VS. PERMANENT IRRIGATION SYSTEMS:

● Temporary Irrigation

It is often important to irrigate plants for a period of months or years to get them established. For areas seeded with grasses and native shrubs this may be for a period of a few months, to achieve germination and initial development. For trees this could be for a period of several years, to help them establish sufficient root development to get them through periods of drought and to give them sufficient top growth to resist wind damage or vandalism.

Some type of temporary system is recommended for areas that will not receive permanent irrigation. Benefits derived during the period of plant establishment are significant and temporary systems do not place an on-going demand on community water resources.

● Permanent Irrigation

Permanent irrigation may be necessary to create an appropriate environment for certain uses or activities. Active recreation facilities such as ballfields require an irrigated turf surface. Where such uses are included in the program for a detention/retention basin, permanent irrigation systems should be installed.

Permanent irrigation systems should be designed and installed to operate with a minimum of labor. Systems should be permanent,

underground, automated systems. Movable or semi-movable systems such as hose bib or quick coupler systems should be avoided due to their high cost of operation.

SOURCES OF IRRIGATION WATER:

- Potable Water

Potable water will typically be available for irrigation at most detention/retention basin sites. Its use must never be indiscriminant and appropriate conservation measures must be taken.

- Treated Effluent

Treated effluent may be available at some detention/retention sites. If available it should be utilized for irrigation as is proposed for various parks in the County park system.

- Storm Water

It would appear that a facility designed to capture water would yield a readily available source of free water, water that could be used for on-site irrigation. It is true the supply is there but its use is not always easy or inexpensive. Difficulties include:

- Capture and storage - Plants do not need supplemental irrigation when it rains and storm water is readily available. Water must be captured and stored. The capture and safe storage of water can necessitate expensive tanks and facilities.
- Pumping of water - If stored, storm water must then be pumped into a distribution system. This is possible but installation of pumps in an area subject to inundation presents technical difficulties and can be costly.
- Water quality - Irrigation systems, particularly drip systems, require relatively clean water. Storm water runoff typically carries a great deal of sediment and debris. This material must be removed from the water before it can be introduced into an irrigation system.

These difficulties should not, however, preclude the use of storm water for irrigation. The costs related to development of catchment and storage systems may well be offset by the long term costs associated with other sources of irrigation water. The long term availability of other water sources must also be considered.

TEMPORARY IRRIGATION SYSTEMS TYPES:

Temporary systems might be used to irrigate slopes or other areas seeded within native plant species. The system should be designed to provide sufficient water for germination and establishment. Typically such a

system would be in place for less than one year. Types of temporary irrigation systems include:

- Movable agricultural type systems

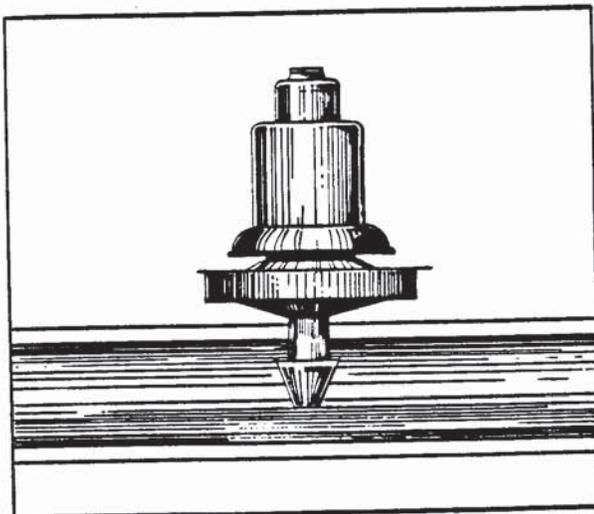
These systems typically utilize quick-coupled aluminum pipe with sprinklers or spray heads as appropriate for the area. The water supply line can be a permanent installation or a temporary connection such as a fire hose connected to a metered hydrant.

- Plastic pipe system (installed on or near surface)

This type of system utilizes plastic pipe, typically PVC, installed at or near the soil surface. Sprinklers are typically installed on fixed risers for easy removal and reuse. The system is designed to be as inexpensive as possible and to last for the intended period of irrigation, typically less than a few years.

- Temporary drip irrigation

Temporary drip irrigation systems are similar to temporary spray irrigation systems in that they are designed to minimize installation costs and to operate for a relatively short period of time. A temporary drip system would typically be utilized to irrigate drought tolerant trees and large shrub plantings for a period of 2 to 5 years. The purpose of this irrigation would be to help these plants to survive initial transplant shock and to establish a sufficient root system that will allow them to survive on natural precipitation. Because these systems are typically operated for a period of several years a substantial, but relatively inexpensive supply line must be provided.



PERMANENT IRRIGATION SYSTEM TYPES:

- Permanent Spray Irrigation

This type of system would likely be used only when there are turf grass fields provided for active recreation. System design would be as for any turf grass installation with consideration given to potential inundation and sediment deposition. Components such as heads should be selected to operate properly even when subjected to some sand or sediment deposits. Electrical components, other than low voltage items, should be located in areas not subject to inundation.

- Permanent Drip Irrigation

A permanent drip irrigation system might be utilized in or around public use areas where tree, shrub or ground cover plants are installed to create a lush "node" or "mini-oasis". As the irrigation system would be designed to operate on an on-going basis, selection of materials, equipment, and installation techniques should be on the basis of life-cycle costs rather than initial installation costs. As with any permanent irrigation system in a detention/retention basin, consideration must be given to potential damage to system caused by inundation or sediment deposition.

WATER HARVESTING:

Water harvesting involves the collection of precipitation that falls over a large area and the application of that water on a small planted area. This approach can significantly increase the "natural precipitation" that the planted area receives. It allows for the growth of plant species that would not survive on normal precipitation. In some cases an entire detention/retention basin might be designed as a water harvesting facility. In other instances water harvesting could occur at several different locations within a basin. As an irrigation technique water harvesting should be considered and utilized whenever possible.

INTRODUCTION:

Public access is an inherent element of the multiple-use detention/retention basin concept. Encouraging public use of areas subject to potential flooding, however, raises the question of safety.

There are two parts to the safety issue. The first relates to the need to identify and communicate potential hazards to the public. Users must be made aware that a potential hazard, specifically flooding, exists.

The second relates to the design and maintenance of the facility. Appropriate steps must be taken to mitigate potentially dangerous conditions. Where the dangerous condition cannot be prevented, appropriate measures must be implemented to keep users away from hazardous locations. If these safety concerns are appropriately addressed there is no reason why public use of detention/retention basins should not be allowed and encouraged.

IDENTIFICATION OF POTENTIAL FLOOD HAZARD

Signs will be the principal means by which basin users are advised of the potential flood hazard within the basin. Signs should be provided at all designated entryways. They should also be provided at intervals (Approximately 100 feet) around the perimeter of the basin to inform visitors who might gain access at other than designated entrances.

In addition to entry and perimeter signs, signs should be installed within the basin. These in-basin signs should restate the potential flood hazard and should provide directions for an appropriate route out of the basin should flooding occur.

Signs should indicate that rain in the immediate area is not a prerequisite for basin flooding. They should indicate that storms elsewhere in the watershed can result in flooding, and in some cases, a wall of water entering the basin. An interpretive display sign illustrating this phenomena might be appropriate at each major entrance.

To be effective in communicating the potential flood hazard to the public, signs must be in place when needed. Consideration must be given to durability and vandal resistance. Materials, fasteners, installation techniques, mounting heights, etc. must be evaluated in the design of important warning signs.

In some instances warning devices other than signs may be appropriate and necessary. An audible alarm, with a remote sensor activated by flood water in an upstream channel, might be considered. This might be necessary in locations where watershed and inlet characteristics could result in a wall of water entering the basin.

