FCD
DON RERRICK

SOUTHEAST PHOENIX REGIONAL DRAINAGE BASIN

DRAFT FINAL BASIN MANAGEMENT PLAN

City of Phoenix
Street Transportation Department
Project No. ST-83120008

July 2002

HDR
2141 East Highland Avenue, Suite 250
Phoenix, Arizona 85016

HDR

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Introduction

The purpose of the Southeast Phoenix Regional Drainage Basin Project is to provide flood control and stormwater management benefits to public, residential and commercial property within and downstream of the nearly five square-mile Southeast Phoenix Regional Basin watershed. The project is intended to significantly reduce flooding of the intersection at 48th Street and Chandler Boulevard and property south and east of the intersection. It is also anticipated to reduce flooding of Salt River Valley Water User's Association (SRP) irrigation facilities in the vicinity. This report is a draft final document until the Santan Channel connection is in place at which time the report will be updated.

Project Background

In 1996, HDR completed a master drainage plan for the rapidly developing area in the vicinity of South 48th Street and Chandler Boulevard for the City of Phoenix. A large regional detention basin was included at 48th Street and Pecos Road, identified as the 48th Street Detention Basin. In 1998 the City of Phoenix also designated the basin site as a city park and purchased 34 acres at the northeast corner of 48th Street and Pecos Road for the multi-purpose facility. In 1998 the Flood Control District of Maricopa County (FCDMC) became a financial participant in the project and the basin site was expanded to 63 acres. The project was renamed the "Southeast Phoenix Regional Drainage Basin Project". *Figure 1- Location Map* shows the location of the basin facility.

The Arizona Department of Transportation (ADOT) also became a participant in 1998 and provided assistance to the City by advanced acquisition of the additional acreage for the basin as part of the right-of-way acquisition activities for the I-10/SR202L Traffic Interchange. ADOT was primarily involved because of the interim interchange (Pecos Road Connector) project and because the 48th Street basin replaces ADOT's Basin 15 in the original design concept for the interchange. The onsite drainage from the interchange is discharged to the basin. The intergovernmental agreements between the City, FCDMC and ADOT are included in Appendix A.

Basin Overview

The project consists of a large primary detention basin (Primary Basin) and associated facilities to retain and treat initial stormwater flows into the basin. The basin complex is designed to protect to the 100-year level. The City of Phoenix intends to develop the facility as a regional park, and the Primary Basin is landscaped and turfed for that purpose. The basin complex includes the Primary Basin, an Equalization/ Sedimentation basin (EQ Basin), two stormwater Treatment Cells along with associated structures, piping, pump stations and miscellaneous items.

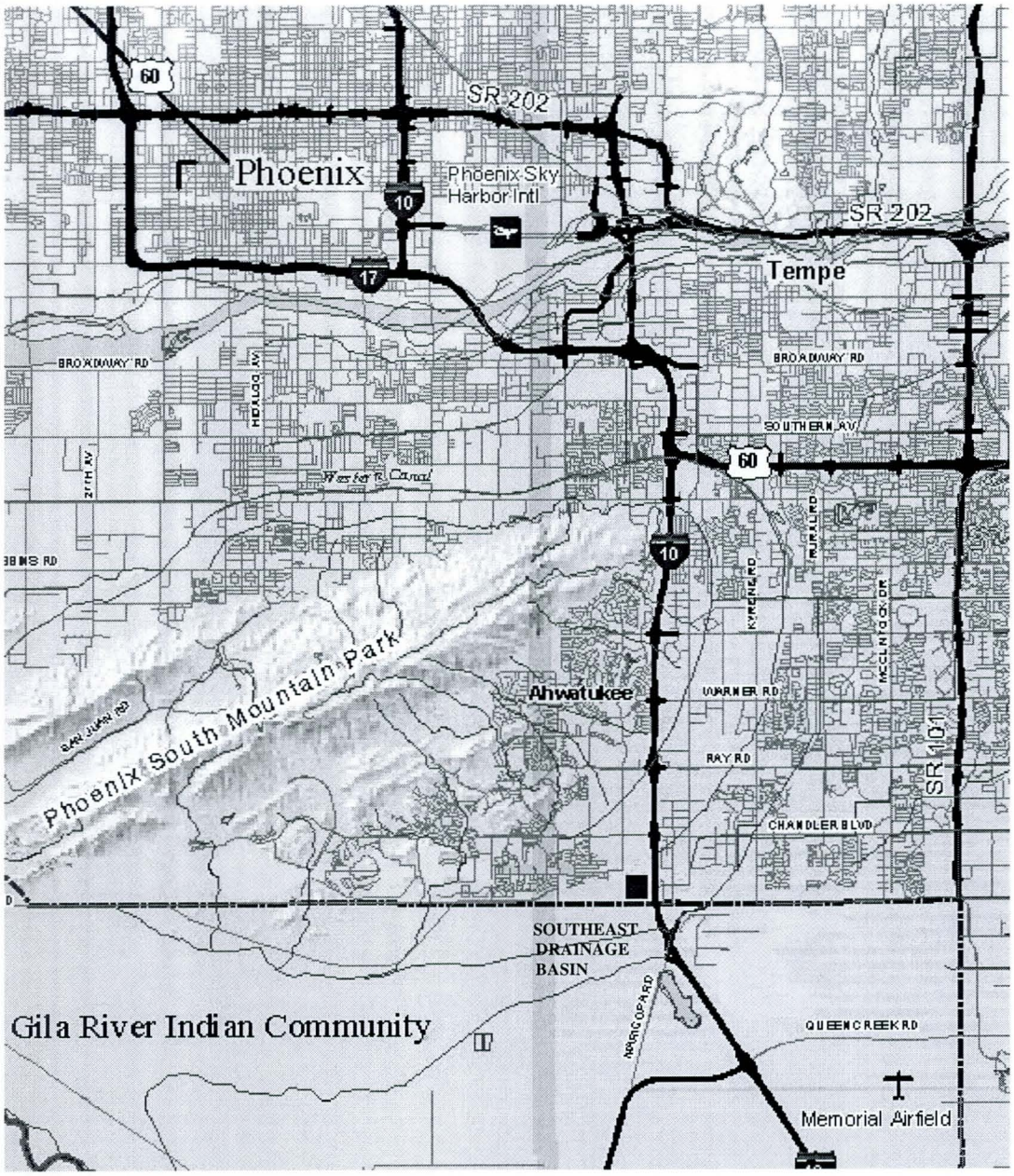


Figure 1 – Location Map

Structures in the basin include a Spillway from the EQ Basin to the Primary Basin, a weir/overflow structure and an emergency spillway at the basin outlet to prevent overtopping of the basin. A number of gate and headwall structures are also required for the basin piping system. Basin piping transfers water to and from the water quality cells and out of the basin complex.

Two pump stations are necessary for the basin operation. The Water Quality Pump Station (WQS) pumps "First Flush" stormwater retained in the EQ Basin to the Treatment Cells. The second pump station, the Evacuation Pump Station (EPS), is required to dewater the basin complex to SRP's tailwater ditch along Pecos Road.

Miscellaneous items in the basin complex include an O & M asphaltic concrete road around the perimeter of the basin, a concrete access ramp in the EQ Basin, perimeter lighting, the Low Flow Channel for the length of the lower basin, chain link fence around the EQ Basin, and handrails along the Spillway crest and Spillway retaining walls. Additionally an Irrigation Booster Pump Station was provided for turf irrigation.

Basin Routing

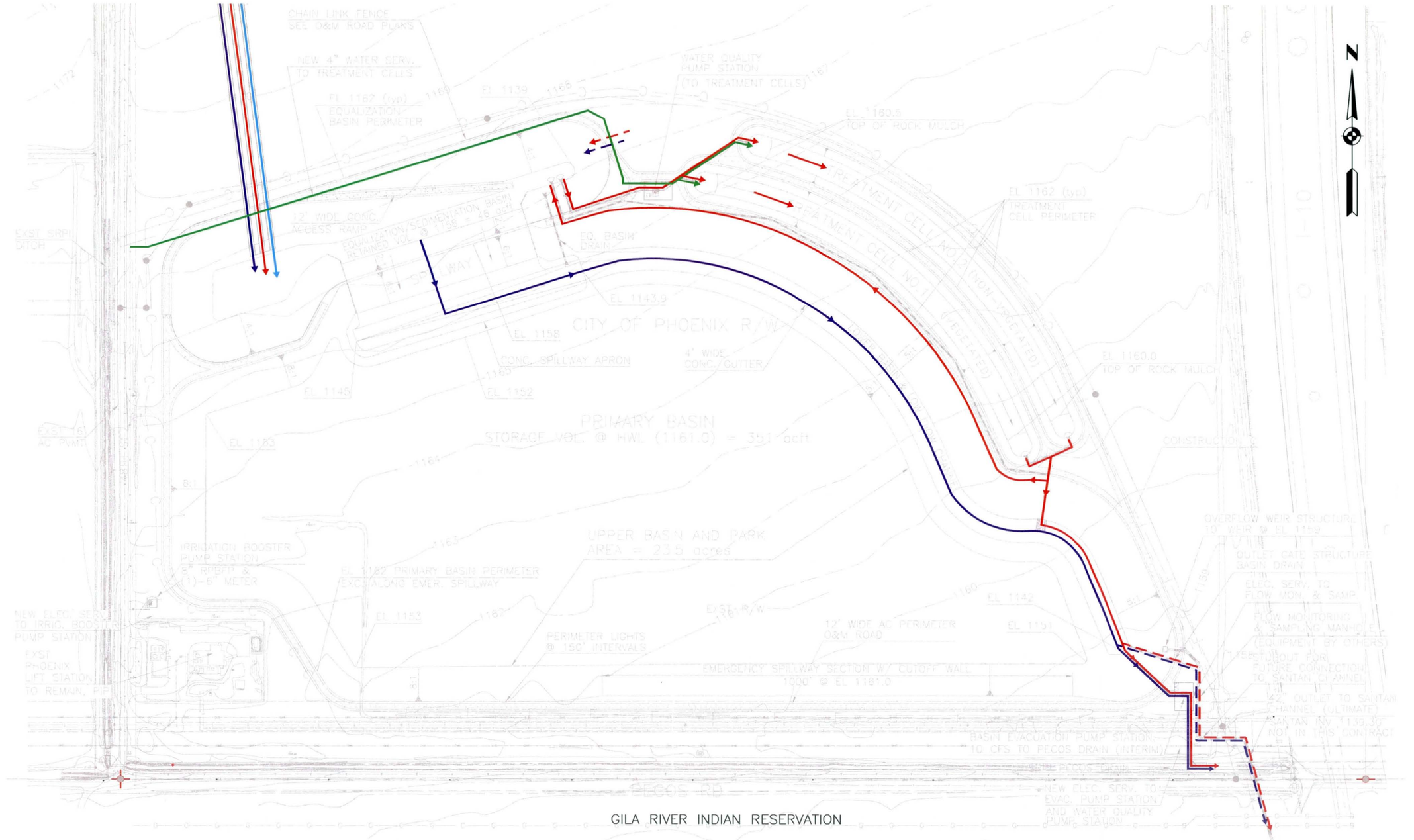
Two types of storm flows are designated for the basin complex. Type I, "First Flush" Storm Event includes the first ¼- inch of rainfall from the contributing watershed. These flows are completely captured and retained in the EQ Basin and are pumped into the Treatment Cells for polishing. After the flowing though the Treatment Cells, the stormwater can be released into the Low Flow Channel, recycled back to the Equalization Basin for more treatment, or can be used to irrigate the plants in the Vegetated Treatment Cell.

The second type of storm considered is a Type II, Large Storm Event. These flows are greater than 46 ac-ft and flow over the Spillway into the Primary Basin. Flows will initially fill the lower basin. Flows exceeding approximately the two-year return period event will begin to flood the upper level of the Primary Basin. Stormwater is then removed from the Primary Basin by the EPS or the future storm drain connection to the Santan Channel.

Figure 2-Stormwater Flow Diagram and *Figure 3-Stormwater Flow Chart* are included to illustrate the routing of storm events though the basin complex.

Component Description

The 100-yr design peak flow into the Equalization Basin from the five square mile watershed is 3,760 cfs. Stormwater can enter the basin through two inlets. A four barrel 10-foot wide by 6-foot high box culvert enters the EQ Basin from the north. The other inlet is a storm drain connection from the new ADOT pump station, which has not yet been completed. This storm drain enters the EQ Basin from the east with a 50-year peak design flow of 160 cfs.



NO.	DESCRIPTION	REV BY	CKD BY	DATE

REVISION BY CITY OF PHOENIX

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REVISION BY CITY OF PHOENIX

- TYPE 1, "FIRST FLUSH" STORM EVENTS
- TYPE 2, LARGE STORM EVENTS
- CITY OF PHOENIX MAKE UP WATER
- SRP MAKE UP WATER
- FUTURE CONNECTION

Two working days before you dig, CALL FOR THE BLUE STAKES 263-1100 Blue Stake Center CALL COLLECT

CITY OF PHOENIX, ARIZONA

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

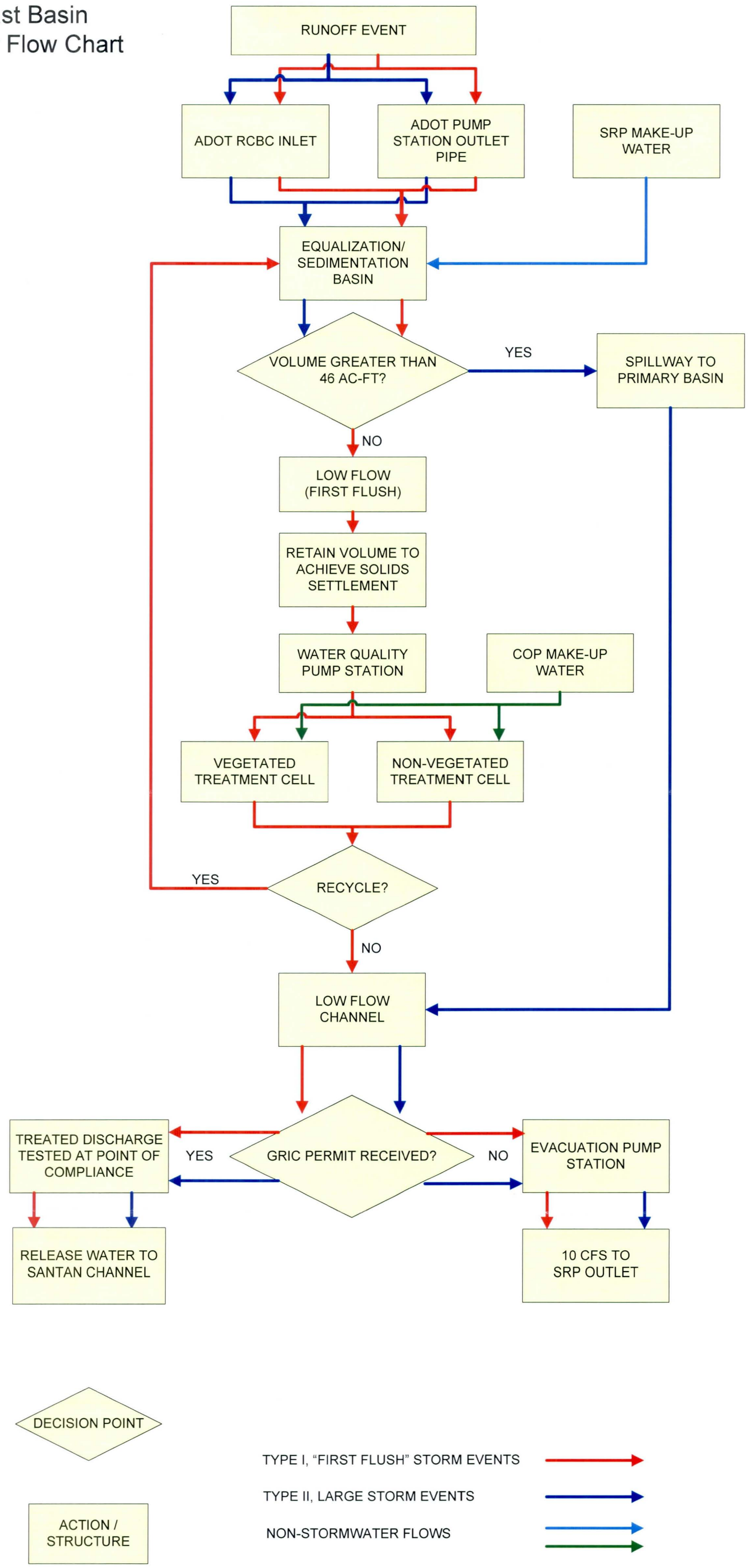
HDR ENGINEERING, INC.
2141 E. HIGHLAND, STE 250
PHOENIX, ARIZONA 85016

SOUTHEAST PHOENIX REGIONAL DRAINAGE BASIN PROJECT
FCD PCN 630-01-30
PHOENIX PROJECT NO. ST-83120008

STORMWATER FLOW DIAGRAM

DR	DES	CK	SHEET NO.	TOTAL SHEETS	AS BUILT
DATE:	DATE:	DATE:			
SCALE: 1"=100'					

FIGURE 2



Stormwater Flow Chart

Figure 3

Equalization / Sedimentation Basin

The purpose of the EQ Basin is two-fold. As an Equalization Basin, the purpose is to capture the "First Flush" stormwater runoff from the contributing watershed. When this initial runoff volume is satisfied, additional runoff will overflow into the Primary Basin. The term "equalization" refers to the fact that when this basin reaches the Spillway crest additional flows are forced over the Spillway into the Primary Basin. When the Primary Basin reaches the Spillway level, the levels of the two basins will equalize.

The second purpose is to provide for removal of sediment by settling, which is desired before the "First Flush" volume is pumped to the Treatment Cells. The settling that occurs in this basin is considered to be a Best Management Practice (BMP) for improving stormwater quality. Captured sediment will be required to be removed for the EQ Basin to work as designed. See *Basin Start-Up and Operation* for more information on the sediment removal schedule. The basin will also capture debris from the watershed that can be removed as required.

If the EQ Basin fills to the Spillway crest, it will take a minimum of approximately 4 days to pump retained flows to the Treatment Cells at the maximum design pumping capacity of 5.6 cfs. The actual pumping rate to the Treatment Cells will depend upon the quality of the water entering and leaving the cells. Resident time for treatment up to 10 days or more could result on much longer times to dewater the EQ Basin. Several days residence time in the EQ Basin is likely sufficient to settle out most of the settleable solids in stormwater. Conserving the available water supply to keep the vegetation and microbes alive in the both cells will also be a factor that will govern how the treatment system is operated. It is recommended that at least 8 to 10 acre-feet (1 to 2 feet in depth) of stormwater be retained in EQ Basin for recycling through the vegetated basin during extended dry periods to minimize the need to use city tap water.

The total allowable volume of the EQ basin is 46 acre-ft and the total "First Flush" volume has been calculated at 26.6 acre-ft. Therefore, up to 20 acre-feet (10 feet deep) could be retained in the basin to irrigate the Treatment Cells during dry periods.

Figure 4 – EQ Basin

When desired, such as when the EQ Basin is full and the water quality is relatively good, the cells can be operated for several days or more as a surface flow system to evacuate excess water in the EQ Basin. The flows can likely be maintained at a high enough rate to prevent mosquito development and if quality is an issue the flows can be recycled indefinitely. When mosquitoes are a potential problem during the summer months the water in level in the cells should be maintained below the rock media to prevent larva development.

The Equalization Basin is equipped with a direct drain to the Low Flow Channel should the basin require rapid dewatering. Because the EQ Basin is four feet deeper than the Low Flow Channel, the EQ Basin cannot be completely dewatered by gravity. The bottom four feet will have to be dewatered by pumping if it is desired to dry out the EQ Basin for periodic cleaning and maintenance. See *Maintenance Procedures* for specific timing of cleaning and dewatering.

Water Quality Pump Station

The Water Quality Pump Station (WQS) pumps water held in the EQ basin to the Treatment Cells for treatment, recycling or discharge. The station has a pumping range of 250 gpm to 2500 gpm to the cells. Three Variable Frequency Drive (VFD) submersible electric pumps (2-1000gpm, 1-500 gpm) are provided and any number can be run at any rate within the range of the VFDs.

Treatment Cells

Stormwater quality arises as an issue in this project because the proposed ultimate outfall is the Santan Channel that will discharge to the Gila Drain Floodway. ADOT is in the process of obtaining a discharge permit from the Gila River Indian Community (GRIC) Department of Environmental Quality to allow the Santan Channel to discharge to the floodway. A draft agreement between ADOT and GRIC is included in Appendix B. Because the City ultimately expects to discharge stormwater to the Santan Channel, it is anticipated that the City will also need to obtain discharge permits from both ADOT and the GRIC. One of the primary conditions of ADOT's permit is that "First Flush" stormwater is to be treated in a passive stormwater treatment system.

The primary function of the Treatment Cells is to provide passive treatment of the "First Flush" stormwater. Dr. Martin Karpiscak of the University of Arizona Office of Arid Lands Research developed the conceptual plan for the cells as described in the attached report entitled *Stormwater Treatment Facility Conceptual Plan*, April 1999 (See Appendix C). The Treatment Cells serve as a Best Management Practice (BMP) to meet GRIC water quality criteria.

There are two treatment cells. One is vegetated with two types of bulrush and the other is non-vegetated at this time. The conceptual design report in Appendix C presents the advantages and disadvantages of surface, subsurface and various hybrid systems that have been evaluated by the Office of Arid Lands Studies. After much discussion on the cost to control mosquitoes in surface and hybrid systems, the City of Phoenix decided upon using a subsurface treatment system that can be operated for short periods of time as a surface flow system. Both cells have a two-foot thick layer of river run rock mulch

of one to three-inch size that will provide a porous media for subsurface flow and treatment, and will keep the vegetation alive in the vegetated cell without propagating mosquitoes. The cells are provided to treat "First Flush" stormwater prior to discharge onto the Gila River Indian Reservation.

The primary function of both of the cells is to reduce relatively low concentrations of nutrients such as Nitrogen and Phosphorous, and suspended solids. The daily flow volumes and the concentrations are not predictable for stormwater. The concentration of these constituents in typical "First Flush" stormwater is quite low. However, storms producing a significant amount of runoff in Phoenix occur very unpredictably, and concentrations of any particular storm can vary considerably from one event to the next.

Low initial concentrations and unpredictability of runoff volumes argue against a design approach based upon a residence time. Instead, the basins have been designed to have a great deal of flexibility in operation. The Water Quality Pump Station volume can be manually adjusted to vary the flow rate to the cells. Additionally, treated stormwater can be discharged to the Low Flow Channel or recycled to the EQ Basin for storage and/or further treatment.

It is to be emphasized that this is an experimental design with the conclusions and recommendations supplied after testing determining if either of these Treatment Cells provides adequate results.

Spillway

A 400-foot long Spillway leads from the EQ Basin to the Primary Basin. Large Storm Events overtop the Spillway and enter the Primary Basin.

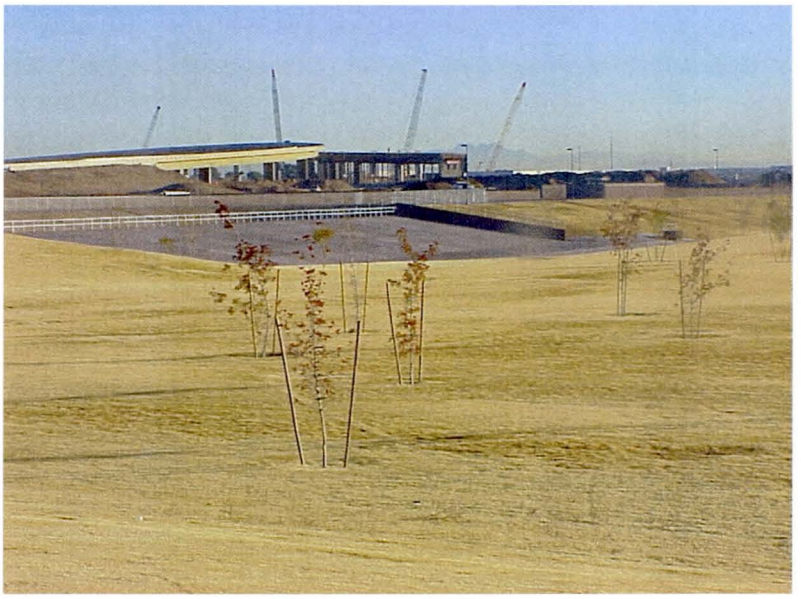


Figure 5 – Spillway

Primary Basin

The 351 acre-foot Primary Basin is turfed and landscaped to provide a large open and grassed area for regional park development. The Primary Basin holds stormwater greater than the "First Flush" volume. This basin is a multi-use basin and responsibility for grass up-keep is through COP Parks and Recreation Department. Excess water from grass irrigation may build up in the Low Flow Channel area and will need to be pumped to the Pecos Drain periodically.

Low Flow Channel

The Low Flow Channel is lower than the Primary Basin in elevation and collects the stormwater and channels flows towards the Evacuation Pump Station.

Evacuation Pump Station

The Evacuation Pump Station (EPS) is a temporary pump station used to remove water from the Primary Basin and Low Flow Channel. The EPS contains two 10-cfs (1-primary and 1-backup) submersible electric pumps with VFDs. Water is pumped to SRP's Pecos Drain. A two-year agreement between SRP and the City of Phoenix specifies that a maximum rate of 10 cfs may be discharged. The EPS will be used until the primary 42" storm drain outlet can be connected to the Santan Channel. The agreements between SRP and the City are included in Appendix D.

The EPS will be the only means to dewater the basin complex stormwater until the City obtains a permit from the Gila River Indian Community (GRIC) to discharge to the Santan Channel. It will take two to three weeks of continuous pumping to completely dewater the Primary Basin if it is full, at a rate of 10 cfs. Although this exceeds the recommended evacuation time of 36 hours, the recommended time will be exceeded only in very rare events above the 50-year event. In the interim period, the basin will not provide the full 100-year protection that will be provided when the 42-inch outlet is functional.

Future Santan Channel Outlet

A future gravity outfall has been designed to discharge water to the Santan Channel. Part of 42" permanent outlet to the channel has been constructed in this phase of the project. The remaining 42" line will not be constructed until a discharge agreement between the GRIC DEQ and City of Phoenix is in place to release water.

A gate structure at the outlet will have a manually operated slide gate that will normally be closed. This gate will be opened to dewater the basin post event when adequate capacity in the Santan Channel is available. When the 42-inch outflow pipe is connected, the full basin (100-year event) can be dewatered in approximately two days.

Overflow Weir & Emergency Spillway

A uncontrolled overflow weir is located at the basin outlet to avoid having to raise the basin another two to three feet to contain the entire 100-year 24-hour flow volume. A 10-foot long weir limits the high water level in the basin and provides one foot of freeboard

as requested by the FCDMC. Also, the uncontrolled discharges from the basin that occur late in the storm were determined not to increase the 100-year peak discharge in the Santan Channel.

Point of Compliance & Flow Monitoring and Sampling Manhole

The Point of Compliance for discharging stormwater is located at a manhole just east of the Evacuation Pump Station. It is designated as the location for the flow monitoring and sampling equipment that is anticipated to be required for the discharge permit. This equipment will be installed when the 42-inch outlet pipe is connected to the Santan Channel. Sampling will occur automatically during a discharge event and results will be provided to GRIC for post event review.

Irrigation Booster Pump Station

An Irrigation Booster Pump Station is provided at the southwest corner of the site for turf irrigation. The COP Parks and Recreation Department will contract out maintenance for the pump station.

Piping

24-inch storm drain piping has been installed to allow for recirculation of the stormwater for additional treatment. Additionally, piping was installed at the southeast corner of the Primary Basin for pumping to the Pecos Drain and future outlet to the Santan Channel.

