RECLAMATION
*Managing Water in the West*

**Appendices**

# Augmentation Alternatives for the Sierra Vista Sub-watershed, Arizona

**Lower Colorado Region**

**U.S. Department of the Interior**
**Bureau of Reclamation**

**June 2007**

## Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Appendices

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## A. Preliminary Appraisal Study of the Water Development Potential of Underground Mine Workings in the Tombstone District

# Preliminary Appraisal Study of the Water Development Potential of Underground Mine Workings in the Tombstone District

Prepared by the Bureau of Reclamation in Cooperation with the Upper San Pedro Partnership

Final

May 5, 2004

**This document was developed by the Bureau of Reclamation (Reclamation) for use by the Upper San Pedro Partnership to describe a preliminary conceptual design. It is intended to begin a dialogue with all interested parties affected by this alternative. The contents are only conceptual and very preliminary in nature.**

**Reclamation defines an appraisal study as a brief investigation to determine whether to proceed with an in-depth "feasibility" study. The appraisal study uses existing data and information to identify plans to meet current and projected goals. It evaluates an array of options and identifies at least one possible solution.**

**Should a feasibility study be deemed necessary in the future, it is a more detailed investigation. In order for Reclamation to conduct such a study, congressional authorization is required. Feasibility studies result in reports to Congress (i.e., a Planning Report/Environmental Impact Statement). This report supports a request for congressional authority for Federal actions. These reports go to the Secretary of the Interior, and ultimately, to Congress. Congress will determine whether to pass a bill authorizing implementation, and the President will decide whether to sign the bill into law.**

**Description:** This report examines an alternative which proposes to recover groundwater that seeps into abandoned mine workings in and around the town of Tombstone, AZ. In addition, treated effluent, which is currently discharged from the Tombstone Wastewater Treatment Plant into Walnut Gulch, would be collected. Tombstone is located about 8 miles east of the San Pedro River (SPR).

Two options have been analyzed for use of this water. The first option is to recharge the water in an arroyo near the San Pedro River, south of Highway 92. This option includes treatment with slow sand filtration. The second option involves conveying the recovered water to Fort Huachuca. The water would then be sent to the Fort's wastewater treatment plant and used in its reclaimed water system.

Each option was developed with two different volumes of water: 1322 AFY and 500 AFY. These volumes correspond to different estimates of sustainable withdrawals from the Tombstone Mine area, including treated effluent. A total of four cost estimates, shown at the end of this document, were generated. A better estimate of the long-term yield from this alternative will be difficult to ascertain. However, an in-depth investigation would be required if this alternative is selected for further analysis as a part of a feasibility study.

This alternative would transfer water from one part of the Sierra Vista Subwatershed to another. The water being transferred would eventually reach the San Pedro river anyway. It does not address the larger issue of overdraft in the Subwatershed. However, this alternative could mitigate an area with a cone of depression in one part of the Subwatershed, a strategy known as subarea management.

**Analysis and Discussion:** The essential information required to analyze this alternative is the amount of water which can be recovered, the end use of the water, the quality of the recovered water, how recovery would be accomplished and the routing of the conveyance pipeline. Reclamation believes that enough information is available to complete this pre-appraisal analysis.

**Amount of Water Available:**
Estimates for sustainable withdrawals for the Tombstone Mine area were taken from ADWR's draft report, "Preliminary Appraisal of the Water Development Potential of Underground Mine Workings in the Tombstone District" (ADWR Report). One interpretation of the amount of water that can be removed on a sustained basis comes from Table 6, page 20, as 1,210 acre-feet per year (AFY). This definition of "sustainable" is a period of about 20 years. A more conservative volume for water that can be recovered would be the natural recharge rate of the area, which is estimated at less than 500 AFY. Even the lesser amount would have some effect on Tombstone area water levels and wells that would have to be evaluated.

Additionally, Reclamation is proposing to pump treated effluent from the Tombstone WWTP's discharge into Walnut Gulch back to the mine recovery point and combine it with recovered mine water. The estimated volume of treated effluent is 100,000 gallons per day or about 112 AFY. Most likely, this volume would increase over time, as the Tombstone area grows.

Therefore, both a quantity of 1,322 AFY (1,210 plus 112) and a quantity of 500 AFY (less than 500 plus 112) were evaluated for recovered water.

**End Use of Water:**
Two options for the end use of the recovered water were evaluated. One option involves conveying the water to a point south of Highway 92, adjacent to the San Pedro River, where it would be recharged. This location was selected to provide maximum benefits to the San Pedro River's riparian ecosystem. A NPDES permit would be required in order to discharge the water.

The second option conveys the water directly to Fort Huachuca, where it would be treated with existing treatment facilities and used as reclaimed water.

**Quality of Recovered Water:**
The primary concern with respect to water quality is the possible contamination with fecal coliform bacteria. To address this issue, treatment with slow sand filtration is suggested for the recharge option. Wastewater treatment at Fort Huachuca would address the problem of fecal coliform.

Existing water quality data for the Tombstone mine and the surrounding area is detailed in the ADWR Report. Besides fecal coliform, testing of wells in the Tombstone area have shown levels of arsenic, fluoride and nitrates that have slightly exceeded drinking water standards. Some of these tests were conducted at City of Tombstone drinking water wells, revealing a problem that needs to be addressed by the City.

Other slight exceedences were detected at wells a few miles north of the Tombstone mine, and probably do not indicate contamination from the mine. The ADWR Report concludes that acid rock drainage from the Tombstone mine is not occurring on a regional basis, as sulfate levels in the mine are surprisingly low. Slight exceedences of the arsenic drinking water standards have also been detected in Benson and Pomerene, further suggesting that the arsenic exceedences are due to background levels in the groundwater. Water quality data collection has not been consistent and it is therefore difficult to draw firm conclusions as to the treatment type and level of treatment that would be required.

However, before proceeding with the recharge option, the quality of the mine water would be investigated. If more extensive treatment than slow sand filtration is indicated, recharge of the recovered water would be significantly more expensive than delivery of the water to Fort Huachuca.

For the reclaimed water option, treatment costs, provided by Army staff, are estimated at $1.19 per 1000 gallons. The existing treatment facilities at the Fort have excess capacity which would be utilized.

**How Recovery Would Be Accomplished:**
A 600-foot deep well would be installed to recover water from the mine workings. Extensive investigation and care would be used in locating the well, since difficulties have been reported with previous installations.

The recovered effluent would be pumped using a single submersible pump and conveyed using a 6-inch diameter pipe, 2.2 miles in length, where it would be combined with the mine water.

**Pipeline Routing**
For the recharge option, the proposed alignment follows Highway 80, roadways and other previously disturbed areas to the greatest extent practical. South of Government Draw, the pipeline would follow an existing road to Lewis Springs. At this point, it would follow the railroad grade south, paralleling the east side of the SPR, until crossing Highway 92. Reclamation proposes that the recovered water be recharged approximately one-half mile upgradient from the San Pedro River, within the SPRNCA.

A wash (or multiple washes) that flows into the SPR would be selected, based on its ability to handle the proposed flows without affecting its channel morphology, as well as its ability to benefit the riparian ecosystem. A site specific, detailed hydrologic evaluation would be required in order to locate the exact point of recharge. The hydrologic investigation would necessarily follow selection of this option as a viable alternative. See the attached map for the location.

An energy dissipation structure would be constructed at the end of the pipe. This would consist of a geomembrane lined excavated hole covered with graded rock.

To convey the recovered water to Fort Huachuca, we propose using the easement for an existing 7-inch inside diameter nickel-steel pipeline which feeds Tombstone potable water from springs in the Huachuca Mountains (Tombstone aqueduct). From that point to the Fort, existing roadways would be used to the greatest extent practical. See the attached map. Care would be necessary to prevent damage to the Tombstone aqueduct.

**Issues and Concerns:**

Environmental

- Although the conveyance pipeline would use previously disturbed easements wherever possible, the pipeline route must still be walked and surveyed for endangered species and cultural resources.
- Potential effects to the following federally listed species and/or designated critical habitat should be addressed in the NEPA document: lesser long-nosed bat, Mexican spotted owl, loach minnow, spikedace, Sonora tiger salamander, southwestern willow flycatcher, and the Huachuca water umbel, as well as any species proposed or listed prior to project implementation.
- Potential use of the Tombstone Mine by bats should be investigated and potential effects determined.
- Sensitive plants such as agaves and cacti located within the pipeline right-of-way should be transplanted.
- Determine impacts (if any) to Walnut Gulch from the removal of treated effluent.
- Removal of water from the Tombstone mine may affect the connectivity of the regional aquifer and its ability to feed the San Pedro River.

Water Rights and Ownership

- Issues of water rights, water ownership and the legal aspects of effects on Tombstone area wells must be addressed.
- Issues of water rights and water ownership at the point of discharge must be addressed. We assume that State recharge protocol would be used.

Effects on Tombstone

- Although the withdrawals in this alternative are designed to be sustainable, there may be impacts on wells in the Tombstone area. The complex geology of the area makes the potential effects very difficult to predict. The 500 AFY of natural recharge in the Tombstone area should minimize the effects. Tombstone is actually drawing spring water that would feed the SPR near Sierra Vista.
- Dropping water levels resulting from this alternative could affect the aging mineworks, causing settlement and subsidence.

- Over the long term, the withdrawal of the low quality water from the mine area may improve the overall groundwater quality for Tombstone.

Further Investigation

- The quality of the recovered water must be ascertained by testing. Should testing results reveal that different treatment is necessary, pilot testing of the treatment method is recommended. Reclamation can provide mobile treatment equipment from the Water Quality Improvement Center, located in Yuma Arizona, to do the pilot testing.
- The quantity of water that can be removed on a sustainable basis would need further in depth study and anaylysis.
- The location for recharge must be identified and evaluated based on benefits to the riparian ecosystem, recharge capacity, water quality impacts (NPDES permit), effects on drainage (flooding) and wildlife/livestock.

Financial

- Financing – where the money comes from, how it is paid back, and by whom, must be determined.

Effectiveness

- It is likely that the water moved from the Tombstone area eventually reaches the SPR. Therefore, this option does not increase the total amount of water in the Sierra Vista subwatershed. However, this may be a way to benefit the SPR's riparian ecosystem at a key location, or to mitigate groundwater pumping near Sierra Vista. This strategy is known as subarea management.

Regulatory

- CWA Section 404 permit coverage is needed for fills associated with pipeline crossings of washes and streams.
- NEPA compliance (EA or EIS) is required if the project is partly or wholly funded by the Federal Government.

Cultural Resources

- A cultural resource survey would be required for the area of potential effect. A Class I survey should be done first to determine what areas may have been surveyed recently.
- Tribal consultation for traditional cultural properties would need to be carried out (minimally with the Hopi, Tohono O'odham, San Carlos and White Mountain Apache, GRIC, and perhaps Zuni). If testing and/or data recovery are required, additional tribal consultation would be required.
- Section 106 consultation with the State Historic Preservation Office must be carried out. The Advisory Council on Historic Preservation would need to be part of the consultation process, but it is likely they would opt not to be part of the process.

**Primary Reference:** Preliminary Appraisal of the Water Development Potential of Underground Mine Workings in the Tombstone District, ADWR Report, October 2003.