SAFETY CONCERNS RELATED TO INLET STRUCTURES

Inlet structures can represent a significant safety hazard. A large volume of water entering the basin at high velocity can literally wash away an individual who is on or near the inlet structure. The design of an inlet that minimizes the velocity of incoming water will greatly enhance safety and should be included in the criteria for inlet structure design.

Where site conditions will not allow for the design of an inlet with low water velocities, energy dissipators might be utilized. Reinforced concrete piers, boulders, stilling basins, or other items that reduce water velocity and energy should be considered. When utilized, however, the hydraulic characteristics and damage that might occur from turbulent flows around such energy dissipators must also be evaluated.

It is also important to design inlet structures so that they do not become attractive nuisances. They should not be suitable for potentially dangerous activities such as skateboarding and moto-cross biking. In this regard, a rough textured surface might be more appropriate than a smooth, troweled-finish concrete surface. Features that preclude inappropriate uses of inlet structures should be utilized.

There may be instances where, due to site conditions, it will be necessary to prevent public access to inlet structures for reasons of safety. The recommended response to this condition is to provide a fence or barrier around the inlet structure but not necessarily around the entire basin. There will likely be other areas within the basin where public access is and multiple uses should be allowed.

As noted above, signs located around the inlet structure can inform the public of potential hazards associated with this area. Informative and well maintained signs will be critically important in basin inlet areas.

SAFETY CONCERNS RELATED TO OUTLET STRUCTURES AND SPILLWAYS

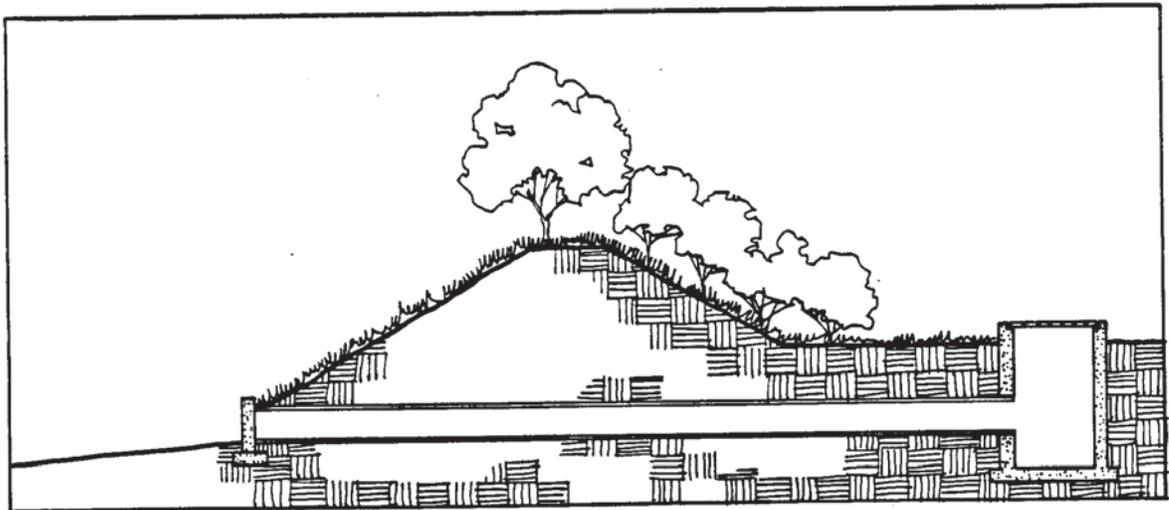
There are two elements of the safety issue as related to outlet structures and spillways. The first deals with the safety of the user during flood conditions. The second deals with the uninterrupted operation of the outlet or drain as required for the release of impounded water.

User safety must be of primary concern with the design of basin outlets or drains. They must be designed so that it is not possible for a user to be washed into an outlet and trapped. This is particularly important when considering children who might be inclined to use the outlet structures as a playground.

In general, the use of vertical inlet drains is preferable to the use of horizontal pipes. Vertical inlet drains can be equipped with a grate cover. These grates typically have openings small enough to prevent children from becoming caught in them.

Where large diameter horizontal pipe drains are utilized, grates must be provided to prevent children from entering and becoming trapped. An alternative to large diameter pipe drains is several small diameter pipes (8" diameter or less). Multiple pipe drains can have the same hydraulic capacity as a single large pipe. They cannot, however, be used as tunnels by children. When small diameter pipe drains are utilized, careful consideration must be given to insure that they can be adequately maintained.

At some sites, the use of surface drains may be possible. Because it is more difficult to become trapped in a surface drain than a subsurface drain their use should be considered wherever feasible. A "V" shaped outlet that allows outflow to increase with water height is an alternative that might be considered.

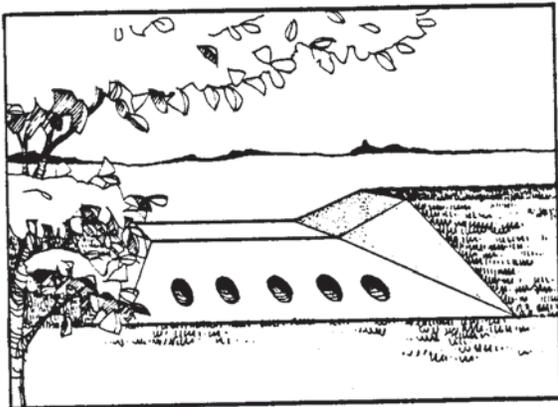


Unlike inlet structures, water will not appear, and start flowing through drains without notice. None-the-less, signs identifying the hazards associated with a specific drain are critically important. Warning signs should be provided at all basin outlet and drain locations.

The second safety concern related to outlet structures and spillways is potential clogging with debris. This could significantly increase the time-to-drain and in the most severe cases, jeopardize the integrity of the basin itself.

To prevent clogging it is important that all developments within the basin be designed to prevent them from "floating" away. Even items such as trash receptacles must be secured if located in flood prone areas. Similarly, grass and weed clippings and other vegetative debris should be regularly cleaned up and removed from the basin.

Safety must also be considered downstream of basin outlets. Release flows, even though they may be controlled, can present a hazard. Specific conditions downstream of a basin outlet must be evaluated in terms of safety.



SAFETY WITHIN THE BASIN

The principal factors associated with safety inside a detention/retention basin are; potential water depth, slopes, routes out of flooded areas, and time to drain.

Safety concerns increase with an increase in potential water depth. A basin with a potential water depth of 2 to 3 feet (less than the head height of most users) is typically less dangerous than a basin with a potential water depth of 5 to 6 feet or more. For reasons of safety, potential water depth in detention/retention basins should be kept to a minimum. It is recommended that potential water depth be three feet or less whenever possible.

In all basins, regardless of depth, slopes in flood prone areas should be kept as shallow as possible. This will allow users who find themselves caught in flooded areas (or users who deliberately enter flooded areas) to walk out and up to unflooded zones. It is recommended that slopes in flood prone areas not exceed 1 on 6.

In addition to slopes, consideration should be given to bottom conditions in flood prone areas. Soils that provide firm footing when saturated are safer than soils which do not. Removal of unsuitable soils may be necessary in severe cases.

In addition to gentle slopes, routes out of flood prone areas must be provided. Barriers that could trap a user in a flood prone area must be avoided. Safe, well signed exit routes, that are negotiable under wet conditions, must be developed.

CLOSURE OF BASINS

The time required for a basin to drain can impact its safety. Generally, basins should be designed to drain as quickly as possible within the constraints of flood control requirements. It is recommended that basins be designed to drain within 36 hours whenever possible.

When this is not possible, as may be the case with some retention basins, other aspects of basin safety must be given highest priority.

FENCING

It is important to state that fencing is not an essential and necessary part of safe detention/retention basin development. It is far better to design a basin that eliminates hazardous conditions than to fence them off.