Water Service Line

A City water supply is also provided to maintain the Treatment Cells during dry periods. A 4" water service has been connected to the City's 12" water main on the east side of 48th Street. The 4" main splits into two 2" supply lines, one to each cell. Each of the 2" lines has a propeller meter to allow the operator to determine the volume of water going into the cell. COP tap water can be used to water the Treatment Cells when required. However, it is highly recommended that stormwater or SRP irrigation water be utilized for cost savings purposes. SRP presently discharges irrigation tailwater into the EQ Basin. Although these discharges are intermittent, they can provide an additional source of water to maintain cell growth.

Gate Structures

The gate structures are equipped with manually operated gates. All of the gates are assumed to be normally in a closed position. They will be manually opened when it is desired to pump flows to the Treatment Cells or dewater the basin complex. None of the operations in the basin complex are automated other than the irrigation system.

Maintenance Procedures

Primary Basin

The Primary Basin was designed to be a 351 ac-ft multi-use basin with future recreation fields. All maintenance for the Primary Basin including trees, grass irrigation piping and the Irrigation Booster Pump Station shall be maintained by COP Parks and Recreation Department. Damage repair to the basin due to large floods is also the responsibility of

the COP Parks and Recreation Department. The basin should be monitored weekly for mosquitoes. The Maricopa County Environmental Services Vector Control will monitor if asked. Construction Plans should be sent to the County for notification of the area for inspection. Treat mosquitoes, if necessary, by method that will not adversely affect water quality.

Maintenance Required	Inspect	Timing	Number of Staff	Approximate Hours	Group Responsible
Mow turf	Turf Condition	Every 2 weeks	3	8	COP PRD
Water turf	Turf Condition	Daily	N/A	N/A	COP PRD
Trees and shrubs up-keep	Condition	As needed	2	Unknown	COP PRD
Post event repair Clean out silt from basin if required.	Turf, trees, future fields / park amenities	After each rain event as required	Unknown	Unknown	COP PRD
Irrigation Booster Pump Station maintenance	Valves, pumps	Quarterly	1	3	COP PRD Contracted out
Sprinkler & Piping maintenance	Heads, PVC piping	As needed	1	Unknown	COP PRD
Future field striping	Fields	Monthly	2	8	COP PRD
Raking	Primary Basin / Low Flow Channel	When needed	1	4	COP PRD
Dewatering basin	Low Flow Channel outlet	When required	1	Unknown	COP Street Maintenance
Weed & Trash Removal	Primary Basin / Low Flow Channel	Every 2 weeks	2	4	COP PRD
Graffiti Removal	Irrigation Booster Pump Station	Monthly	1	2	COP Neighborhood Services
Mosquito Control Treat if required	Basin	Weekly	1	1	COP Street Contacted Out

Equalization Basin

The Equalization Basin requires monthly maintenance for weed control. Additionally, the EQ Basin should be evaluated twice a year for erosion. Sediment should be removed from the bottom of the basin maintaining the volume required for storage. A concrete access ramp is provided for that purpose. Fences and handrail shall be inspected to deny public access to the basin. The basin should be monitored weekly for mosquitoes. The Maricopa County Environmental Services Vector Control will monitor if asked. Construction plans should be sent to the County for notification of the area for inspection. Treat mosquitoes if necessary by method that will not adversely affect water quality. A depth gage and rain gage are recommend for installation. See *Basin Start-up and Operation* for more detail.

Maintenance Required	Inspect	Timing	Number of Staff	Approximate Hours	Group Responsible
Control weeds	Side slopes and bottom of basin	Monthly	1	4	COP Street Maintenance
Remove sediment	Bottom of basin for sediment deposition	Twice /year	4	8	COP Street Maintenance
Inspect concrete integrity	Concrete access ramp	Monthly	1	1	COP Street Maintenance
Fence, gate & handrail inspection	Chain link fence and access gates for integrity	Monthly	1	1	COP Street Maintenance
Release water if required	Water depth	Weekly	1	1	COP Street Maintenance
Mosquito Control Treat if required	Basin	Weekly	1	1	COP Street Contacted Out

Water Quality Pump Station

The Water Quality Pump Station includes three Flygt pumps and corresponding electrical controls to move water from the EQ Basin to the Treatment Cells. The pumps and electrical equipment must be maintained according to the requirements of the manufacturer. Contact electrical and pump supplier shown in the *Contacts* section for further information. Valves shall be exercised twice a year to prevent freezing. Graffiti on the pump station walls will need to be removed or painted over. Gates should be inspected regularly to maintain security.

Maintenance Required	Inspect	Timing	Number of Staff	Approximate Hours	Group Responsible
Pump start up / maintenance	Start pumps and check oil supply & color. Follow manufactures recommendations for pump maintenance.	Twice /year	1	4	COP Street Maintenance
Exercise valves	Valve stems and wheels	Twice /year	1	1	COP Street Maintenance
Control panel inspection	Control panels, lights indicators and switches according to manufacturers recommendations	Twice /year	1	4	COP Street Maintenance
Block fence & gate inspection	Block walls for graffiti and access gates for integrity	Monthly	1	1	COP Street Maintenance

Maintenance Required	Inspect	Timing	Number of Staff	Approximate Hours	Group Responsible
Inspect wet well & float		Monthly	1	2	COP Street Maintenance
Inspect stilling well & float		Monthly	1	2	COP Street Maintenance

Evacuation Pump Station

The Evacuation Pump Station contains two Flyght pumps and must be maintained according to the pump and electrical requirements of the manufactures. Electrical components should be inspected twice a year. Graffiti on the pump station walls will need to be removed or painted over. Gates should be inspected regularly to maintain security. Valves shall be exercised twice a year to prevent freezing. Contact electrical and pump supplier shown in the *Contacts* section for further information.

Maintenance Required	Inspect	Timing	Number of Staff	Approximate Hours	Group Responsible
Pump start up / maintenance	Start pumps and check oil supply & color. Follow manufactures recommendations for pump maintenance	Twice /year	1	4	COP Street Maintenance
Exercise valves	Valve stems and wheels	Twice /year	1	1	COP Street Maintenance
Control panel inspection	Control panels, lights indicators and switches according to manufacturers recommendations	Twice /year	1	4	COP Street Maintenance
Block fence & gate inspection	Block walls for graffiti and access gates for integrity	Monthly	1	1	COP Street Maintenance
Inspect wet well & float		Monthly	1	2	COP Street Maintenance
Inspect stilling well & float		Monthly	1	2	COP Street Maintenance

Structures

Headwalls, retaining walls and the Low Flow Channel shall be maintained to prevent damage to the concrete. Graffiti on the headwalls, Spillway and Low Flow Channel will need to be removed or painted over. Valves and gates shall be maintained according to the manufactures instructions. Additionally, the stems, cranks and protective bollards shall be inspected for damage.

Maintenance Required	Inspect	Timing	Number of Staff	Approximate Hours	Group Responsible
Inspect concrete integrity	Headwalls, retaining walls and Low Flow Channel	Monthly	1	1	COP Street Maintenance
Exercise gates and valves	Check stems, bollards, crank and seals	Twice /year	1	2	COP Street Maintenance
Remove graffiti	Headwalls, retaining walls and Low Flow Channel	Monthly	1	2	COP Neighborhood Services

Treatment Cells

Treatment Cells are a form of passive treatment constituting a Best Management Practice (BMP) for stormwater quality. The cells are intended to satisfy the future GRIC discharge permit, which may be similar to the Draft Discharge Agreement between ADOT and GRIC included in Appendix B. Maintenance for the cells will require weeding. Weeds should be hand pulled if possible and chemicals to control weeds should be avoided in order to maintain water quality. Erosion should be monitored on the side slopes along with sediment in the rock to make sure voids are maintained for subsurface flow capacity.

Mosquito monitoring and removal is also required for the system. The Maricopa County Environmental Services Vector Control will monitor if asked. Construction plans should be sent to the County for notification of the area for inspection. Mosquitoes should be controlled by utilizing subsurface flow. Ponded surface water with contact to plants or weeds should be avoided. Chemical sprays should also be avoided due to water quality issues. Treat mosquitoes, if necessary, by method that will not adversely affect water quality.

The Vegetated Treatment Cell will require watering to keep the plants alive. Initial recommendations include watering once a week in the winter and twice a week in the summer. The water schedule should be adjusted according to the initial results to maintain water in the cell. The Non-Vegetated Treatment Cell must also have water in the system for microbacteria to remain alive. Treatment of the stormwater may be less effective without these bacteria in the rock layer. The Non-Vegetated Treatment Cell should also be initially watered once a week in the winter and twice a week in the summer until results determine a schedule to maintain water in the cell.

Watering can occur via the Water Quality Pump Station or City of Phoenix waterline. Currently the water is turned on and left running until water is visible at the surface. It is recommended that several PVC ports be installed to determine the water level below the rock surface. See *Start-up and Operation* for further information. Ideally, the water should be 6" below the surface to prevent mosquitoes while continuing to provide nutrients for the plants and bacteria.

The Bulrush planted in the Treatment Cell is a seasonal plant and goes dormant in the winter months. Treatment still occurs in this time in the rock layer. In the unlikely event that greater than 50% of the plants die out, they should be replaced by a contractor hired by the COP Street Transportation Department.

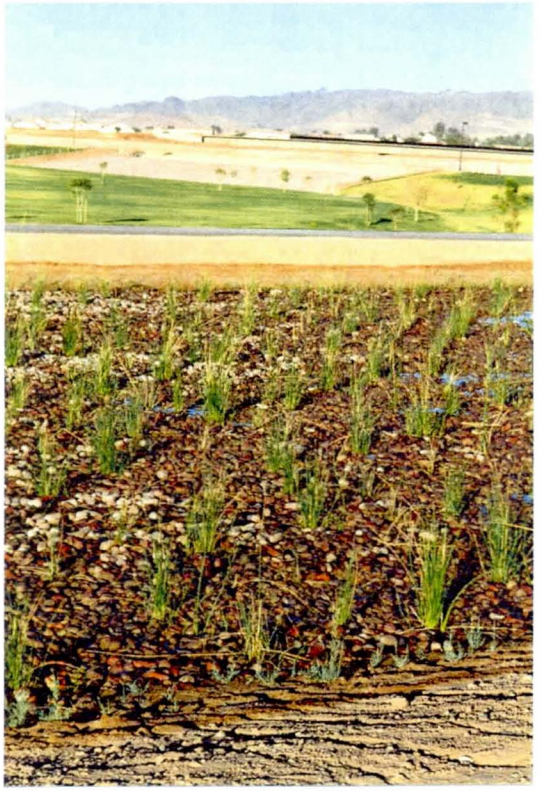


Figure 6 - Treatment Cell

Maintenance Required	Inspect	Timing	Number of Staff	Approximate Hours	Group Responsible
Inspect plant growth	Vegetated Cell	Twice /year	1	1	COP Street Maintenance
Control slope erosion	Side slopes and rock mulch	Twice /year	4	8	COP Street Maintenance
Water plants	Vegetated and Non-Vegetated Cells	Weekly / twice a week depending on season	1	5	COP Street Maintenance
Test water quality	Vegetated and Non-Vegetated Cells	After rainfall events	2	8	COP Street Maintenance
Mosquito Control Treat if required	Basin	Weekly	1	1	COP Street Contracted out
Control weeds	Side slopes and bottom of both cells	Monthly	1	4	COP Street Maintenance

Spillway

The 400 foot long Spillway allows large stormwater flows to spill into the Primary Basin. Maintenance includes graffiti removal and handrail inspection.

Maintenance Required	Inspect	Timing	Number of Staff	Approximate Hours	Group Responsible
Inspect concrete integrity	Spillway	Monthly	1	1	COP Street Maintenance
Remove graffiti	Spillway	Monthly	1	2	COP Neighborhood Services
Handrail inspection for integrity	Spillway	Monthly	1	1	COP Street Maintenance

Operation & Maintenance Road

O & M Road shall be maintained to avoid ruts and potholes. This road is likely to become a path used by the public for jogging, rollerblading and biking.

Maintenance Required	Inspect	Timing	Number of Staff	Approximate Hours	Group Responsible
Remove Sediment	Roadway	Monthly	1	1	COP Street
Inspect asphaltic Concrete	Concrete integrity	Monthly	1	1	COP Street

Basin Start-up and Operation

Equalization Basin

The basin is presently unlined and the side slopes will experience some erosion. Applying shotcrete or soil stabilizer to the side slopes may be an option to protect against erosion in the EQ Basin. DustPro or similar stabilizer should be considered. Concrete may be applied to the bottom of the basin to allow for faster sediment removal. A depth gage should be installed at the bottom of the basin to provide a bottom elevation for sediment removal along with a water depth measurement. MAG Detail 552 modified to 15 feet in height is recommended. Additionally, it is recommended that a rain gage be installed in the basin area. The Flood Control District will install and monitor the rain gage for a one time fee of $3000. Coordination between the Flood Control District and COP is required for installations.

Operation	Locations	Timing	Number of Staff	Approximate Hours	Group Responsible
Control erosion Apply soil stabilizer or shotcrete if required	Side slopes for riling	Twice /year	1	1	COP Street Maintenance
Install MAG Detail 552 modified	EQ Basin bottom				COP Street / FCD
Install Rain Gage	EQ Basin				COP Street / FCD

Pump Station Control

Pump station operators are required to have Level 1 Operators Training. At the request of the City, all pumps have been designed as manually operated however, the equipment for automation control is available for both pump stations. Both pump stations are equipped with automatic low-level and high-level shut-offs. The low-level float switch is located in each wet well to prevent dry pumping operation. Additionally, high-level float switches are installed to prevent flooding of the Treatment Cells and the Pecos Drain. The high-level float for the WQP is located in a PVC stilling well at the inlet end to the Treatment Cells. For the EPS, the high-level float is located in a stilling well at the Pecos Drain. In addition, SRP has installed a valve in the Pecos Drain manhole that must be opened by SRP before the EPS can be operated. SRP must be notified prior to pumping into the Pecos Drain according to the City's license included in Appendix D.

Operation	Locations	Timing	Number of Staff	Approximate Hours	Group Responsible
Turn on pumps	WQPS and EPS	After event	1	2	COP Street Maintenance

Gate Operation

All gates are manually operated. The gates are initially in the closed position. They will be required to be manually opened when it is desired to pump flows to the Treatment Cells or dewater the basin complex.

Operation	Locations	Timing	Number of Staff	Approximate Hours	Group Responsible
Open gates	Throughout basin complex	After event	1	2	COP Street Maintenance

Treatment Cells

It is recommended that perforated PVC ports be installed in both Treatment Cells for determination of water level and monitoring of water quality in the cells.

In the future automated controls such as float switches maybe considered to automatically open and close valves for watering or to provide notification/warning of low water levels in the Treatment Cells. There is no provision for automatically watering Treatment Cells at the present time.

Operation	Locations	Timing	Number of Staff	Approximate Hours	Group Responsible
Install perforated PVC ports	Vegetated and Non-Vegetated Treatment Cells		2	8	COP Street Maintenance

Water Quality Testing

The system should be frequently monitored and sampled by experienced personnel to optimize the performance of the system and to compare the performance of the Vegetated and Non-Vegetated Treatment Cells. Monitoring shall be performed on all elements specified by the permitting agencies such as ADOT or the GRIC DEQ. The draft discharge agreement between ADOT and GRIC allows for some tests to be dropped if the chemical is not found after the first two testing cycles. A list of potential chemicals for testing is included in the draft permit in Appendix B.

It is recommended that performance testing of the Treatment Cells be conducted in the interim until the actual permit is in place. Initial concentrations of "First Flush" stormwater can be tested in the EQ Basin or at the inlet end of the Treatment Cells. Additional Testing should occur at the outlet of the Treatment Cells for comparison between cells and to determine if recycling is required. If the requirements are not met by the Treatment Cells at the end of the first pass, flows can be recycled though the basin complex multiple times to treat the water until qualifications are met or all water is evaporated/infiltrated. Additionally, COP tap water can be integrated into the system to dilute chemical concentrations as required. Once the permit is in place testing should be conducted at the Point of Compliance and results shall be provided to GRIC.

Operation	Locations	Timing	Number of Staff	Approximate Hours	Group Responsible
Water quality testing	Inlet and outlet to Treatment Cells and Point of Compliance	After storm events	2	8	COP Street Maintenance

Future Agreement Possibilities

The basin complex was designed to discharge to the Santan Channel. A discharge agreement is required between COP and GRIC to release stormwater. As discussed previously ADOT and GRIC are developing an agreement for a similar treatment complex. It is in the City's interest to be involved and aware of negotiations between ADOT and GRIC. Contact with GRIC is recommended to gain information on environmental policies and requirements. A consultant may be hired by the City to coordinate this agreement.

Operation	Locations	Timing	Number of Staff	Approximate Hours	Group Responsible
GRIC discharge agreement and coordination		ASAP	1	Unknown	COP Street Contacted out

SRP Tailwater Deliveries

It is possible to receive SRP irrigation water through the RCBC and into the EQ Basin. This water may be a less expensive alterative to using City tap water to keep water in the Treatment Cells. Negotiations must be made with SRP for allocation and allotment fees.

Operation	Locations	Timing	Number of Staff	Approximate Hours	Group Responsible
SRP Water Delivery Coordinate with SRP	EQ Basin		1	4	COP Street Maintenance

Emergency Controls

Possible contaminates may enter the EQ Basin from the box inlet or the ADOT pump station inlet. Since all valves and gates are manual in the complex, low flows can be contained in the EQ Basin and treated before release. Ideally, gas and oils spills on the Pecos Road Connector will be controlled by the ADOT pump station. The normal operating procedure for the ADOT pumphouse during detection of flammable gasses at the stations are as follows:

1) Low LEL detection activates ventilation to attempt clearing of gasses.
2) If LEL continues to rise reaching high level state, pumps are disabled preventing any liquid discharge from wet well to occur.

However, if flows make into the EQ Basin, contaminants will be contained. Communication between ADOT, COP Street and Transportation Department, and local fire and police department is required to prevent release into the system.

Additionally, this site will comply with the City's hazardous waste and illicit discharges policies and also will comply with the City NPDES Permit.

Operation	Locations	Timing	Number of Staff	Approximate Hours	Group Responsible
Emergency treatment	EQ Basin	When required			COP Street Maintenance

Public Access

Public access to the EQ Basin and the Treatment Cells is not recommended. The EQ Basin is fenced by a 6-foot chain link fence and 3'-6" handrail on the Spillway. At the present time, the Treatment Cells and Low Flow Channel are accessible to the public. It is recommended that the cells and the Low Flow Channel be fenced to avoid public access.

Operation	Locations	Timing	Number of Staff	Approximate Hours	Group Responsible
Install fence	Treatment Cells		4	24	COP Street

ADOT Coordination

The Southeast Phoenix Regional Drainage Basin Project is a joint project between the City of Phoenix, the Flood Control District of Maricopa County and the Arizona Department of Transportation. Coordination is required between these entities to make the basin a successful project. ADOT is in the process of building the pump station and outlet into the EQ Basin.

404 Permitting

There are several potential maintenance issues related to Section 404 of the Clean Water Act. When the facilities are connected to the Santan Channel, they could potentially become waters of the U.S. and be subject to regulation under Section 404 because they would be tributary to waters of the U.S. and therefore jurisdictional. However, in any event, the Treatment Cells are excluded from the definition of waters of the U.S. and therefore are not subject to regulation under Section 404. Portions of the Primary Basin and the Low Flow Channel may be jurisdictional under Section 404. A jurisdictional delineation request could be submitted to the U.S. Army Corps of Engineers (USACOE) for a final determination.

Assuming that the Primary Basin and the Low Flow Channel are Section 404 jurisdictional, many routine maintenance activities can be performed without a Section 404 permit including: mowing and trimming vegetation, driving using rubber-tired vehicles, and trash and debris removal. Any ground-disturbing activities may require a Section 404 permit. Such activities should be coordinated in advance through the COP Street Transportation Department 404 liaison and the citywide 404 coordinator.

Manpower Estimate

An initial estimate of manpower includes all the items described above including watering of the Treatment Cells, weed removal, sediment removal, valves and pump station maintenance, checking general condition of the site and water quality monitoring after "First Flush" storms occur to evaluate the level of treatment completed.

Contracting

Many items described above may be contracted out to independent contractors or research groups if it is in the best interest of the City.

Items for possible contracting include the following. See *Maintenance Procedures* and *Basin Start-up and Operation* for more information.

- Irrigation Booster Pump maintenance
- Monitoring and treatment for mosquitoes
- Weed control
- Sediment removal
- Fence, gate and handrail inspection
- Dewatering basins
- Pump maintenance
- Control panel inspection

Wet well / stilling well and float inspection
Valve exercising
Plant growth
Slope erosion
Slope stabilizer
Watering plants
Water quality monitoring
Installation of rain and depth gages
Pump operation
Gate operation
PVC port installation
GRIC discharge agreement
Emergency treatment

Contacts

City of Phoenix Contact:

Steve Kandybowicz
Parks and Recreation Department
602-256-3470

Art Glover, PE
Street Transportation Department
602-262-4055

Mike Loffa
Water Quality / Storm Water Management
602-256-3511

Brian Hendricks
Street Transportation Department & Maintenance
602-256-4337

Pump Contact:

Ed Martin
James Cook & Hobson, Inc.
602-243-0585x1200
fax 602-276-5402

Electrical Contact:

Pete Wekell
Keller Equipment Co. Inc,
602-437-3015
fax 602-437-9141

SRP Contact:

Gerald Bastian, PE
SRP Water
602-236-4609

Dan Hawkins
SRP Power
602-236-8603

Engineering Contact:

Jami Erickson, PE
HDR
602-508-6600

Jerry Zovne, PhD, PE
Parsons Engineering Science
602-852-9110

GRIC Contact:
Glen Stark
Department of Environmental Quality
520-562-2234

ADOT Contact:
John Stepins
Pump Station
602-712-6709

Craig Cornwell
Maintenance
602-712-6585

References

HDR Engineering, "Design Memorandum Southeast Regional Drainage Basin" Prepared for the City of Phoenix and the Flood Control District of Maricopa County, June 1999.

Appendix A

Intergovernmental Agreements

Intergovernmental Agreement
for the
Design, Rights-of-Way Acquisition, Utility Relocations, Construction, and Operation and Maintenance
of the
Southeast Phoenix Regional Drainage Basin Project
Between
Flood Control District of Maricopa County
And
City of Phoenix
98035
October 5, 1998

Intergovernmental Agreement
among
State of Arizona
City of Phoenix
and
Flood Control District of Maricopa County
98035A
March 30, 2000

OFFICIAL RECORDS OF
MARICOPA COUNTY RECORDER
HELEN PURCELL
98-1120457 12/11/98 10:42
LILIAN 4 OF 6

CLERK OF THE BOARD
BASKET PICK UP

Intergovernmental Agreement
for the
Design, Rights-of-Way Acquisition, Utility Relocations, Construction, and Operation and Maintenance
of the
Southeast Phoenix Regional Drainage Basin Project
Between
The Flood Control District of Maricopa County
and
City of Phoenix
C69-99-046-2
IGA FCD 98035

This Intergovernmental Agreement (Agreement) is entered into by and between the Flood Control DISTRICT of Maricopa County, a municipal corporation and political subdivision of the State of Arizona, acting by and through its Board of Directors hereinafter called the DISTRICT, and the City of Phoenix, acting by and through the City Council, hereinafter called the CITY.

This Agreement shall become effective as of the date it has been executed by all parties.

DATE FILED WITH MARICOPA COUNTY RECORDER _____

STATUTORY AUTHORIZATION

1. The DISTRICT is empowered by A.R.S. Section 48-3603, as revised, to enter into this Agreement and has authorized the undersigned to execute this Agreement on behalf of the DISTRICT.

2. The CITY is empowered by Arizona Revised Statutes Section 11-952, as amended, to enter into this Agreement, and is further authorized to enter into this Agreement pursuant to Article II, Chapter II, Section 2 of the Phoenix City Charter, and has authorized the undersigned to execute this Agreement on behalf of the CITY.

BACKGROUND

3. The Flood Control District of Maricopa County (DISTRICT) has been closely coordinating with the City of Phoenix (CITY) and others to resolve recurring flooding problems in the southeast area of the CITY. The CITY has developed a solution to some of these flooding problems that could also serve as an outlet for some of the regional drainage collected in this area. A regional flood control basin and

When Recorded Return to:
Flood Control District of Maricopa County
2801 West Durango
Phoenix, Az. 85009

Intergovernmental Agreement
for the
Design, Rights-of-Way Acquisition, Utility Relocations, Construction, and Operation and Maintenance
of the
Southeast Phoenix Regional Drainage Basin Project
Between
The Flood Control District of Maricopa County
and
City of Phoenix
C 69-99-046-2
IGA FCD 98035

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This Agreement shall become effective as of the date it has been executed by all parties.

DATE FILED WITH MARICOPA COUNTY RECORDER _____

STATUTORY AUTHORIZATION

1. The DISTRICT is empowered by A.R.S. Section 48-3603, as revised, to enter into this Agreement and has authorized the undersigned to execute this Agreement on behalf of the DISTRICT.

2. The CITY is empowered by Arizona Revised Statutes Section 11-952, as amended, to enter into this Agreement, and is further authorized to enter into this Agreement pursuant to Article II, Chapter II, Section 2 of the Phoenix City Charter, and has authorized the undersigned to execute this Agreement on behalf of the CITY.

BACKGROUND

3. The Flood Control District of Maricopa County (DISTRICT) has been closely coordinating with the City of Phoenix (CITY) and others to resolve recurring flooding problems in the southeast area of the CITY. The CITY has developed a solution to some of these flooding problems that could also serve as an outlet for some of the regional drainage collected in this area. A regional flood control basin and

collection system project, called the Southeast Phoenix Regional Drainage Basin Project (Project), is proposed in the vicinity of 48th Street and Pecos Road to resolve some of these recurring flooding problems by providing a 100-year level of protection. The DISTRICT evaluated the proposed Project through its "Procedure for Identifying and Prioritizing Potential Five Year Capital Improvement Program (CIP) Projects" and recommended that it be included in the DISTRICT's CIP.

The CITY and the DISTRICT propose to share equally in all Project costs, estimated to be $7,000,000, for the design, rights-of-way acquisition, utility relocations, construction, and construction management, for the Project.

PURPOSE OF THE AGREEMENT

4. The purpose of this Intergovernmental Agreement is to identify and define the responsibilities of the DISTRICT and the CITY for the design, rights-of-way acquisition, utility relocations, construction, construction management, and operation and maintenance of the Project.

TERMS OF AGREEMENT

5. The DISTRICT shall:

5.1 Contribute fifty percent (50%) of all Project costs, estimated to be $7,000,000, with the DISTRICT's share of design, rights-of-way acquisition, utility relocations, construction, and construction management not to exceed $3,500,000.

5.1.1 Credit the CITY for 50% of the design costs to be applied towards the CITY's fifty percent cost for construction and construction management.

5.1.2 Credit the CITY for 50% of the rights-of-way acquisition costs to be applied towards the CITY's fifty percent cost for construction and construction management.

5.1.3 Credit the CITY for 50% of the utility relocation costs to be applied towards the CITY's fifty percent cost for construction and construction management.

5.1.4 Fund 100% of the construction and construction management costs, and invoice the CITY for its 50% share of the construction and construction management costs, minus the CITY's combined credits for design, rights-of-way acquisition and utility relocations at the completion and acceptance of the construction contract. Construction management costs shall be calculated at 8% of the actual construction costs.

5.2 Be the lead agency for the construction of the Project, including but not limited to the following activities; issue invitations for bids, receive, protect and open bids, determine the lowest responsible and responsive bidder, award the contract, issue the notice to proceed, and provide Record Drawings.

5.2.1 Include construction items at the request of the CITY which are not part of the Project, to be funded 100% by the CITY, plus 8% for construction management.

5.2.2 Invite the CITY to participate in Project meetings, inspections, and acceptance of the completed Project.

5.2.3 Process change orders requested by the CITY, the cost of such change orders to be funded 100% by the CITY, plus 8% for construction management.