# Summary Tables

| Deliver Water to the SPR for Recharge | | | | | | |
|---|---|---|---|---|---|---|
| Volume | Capital cost (millions) | Annualized Capital Cost (millions) | O&M Cost (millions) | Total Annual Cost (millions) | Cost per Acre-Foot | Cost per 1000 gallons |
| 500 AFY | $8.09 | $0.60 | $0.14 | $0.73 | $1,466 | $4.50 |
| 1322 AFY | $10.91 | $0.80 | $0.27 | $1.07 | $809 | $2.48 |

| Deliver Water to the Ft Huachuca for WWTP Treatment | | | | | | |
|---|---|---|---|---|---|---|
| Volume | Capital cost (millions) | Annualized Capital Cost (millions) | O&M Cost (millions) | Total Annual Cost (millions) | Cost per Acre-Foot | Cost per 1000 gallons |
| 500 AFY | $6.35 | $0.47 | $0.26 | $0.72 | $1,449 | $4.45 |
| 1322 AFY | $9.19 | $0.68 | $0.66 | $1.34 | $1,013 | $3.11 |

Notes
1. Cost of effluent has not been addressed.
2. R.O.W. cost for recharge sites has not been addressed.
3. Power costs are included in the annual O&M for wells & booster pumps.
4. Additional pumping may be required at the mine recovery well.
5. Used 12 cents per kwh.(per Fluid Solutions/BBC report)
6. Present value 4%, 20yr, 0.0736 (per Fluid Solutions/BBC report)

# Detailed Cost Tables

| Deliver Water to the SPR for Recharge | | | | | | |
|---|---|---|---|---|---|---|
| 500 acre-feet per year | | | | | | |
| Item | Capital cost ($1000) | Annualized Capital Cost ($1000) | O&M Cost ($1000) | Total Annual Cost ($1000) | Cost per Acre-Foot | Cost per 1000 gallons |
| Effluent Booster Pump | $58 | $4 | $10 | $14 | $28.76 | $0.09 |
| Effluent Conveyance Pipeline | $401 | $29 | $4 | $33 | $67.00 | $0.21 |
| Recovery Mine/Well | $184 | $14 | $51 | $65 | $129.80 | $0.40 |
| Conveyance Pipeline | $7,024 | $517 | $70 | $587 | $1,174.47 | $3.60 |
| Water Treatment | $421 | $31 | $2 | $33 | $65.17 | $0.20 |
| Recharge Infrastructure | $5 | $0 | $0 | $0 | $0.79 | $0.00 |
| | | | | | | |
| Total | $8,093 | $596 | $137 | $733 | $1,466 | $4.50 |

| Deliver Water to the SPR for Recharge | | | | | | |
|---|---|---|---|---|---|---|
| 1322 acre-feet per year | | | | | | |
| Item | Capital cost ($1000) | Annualized Capital Cost ($1000) | O&M Cost ($1000) | Total Annual Cost ($1000) | Cost per Acre-Foot | Cost per 1000 gallons |
| Effluent Booster Pump | $58 | $4 | $10 | $14 | $10.88 | $0.03 |
| Effluent Conveyance Pipeline | $401 | $29 | $4 | $33 | $25.34 | $0.08 |
| Recovery Mine/Well | $359 | $26 | $158 | $184 | $139.53 | $0.43 |
| Conveyance Pipeline | $8,977 | $661 | $90 | $750 | $567.66 | $1.74 |
| Water Treatment | $1,112 | $82 | $4 | $86 | $65.17 | $0.20 |
| Recharge Infrastructure | $5 | $0 | $0 | $0 | $0.30 | $0.00 |
| | | | | | | |
| Total | $10,912 | $803 | $266 | $1,069 | $809 | $2.48 |

Appendix A:
A. Intra-basin transfer: Tombstone Mine to Fort Huachuca Reclaimed Water System

| Deliver Water to Ft. Huachuca<br>500 acre-feet per year | | | | | | |
|---|---|---|---|---|---|---|
| Item | Capital cost ($1000) | Annualized Capital Cost ($1000) | O&M Cost ($1000) | Total Annual Cost ($1000) | Cost per Acre-Foot | Cost per 1000 gallons |
| Effluent Booster Pump | $58 | $4 | $10 | $14 | $28.76 | $0.09 |
| Effluent Conveyance Pipeline | $401 | $29 | $4 | $33 | $67.00 | $0.21 |
| Recovery Mine/Well | $184 | $14 | $51 | $65 | $129.80 | $0.40 |
| Conveyance Pipeline | $4,781 | $352 | $48 | $400 | $799.42 | $2.45 |
| Combined Booster Pump | $58 | $4 | $14 | $18 | $35.96 | $0.11 |
| WWTP Treatment | $869 | $64 | $130 | $194 | $387.76 | $1.19 |
| | | | | | | |
| Total | $6,352 | $468 | $257 | $724 | $1,449 | $4.45 |

| Deliver Water to Ft. Huachuca<br>1322 acre-feet per year | | | | | | |
|---|---|---|---|---|---|---|
| Item | Capital cost ($1000) | Annualized Capital Cost ($1000) | O&M Cost ($1000) | Total Annual Cost ($1000) | Cost per Acre-Foot | Cost per 1000 gallons |
| Effluent Booster Pump | $58 | $4 | $10 | $14 | $10.88 | $0.03 |
| Effluent conveyance Pipeline | $401 | $29 | $4 | $33 | $25.34 | $0.08 |
| Recovery Mine/Well | $359 | $26 | $158 | $184 | $139.53 | $0.43 |
| Conveyance Pipeline | $5,876 | $432 | $59 | $491 | $371.56 | $1.14 |
| Combined Booster Pump | $201 | $15 | $89 | $103 | $78.16 | $0.24 |
| WWTP Treatment | $2,298 | $169 | $343 | $513 | $387.76 | $1.19 |
| | | | | | | |
| Total | $9,193 | $677 | $663 | $1,339 | $1,013 | $3.11 |

# *Appendix A - State Recharge Regulations*

Recharge of groundwater is required to comply with Federal and State water quality standards. This can either be done through a Federal NPDES permit or through Arizona's Title 45 process. Under Title 45, ADWR requires recharge facilities within Active Management Areas to obtain up to three permits. Although it is not strictly required to obtain ADWR permits in order to recharge water outside of Active Management Areas, Reclamation recommends that the USPP comply with State permit guidelines. The guidelines ensure that recharge is effective and does not cause harm to other entities. The required studies can also be used to implement a maintenance, monitoring, and operational regime that ensures optimum recharge efficiency.

An **Underground Storage Facility (USF) Permit** (A.R.S. § 45-811.01) allows the permit holder to operate a facility that stores water in the aquifer. The criteria a USF must meet in order to be permitted include:

1. The applicant must demonstrate financial and technical capability

2. The project must be hydrologically feasible

3. The project may not cause unreasonable harm to land or other water users within the area of impact

4. The applicant must agree in writing to obtain any required floodplain use permit from the county flood control district before beginning any construction activities

5. The director of environmental quality has determined that the facility is not in a location that will cause the migration of a contaminant plume or poor quality groundwater or will not cause pollutants to be leached, so as to cause unreasonable harm.

A Constructed Underground Storage Facility Permit allows for water to be stored in an aquifer by using some type of constructed device, such as an injection well or percolation basin.

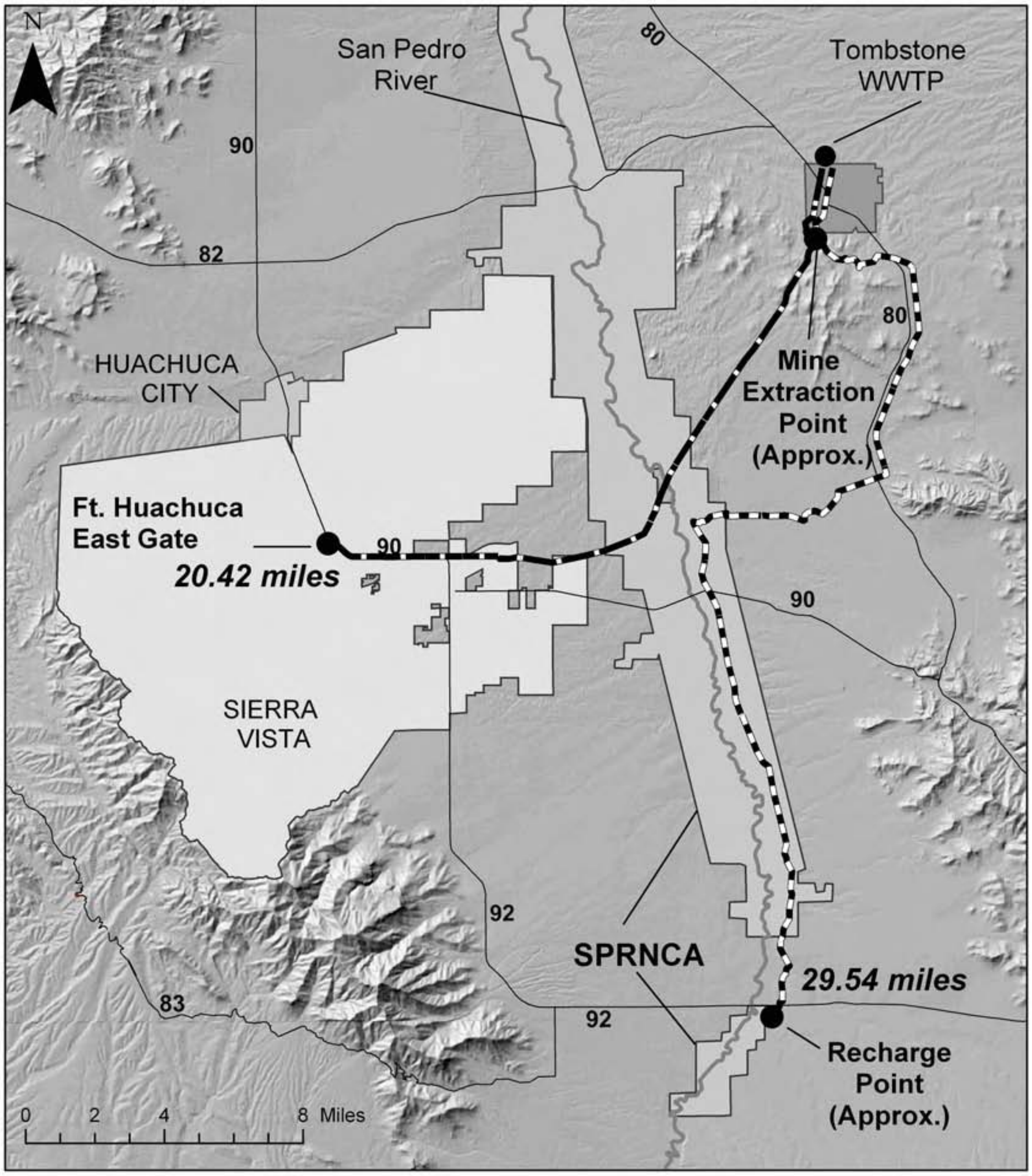
A Managed Underground Storage Facility Permit allows for water to be discharged to a naturally water-transmissive area such as a streambed that allows the water to percolate into the aquifer without the assistance of a constructed device. All surface flows entering and exiting a managed underground storage facility must be measured at the facility boundaries in a manner consistent with the Department's measuring device rules (R12-15-905 & 906)

A **Water Storage (WS) Permit** (A.R.S. § 45-831.01) allows the permit holder to store water at a USF

A **Recovery Well (RW) Permit** (A.R.S. § 45-834.01) allows the permit holder to recover long-term storage credits or to recover stored water annually. The impact of recovering stored water in the proposed location must not damage other land and water users, as noted in the adopted well spacing and impact rules (R12-15-830 & 840). An impact analysis is required under certain circumstances

Although recharge of CAP water and other non-effluent waters is exempt from Arizona Aquifer Protection Permit requirements (A.R.S.§ 49-250(B)(12) and (13)), if a permit to operate a recharge facility is secured under Title 45, any discharge must still comply with Arizona Water Quality Standards. This exemption from the APP program should expedite recharge permitting of non-effluent water while still providing ample protection to the aquifer through permit and monitoring requirements.

## Preliminary Appraisal Level
## Location of Tombstone Pipelines




Pipeline from Tombstone to Fort Huachuca (End Use - Reclaimed Water)

Pipeline from Tombstone to South of Highway 92 (End Use - Recharge)

B. Preliminary Appraisal Study of Relocation of Sierra Vista Subwatershed Wells to Benson Subwatershed

# Preliminary Appraisal Study of Relocation of Sierra Vista Subwatershed Wells to Benson Subwatershed
# FINAL

June 24, 2004

**This is a draft working document being developed by the Bureau of Reclamation for use by the Upper San Pedro Partnership in describing a preliminary conceptual design. It is intended to initiate a dialogue with all interested parties affected by this alternative. The contents are only conceptual and very preliminary in nature.**

**The Bureau of Reclamation defines an appraisal study as a brief investigation to determine whether to proceed with an in-depth "feasibility" study. The appraisal study uses existing data and information to identify plans to meet current and projected goals. It evaluates an array of options and identifies at least one solution to justify potential federal involvement. Typical duration of an appraisal study is one year or less.**

**The feasibility study is a detailed investigation and must be authorized by an Act of Congress. It is used to determine the desirability of seeking Congressional authorization for the implementation of a project. All feasibility studies contain a detailed environmental impact statement pursuant to the National Environmental Policy Act (NEPA) and other related statutes.**

**Description:** The preliminary concept for this alternative consists of purchasing agricultural land north of Benson, and retiring existing agricultural irrigation. Water would be pumped from existing wells on the properties to serve municipal demand at Fort Huachuca and/or the Sierra Vista area.

**Analysis and Discussion:**
The historical maximum irrigated area was determined by ADWR as part of a 1991 Hydrographic Survey Report (HSR). An estimate of the historical maximum water use was calculated using irrigation duties reported in the 1991 HSR. A subsequent field survey of the same properties in 2002 showed the number of irrigated acres had decreased significantly. Water use was re-estimated using the 2002 irrigated area figures and the 1991 HSR irrigation duties. These figures are shown in Table 1.