Recognizing that complete elimination of hazardous conditions is not possible, alternatives to fencing should be considered. Earthwork and vegetation can often be used to create effective barriers. They are often less expensive to construct and maintain and are a more subtle means of controlling user movement. Their use in-lieu-of fencing is recommended.

GENERAL SAFETY CONCERNS

While focusing on the safety concerns related to the flooding of multiple-use detention/retention basins, it is important to also consider safety issues related to all public parks. All facilities must be designed to prevent injury to the public. They must be maintained and repaired so that they will remain safe. Safety criteria used in the design and maintenance of public parks should also be used in the design of multiple-use detention/retention facilities.

SUMMARY OF RECOMMENDATIONS

- Provide flood warning signs at all entrances.
- Provide flood warning signs (approximately 100 feet on center) around the perimeter of basin.
- Provide warning signs inside the basin with indication of way out in event of flooding.
- Provide warning signs at inlet and outlet structures.
- Design inlet structures to minimize water velocity and/or dissipate energy of inflow.
- Design inlet structures that preclude their use for inappropriate and unsafe activities.
- Control access to inlet structures if hazardous conditions exist.
- Utilize surface flow outlet structures or vertical inlet drains whenever possible.
- Use large diameter pipes with grates or multiple, small diameter pipes when horizontal pipe drains are utilized.
- Anchor all objects/developments in flood prone areas to keep them away from outlet structures.
- Clean vegetative debris from basins on a regular basis.
- Keep potential water depth in basin to 3 feet or less whenever possible.
- Keep slopes 1 on 6 or flatter in all flood prone areas.
- Provide safe routes out of basin during flood conditions.
- Design basin to drain within 36 hours, whenever possible.
- Provide for temporary closure of basins during storm periods.
- Consider alternatives to fencing when protecting public from hazardous conditions.
- Utilize safety criteria as appropriate for the design of any public park or facility.

SEDIMENT CONTROL

INTRODUCTION:

Sediment transport occurs naturally along the washes and drainage channels of Pima County. These drainageways are dynamic and some scour may result from one storm while some deposition may result from another.

Urban development modifies this natural process. When land is cleared for development, large volumes of soil can be eroded and washed into natural drainage courses. The alignment of a channel and its hydraulic capacity can be significantly altered. Flooding or damage of downstream areas can result.

Detention/retention basins can be effective in trapping sediments and in preventing problems downstream. In multiple-use detention/retention basins, however, the areas where sediments are deposited must be controlled. Additionally, deposited sediments must be removed from time to time to maintain the volumetric capacity of the basin.

CONTROLLING SEDIMENT DEPOSITION:

Sediments are removed from storm water runoff by slowing the velocity of the water to a point where the suspended sediment settles out of the water. To prevent this from occurring throughout the basin, sediment traps or stilling basins should be provided. These are defined areas, typically located close to the inlet, where runoff is trapped before it is released into the balance of the basin. When a multiple basin system is utilized the first basin is often designed to function as the sediment trap.

REMOVAL OF SEDIMENT:

Deposited sediments should be removed on a regular basis. Access to sediment traps for loaders and trucks must be provided. Adequate clear space, as required for the efficient operation of large equipment is important.

If sediment is not removed from traps, deposition is likely to occur in other areas of the basin where its removal may be more difficult and expensive.

IMPACT OF SEDIMENT ON INFILTRATION:

If not controlled and removed, sediments can, over time, seal the bottom of a basin with a layer of fine soil particles. This can be a significant problem in retention basins where infiltration is the principal means by which storm water is dissipated. Similarly it is a problem in basins where ground water recharge is an objective. Controlled deposition in traps and regular removal of sediment can prevent this problem.

OFF-SITE CONTROLS:

The sediment problem can be significantly reduced if strict controls on soil erosion are developed and enforced at construction sites. Stopping sediments at their source can minimize problems in downstream detention/retention basins.

SUMMARY OF RECOMMENDATIONS:

- Develop and enforce controls on erosion at construction sites.
- Provide sediment traps in all detention/retention basins to control where sediments are deposited.
- Use first basin as sediment trap where multiple basins are used.
- Remove deposited sediment from traps on a regular basis.
- Provide access to traps for equipment required to remove sediment.

INTRODUCTION

Urban runoff is distinguished from undeveloped area runoff in two principal ways: It occurs at greater discharge rates and volumes, and it contains varying but commonly higher concentrations of toxic substances, bacteria, and dissolved organic matter. In 1978 the Pima County Association of Governments stated that urban runoff in the Tucson region "...is considered a low level immediate health hazard, but a high level long range problem." Detention/retention basins can play a significant role in mitigating the pollution problems associated with urban runoff.

MAJOR POLLUTANTS

- **Suspended materials:** These include particulate matter and floating material such as oils and scum. Suspended solid concentration in urban runoff may be 2 to 3 times that found in domestic waste.
- **Oxygen demanding materials:** These include degradable organic matter and certain nitrogen compounds that consume the available dissolved oxygen as they degrade. The biochemical oxygen demand of stormwater runoff is usually in the 20 to 30 mg/L range, almost the same range as sewage effluent after secondary treatment.
- **Pathogenic Bacteria and Viruses:** These include coliform, fecal coliform, and fecal streptococci. These are the same pathogenic bacteria and viruses found in domestic sewage.
- **Toxic Substances:** These include heavy metals and a full range of EPA designated pollutants. The EPA list contains approximately 100 primarily organic substances such as TCE.

MAJOR SOURCES OF POLLUTANTS

Studies show that the areas contributing the greatest amounts of pollution are those with highly erodible surface conditions, such as plowed land or construction sites, or those areas characterized by highly impermeable surfaces, such as shopping malls, industrial areas and large housing complexes. Runoff from vehicular right-of-ways, which accounts for over 20% of some urban lands, will contain hydrocarbons, other organics and a diminishing but still significant amount of lead. Fertilizers and pesticides will be transported by runoff from residential and agricultural areas.

ROLE OF DETENTION/RETENTION BASINS IN POLLUTION CONTROL:

Detention/retention basins can function as a trap for pollutants to prevent them from moving downstream. Most pollutants have a high affinity for the soil particles or sediments that are a common component of urban runoff. By settling out the sediment it is possible to reduce the concentration of pollutants moving downstream. Natural decomposition of pollutants or removal of sediments from the basin rids the water system of these contaminants.

Where concentrations of sediment in the runoff are low it may be desirable to expose the runoff to as great an area of soil as possible. Contaminants will attach to soil particles as the runoff passes over, or infiltrates through, the soil.

Turf grasses can also be used to filter contaminants from urban runoff. Pollutants trapped by the turf are held until natural decomposition can occur.

FIRST FLUSH:

The runoff that immediately follows the start of a storm is often referred to as the first flush. This is due to the high concentration of pollutants typically carried by the initial runoff. The settling out of sediments in the first flush or the exposure of this runoff to soil and turf areas can serve to reduce the concentration of pollutants moving downstream.

POTENTIAL POLLUTION OF GROUND WATER:

In areas where the water table is close to the surface and significant recharge is possible, contamination of the ground water is a potential problem.

When basins are developed in such areas, it is critical that the pollutants in the local runoff be identified and evaluated. If they pose even a moderate threat to the ground water the recommendations noted should not be implemented. Rather, the detention/retention basin should be designed to minimize the infiltration of storm water runoff.

DESIGN RECOMMENDATIONS FOR WATER QUALITY CONTROL

- Development of a grass cover for the basin floor.
- Utilization of long narrow configurations (width to length ratios of 2:1 and 3:1).
- Installation of inlet/outlet structures at extreme ends of the basin.
- Utilization of baffles and flow retarders.
- Utilization of riser outflow structures instead of ground level pipes to maintain a non-drainable pool and encourage infiltration.
- Construction of detention/retention facilities that are a series of small basins.
- Utilization of underground tile drains for outlet discharge to provide soil filtration of runoff.