5.3 Provide construction management services, at a rate of 8% of the total construction costs, charging the CITY for 50% of those construction management services costs.

5.4 Review and approve the plans and specifications for the Project, and provide review comments to the CITY in a timely manner not to exceed three weeks from receipt of the plans and specifications for review.

5.5 Participate in public involvement activities conducted by the CITY.

5.6 Retain the right to review and approve any future changes to the Project that may affect the design and/or function of the Project.

6. The CITY shall:

6.1 Be the lead agency for the design, for the acquisition of rights-of-way, and for the relocation of all conflicting utilities not relocated during construction.

6.2 Contribute fifty percent (50%) of all Project costs, estimated to be $7,000,000, the CITY's share then being estimated to be $3,500,000. The CITY shall fund all Project costs in excess of $7,000,000.

6.2.1 Fund 100% of the design costs, and inform the DISTRICT in writing of its 50% share of the design costs at the completion of the design contract.

6.2.2 Fund 100% of the right-of-way acquisition costs, and inform the DISTRICT in writing of its 50% share of the land acquisition costs at the completion of the land acquisition process. The CITY shall certify to the DISTRICT that all rights-of-way required for the Project have been acquired prior to the DISTRICT's advertising for construction.

6.2.3 Fund 100% of the utility relocation costs, and inform the DISTRICT in writing of its 50% share of the utility relocation costs at the completion of the relocations.

6.2.4 Reimburse the DISTRICT 50% of the construction and construction management costs, minus the CITY's combined credits for design, rights-of-way acquisition and utility relocations at the completion and acceptance of the construction contract, and upon receipt of an invoice from the DISTRICT. Construction management costs shall be figured at 8% of the actual construction costs. Payment shall be made within 30 calendar days of receipt of the invoice.

6.2.5 The DISTRICT's total cost share contribution for the above Project elements, including design, rights-of-way acquisition, utility relocations, construction, and construction management will not exceed $3,500,000.

6.3 Acquire all permits and licenses required for the construction of the Project prior to the DISTRICT advertising for construction, and shall not charge for any CITY issued permits or licenses required for the Project.

6.4 Provide to the DISTRICT the plans and specifications for the Project for review and approval, and incorporate comments from the DISTRICT as deemed appropriate. If comments are not received within three weeks of submittal of the plans and specifications, the CITY will consider this as acceptance by the DISTRICT of the plans and specifications.

6.5 Designate CITY staff to coordinate the Project with the DISTRICT, to attend construction meetings, to perform inspections, and to accept the Project in writing at the completion of construction.

6.6 Conduct all public involvement activities, and invite the DISTRICT to participate.

6.7 Own, operate and maintain the completed and accepted Project.

6.8 Obtain from the DISTRICT review and approval of any future changes to the Project that may affect the design and/or function of the Project.

6.9 Be responsible for any landscaping and aesthetic improvements to the Project, and be responsible for the operation and maintenance of such landscape and aesthetic improvements.

6.10 Fund 100% of any non-Project items requested by the CITY, and as approved by the DISTRICT, plus 8% of actual costs for construction management services provided by the DISTRICT.

7. Each party to this Agreement may with mutual written agreement of all parties delegate responsibilities to another party. Any delegation, however, shall not relieve the delegating party of its original responsibilities as defined herein.

8. In the case of any dispute over any items in this Agreement, the parties agree to use their best efforts and enter into good faith negotiations to resolve the disputed matters. However, this shall not limit the rights of the parties to seek any remedies provided by law.

9. Each party to this Agreement shall take reasonable and necessary actions within their authority to assure that any water discharged into the Project through their storm drain facilities comply at the point of discharge with any applicable requirements of the Clean Water Act, National Pollutant Discharge Elimination System (NPDES), or any other applicable discharge requirements, including any permit requirements.

10. Each party to this Agreement (indemnitor) shall, to the extent permissible by law, indemnify, defend and save harmless the others (indemnitees) including, agents, officers, directors, governors and employees thereof, from and against any loss or expense incurred as a result of any claim or suit of any nature whatsoever, which arises out of indemnitor's negligent or wrongful acts or omissions pursuant to this Agreement. Such indemnification obligation shall encompass any personal injury, death or property damages resulting from the indemnitor's acts or omissions, as well as reasonable attorney's fees, court costs, and other expenses relating to the defense against claims or litigation, incurred by the indemnitee. Indemnitee shall be liable for their own negligence or wrongful acts as provided by law.

11. All notices or demands upon any party to this Agreement shall be in writing and shall be delivered in person or sent by mail addressed as follows:

Flood Control District of Maricopa County
Chief Engineer and General Manager
2801 West Durango Street
Phoenix, AZ 85009

City of Phoenix
Director
Street Transportation Department
200 West Washington Street, 5th Floor
Phoenix, Arizona 85003

12. Each party to this Agreement will pay for and not seek reimbursement for its own personnel and administrative costs associated with this Project, including but not limited to the following unless specifically identified otherwise in this Agreement: design, land acquisition, inspection, public involvement, permitting, management and administration, and operation and maintenance.

13. This Agreement shall expire ten (10) years from the date of recording with the County Recorder or completion of the Project whichever is the first to occur. However, by mutual written agreement of all parties, this Agreement may be amended or terminated. The operation and maintenance, District review and approval of future changes, and indemnification provisions of this Agreement shall survive the expiration of this Agreement.

14. This Agreement is subject to cancellation by any party pursuant to the provisions of A.R.S. Section 38-511.

15. Attached to this Agreement or contained herein are the written determinations by the appropriate attorneys for the parties to this Agreement, that these agencies are authorized under the laws of the State of Arizona to enter into this Agreement and that it is in proper form.

16. If legislation is enacted after the effective date of this Agreement which changes the relationship or structure of one or more parties to this Agreement, the parties agree that this Agreement shall be renegotiated at the written request of any party. The preceding sentence does not bind any party's governing board in any way to accept or approve any amendment or changes to this Agreement.

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
A Municipal Corporation

Recommended by:

11/5/98
Michael S. Ellegood, P.E. Date
Chief Engineer and General Manager

Approved and Accepted:

By: Jan Brewer
Chairman, Board of Directors

Attest:

By: Jan McCarroll DEC 0 2 1998
Clerk of the Board Date

The foregoing Intergovernmental Agreement IGA FCD-98035 has been reviewed pursuant to Arizona Revised Statutes 11-952, as amended, by the undersigned General Counsel, who has determined that it is in proper form and within the powers and authority granted to the Flood Control District of Maricopa County under the laws of the State of Arizona.

Kelli M. Lynn 11/6/98
General Counsel Date

CITY OF PHOENIX

CITY OF PHOENIX, a Municipal Corporation
Frank Fairbanks, City Manager

By: _____ 11/20/98
James H. Matteson, P.E. Date
Street Transportation Director

Attest:

By: _____
ACTING City Clerk Date

The foregoing Intergovernmental Agreement IGA FCD-98035 has been reviewed pursuant to Arizona Revised Statues 11-952, as amended, by the undersigned attorney who has determined that it is in proper form and within the power and authority granted to the City of Phoenix under the laws of the State of Arizona.

By: _____ 11/13/98
Acting City Attorney Date
RB

AG Contract No. KR99-2830-TRN
ADOT ECS File No. JPA 99-197
Project: Santan, 202L
Section: Southeast Phoenix Regional Drainage Basin (48th Street/202L)
TRACS No.: H 5087 01C
IGA FCD 98035A (Amendment)
C69. 99.046.2-01

INTERGOVERNMENTAL AGREEMENT
AMONG
THE STATE OF ARIZONA,
THE CITY OF PHOENIX
AND
THE FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

90787

THIS AGREEMENT is entered into ~~MARCH 15~~ March 30, 2000, pursuant to Arizona Revised Statutes, Sections 11-951 through 11-954, as amended, between the STATE OF ARIZONA, acting by and through its DEPARTMENT OF TRANSPORTATION (the "STATE"), the CITY OF PHOENIX acting by and through its CITY MANAGER, (the "CITY") and the FLOOD CONTROL DISTRICT OF MARICOPA COUNTY, acting by and through its BOARD OF DIRECTORS (the "DISTRICT").

I. RECITALS

1. The STATE is empowered by Arizona Revised Statutes Section 28-401 to enter into this agreement and has by resolution, a copy of which is attached hereto and made a part hereof, resolved to enter into this agreement and has delegated to the undersigned the authority to execute this agreement on behalf of the STATE.

2. The CITY is empowered by Chapter II, Section 2.i. of the City Charter to enter into this agreement and has by resolution, a copy of which is attached hereto and made a part hereof, resolved to enter into this agreement and has authorized the undersigned to execute this agreement on behalf of the CITY.

3. The DISTRICT is empowered by Arizona Revised Statutes Section 48-3603 to enter into this agreement and has by resolution, a copy of which is attached hereto and made a part hereof, resolved to enter into this agreement and has authorized the undersigned to execute this agreement on behalf of the DISTRICT.

4. The CITY in conjunction with the DISTRICT, has programmed the construction of the Southeast Phoenix Regional Drainage Basin on the south-east corner of the future intersection of the SR 202L and 48th Street, herein referred to as the "PROJECT", and executed an intergovernmental agreement (IGA), under Flood Control District (FCD) No. 98035 on December 2, 1998, attached hereto by reference, addressing the design and construction of the PROJECT. Design of the PROJECT has been completed.

5. The purpose of this agreement is to define the responsibilities for the construction of the PROJECT on STATE's right-of-way.

THEREFORE, in consideration of the mutual agreements expressed herein, it is agreed as follows:

NO. 23912
Filed with the Secretary of State
Date Filed: 03/30/00
Betsey Bayless
Secretary of State
By Vicky D. Shoenewald

II. SCOPE OF WORK

1. The STATE:

a. Will use its best efforts to acquire and dedicate to the PROJECT, at its sole cost and expense, approximately 28.7 acres of land needed for the construction of the PROJECT. The cost of such right of way is approximately $4,500,000.00. The legal description of the property the State is acquiring, to be utilized as a detention basin, is described on Exhibit "A", attached hereto and made a part hereof,

b. The above referenced property which is land locked, will become a drainage basin for runoff from adjacent STATE freeways and land within the jurisdiction of the CITY.

c. Will grant to the CITY, a perpetual easement of the property referenced in II.1.a. above, for the purpose of operating and maintaining the PROJECT, so long as the area is needed for use as a drainage basin.

d. Will issue a permit to the DISTRICT for construction of the PROJECT within its right of way.

e. If it is determined to sell the property described in Exhibit "A", such sale will contain a clause that the property will continue to be used as a drainage basin so long as it is needed for that purpose. This shall not prevent the STATE from selling the property to another public agency.

2. The CITY will:

a. Fund a portion and participate in the construction of the PROJECT under the terms in IGA No. FCD-98035 with the DISTRICT.

b. Upon acceptance of the PROJECT, assume the operation and maintenance responsibility of the PROJECT.

3. The DISTRICT will:

Fund a portion and manage the construction of the PROJECT under the terms in IGA No. FCD-98035 with the CITY.

III. MISCELLANEOUS PROVISIONS

1. The terms of the original IGA FCD-98035 between the DISTRICT and the CITY remain applicable unless specifically changed by this Amendment.

2. Each party to this agreement shall take reasonable and necessary actions within their authority to assure that the release of any water into the PROJECT through their respective storm drain systems complies at the point where water enters the PROJECT, with all applicable state, federal or local laws including, but not limited to, requirements of Clean Water Act, National Pollutant Discharge Elimination System (NPDES) permits.

3. No party to this agreement may release or dispose of waste materials of any kind in the PROJECT.

4. The CITY may regulate the flow of water into or out of the PROJECT as necessary to comply with applicable legal requirements concerning water quality without adversely impacting any of the upstream or adjacent properties or roadway.

5. This agreement shall become effective upon filing with the Secretary of State.

6. The provisions of Arizona Revised Statutes Section 35-214 are applicable to this agreement.

7. This agreement may be cancelled in accordance with Arizona Revised Statutes Section 38-511.

8. In the event of any controversy which may arise out of this agreement, the parties hereto agree to abide by required arbitration as is set forth for public works contracts in Arizona Revised Statutes Section 12-1518.

9. This agreement shall remain in force and effect until completion of said Project, except any provisions herein for easements, maintenance and operation, which shall be for perpetual provided, however, that this agreement, may be cancelled at any time prior to the award of a construction contract, upon thirty (30) days written notice to the other party.

10. Each party to this agreement will pay for and not seek reimbursement for its own personnel and administrative costs associated with this Project, including but not limited to the following, unless specifically identified otherwise in this agreement: design, land acquisition, inspection, public involvement, permitting, management and administration, and operation and maintenance.

11. All notices or demands upon any party to this agreement shall be in writing and shall be delivered in person or sent by mail addressed as follows:

Arizona Department of Transportation
Joint Project Administration
205 South 17th Avenue, Mail Drop 616E
Phoenix, AZ 85007

City of Phoenix
Street Transportation Director
200 W. Washington Street 5th floor
Phoenix, AZ 85003-1611

Flood Control District of Maricopa County
Chief Engineer and General Manager
2801 W. Durango Street
Phoenix, AZ 85009

12. Attached to this agreement or contained herein are the written determinations by the appropriate attorneys for the parties to this agreement, that these agencies are authorized under the laws of that it is in proper form.

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
a Municipal Corporation and Political
Subdivision of the State of Arizona

Recommended:

By: _____ 02/23/00
MICHAEL S. ELLEGOOD, P.E. (DATE)
Chief Engineer and General Manager

Approved and Accepted:

By: _____
ANDREW KUNASEK
Chairman, Board of Directors

Attest:

By: _____ 3/15/2000
Clerk of the Board

The forgoing Intergovernmental agreement has been reviewed pursuant to Arizona Revised Statutes 11-952, as amended, by the undersigned General Counsel, who has determined that it is in proper form and within the powers and authority granted to the Flood Control District of Maricopa County under the laws of the State of Arizona.

By: _____ 2/21/00
General Counsel (DATE)

CITY OF PHOENIX, a Municipal Corporation, Frank Fairbanks, City Manager

By: Thomas E Callow
THOMAS E. CALLOW, P.E.
Interim Street Transportation Director

ATTEST:

By: Vicky Miel
VICKY MIEL
City Clerk

STATE OF ARIZONA
Department of Transportation

By: Daniel S Lance
DANIEL S. LANCE, P.E.
Deputy State Engineer

99-197.DOC
09Feb2000

STATE OF ARIZONA

OFFICE OF THE ATTORNEY GENERAL

1275 WEST WASHINGTON, PHOENIX, AZ. 85007-2926

TRN Main: (602) 542-1680
Direct: (602) 542-8837
Fax: (602) 542-3646

MAIN PHONE: (602) 542-5025
FACSIMILE: (602) 542-4085

JANET NAPOLITANO
ATTORNEY GENERAL

INTERGOVERNMENTAL AGREEMENT DETERMINATION

A.G. Contract No. KR99-2830TRN, an agreement between public agencies, has been reviewed pursuant to A.R.S. § 11-952, as amended, by the undersigned Assistant Attorney General who has determined that it is in the proper form and is within the powers and authority granted to the State of Arizona.

No opinion is expressed as to the authority of the remaining parties, other than the State or its agencies, to enter into said agreement.

DATED March 29, 2000.

JANET NAPOLITANO
Attorney General

JAMES R. REDPATH
Assistant Attorney General
Transportation Section

JRR:et/618983

Enc.

JPA 99-197

APPROVAL OF THE CITY OF PHOENIX ATTORNEY

I have reviewed the above referenced proposed intergovernmental agreement, between the DEPARTMENT OF TRANSPORTATION, INTERMODAL TRANSPORTATION DIVISION, and the CITY OF PHOENIX and declare this agreement to be in proper form and within the powers and authority granted to the City under the laws of the State of Arizona. No opinion is expressed as to the authority of the State to enter into this agreement.

DATED this 30th day of March, 2000.

Jane Sean

ACTING City Attorney

DB

DESCRIPTION FOR PROPOSED DETENTION AREA

That portion of the Southwest quarter (SW¼) of Section 32, Township 1 South, Range 4 East, Gila and Salt River Meridian, Maricopa County, Arizona, described as follows:

Commencing at a Pin in a floor marking the South quarter corner of said Section 32;

thence along the South line of said Section 32, South 89° 56' 17" West 276.72 feet to the POINT OF BEGINNING;

thence continuing along said South line South 89° 56' 17" West 567.54 feet to a Bureau of Land Management (B.L.M.) brass cap marking the West sixteenth corner of Section 6, Township 2 South, Range 4 East, Gila and Salt River Meridian;

thence continuing along said South line South 89° 55' 21" West 297.92 feet, to the East line of the West 1500.00 feet of said Southwest quarter (SW¼) of Section 32, from which a B.L.M. brass cap Marking the Northwest corner of said Section 6 bears South 89° 55'' 21" West 1025.04 feet;

thence leaving said South line along said East line North 0° 00' 03" East 1000.00 feet to the North line of the South 1000.00 feet of said Southwest quarter (SW¼) of Section 32;

thence along said North line South 89° 55' 28" West 1445.25 feet;

thence North 0° 00' 54" West 100.22 feet;

thence North 36° 53' 34" East 149.89 feet;

thence North 73° 45' 32" East 656.32 feet to a non-tangent curve to the Right;

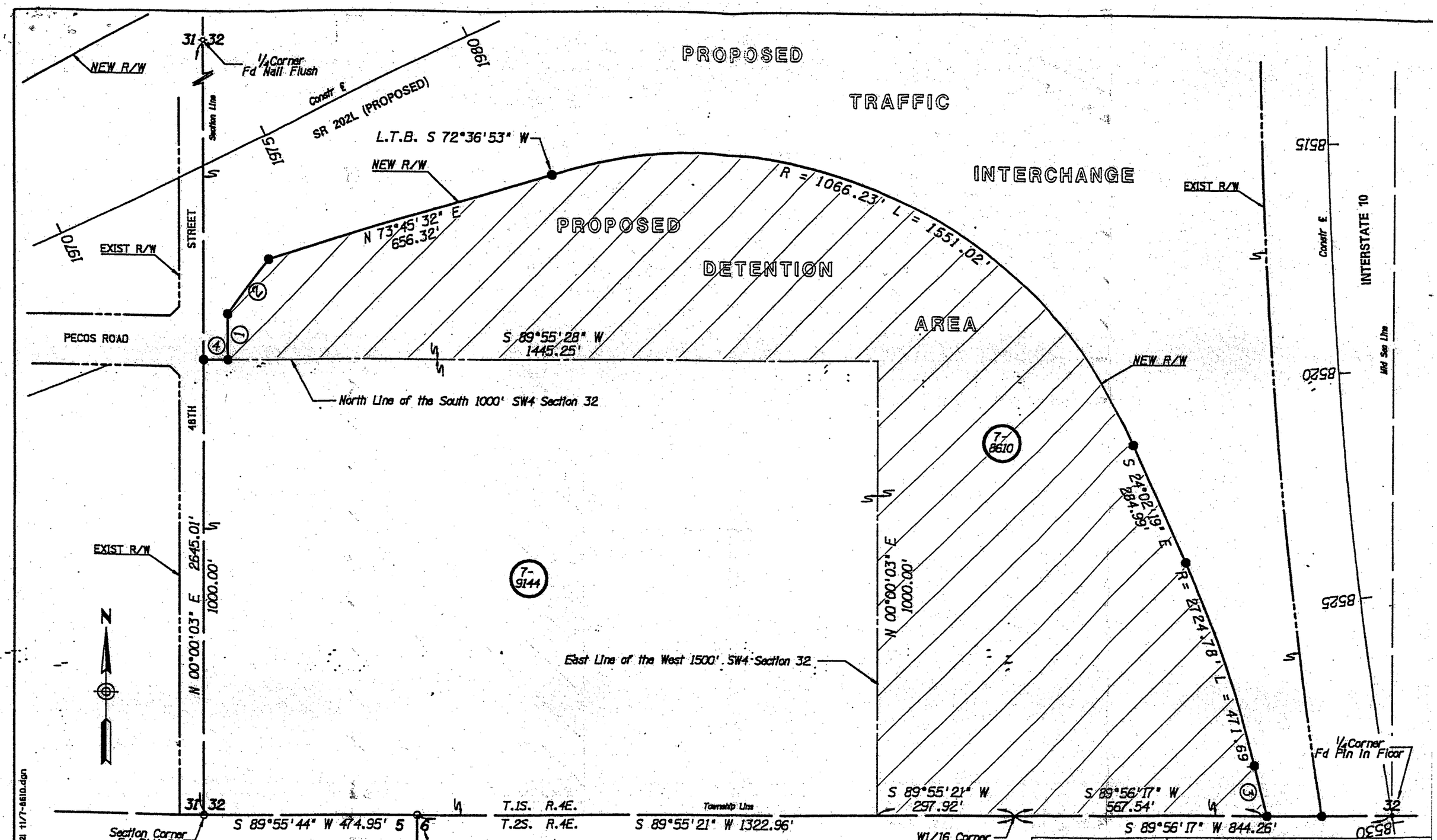
thence from a Local Tangent Bearing of North 72° 36' 53" East, along said non-tangent curve to the Right, having a radius of 1066.23 feet, a length of 1551.02 feet;

thence South 24° 02' 19" East 284.99 feet to a tangent curve to the Right;

thence along said tangent curve to the Right, having a radius of 2724.78 feet, a length of 471.69 feet;

thence South 14° 07' 12" East 115.54 feet to the POINT OF BEGINNING.

EXHIBIT "A"



NUMBER	BEARING	DISTANCE
1	N 00°00'54" W	100.22'
2	N 36°53'34" E	149.89'
3	S 14°07'12" E	115.54'
4	N 89°55'28" E	54.75'

EXHIBIT

Drawing Date: 1-12-00

DRAWING NO.	NONE	ARIZONA DEPARTMENT OF TRANSPORTATION INTERMODAL TRANSPORTATION DIVISION RIGHT OF WAY PLANS SECTION
HARD COPY		HIGHWAY: SANTAN FREEWAY
COUNTY	MARICOPA	PROJECT NO. RAM-600-6-702
DRAWN	BG	TRACS NO. 202L MA 000 H4608 01R
CHECKED		
SCALE	1" = 200'	ROUTE: SR 202L SECTION: 48th Street - 56th Street (I-10 TI)

SHEET 1 OF 1

benuds/agpt/proj/2021 11/7-4610.dgn

SYSTIME NON-SPECIFICATION

Appendix B

Gila Floodway Draft Discharge Permit

Draft Agreement between
Arizona Department of Transportation
And
Gila River Indian Community

INTERGOVERNMENTAL AGREEMENT
AMONG
THE STATE OF ARIZONA
AND
THE GILA RIVER INDIAN COMMUNITY

THIS AGREEMENT is entered into _____, 2000 pursuant to Arizona Revised Statutes, Sections 11-951 through 11-954, as amended, among the STATE OF ARIZONA, acting by and through its DEPARTMENT OF TRANSPORTATION (the "State"), and the GILA RIVER INDIAN COMMUNITY, acting by and through its TRIBAL COUNCIL (the "Community").

I. RECITALS

1. The State is empowered by Arizona Revised Statutes Section 28-401 to enter into this agreement and has by resolution, a copy of which is attached hereto and made a part hereof, resolved to enter into this agreement and has delegated to the undersigned the authority to execute this agreement on behalf of the State.

2. The Community is empowered by Tribal Council Resolution, a copy of which is attached hereto and made a part hereof, to enter into this agreement and has authorized the undersigned to execute this agreement on behalf of the Community.

3. The State's construction of the Santan and Price Freeways and the Southeast Valley Regional Drainage System (SEVRDS) shall result in the collection of stormwater that may be discharged via SEVRDS into the Gila Floodway on Community lands. SEVRDS was built as a cooperative partnership among the State, the Flood Control District of Maricopa County and the City of Chandler. A previously established Memorandum of Agreement (JPA 90-138), attached hereto and made a part hereof, between the State and the Community, granted the State a perpetual drainage easement to discharge stormwater runoff from SEVRDS to the Gila Floodway.

4. Part II.2.f. of Memorandum of Agreement JPA 90-138 stated that discharges from SEVRDS to the Gila Floodway should "meet any State of Arizona, Federal and GRIC [Community] water quality standards and requirements which are now or may be in place in the future, including development of a water quality monitoring plan approved by the respective agencies." The State and Community have agreed that for the purposes of implementing this portion of JPA 90-138 a stormwater discharge permit shall be established.

THEREFORE, in consideration of the mutual agreements expressed herein, it is agreed as follows:

II. SCOPE OF WORK

1. The Community will:

a. Issue a permit with monitoring, reporting and compliance requirements to discharge stormwater from SEVRDS to the Gila Floodway for a period not to exceed five years. A permit may be renewed for additional periods not to exceed five years. Renewal of a permit is contingent upon the record of the State's compliance with permit requirements.

b. Provide the State with the opportunity to participate in public Community discussions or meetings regarding the establishment of water quality standards and requirements as they may apply to the Gila Floodway.

c. Agree that the State is not responsible for the quality of water discharged from sources downstream of the State's point-of-compliance established in the permit.

2. The State will:

a. Agree that it will not discharge stormwater from SEVRDS to the Gila Floodway without obtaining a permit from the Community.

b. Agree that stormwater shall not be discharged from SEVRDS to the Gila Floodway until the State completes construction of SEVRDS and implements all best management practices according to requirements specified in the permit.

c. Agree that it is responsible for the quality of stormwater at the point-of-compliance specified in the permit and resolving in a timely manner, as stated in the permit, any exceedances of surface water quality criteria established in the permit. If necessary, the State shall secure the cooperation of SEVRDS partners in resolving exceedances of surface water quality criteria.

III. MISCELLANEOUS PROVISIONS

1. This agreement shall remain in force and effect for as long as the State operates the SEVRDS in a manner that may result in the discharge of stormwater from SEVRDS to the Gila Floodway.

2. The agreement shall become effective upon filing with the Arizona Secretary of State.

3. This agreement may be cancelled in accordance with Arizona Revised Statutes Section 38-511.

4. This agreement shall be construed in accordance with Arizona law and any legal action except arbitration shall be initiated in the United States District Court of Arizona.

5. All notices or demands upon any party to this agreement shall be in writing and shall be delivered in person or sent by mail addressed as follows:

Arizona Department of Transportation Address Address Phoenix, Arizona 85007	Gila River Indian Community Director, Gila River Department of Environmental Quality Address Sacaton, Arizona 85247

6. Attached hereto and incorporated herein is the written determination of each party's legal counsel that the parties are authorized under their respective laws to enter into this agreement and that the agreement is in proper form.

IN WITNESS WHEREOF, the parties have executed this agreement the day and year first above written.

GILA RIVER INDIAN COMMUNITY

By _____
DONALD R. ANTONE
Governor

ATTEST

By _____
ROD LEWIS
Tribal Attorney

STATE OF ARIZONA
Department of Transportation

By _____
Mary Peters
Director, Department of Transportation

Revision: May, 17, 2000

Gila River Indian Community

Gila Floodway Discharge Permit No. GR-ST0001

In compliance with the provisions of Inter-Governmental Agreement JPA ##-##, Gila River Resolution GR-##-## and the conditions set forth in this permit, the permittee:

Arizona Department of Transportation
206 South Seventeenth Avenue
Phoenix, Arizona 85007

is authorized to discharge stormwater from the Southeastern Valley Regional Drainage System (SEVRDS) to the Gila Floodway. SEVRDS, located in Phoenix and Chandler, Arizona in Maricopa County, discharges to the Gila Floodway in Township 2 S, Range 4 E, Section 5, SW ¼ - Gila and Salt River Base Line and Meridian.

Latitude: _____
Longitude: _____

This permit shall become effective on the date of signature of the Executive Director of the Gila River Indian Community Department of Environmental Quality. The permit shall be valid for five years from the date of signature provided that the permittee fully complies with the conditions of the permit.

_____
Patricia Mariella, Ph.D., Executive Director
Gila River Department of Environmental Quality

Signed this _____ day of _____, 2000.