## Table 1
**Comparison of Irrigated Acreage and Water Use on Benson Properties, 1991 and 2002**

| Benson Alternative - Irrigated Acres | | | | | |
|---|---|---|---|---|---|
| | **1991 ADWR HSR Maximum Observed Irrigation (Acres)** | **1991 ADWR HSR Irrigation Duty (AF/acre)** | **1991 ADWR HSR Estimated Water Use (AFY)** | **2002 ADWR Field Inv. Currently Irrigated Area (Acres)** | **Estimated 2002 Water Use, Based on 1991 Irrigation Duty (AFY)** |
| Property 1 | 666 | 4.5 | 2967 | 144 | 640 |
| Property 2 | 735 | 3.7 | 2728 | 446 | 1657 |
| Property 3 | 318 | 5.4 | 1704 | 28 | 148 |
| Sum of top two | | | 5695 | | 2297 |
| Sum of top three | | | 7399 | | 2444 |

Detailed appraisal level designs and corresponding costs were developed for the project using three water recovery volumes within minimum and maximum shown in Table 1. The designs include a well water collection system, booster pumps, and conveyance pipeline. One of the detailed cost breakdowns for a volume of 3375 AFY is shown on Table 2. Table 2 provides information on approximate cost for specific components of the project.

A curve was developed using the detailed costs and corresponding volumes. The curve allows an approximate unit cost to be determined for a range of water yields from 500 AFY to 7400 AFY, which represents 100% of the estimated historical maximum water use. The curve will provide policy makers information with which to make decisions. The graphs showing the curve are shown at the end of this document in both dollars per acre-foot and dollars per thousand gallons.

At this time, no legal determination has been made as to whether the wells on these properties are pumping groundwater or surface water “subflow”. ADWR expects that this determination will take at least several years (personal communication, Rich Burtell, 6/22/2004). Should it be determined that these wells are pumping subflow, they would be subject to surface water regulations. The legal water rights claims associated with these properties can only be determined through an adjudication process.

The cost evaluation includes the full fee acquisition of the properties, pipeline and booster construction costs and right-of-way costs. The project would use five existing wells on each of the purchased properties. The wells would feed into a manifold system and then to a storage tank reservoir located at the well field. A pipeline and booster pumping stations would then convey the water to Fort Huachuca, near Sierra Vista. No significant peaking capacity would be required since a 4.5 to 7 million gallon (MG) reservoir at the end of line would be provided.

The easement for the conveyance pipeline would follow existing public roads in order to mitigate environmental impacts. (An appraisal level pipeline alignment is shown in the attached map.) A 50-foot easement would be adequate for installation. Additional fee title lands may be required for the larger booster station facilities. See the Table 2 for a summary of costs.

**Quality and Treatment of Recovered Water:**
The primary concern with respect to water quality is the potential for naturally occurring presence of arsenic and fluoride. Both constituents appear in water quality data at levels slightly above the drinking water standards of 10 parts per billion (ppb) for arsenic and 2 ppm for fluoride. To address this issue, treatment with activated alumina is recommended at a cost of $0.50 per thousand gallons.

**Issues and Concerns:**

<u>Environmental</u>

- The effects of continued groundwater withdrawal within the local vicinity and on the San Pedro River downstream of Benson must be determined. Reclamation has purchased a conservation easement on 1420 acres of habitat along the San Pedro River approximately 14 miles north of Benson. The conservation easement mitigates impacts to non-aquatic habitat from construction of fish barriers, required as a part of the Central Arizona Project. The effect to San Pedro River flows in this reach and the effects on endangered species must be evaluated.

- Although the conveyance pipeline would use previously disturbed easements wherever possible, the pipeline route must still be surveyed for endangered species and cultural resources.

- Potential effects to the following federally listed species and/or designated critical habitat should be addressed in the NEPA document: lesser long-nosed bat, Cochise pincushion cactus, loach minnow, spikedace, southwestern willow flycatcher, yellow-billed cuckoo and the Huachuca water umbel, as well as any species proposed or listed prior to project implementation. Critical habitat for both loach minnow and spikedace starts ~ 15 miles downstream of Benson.

- Sensitive plants such as agaves and cacti located within the pipeline right-of-way should be transplanted.

<u>Water Rights, Ownership, Effects on Benson Wells</u>

- Issues of water rights are currently unresolved, and are likely to remain so for the near future. If it is determined that the water from the wells is subflow, the priority of the surfaces water right will need to be established.

- Effects on Benson area wells must be addressed. Although water pumping may be reduced from current levels under this alternative, nothing stops other water users in the area from increasing pumping.

- The water could be delivered to private water companies in the Sierra Vista area. However, the Arizona Corporation Commission typically does not allow the companies to buy more expensive water and pass the cost on to the consumer.

<u>Effectiveness</u>

- Nothing in this alternative prevents other water users in the Benson area from increasing their groundwater pumping rates in the future. Coordinated watershed-scale groundwater management planning would be required in the future to ensure that the combined water demands placed on the aquifer near Benson area did not result in negative consequences.

<u>Financing</u>

- Financing – where the money comes from, how it is paid back and by who must be ascertained.

<u>Regulatory</u>

- CWA Section 404 permit coverage is needed for fills associated with pipeline crossings of washes and streams.

- NEPA compliance (most likely an EIS) is required if project is partly or wholly funded by the Federal Government.

Cultural Resources

- A cultural resource survey would be required for the area of potential effect. A Class I survey (literature search) should be done first to determine what areas may have been surveyed recently.

- Tribal consultation for traditional cultural properties would need to be carried out (minimally with the Hopi, Tohono O'odham, San Carlos and White Mountain Apache, Gila River Indian Community, and perhaps Zuni).

- If testing and/or data recovery are required, additional tribal consultation would be conducted.

- Section 106 consultation with the State Historic Preservation Office must be carried out. Because this is not CAP, the Advisory Council on Historic Preservation would need to part of consultation process, but it is likely they will opt not to be.

**Primary References:**

1 ) Preliminary Cost/Benefit Analysis for Water Conservation, Reclamation and Augmentation Alternatives for the Sierra Vista Sub-watershed, Fluid Solutions/BBC Research and Consulting Report, November 2003 (FS report).

2) Hydrographic Survey Report for the San Pedro River Watershed, ADWR, 1991.

3) Removal of Arsenic from Drinking Water Using Adsorptive Media, Frederick Rubel, P. E., (EPA design manual) (http://www.epa.gov/ORD/NRMRL/Pubs/600R03019/600R03019.pdf)

# Table 2 - Detailed Cost Table

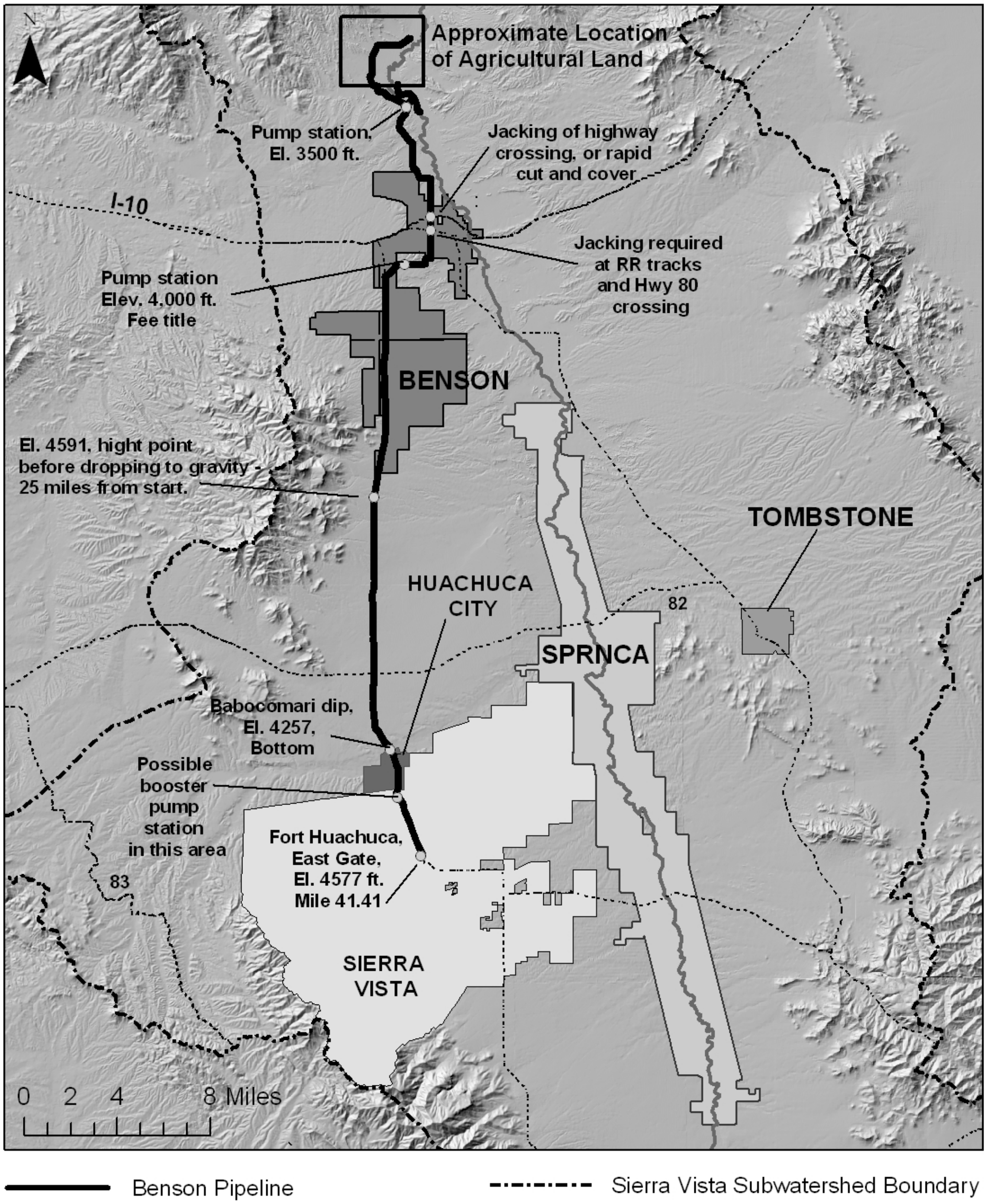
**Water Importation from Benson Subbasin Area**

| 3375 acre-feet per year | | | | | | |
|---|---|---|---|---|---|---|
| **Item** | **Capital cost ($1000)** | **Annualized Capital Cost ($1000)** | **O&M Cost ($1000)** | **Total Annual Cost ($1000)** | **Cost per Acre-Foot** | **Cost per 1000 gallons** |
| Purchase Farms | $5,768 | $425 | $58 | $482 | $143 | $0.44 |
| On Farm Wells | $595 | $44 | $24 | $68 | $20 | $0.06 |
| Well Power | | | $122 | $122 | $36 | $0.11 |
| On Farm Wells Collector Pipes | $1,925 | $142 | $19 | $161 | $48 | $0.15 |
| Booster Stations and Tanks | $2,534 | $186 | $25 | $212 | $63 | $0.19 |
| Booster Station Power | | | $1,052 | $1,052 | $312 | $0.96 |
| Main Pipeline | $14,845 | $1,093 | $148 | $1,241 | $368 | $1.13 |
| Water Treatment | $2,316 | $170 | $511 | $682 | $202 | $0.62 |
| Storage Reservoir | $3,654 | $269 | $37 | $305 | $91 | $0.28 |
| Total | $31,637 | $2,328 | $1,997 | $4,325 | $1,282 | $3.93 |

Notes

1. Used 12 cents per kwh.(per Fluid Solutions/BBC report)
2. Present value (4%, 20yr, 0.0736) (per Fluid Solutions/BBC report)