PERMANENT WATER FEATURES

INTRODUCTION:

Permanent bodies of water have great appeal in the arid environment of Pima County. The inclination to develop permanent bodies of water within our parks and recreation sites, however, must be tempered by the need to conserve our water resources. Permanent water features may be appropriate at some, but will not be appropriate at all multiple-use detention/retention basin sites.

TYPES OF WATER FEATURES:

There are two types of permanent water features. The first includes swimming pools and fountains. The second includes ponds and small lakes.

Swimming pools may be appropriate at detention/retention sites if there is a community need for this type of facility. Fountains can be justified in highly visible, heavily used public spaces. The requirements for the operation of these facilities are fairly straight forward. Standard procedures for water quality and safety must be observed.

The construction and operation of ponds and small lakes is much more complex. The difficulties, however, should not preclude their development. The Arizona State Comprehensive Outdoor Recreation Plan has identified water based recreational facilities as the number one recreation need in the State. Ponds and small lakes can help address this need. They can also provide the necessary habitat for various types of wildlife. Irrigation water storage is another use for these facilities. If and when developed, several technical issues must be addressed.

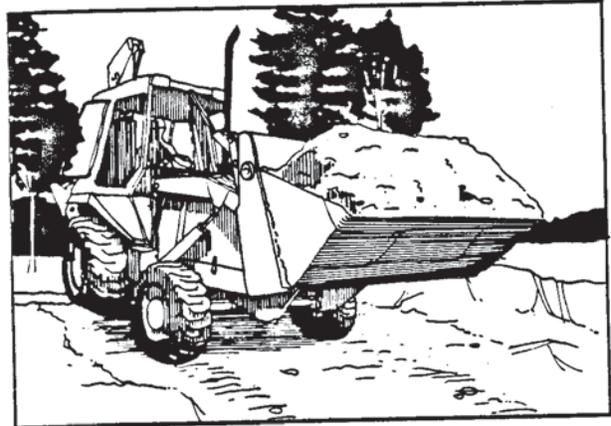
TECHNICAL ISSUES RELATED TO PONDS AND LAKES:

- Water Quality - If storm water is the principal water supply, water quality will be of major concern. The pollution in some urban runoff will preclude it from being used to fill a lake. Even when the quality of the water entering the lake is good, stagnation can be a problem. Aeration, chemical treatments (algaecides), and close monitoring will be necessary.
- Sedimentation - Accumulation of sediments can, over time, fill in a small lake. Sediment traps must be used to remove suspended material before it enters the lake.
- Vector Control - Standing water can serve as a breeding area for disease carrying insects. An on-going program for vector control must be a part of any pond or lake development.

- Augmentation - Extended dry periods in Pima County could result in the evaporation of large amounts of water, enough to eliminate a small lake. Without storm water runoff, other sources of water would be required to maintain minimum water levels.
- Infiltration Control - Pima County soils are typically coarse and will allow for high rates of infiltration. To maintain a lake, it will be necessary to seal the bottom using bentonite, a synthetic membrane, or by other means.
- Public Safety - There are public safety concerns related to any body of water. Unlike a pool, it is often not possible to fence off a pond or lake. With limited control on access to the lake, additional emphasis must be given to the design of safe public use areas at the waters edge.

SUMMARY OF RECOMMENDATIONS:

- Develop permanent water features only when there is a public need for such a facility in the immediate detention/retention basin area.
- Project long term costs for maintenance of water feature before making decision to construct. Recognize that maintenance costs will be high for permanent water features. Ascertain that adequate funds for maintenance will be available.
- Identify specific uses for water feature (i.e., waterfowl habitat) and design to accommodate the requirements for that use.
- Perform detailed study to confirm that water quality can be maintained at acceptable levels.
- Design for safe public use areas around the lake.



INTRODUCTION:

It is important to recognize that some on-going maintenance will be required at all detention/retention basin sites. A quality maintenance program will be of critical importance to the success of basins designed for multiple use.

Basin maintenance will fall into two categories; scheduled and unscheduled. Scheduled maintenance includes those activities such as mowing, pruning, and removal of trash. These activities can be predicted and will be performed on a regular basis.

Unscheduled maintenance will involve the repair of facilities after storms and flooding. The frequency and scope of this type of maintenance cannot be predicted. It is important, however, that adequate funding be provided for "unscheduled" maintenance so that repairs can be made immediately after damage occurs.

DESIGN RECOMMENDATIONS TO MINIMIZE MAINTENANCE:

The design of a multiple use basin can do a great deal to facilitate its maintenance. The following is an outline of design recommendations that can help to facilitate specific maintenance activities.

● Sediment Removal

Sediment will inevitably be deposited in the detention/retention basin. Conditions will be worst during initial years when construction activity in the watershed is greatest.

Design Recommendations:

- Provide stilling basin or fore-basin where most sediment will be deposited.
- Provide controlled vehicular access into the basin for trucks and loaders. Access road grades should be 15% or less. Turning radii should be 50 feet or more and wheel load capacities should not be less than 12,000 lbs.

● Repair of Eroded Slopes

Immediate repair of eroded slopes can minimize cost for this activity. Small areas can be repaired by hand with on-site materials. Large eroded areas are much more difficult and expensive to correct.

Design Recommendations:

- Keep slopes to minimum percentage to reduce likelihood of erosion.
- Provide vegetative or inert material cover on all slopes to minimize erosion.
- Adequately protect slopes subject to moving water or foot traffic. Make detailed evaluation of likely condition and design protection accordingly. Use collector ditches at top of slopes.

● Weed Control

Weed growth can adversely effect; the use, the appearance, and the hydraulic characteristics of a basin. Weed growth needs to be controlled. Extensive use of herbicides in basins where the primary or secondary purpose is ground water recharge is not acceptable.

Design Recommendations:

- Plant or seed all non-paved areas in or around the basin to establish a cover of vegetation. Weed infestation is much less likely in areas with a cover of desirable plants than on disturbed, untreated land.
- Design basins to allow all areas, including slopes, to be accessible by equipment such as flail mowers which can cut or remove unwanted weed growth.

● Maintenance of Low Flow Channels - Drainage Structures

In-basin drainage structures and facilities must be maintained to insure their proper operation. Design can influence maintenance requirements.

Design Recommendations:

- Provide access to channels for loaders and hauling equipment. Provide clear areas, free of trees, to accommodate movement of equipment.
- Provide energy dissipators to prevent damage to channel or structures during high inflow conditions.
- Design structures so that they will not collect debris which could impact their operation.

- Plant Maintenance

Some degree of plant maintenance will be required even when utilizing native, drought tolerant species.

Design Recommendations:

- Select species with growth habits that minimize the need to prune, trim or otherwise maintain.
- Within budgetary constraints, specify and utilize plants that are as large as possible. This will minimize potential damage by users (and abusers) during initial growth seasons.
- Space trees or plant masses so that maintenance equipment can move in and around plant groupings.

- Irrigation System Maintenance

Considerations for maintenance of irrigation system are critical when a permanent irrigation system is installed.

Design Recommendations:

- Specify and utilize equipment that will continue to operate when "contaminated" with sand or other soil deposition.
- Zone and layout system to avoid crossing channels where scour and erosion are likely.
- Increase depth of bury or concrete encase lines (particularly mainlines) that cross channels that are likely to be eroded.
- Install control equipment (other than Remote Control Valves) in areas not subject to inundation.

- Sign, Wall, and Fence Maintenance

For the protection of the public, informational signs and fences must be maintained and kept in good repair.

Design recommendations:

- Utilize signs that are made of aluminum or other durable material that cannot corrode or be burned.
- Secure signs to posts or standards with tamper proof fasteners. Utilize posts or standards that will not be damaged by anticipated use or flooding.