1.0. Definitions

1.1 "ADOT" means Arizona Department of Transportation.

1.2 "Agricultural Livestock Watering" (AgL) means the use of the Gila Floodway as a supply of water for consumption by livestock.

1.3 "Aquatic & Wildlife [ephemeral]" (A&We) means the use of the Gila Floodway by animals, plants or other organisms, excluding fish, for habitation, growth, or propagation.

1.4 "Best management practices" (BMPs) means activities, practices or procedures designed to prevent or reduce pollutants in stormwater discharged to the Gila Floodway.

1.5 "DEQ" means the GRIC Department of Environmental Quality.

1.6 "Designated uses" means the beneficial uses designated for the Gila Floodway. The Gila Floodway has three designated uses: Aquatic & Wildlife [ephemeral], Partial Body Contact and Agricultural Livestock Watering.

1.7 "Discharge" means the direct addition of water to the Gila Floodway as a result of stormwater flows from the SEVRDS channel.

1.8 "Gila Floodway" means the waterbody on GRIC lands that receives stormwater delivered by SEVRDS.

1.9 "GRIC" means Gila River Indian Community.

1.10 "Municipal stormwater" means stormwater derived from a conveyance or system of conveyances (including, but not limited to, roads with drainage systems, catch-basins, curbs, gutters, ditches, man-made channels or storm drains) owned or operated by a public body (created pursuant to State of Arizona law) having jurisdiction over the stormwater.

1.11 "Partial Body Contact" (PBC) means the use of the Gila Floodway in a way which may cause the human body to come into direct contact with the water, but normally not to the point of complete submergence. The use is such that ingestion of the water is not likely to occur, nor will sensitive body organs such as the eyes, ears, or nose normally be exposed to direct contact with the water.

1.12 "Permit" means the document that establishes the requirements under which ADOT is authorized to discharge stormwater to the Gila Floodway. This permit was established to implement existing agreements between ADOT and GRIC and was not established for the purposes of complying with any tribal, state, or federal statutory requirement.

1.13 "Point-of-compliance" means the location where water quality samples shall be collected to determine compliance with the water quality standards established for the Gila Floodway.

1.14 "SEVRDS" means the Southeastern Valley Regional Drainage System. SEVRDS was built as a cooperative partnership among ADOT, Flood Control District of Maricopa County and City of Chandler. SEVRDS is comprised of (a) conveyances that collect stormwater from the Santan/Price freeways and surrounding area; (b) the constructed basins used to manage stormwater quality and flow; and (c) the Santan Outfall Channel that delivers stormwater to the Gila Floodway.

1.15 "Stormwater" means surface water runoff resulting from a precipitation event.

1.16 "Surface water quality criteria" means the numeric and narrative water quality standards that apply to the Gila Floodway. These criteria are defined in Section 3.0 of this permit.

2.0. Effluent Limitations and Monitoring Requirements

2.1 ADOT is only responsible for stormwater-carried pollutants discharged to the Gila Floodway in the portion of SEVRDS upstream of the point-of-compliance established for this permit. Discharges to SEVRDS downstream of the point-of-compliance are regulated separately and not the responsibility of ADOT.

2.2 ADOT shall control pollutants in stormwater discharges from SEVRDS to the Gila Floodway to meet the requirements of Sections 3.0 and 4.0. BMPs shall be used as the means to control pollutants in the stormwater. The initial required BMPs for the implementation of this permit are prescribed in Section 9.0.

2.3 To evaluate the effectiveness of the BMPs implemented by ADOT to control pollutants, ADOT shall monitor for pollutants in stormwater at the point-of-compliance. Monitoring shall be carried out according to the stormwater monitoring and reporting plan established to implement Section 10.0 of this permit.

2.4 Water quality samples shall be collected at the point-of-compliance whenever sufficient flow occurs at the point-of-compliance to collect a representative sample.

3.0. Applicable Surface Water Quality Criteria

3.1 The Gila Floodway has the following beneficial designated uses: Aquatic and Wildlife (ephemeral), Partial Body Contact and Agricultural Livestock Watering.

3.2 The applicable numeric criteria for each designated use are shown in Section 10.0, Table 1 of this permit. These criteria shall apply at all times.

3.3 Contributions from SEVRDS to the Gila Floodway shall be free from pollutants in amounts or combinations that (1) settle to form bottom deposits that inhibit or prohibit the habitation, growth or propagation of aquatic life or that impair recreational uses and (2) cause objectionable odor in the area in which the Gila Floodway is located.

3.4 Contributions from SEVRDS to the Gila Floodway shall be free from oil, grease and other pollutants that float as debris, foam or scum; or that cause a film or iridescent appearance on the surface of the water; or that cause a deposit, e.g., trash, garbage or similar debris, on the shoreline, bank, aquatic vegetation or bed of the Gila Floodway.

4.0. Compliance

4.1. The point-of-compliance for evaluating compliance with surface water quality numeric criteria is at the ADOT monitoring station located 27.20 feet right of Station 10+78.38 (Forebay Channel Cst. Centerline & PGL). The latitude and longitude of this monitoring station are *XX*.

4.2 To evaluate compliance with numeric water quality criteria, GRIC's DEQ shall rely upon the data collected from the implementation of the approved stormwater monitoring and reporting plan prepared to implement Section 10.0 of this permit.

4.3 Compliance with surface water quality numeric criteria shall be determined on a pollutant-by-pollutant basis. If the concentration of a pollutant sampled at the point-of-compliance is more than twice the surface water quality criterion listed in Section 10.0, Table 1 on any sample date, then ADOT is not in compliance with this permit. However if the concentration of a pollutant exceeds the surface water quality criterion listed in Section 10.0, Table 1 but the exceedance is less than twice the criterion, then ADOT is in non-compliance with this permit only if the exceedance occurs on more than three consecutive sample dates.

4.4 Compliance with Sections 3.3 and 3.4 of this permit shall be determined by inspection of SEVRDS upstream of the ADOT point-of-compliance monitoring station following a discharge at the point-of-compliance. GRIC DEQ shall document potential violations of Sections 3.3 and 3.4 with photographs before notifying ADOT of potential violations of Sections 3.3 and/or 3.4 of this permit.

4.5 If after all pollutant control measures prescribed in Section 9.0 of this permit have been implemented and stormwater discharged to the Gila Floodway is not in compliance with this permit according to Sections 4.3 and 4.4, then:

4.5.1 ADOT shall work with GRIC DEQ to resolve the non-compliance; and

4.5.2 ADOT shall identify and implement additional BMPs in a timely manner to resolve the identified non-compliance, or implement other actions, as necessary, to

come into compliance with this permit. Newly implemented BMPs shall become part of Section 9.0 for the remaining period of time that the permit is in effect.

5.0 Reporting Requirements

5.1 ADOT shall notify the GRIC DEQ Director of an exceedance of any surface water quality criteria as soon as the exceedance is identified.

5.2 ADOT shall provide GRIC DEQ with the results of all stormwater quality sampling conducted at the point-of-compliance. These data shall be provided within 60 days following a sampling event.

5.3 ADOT shall implement the monitoring and reporting plan established in Section 10.0 of this permit.

6.0 General Permit Conditions

6.1 The SEVRDS system shall only transport municipal stormwater. ADOT shall work with SEVRDS' partners to ensure that SEVRDS only contains municipal stormwater.

6.2 ADOT shall comply with all conditions and requirements of this permit. Failure to comply is grounds for permit revocation or denial of a reissuance of the permit beyond five years after the effective date. This permit shall not be terminated without providing an opportunity for ADOT to come into compliance according to the requirements of Section 4.5 of this permit.

6.3 ADOT shall take all reasonable steps to prevent or minimize any discharge of stormwater which has a reasonable likelihood of resulting in non-compliance of surface water quality criteria, especially if the discharge could adversely affect human health or the environment.

6.4 ADOT shall at all times properly operate and maintain all facilities and systems of treatment and control which are used by ADOT to achieve compliance with the conditions of this permit. Proper operation and maintenance also includes adequate laboratory controls and appropriate quality assurance procedures for the gathering of data.

6.5 Unless mutually agreed to by all signatories to this permit, all permit requirements shall remain in effect regardless of a request from ADOT for a permit extension, modification, or termination or notification by ADOT of planned changes or anticipated non-compliance.

6.6 ADOT shall provide GRIC DEQ, within a reasonable time frame, any information requested by GRIC DEQ to evaluate compliance with this permit. ADOT shall also provide to GRIC DEQ, upon written request, copies of records required by this permit.

6.7 ADOT shall allow GRIC to construct and operate a permanent stormwater quality monitoring station in the SEVRDS channel downstream of ADOT's point-of-compliance located at *XX*. ADOT shall also allow authorized representatives of GRIC's DEQ staff access to the SEVRDS to collect water quality samples at ADOT's point-of-compliance.

7.0 Permit Modification, Extension and Termination

7.1 Permit Modification

7.1.1 This permit may not be modified before its expiration date except by agreement of both ADOT and GRIC.

7.2 Permit Extension

7.2.1 No later than four years after the effective date of the existing permit, ADOT shall submit notice to GRIC DEQ of its intent to extend the permit an additional five years.

7.2.2 Any permit extension shall consider changes in State of Arizona, Federal and GRIC water quality standards and requirements that have occurred since the implementation of the existing permit as well as any relevant water quality data collected during the previous five years.

7.2.3 With the implementation of each permit extension, ADOT shall be required to conduct another analysis of all parameters in Table 1 as specified in Section 10.0, except that the analysis of all of parameters in Table 1 shall be done for only the first stormwater event that results in the collection of water quality samples at the point-of-compliance following the effective date of the permit extension.

7.3 Permit Termination

7.3.1 The DEQ may revoke this permit for cause including:

7.3.1.1 Failure to provide notifications, information, data or documents, as required;

7.3.1.2 Failure to implement pollutant controls as required by Section 9.0;

7.3.1.3 Failure to monitor at the point-of-compliance as required by the GRIC-approved stormwater monitoring plan;

7.3.1.4 Failure to resolve in a timely manner exceedances of surface water quality criteria identified at the point-of-compliance that result in non-compliance with this permit.

7.3.2 If this permit is terminated, discharges from SEVRDS to the Gila Floodway, as a result of flows upstream of ADOT's point-of-compliance, shall cease.

8.0 Legal Authority

8.1 By accepting this permit, the signatory for ADOT agrees that ADOT is responsible for the quality of stormwater at the point-of-compliance. As the responsible party, ADOT is responsible for securing the cooperation of SEVRDS partners in resolving exceedances of surface water quality criteria established in this permit.

9.0 Initial Required Best Management Practices to Control Pollutants in SEVRDS Stormwater

9.1 ADOT shall operate a vegetative treatment system (VTS) to treat the first flush of stormwater in SEVRDS upstream of the point-of-compliance.

9.1.1 The VTS consists of an equalization basin, two lined treatment cells (cells A and B), a detention basin (basin B) and a pump station for evacuation of flows. The equalization basin shall be sized to contain the volume of "first flush" water generated by a rainstorm over the contributing drainage area. From the equalization basin, flows shall be metered into one of the treatment cells. In cell A, water shall slowly flow through a two foot-thick layer of coarse gravel. Cell B contains a similar gravel layer as cell A, but also has vegetation. These cells shall be continuously irrigated to keep the vegetation and microbial community active. Water leaving the treatment cells shall enter Basin B from where it will be pumped to the outfall channel for discharge to the Gila Floodway or returned to the equalization basin for additional treatment in the treatment cells.

9.1.2 The VTS shall be operated for a minimum of two years from the date of the first storm event that results in first flush stormwater entering the equalization basin. Following this two year minimum period, ADOT may evaluate the efficacy of the VTS for treating pollutants in stormwater carried by SEVRDS upstream of the point-of-compliance.

9.1.3 If the results of an analysis by ADOT of the efficacy of the VTS demonstrate that operation of the VTS is unnecessary to meet the water quality criteria in Table 1 of Section 10.0, ADOT may request a modification of the permit to remove the VTS as a BMP.

9.1.4 Pursuant to Sections 6.5 and 7.1.1 of this permit, the VTS shall remain in operation until a permit modification has been approved.

9.2 ADOT shall implement and remain in compliance with the National Pollutant Discharge Elimination System (NPDES) permit which has been issued by the United States

Environmental Protection Agency for its Municipal Separate Storm Sewer System (NPDES Permit No. AZS000018).

10.0 Monitoring and Reporting Plan

10.1 ADOT shall implement the GRIC DEQ-approved monitoring and reporting plan attached as Appendix 1 to this permit to execute the requirements of this permit. The monitoring and reporting plan shall be based on the following requirements:

10.1.1 The monitoring and reporting plan shall be based on Table 1 which lists the pollutants with surface water quality criteria established to protect the designated uses of the Gila Floodway.

10.1.2 The first two stormwater events that result in the collection of water quality samples at the point-of-compliance, either as a result of the discharge of treated first flush stormwater or as a result of a bypass of the treatment system during large storm events, after the effective date of this permit shall include an analysis of all parameters listed in Table 1.

10.1.3 Water quality data collected for the purposes of Section 10.1.2 shall be used to establish the required pollutant monitoring list for the remaining time that the permit is in effect. This list shall be established according to the following requirements:

10.1.3.1 If the data collected pursuant to Section 10.1.2 confirm that stormwater quality does not exceed any of the surface water quality criteria in Table 1, the required pollutant monitoring list shall include only those parameters with a "Y" in Table 1.

10.1.3.2 If the data collected pursuant to Section 10.1.2 indicate that a parameter in Table 1 exceeds any surface water quality criterion established for that parameter, that parameter shall be added to the list of parameters in the required pollutant monitoring list.

10.1.4 GRIC DEQ my request that ADOT monitor for additional parameters if during the period in which the permit is in effect, GRIC DEQ demonstrates that there is a reasonable potential for a pollutant in Table 1 to exceed a surface water quality criterion.

Section 10.0 - Table 1. Surface Water Quality Criteria Applicable to the Gila Floodway (unless otherwise indicated, criteria are in micrograms per liter)				
PARAMETER	Required Pollutant Monitoring List	PBC	AgL	A&We
Acenaphthene		8400	NNS	NNS
Acrolein		2200	NNS	NNS
Alachlor		1400	NNS	NNS
Aldrin		4.2	NNS	4.5
Aldrin/Dieldrin		NNS	0.003	NNS
Anthracene		42000	NNS	NNS
Antimony (as Sb)	Y	56 T	NNS	NNS
Arsenic (as As)	Y	50 T	200 T	440 D
Atrazine		4900	NNS	NNS
Barium (as Ba)	Y	9800 D	NNS	NNS
Benzidine		420	0.01	10000
Beryllium (as Be)	Y	700 T	NNS	NNS
Bis (2-chloroisopropyl) ether		5600	NNS	NNS
Boron (as B)	Y	12600	NNS	NNS
Bromodichloromethane		2800	NNS	NNS
Bromoform		2800	NNS	NNS
Bromomethane		200	NNS	NNS
Butyl benzyl phthalate		28000	NNS	NNS
Cadmium (as Cd)	Y	70 T	50 T	H D
Carbofuran		700	NNS	NNS
Carbon tetrachloride		98	NNS	NNS
Chlordane		8.4	NNS	3.2
Chlorine (total residual)		14000	NNS	NNS
Chlorobenzene		2800	NNS	NNS
Chloroform		1400	NNS	NNS
Chloronapthalene beta		11000	NNS	NNS
2-Chlorophenol		700	NNS	NNS
Chromium (as Cr III)	Y	140000 T	NNS	H D
Chromium (as Cr VI)	Y	700 T	NNS	34 D
Chromium (Total as Cr)		NNS	1000 T	NNS

Section 10.0 - Table 1. Surface Water Quality Criteria Applicable to the Gila Floodway (unless otherwise indicated, criteria are in micrograms per liter)				
PARAMETER	Required Pollutant Monitoring List	PBC	AgL	A&We
Copper (as Cu)	Y	5200 D	500 T	H D
Cyanide	Y	2800 T	200 T	84 T
Dibromochloromethane		2800	NNS	NNS
Dibutyl phthalate		14000	NNS	1100
1,2-Dichlorobenzene		13000	NNS	5900
1,3-Dichlorobenzene		1880	NNS	NNS
1,4-Dichlorobenzene		1880	NNS	6500
p,p'-Dichlorodiphenyldichloroethane (DDD)		NNS	0.001	1.1
p,p'-Dichlorodiphenyldichloroethylene (DDE)	Y	NNS	0.001	1.1
p,p'-Dichlorodiphenyltrichloroethane (DDT)		70	0.001	1.1
1,1-Dichloroethylene		1300	NNS	NNS
1,2-trans-Dichloroethylene		2800	NNS	NNS
Dichloromethane		8400	NNS	NNS
2,4-Dichlorophenol		420	NNS	NNS
2,4-Dichlorophenoxyacetic acid (2,4-D)		1400	NNS	NNS
1,3-Dichloropropene		42	NNS	NNS
Dieldrin (see aldrin/dieldrin)		7	NNS	4
Diethyl phthalate		110000	NNS	NNS
Di(2-ethylhexyl) phthalate		2800	NNS	3100
2,4-Dimethylphenol		2800	NNS	150000
Dimethyl phthalate		1400000	NNS	NNS
4,6-Dinitro-o-cresol		55	NNS	NNS
2,4-Dinitrophenol		280	NNS	NNS
2,4-Dinitrotoluene		280	NNS	NNS
Endosulfan sulfate		7	NNS	3
Endosulfan (Total)		840	NNS	3
Endrin		40	0.004	0.7
Endrin aldehyde		420	NNS	0.7
Ethylbenzene	Y	14000	NNS	NNS
Fluoranthene		5600	NNS	NNS
Fluorene		5600	NNS	NNS

Section 10.0 - Table 1. Surface Water Quality Criteria Applicable to the Gila Floodway (unless otherwise indicated, criteria are in micrograms per liter)				
PARAMETER	Required Pollutant Monitoring List	PBC	AgL	A&We
Fluoride	Y	8400	NNS	NNS
Heptachlor		70	NNS	0.9
Heptachlor epoxide		2	NNS	0.9
Hexachlorobenzene		280	NNS	NNS
Hexachlorocyclohexane alpha		NNS	NNS	1600
Hexachlorocyclohexane beta		NNS	NNS	1600
Hexachlorocyclohexane delta		NNS	NNS	1600
Hexachlorocyclohexane gamma (lindane)		42	NNS	11
Hexachlorocyclopentadiene		1000	NNS	NNS
Isophorone		28000	NNS	NNS
Lead (as Pb)	Y	NNS	100 T	H D
Manganese (as Mn)	Y	19600 T	NNS	NNS
Mercury (as Hg)	Y	42 T	10 T	5 D
Methoxychlor		700	NNS	NNS
Nickel (as Ni)	Y	2800 T	NNS	H D
Nitrate (as N)	Y	224000	NNS	NNS
Nitrite (as N)		14000	NNS	NNS
Pentachlorophenol		2000	NNS	P
Phenol		84000	NNS	180000
Polychlorinatedbiphenyls (PCBs)	Y	NNS	0.001	11
Pyrene		4200	NNS	NNS
Selenium (as Se)	Y	700 T	50 T	33 T
Silver (as Ag)	Y	NNS	NNS	H D
Styrene		28000	NNS	NNS
Sulfides		NNS	NNS	100
2,3,7,8-Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD)		NNS	NNS	0.1
Tetrachloroethylene		1400	NNS	15000
Thallium (as Tl)	Y	12 T	NNS	NNS
Toluene	Y	28000	NNS	NNS
Toxaphene		NNS	0.005	11
1,2,4-Trichlorobenzene		1400	NNS	NNS

Section 10.0 - Table 1. Surface Water Quality Criteria Applicable to the Gila Floodway (unless otherwise indicated, criteria are in micrograms per liter)				
PARAMETER	Required Pollutant Monitoring List	PBC	AgL	A&We
1,1,2-Trichloroethane		560	NNS	NNS
2,4,6-Trichlorophenol		NNS	NNS	3000
2-(2,4,5-Trichlorophenoxy) proprionic acid (2,4,5-TP)		1120	NNS	NNS
Xylenes (Total)	Y	280000	NNS	NNS
Zinc (as Zn)	Y	42000 T	25000 T	H D
Fecal coliform (single sample maximum, number of colony forming units per 100 milliliters water)	Y	4000	4000	4000
Hardness (mg $CaCO_3$)	Y[1]	NNS	NNS	NNS
pH (as measured in standard units)	Y	6.5 - 9.0	6.5 - 9.0	6.5 – 9.0
Specific Conductivity	Y[2]	NNS	NNS	NNS

1 No water quality criterion has been established for any designated use, but hardness data are required for evaluating the metals criteria designated with (H).

2 No water quality criterion has been established for any designated use, but GRIC requests that data be collected for this parameter.

T Criterion based on Total Recoverable portion.

D Criterion based on Dissolved portion.

NNS No numeric standard.

H Criterion based on water hardness. Hardness-specific criteria may be calculated by using the following equations:

- Cadmium $e^{(1.128[\ln(Hardness)]-0.9691)}$
- Chromium III $e^{(0.8190[\ln(Hardness)]+3.688)}$
- Copper $e^{(0.9422[\ln(Hardness)]-1.1514)}$
- Lead $e^{(1.2730[\ln(Hardness)]-0.7131)}$
- Nickel $e^{(0.8460[\ln(Hardness)]+4.4389)}$
- Silver $e^{(1.72[\ln(Hardness)]-6.52)}$
- Zinc $e^{(0.8473[\ln(Hardness)]+3.1342)}$

P Criterion based on the pH of the water. pH-specific criteria may be calculated using the following equation: $e^{(1.005(pH)-3.4306)}$

Appendix 1

Monitoring and Reporting Plan

(to be attached)

JEFF MINCH

GILA RIVER INDIAN COMMUNITY

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500.5.4,
600

DEPARTMENT OF ENVIRONMENTAL QUALITY
Post Office Box 97
Sacaton, Arizona 85247
(520) 562-2234 • Fax: (520) 562-2245

RECEIVED
MAY 30 2000
VALLEY PROJECT MANAGEMENT

May 20, 2000

Mr. Javier O. Guana
Arizona Department of Transportation
Valley Project Management Section
205 S. 17th Ave., 614E
Phoenix, AZ 85007-3212

TM
TM
PW (1)
SW
TO
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JG
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SI (2)
JM
TM
ADOT GEN. C.
Bud Ruyes
FILE (3)

Re: IGA and Permit for Gila Floodway

Dear Mr. Guana:

Please find attached two draft documents. The Gila Floodway Discharge Permit and IGA to implement the permit. These two documents have undergone recent technical reviews by the GRIC Department of Environmental Quality. Only minor changes to the documents have been made including the modifications discussed at our last meeting at Ecoplan.

We believe we are ready to take the next step, which is to have a legal review of the documents. Linus Everling, with GRIC Legal Counsel, will be reviewing the documents for GRIC.

Let me know if you have any questions. I assume that you will be forwarding the documents for legal reviews with the State.

Again, thank you for your cooperation and assistance. If you have any questions please call me at (520) 562-2234 ext 233.

Sincerely,

Glenn Stark

Glenn Stark
Water Quality Section Manager

Appendix C

Initial Stormwater Treatment Facility Conceptual Plan

Dr. Martin M. Karpiscak
Office of Arid Land Studies
University of Arizona

April 29, 1999

DRAFT

STORMWATER TREATMENT FACILITY CONCEPTUAL PLAN

48th Street Detention Basin Project

City of Phoenix Project No. ST83120008

Prepared by

Martin M. Karpiscak
Office of Arid Lands Studies
The University of Arizona
1955 East 6th Street
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Submitted to

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April 1999

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48th STREET DETENTION BASIN PROJECT

I. INTRODUCTION

All wastewater treatment technologies require the use of natural processes such as microbial reactions or gravity for sedimentation. The great advantage of a constructed wetland or ecosystem for water quality enhancement is that these systems do not require large amounts of energy generated from fossil energy sources nor elaborate treatment facilities.

Natural wetlands are typically called marshes, swamps, or bogs. These natural areas are vegetated with dense and, many times, diverse plant communities that can provide habitat for birds, reptiles, mammals, amphibians, invertebrates, as well as complex microbial communities. Thus, these ecosystems can be rich, complex "natural communities" that perform as nature's mechanism for enhancing water quality.

The use of a constructed wetland for treating various types of wastewater is a relatively recent adaptation of the use of nature's own water treating "facility". The oldest full-scale constructed wetland system has been operating for only about 20 years. There are 3 major types of constructed wetland systems currently in use: floating aquatic plants (FAP), subsurface flow (SSF), and surface flow (SF), also called free water surface (FWS). The use of these systems is rapidly expanding for the treatment of many types of wastewater, including stormwater (Schueler, 1992; Olson, 1993).

Some of the major components of a constructed wetland that can impact the efficiency of the treatment process include: plant species, soils, detritus, microbial species, and presence/ab-

sence of animals. These components are in turn influenced by water depth, air/water temperature, pH, and dissolved oxygen (Reed *et al.*, 1995).

Stormwater quality has become a major concern, especially in urban areas. Stormwater runoff from urban areas can contain high levels of nutrients, sediments, residues from exhaust fumes, and other contaminants (Environet, 1997). A study conducted in Ontario indicated that bacteria and heavy metals, principally lead, zinc and cadmium, were of primary concern from stormwater runoff. Contaminants from industrial and residential activities were found to already impact the local river. Typically reported were illicit discharges arising from poor housekeeping practices, especially in industrial areas (Environet, 1997).

Carefully designed and built constructed wetland treatment systems can serve as a component of a facility to treat non-point source (NPS) pollution problem occurring in stormwater runoff (Schueler, 1992; Olson, 1993). A constructed wetland can remove many of the NPS contaminants found in stormwater runoff by biological, chemical and physical means, in much the same way as a natural wetland or more conventional treatment systems. These engineered wetlands can be designed to treat specific contaminants, enhance flood control, and provide many of the ancillary benefits of natural wetlands such as wildlife habitat, aesthetically pleasing open space and recreational opportunities (Environet, 1997).

Constructed wetland basins, cells, raceways, or ponds can act as natural filters by trapping sediments. Macrophytes (emergent or aquatic vegetation) growing within the cells can utilize nutrients such as phosphates and nitrates. They can also take up and use and/or concentrate heavy metals contained in the stormwater or the sediment. The primary design parameters for a

constructed wetland include: hydraulics, detention times, flow rates, water velocities, aquatic vegetation and fauna, access for maintenance, and harvesting and monitoring.

During a study conducted in Bayswater, Perth, Australia (Environet, 1997), samples were taken at the inlet and outlet of the two wetland basins designed for stormwater runoff under steady flow conditions. Cage structures with weirs are situated at the outlet of each wetland. Both wetlands successfully filter sediment, but the efficiency is dependent on the design of each wetland. The following results from the water sampling were obtained. Values are expressed as the mean.

Species	Inlet (mg/l)	Outlet (mg/l)
Total Suspended Solids	16.3	6.6
Volatile Suspended Solids	9.5	6.6
NO_3-N	3.1	1.7
Total Kjeldahl Nitrogen	1.0	0.9
Heavy Metals	<0.02	<0.02
Total Phosphorus	some samples higher in outflow than inflow, particularly for samples taken after rainfall	

Aquatic species in the basins include *Typha orientalis*, *Potamogeton cripus*, *Juncus pallidus*, *Juncus krassii*, *Cyperus rotundus*, *Bolboschoenus caldwellii*, and *Avena satira,* with *Juncus pallidus* as the dominant species.

II. TRADITIONAL STORMWATER TREATMENT SYSTEM DESIGNS

Introduction

Stormwater detention basins can be designed with aesthetic features and can provide for water quality improvements. Some have termed these areas "biofilters". Included in these are shallow water marshes, reasonably flooded basins, and wet and dry meadows (Ferlow, 1993).

Ponding stills the stormwater and permits silts and sediments as well as their attached pollutants to settle out and sometimes bind with bottom sediments. Soluble pollutants are probably best removed in a permanent pond, emergent wetland or by means of extended runoff retention, utilizing microbial activity within a shallow intermittently wet scrub shrub brush habitat (Ferlow, 1993). Pollutant removal will vary seasonally with the highest removal rates occurring in summer.