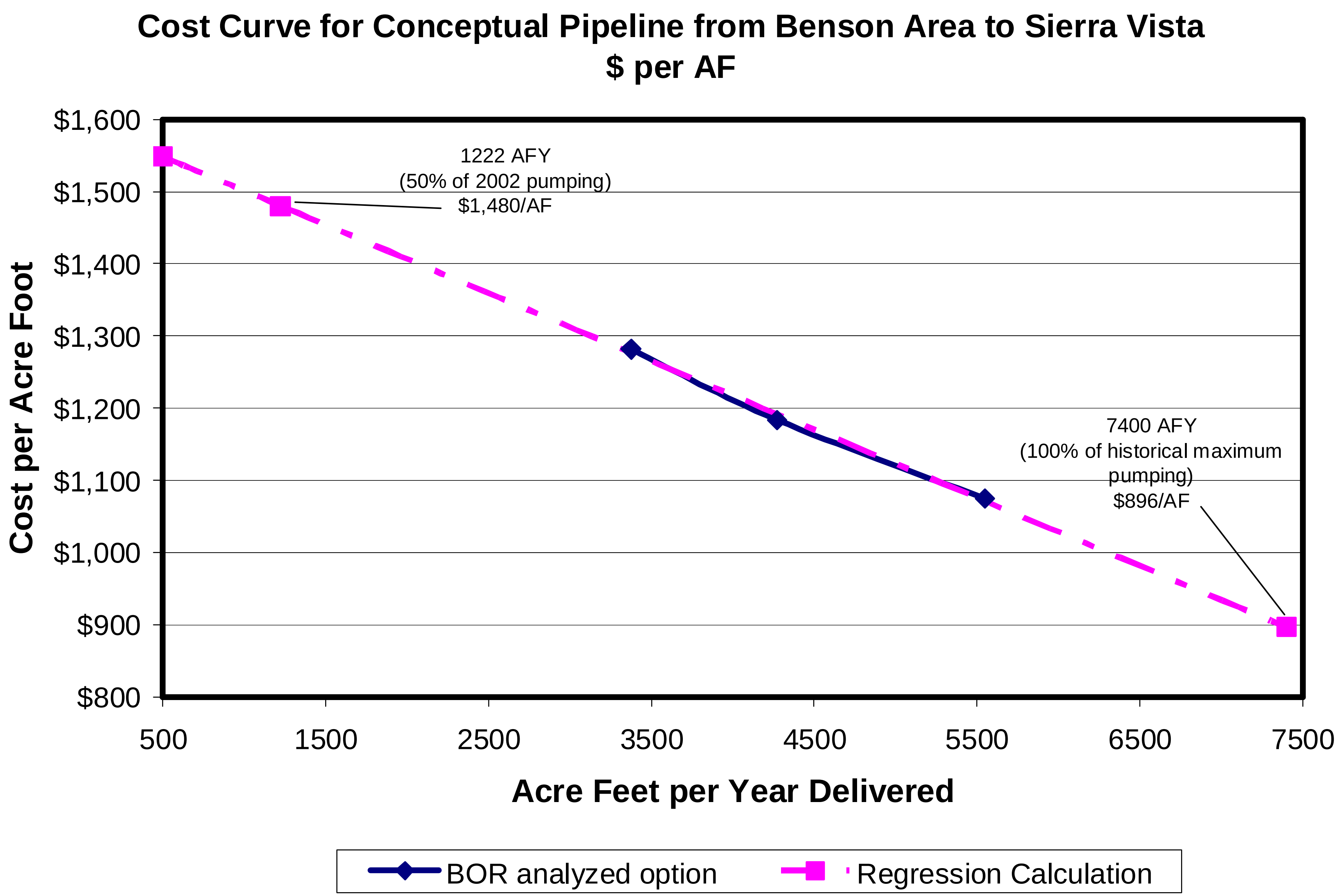
## Appraisal Level Location of Benson Pipeline




Yield: 500 AFY - 7500 AFY, depending on number of properties purchased.

Cost in $/AF = 1596 - (0.095 * Yield in Acre-Feet)

Example: $1282/AF for yield of 3375 Acre-Feet


Cost Curve for Conceptual Pipeline from Benson Area to Sierra Vista
$ per AF
Cost per Acre Foot
$1,600
$1,500
$1,400
$1,300
$1,200
$1,100
$1,000
$900
$800
500
1500
2500
3500
4500
5500
6500
7500
Acre Feet per Year Delivered
1222 AFY
(50% of 2002 pumping)
$1,480/AF
7400 AFY
(100% of historical maximum pumping)
$896/AF
BOR analyzed option
Regression Calculation

C. Preliminary Appraisal Study of the Water Development Potential of the Copper Queen Mine in the Bisbee District

# Preliminary Appraisal Study of the Water Development Potential of the Copper Queen Mine in the Bisbee District

Prepared by the Bureau of Reclamation in Cooperation with the Upper San Pedro Partnership

July 18, 2006

FINAL

**This is a draft working document being developed by the Bureau of Reclamation (Reclamation) for use by the Upper San Pedro Partnership to describe a preliminary conceptual design. It is intended to initiate a dialogue with all interested parties affected by this alternative. The contents are only conceptual and very preliminary in nature.**

**Reclamation defines an appraisal study as a brief investigation to determine whether to proceed with an in-depth "feasibility" study. The appraisal study uses existing data and information to identify plans to meet current and projected goals. It evaluates an array of options and identifies at least one solution.**

**The feasibility study is a detailed investigation. In order for Reclamation to conduct such a study, congressional authorization is required. Feasibility studies result in reports to Congress (i.e., a Planning Report/Environmental Impact Statement). These reports support a request for congressional authority for Federal actions. They go to the Secretary of the Interior, and ultimately, to Congress. Congress will determine whether to pass a bill authorizing implementation and the President will decide whether to sign the bill into law.**

**Description:** This alternative investigates the possibility of recovering groundwater which inundates the workings of the Copper Queen Mine (CQM), located in the Warren Mining District near the town of Bisbee, AZ. After treatment, the recovered water would be used for potable purposes in either the Fort Huachuca/Sierra Vista area or the Naco/Bisbee area. In the case of the Naco/Bisbee option, water in excess of potable demand could be recharged into Greenbush Draw, or be direct injected into the regional aquifer using an existing well.

The CQM is located about 5 miles north of Naco, 26 miles southeast of Sierra Vista, and 13 miles east of the San Pedro River. The mine water is considered to be contained within the geologic features of the CQM. Therefore, this alternative would reduce groundwater pumping in some part of the Sierra Vista Subwatershed without significantly diminishing the sources of flow to the San Pedro River.

**Analysis and Discussion:** The information required to analyze this alternative is the amount of water which can be recovered, the recovery method, the quality of the recovered water, the end use of the water, the appropriate treatment level, the routing of the conveyance pipeline and the associated recovery, treatment and delivery costs. Reclamation believes that enough information is available to complete this appraisal-level analysis.

### Amount of Water Available:

Estimates for long-term withdrawal rates for the CQM were drawn from a report entitled "Water Supply Potential Phelps Dodge Copper Queen Mine", completed by Southwest Ground-water Consultants, Inc. for Phelps Dodge (PD Report). The amount of water that can be recovered on a long-term basis, which the report defines as 21-25 years, is given on page 2 as 4,000 acre-feet per year (AFY) or 2,500 gallons per minute (gpm). This estimate was derived by the examination of pumping data dating back to 1906, as well as a two-dimensional MODFLOW model.

The groundwater system within the CQM mine workings is not a completely "closed-system". Most of the CQM perimeter is surrounded by bounding faults that act as partial flow barriers and impede exterior inflows. Generally, steep groundwater flow paths occur across most of those structures. The PD report shows groundwater contour elevation map flows converging into the CQM "bathtub", except for a ground water flow divide at the south margin. Furthermore, when the mine pumping in the workings ceased in 1987, the water table rose, not strictly due to precipitation runoff, which alone would not be expected to sustain 4,000 AFY pumping in a normal year, but primarily from external groundwater seepage induced by the former pumping.

**How Recovery Would Be Accomplished:**
A 1,262-foot deep system of submersible pumps would be installed in the existing Campbell mine shaft. Extensive investigation and care would be required in designing the pumping system, since the mine working has been out of operation for about 15 years, and there may be problems with the integrity of the mine shaft. The cost of this effort is included in the pumping costs.

The water would be conveyed to a modular reverse osmosis (RO) treatment plant located south of the mine, near the north tailing impoundment.

**Quality of Recovered Water:**
The primary concerns with respect to water quality are the relatively high concentrations of total dissolved solids (TDS), especially sulfate ($SO_4$), in the CQM water. High concentrations of TDS, including sulfates, are associated with hardness, deposits, colored water, staining and salty taste. The EPA Secondary Drinking Water Standards for TDS and sulfate are 500 mg/L and 250 mg/L, respectively.

There is great variation in the water quality of samples taken at different locations within the CQM, making predictions about water treatment costs difficult. Values for TDS range from 300 ppm to higher than 8,000 ppm, and $SO_4$ concentrations above 1000 ppm have been reported. Treatment by reverse osmosis would be required to lower TDS and $SO_4$ concentrations. Electrodialysis is another possible treatment, but it is neither cheaper nor more efficient than reverse osmosis.

Existing water quality data for the CQM and the surrounding area are detailed in the PD Report. Before proceeding with this alternative, additional sampling and analysis of the mine water would be performed to complement existing information and enable the development of a detailed treatment strategy.

**End Use of Water:**
Reverse osmosis treatment can yield water suitable for human consumption. The most cost-efficient use for RO-treated CQM water would be to supply it to Bisbee and/or

Naco, Arizona to replace groundwater pumping in the Sierra Vista Subwatershed. Water in excess of Naco and Bisbee's demand could be recharged into an existing production well using direct injection, or put directly into Greenbush Draw, near Naco. Another option is to transport the water to the Sierra Vista area, where it could replace ground water pumping by Fort Huachuca and/or private water companies.

**RO Treatment**

CQM waters will require advanced treatment to remove the wide range of constituents they contain. Advanced treatment by reverse osmosis (RO) removes most dissolved inorganic and organic constituents. RO produces two streams from a feedwater source: RO product (or permeate) and RO concentrate. The RO product water contains very low levels of contaminants, since most of these are rejected by the RO membrane into the concentrate. The RO concentrate contains contaminants in much higher concentrations than in the feedwater. The percentage of feedwater that RO "recovers" as product is called "water recovery."

RO recovery is affected by two processes, "fouling" and "scaling". Fouling is caused by suspended solids and high concentrations of iron and manganese that tend to plug RO elements. Scaling is caused by precipitates of sparingly soluble compounds that coat the RO membranes. Some kind of pretreatment is necessary to prevent fouling. Scaling is controlled by the concentrations of sparingly soluble compounds.

RO systems consist of elements arranged in a series. Water which permeates through the first RO membrane travels through a spiral path and collects into a central product water tube. The feed water which does not permeate through the first element leaves the annular space of the first element and enters the annular passages of the second element. This process continues through the series. As the feedwater flows through the system, the concentration of dissolved solids increases. Therefore, the first RO elements are prone to fouling, while elements at the end of the series are prone to scaling.

Fouling assessment

CQM waters contain high concentrations of iron and manganese which are commonly associated with RO fouling. This appraisal uses the conservative assumption that CQM waters also contain suspended solids. A typical pretreatment would consist of oxidation and greensand filtration to remove the iron and manganese, followed either by media (slowsand) filtration, microfiltration, or ultrafiltration to remove suspended solids. Effective pretreatment must produce water with a turbidity level less than 1 NTU (Nephelometric Turbidity Unit) and a SDI (Silt Density Index) less than 5.

Scaling assessment

The calcium sulfate concentration in CQM waters limits RO water recovery. Recovery could be even lower depending on the concentrations of barium, strontium, and silica, which were not available from the PD report. Further testing of barium, strontium and silica is necessary to determine recovery limits.

Treatment Cost Estimates:

Two sets of water quality data were used to develop a range of costs. The first data set was from well MG-1, which was selected because its concentrations for most constituents fall in the middle of the range. The second data set was an average of the data for many of the samples reported to ADEQ as part of the Aquifer Protection Permit reporting process. The TDS levels of the MG-1 sample and the "composite" sample were 3880 mg/L and 2253 mg/L, respectively.

RO product and concentrate volume and quality

The calcium sulfate concentration in the MG-1 sample limits RO recovery to 45%. From a 4,000 AFY water supply containing 3,880 mg/L TDS, the RO equipment would produce 1,800 AFY of RO product water with a TDS level of about 45 mg/L. The 2,200 AFY of RO concentrate would have with a TDS concentration of about 7,000 mg/L, approximately one-fifth the concentration of seawater.

For the composite sample with a TDS concentration of 2250 mg/L, RO recovery would increase to 65%. The concentration of calcium sulfate still limits the RO recovery rate. For this case the 4,000 AFY of feedwater would produce 2,600 AFY of RO product water with a TDS concentration of about 27 mg/L. The 1,400 AFY of RO concentrate would have a TDS level of about 6375 mg/L. Table 1 lists concentrations of calcium, barium, and sulfate for two water compositions and the estimated maximum RO recovery rates.

Table 1. Concentrations of sparingly-soluble solutes and estimated RO recovery

| | Well identification | | | |
|---|---|---|---|---|
| | MG-1<br>11/20/97 | | 1989 – 1997 average composition for several wells | |
| Solute | Concentration | Limits RO recovery? | Concentration | Limits RO recovery? |
| Calcium, mg/L | 670 | yes | 414 | yes |
| Barium, µg/L | insufficient information | unknown | 86 | no |
| Strontium, µg/L | not analyzed | unknown | not analyzed | unknown |
| Sulfate, mg/L | 2,130 | yes | 1,086 | yes |
| Silica, mg/L | not analyzed | unknown | not analyzed | unknown |

Cost estimates

Treatment costs, including pretreatment and RO but excluding concentrate disposal costs, are estimated at $2.25 per thousand gallons at 65% recovery and at $2.50 per thousand gallons at 45% recovery of RO product water. This cost could be as high as $3.00 per thousand gallons depending on further investigation of water quality.