- Locate fences away from areas where they are likely to collect debris and act as dams to incoming water or water moving within the basin.
- Design fences, gates, walls, etc. so that they cannot be damaged or opened during normal area use or by flooding.
- In non-critical areas design fences with "clear-space" at grade to allow water and debris to flow or blow under them.
- Design fences (such as backstops) with break or swing-away panels so that they do not impede critical flows through basin.

- Access Road and Gate Maintenance

It is critical that access control gates be maintained to prevent unauthorized access by motorized vehicles. Access roads for service and maintenance vehicles should be maintained to allow for equipment access to basin whenever needed.

Design Recommendations:

- Locate service drives and gates in readily accessible, but inconspicuous locations so as to not encourage unauthorized use.
- Design access control gates and adjacent areas to be as secure as economically feasible. Initial expenditures for access control can save significant costs in repairs later.

OPERATION AND MANAGEMENT

FACILITY OPERATION AND MANAGEMENT

INTRODUCTION:

Multiple use regional detention/retention basins are new to Pima County. Responsibilities and appropriate procedures for the operation and management of these facilities must be established.

It is assumed that all regional detention/retention basins will be constructed on sites that are owned, or that will be acquired by Pima County. It is assumed that Pima County will retain ownership after detention/retention facilities are constructed.

With flood control being the principal reason for basin construction, the Flood Control District will play an on-going role in the management of these facilities. With anticipated use of basins for recreation and open space it is inevitable that the County Parks Department will also participate in the management of at least some of these facilities.

While the Flood Control District and Parks Department will always have a role in the management of these facilities, it may be desirable to involve other agencies, organizations and institutions. Groups that might be involved include:

- Arizona Game and Fish Department
- School Districts
- University of Arizona
- Pima Community College
- Research Organizations
- Community Organizations
- Local Businesses

The intended uses of each basin will determine if and when outside involvement is appropriate.

MANAGEMENT OPTIONS:

There are several different options that should be considered relative to the management of multiple use detention/retention facilities. These options include:

- Management by Flood Control District:
All operations and maintenance handled directly by Flood Control District personnel.
- Management by Flood Control District with maintenance contractor:
Flood Control District oversees and "operates" facility but contracts with private company for maintenance.

- Management by Parks Department:
Operations and maintenance handled by Parks Department personnel.
- Management by Parks Department with maintenance contractor:
Parks Department oversees and "operates" facility but contracts with private company for maintenance.
- Management by Concessionaire:
Indirect management by Flood Control District and/or Parks Department with direct management by concessionaire who has long term agreement for facility operation.
- Management by other Agency with Use Agreement:
Indirect management by Flood Control District or Parks Department with some other agency or institution charged with day to day operations and maintenance.

FUNDING FOR FACILITY OPERATIONS:

It is critical that long term funding be provided for the operations and maintenance of multiple use regional detention/retention basins. If these facilities are to be operated and maintained by the Flood Control District and/or Parks Department, then adequate moneys must be included in their respective budgets for this purpose. If budgets cannot be increased to meet these needs, then other options should be considered.

There are several other options that might be used to fund, at least in part, the operation and maintenance of these facilities. They include:

- Operation by Concessionaire
An agreement could be developed between the County and a private concessionaire. Under this agreement the concessionaire would be responsible for the operation, maintenance, and possibly the construction of public use facilities.

This option would be most appropriate when uses include active recreation facilities such as baseball/softball diamonds and tennis courts.
- Operation by Use Agreement
Under certain circumstances it may be appropriate for the County to enter into a use agreement with an institution or commercial organization. The organization would be charged with the maintenance of the basin in return for use of all or part of it.

With this option the County could come to an agreement with an educational institution who would use the basin as a research area. The agreement could also be with a private business, such as a nursery, with the basin area used as a field growing area for a specific period of years.

The use to which the basin would be put would have to be compatible with its function as a flood control facility. If an appropriate use were identified, this option could provide "funding" for basin operation and maintenance.

- Enterprise System

The concept of an enterprise system involves the charging of user fees. Fees collected are used to pay for (or partially offset) costs related to facility operation and maintenance. This approach would be possible only when the facilities developed within the basin are such that fees could reasonably be charged for their use. It should be noted that vandalism is typically less of a problem at facilities where admission is charged than at facilities where admission is free.

COMMUNITY INVOLVEMENT IN FACILITY MANAGEMENT:

Community involvement in the operation of multi-use detention/retention facilities can serve to generate interest and concern for a facility rather than neglect or abuse. As such, it should be encouraged whenever possible. Volunteer groups, community service organizations, and community youth groups should be invited to participate in facility operation.

In this regard it is important to realize that it is unrealistic to think such organizations can or will operate and maintain a facility on their own. While they can contribute to this effort, the County must assume primary responsibility for these activities.

MECHANISMS FOR COMMUNITY INVOLVEMENT:

In Pima County there is a very strong Little League organization. It has made a significant contribution to the construction and maintenance of playing fields and related facilities. Through organizations such as the Little League and "Adopt-a-Park" program might be established.

Other organizations such as garden clubs might also be involved. Through the provision of free space for club activities, the County might be able to generate some assistance for its operations and maintenance programs.

SOCIAL / COMMUNITY ISSUES

INTRODUCTION:

Most Tucsonans are aware of the seasonal flood hazard. However, many Tucsonans are probably not aware of what is being done to alleviate the problem. Disseminating information on flood control and water conservation projects could be very helpful in winning the public support on future regional detention/retention basin development.

METHODS:

There are a number of mediums available for getting the message to the public. These include:

- Brochures on the county's flood control (emphasis on retention/detention basins) and water conservation projects. These brochures could be included in the SAWARA handout.
- Films or video tapes of flood control and water conservation projects. These could be loaned to organizations and used for education of citizens groups involved in retention/detention basin design.
- Development of an educational package for children on flood control and water conservation projects. This package could include video tapes, brochures and field trips to flood control and water conservation projects around town. This project could be carried out through coordination with the school districts.
- An Arizona Illustrated program on flood control.
- Newspaper feature article on flood control and water conservation.
- A pilot multiple use regional detention/retention basin should be developed by the county as a demonstration project.

CITIZEN PARTICIPATION

INTRODUCTION:

Prior to the 1960's planning was the exclusive domain of planning professionals. In the 1960's, in an effort to induce cooperation in urban renewal projects, the planning process was opened up to citizens participation. The City of Tucson established a citizens participation office in 1968. It is generally recognized that there is wisdom in the people and their input and recommendations are crucial in the planning process.

BENEFITS OF CITIZEN PARTICIPATION:

- Citizens are a valuable source of information and help improve the effectiveness of planning decisions.
- Citizen participation forces planning agencies and developers to be accountable for their actions.
- Citizen participation stimulates creativity.
- Citizen participation is a way of protecting individual and collective rights.
- It is a device for organizing approval and support for planning and program goals.

INVOLVING CITIZENS

Citizens should be involved in all phases of the design process, from the pre-design phase to the construction/maintenance phase. There are a number of advantages to involving citizens in all phases of a project.

- Pre-Design Phase (General area a detention/retention basin is to be located is identified)
 - Allows the County the opportunity of educating residents on the benefits and possible uses of detention basins.
 - Allows the residents the opportunity of being part of the planning process from the very beginning. This will help eliminate misconceptions about what is being planned for the area and limit the potential of adversary roles developing.
 - Allows neighborhood residents to strengthen neighborhood associations.

- Preliminary Design Phase (In this phase detention/retention basin location is decided)
 - Allows the County the opportunity to determine the area residents wants and needs.
 - Allows the County the opportunity of making residents aware of the site's opportunities and constraints.
 - Allows for development of a plan that is acceptable to both the County and area residents.
- Construction and Maintenance Phase
 - Keeps the neighborhood involved in the project.
 - Encourages the idea that the completed design is a shared responsibility.