Detention/Retention Systems

Most stormwater detention ponds dry out quickly under arid conditions. Often, during the rainy season, the water levels in these ponds remain at or near the outflow structures. Stormwater entering a detention area under these conditions displaces an equivalent amount of water that usually overflows to an adjacent man-made or natural drainage system. The detention pond acts as a sink or trap where pollutants picked up by the initial surge of stormwater settle out before leaving the detention pond. These ponds are usually referred to as "Wet-detention systems" (O'Meara and Purcell, 1993).

By contrast, retention areas are designed to hold stormwater until the effects of percolation and evapotranspiration return the area to its normal dry state. Since these stormwater retention areas are designed to dry out rapidly, they are usually called "dry-retention systems" (O'Meara

and Purcell, 1993). The Equalization Basin in the proposed complex represents a dry-retention system. First-flush stormwater is retained and is slowly discharged to the treatment cells, providing primary sedimentation.

Wet Detention Ponds

A wet detention pond is a pond that is specifically designed, built and/or modified to maintain a permanent pool of water within a designated area and that relies on physical, biological, and chemical processes to remove pollutants from stormwater runoff. Pollutants removed include sediment, organic matter, dissolved metals, and nutrients. In addition, wet detention ponds control stormwater flow that prevents downstream flooding. As stormwater enters the pond, treated water is displaced and discharged into a receiving body of water. Enhanced treatment of stormwater runoff can be achieved through extended detention and the use of aquatic plants in the perimeter of the pond or by the addition of a constructed wetland. Sediment removal can also be increased through the use of sediment traps in the perimeter of the pond. Sediment removal can also be increased through the use of a sediment forebay (EnviroSense, 1997).

Before construction of a pond begins, local, state, and federal permits should be confirmed and approved for all aspects of construction including wetlands, water quality, dam safety, grading, erosion control, and land use. Wet detention ponds rely on the existence of a permanent pool of water within the pond and, therefore, should be placed in areas with adequate baseflow from groundwater or from other sources to maintain an adequate water level. Soils under the pond should have a low permeability (10^{-5} to 10^{-6} cm/sec) to ensure future existence of the pond. Placement should take into consideration a location that allows for maximum detention volume while requiring minimal earth removal, thus lowering construction costs. Pond construction

should not be considered near land constraints such as utilities or underlying bedrock (EnviroSense, 1997).

Pollutant removal in the pond is determined using one of two methods: solids settling and eutrophication. The solids settling method relies on pollutant removal through sedimentation and the eutrophication method removes nutrients using natural biological processes. According to the National Urban Runoff Program (NURP), up to two-thirds of the sediments, trace metals, and nutrients are removed as a result of sedimentation within 24 hours. Other studies that looked at biological removal suggest hydraulic residence times (HRTs) close to two weeks to get adequate phosphorus removal (EnviroSense, 1997). Documented removal efficiencies for wet detention ponds are as follows:

	Percent Removal	
Parameter	**Schueler, 1992[1]**	**Hartigan, 1988[2]**
Total Suspended Solids	50-90	80-90
Total Phosphorous	30-90	
Soluble Nutrients	40-80	50-70
Lead		70-80
Zinc		40-50
Biochemical Oxygen Demand		20-40
Chemical Oxygen Demand		20-40

[1]hydraulic residence time varies
[2]hydraulic residence time of 2 weeks

Two ratios are useful at predicting pollutant removal efficiencies: volume ratio and area ratio. Volume ratio (VB/VR) is the ratio of permanent pool storage (VB) to the mean storm runoff (VR). Area ratio (A/As) is the ratio of the contributing drainage area (A) to the permanent pool surface area (As). Both of these ratios are correlated with treatment efficiencies. Large

volume ratios result in increased retention and treatment between storms while low pollutant efficiencies are achieved with low volume ratios (EnviroSense, 1997).

Pool depth can play a critical role in pollutant removal and storage, but caution should be taken when increasing the depth of the pool. A pond with an HRT of two weeks would function optimally at depth ranges from 3 to 9 feet; shallower depths with the same pond surface area have shorter HRTs (EnviroSense, 1997).

Water within the pond is discharged through an outlet. A wet pond outlet consists of a vertical riser, either concrete or corrugated metal, attached to a horizontal barrel that conveys stormwater flow under the embankment to a receiving stream. The outlet is designed to pass excess water while maintaining a permanent pool. Risers are typically placed in or on the edge of the embankment and are capped with a trash rack to prevent clogging (EnviroSense, 1997). Due to the intermittent occurrences of runoff events in the Phoenix area and the high evaporation rates, a wet-detention pond would require large quantities of supplemental water to maintain the aquatic system. Therefore, a wet detention pond is not recommended for this project.

Maintenance

As with any stormwater best management practice (BMP), proper maintenance will be required to ensure proper functioning of the pond (EnviroSense, 1997). Proper maintenance may include any or all of the following:

- Clearing trash and debris
- Conducting routine inspections of the embankment and spillway to check structural integrity and look for signs of erosion or animal habitation
- Conducting periodic repairs on the embankment, emergency spillway, inlet, and outlet

- Maintaining that outfall area (i.e., replacing rip-rap, removing sediments, etc.)

Sediments collected by the wet detention pond typically meet toxicity limits and can be land-filled safely. Testing of the sediments may be required if the upstream drainage area is industrial and/or results in highly contaminated runoff. Non-toxic sediments can also be disposed on site, but away from the high water line to prevent their re-entry into the pond. The removal of sediments in a pond may be necessary every 20 years. This can be decreased to every 50 years if a sediment forebay is used prior to the wet pond. The sediment forebay would require maintenance every 5 to 7 years (EnviroSense, 1997).

Disadvantages

Pond construction should not be considered near land constraints such as utilities, underlying bedrock, or abundant landfills or wildcat dumps. Sediments from upstream industrial or highly contaminated runoff areas may be a hazardous waste requiring special disposal/treatment (EnviroSense, 1997). To our knowledge, the watershed that would drain into the proposed facility does not have an unusually high potential for extremely contaminated runoff, although hazardous spills can and do happen in any urban watershed.

Economic Analysis

Budgeting for construction of a wet detention pond should include costs for permitting, designing, constructing, and maintaining the pond. Costs will vary for permitting from state to state as will the construction of a pond in a developing area versus a developed area. Developing areas tend to be less costly, as there are less problems with existing utility and structure constraints. An average cost for a 1-acre, 5-foot deep pond with a storage volume of 180,000

cubic feet is $75,000 (EnviroSense, 1997). Costs for the recommended plants in the treatment cells are needed as well as annual maintenance costs.

Annual maintenance and operation costs typically range between 3 to 5 percent of construction costs. Maintenance costs include sediment removal, grass mowing, nuisance control (problematic animals), trash removal, routine inspections, and monitoring and sampling. On-site sediment disposal should be utilized when possible, as costs can be reduced by as much as 50 percent (EnviroSense, 1997).

Planting costs vary depending on the design of the system, the plant species used and the type of plant material used. It is estimated that planting costs for wetlands would be in the area of $2,000 to $5,000 per acre with adjacent landscaping costing as much as $20,000.

III. CONSTRUCTED WETLAND DESIGN ALTERNATIVES

There are several design alternatives for treatment of water at the 48th Street Detention Basin Project. These can be described as free water surface wetland (FWS), subsurface flow wetland (SSF), aquatic ponds, an "arid wetland", and planted filter strips.

Free Water Surface

The most used wetland design for large-scale constructed wetlands in the United States is the free water surface wetland. This system is typical of what would be found in nature. It has areas of open water as well as dense stands of emergent and sometimes submerged plants. The dominate species are cattail, bulrush, and common reed. Some of these systems are planted with additional species to enhance the wildlife habitat value of the system. Less costly to build than a subsurface flow wetland, this system has all the problems of open water, i.e. potential mosquito issues.

Subsurface Flow

The subsurface flow wetland design is widely used for many small-scale systems such as at individual residences. It also can be designed to operate in a vertical mode, not only the typical horizontal flow. Plant species usually employed are the same as in the free water surface wetland. The major problems associated with this design are the cost of gravel or other media to support the emergent plants and the potential for the media to clog over time.

Aquatic Pond

Aquatic ponds typically are covered by floating macrophytic plants such as water hyacinth and duckweed. These ponds can vary in depth and shape and can be lined or unlined, depending on water quality, depth of water, and permit requirements. Both water hyacinths and duckweed

require harvesting. Mosquitoes can be present because of the open water surface, especially that created during harvesting of the plants.

Planted Filter Strips

Another possible alternative treatment design is an overland flow system. This typically consists primarily of grass or grasslike plants through which large volumes of water flow on a very regular basis. *Cynodon dactylon* (Bermuda grass) might be a candidate species. This plant is a particularly aggressive weed that can withstand some degree of inundation, high salt levels, and almost anything that man can try as a weed control method. Because of allergy concerns, the plant would likely have to be harvested regularly. Mosquitoes are also known to breed in well-watered Bermuda grass. This type of system is basically a meadow and must be planted with a water-tolerant grass or sedge. It can be operated in a continuous mode with 1 to 5 cm of water depth. In any case, supplemental water would be required to maintain the plants. Olson (1993) reported that one water-tolerant grass species that has been used in this kind of system is *Phalaris arundinacea* (reed canary grass). Canary grass has been found growing in parts of Arizona.

"Arid Wetland"

A variation on the concept of planted filter strips could be called an "arid wetland". This type of wetland can be created with plants that are adapted to periodic flooding and can be found growing in similar conditions in Arizona. An example of this type of wetland is the St. David cienega near Benson, Arizona. This kind of wetland is not suitable for permanent flooding, but requires that periodic flooding occur. Two of the most likely candidate plant species for this type of wetland are *Hilaria mutica* (Tobosa grass) and *Prosopis juliflora* (mesquite).

This particular type of wetland has never been built. Therefore, many questions would need to be addressed such as length of the period of inundation, depth of inundation, treatment efficiency, plant species composition, etc. This experimental system if successful, however, might prove to be suitable for many arid portions of Arizona that have limited periods of adequate water availability combined with long periods of little or no water. Floodwater mosquitoes might prove to be a problem. Other types of mosquitoes also could become a problem if long periods of inundation are possible (see section below on Mosquitoes). Another possible issue could be weed control, although dense stands of established *Hilaria* should out-compete most other weeds.

"Hybrid' System

An experimental system currently under development at the Constructed Ecosystems Research Facility in Tucson might provide operational flexibility. This system could be operated as a surface flow system as well as a subsurface flow system if mosquito breeding became a significant problem. If required to control mosquito larvae, exposed surface water could be concentrated in deep zones that would have little cover for larvae in and around emergent vegetation, thus making it easier to control breeding (see Section VII).

IV. WETLAND OPERATIONS

Control Mechanisms

There are only a few control mechanisms for operating a wetland system. These include variation of influent flow, loading rates, water level within the cells, rotation in the use of individual cells, and variations in pretreatment. Vegetation management options include species selective removal, and the control of fire (Kadlec and Knight, 1996).

At the 48th Street Detention Basin facility, the supply of water will be controlled with external water applied as necessary to establish and maintain the treatment cells. The water can be recycled and therefore, a traditional "residence" or "detention" time approach to design is not meaningful.

"Time???"

Created wetland biofilters require a period of time to establish, stabilize, and grow into a viable functioning wetland. This may involve 2 to 5-plus years, as each system is different and dependent upon the specific site conditions related to the hydraulic regime. For example, a pond or permanent shallow marsh biofilter may be an almost "instant" wetland success with dense growth achieved in one season, whereas an intermittently wet and dry scrub brush biofilter will require at least several growing seasons to become established and several more years to present a natural stable visual character (Ferlow, 1993). If the "arid wetland" or a "hybrid" concept is chosen, then the 48th Street Detention Basin facility could have two different types of wetland.

Pond biofilters, used as landscape features, have the potential to be impacted by run-off-carried debris and petroleum products which "float" across the surface and degrade general visual quality. These aesthetic impacts can be significantly reduced through construction of a stone-

lined, heavily vegetated, bowl-shaped "trap" at the inlets. Entering runoff must pass through the rough stone layer and plant material growth. A significant percentage of the "floatables" will be caught and held at this point. "Trap" locations should be designed for easy access and periodic removal of the collected materials (Ferlow, 1993). At the 48th Street Detention Basin facility, there are trash racks at the inlet to the cells and at the outlets from the cells.

To ensure the potential for reasonable success, created wetland biofilters require detailed construction monitoring and maintenance during their time of establishment. Water levels must be checked, adjusted, and stabilized at optimum levels. Water elevation fluctuations of several inches can change the type from wetland-oriented to upland, or drown desired plants. Undesirable pioneer plant growth must be controlled or weeded out until desirable higher-quality vegetation has had time to become established and has a reasonable chance for continuance. Once established, the desirable wetland vegetation appears to have the potential to complete reasonably with the more aggressive weed species (Ferlow, 1993).

In a newly-created biofilter, wildlife impacts may have to be controlled to manageable levels, at least until the ecosystem can survive what might be considered normal wildlife predation impacts. For example, fine tuning of "normal" water level in a shallow marsh biofilter may be necessary to limit the habitat value of the created wetland for species that have the potential for negative impacts on the recently planted vegetation (Ferlow, 1993).

As a created wetland biofilter grows and matures, it may change in visual character and habitat type from the original design. Rainfall cycles, water levels, natural plant growth patterns, and wildlife utilization will play a role in and the establishment of wetland functional values (Ferlow, 1993).

Though designed with the same basic standards, healthy functioning biofilters display quite diverse results. When correctly sited within the development plan, created wetland biofilters provide strong visual interest in the landscape and act as natural open-space buffers (Ferlow, 1993).

The strong natural visual values, open-space elements, wildlife habitat characteristics, run-off control features, and water-borne materials reduction within created wetland biofilters represent positive environmental conditions (Ferlow, 1993.)

Water Requirements

In order to maintain a typical constructed wetland planted with bulrush, cattail, or common reed that is designed to capture and treat stormwater runoff in Phoenix, supplementary water will be required. Based on the water required by traditional agricultural crops such as cotton, alfalfa, and pecans, and on a pan evaporation rate of about 9,000 mm (108 inches) annually, it can be estimated that about 3 m (9 feet) of water will be required annually if significant amounts of water are not lost to seepage. In metro Phoenix, only 5 to 10 storm events on average per year will produce adequate precipitation to yield stormwater runoff to the 48th Street Detention Basin system.

For design purposes, the evapotranspiration rate should be estimated as 80 percent of pan evaporation for the greater Phoenix area. This would be about the same as a lake evaporation rate. In the continuing discussion over the issue of evapotranspirational losses from aquatic systems and wetlands, the general consensus is that shading from floating aquatic plants or emergent species decreases evaporation from the water surface, but plants continue to transpire. Therefore, the effect is that the presence or absence of plants results in about the same rate of

water loss (Reed *et al.*, 1995). Preliminary data indicate that, after about one year of operation, evapotranspirational and seepage losses from the Sweetwater Wetlands in Tucson are over 40 percent of the incoming water. At Tres Rios in the Greater Phoenix area, overall water loss has been reported to be approximately 12 to 15 percent with 3 to 5 percent being attributed to evapotranspirational losses or about 5 to 6 feet (Wass, 1998).

The use of supplemental water in arid Arizona may create some negative public perceptions and negative press. It is critical, therefore, that low quality water or water that is currently not being used for productive purposes be applied and that this information be well-documented and clearly stated in any information distributed about the system.

Single- Vs. Multi-celled System

It is generally agreed in the engineering community that a constructed wetland should be designed as a multi-celled system. The presence of multi-cells provides operational flexibility from a perspective of water availability as well as for maintenance and/or repair. Planting individual cells with different species facilitates operation of the system. The use of a single-cell system should be avoided.

Animals and the System

As noted above, the presence of water and plants will attract many animals. Most of these will have little impact on the operation of the wetland facility. However, rabbits and/or herbivores can denude a recently-planted area rapidly. Inundation of 15 cm (6 inches) will prevent rabbits from browsing newly planted material. Areas that are not inundated will need to be fenced to prevent destruction of the plants. This applies even to desert plants such as mesquite. Once established, most of the plant species can readily endure browsing by rabbits, deer, or other

mammals. At the 48th Street Detention Basin facility, the Basin site will be fenced. However, some animals will still be able to enter the system unless the fencing is specifically designed to exclude them.

Typically, birds have minimal direct impact on the plants, but the presence of large numbers of birds at particular times of the year can adversely impact the quality of the water leaving the wetland. The birds also will introduce seeds, especially cattail, from other areas and can add significantly to the organic waste load.

Overall, it will be impossible to exclude birds, mammals, insects, and other animals from the system. Therefore, the only control measures that should be undertaken are as noted above for initial plant protection or as mentioned in the section under mosquito control.

Public Access

The presence of water and a diverse plant community in an arid area such as the proposed siting for the 48th Street Detention Basin project will attract birds and other animals whether or not the wetland is designed to do so. The presence of birds and other animals will, in turn, draw the attention of people. In Tucson, at the Sweetwater Wetlands and to a lesser degree at the 91st Avenue Wetland in Phoenix, the public's presence has been encouraged. The opportunity for the public to visit and view these systems is very positive from both a multiple use concept as well as from a public educational and public relations aspect. Nevertheless, inviting the public into the wetland environment has some significant consequences. The first of these is the cost of designing the system to accommodate the presence of the public. At the Sweetwater Wetlands, paved paths, restroom facilities, overlooks, parking, signage, and other amenities are being provided at significant costs. At 91st Avenue, fewer amenities are provided. At both facilities, the issue of

liability and protecting the public are of concern. The presence of mosquitoes at 91st Avenue raises issues of public perception and safety as well. The Sweetwater facility is too new to evaluate the issue of mosquitoes at that location.

From the standpoint of the Arizona Department of Transportation (ADOT) and Maricopa County, the least costly, lowest maintenance and most easily implemented alternative would be to exclude the public. A possible compromise would be to post signage around the facility informing the public about the facility and its purpose, and only permitting occasional visits by organized groups.

The decision to use this facility as strictly a fenced operational facility with little if any public access will eliminate the need to maintain the 48th Street Detention Basin facility in a manner required by public aesthetics or for public access. Maintenance, therefore, will be dictated by operational concerns.

Weed Control

The presence of weeds at the site is to be expected, both within and around the wetland cells. One of the major weeds to be expected around the cells in the dry areas is likely to be *Salsola kali* (Russian thistle or tumbleweed). Other annual and perennial weeds are also to be expected. These can be controlled readily by minimizing soil disturbance, using pre-emergent herbicides and/or Roundup® or other weeding methods. An important concern, however, is if these herbicides should get into the water stream flowing in the wetland cells.

Within the wetland cells, cattail is the most likely herbaceous weed and can be removed by hand until the other desired species are firmly established. At that time, the desired species should maintain themselves. Around the edge of the cells, *Tamarix chinesis* (salt cedar) and

Cynodon dactylon sp. (Bermuda grass) will be present. It is strongly recommended that any young seedlings of both salt cedar and Bermuda grass be removed immediately, because once established, these prolific seedling exotic plants will rapidly become major components of the plant community as well as major pests. Also, once established, they are difficult, if not impossible, to remove and/or control. It would require extensive, repeated physical control as well as the use of selected herbicides. Control of these species, however, has proven to be very difficult.

Within the "arid wetland," weeds will tend to be a greater problem unless one or some combination of several options are used to control their development: (1) the use of pre-emergent herbicides, (2) the use of Roundup®, (3) mechanical control (blading, mowing, hoeing), (4) development of a dense ground cover, or (5) the use of a rock or other mulch cover. Weeds that could be expected in this area are both dry land weeds such as tumbleweed and careless weed (*Amanthus palmeri*) as well as other weeds such as Bermuda grass (*Cynodon dactylon*).

The use of decomposed granite on the sides of any of the wetland system is unlikely to completely prevent the growth of weeds. Water is likely to wick up the sides in sufficient quantities to support the growth of weeds. A geotextile liner at the surface would provide a very good barrier to weed development. However, the cost for material and installation would likely be substantial and the liner would be subject to damage. If the liner were buried, the wicking problem would still occur and weeds would still have to be removed.

Water Depth

Water depth in surface flow (SF) constructed wetland treatment systems affects the growth, survival, and reproduction of plants, the detention time, the ability of oxygen to diffuse from the

atmosphere into the water, and the composition of the microbial community. Typical operational water depths in SF constructed wetland treatment systems range from about 15 to 60 cm (0.5 to 2 feet). When combined with high organic loadings, greater depths provide poor root oxygenation and poor plant growth. Water depth in SF systems should be adjusted to optimize plant growth, especially during start-up, as long as treatment goals are being accomplished. Outlet structures should be designed to permit water depths ranging from zero up to the maximum design depth (Knight *et al.*, 1995). Gates with weirs can be used to control the depth of water at the 48th Street Detention Basin facility with the typical operational depth above the planting media being 15 to 30 cm (0.5 to 1 foot).

Bed depth of subsurface flow (SSF) constructed wetland is typically the most important factor in system cost. The Water Pollution Control Federation (1990) recommends a bed depth of 30 to 90 cm (1 to 3 feet). European designers who have applied this technology to hundreds of systems (Cooper, 1990) recommend a bed depth of about 60 cm (2 feet). Green and Upton's (1994) estimate of a bed width requirement of about 0.4 m per m^3/d of flow for tertiary treatment is based on a bed depth of 60 cm (2 feet) and the use of 5 to 10 mm (0.2 to 0.4 inches) gravel with a bed slope less than 5 percent and a steady state hydraulic conductivity of 1×10^{-3} m/s. Recommended bed widths for secondary treatment of settled wastewater are wider at 0.85 to 2 m per m^3/d (Cooper, 1990).

Soils/Substrate

Surface flow or free water systems usually use on-site soils as a substrate for plant growth. A constructed wetland can be built on almost any soil type and on gravel, but preferred soils are loams and sands because of the ability of plants to develop extensive root systems and to propagate

through rhizome development. Loamy soils are advantageous because of their fertility and texture. Clays may have excellent fertility, but their texture hinders root penetration and diffusion of oxygen and other gases to and from the roots. Preferred wetland construction includes from 15 to 30 cm (0.5 to 1 foot) of loamy or sandy topsoil within the wetland to provide an adequate substrate for the rooting of wetland plants (Knight *et al.*, 1995). Suitable topsoil (medium to sandy textured) should be used for a FWS at the 48th Street Detention Basin facility.

Substrate conditions are much more critical to the design of SSF wetlands than they are to SF systems. Subsurface flow wetlands have been constructed with substrates ranging from coarse sands to pea gravels with diameters of less than 1 cm (0.4 inch) to large rocks (up to 10 to 15 cm [4 to 6 inches] in diameter). Excessive fines associated with SSF substrate can result in hydraulic failure and should be avoided. Media permeability must be determined to permit appropriate design. If permeability is not determined correctly or the design is inadequate, surface flows will result. Gravel should be used at the 48th Street Detention Basin facility if an SSF system is desired. The gravel should be about 2.5 cm (1 inch) in diameter. This same gravel should be used as the planting media if the "hybrid" system is chosen.

Liner Requirements

Underlying soil permeability must be considered in the design of a constructed wetland. The most desirable soil permeability is less than 10^{-6} to 10^{-7} m/s (0.14 to 0.014 inches/hr). Lining is sometimes needed to decrease soil permeability and thus reduce seepage losses through the bottom of the wetland. Lining can consist of installing artificial materials, such as a geomembrane, or placing a layer of less permeable soils in the bottom of the wetland. Mechanical

compaction of existing or imported soils can also be effective in creating a less permeable barrier to seepage.

Generally, liners will be required for constructed wetlands receiving primary wastewater (including SSF systems receiving septic tank effluents), but not for systems receiving secondary or tertiary quality wastewater. Systems designed with multiple cells may only require liners in those cells receiving primary effluent. If the effluent discharged from one cell to another is of secondary quality or higher, a liner may not be required in the downstream cells.

A liner also may be used to prevent excessive loss of wastewater that is intended for some other beneficial use, such as landscape irrigation or wildlife habitat. In these cases, lining may be partial to reduce infiltration through particularly permeable site soils and may be accomplished by adding less permeable subsoils or top soils to portions of the site.

A liner will add significant cost and, in some instances, may hamper performance of the system. At some sites where site and/or soil characteristics can be demonstrated to perform hydrologically like a liner, no liner may be required (Knight *et al.*, 1995). Existing soils in the cells at the 48th Street Detention Basin facility are fairly tight and typically these should seal over time. Possible loss of water to the ground could be checked if desired to verify actual conditions. This could be achieved by installation of monitoring wells or the use of neutron probe monitoring or some combination of these two techniques.

High length-to-width ratios are useful to minimize short-circuiting. However, Knight *et al.* (1995) recommend ratios of 1:1 to 2:1 because of the increased cost of construction resulting from increasing the ratio of berm to volume to treatment area. They also recommend the use of

deep zones or low parallel berms to help reduce short circuiting. Their suggestions on design did not address the issue of maintaining access for the control of mosquitoes.

The cost for a constructed surface flow wetland is about $32,600/ha ($13,200/ac), while subsurface flow systems are about $350.000/ha ($141,000/ac) (Knight *et al.*, 1995).

V. PLANT MATERIALS OPTIONS

Although a wide variety of aquatic plants have been planted in constructed wetlands, the most commonly used plants in free water surface constructed wetlands for wastewater treatment are *Typha* sp. (cattail), *Scirpus* sp. (bulrush), and *Phragmites australis* (common reed). Less commonly used are *Juncus* sp. (rushes) and *Carex* sp. (sedges). The three major species spread rapidly, provide large surface areas for microbial attachment, and have high potential for pollutant removal that is well-documented. Cattail and bulrush species are commonly used in free water surface wetlands in the United States while common reed is used most in Europe.