Capital and O&M costs for the construction of single-lined evaporation ponds needed to dispose of concentrate from the reverse osmosis treatment at 45% recovery (2400 AFY of concentrate) were developed using a combination of information provided by Mickley, et al. (1993) and Reclamation reports referenced below.

It is estimated that a concentrate flow of 2400 AFY (45% recovery) would require about 490 acres of pond surface. The costs for these ponds are shown in the table. O&M costs for landfill disposal of dried salts are not included because the salts are assumed to remain in the ponds throughout the project duration. Determining the exact location for the evaporation ponds is beyond the scope of this appraisal. In order to develop an initial cost estimate, it was assumed that an existing area in the north tailing impoundment would be used. The tailing impoundment is located immediately south of the CQM.

The second estimate using 65% recovery from the reverse osmosis treatment was calculated to show the potential cost saving if the quality of the CQM waters turned out to be similar to the "composite" sample. It is estimated that a concentrate flow of 1800 AFY would require about 310 acres of pond surface.

Should policy makers want to consider other locations for use, cost for construction of a pipeline varies from about $300,000 to $400,000 per mile, depending on the volume of water to be conveyed.

**Pipeline Routing**

A pipeline alignment was generated for each proposed delivery point. Previously disturbed areas were utilized to the greatest extent practical. A 3.5 mile pipeline on the CQM site will carry untreated water from the Campbell mine shaft to a modular RO plant. Treated product water will be transported via either the Naco/Bisbee or the Ft. Huachuca / Sierra Vista alignment. For the Naco/Bisbee option, a 1.5 mile pipeline will deliver RO product water to Bisbee's water tanks. A separate 5.3 mile pipeline to Naco would run along the Bisbee/Naco Highway. For the Fort Huachuca / Sierra Vista option, the alignment runs along Highway 92 for about 6.6 miles, follows an old railroad alignment northwest, and proceeds along Highway 90 to Fort Huachuca, for a total of 32.5 miles. Conceptual pipeline routes are shown on the attached map.

## Issues and Concerns:

<u>Environmental</u>

- Although the conveyance pipeline would use previously disturbed easements wherever possible, the pipeline route must still be walked and surveyed for endangered species and cultural resources.
- Although the evaporation ponds would use previously disturbed areas to the greatest extent possible, any undisturbed areas must still be surveyed for endangered species and cultural resources (NEPA clearance).
- Potential effects to the following federally listed species and/or designated critical habitat should be addressed in the NEPA document: Yellow-billed cuckoo, lesser long-nosed bat, Mexican spotted owl, loach minnow, spikedace, Sonora tiger salamander,

southwestern willow flycatcher, and the Huachuca water umbel, as well as any species proposed or listed prior to project implementation.

- Sensitive plants such as agaves and cacti located within the pipeline right-of-way should be transplanted.
- If the evaporation ponds concentrate potentially toxic constituents, then there may be a need to design "bird-free" operation for the ponds

Issues with Phelps Dodge

- The cost, if any, for the water would have to be discussed with PD.
- Although the withdrawals in this alternative are assumed to remain constant over a period of 20 – 25 years, PD may want to begin mining operations in the future. A long-term contract would be required to address this issue.
- There may be benefits to PD by allowing others to dewater the mine workings on a long-term basis.

Further Investigation

- To enable Reclamation to develop a preliminary description and cost of expected water recoveries, RO permeate compositions, and RO concentrate compositions, further water quality analyses must be performed. Pilot tests would be needed to evaluate pretreatment effectiveness, including turbidity and silt density index (SDI) measurement and to evaluate RO performance. Reclamation can provide mobile treatment equipment from the Water Quality Improvement Center, located in Yuma, Arizona to do the pilot testing.

Financial

- Financing – where the money comes from, how it is paid back, and by whom, must be determined.

Effectiveness

- The PD report concluded that most likely only a very small amount of the water in the CQM reaches the San Pedro River, due to the geology of the area. The CQM is surrounded by faults to the east, west and south that function as aquitards. Therefore, this alternative actually augments the amount of water in the Sierra Vista Subwatershed.

Regulatory

- CWA Section 404 permit coverage is needed for fills associated with pipeline crossings of washes and streams.
- NEPA compliance (EA or EIS) is required if the project is partly or wholly funded by the Federal Government.
- Consultation with the Department of Environmental Quality regarding water treatment, Safe Drinking Water Act regulations and recharge will be required.

Cultural Resources

- A cultural resource survey would be required for the area of potential effect. A Class I survey should be done first to determine what areas may have been surveyed recently.

- Tribal consultation for traditional cultural properties would need to be carried out (minimally with the Hopi, Tohono O'odham, San Carlos and White Mountain Apache, GRIC, and perhaps Zuni). If determination of historic site status and/or archaeological investigation are required, additional tribal consultation would be necessary.

- Section 106 consultation with the State Historic Preservation Office must be carried out. The Federal Advisory Council on Historic Preservation would need to be part of the consultation process, but it is likely they would opt not to be part of the process, as they tend to become involved only in large-scale or controversial projects.

**Primary References:**
Water Supply Potential Phelps Dodge Copper Queen Mine, completed by Southwest Ground-water Consultants, Inc. for Phelps Dodge (PD Report), February 2004.

Alternatives for Using CAP Water in the Northwest Tucson Area, Reclamation, August 2000.

Pilot Investigation of Slowsand Filtration and Reverse Osmosis Treatment of CAP Water, Reclamation, August 2002.

Membrane Concentrate Disposal, Mickley, M. et al., American Water Works Association and AWWA Research Foundation, Denver, CO, 1993.

**Cost Summary**

| To Fort Huachuca / Sierra Vista | | | | | | |
|---|---|---|---|---|---|---|
| Volume | Capital cost (millions) | Annualized Capital Cost (millions) | O&M Cost (millions) | Total Annual Cost (millions) | Cost per Acre-Foot | Cost per 1000 gallons |
| 1800 | $51.9 | $3.8 | $1.3 | $5.1 | $2,860 | $8.78 |
| 2600 | $54.0 | $4.0 | $1.4 | $5.4 | $2,062 | $6.33 |

| To Naco / Bisbee / Recharge | | | | | | |
|---|---|---|---|---|---|---|
| Volume | Capital cost (millions) | Annualized Capital Cost (millions) | O&M Cost (millions) | Total Annual Cost (millions) | Cost per Acre-Foot | Cost per 1000 gallons |
| 1800 | $41.6 | $3.1 | $1.3 | $4.3 | $2,397 | $7.36 |
| 2600 | $40.5 | $3.0 | $1.3 | $4.3 | $1,635 | $5.02 |

1. Used 12 cents per kwh.(per Fluid Solutions/BBC report)
2. Present value 4%, 20yr, 0.0736 (per Fluid Solutions/BBC report)
3. Used evaporation rate of 63-inches per year

Appendix A:
C1 Intra-basin transfer: Copper Queen Mine to Fort Huachuca / Sierra Vista

| **Water Development Potential of Bisbee Mine Water Recovery and Pipeline Alternative - Campbell Mine - 1800 AFY to Fort Huachuca / Sierra Vista (3880 mg/L TDS, 45% Recovery)** | | | | | | |
|---|---|---|---|---|---|---|
| Item | Capital cost ($1000s) | Annualized Capital Cost ($1000s) | O&M Cost ($1000s) | Total Annual Cost ($1000s) | Cost per Acre-Foot | Cost per 1000 gallons |
| Campbell Mine Water Recovery Pump Station | $2,267 | $167 | $23 | $190 | $105 | $0.32 |
| Campbell Mine Pump Power | | | $927 | $927 | $515 | $1.58 |
| Water Treatment - Pretreatment and Reverse Osmosis | $17,931 | $1,320 | $147 | $1,466 | $815 | $2.50 |
| Evaporation Ponds (450 acres) | $19,497 | $1,435 | $97 | $1,532 | $851 | $2.61 |
| Small Booster Station and Tank before pipeline | $337 | $25 | $20 | $44 | $25 | $0.08 |
| 12" Pipeline to FtH | $11,820 | $870 | $118 | $988 | $549 | $1.68 |
| **Total** | **$51,852** | **$3,816** | **$1,331** | **$5,148** | **$2,860** | **$8.78** |

| **Water Development Potential of Bisbee Mine Water Recovery and Pipeline Alternative - Campbell Mine - 2600 AFY to Fort Huachuca / Sierra Vista (2250 mg/L TDS, 65% Recovery)** | | | | | | |
|---|---|---|---|---|---|---|
| Item | Capital cost ($1000s) | Annualized Capital Cost ($1000s) | O&M Cost ($1000s) | Total Annual Cost ($1000s) | Cost per Acre-Foot | Cost per 1000 gallons |
| Campbell Mine Water Recovery Pump Station | $2,267 | $167 | $23 | $190 | $73 | $0.22 |
| Campbell Mine Pump Power | | | $927 | $927 | $356 | $1.09 |
| Water Treatment - Pretreatment and Reverse Osmosis | $23,310 | $1,716 | $191 | $1,906 | $733 | $2.25 |
| Evaporation Ponds (285 acres) | $12,491 | $919 | $62 | $982 | $378 | $1.16 |
| Small Booster Station and Tank before pipeline | $486 | $36 | $28 | $64 | $25 | $0.08 |
| 14" Pipeline to FtH | $15,464 | $1,138 | $155 | $1,293 | $497 | $1.53 |
| **Total** | **$54,018** | **$3,976** | **$1,385** | **$5,361** | **$2,062** | **$6.33** |

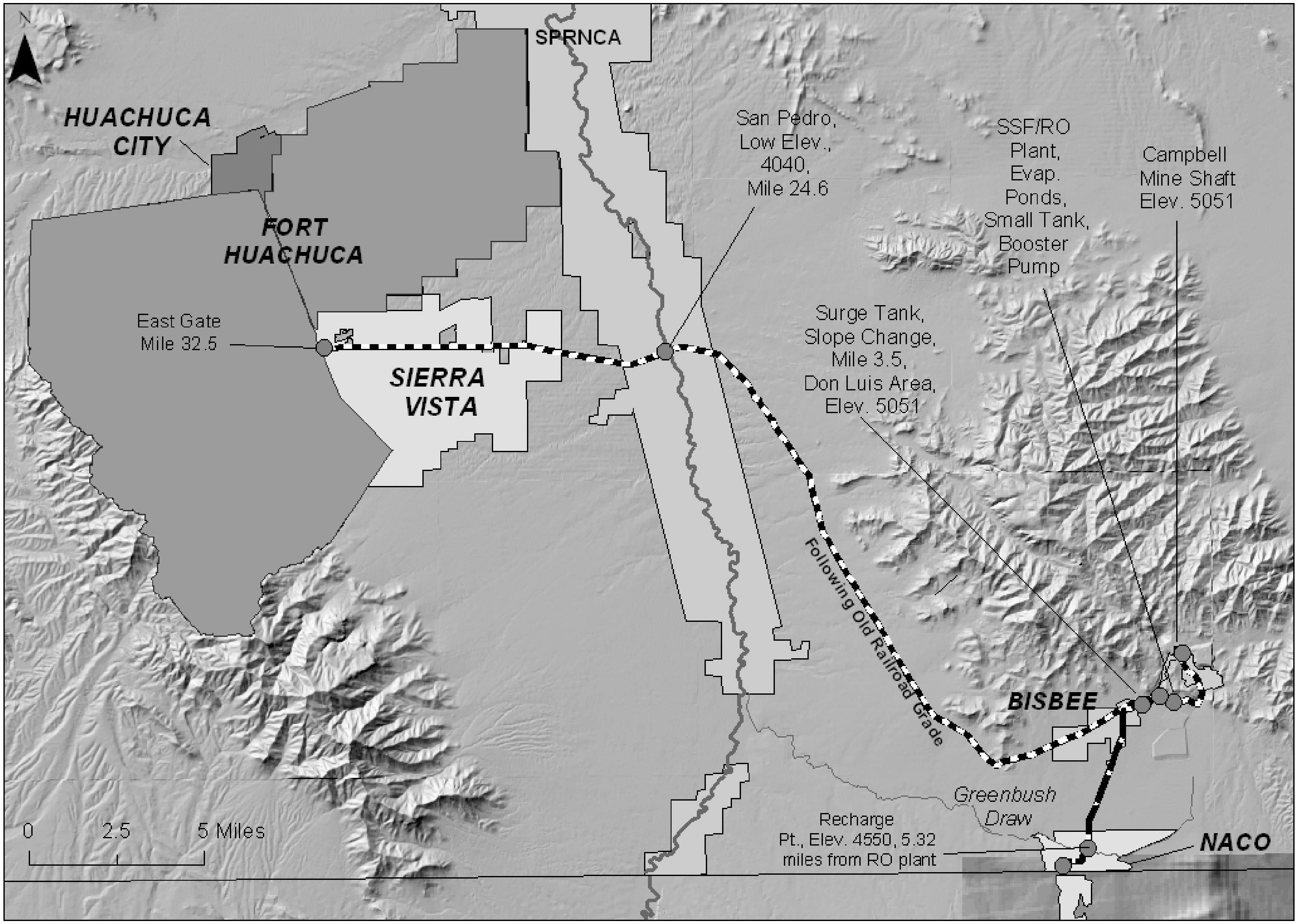
| Water Development Potential of Bisbee Mine Water Recovery and Pipeline Alternative - Campbell Mine - 1800 AFY to Naco/Bisbee/Recharge (3880 mg/l TDS, 45% Recovery) | | | | | | |
|---|---|---|---|---|---|---|
| Item | Capital cost ($1000s) | Annualized Capital Cost ($1000s) | O&M Cost ($1000s) | Total Annual Cost ($1000s) | Cost per Acre-Foot | Cost per 1000 gallons |
| Campbell Mine Water Recovery Pump Station | $2,267 | $167 | $23 | $190 | $105 | $0.32 |
| Campbell Mine Pump Power | | | $927 | $927 | $515 | $1.58 |
| Water Treatment - Pretreatment and Reverse Osmosis | $17,931 | $1,320 | $147 | $1,466 | $815 | $2.50 |
| Evaporation Ponds (450 acres) | $19,497 | $1,435 | $97 | $1,532 | $851 | $2.61 |
| Small Booster Station and Tank from RO | $337 | $25 | $20 | $44 | $25 | $0.08 |
| Product Water Distribution - Naco/Bisbee/Recharge | $1,576 | $116 | $40 | $156 | $87 | $0.27 |
| **Total** | **$41,608** | **$3,062** | **$1,253** | **$4,315** | **$2,397** | **$7.36** |