METHODS OF NOTIFYING CITIZENS:

- Newsletters

The initial newsletter should introduce and explain the planning process, describe and identify problems and announce public meetings.
- Newspapers
- Announcements posted in the area (Shopping centers, community centers)

SETTING UP MEETINGS AND WORKSHOPS:

- Announcement of public meetings should be given a minimum of one week in advance.
- The location chosen for the public meetings should be central to the area residents. The location of the meeting place should be the same for each meeting.
- Out of state consultants should not conduct public meetings. Out of state consultants are perceived to be unaware and insensitive to the neighborhoods concerns.
- Ample time should be allotted for discussion.

METHODS FOR DETERMINING USER NEEDS:

- Neighborhood Forum

Ideas and problems are discussed by all members of the group. No distinction is made between professionals and residents.

- Workshops in which brainstorming, role playing and gaming can take place.

- Personal interviews

- Mailed Questionnaires

Before choosing among these techniques there are a number of considerations that need to be taken into account. These are:

- The type of information sought must be identified.
- The cost of each technique must be considered.
- The phase of the design process at which the technique will be employed must be considered.

RECOMMENDATIONS FOR SUCCESSFUL CITIZEN PARTICIPATION:

- Keep area residents informed about plans for their area.
- Involve area residents as early as possible and in all phases of the planning process.
- Keep the lines of communication open between area residents and all of the agencies involved.
- Deal with each issue separately, particularly controversial issues.

**RECOMMENDED PLANNING
PROGRAMMING & DESIGN PROCESS**

RECOMMENDED PLANNING, PROGRAMMING AND DESIGN PROCESS

INTRODUCTION:

The construction of regional, multiple-use detention/retention basins is new to Pima County. The planning and development of such basins will require cooperation between; departments within County government, intergovernmental agencies, and community organizations. Transportation and Flood Control will have the primary responsibility for the development of detention/retention basins. Other departments, however, should also participate in the process. These include; Parks and Recreation, Planning and Development Services, and Risk Management.

A detailed process for the development of detention/retention facilities from concept to completed project does not exist. The intent of this chapter is to outline such a process. An eight step process is outlined below. The first two steps are general flood control planning activities and do not relate to a specific detention/retention facility. The remainder of the steps are project specific.

In conjunction with each major step there is a list of agencies and groups that might be involved in that phase of the project. Similarly there is a list of principal steps or activities. The participation of each of these agencies and the performance of each activity may not be required for each and every project. Similarly, the participation of groups and the performance of tasks not mentioned may be appropriate.

GENERAL FLOOD CONTROL PLANNING

① GENERAL EDUCATIONAL PHASE



② DRAINAGE BASIN/WATERSHED PLANNING PHASE



PROJECT PLANNING, DESIGN AND CONSTRUCTION

③ ALTERNATE SITE IDENTIFICATION AND EVALUATION PHASE



④ SITE SELECTION PHASE



⑤ PROGRAMMING AND PRELIMINARY DESIGN PHASE



⑥ DETAILED DESIGN PHASE



⑦ CONSTRUCTION PHASE



USE AND MAINTENANCE

⑧ OPERATIONS AND MAINTENANCE PHASE

- Objective: To develop within the community an understanding of the function and cost advantages of detention/retention as a flood control mechanism, and to develop an understanding of the potential for multiple use of these facilities.
- Time Frame: On-going with start up as soon as possible.
- Agencies/Groups Involved:
1. Pima County Flood Control District
 2. Local Print and Electronic Media
 3. School Districts
 4. Community Service Groups
- Principal Steps:
1. Implementation of Pilot Study
 2. Development of Informational Literature, Films, etc.
 3. Liaison with Community Groups, Schools, etc.
- End Product: A general community understanding of the function of detention/retention and the opportunity for multiple use. A completed demonstration/pilot project.

- Objective: General determination of need for and appropriateness of regional detention/retention basin within specific watershed.
- Time Frame: Initial step. Must proceed all other work related to development of a specific regional basin.
- Agencies/Groups Involved:
1. Pima County Flood Control District
 2. Hydrology Consultants
 3. Arizona Department of Water Resources.
- Principal Steps:
1. Hydrologic evaluation of basin
 2. Evaluation and projections for urban development within basin
- End Product: A general determination of need for and viability of regional detention/retention facility within a specific watershed.

- Objective:** Identification of alternative sites that will accommodate flood control requirements.
Establishment of a mechanism for public participation in the planning process.
- Time Frame:** Immediately following drainage basin study. As far in advance of facility development as is reasonably possible.
- Agencies/Groups Involved:**
1. Pima County Flood Control District
 2. Hydrology Consultant
 3. Arizona Department of Water Resources
 4. Neighborhood Groups - Associations
 5. Pima County Planning and Development Services
 6. Pima County Parks and Recreation Department
 7. Landscape Architectural/Planning Consultant
 8. Soils Engineering Consultant
- Principal Steps:**
1. Development of advisory committee consisting of residents in the area.
 2. Identification of sites that meet requirements for flood control detention/retention basin.
 3. Evaluation of natural and physical features within the area by landscape architectural consultant.
 4. Evaluation of social/cultural/demographic conditions within the area by planning consultant.
 5. Evaluation of current and projected open space and recreational needs in area by County Parks Recreation Department.
 6. "Short listing" of potential sites.
- End Product:** A map identifying potential sites with a description of the general constraints and limitations associated with each.

- Objective: Selection of most appropriate and feasible site(s) for basin development.
- Time Frame: Immediately following identification and evaluation of alternative sites. As far in advance of construction as possible to allow for acquisition of required land.
- Agencies/Groups Involved:
1. Pima County Flood Control District
 2. Pima County Planning and Development Services
 3. Pima County Parks and Recreation Department
 4. Landscape Architectural Consultant
 5. Public Participation Consultant
 6. Neighborhood Groups and Associations
 7. Area Residents/Land Owners
- Principal Steps:
1. Detailed evaluation/site analysis of alternative sites by landscape architectural consultant.
 2. Preliminary program development for alternative sites by neighborhood groups with public participation consultant.
 3. Concept Plan development for alternative sites by Flood Control District and Landscape Architectural consultants.
 4. Cost analysis for land acquisition and construction at alternative sites.
 5. Interagency review with Planning, Parks, ADWR, others asked to review and make recommendations.
 6. Public Meeting(s) - presentation of site alternatives, solicitation of public comment.
 7. Selection of site.
 8. Development of Detailed Scope of Work for design and engineering consultants.
- End Product: Selected site with documents as needed to initiate acquisition proceedings.

- Objective: To develop a program and master plan for multiple use, detention/retention facility.
- Time Frame: After completion of site selection. As far in advance of scheduled facility construction as needed for planning and design activities.
- Agencies/Groups Involved:
1. Pima County Flood Control District
 2. Pima County Planning and Development Services
 3. Pima County Parks and Recreation Department
 4. Landscape Architectural Consultant
 5. Engineering/Hydrology Consultant
 6. Neighborhood Groups and Organizations
 7. Potential User Groups
 8. Pima County Risk Management Department
 9. University of Arizona (Soils, Water and Engineering Department, School of Renewable Natural Resources)
- Principal Steps:
1. Detailed engineering study. Determination of capacity, requirements for inlet/outlet structures, etc.
 2. Preliminary Program of development for facilities and uses to be included.
 3. Alternative design schemes and cost studies.
 4. Interagency review (Parks Dept., Planning Dept., Risk Management, ADWR, etc.). Various agencies asked to review and make recommendations related to alternatives.
 5. Public Meeting - presentation of recommended plan, solicitation of public comment.
 6. Finalization of preliminary program and master development plan.
- End Product: Master Plan and preliminary program for basin development.