Species of bulrush have the greatest wildlife habitat potential. However, three-square bulrush has been observed as possibly impeding the free movement of *Gambusia*, thus creating enhanced conditions for mosquitoes. Cattail provide somewhat lower habitat value, while common reed has little habitat value. *The Arizona Guidance Manual* (Knight *et al.*, 1995) provides an extensive listing of other Arizona plant species with potential for use in constructed wetlands (Appendix A). Most of these plants would be difficult to obtain and little, if any, documentation exist on the suitability and effectiveness of these other species for water quality improvement. Below is a discussion of pros and cons of the major plant genera as presented in Reed *et al.* (1995):

> **Cattail:** Typical varieties: *Typha angustifolia*, narrow-leaf cattail; *T. latifolia*, broad-leaf cattail. Distribution: worldwide. Optimum pH: 4-10. Salinity tolerance: narrow leaf, 15-30 ppt; broad leaf, <1 ppt. Growth: rapid, via rhizomes, spreads laterally, dense cover in <1 yr with plant spacing 0.6 m (2 ft). Relatively shallow root penetration in gravel ≈0.3 m (1 ft). Annual yield: ≈30 (dw) mt/ha (14 tons/ac). Tissue: (dw basis) ≈45% C, 14% N; 2% P; 30% solids. Habitat values: seeds and roots a food source for water birds, muskrat, nutria, and beaver; nesting cover for birds. Hydroperiod: can be permanently inundated >0.3 m (1 ft), can also tolerate drought. Commonly used on many FWS and

SF wetlands in the United States. The relatively shallow root penetration is not desirable for SF systems without adjustment in design depth of the bed. (page 179)

Bulrush: Typical varieties: *Scirpus acutus*, hardstem bulrush, common tule; *S. cypernius*, wool grass; *S. fluviatilis*, river bulrush; *S. robustus*, alkali bulrush; *S. validus*, soft-stem bulrush; *S. lacustris*, bulrush. Distribution: worldwide. Optimum pH: 4-9. Salinity tolerance: hardstem, wool grass, river, soft stem: 0-5 ppt, alkali, Olney's, 25 ppt. Growth: alkali bulrush, wool grass, river bulrush moderate, dense cover in 1 yr with plant spacing 0.3 m (1 ft); all others moderate to rapid, dense cover in 1 yr with plant spacing 0.3-0.6 m (1-2 ft). Deep root penetration in gravel ≈0.6 m (2 ft). Annual yield: ≈20 (dw) mt/ha (9 tons/ac). Tissue: (dw basis) ≈18% N; 2% P; 30% solids. Habitat values: seeds and rhizomes a food source for many water birds, muskrat, nutria, and fish; nesting area for fish when inundated. Hydroperiod: can be permanently inundated, hardstem up to 1 m (3 ft), most others 0.15-0.3 m (0.5-1 ft), some can tolerate drought conditions. Commonly used on many SF constructed wetlands in the United States. (page 179)

Reeds: Typical varieties: *Phragmites australis*, common reed, wild reed. Distribution: worldwide. Optimum pH: 2-8. Salinity tolerance: <45 ppt. Growth: very rapid, via rhizomes, lateral spread ≈1 m/yr (3 ft/yr), very dense cover in 1 yr with plants spaced at 0.6 m (2 ft). Deep root penetration in gravel ≈0.4 m (1.5 ft). Annual yield: ~40 (dw) mt/ha (18 tons/ac). Tissue: (dw basis) ≈45% C, 20% N; 2% P; 40% solids. Habitat values: low food value for most birds and animals, some value as nesting cover for birds and animals. Hydroperiod: can be permanently inundated, up to ≈1 m (3 ft), also very drought resistant. Considered by some to be an invasive pest species in natural wetlands in the United States. Very successful utilization at constructed wastewater treatment wetlands in the United States. The dominant species used for this purpose in Europe. Because of its low food value, this species is not subject to the damage caused by muskrat and nutria that has occurred in constructed wetlands supporting other plant species. (pages 179-180)

Rushes: Typical varieties: *Juncus articulatus*, jointed rush; *J. balticus*, Baltic rush; *J. effusus*, soft rush. Distribution: worldwide. Optimum pH: 5-7.5. Salinity tolerance: 0-<25 ppt depending on type. Growth: very slow, via rhizomes, lateral spread <0.1 m/yr (<0.3 ft/yr), dense cover in 1 yr with plants spaced at 0.15 m (0.5 ft). Annual yield: 50 (dw) mt/ha (45 tons/ac). Tissue: (dw basis) ≈15% N; 2% P; 50% solids. Habitat values: food for many bird species, roots food for muskrat. Hydroperiod: some types can sustain permanent inundation up to <0.3 m (1 ft), prefers dry-down periods. Other plants better suited as the major species for wastewater wetlands; rushes are well suited as a peripheral planting for habitat enhancement. (page 180)

Sedges. Typical varieties: *Carex aquatilis*, water sedge; *C. lacustris*, lake sedge; *C. stricata*, tussock sedge. Distribution: worldwide. Optimum pH: 5-7.5. Salinity tolerance: <0.5 ppt. Growth: moderate to slow, via rhizomes, lateral spread <0.15 m/yr (0.5 ft/yr), dense cover in 1 yr with plants spaced at 0.15 m (0.5 ft). Annual yield: <5

(dw) mt/ha (<4 tons/ac). Tissue: (dw basis) ≈1% N; 0.1% P; 50% solids. Habitat values: food source for numerous birds and moose. Hydroperiod: some types can sustain permanent inundation, others need a dry-down period. Other plants are better suited as the major species for wastewater wetlands; sedges are well suited as a peripheral planting for habitat enhancement. (page 180)

Floating Species: The species most likely to occur incidentally in FWS wetlands are *Lemna* sp. (duckweed). The presence of duckweed on the water surface of a wetland can be both beneficial and detrimental. The benefit occurs because the growth of algae is suppressed; the detrimental effect is the reduction in transfer of atmospheric oxygen at the water surface because of the duckweed mat. The growth rate of this plant is very rapid, and the annual yield can be 20 (dw) mt/ha (18 tons/ac) or more. The tissue composition is: (dw basis) ≈6 N, ≈2% P; 5% solids. Salinity tolerance: <0.5 ppt. Habitat values: food source for ducks and other water birds, muskrat, and beaver. The presence of duckweed on FWS wetlands cannot be prevented, since the plant also tolerates partial shade. Open-water zones in FWS wetlands should be large enough so that wind action can periodically break up and move any duckweed mat to permit desirable reaeration. The decomposition of the unplanned duckweed may also impose an unexpected seasonal nitrogen load on the system. (page 181)

A key to successful plant establishment of the species noted above is the propagation of these plants from good rhizomes or seedlings. In addition, it is critical that these be planted between April and September, with spring planting times significantly superior to fall. After planting, the plants must be kept in wet soil without deep flooding (usually 5 to 15 cm [2 to 6 inches]). If the small propagules are inundated too deeply, they will not develop.

Plant materials typically come in a variety of forms:

- container-grown plants
- wild-harvested material
- existing facilities
- bare root stock
- seed

Typically prices for plant materials are:

- Herbaceous species, bare root: $0.35 to $0.70
- Woody species: $0.40 (15 cm [~6 inches]) to $41.00 (3 m [10 foot])

Container-grown materials offer several advantages over other plant materials:

- Minimal transplant shock because the root system remains intact
- Better growth rate because the entire plant remains intact
- Greater flexibility in planting time because the plant undergoes minimal shock

Note that on a per acre basis, the cost for plants is from $2,000 to $5,000 per acre depending on the species of plant materials used, the method of planting, time of year, and performance guarantee requirements.

Recommended plant spacing for bulrush, cattail, and common reed is typically 1 m (3 feet) between transplants, whether they be root balls or rhizomes. Operational water depth is typically 15 to 30 cm (6 to 12 inches). Deep zones 2 m (6 feet) in depth can be used to help mix the flow within the individual cells. These zones, if they are perpendicular to the flow of long and narrow ponds, can also provide access as well as habitat for *Gambusia* and thus facilitate mosquito control. These deep areas need to be greater in width than the emergent vegetation or >6 m (18 feet).

No full-scale system has been built to use submerged aquatic plants (Etnier and Guterstam, 1997) and there are little data for designing systems based on submerged plants as a major component of the system (Etnier and Guterstam, 1997; Reed *et al.*, 1995). Species studied for these systems include: pennywort (*Hydrocotyle umbellata*) (the most commonly studied plant), pondweed (*Potamogeton amplifolius)*, water-milfoil (*Myriophyllum heterophyllam*), hornwort (*Certophyllum demersum*), and fanwort (*Cabomba caroliniana*). Guntenspergen, *et al.* (1989)

reported that *Egeria densa*, *Elodea nuttalii* and *Myriophyllum aquaticum* were tested for use in constructed wetlands.

The following submergent species are found in Arizona (Knight *et al.*, 1995):

Common Name	Scientific Name
Arrow-head	*Sagittaria cuneata*
Horned-pondweed	*Zannichellia palustris*
Hornwort	*Ceratophyllum demersum*
Naiad	*Najas maritima*
Pondweed	*Potamogeton crispus*
Pondweed	*Potamogeton foliosus*
Water buttercup	*Ranunculus aquatilus*
Water-milfoil	*Myriophyllum sibiricum*
Water-weed	*Elodea canadensis*

Submergent plants listed for use at the Sweetwater Wetlands in Tucson were *Potamageton* spp. and *Ceratophyllum* spp.

Currently, plants adaptations to their environment as well as their effects on water quality are only beginning to be understood. Submerged plants only grow well in oxygenated water and so their use in wastewater with a high organic content likely would be limited. Nevertheless, some submergent species likely would do well in various zones of the deep areas of the "hybrid" and traditional systems. The most likely candidates are unknown. It is suggested that the availability of plant material as listed above from local sources used as the determining criteria for species selection.

Some potential wetland plant species are regulated as noxious weeds. None of the recommended species are found on the list as of the date of this report. Appendix B contains a listing of the noxious weeds and noxious weed regulations.

Plant materials and information may be obtained from:

Western Sods Arid Adapted Revegetation
P.O. Box 10610
Casa Grande Arizona 85230
Mobile Phone: (602)320-1232
Phoenix phone: (602)268-8811 or 1-800-832-8873
Fax: (602)836-2146

Aquatic and Wetland Nurseries
9999 Weld County Road 25
Fort Lupton, Colorado 80621
Phone: (303)857-6157
Fax: (303)857-2455
- OR -
P.O. Box 82
Avondale, Arizona 85323

VI. MOSQUITOES

Introduction

In North America north of Mexico, there are now known to be 171 species of mosquitoes. These insects are important because they are not only pests, but also they are vectors for diseases such as eastern encephalitis, St. Louis encephalitis, dengue fever, malaria, and filariasis (Darsie, 1997).

Mosquito Production

Mosquito species of Arizona occupy an array of habitats and environmental conditions. Habitats for larval mosquitoes include lake edges, ponds, ditches, bogs, swamps, marshes, springs, snowmelt pools, rock pools, slow reaches of streams, floodwater or overflow depressions, tree holes, and containers (e.g., artificial containers such as rain barrels, cans, and tires) (Laird, 1988). The major requirement for mosquito larval development is standing water, the duration of which can be as little as one week. Food and protective cover are also critical. The high reproductive rate of the mosquito can rapidly bring about nuisance levels (Tennessen, 1993).

Mosquitoes are common in natural wetlands, so their presence in constructed wetlands is to be expected. The availability of standing water, high nutrient levels, and plant cover in constructed wetlands offers an ideal medium for larval growth. Anaerobic, bacteria-laden water has been found to be attractive to ovipositing females (Gerhard, 1959; Rockett, 1987). The potential for mosquito problems in nutrient-enriched constructed wetlands and the annoyance and vector capabilities of some species require consideration of alternatives for mosquito control early in the design and operation process.

In Arizona around the turn of the century, many wetland areas that provided suitable aquatic habitats for a variety of mosquito species were eliminated. This occurred as rivers and streams were driven underground by excessive pumping of groundwater. However, with the rapid growth of population in recent years, many ponds, lakes and other areas suitable as mosquito habitat are being created.

The diversion of stormwater can both dump pollutants into riparian systems and also greatly diminish the amount of stormwater that enters recharge areas for replenishing the groundwater. To alleviate these water quality and supply problems, various types of stormwater detention/retention areas are being incorporated into new commercial and residential developments. Some established developments also are retrofitted with stormwater retention and detention systems. The widespread use of these stormwater systems also may lead to increased mosquito production unless adequate precautions are taken (O'Meara and Purcell, 1993).

In Arizona, detention ponds for holding stormwater runoffs usually do not produce mosquitoes in sufficient numbers to cause major problems because they rapidly dry out. A similar type of invasion can occur in detention ponds that receive both stormwater and wastewater. Wide fluctuations in water levels, especially when they are frequent events, may make the detention system a suitable habitat for floodwater mosquitoes. Floating and rooted aquatic plants may foster the growth of some populations of mosquitoes (O'Meara and Purcell, 1993).

Although stormwater entering retention systems is supposed to percolate into the ground within 72 hours, retention areas often remain wet for longer periods. Floodwater mosquitoes are normally the first to appear in retention areas. Later in the rainy season, it is not uncommon to

find *Culex* spp., especially if grass cuttings have been accumulating in these areas (O'Meara and Purcell, 1993).

Overall, abundant populations of pest and disease-vectoring mosquitoes are much more frequently associated with retention systems than they are with detention systems. Moreover, it is much easier to achieve long-term mosquito abatement in detention areas. Retention systems, however, are much more effective for improving water quality than are mere detention systems. Therefore, water management experts often recommend the installation of retention systems for new developments.

In Arizona, an additional consideration in regard to mosquitoes and constructed wetlands is the possibility that the presence of the dense vegetation itself in the wetland cells will act as an attractant for adult mosquitoes. Thus, even if the development of larvae is controlled by design and/or application of larvicidal agents, there could be some additional adult mosquitoes in and around the wetland.

Control Considerations

Local mosquito control programs should be actively involved in the planning and approval stages for all new stormwater management schemes. If retention areas are placed at these sites, then a dual retention/detention system might be the best approach for both stormwater management and mosquito abatement. With proper design and construction, excess water in the retention part of the system can be sent to the detention pond, thus reducing the chances for mosquito production (O'Meara and Purcell, 1993).

Detention ponds should receive only stormwater. Banks on detention ponds should be steep, but not too steep to hinder mowing and other maintenance activities. Deeper ponds are preferable to shallow ones (O'Meara and Purcell, 1993).

Weed control around ponds is important and proper maintenance procedures should be followed to prevent possible mosquito breeding areas. The presence of a mechanical aerator, such as a fountain in the middle of the pond, often makes the site more visually attractive, deters the growth of unwanted vegetation, and makes the habitat more suitable for fish (O'Meara and Purcell, 1993).

The bottoms of retention areas should be free of depressions where water might accumulate and remain for periods sufficient to allow mosquito production. Mowing and other maintenance operations should be done without producing ruts. Grass cuttings and other types of debris should be removed from retention areas. Long-term responsibilities for proper maintenance of retention areas should be clearly stipulated (O'Meara and Purcell, 1993).

Once a retention system has been installed at an inappropriate location (e.g., on a site where the water table is too close to the surface), not much can be done to change the situation without eliminating the system. Under these conditions, mosquitoes must be controlled with larvicide. For a larvicide operation to be effective, it must be supported with a quality inspection program. The widespread occurrence of potential mosquito breeding sites in retention areas greatly increases the costs and man-power needs of inspection programs. Perhaps, through educational programs directed at the general public, we could generate more service requests for the control of mosquito larvae and fewer for adult mosquito control (O'Meara and Purcell, 1993).

The mosquito problems generated by various types of detention/retention systems, their solutions and control costs, should not be neglected when local governments are in the process of creating stormwater utilities. However, these items probably will receive adequate attention only if representatives of the local mosquito control district actively participate in the design phase (O'Meara and Purcell, 1993).

The abundance of organic matter and the presence of high populations of microorganisms found in a constructed wetland appears to be a factor impacting mosquito population densities. Higher population densities of mosquitoes appear to be present in constructed wetlands compared to natural wetlands (Tennessen, 1993). The species found in greatest abundance is the genus *Culex*. They are called "filth breeders" because they are known to be attracted to the presence of high levels of organic material in wastewater (O'Meara and Evans, 1983). *Culex* ssp. will do well in high-quality treated-effluent or in stormwater if the water is present for an extended period of time.

In areas controlled by the Tennessee Valley Authority, a level of 0.25 larvae per dipper sample near human residences usually results in a request to apply adulticide (Tennessen, 1993). The presence of high populations of *Gambusia affinis* (mosquito fish) as well as invertebrate predators did not remove the problem with mosquitoes in studies conducted in Kentucky (Tennessen, 1993).

Some problems with controlling mosquitoes in a constructed wetland can be readily overcome during the initial engineering of the system. Narrow paths between cells should be widened to facilitate movement around the cells. These would permit better access around cells so that mowing or other heavy equipment could control tall weeds that tend to deflect application

materials from backpack blowers. Large cells tend to be more difficult to treat, thus increasing costs. Slug injection of insecticide would probably save effort, but it would require that dispersal of the material be adequate and reasonably uniform (Tennessen, 1993).

There is also potential for breeding "nuisance mosquitoes" in large numbers. "Floodwater mosquitoes," which include species in the genera *Psorophora* and *Aedes*, breed in areas where the ground is periodically flooded and re-flooded. Even though these mosquitoes are not disease vectors, they can be an annoyance to residents by virtue of their large numbers. The "arid wetland" cells will receive water periodically (up to 10 cm [4 inches] deep) to maintain soil saturation. The periodic soaking of soil may create large populations of floodwater mosquitoes as is known to occur in many desert areas.

The construction of a typical wetland will likely create habitat for "permanent water breeding mosquitoes" such as *Culex* and *Anopheles* species. These permanent water mosquitoes prefer breeding in shallow water with emergent vegetation that will be abundant through out any surface wetland. *Culex* mosquitoes, especially *Culex tarsalis*, is a known vector for mosquito-borne encephalitis viruses, including St. Louis encephalitis (SLE) and western equine encephalitis (WEE). Both of these viruses may be pathogenic to humans, and WEE is also pathogenic to horses. Both of these viruses have been isolated in mosquitoes collected in Maricopa County in past years (Table 1). A wetland will also attract birds to the area, and many birds serve as carriers of encephalitis virus and thus provide the source of virus to local mosquito populations. The proximity of these systems to development increases the public health concern (Levy, 1994).

With these concerns in mind, it is necessary to incorporate an effective mosquito surveillance and control program into the plan. Some of the mosquito prevention options include

Table 1. Maricopa County Mosquito Species.

Species	Vector Capability[a]	Other
Anopheles franciscanus		
Aedes dorsalis *Aedes nigromaculis* *Aedes vexans*	CE, EEE, WEE	Dog heartworm
Culex peus *Culex quinquefasciatus* *Culex tarsalis* *Culex thriambus*	SLE, WEE CE, SLE, WEE	
Culiseta incidens *Culiseta inornata*	JBE, SLE, WEE	
Psorophora confinnis[b] *Psorophora signipennis*		

[a] CE: California group Encephalitis
JBE: Japanese B Encephalitis
EEE: Eastern Equine Encephalitis
SLE: St. Louis Encephalitis
WEE: Western Equine Encephalitis

[b] These species lay their eggs on the ground. The eggs can lie dormant for months or years and hatch readily in the presence of water.

Sources:

1. G.A. Moshiri (ed.), *Constructed Wetlands for Water Quality Improvement*. Lewis Publishers, Boca Raton, Florida. 1993. p. 598.
2. T.G. Engethaler, Maricopa County Vector Control, Written communication. Phoenix, Arizona. 1995.
3. R. Matheson, *A Handbook of the Mosquitoes of North America*. Charles C. Thomas Publisher, Springfield, Illinois. 1929. p. 34.

modifying the habitat to prevent successful breeding, such as creating steeper banks, deeper water, and/or faster water flow or movement, etc. However, since these modifications would adversely affect the primary function of the project to treat wastewater, these alternatives are not an option (Levy, 1994).

Another option is to introduce natural controls into the habitat such as mosquito-eating fish, but the use of fish alone in the wetland/cells would not be sufficient to prevent all mosquito breeding. Successful mosquito control using fish is contingent upon (1) introducing an effective larvivore such as mosquito fish (*Gambusia affinis*), and (2) that the fish have easy access to the mosquito larvae. In the Tres Rios wetland/cells, the presence of emergent vegetation has reduced or denied accessability of fish to many isolated pockets of mosquito larvae. Also, the plan is contradictory in that it calls for introducing *Gambusia* into the wetland/cells, but also suggests using only native Arizona species. *Gambusia affinis* is not only an introduced species, but it tends to out-compete native Arizona fish such as top-minnow and pup fish. Unfortunately, using native fish species for mosquito control, such as pup fish or top minnow, is even less effective than *Gambusia* due to differences in feeding habits among the species. This does not preclude the introduction of fish (native or non-native) into the cells. It only suggests that fish alone will not control the mosquito problem (Levy, 1994).

The best (if not only) option/strategy to address the mosquito issue is to incorporate a plan that involves regular monitoring and control of mosquito breeding. Mosquito breeding should be checked weekly (preferably) by conducting "larval dipping surveys" and following up with application of an appropriate larvicide where breeding is found. A pupaecide, Altosid®, was used in Arcata, California, to control mosquitoes (Rogers, 1997). Altosid® is a sustained release

mosquito growth regulator that prevents adult mosquito emergence. This product is manufactured by Zoecon Corporation, Dallas, Texas. Altosid® should be not be applied to known fish habitat.

Another option is 5 percent Skeeter Abate®, an insecticide that is used for control of mosquito and midge larvae. This material is manufactured by Clarke Mosquito Control Products, Inc., Roselle, Illinois (1-800-323-5727). Skeeter Abate® can be toxic to birds, fish and other aquatic organisms. However, when applied at labeled rates, it has been shown not to affect non-target species and is approved for use in drinking water.

Larvicides with BTI (*Bacillus thuringiensis israeliensis*) are both effective and selective in killing mosquito larvae without affecting other aquatic invertebrates. BTI comes in granule, pellet, and liquid formulations. The granules and pellets can be applied safely and easily without expensive equipment. Other larvicide options are also available including growth regulators and mosquito larviciding oils. Whatever control measures are used, efficacy of larvicide treatments should be checked with post-treatment dipping surveys (Levy, 1994).

A recently developed alternative, *Bacillus sphaericus* (BS), has been produced by Abbott laboratories and is being tested in the metropolitan Phoenix area.

Developing an efficient and effective larviciding program will be easier and cheaper than developing a mosquito adulticiding program. However, an effective larviciding program is contingent upon (1) having access to mosquito breeding areas, (2) having staff and time available to conduct surveys and apply larvicides, and (3) having a budget for purchasing pesticide. The large area involved may require one half-time employee and sufficient larvicide to treat up to 16 acres every two weeks. The dense growth of vegetation such as cattail and bulrush may eventually

hamper mosquito surveillance and control efforts, so measures should also be taken to maintain accessability to shallow water environments (Levy, 1994).

Various other agents, such as Malathion and Pyrethrins, are available for control of adult mosquitoes. According to Clarke, Mosquito Control Products, Inc., Dursban® (ultra low volume), an adulticide, has been used successfully and is one of the least toxic organophosphates. These products, however, would not eliminate the potential breeding within the wetland cells. Dursban® also has been used as a prehatch preventative for mosquito larvae in detention basins (Melvin, 1998).

The public health and nuisance concerns associated with mosquito breeding are important issues, and they must be addressed (Levy, 1994).

For information regarding mosquitoes, contact

Arizona Department of Health Services
Disease Prevention Services
Vector-borne and Zoortic Disease Section
3815 North Black Canyon Highway
Phoenix Arizona 85015
(602)230-5918 or (602)230-5919

Department of Environmental Services
Division of Field Services
Office of Vector Control
4707 East Washington
Phoenix Arizona 85034
(602)273-0895

VII. RECOMMENDATIONS

Wetland Design

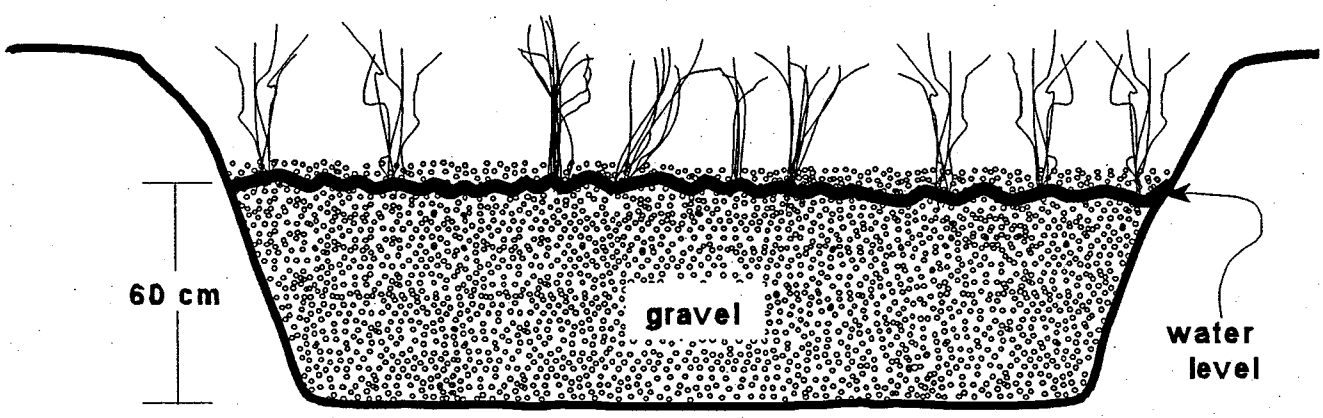
Four options are presented for the 48th Street Detention Basin facility and each of these is discussed briefly as to the pros and cons of the particular design option. It is recommended that one of the four design options be used at the site. The first option listed below is suggested as the best alternative for the proposed site.

The recommended option is to create a dual-cell subsurface flow wetland or vegetated treatment system (VTS). This design option will minimize any potential mosquito control problems and is likely to provide the most treatment per unit area. The biggest difficulties to the use of this alternative are the initial cost of the gravel and the potential for the gravel to clog over time. These systems have, however, proven to be effective at many sites and appear to be growing in popularity. One of the two cells of the VTS should be planted randomly with one or more plant species. The other cell should be unplanted and used to compare the treatment effectiveness of the planted cell versus a cell that contains only the gravel media (Figure 1). The water level in both cells should be maintained just below the surface of the gravel. During large storms, however, the cells could be flooded to a depth of 15 to 30 cm (6 to 12 inches) for brief periods without damage to the plants.

The second option is to create a "hybrid system" that will have a surface flow wetland appearance with the potential mosquito control ability of a subsurface flow wetland. This system would be operated typically as a surface flow wetland with water 15 to 30 cm (6 to 12 inches) above the gravel surface (Figure 2) with the side slope as regular and steeply sloping as possible. Planting beds would be about 30 m (100 feet) in width and alternating deep zones would be about

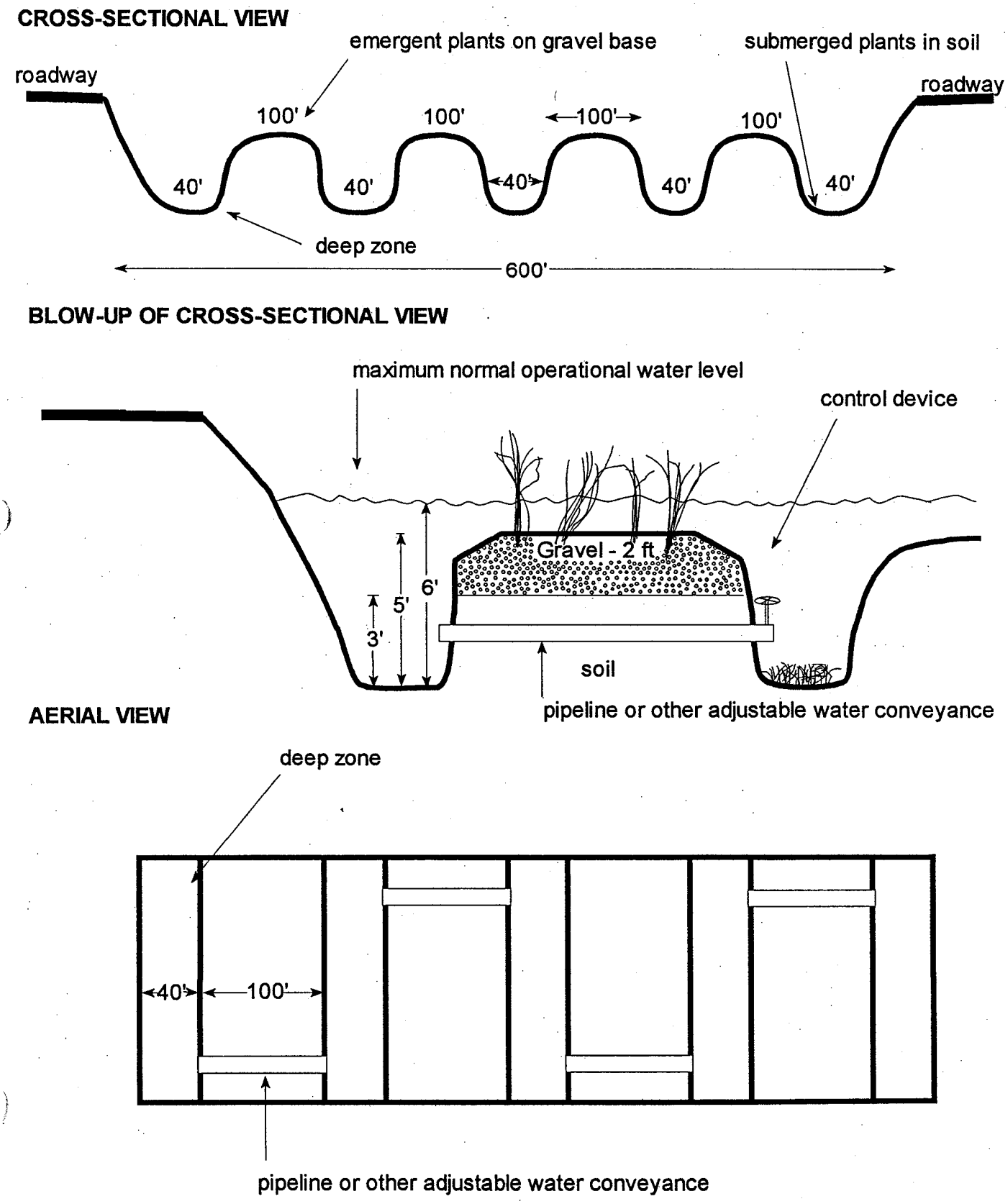
13 m (40 feet) in width. If mosquito larvae become a problem, water levels would be reduced to approximately 5 to 10 cm (2 to 4 inches) below the surface level of the gravel media. This lower water level should eliminate areas of exposed water covered by dense vegetation and thus also eliminate prime mosquito breeding habitat. Treatment would still occur as water flowed

Figure 1. Vegetated Treatment System (VTS).



through the planted gravel beds placed on the ridges of the wetland beds. *Gambusia* would retreat to deep water zones and mosquito larvae should be vulnerable in the open water of the deep zones. If clogging occurs in the gravel or more flow is required, water flow through pipes or another water conveyance set in the ridges along alternating sides of the wetland planting beds could be controlled with a valve or other flow device. Water would move from compartment to compartment, maintaining flow throughout the system. Again, this design would provide the appearance of a surface flow system with the potential benefit of maximum ability to control the development of mosquito larvae, although at a somewhat diminished treatment capacity. This system is currently under development and study at the Constructed Ecosystems Research Facility

Figure 2. "Hybrid" Free Water Surface/Subsurface Flow Wetland System.



in Tucson, but is not recommended at this time because it is costly, still in the experimental stage, and would require more operation and maintenance than the VTS system recommended above.