Appendix A:
C1 Intra-basin transfer: Copper Queen Mine to Fort Huachuca / Sierra Vista

**Water Development Potential of Bisbee Mine Water Recovery and Pipeline Alternative - Campbell Mine - 2600 AFY to Naco/Bisbee/Recharge (2250 mg/L TDS, 65% recovery)**

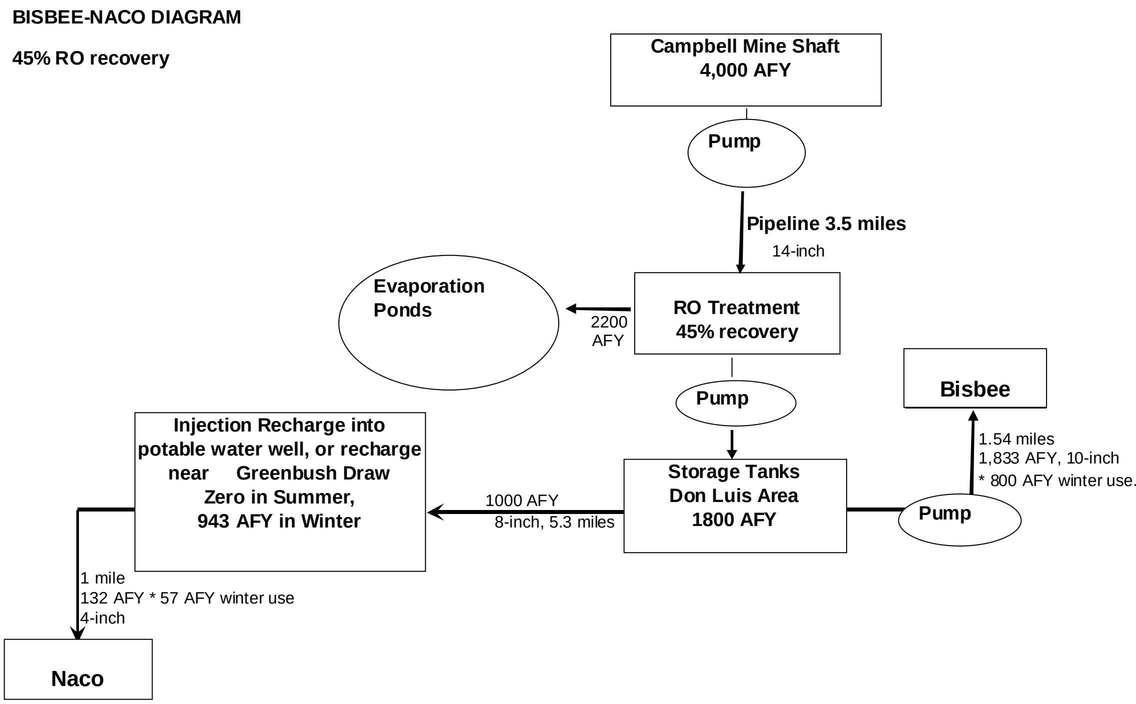
| Item | Capital cost ($1000s) | Annualized Capital Cost ($1000s) | O&M Cost ($1000s) | Total Annual Cost ($1000s) | Cost per Acre-Foot | Cost per 1000 gallons |
|---|---|---|---|---|---|---|
| Campbell Mine Water Recovery Pump Station | $2,267 | $167 | $23 | $190 | $73 | $0.22 |
| Campbell Mine Pump Power | | | $927 | $927 | $356 | $1.09 |
| Water Treatment - Pretreatment and Reverse Osmosis | $23,310 | $1,716 | $191 | $1,906 | $733 | $2.25 |
| Evaporation Ponds (285 acres) | $12,491 | $919 | $62 | $982 | $378 | $1.16 |
| Small Booster Station and Tank from RO | $486 | $36 | $28 | $64 | $25 | $0.08 |
| Product Water Distribution - Naco/Bisbee/Recharge | $1,902 | $140 | $43 | $183 | $70 | $0.22 |
| **Total** | **$40,455** | **$2,978** | **$1,274** | **$4,251** | **$1,635** | **$5.02** |

## Appraisal Level Location of CQM to Ft. Huachuca/Sierra Vista and CQM to Bisbee/Naco Pipelines

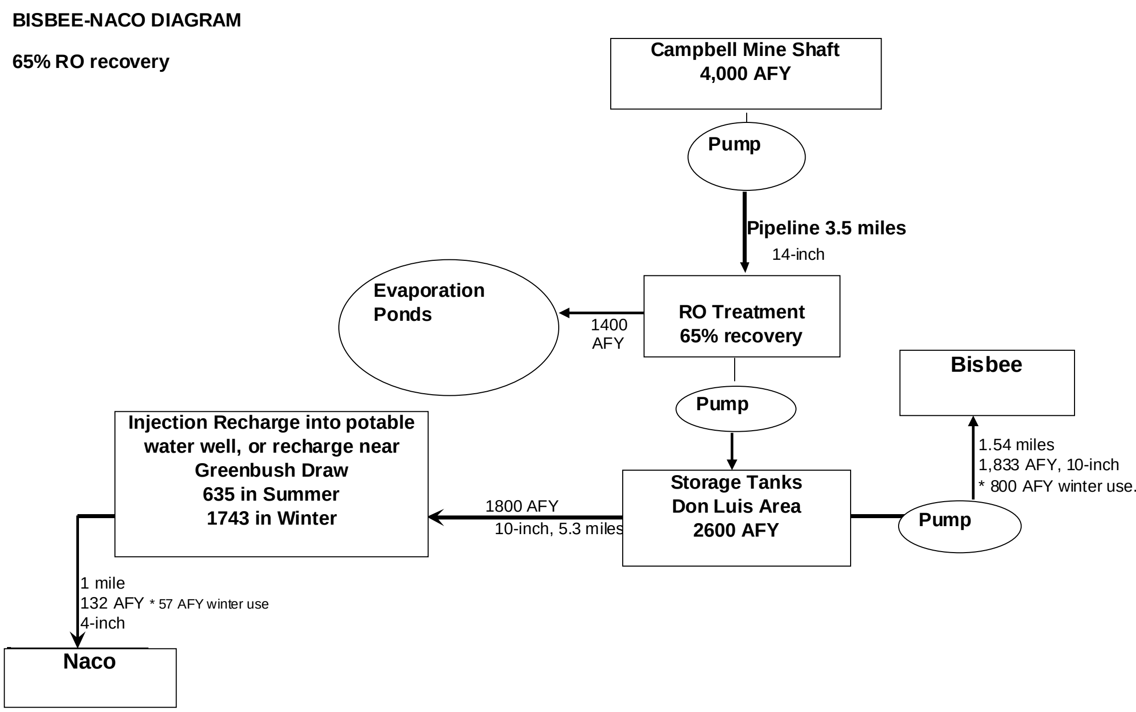



U.S. Bureau of Reclamation, Tucson Field Office, updated 7/26/2006

Appendix A:
C Intra-basin transfer: Copper Queen Mine to Fort Huachuca / Sierra Vista



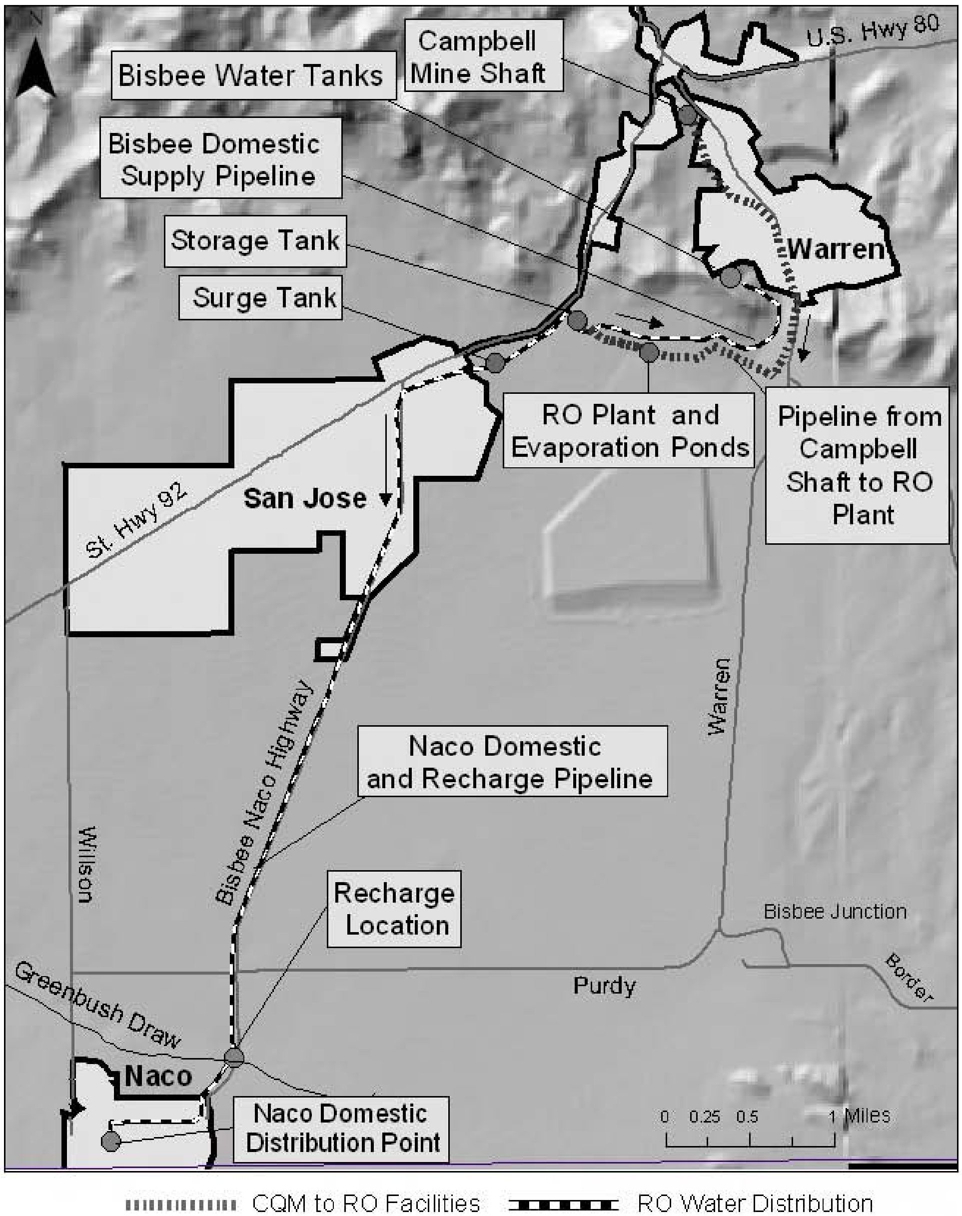

WkSht: Bisbee-Naco Diagram




WkSht: Bisbee-Naco Diagram

## Appraisal Level Locations - CQM to Bisbee / Naco Pipelines

Domestic Supply Pipeline, CQM to Bisbee
Domestic Supply and Recharge Pipeline, CQM to Naco



# D. Preliminary Appraisal Study of CAP Water to Sierra Vista Alternative

# Preliminary Appraisal Study of
# CAP Water to Sierra Vista Alternative
# FINAL

November 27, 2006

**This is a draft working document being developed by the Bureau of Reclamation for use by the Upper San Pedro Partnership in describing a preliminary conceptual design. It is intended to initiate a dialogue with all interested parties affected by this alternative. The contents are conceptual and preliminary in nature.**

**The Bureau of Reclamation defines an appraisal study as a brief investigation to determine whether to proceed with an in-depth "feasibility" study. The appraisal study uses existing data and information to identify plans to meet current and projected goals. It evaluates an array of options and identifies at least one solution to justify potential federal involvement. Typical duration of an appraisal study is one year or less.**

**The feasibility study is a detailed investigation and must be authorized by an Act of Congress. It is used to determine the desirability of seeking Congressional authorization for the implementation of a project. All feasibility studies contain a detailed environmental impact statement pursuant to the National Environmental Policy Act (NEPA) and other related statutes.**

**Description:**

This alternative consists of acquiring and conveying a Colorado River (CR) water entitlement to the Sierra Vista area. An extension to the Central Arizona Project (CAP) pipeline, including several pumping plants, would be constructed. The extension would run from the CAP Terminus, located at Pima Mine Road and the I-19 freeway in Tucson, to Sierra Vista. The water could be used for municipal, industrial and turf demand, as well as environmental mitigation/restoration in the Sierra Vista Subwatershed.