- Objective: Preparation of construction documents, specifications, and cost estimates for basin construction.
- Time Frame: After completion and acceptance of master plan and program.
- Agencies/Groups Involved:
1. Pima County Flood Control District
 2. Pima County Parks and Recreation Department
 3. Pima County Risk Management Department
 4. Landscape Architectural Consultant
 5. Engineering Consultant
 6. Soils Engineering Consultant
- Principal Steps:
1. Schematics and Design Development Drawings.
 2. Interagency review.
 3. Construction Documents, Cost Estimates, Specifications, and Bid Documents.
 4. Preparation of long term Operations and Maintenance Plan
- End Product: Bid Ready Construction Documents.

- Objective: Construction of basin and related facilities.
- Time Frame: As needed to implement flood control in specific area. Construction scheduled to minimize impact of seasonal rains. Phasing may be required if funding is provided over a period of time.
- Agencies/Groups Involved:
1. Pima County Flood Control District
 2. Construction Contractor
 3. Landscape Architectural and Engineering Consultants
 4. Neighborhood groups/community organizations
- Principal Steps:
1. Facility Construction.
 2. Participation by area residents to initiate interest and concern for facility.
- End Product: Completed Facility.

- Objective: To operate the facility for intended uses and to maintain the facility to insure proper operation for flood control and safe use by public.
- Time Frame: Commences upon completion of construction and is on-going.
- Agencies/Groups Involved:
1. Pima County Flood Control District
 2. Pima County Parks and Recreation Department
 3. User Groups - Concessionaires
 4. Maintenance Contractor
- Principal Steps:
1. Routine, scheduled maintenance as required to keep facility attractive, operation, and safe.
 2. Unscheduled maintenance and repair to correct damage resulting from major storm events.
 3. Participation by area residents and user groups to create an interest and concern for the upkeep of the facility.
- End Product: A well kept, attractive, safe, usable facility.

APPENDICES



Arizona Commission of Agriculture and Horticulture

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ARIZONA NATIVE PLANT LAW

Arizona Revised Statutes, Chapter 7

ARTICLE 1, PROTECTION

Sec. 3-901 Protected group of plants; botanical names govern; power to add or remove plants.

- A. The botanical names of the plants referred to in this article shall in all cases govern in the interpretation of this article. Protected native plants shall be any plant or part thereof, except its fruit, named in the protected group which is growing wild on state land or public land or privately owned land without being propagated or cultivated by human beings and the dead plants or parts thereof of those plants which are named in subsection C, paragraph 4, of this section.
- B. The following shall constitute certain protected native plants that are prohibited from collection except under permit from the commission of agriculture and horticulture for scientific or educational purposes or threatened by its location or a change in land usage:
Washingtonia filifera (fan palm), *Lysiloma thornberi* (ornamental tree), *Bursera fagaroides* (elephant tree), *Cereus schottii* (senita or "old one"), *Cereus thurberi* (organ pipe cactus), *Toumeyia papryacantha*, *Toumeyia peeblesiana*, *Neoevansia diguetii* (dahlia cactus) *Pediocactus paradinei*, all *Pediocactus* species, all *Schlerocactus* species and all *Agave arizonica*.
- C. The following shall constitute the protected group of plants:
1. All species of the following families: *Liliaceae* (lily family), *Amaryllidaceae* (amaryllis family), *Orchidaceae* (orchid), *Crassulaceae* (orpine family), *Cactaceae* (cactus family).
 2. All species of the following genera: *Aquilegia* (columbine), *Lobelia* (Lobelia), *Dodecatheon* (shooting star), *Frimula* (primrose), *Fouquieria* (ocotillo).
 3. The following species: *Atriplex hymenelytra* (desert holly), *Cercis occidentalis* (western redbud), *Dalea spinosa* (smoke tree), *Holacantha emoryi* (crucifixion thorn), *Fremontia californica* (flannel bush) *Pinus aristata* (bristlecone pine), *Rhus kearneyi* (Kearney sumac), *Sapium biloculare* (Mexican jumping bean) and *Sabastiana pavoniana* (Mexican jumping bean).

4. The following species of live or dead plants or parts thereof shall include: *Prosopis juliflora* (common or honey mesquite), *Prosopis pubescens* (screwbean mesquite), *Cercidium microphyllum* (little leaf palo verde), *Cercidium floridum* (blue palo verde), *Parkinsonia aculeata* (Jerusalem thorn, long leaf palo verde), *Olneya tesota* (ironwood tree).

- D. The Arizona commission of agriculture and horticulture may, after public hearing, add or remove any native plant to or from the protected group. A public hearing on native plants shall be held at least every twelve months.

Sec. 3-902. Prohibition against taking protected native plants without permit, tags and seals or wood receipts; exceptions; fees; salvage; powers of commission

- A. The commission of agriculture and horticulture shall issue permits, tags, and seals for a fee as prescribed by the commission. The fees are as follows:
 1. For *Cereus giganteus* (saguaro), at least two dollars for each plant.
 2. For all native plants except *Cereus giganteus* (saguaro), at least one dollar for each plant.
 3. For wood receipts for live or dead mesquite, palo verde, or ironwood species of trees cut or removed for wood, at least one dollar per cord.
- B. If a state agency engages in large-scale removal of protected native plants from state land, the agency shall notify the commission of agriculture and horticulture at least sixty days prior to commencing removal of the plants. The commission shall make rules as to effect the disposal and salvage of these plants either under permit to other government agencies, nonprofit organizations or sale to the general public or commercial dealers. The commission shall encourage commercial businesses engaged in land development or other activities conducted on private land to salvage protected native plants to the greatest extent feasible. The commission may issue permits to donate, sell or salvage plants after the commission ascertains the validity of the request, and determines the kinds and approximate number of the plants involved. The permit shall specify the number and species of protected native plants and the area from which they may be taken. The state and any agency or political subdivision of the state are exempt from all fees for salvaged plants.

- C. Except as provided for in this article, a person shall not take, transport, or have in his possession any protected native plant taken from the original growing site in this state without having a valid permit in his possession. The commission shall issue permits in a name or business name. A permittee shall attach tags and seals to the plants at the time of taking. A permittee shall make permits, wood receipts, tags and seals available for inspection by an authorized agent of the commission or by any peace officer as provided for in this chapter. A wood receipt, tag or seal is invalid unless it is issued with a valid permit. A permit is invalid unless it bears the tag numbers or wood receipt numbers on its face.
- D. The commission of agriculture and horticulture shall provide tags and seals for each permit issued for the taking, transporting or possessing of protected native plants, except for trees cut or removed for wood as provided for in subsection E of this section. Tags and seals shall be attached to the plant at the time of taking and before transporting. It is unlawful to remove a tag or seal from a protected native plant that has been taken and tagged pursuant to this article before the plant has been transplanted at its designated site. A tag or seal may be removed only by a designated agent of the commission or by the owner of the plant. It is unlawful to take, transport or possess native plants in excess of the amounts listed on a permit. A permit to take, transport or possess protected native plants is nontransferable. Protected native plant fees are nonrefundable. It is unlawful to alter or deface any tag, seal or permit. A permittee is responsible for the actions of persons acting under his expressed or implied authority.
- E. The commission of agriculture and horticulture shall provide wood receipts with each permit authorizing the taking, transporting, or possessing of live or dead mesquite, palo verde, or ironwood species of trees cut or removed for wood. It is unlawful for a person to take, transport, or possess such a tree if he is not in possession of a receipt. A permit or wood receipt is not transferable by the permittee or his agent, nor shall it be used by anyone other than the person to whom the permit and wood receipt was issued, except that the permittee shall transfer the wood receipt to the purchaser of a cord of wood covered by the receipt as proof of ownership.
- F. A person in possession of a valid permit for the removal of dead plants or wood issued by the United States Department of Agriculture or the United States Department of the Interior from lands under the administration of the United States Forest Service or the United States Bureau of Land Management is exempt from the required permit as defined in Section 3-904.
- G. The commission of agriculture and horticulture may promulgate rules for the enforcement of this chapter.