The third option is to construct a typical surface flow wetland with three deep zones placed at intervals of about 50 m (150 feet) with smaller open areas at the influent and effluent points. The shallow emergent zones would operate at 15 to 30 cm (6 to 12 inches) of water depth. The deep zones would be about 25 m (75 feet) in width and 1 to 1.5 m (4 to 6 feet) in depth set perpendicular to the water flow. This option is more traditional and would provide maximum treatment at minimal capital cost. It is also the most likely choice to create a mosquito breeding control problem. Therefore, this option is not recommended for the 48th Street Detention Basin project.

The forth option is to build an "arid wetland". This system is completely theoretical in concept and design. It would provide the most creative option for the possible use of wetlands in the drier areas of Arizona where there is little if any supplemental water available to maintain a more traditional wetland system. In this option, plant species used would be those native to cienegas in the deserts of south central Arizona (see Plant section above for suggested species). Mosquito control is an unexplored issue although the ability to dry out the system should decrease concern about *Culex* spp. Floodwater mosquitoes are a possible concern although the use of Dursban® as a prehatch treatment might address this issue. This option, however, would preclude the possibility of storing significant amounts of water within the wetland cells during particularly wet periods since the plant species within the "arid wetland" could not withstand long periods of deep water (30 cm [12 inches]). This alternative is not recommended, at this time, because of its theoretical nature.

Plants

If the recommended option is chosen, one of the two cells of the VTS should be planted randomly with both *Scirpus olneyi* (three-square bulrush) and *Scirpus validus* (soft-stem bulrush). The transplants should be placed about 1 m (3 feet) apart in alternating rows that are set perpendicular to the flow of water. This will provide an overall wetland appearance and some plant diversity. These two species have been grown successfully both in constructed wetlands in Arizona and in gravel media, and should be readily available from suppliers.

Emergent plants for the "hybrid" and surface flow wetland options should consist of the following species: *Scirpus validus* (soft-stem bulrush), *Phragmites australis* (common reed) and *Typha domingensis* (cattail). It is suggested that common reed be the predominant species in both the typical surface and "hybrid" systems. This is an aggressive species that has been used extensively for constructed wetlands, especially in Europe. Although common reed is not considered a noxious weed in Arizona and is found growing in Maricopa County, it could escape. Cattail could be used in place of common reed if there were concerns about its escaping. Cattail likely will enter the system without being purposely planted. The use of another species such as soft-stem bulrush would provide diversity to the plant community. As noted previously, little is known about submergent species for the deep zones. It is suggested, therefore, that potential suppliers be asked about availability and planting recommendations for the submergent species listed previously in the section on plants.

Soil

The planting substrate for the VTS should not contain soil. The cells should be filled to a depth of about 60 cm (2 feet) with 2.5 to 7.5 cm (1 to 3 inch) gravel. In the "hybrid" system,

plants will be placed in 2.5 cm (1 inch) gravel. The gravel depth would be 60 cm (2 feet). In the traditional wetland, it is recommended that a medium to sandy textured soil be used.

Mosquito Control

Mosquito breeding should not be an issue in the VTS except in small areas of surface water around contact boxes, etc. *Gambusia* should be added to the system in both the "hybrid" and traditional options. *Gambusia* will not be appropriate for either the VTS or the "arid wetland". For the "arid wetland", mosquito control would be similar to other detention/retention ponds currently operated by Arizona Department of Transportation.

Monitoring/Research

Monitoring of water quality should be conducted to establish and document the effectiveness of the system option(s) chosen for implementation. Water samples should be taken at least monthly and as required by storm events (Table 2).

Routine Maintenance

Routine maintenance and operational activities for any of the options discussed above should include most of the following:

1. Inspection for proper operation of all pumps and outflow gates as well as for appropriate water levels within the system [daily]
2. Removal or application of weed control agents for salt cedar, tumbleweed and other undesirable plant species [weekly during the growing season]
3. Mosquito larvae monitoring by dipping if surface water is present [weekly during the growing season (primarily during March through November)]

Table 2. Monitoring Parameters, Sampling Points and Suggested Frequency.

Parameter	Points	Suggested Minimum Frequency
Flow*	Inflow and Outflow	Daily
Water Stage*	In Each Cell	Daily
Biochemical Oxygen Demand (BOD_5)	Inflow and Outflow	Monthly/Following Each Event
Dissolved Organic Carbon (DOC)	Inflow and Outflow	Monthly/Following Each Event
Biodegradable Dissolved Organic Carbon (BDOC)	Inflow and Outflow	Monthly/Following Each Event
Total Suspended Solids (TSS)	Inflow and Outflow	Monthly/Following Each Event
pH	Inflow and Outflow	Monthly/Following Each Event
Dissolved Oxygen (DO)	Inflow and Outflow	Monthly/Following Each Event
Temperature	Inflow and Outflow	Monthly/Following Each Event
Conductivity	Inflow and Outflow	Monthly/Following Each Event
Nitrogen Species	Inflow and Outflow	Monthly/Following Each Event
Total Phosphorous	Inflow and Outflow	Monthly/Following Each Event
Chloride	Inflow and Outflow	Monthly/Following Each Event
Sulfate	Inflow and Outflow	Monthly/Following Each Event
Total and Fecal Coliform	Inflow and Outflow	Monthly/Following Each Event
Selected parasites and other microbial pathogens	Inflow and Outflow	Monthly/Following Each Event
Selected metals and other parameters	Inflow and Outflow	After Major Storm Events

* Equipment is available for remote monitoring of this parameter and for some of the other suggested parameters.

Safety and health concerns during sample collection are dependent on the types of contaminants in the stormwater. Metals and phosphorus, for instance, require caution in handling. They are skin irritants. Protection should be worn when handling contaminants like fecal coliform. Proper personal protection equipment is, therefore, recommended whenever water samples are collected.

4. Application of larvicides to the wetland system [weekly or as needed during the growing season]
5. Cleaning of trash and debris [monthly]
6. Inspection of embankments and structural integrity for signs of erosion or animal habitation; check fencing and other equipment and structures [monthly]
7. Repairs to system components [as required]

Active and aggressive control of water weeds and undesirable plant species is vital. Every effort should be made to eradicate all salt cedar plants as soon as observed by physical removal, including the roots. Use a preemergent herbicide for control of most other weeds outside the treatment cells. However, if preemergent herbicide application is unsuccessful in stopping weed growth, other weeds growing along the banks also should be physically removed or killed while still small by carefully applying Roundup®.

Harvesting of the plant biomass within the wetland cells is not a routine annual maintenance item from a treatment perspective. When needed, burning is the easiest and least expensive method to use. However, air quality problems within the Valley likely will preclude this option under most circumstances. Mechanical or hand harvesting, therefore, may occasionally be required. Data on harvesting frequency requirements do not exist and it is suggested that harvesting not be conducted, in general, as a routine maintenance activity.

It is estimated that during the start-up period, an average of about 16 hours of on-site time per week would be required to operate and maintain the wetland system, perform field measurements, monitoring and research, and collect water samples. After the start-up and research period are completed, routine operation and maintenance should require on average only

about 4 hours per week. Typically, one individual could carry out these activities although additional assistance would be required periodically. It also might be beneficial to occasionally have two employees work as a team for a shorter period of time.

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APPENDICES

APPENDIX A

Selected Arizona Wetland and Riparian Plants

Table A. Selected Arizona Wetland and Riparian Plants.[a]

Common Name and Species	Growth Form/ Habit	Hydrologic Regime	Soil/Substrate	Geographic Range	Elevation	Frequency of Occurrence	Comments
Alder *(Alnus oblongifolia)*	TR/SH	HY	SI/CO	CP/CH	5000-7500	FR	Often forms tall closed-canopy riparian woodland but also forms thickets along less stable water courses checking erosion; A. tenuifolia occurs at higher elevations (7500-9500') in Arizona
Annual rush *(Juncus bufonius)*	AN	HY/ME	CL/SA-T	BR	<3000	FR	The only annual rush, often very abundant over large areas
Arizona walnut *(Juglans major)*	TR	HY/ME	SI/CO	CH	4000-6000	FR	Large deciduous tree forming shady groves along streams and on flood plains; suspected of releasing allelopathogens into the soil; seedlings available through the Arizona State Land Department
Arrow-grass *(Triglochin concinna)*	PE	HY	NP	CP	6000-7000	IN	Rushlike perennial of wet soil; T. maritima also occurs in Arizona
Arrow-head *(Sagittaria cuneata)*	EM/SU	HY/SE-AQ	CI/SA	CP/CH/BR	<7000	IN	Leafy perennial spreading by rhizomes in wet soil; leaves submerged when water is present; similar species of Arizona include S. graminea, S. latifolia, S. longiloba, and S. greggii
Arrow-weed *(Tessaria sericea)*	PE	HY	CL/SA-T	BR	<4000	FR	Similar to seep-willow (Baccharis salicifolia) in habit and belongs to the same family; flowers pale lavender; often placed within the genus Pluchea
Azolla *(Azolla filiculoides)*	FL	AQ	N/A	CH/BR	2000-4000	IN	Clones of small leaves often cover large surface areas; technically a fern but similar in habit to the flowering plant Lemna (duck-weed)
Betony *(Stachys coccinea)*	PE	HY/ME	SI/CO	CH/BR	<8000	FR	Very attractive perennial with dark green leaves and bright red flowers; easily propagated; available from local nurseries
Bulrush *(Scirpus acutus)*	EM/PE	SE/HY	NP	CP/CH/BR	2500-9000	FR	Spreads by thick rhizomes forming dense tule-like masses of dark green terete stems generally ca. 2m tall (up to 5m); easily propagated by rhizomes; similar species or commonly-used synonyms include S. californicus (< 3500') and S. validus (2500-9000'); S. pallidus (<9000), S. americanus (< 6000'), and S. olneyi (< 7000,) have three-edged stems

Table A. (Continued)

Common Name and Species	Growth Form/ Habit	Hydrologic Regime	Soil/Substrate	Geographic Range	Elevation	Frequency of Occurrence	Comments
Bulrush *(Scirpus paludosus)*	EM/PE	SE/HY	NP	CH/BR	<5000	IN	Habit similar to sedges, generally < 1m tall
Button-bush *(Cephalanthus occidentalis)*	SH	HY/ME	SI/SA	CH/BR	<5000	IN	Handsome shrub to 2.5m tall with large leaves; prefers wet soil along streams
Cattail *(Typha domingensis)*	EM/PE	SE/HY	NP	CP/CH/BR	<4000	FR	Easily established, fast growing perennial spreading by rhizomes forming extensive thickets (tules) in shallow (< ca. 1m) water or mud; very important waterfowl habitat; seeds are wind- disperses en masse; shoots above ground die back each year
Cattail *(Typha latifolia)*	EM/PE	SE/HY	NP	CH/BR	3500-7500	IN	Very similar to T. dominguensis but occurs generally at higher elevations within Arizona
Columbine *(Aquilegia chrysantha)*	PE	HY/ME	SI/SA	CP/CH/BR	>3000	FR	Large showy bright green leaves and yellow flowers; shade tolerant; rhizomes easily divided and transplanted; this is the most common and widespread species but several others occur in Arizona
Cottonwood *(Populus angustifolia)*	TR	HY/ME	NP	CP/CH	5000-7000	FR	More similar in appearance to some willows (Salix) than to P. fremontii; P. acuminata is a species morpholocally intermediate between P. angustifolia and P. fremontii
Cottonwood *(Populus fremontii)*	TR	HY	NP	CH/BR	<6000	FR	Common and abundant deciduous tree with a large canopy; fruit wind-dispersed en masse
Coyote willow *(Salix exigua)*	SH	HY	SI/CO	CP/CH/BR	<9500	FR	Deciduous shrub spreading by rhizomes forming extensive tule-like areas along perennial waterways; easily propagated from shoots of the previous year
Duckweed *(Lemna gibba)*	FL	AQ	N/A	CP/CH/BR	<7000	FR	Often covers large surfaces of still or slow moving water; easily transplanted by casting a few live individuals; grows rapidly; an important species for waterfowl; although other species of the genus occur in Arizona, this is the most common and easily recognized; L. minor is also common

Table A. (Continued)

Common Name and Species	Growth Form/ Habit	Hydrologic Regime	Soil/Substrate	Geographic Range	Elevation	Frequency of Occurrence	Comments
Flat-sedge *(Cyperus niger)*	PE	HY/ME	SI/SA	CP/CH/BR	3000-7000	FR	One of the more common of ca. 25 species of the genus that occur in Arizona; similar in habit to the true sedge (Carex) but not as important in terms of bank stabilization
Godding willow *(Salix gooddingii)*	SH/TR	HY	SI/CO	CH/BR	<7000	FR	Common and abundant, often large deciduous tree of Arizona's middle and lower elevations; easily propagated from stems ca. 1" in diameter
Heliotrope *(Heliotropium curassavicum)*	PE	HY/ME	CL/SA-VT	CH/BR	<5000	FR	A low dark green succulent with small white flowers; often abundant but not usually dense
Hierba-mansa *(Anemopsis californica)*	PE	SE/ME	SI/SA-T	CH/BR	2000-5000	IN	Often forms thick masses in wet saline soil; frequently-used folk medicine
Horned-pondweed *(Zannichellia palustris)*	SU	AQ	N/A	CP/CH/BR	<8000	IN	The thin bright green grass-like leaves often occur in abundance near the surface of ponds and slow-moving waterways
Hornwort *(Ceratophyllum demersum)*	SU	AQ	N/A	CP/CH/BR	2000-6500	IN	Forms large masses under the surface of motionless or slow-moving water; restricts swimming and boat travel
Horsetail *(Equisetum laevigatum)*	EM/PE	SE/HY	SI/SA	CP/CH	4000-8000	FR	Spreads by rhizomes in wet and moist soils, often covering extensive areas; E. hiemale is another common species which occurs in Arizona
Knot grass *(Paspalum distichum)*	PE	HY	SI/SA	CH/BR	<4000	FR	Forms extensive stoloniferous masses along stream banks and in other areas of moist soil
Knotweed *(Polygonum amphibium)*	EM/PE	SE	NP	CP	5000-9000	FR	Often forms large masses in shallow water; the infloresences are tinged pink and conspicuous in full flower
Knotweed *(Polygonum bistortoides)*	PE	HY	NP	CH	8500-1100	FR	See P. fusiforme
Knotweed *(Polygonum coccineum)*	EM/PE	SE	NP	CP/CH/BR	2500-7000	IN	Similar to P. amphibium in habit but occurs also at lower elevations in Arizona
Knotweed *(Polygonum fusiforme)*	PE	HY	CL/SA	CH/BR	<4500	FR	One of several species of knotweed that often occur in abundance on wet soil; see also P. persicaria and P. bistortoides

Table A. (Continued)

Common Name and Species	Growth Form/ Habit	Hydrologic Regime	Soil/Substrate	Geographic Range	Elevation	Frequency of Occurrence	Comments
Knotweed *(Polygonum persicaria)*	PE	HY	NP	CP	5000-7000	FR	See P. fusiforme
Lobelia *(Lobelia cardinalis)*	PE	HY	CL/SA	CP/CH/BR	3000-7500	FR	The most common and abundant of the Arizona lobelias; often a significant element of the flora along water courses; flowers bright red and showy; rhizomes and corms are easily transplanted
Locust *(Robinia neomexicana)*	SH/TR	HY/ME	NP	CP/CH	4000-8500	FR	Large shrub or small tree with very showy clusters of white to violet flowers; large prickles deter pedestrian mobility; spreads by rhizomes forming large thickets; very fast growing and rhizomes easily transplanted
Manna grass *(Glyceria borealis)*	PE	HY	CL/SA	CP	7500-9000	FR	A tall graceful grass; three additional species occur in Arizona
Monkey-flower *(Mimulus cardinalis)*	PE	SE/HY	SI/CO	CP/CH/BR	2000-8500	IN	An attractive perennial with bright orange-red flowers; prefers seeps; similar to M. eastwoodiae, a stoloniferous species
Monkey-flower *(Mimulus guttatus)*	PE	SE/HY	SI/SA	CP/CH/BR	<9500	FR	Ubiquitous in wet soil; spreading by rhizomes and stolons; large and showy when in or near perennial water; flowers yellow; several other species of yellow monkey-flower occur in Arizona
Naiad *(Najas maritima)*	SU	AQ	N/A	BR	<4000	IN	
Nettle *(Urtica gracilis)*	HY	HY	CL/SA	CP/CH/BR	<9000	IN	Fast-growing leafy perennial spreading by rhizomes; herbage with stinging hairs
Paint-brush *(Castilleja minor)*	AN	HY	SI/SA	CP/CH/BR	3000-7500	IN	A thin annual to ca. 1m tall; top of stem has conspicuous red bracts when flowering
Panic grass *(Dichanthelium oligosanthes)*	PE	HY/ME	CL/SA	CH/BR	3000-6000	FR	Spreads by stolons; prefers moist sandy banks
Pepperwort *(Marsilea vestita)*	FL	AQ	N/A	CP/CH/BR	1500-7000	IN	The attractive clover-like leaves of this aquatic fern often cover large surface areas on still or slow-moving water

Table A. (Continued)

Common Name and Species	Growth Form/ Habit	Hydrologic Regime	Soil/Substrate	Geographic Range	Elevation	Frequency of Occurrence	Comments
Pink-stars *(Centaurium calycosum)*	AN	HY	SI/SA-T	CH/BR	<6000	FR	A thin annual of alkali seeps with showy pink flowers
Pondweed *(Potamageton crispus)*	SU	AQ	N/A	CH	3500-6000	IN	A species only recently discovered within Arizona which indicates that it is possibly a recent introduction; forms olive-green masses at and below the surface of still or slow-moving water no more than ca. 2m deep; the wavy margins of the leaves make them rather attractive
Pondweed *(Potamogeton foliosus)*	SU	AQ	NP	CP/CH/BR	<8500	FR	Forms green masses at and below the surface of still or slow-moving water gen. < ca. 1m deep; similar species that occur in Arizona are P. pectinatus (1000 -5000'), P. pusillus (>6000'), and the submergent form of P. diversifolius (5000-7500')
Pondweed *(Potamogeton nodosus)*	FL	AQ/SE	NP	CP/CH/BR	<8000	FR	The oval leaves lie flat on the surface covering large areas where the water is no more than ca. 1m deep; similar species that occur in Arizona include P. natans (>8000'), P. gramineus (>5000), and the floating form of P. diversifolius (5000-7500')
Reed *(Phragmites communis)*	PE	HY	SI/SA-T	CH/BR	<6000	IN	Spreading by thick rhizomes to form extensive tule communities
Rose *(Rosa woodsii)*	SH	HY/ME	SI/CO	CP/CH	4000-9000	FR	Prickly shrubs spreading by rhizomes, often forming extensive masses along streambanks and moist in rocky drainage bottoms; flowers pink, showy; fruit valuable food for wildlife; the species is often split into several species or varieties
Rush *(Juncus balticus)*	EM/PE	SE/HY	CL/SA	CP/CH/BR	3000-7000	FR	A common species usually forming extensive, dense stands of wiry dark green stems; a good soil stabilizer; one of numerous species that occur in Arizona; rhizomes are easily divided and transplanted
Rush *(Juncus xiphioides)*	EM/PE	SE/HY	SI/CO	CP/CH/BR	>3500	FR	A common rush with flat, iris-like leaves; the group is taxonomically confusing and numerous synonyms are found in the literature

Table A. (Continued)

Common Name and Species	Growth Form/ Habit	Hydrologic Regime	Soil/Substrate	Geographic Range	Elevation	Frequency of Occurrence	Comments
Salt grass *(Distichlis spicata)*	PE	HY/ME	CL/SA-VT	CP/CH/BR	<7000	FR	This common sod-forming grass often occurs singularly in saline soils
Sedge *(Carex praegracilis)*	PE	HY	SI/SA	CP/CH	>3000	FR	Forms grass-like masses in wet meadows and along shallow waterways; an excellent soil stabilizer
Sedge *(Carex senta)*	PE	HY	SI/SA	CP/CH/BR	>2000	FR	One of the most common and elegant of the sedges; its roots, rhizomes and stems are very dense and are therefore useful for bank stabilization; ca. 50 species of Carex occur in Arizona and many are similar in habit and habitat preference to C. senta.
Sedge *(Carex siccata)*	PE	HY	SI/SA	CP	>8000	FR	A common sedge of higher elevations
Seep-willow *(Baccharis salicifolia)*	SH	HY/ME	SI/CO	CH/BR	<5000	FR	Often forming dense thickets 2-3m tall; not a true willow but similar to coyote willow (Salix exidua) but evergreen and more drought-tolerant; releases myriads of wind-born seeds in fall; often referred to as B. glutinosa
Spike-rush *(Eleocharis macrostachya)*	EM/PE	SE/HY	CL/SA-T	CP/CH/BR	<8000	IN	Although several species of spikerush occur in Arizona, this species is the most frequent and abundant
Spike-rush *(Eleocharis rostellata)*	EM/PE	SE/HY	CL/SA-T	CP/CH/BR	<8000	IN	One of the most salt-tolerant of the spike-rushes
Sycamore *(Platanus wrightii)*	TR	HY	NP	CH/BR	2000-6000	FR	Large deciduous tree with white trunks; often forming closed canopy riparian woodlands
Toad-flax *(Linaria texana)*	AN	HY/ME	SI/SA	CH/BR	1500-5000	IN	Tall annual with dark blue flowers
Triodanis *(Triodanis perfoliata)*	AN	HY/ME	CL/SI	CP/CH/BR	<7500	IN	In wet soil of warmer climates grows tall (ca. 1m) with showy purple flowers
Velvet ash *(Fraxinus velutina)*	TR	HY/ME	SI/CO	CP/CH/BR	2000-7000	FR	A common and abundant deciduous tree along intermittent and perennial streams especially in the mid-elevations of Arizona; morphologically variable; seedlings available through the Arizona State Land Department

Table A. (Continued)

Common Name and Species	Growth Form/ Habit	Hydrologic Regime	Soil/Substrate	Geographic Range	Elevation	Frequency of Occurrence	Comments
Water bird *(Betula fontinalis)*	TR/SH	HY/ME	NP	CP	7000-8000	IN	Primarily a streamside tree with smooth, glossy, red-brown bark
Water buttercup *(Ranunculus aquatilus)*	SU	AQ	NP	CP/CH	4500-9000	FR	Forms delicate masses of thin leaves and stems in shallow slow-moving or still water; flowers white, emergent; R. circinatus is a similar Arizona species
Water lupine *(Lupinus latifolius)*	PE	HY	SI/SA	CH	5000-6000	IN	Leafy perennial often forming large masses to 1.5m tall along waterways; flowers large but not colorful; common only in the Prescott area; L. latifolius var. leucanthus is the from found in Arizona and it is often referred to as L. parishii
Water speedwell *(Veronica anagallis-aquatica)*	EM/PE	SE/HY	NP	CP/CH/BR	<7000	FR	Forms leafy, often extensive, patches along perennial stream banks; V. americana (< 9500') is a similar Arizona species
Water-milfoil *(Myriophyllum sibiricum)*	SU/FL	AQ	N/A	CP/CH	5000-9000	IN	Forms masses of feathery vegetation on and below the surface of still or slow- moving water; M. brasiliense is also known from Arizona
Water-pimpernel *(Samolus valerandi)*	PE	SE/HY	NP	CH/BR	<5000	IN	An attractive perennial for its thin green leaves; often locally abundant along perennial streams
Water-plantain *(Alisma plantago-aquatica)*	EM	SE	CL/SA	CP/CH	4000-8000	FR	Similar to A. subcordatum
Water-plantain *(Alisma subcordatum)*	EM	SE	CL/SA	CP/CH	5000-7000	FR	Fibrous roots, leaves mostly emersed, blades broadly ovate, leaves occasionally floating, flowering in summer
Water-weed *(Elodea canadensis)*	FL/SU	AQ	N/A	CP/CH	4000-8000	IN	Forms masses on and below the surface of still or slow-moving water
Willow *(Salix laevigata)*	TR	HY	SI/CO	CP/CH/BR	2000-7000	FR	Large deciduous shrub or tree; easily propagated from green shoots ca. 1" in diameter; similar Arizona species include S. lasiolepis (4000-7500') and S. bonplandiana (5000-6500')

Table A. (Continued)

*This table illustrates the diversity of native plants that can be used in wetlands constructed for wastewater treatment. This list includes species, such as cattail that have long been associated with wetland wastewater treatment systems and other plants whose efficiency for wastewater treatment have not been demonstrated. Included with this list are general information regarding the geographic distribution within the state, frequency of occurance, typical hydrologic regime, soil preference, and elevational range. The availability in nurseries of these and other wetland plants not listed can not be quaranteed. During the early planning phases of a constructed wetland project, after funding and construction schedules are known, it would be prudent to contract-grow in advance those plants that will not be collected from wild populations.

(Growth Form/Habit = SHrub, TRee, PErennial herb, ANnual, VIne, SUbmergent, EMmergent, FLoating; Typical Hydrologic Regime = AQuatic, SEmi-aquatic, HYdroriparian, MEsoriparian; Soil Preference = CLay, SIlt, SAnd, GRavel, CObble, No Preference (When known the salt tolerance of a given species is included as a modifier as follows: Not Tolerant, Moderately Tolerant, Very Tolerant.); Geographic Range = Basin & Range, Central Highlands, Colorado Plateau Elevation Range = reported in feet above MSL Frequency of Occurance (Natural Populations) = INfrequent, FRequent, Frequent & Abundant.)

APPENDIX B

Noxious Weed Regulations and Noxious Weed Lists

facsimile
TRANSMITTAL

To: Martin Karpicak
University of Arizona

Fax #: 520/621-3816

Re: Noxious Weed Regulations and Noxious Weed Lists

Date: June 1, 1998

Pages: 1

Attached you will find copies of the Two Noxious Weed Regulations currently on the books. These are enforced by the Arizona Department of Agriculture. The Agency also enforces the Federal Noxious Weed Act of 1974.