**Analysis and Discussion:**

This report evaluates the acquisition and conveyance of 20,000, 30,000 or 40,000 acre-feet per year (AFY) of Colorado River water to offset current groundwater mining in the Sierra Vista Subwatershed and provide water for future use. These volumes would provide all or a significant portion of the 38,500 AFY of groundwater pumping that is expected to occur in the Sierra Vista Subwatershed by the year 2050, given current estimates of population growth by the Arizona Department of Economic Security. This document updates a 1993 Reclamation concept report for an extension of the CAP pipeline to Sierra Vista to an appraisal level. This revised report will be used for comparison with other USPP augmentation alternatives.

Detailed appraisal level designs and corresponding costs were developed for three alignments. Their locations are shown in the attached map. The alignment characteristics are detailed in Table 1. The preferred alternative appears to be the I-10 route. This assessment is based on construction costs, annual power cost, access for construction, presence of existing underground utilities and easements, and the fewest number of environmental issues.

The designs include the connection to the CAP Terminus structure, a conveyance pipeline, booster pump stations, power lines, tanks and appurtenant structures. A detailed cost breakdown of the I-10 alignment, with a capacity of 30,000 AFY, is shown in Table 2.

**Colorado River Water Acquisition:**
Opportunities exist to obtain Colorado River water supplies, either through the acquisition of a Colorado River entitlement from a non-Indian Colorado River contractor, or through the acquisition of a CAP allocation. Issues regarding the acquisition of a Colorado River water entitlement are discussed first.

It may be possible to purchase or lease non-Indian Colorado River entitlements. The risk of shortage to a Colorado River entitlement will depend on its priority. The water could be transported off the river by "wheeling" it through the CAP conveyance system. Wheeling refers to the transportation of non-CAP water supplies through the CAP conveyance system for a fee. Wheeling this water will require the owner to pay the market rate of pump energy and additional CAP use fees. The "postage stamp" rate of water does not apply.

The CAP conveyance system is operated by the Central Arizona Water Conservation District (CAWCD). The CAWCD is a multi-county water conservation district established as a special taxing district for the purpose of contracting with the U.S. for the delivery of CAP water and the repayment of associated CAP costs. It has not yet developed a wheeling policy.

Under A.R.S. § 45-107(D), participants of a proposed transfer of a non-Indian Colorado River water entitlement are required to consult with the Director of the Arizona Department of Water Resources (ADWR). ADWR has adopted a policy that governs this procedure. Upon completion of a transfer process, ADWR makes a recommendation to the U. S. Secretary of the Interior regarding allocation of the entitlement.

Currently, there is no allocation of CAP water available for the Sierra Vista area. The CAWCD has no plans to provide water to Sierra Vista or Fort Huachuca. CAP water supplies could potentially be acquired through future reallocation processes. In addition, although it is not currently an option, future transfers, exchanges, or long-term lease agreements with CAP entitlement holders may be possible.

The Arizona Water Settlement Agreement includes a provision for a future reallocation of non-Indian agricultural (NIA) priority CAP water. However, the Director of ADWR cannot make reallocation recommendations to the Secretary prior to January 1, 2010. The amount of water that will be available for reallocation is presently unknown. The process is expected to be very competitive between interested water providers.

At the present time, Indian CAP entitlements cannot be leased for exportation and use outside of the CAWCD service area, which includes Maricopa, Pinal and Pima counties, except by exchange. Provisions for lease and export of Indian entitlements out of the CAWCD service area would require modification of existing Indian water contracts, as well as modifications to state law and the CAP Master Repayment Contract.

The current delivery cost of CAP Indian water allocations is $75 per acre-foot, which covers the fixed operation and maintenance costs. There is no capital charge assessed to Indian entitlements. Leases of Indian CAP entitlements pursuant to specific congressional authorization have been issued for $1,200 to $1,500 per acre-foot (AF), with and without increases for inflation. It is anticipated that the base price for leases will increase to at least $2,000 per AF. The duration of the leases vary from short- term to 100 years (which provides for an ADWR assured or adequate water supply).

Similar to proposed transfers of non-Indian Colorado River entitlements, non-Indian CAP subcontract entitlement transfer participants are required to consult with the Director of ADWR. ADWR's current CAP municipal and industrial (M&I) subcontract entitlement transfer policy limits proposed transfer actions to water providers that are located within the CAWCD service area.

The priority of a CAP allocation will be used to determine how extensively the allocation is impacted during shortages on the Colorado River and outages within the CAP system. Due to the lower priority of CAP water supplies on the Colorado River, CAP water supply availability may be impacted when shortages are declared for the Lower Colorado River Basin States. Within the CAP system, the highest priority "pools" are the last to be reduced when system shortages occur. Indian and non-Indian M&I allocations have the highest priority, while non-Indian agricultural water is subject to first reduction during times of shortage.

This study used a 20 year contract for lease of Indian allocations and amortized the $1,500 per acre-foot cost at 3% interest over the contract duration. In addition, a cost of CAP water of $150 per acre-foot was used, anticipating additional use fees for exportation of CAP water outside the service area or an upstream exchange agreement.

**Cost Evaluation**:
The cost evaluation includes construction and right-of-way costs for the pressurized pipeline, reservoir tanks, power lines and booster pump stations. All alignments begin with a pressurized (pumped) pipeline length to an elevation high point and in general, a gravity pipeline to the terminus at the Main Gate of Fort Huachuca. The project would use pipeline sections pressurized with booster pumps up to a high point in the alignment. From the high point, the water would go to an operating reservoir tank and then into gravity pipeline sections on the down gradient slope. Each of the booster pump stations will contain four pumps to provide rotation, redundancy, reliability and variable capacity. No significant peaking capacity would be available in the pipeline system, so a thirteen and a half million gallon (MG) reservoir would be provided at the end of line.

The easement for the pipeline would follow existing public roads, highways and interstates in order to minimize environmental impacts. A 50-foot easement would be adequate for installation. Additional lands may be required for booster stations and tanks. See Table 2 for a summary of costs.

**Table 1 - Comparison of the three alignments**

| Description \ Route | I-10 | Highway 83 | Santa Rita Mountains |
|---|---|---|---|
| | | | |
| **Beginning of Line** | End of Reach 6, Pima Mine Road and I-19, elevation 2790 ft | | |
| **End of Line** | Fort Huachuca Main Gate, Fry Road and Hwy 90, elev. 4580 ft | | |
| **Length of alignment (miles)** | 72 | 70 | 64 |
| **Length uphill (miles)** | 52 | 36 | 28 |
| **Length downhill (miles)** | 20 | 34 | 36 |
| **Elev. Low point, pump section** | 2654 feet elevation at Santa Cruz River crossing at Pima Road | | |
| **Elev. Highest point - Tank (ft)** | 4596 | 5214 | 5210 |
| **Elev. Low Pt, gravity section** | 4260 feet elevation at Babocomari River crossing at Hwy 90 | | |
| **Vertical Ascends (ft)** | 1806 | 2424 | 2420 |
| **Vertical Descents (ft)** | 16 | 634 | 630 |
| **Total Static Lift (ft)** | 1790 | 1790 | 1790 |
| **Total Dynamic Lift (ft)** | 2550 | 2700 | 2700 |
| **# of Booster Pump Stations** | 5 | 4 | 4 |
| **High point reservoir required** | Yes | Yes | Yes |
| **Existing Power lines available** | Yes, adjacent and within 1 mile of plants | No, some available, but undersized | No, some available, but undersized |
| **Estimated length of power lines required for pumps** | 5 miles with substations | 12 miles, from I-10 | 24 miles, Sahuarita, along pipeline |
| **Major crossings, environmentally sensitive areas, special construction considerations.** | Santa Cruz River, Area adjacent to Sahuarita Air Force Range (not used), Davidson Canyon, Cienaga Creek, San Ignacio Del Babocomari, Babocomari River | Santa Cruz River, San Ignacio Del Babocomari, Babocomari River | Santa Cruz River, Santa Rita Experimental Range and Wildlife Area, Santa Rita Mtns, Coronado National Forest, hard rock excavation thru Santa Rita Mountains, San Ignacio Del Babocomari, Babocomari River |
| **Other minor (less than 30' deep) canyon, washes, creeks** | 140 | 70 | 70 |
| **Required jacking crossings** | 8 | 4 | 4 |
| **Possible cooperators** | City of Tucson, Spanish Trail Water Co., Vail Water Co., Benson, Huachuca City | City of Tucson, Spanish Trail Water Co., Vail Water Co., Sonoita, Elgin, Huachuca City | Community Water Co. of Green Valley, Green Valley Domestic Water Improvement District, Sonoita, Elgin, Huachuca City |
| **Cost Per Acre-Foot**<br>**Cost Per 1,000 Gallons**<br>**(30,000 AFY)** | $1,233<br>$3.78 | $1,262<br>$3.87 | $1,288<br>$3.95 |

**Table 2 - Detailed Cost Table for 30,000 AFY (I-10 Route)**

| Item | Capital cost (millions) | Annualized Capital Cost (millions) | O & M Cost (millions) | Total Annual Cost (millions) | Cost per Acre Foot | Cost per 1,000 Gallons |
|---|---|---|---|---|---|---|
| Pipes | $132.97 | $9.79 | $1.15 | $10.94 | $365 | $1.12 |
| Other Structures | $9.63 | $0.71 | $0.08 | $0.79 | $26 | $0.08 |
| Pump Plants | $23.63 | $1.74 | $0.21 | $1.94 | $65 | $0.20 |
| Powerlines | $1.62 | $0.12 | $0.01 | $0.13 | $4 | $0.01 |
| Reservoirs | $22.59 | $1.66 | $0.20 | $1.86 | $62 | $0.19 |
| Power | | | $13.60 | $13.60 | $453 | $1.39 |
| CAP cost | | | $4.50 | $4.50 | $150 | $0.46 |
| Leased water | | | $3.02 | $3.02 | $101 | $0.31 |
| Right of way | $2.62 | $0.19 | | $0.19 | $6 | $0.02 |
| **Total** | **$193.07** | **$14.21** | **$22.77** | **$36.98** | **$1,233** | **$3.78** |

Notes

1. Used 12 cents per kwh (per Fluid Solutions/BBC report)
2. For CAP water lease: 3%, 20 year (0.0672)
3. All other items: present value (4%, 20yr, 0.0736) (per Fluid Solutions/BBC report)

**CAP Water Quality:**

CAP water originates from two sources, the Colorado River and the Agua Fria River. Since it is surface water, its chemical and biological composition is very different from Sierra Vista Subwatershed groundwater. CAP water has higher levels of total organic carbon (TOC) and algae, the possible presence of coliform bacteria, and higher concentrations of suspended and dissolved solids. CAP water requires more treatment than groundwater to meet drinking water standards.

CAP water has a higher total dissolved solids (TDS) level (about 700 mg/L) than that of native groundwater (about 265 mg/L). Although the level of total dissolved solids, or salinity, is not a health hazard, it can be aesthetically unpleasing and have undesirable impacts. These include taste and color problems, hardness, scaling and sedimentation. The EPA sets an optional National Secondary Water Drinking Regulation of 500 mg/L for TDS.

Nitrate concentrations of raw CAP water average 0.13 mg/L, far below the Safe Drinking Water Maximum Contaminant Level of 10 mg/l. CAP water also contains natural organic matter (referred to as disinfection by-product [DBPs] precursors) which can, in combination with chlorine, react to form trihalomethanes (THMs). THMs have been shown to cause cancer in laboratory animals.