- H. An employee, officer or agent of the commission may enter in or on any premises or other place, train, vehicle or other means of transportation within or entering this state if he has reason to believe there is present in or on such premises or means of transportation a protected native plant taken, transported or possessed in violation of this article.
- I. A power granted pursuant to this chapter to any person may be exercised by a deputy, inspector or agent of the authorized person. A person authorized to enforce this chapter including an employee of a state, the federal government or an Indian agency with which cooperative agreements have been made by the commission has the powers of a peace officer to enforce this chapter.
- J. The commission may enter into agreements with an agency of this state to conduct native plant surveys and appraisals on state land and may collect monies as reimbursement for providing services. Notwithstanding Section 35-148, Subsection A, the commission shall deposit any monies received under this subsection in the special fund created by Section 3-908.

Sec. 3-903. Board of supervisors; power to preserve plants

The board of supervisors of each county is authorized to adopt and enforce ordinances not in conflict with law for the preservation of protected groups of plants.

Sec. 3-904. Taking of plants; permit; tag fees; importation; exceptions.

- A. Except as provided in this article, it shall be unlawful for any person to destroy, dig up, mutilate or take any living plant, or the living or dead parts of any trees, except fruit, of the protected group from state land or public land without obtaining a permit and any required wood receipts or tags and seals from the commission of agriculture and horticulture. It shall be unlawful for any person to falsify any paper or document issued to give permission for any person to take native plants of the protected group or to take more native plants than authorized by the permit or to take native plants from areas other than those authorized by the permit.
- B. The commission of agriculture and horticulture may give written permission for a person or a scientific or educational institution to take a definite number of specified plants in the protected group from areas specified by the commission for scientific or educational purposes. In addition the commission may give written permission for a person to take specific plants or parts of plants in the protected group from areas specified by the commission for manufacturing or processing purposes or for the cutting or removal of wood and assess reasonable and proper fees for such taking of the plants or parts thereof. It shall be unlawful for any person or scientific or educational institution to misuse a permit in any manner.

- C. Permits issued for the removal of native plants, including live or dead mesquite, palo verde or ironwood species of trees, will be for a stated period of time to allow the permittee to remove the specific amount of plants or wood stated in the permit, or that period of time stated by the landowner as part of such landowner's permission, whichever is shorter. Such permit will expire on the termination date shown on such permit.
- D. Any permit provided by subsections A and B shall expire when the tags and seals issued therewith have been attached to the plants covered by such permit and such plants are no longer in the possession of the permittee. Any permit shall be valid until expiration or for one year from date of issuance, whichever occurs first, except that any permit and the tags and seals or wood receipts issued therewith shall be null and void when the land on which the plants are growing, as described in the permit, changes ownership, unless the new owner certifies in writing that the permittee may continue taking such plants as specified on the permit.
- E. Nothing in this article shall be construed to prevent the clearing of land, cleaning or removal of protected native plants from a canal, lateral ditch, survey line, building site, or road or other right-of-way by the owner of the land or his agent if the protected native plants are not to be transported from the land or offered for sale and provided the commission is given at least thirty days notice. Use of dead wood for branding fires or at permissible camping or cooking sites, for camping or cooking fires, is exempt from this section.
- F. Nothing in this article shall be construed to prohibit any person from cutting, removing, transporting or possessing any dead mesquite, palo verde or ironwood as wood in amounts of one cord or less in quantity from land owned or leased by such person, other than state-owned land or other public land, or from land, the owner of which has given written consent to such person to cut, remove, transport or use such wood.
- G. The commission of agriculture and horticulture shall collect fees for the issuance of permits, tags and seals and wood receipts under this article, except for scientific and educational purposes, or for a landowner moving protected plants from one of his properties to another, providing that no such plants are to be offered for sale.
- H. Any protected native plant found without a valid tag and seal securely and properly affixed thereto, or any mesquite, ironwood or palo verde wood found in the possession of a person without a valid wood receipt, may be confiscated as evidence of a violation.

Sec. 3-905. Shipment of plants; exhibition of permit and certificate of inspection to carrier

- A. No person or common carrier shall transport a plant, or any part thereof, belonging to the protected group, nor receive or possess a protected native plant for transportation within or without the state, except for manufactured wood articles, unless the person offering the plant for shipment exhibits to the person or common carrier a valid written permit for the transportation of the plant or part thereof, and has securely and properly attached thereto a valid native plant tag and seal. If for transport without the state, the plant shall also bear a certificate of inspection by the commission. All protected native plant species or varieties, when not grown in Arizona and imported into this state, shall be declared at an Arizona agricultural inspection station or a district office of the commission, and proceed to destination under quarantine orders issued by agents of the commission employed at such station or district office.
- B. Plants of the protected group which are shipped into this state shall be accompanied by all permits, tags and seals required by the exporting state or country.

Sec. 3-906. Arrests without warrant; confiscation of plants

A peace officer or an officer or employee of the commission of agriculture and horticulture may, in the enforcement of this article, make arrests without warrant for a violation of this article which he may witness, and may confiscate plants or parts thereof belonging to the protected group when unlawfully taken, transported, possessed, sold or otherwise in violation of this article.

Sec. 3-906.01 Additional enforcement authority

An officer, employee or agent of the commission of agriculture and horticulture who is duly authorized to enforce this article is authorized in addition to peace officers, to enforce Title 41, Chapter 4.1, Article 4 and Sections 13-3702 and 13-3702.01. Such an officer, employee or agent may make an arrest without a warrant for violations witnessed by the officer, employee or agent and may confiscate archaeological and other specimens or objects if unlawfully excavated or collected.

Sec. 3-907. Violation; classification

- A. A person violating any provision of this article is guilty of a class 3 misdemeanor.

- B. Upon conviction of a violation of this article, all permits issued to the person convicted shall be revoked and the permittee shall be required to surrender any unused tags and seals or wood receipts to the commission and the commission shall not issue new or additional permits to the permittee for a period of a year from the date of conviction. It is unlawful for a person convicted of a violation of this article to act as an agent for any other permittee.
- C. A second offense is a class 1 misdemeanor. Each violation constitutes a separate offense.

Sec. 3-908. Arizona commission of agriculture and horticulture fund

- A. All fees or monies collected under the provisions of this article shall be deposited with the state treasurer at the end of each month, who shall place it in a special fund which is created to be known as the Arizona commission of agriculture and horticulture fund.
- B. Ninety percent of all money deposited with the state treasurer shall constitute a separate and permanent fund for the use of the Arizona commission of agriculture and horticulture in the enforcement of the provisions of this chapter, and ten percent shall be credited to the general fund of this state.

Sec. 3-909. Violation, civil penalty

- A. The knowing violation of this chapter or a rule, regulation or order issued or promulgated under this chapter is punishable by a civil penalty in an amount not to exceed five thousand dollars.
- B. Upon request by the commission of agriculture and horticulture the attorney general may bring an action in the superior court in which a violation of this chapter or any rule, regulation or order is alleged to have occurred. Upon the finding of a knowing violation by the defendant in any such action the court may impose the civil penalty provided by this section in an amount as it deems appropriate for each violation.

Sec. 3-910 Violation of order or injunction; penalty

Any person who violates any order or injunction issued by a court of competent jurisdiction pursuant to this chapter shall, in addition to any other penalty or remedy for contempt of court, forfeit and pay to this state a civil penalty of not more than ten thousand dollars for each violation as the court deems just and proper.

For purposes of this section the superior court issuing any order or injunction retains jurisdiction. The attorney general acting in the name of this state may petition for recovery of civil penalties pursuant to this section.

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