Listed below are those **aquatic** or **semiaquatic** plant species regulated under the State's noxious weed regulations:

Catergory: Regulated Noxious Weeds
Floating Water Hyacinth *Eichhornia crassipes*

Catergory: Prohibited Noxious Weeds
Alligatorweed - *Alternantherea philozeroides*
Anchored Waterhyacinth - *Eichhornia azurea*
Aquatic Morningglory - *Ipomoea aquatica*
Hydrilla - *Hydrilla verticillata*
Purple Loosestrife - ***Lythrum salicaria***
Torpedo Grass - *Panicum repens*
Water-chestnut - *Trapa natans*

When I faxed you the Noxious Weed Regulations earlier today I neglected to include Purple Loosestrife in the above list of regulated aquatic weeds. I apologize for any inconvenience this may have caused.

Thank you,
Everett

FROM:

Everett L. Hall
Noxious Weed Program Manager
Arizona Department of Agriculture
1688 West Adams Street
Phoenix, Arizona 85007

602/542-3309
Fax: 602/542-0999

State of Arizona
Noxious Weed Regulations

Regulation R3-4-244 "Regulated and Restricted Noxious Weeds"
Regulation R3-4-245 "Prohibited Noxious Weeds"

Plant Services Division
Arizona Department of Agriculture
August 1996

Definitions

Exotic Organism:

A plant or animal that is NOT native (indigenous) to the region, area or locale in which it occurs. It can be introduced intentionally or unintentionally.

Weed:

A plant that is competitive, persistent and pernicious. It interferes with human activities and as a result is UNDESIRABLE.[1]

Noxious Weed:

A weed SPECIFIED BY LAW OR REGULATION for being particularly undesirable, destructive and difficult to control.[2]

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1. Ross, Merrill and Carole A. Lembi "Applied Weed Science". Minneapolis: Burgess Publishing Company. 340pp. Illus. 1985.

2. California Weed Conference "Principles of Weed Control in California". El Macero, CA: Thomson Publications. 474pp. Illus. 1985.

Categories of Noxious Weeds

Regulated Noxious weeds

Regulated Noxious Weeds are those exotic plant species which are **WELL ESTABLISHED AND GENERALLY DISTRIBUTED** in Arizona. These plants are recognized to have undesirable characteristics and economic/environmental significance as to justify regulation under certain circumstances.

Restricted Noxious weeds

Restricted Noxious Weeds are those exotic plant species having noxious characteristics and are of economic and/or environmental significance. They **OCCUR** in Arizona in isolated infestations or very low populations.

Prohibited Noxious Weeds

Prohibited Noxious Weeds are those exotic plant species with known undesirable qualities of economic and/or environmental significance. The plants **ARE NOT KNOWN TO OCCUR** in Arizona.

Noxious Weed Regulations
Changes in Noxious Weed Listings

After July 1998

R3-4-245 "Prohibited Noxious Weeds"

Removed from regulation completely:
Kikuyugrass (*Pennisetum clandestinum*)

Added as a Prohibited Noxious Weed:
Tropical Soda-apple (*Solanum viarum*)

R3-4-244 "Restricted Noxious Weeds and Regulated Noxious Weeds

Moved from Restricted Noxious Weed Category and placed in Regulated Noxious Weed Category:
Floating Waterhyacinth (*Eichhornia crassipes*)

After September 1998

R3-4-244 "Restricted Noxious Weeds and Regulated Noxious Weeds"

Added as a Restricted Noxious Weed:
Sweet Resinbush (*Euryops subcarnosus* subsp. *vulgaris*)

ARIZONA DEPARTMENT OF AGRICULTURE
CHAPTER 4. PLANT SERVICES DIVISION

SECTION	ARTICLE 2. QUARANTINE
R3-4-244.	Regulated and Restricted Noxious Weeds
R3-4-245.	Prohibited Noxious Weeds

R3-4-244. Regulated and Restricted Noxious Weeds

A. Definitions. In addition to the definitions provided in A.R.S. § 3-201, the following shall apply to this rule:
   1. "Infested area" means each individual container in which the pest is found or the specific area which harbors the pest.
   2. "Regulated pest" means any of the following plant species, including viable plant parts (stolons, rhizomes, cuttings and seed, except agricultural, vegetable and ornamental seed for planting purposes), which are regulated noxious weeds:
      a. *Cenchrus echinatus* L. -- Southern sandbur
      b. *Cenchrus incertus* M.A. Curtis -- Field sandbur
      c. *Convolvulus arvensis* L. -- Field bindweed
      d. *Medicago* ~~[illegible]~~ *polymorpha* L. -- Burclover
      e. *Portulaca oleracea* L. -- Common purslane
      f. *Tribulus terrestris* L. -- Puncturevine
   3. "Restricted pest" means any of the following plant species, including viable plant parts (stolons, rhizomes, cuttings and seed, except agricultural, vegetable and ornamental seed for planting purposes), which are restricted noxious weeds:
      a. *Acroptilon repens* (L.) DC. -- Russian knapweed
      b. *Aegilops cylindrica* Host. -- Jointed goatgrass
      c. *Alhagi pseudalhagi* (Bieb.) Desv. -- Camelthorn
      d. *Cardaria draba* (L.) Desv. -- Globed-podded hoary cress (Whitetop)
      e. *Centaurea diffusa* L. -- Diffuse knapweed
      f. *Centaurea maculosa* L. -- Spotted knapweed
      g. *Centaurea solsritialis* L. -- Yellow starthistle (St. Barnaby's thistle)
      h. *Cuscuta* spp. -- Dodder
      i. *Eichhornia crassipes* (Mart.) Solms -- Floating waterhyacinth
      j. *Elytrigia repens* (L.) Nevski -- Quackgrass
      k. *Halogeton glomeratus* (M. Bieb.) C.A. Mey -- Halogeton
      l. *Helianthus ciliaris* DC. -- Texas blueweed
      m. *Ipomoea triloba* L. -- Three-lobed morning glory
      n. *Linaria genistifolia* var. *dalmatica* -- Dalmation toadflax
      o. *Onopordum acanthium* L. -- Scotch thistle

B. Area under quarantine: All infested areas within the state.

C. The following commodities are hosts or carriers of the regulated or restricted pest:
   1. All plants and plant parts other than those categorized as a regulated or restricted pest;
   2. Forage, straw and feed grains;
   3. Live and dead flower arrangements;
   4. Ornamental displays; and

5. Any appliance, construction or dredging equipment, boat, boat trailer or related equipment, or any other vehicle with soil attached or carrying plant debris.

D. The Department may quarantine any commodity or area infested or contaminated with a regulated pest and notify the owner or carrier of the restrictions and treatments listed in subsections (F) and (G). If the regulated pest is not quarantined, the Department shall provide the grower with technical information on effective weed control activities through integrated pest management.

E. The Department shall quarantine any commodity or area infested or contaminated with a restricted pest and shall notify the owner or carrier of the restrictions and treatments of the pest listed in subsections (F) and (G).

F. Restrictions.

1. No regulated or restricted pest or commodity infested or contaminated with a regulated or restricted pest shall be moved to a non-infested area unless the Director issues a permit for the transporting or propagating of such pest.
2. The owner or the owner's representative shall notify the Department at least two working days in advance of moving contaminated equipment from the infested area.
3. The Department may inspect all equipment within two working days after the request to inspect the equipment is made.

G. Treatments.

1. The owner or the owner's representative shall treat all soil and debris from the equipment used in the quarantined area to such a degree that it is free of the regulated or restricted pest before the equipment is moved from the infested area. Removal or destruction of the weed and weed seed shall be accomplished through one of the following methods:
   a. Autoclaving.
      i. Dry heat. The commodity shall be heated for 15 minutes at 212°F;
      ii. Steam heat. The commodity shall be heated for 15 minutes at 212°F.
   b. Fumigating with ethylene oxide, chamber only; The commodity shall be fumigated with 1,500 mg/L for four hours in a chamber pre-heated to 115-125°F.
   c. High pressure water spray;
   d. Crushing;
   e. Incinerating; or
   f. Burying in a sanitary landfill to a depth of six feet.
2. The owner or the owner's representative shall treat the infested area, including the area within the crop, rangeland, ditchbank, roadside, private property or body of water, with treatments based on an integrated pest management program appropriate to the commodity. The treatments shall take place under the direction of an inspector and shall include:
   a. Reshipment from the state;
   b. Manual removal;
   c. Application of a herbicide;
   d. Biological control including insects, fungi, nematodes or microbes; or
   e. Any other treatment approved by the Director.

EFFECTIVE July 10, 1995

R3-4-245. Prohibited Noxious Weeds

A. Definition. In addition to the definitions provided in A.R.S. § 3-201, the following shall apply to this rule:

1. "Infested area" means each individual container in which the pest is found, the specific area which

harbors the pest, or any shipment which has not been released to the receiver and is found to be infested with a pest.

2. "Pest" means any of the following plant species, including viable plant parts (stolons, rhizomes, cuttings and seed, except agricultural, vegetable and ornamental seed for planting purposes), which are prohibited noxious weeds:

a. *Alternanthera philoxeroides* (Mart.) Griseb. -- Alligator weed
b. *Cardaria chalepensis* (L.) Hand-Muzz -- Lens podded hoary cress
c. *Cardaria pubescens* (C.A. Mey) Jarmolenko -- Hairy whitetop
d. *Carduus acanthoides* L. -- Plumeless thistle
e. *Centaurea calcitrapa* L. -- Purple starthistle
f. *Centaurea iberica* Trev. ex Spreng. -- Iberian starthistle
g. *Centaurea sulphurea* L. -- Sicilian starthistle
h. *Centaurea squarrosa* Willd. -- Squarrose knapweed
i. *Chondrilla juncea* L. -- Rush skeletonweed
j. *Cirsium arvense* L. Scop. -- Canada thistle
k. *Coronopus squamatus* (Forskal) Ascherson -- Creeping wartcress (Coronopus)
l. *Cucumis melo* L. var. Dudaim Naudin -- Dudaim melon (Queen Anne's melon)
m. *Drymaria arenarioides* H.B.K. -- Alfombrilla (Lightningweed)
n. *Eichhornia azurea* (SW) Kunth. -- Anchored waterhyacinth
o. *Euphorbia esula* L. -- Leafy spurge
p. *Hydrilla verticillata* Royale -- Hydrilla (Florida-elodea)
q. *Ipomoea* spp. -- Morning glory. All species except *Ipomoea carnea*, Mexican bush morning glory; *Ipomoea triloba*, three-lobed morning glory (which is considered a restricted pest); and *Ipomoea aborescens*, morning glory tree.
r. *Isatis tinctoria* L. -- Dyers woad
s. *Lythrum salicaria* L. -- Purple loosestrife
t. *Nassella trichotoma* (Nees.) Hack. -- Serrated tussock
u. *Orobanche ramosa* L. -- Branched broomrape
v. *Panicum repens* L. -- Torpedo grass
w. *Peganum harmala* L. -- African rue (Syrian rue)
x. *Pennisetum clandestinum* Hochst. ex. Chiov. -- Kikuyu grass
y. *Rorippa austriaca* (Crantz.) Bess. -- Austrian fieldcress
z. *Senecio jacobaea* L. -- Tansy ragwort
aa. *Solanum carolinense* L. -- Carolina horsenettle
bb. *Sonchus arvensis* L. -- Perennial sowthistle
cc. *Stipa brachychaeta* Godr. -- Puna grass
dd. *Striga* spp. -- Witchweed
ee. *Trapa natans* L. -- Water-chestnut

B. Area under quarantine: All states, districts and territories of the United States except Arizona.

C. The following commodities are hosts or carriers of the pest:

1. All plants and plant parts other than those categorized as a pest;
2. Forage, straw and feed grains;
3. Live or dead flower arrangements;
4. Ornamental displays; and
5. Any appliance, construction or dredging equipment, boat, boat trailer or related equipment, or any other vehicle with soil attached or carrying plant debris.

D. The Department shall quarantine any commodity infested or contaminated with a pest and shall notify the owner or carrier of the methods of removing the pest from the commodity. The Department shall

reject any shipment not released to the receiver and reship to the shipper.

E. Restrictions:

1. No pest or commodity infested or contaminated with a pest shall be admitted into the state unless the Director issues a permit for the transporting or propagating of such pest.
2. The Department shall regulate the movement of the commodity out of a quarantined area within the state until the pest is eradicated. Any shipment or lot of a commodity infested or contaminated with a pest arriving in the state in violation of this quarantine shall, pursuant to A.R.S. § 3-205(A), be immediately reshipped from the state, or be treated or destroyed using one of the following methods:
   a. Fumigating with ethylene oxide, chamber only. The commodity shall be fumigated with 1,500 mg/L for four hours in a chamber pre-heated to 115-125°F;
   b. Incinerating;
   c. Burying in a sanitary landfill to a depth of six feet;
   d. Application of a herbicide; or
   e. Any other treatment approved by the Director.

EFFECTIVE July 10, 1995

Arizona Noxious weeds
Alphabetical Listing of Botanical Names

Acroptilon repens **- Asteraceae (R,I)**[1]
Russian Knapweed - Sunflower Family

Aegilops cylindrica **- Poaceae (R,I)**
Jointed Goatgrass - Grass Family

Alhagi pseudalhagi **- Fabaceae (R,I)**
Camelthorn - Legume Family

Alternanthera philoxeroides **- Onagraceae (P,U)**
Alligatorweed - Evening-primrose Family

Cardaria pubescens **- Brassicaceae (P,U)**
Hairy Whitetop - Mustard Family

Cardaria chalepensis **- Brassicaceae (P,U)**
Lens-podded Hoarycress - Mustard Family

Cardaria draba **- Brassicaceae (R,I)**
Globe-podded Hoarycress

Carduus acanthoides **- Asteraceae (P,U)**
Plumeless Thistle - Sunflower Family

Cenchrus incertus **- Poaceae (G,N)**
Southern Sandbur - Grass Family

Cenchrus echinatus **- Poaceae (G,A)**
Field Sandbur - Grass Family

Centaurea calcitrapa **- Asteraceae (P,U)**
Purple Starthistle - Sunflower Family

Centaurea diffusa **- Asteraceae (R,I)**
Diffuse Knapweed - Sunflower Family

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1. **(G) - Regulated Noxious Weeds (R) - Restricted Noxious Weeds (P) - Prohibited Noxious Weeds U - Not known to occur in Arizona; I - Introduced into Arizona; N - Naturalized after being introduced into Arizona; A - Native to Arizona.**

Centaurea iberica **- Asteraceae (P,U)**
Iberian Starthistle - Sunflower Family

Centaurea maculosa **- Asteraceae (R,I)**
Spotted Knapweed - Sunflower Family

Centaurea solstitialis **- Asteraceae (R,I)**
Yellow Starthistle - Sunflower Family

Centaurea squarrosa **- Asteraceae (P,U)**
Squarrose Knapweed - Sunflower Family

Centaurea sulphurea **- Asteraceae (P,U)**
Sicilian Starthistle - Sunflower Family

Chondrilla juncea **- Asteraceae (P,U)**
Rush Skeletonweed - Sunflower Family

Cirsium arvense **- Asteraceae (P,U)**
Canada Thistle - Sunflower Family

Convolvulus arvensis **- Convolvulaceae (G,N)**
Field Bindweed - Morning Glory Family

Coronopus squamatus - Brassicaceae (P,U)
Creeping Wartcress - Mustard Family

Cucumis melo var. dudaim **- Cucurbitaceae (P,U)**
Dudaim Melon - Cucurbit Family

Cuscuta **spp. - Convolvulaceae (R,I.A)**
Dodder - Morning Glory Family

Drymaria arenarioides **- Caryophyllaceae (P,U)**
Alfombrilla - Pink Family

Eichhornia azurea **- Ponteridaceae (P,U)**
Anchored Waterhyacinth - Pickerelweed Family

Eichhornia crassipes **- Ponteridaceae (G,I)**
Floating Waterhyacinth - Pickerelweed Family

Elytrigia repens **- Poaceae (R,I)**

Quackgrass - Grass Family

Euphorbia esula **- Euphorbiaceae (P.U)**
Leafy Spurge - Spurge Family

Halogeton glomeratus **- Chenopodiaceae (R,I)**
Halogeton - Goosefoot Family

Helianthus ciliaris **- Asteraceae (P,A)**
Blueweed - Sunflower Family

Hydrilla verticillata **- Hydrocharitaceae (P,U)**
Hydrilla - Frogs-bit Family

Ipomoea **spp. - Convolvulaceae (P,I,A)[2]**
Morning Glory - Morning Glory Family

Ipomoea triloba **- Convolvulaceae (R,I)**
Three-lobed Morning Glory

Isatis tinctoria **- Brassicaceae (R,U)**
Dyers Woad - Mustard Family

Linaria genistifolia **subsp.** ***dalmatica*** **- Schrophulariaceae (R,I)**
Dalmation Toadflax - Figwort Family

Lythrum salicaria **- Lythraceae (P,U)**
Purple Loosestrife - Loosestrife Family

Medicago polymorpha **- Fabaceae (G,N)**
Burclover - Legume Family

Nasella trichotoma **- Poaceae (P,U)**
Serrated Tussock - Grass Family

Onopordum acanthium **- Asteraceae (R,I)**
Scotch Thistle - Sunflower Family

Orobanche ramosa **- Orobanchaceae (P,U)**

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2. **Excepting Morning Glory Tree (*I.arborescens*) and Mexican Morning Glory Bush (*I. fistulosa*). These species are not regulated in Arizona.**

Branched Broomrape - Broomrape Family

***Panicum repens* - Poaceae (P,U)**
Torpedo Grass - Grass Family

***Peganum harmala* - Zygophyllaceae (P,U)**
African Rue - Caltrop Family

Pennisetum clandestinum* - *Poaceae (P,U)
Kikuyu Grass - Grass Family

***Portulaca oleracea* - Portulaceae (G,N)**
Common Purslane - Portulaca Family

***Rorippa austriaca* - Brassicaceae (P,U)**
Austrian Fieldcress - Mustard Family

***Senecio jacobaea* - Asteraceae (P,U)**
Tansy Ragwort - Sunflower Family

***Solanum carolinense* - Solanaceae (P,U)**
Carolina Horsenettle - Nightshade Family

***Sonchus arvensis* - Asteraceae (P,U)**
Perennial Sowthistle - Sunflower Family

***Stipa brachychaeta* - Poaceae (P,U)**
Puna Grass - Grass Family

***Striga* spp. - Schrophulariaceae (P,U)**
Witchweed - Figwoirt Family

***Trapa natans* - Trapaceae (P,U)**
Water-chestnut - Water-chestnut Family

***Tribulus terrestris* - Zygophyllaceae (G,N)**
Puncture-vine - Caltrop Family

Appendix D

Coordination Letters
between
Salt River Power ,
City of Phoenix
and
Arizona Department of Transportation

SALT RIVER PROJECT

Central Records

SALT RIVER PROJECT
LICENSE TO USE RIGHT-OF-WAY

DATE: March 28, 2000 LICENSE #: 0000106

The Salt River Valley Water Users' Association (hereinafter referred to as Salt River Project) hereby grants a License to install facilities within the right-of-way of the Salt River Project for the following purpose(s):

STORM DRAIN DISCHARGE

The Licensee, having read and understood the Special Conditions below (and attached) and the General Conditions, agrees to these conditions for the installation at the following location(s):

DRAIN DISCHARGE——————PECOS ROAD AND I-10
(19.5E -6.0S) Approximately West of the South ¼ corner of Section 32: T-1S; R-4E

SPECIAL CONDITIONS

A. CONSTRUCTION ITEMS:

QUANTITY	ITEM
*	Discharge into Pecos Drain

B. DRAWINGS:

PROJECT	CONSULTANT
City of Phoenix Project No. ST83120008 ✓ Southeast Phoenix Regional Drainage Basin	HDR Engineering, Inc.

APPROVED: Susan Ortega
Salt River Water Users Association

ACCEPTED: Ryl. N. Dl
Licensee (Owner/Agent)

CITY OF PHOENIX
Licensee

200 W. Washington Street
Address

Phoenix, Arizona 85003-1622
City, State Zip

SALT RIVER PROJECT

SALT RIVER PROJECT
LICENSE TO USE RIGHT-OF-WAY

DATE: March 28, 2000 LICENSE #: 0000106

C. SPECIFICATIONS:

1. Discharge into the SRP Pecos Drain shall occur only after receiving verbal approval for each event from SRP Association Dispatch Center
2. Discharge shall not exceed 10 cfs.
3. SRP reserves the right to deny a request to discharge as determined solely by SRP personnel.
4. This permit is will expire two years from the date the basin is constructed.

D. CONSTRUCTION NOTIFICATION:

The SRP Inspector is the "single point of contact" for proceeding with construction. Please call the Southside inspector, John Evans, at (602) 236-5664, 48 hours in advance of requiring any of the following:

- CONSTRUCTION CLEARANCE – Required prior to start of construction. A construction clearance does not assure a dryup.
- IRRIGATION OUTAGES – Should a dryup of the irrigation system be necessary for construction of this project, a TEMPORARY IRRIGATION OUTAGE AGREEMENT is required to be executed between the contractor and SRP. Please notify the inspector to schedule an on-site preconstruction meeting.
- INSPECTION – Installation of SRP facilities, or any construction within SRP right-of-way, require inspection prior to backfill and compaction.

E. BLUESTAKE:

Prior to construction, the contractor shall contact Bluestake (602-236-1100) and such other locators/utilities as needed to locate and flag all existing underground utilities.

F. DUST CONTROL:

The Licensee's contractor assumes sole responsibility for obtaining a dust control permit and complying with any required dust control plan pursuant to Maricopa County Environmental Services Rule 310.

G. ARCHAEOLOGICAL:

As required by federal law, state law and SRP Archaeological Policy 8-70-1, any cultural remains, both historical and pre-historical, or fossil remains, discovered during construction, must be immediately reported to the inspector.

SALT RIVER PROJECT

SALT RIVER PROJECT
LICENSE TO USE RIGHT-OF-WAY

DATE: March 28, 2000 **LICENSE #:** 0000106

GENERAL CONDITIONS

1. Licensee warrants and represents that he is qualified to perform, or will contract with qualified parties to perform, the undertaking which is the subject of the license.
2. Licensee agrees to obtain such other licenses, permits and agreements as may be required by other governing bodies having jurisdiction over the location which is the subject hereof.
3. Licensee agrees that any work in the Salt River Project right-of-way shall be completed and maintained in conformity with all applicable safety standards and regulations, and in a manner to avoid the creation of potentially dangerous conditions and harm to others.
4. Failure to obtain a specific construction clearance from the designated Salt River Project department will automatically void this license and subject Licensee to liability for any resulting damage to the property of others, including, though not limited to, that of the Salt River Project. If a construction clearance is not obtained and subsequent damage to Licensee's unauthorized installation occurs, Licensee agrees to waive all rights and claims for such damage and to assume sole responsibility for same. NOTE: A construction clearance does not necessarily assure a dryup.
5. In the event that said installation does not comply with the specifications and conditions stated herein or upon revocation of the license, Licensee shall remove at his sole cost, within ninety (90) days after written notice, any improvements or installations placed on said right-of-way pursuant to this license, and restore the irrigation facilities to the satisfaction of Salt River Project. In the event that Salt River Project determines that the irrigation facilities must be restore immediately for operational purposes, or Licensee fails to remove the installations or improvement within the time specified above or restore the irrigation facilities, the Salt River Project may remove the installations from the said right-of-way and/or restore the irrigation facilities, and the cost so incurred (as solely and conclusively determined by the Salt River Project) shall be paid by Licensee within ten (10) days after receipt of a statement of such cost. Licensee hereby releases the United States of America, the Salt River Valley Water Users' Association, and the Salt River Project Agricultural improvement and Power District from all claims for damages that may result to the Licensee or others by reason of such removal.
6. Should any Salt River Project facilities be damaged by Licensee, such facilities shall be repaired at Licensee's expense, to the satisfaction of Salt River Project. Salt River Project reserves the right, depending upon the nature and extent of the damage, to make such repairs and bill Licensee for all costs associated therewith.
7. Licensee shall be liable for any and all damages to the property of the United States of America, Salt River Project Agricultural Improvement and Power District, or any other party or parties by reason of the exercise of the privilege herein granted to Licensee. Licensee agrees to indemnify and hold harmless the United States of America, the Salt River Valley Water Users' Association, and the Salt River Project Agricultural Improvement and Power District, against any claims, actions, costs, expenses, or other liabilities for property damage or personal injuries in any way caused by or related to the exercise of rights herein granted, except those caused solely and exclusively by the negligence of the Salt River Project. Licensee understands and agrees that he enters upon the property of Salt River Project at his own risk.
8. Should Licensee fail to start construction within one (1) year following execution of this license, this license is automatically revoked and terminated, and Licensee shall secure a new license to construct the installation under conditions and specifications then in force.
9. All facilities installed pursuant to this license are subject to inspection and approval by agents of the Salt River Project and must comply with the specifications and conditions listed on both sides of this form (and attached). Said inspection, however, is not intended nor understood to be or constitute more than a determination that the specifications set forth herein have been complied with by Licensee and is not to be considered as an approval or ratification by Salt River Project of the quality or fitness of Licensee's improvements.
10. Licensee agrees to keep in proper maintenance and repair any facilities placed with said right-of-way.
11. This license shall continue in effect so long as it is considered to be expedient as conclusively determined by Salt River Project and shall be revocable within ninety (90) days after written notice is sent to Licensee.

SALT RIVER PROJECT

SALT RIVER PROJECT
LICENSE TO USE RIGHT-OF-WAY

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12. Licensee shall move or modify any facility constructed in the Salt River Project right-of-way at its sole expense if at any time the existence of said facility conflicts with the maintenance of, or future installations of Salt River Project's facilities.
13. It is mutually understood that Salt River Project may have only easement rights to the right-of-way covered by this license, and consent by the record owner of the underlying fee title to the land is not to be implied.

City of Phoenix
STREET TRANSPORTATION DEPARTMENT

June 13, 2000

Mr. Steven A. Jimenez, P.E.
Assistant State Engineer
Arizona Department of Transportation
205 S. 17th Avenue, #295, MD 614E
Phoenix, Arizona 85007-3212

Dear Mr. Jimenez:

This acknowledges your letter of June 7, 2000.

The City agrees to accept the excess SRP water into the drainage basin at 48th Street and Pecos Road. This will be based on ADOT's willingness to fund any upgrades to the system that may be required as a direct result of the frequency and amount of discharge from the SRP irrigation ditch, along with the modification of the language in the Water Quality Permit ADOT is negotiating with the Gila River Indian Community.

Sincerely,

J. Donald Herp

J. Donald Herp, P.E.
Deputy Street Transportation Director

Jdh:cr:F:\SEC_SVCS\PDP\HERP\Jdh06004.doc

c: Mr. Matthews
Mr. Godbee
Mr. Glover
Mr. Dovalina

200 West Washington Street, Fifth Floor, Phoenix, Arizona 85003-1611 602-262-6284 FAX: 602-495-2016
Recycled Paper

P.O. Box 52025
PHOENIX, AZ 85072-2025

License No: 0000106
File: RD-02156
Coord: 19E-6S

May 6, 2002

Mr. Art Glover
Street Transportation Department
City of Phoenix
200 W. Washington Street
Phoenix, AZ 85003-1611

RE: City of Phoenix Project No. ST83120008
Southeast Phoenix Regional Drainage Basin
48th Street and Pecos Road

Dear Mr. Glover:

We received notice that the City of Phoenix began discharging into the SRP Pecos Drain on March 13, 2002. This constitutes initiation of the two-year period (per SRP License # 0000106) for storm drain discharge. As a result, permission to discharge into the Drain will expire on March 12, 2004.

If you have questions, please contact me at 602-236-5799. Please reference our file number RD-02156 on any correspondence regarding this project.

Sincerely,

Susana Ortega

Susana Ortega
Water Engineering

c: Don Rerick, Flood Control District of Maricopa County
J. Donald Herp, City of Phoenix
Paul Cherrington
Gerry Bastian