One of the biggest drinking water quality concerns in the last few years is the monitoring for bacteria, viruses, and parasites. The most common species associated with human infection are the Giardia and Cryptosporidium parasites. Designated sampling sites on the CAP system produced results showing no detection of these parasites. Given that CAP water is a surface source, it can be expected that low to moderate levels of total coliform could be present. Appropriate treatment is necessary to ensure that CAP water meets Safe Drinking Water Standards.

**Alternatives for Using CAP Water in the Sierra Vista Subwatershed:**

Options for the use of CAP water in the Sierra Vista Subwatershed include recharge and recovery, as well as treatment and direct delivery. The concepts and issues involved in the utilization of CAP water once it is delivered are complex. The appraisal level conceptual plans and information for using CAP water are provided to allow the reader to comprehend the most important issues, such as cost and water quality.

An important aspect of using CAP water is balancing delivery with demand and long-term storage over the life of the project. This report assumes the project is built to the design capacity (is not staged). Therefore, in the early stages of delivery, supply will exceed demand, (demand gradually increases over time). In order to make this project viable over the long term, it is essential that any CAP use option include the ability to store (bank) water.

**Recharge options:**

Recharge of groundwater is required to comply with Federal and State water quality standards. If recharge is taking place along a stream channel, a Federal NPDES permit is required. Outside of a stream, recharge projects can either be done through an Aquifer Protection Permit (APP) or through Arizona's Title 45 process. Under Title 45, ADWR requires recharge facilities within Active Management Areas to obtain up to three permits. Although it is not strictly required to obtain ADWR permits in order to recharge water outside of Active Management Areas, Reclamation recommends that the USPP comply with State permit guidelines. The guidelines ensure that recharge is effective and does not cause harm to other entities. The required studies can also be used to implement a maintenance, monitoring, and operational regime that ensures optimum recharge efficiency. State regulations regarding the recharge of CAP water are described in the regulatory appendix.

***Continue Using Wells, Recharge CAP water completely outside Area of Hydrologic Impact***

This water supply alternative involves the continued use of existing wells to meet customer demand. The "Continue Using Wells Option" assumes that renewable supplies are recharged **completely outside** the area of hydrologic impact (AHI). The AHI consists of facilities that have a significant effect on the level of the aquifer, such as drawdown effect of wells and pumping centers or mounding from recharge facilities. **Under this recharge option, no action is taken to deliver renewable supplies to the area where the groundwater will continue to be pumped out.** As demand increases over time, additional wells must be installed in order to increase capacity.

Although it would be technically possible to meet future water needs in this manner, the use of existing production wells without recharge in the Area of Hydrologic Impact would likely result in the continued lowering of the groundwater table with consequent effects on the discharge of groundwater to the San Pedro River. This alternative could drastically lower the groundwater table and most likely decrease flow in the San Pedro River. Therefore, it is extremely unlikely that such an alternative would be considered acceptable. Consequences of continuing to lower the water table include an increased chance of subsidence, degraded water quality associated with pumping deeper in the aquifer, diminishment of riparian areas along the San Pedro River, increased pumping costs, and the need to deepen existing wells and drill new wells deeper.

As mandated Environmental Protection Agency water quality regulations become more restrictive over time, additional costs for treatment at the wellhead (e.g., arsenic or radon) must be considered. At present, the addition of chlorine is usually all that is required at most wellheads.

Costs which would be associated with this alternative include:

- Operation of existing wells
- Increased energy costs for pumping from existing wells as depth to water increases
- Installation of new wells and collector piping needed to meet future demand
- Cost to recharge renewable supplies
- Cost of allocation (Capital and operation and maintenance [O&M] costs)
- Cost of expected water treatment

***Recharge and Recovery Option:***

The Recharge and Recovery Option concept involves construction of a pipeline to several sites suitable for recharge, located adjacent to well pumping centers. The primary difference between this option and the "Continued Use of Wells Option" is that a portion of the water is recharged in the area where it will be recovered (the Area of Hydrologic Impact).

The water would be recharged using constructed basins, into the natural channels downstream from the basins and potentially into natural channels which would recharge the recent alluvium adjacent to the San Pedro River. In order to avoid fine-grained soils typically found at ground surface, which impede recharge rates, the basins are excavated to a depth of about 5 feet.

Replenishing the aquifer and maintaining higher groundwater levels, instead of mining the groundwater, benefits water providers. It helps keep pumping energy costs down, mitigates the need to drill deeper new wells or deepen existing wells, and helps assure the future of groundwater supplies. The recharged water may be recovered via the existing supply well system and put to beneficial use. Basic water quality standards would likely be met through "soil-aquifer treatment" which occurs during the recharge process. Soil-aquifer treatment is effective at removing pathogens and dissolved organic carbon. However, it **does not** remove dissolved solids from the recharged water. In addition, THM formation potential and DBP will have to be evaluated. (In general, the problem of THM formation is solved by using chloramine rather than chlorine as a disinfectant.)

This option affords the possibility of recharging the recent alluvium of the SPR, using multiple strategically located natural tributaries. If an artificial perennial stream reach can be created as part of the project, it would enhance existing riparian corridors. Direct delivery of raw CAP water to major turf irrigation users, mainly golf courses, and sand and gravel operations may be a facet of this option.

Multiple use benefits and economies of scale can be achieved through construction of a recharge and recovery project. Potential benefits include:

- Substitution of CAP water for groundwater currently used for turf irrigation, mining and industry.
- Drought protection from serious long-term CAP water shortages
- Increased regional reliability for short-term CAP water shortages
- Use of existing well recovery facilities and water delivery system
- Minimizing the risk of future ground subsidence
- Potential environmental enhancement by improving and expanding an existing riparian corridor
- Recreational opportunities associated with trails, equestrian development and bird watching

An evaluation of geomorphology, hydrogeology, water quality, and geochemistry will be necessary in order to determine the technical feasibility of recharge and recovery.

The conceptual plan to recharge and recover 30,000 AFY would include at least two separate recharge sites. More than one recharge facility is recommended to reduce the mounding of groundwater in the area of recharge. It is also unlikely that one site will have the proper hydrogeologic conditions to recharge 30,000 AFY. In fact, several sites and miles of natural channel will most likely be required to handle this amount of recharge. The duration of the recharge project also influences amount of groundwater mounding that occurs: the planned life of the project will affect the number of sites required.

One scenario includes the following features: Site 1 would be designed to recharge about 12,000 AFY. Approximately 6,500 AFY would be recharged using basins, while 5,500 AFY would be recharged in-channel, downstream from the site. The recharge site would consist of about 22 acres of spreading basins with additional acreage for berms and amenities. The recharge basins would be sized based on an operational scenario of a 50-percent wet to a 50-percent dry cycle and a recharge rate (long-term infiltration rate) of 2 feet per day.

A second site would be designed to recharge about 18,000 AFY, with 9,700 AFY recharged via basins and the balance through in-channel recharge downstream from the site. The recharge site will consist of about 33 acres of spreading basins with additional acreage for berms and amenities.

Recharge in the low flow channel downstream from each of the basin recharge sites might be aided by t-dike berms constructed within the wash in order to slow the flow of water downstream. This action will have the effect of increasing hydraulic loading, thereby increasing the amount of recharge per unit length. Although the berms would be washed out during any significant natural flow event, they can easily be rebuilt within two weeks at a low cost.

The infiltration (recharge) rate in natural channels can vary considerably. The infiltration (recharge) rate is typically expressed as acre-feet per mile per day. (The recharge rate is better defined as the long-term infiltration rate. It is affected not only by surface infiltration, but by subsurface geology and storage capacity in the vadose zone.) In Tucson, recharge rates vary from 2 AF/mi/day to 6 AF/mi/day. Using the above assumptions for recharge in natural channels, 13,800 AF, at a recharge rate of 3 AF/mi/day, would require from 12 to 14-miles of natural channel.

A network of new monitoring wells and existing production wells would be used to monitor groundwater levels and quality in the regional aquifer during recharge operations. Existing wells would be used for data acquisition whenever possible.

For recovery, we assumed an existing pumping capacity of 10,000 AFY. The balance needed for recovery would require new wells. A “unit well” with a capacity of 2,000 AFY (1,200 gallons per minute), an installation cost of $700,000 (including wellhead treatment) and a required “peaking” factor of 2.0 was used to estimate the recovery cost.

**Table 3 – Recharge and Recovery Costs**

| Recharge | | | | | | |
|---|---|---|---|---|---|---|
| Volume | Capital | Annualized Capital | O&M | Total Annual | $ per acre-foot | $ per 1000 gallons |
| 20,000 AFY | $8,503,525 | $571,437 | $566,770 | $1,138,207 | $56 | $0.17 |
| 30,000 AFY | $12,219,576 | $821,155 | $835,461 | $1,656,616 | $56 | $0.17 |
| 40,000 AFY | $16,777,057 | $1,127,418 | $1,103,924 | $2,231,343 | $56 | $0.17 |
| | | | | **Recovery** | $306 | $0.94 |
| | | | | **Total Recharge and Recovery** | **$362** | **$1.11** |

**Treatment and Direct Delivery of CAP Water Options:**

Even if a direct delivery option is selected, Reclamation recommends that well water systems be kept operational to address concerns with long-term CAP water availability. Alternative water sources should be available in case of shortages on the Colorado River, as well as short-term CAP and direct delivery system maintenance outages. Making the well system an integral part of the supply ensures that wells are maintained and functionally operational. Wells that are periodically operated should function much more efficiently and reliably over the long term.

Under this scenario, water delivered from the CAP pipeline will be impounded in a reservoir prior to delivery to a water treatment plant (WTP). After treatment at the WTP, the finished water will be stored in a covered reservoir. A pumping plant would lift the water for delivery via a distribution pipeline. The proposed main distribution pipeline alignment would deliver water throughout the Sierra Vista area.

Water providers would propose turnouts for potable water deliveries into each individual system. Tanks would need to be located to provide storage, surge protection and fire protection. The distribution system would be designed to take advantage of existing infrastructure and opportunities for operational cooperation among the water providers.

For a Direct Delivery alternative, CAP system reliability is a significant concern. Previously, Reclamation had considered providing CAP system reliability under the "Tucson Aqueduct System Reliability Investigation" (TASRI) with a 30-day winter maintenance outage on the CAP system. Reliability and redundancy for the treated water distribution system downstream from the CAP system remains a water provider responsibility.

There are several methods for treating CAP water. The methods vary in their cost and the quality of the treated water. A description of treatment methods and estimated cost is provided. This will provide the public and policy makers with a full range of options for evaluating water quality and corresponding cost.

***Water Treatment Options and Cost:***
As mentioned previously treatment of CAP water under the recharge and recovery alternative is accomplished by soil-aquifer treatment (SAT). Recovered water would also require disinfection prior to delivery. SAT does not reduce the TDS level, but does provide effective pre-treatment for reverse osmosis, which is used to lower the TDS.

For direct delivery of CAP water, various primary treatment methods are available which meet Safe Drinking Water Act (SDWA) standards. However, basic water treatment methods do not remove TDS (also known as mineral content or salinity). Reverse osmosis (RO) is commonly used to reduce salinity due to its relatively low cost. In order to be cost effective, RO requires a quality of water that exceeds the SDWA standards. Therefore, an effective type of primary treatment is required as a pretreatment to RO.

The following water treatment options apply to direct delivery.

*No desalting with variable-production plants*

- CAP water with Conventional Treatment (CT)
- CAP water with slowsand filtration (SSF)
- CAP water with microfiltration (MF) or ultrafiltration (UF)

*Desalting with constant-production plants and aquifer storage and recovery (ASR)*

- CAP water with Conventional Treatment (CT) and RO
- CAP water with slowsand filtration (SSF) and RO
- CAP water with microfiltration/ultrafiltration (MF/UF) and RO

Costs are given for a volume of 30,000 AFY. The variable-production plants supply water deliveries to meet maximum (peak) day deliveries of 40.14 million gallons per day (MGD) (45,000 AFY). The annual average plant production is 26.76 MGD (30,000 AFY). The annual plant factor[1] is 67 percent (26.76 MGD / 40.14 MGD *100%).

The constant-production RO plants, with aquifer storage and recovery of desalted water, would operate at an approximate rate of 23.95 MGD (27,000 AFY) throughout the year. The annual RO plant factor is 95 percent. The RO pretreatment (CT, SSF, or MF/UF) treats

[1] Plant factor is the ratio of how often a facility is actually used over the course of the year versus maximum use. If a WTP is operated at full capacity all year long, the plant factor would be 1.0. The most efficient and realistic plant factor that can be expected is about 0.95.

approximately 28.2 MGD with an installed capacity of 29.7 MGD (33,000 AFY). The RO plant recovery factor[1] is 85 percent with an installed capacity of 28.2 MGD (31,600 AFY). The 15-percent concentrate that must be disposed of is 4.5 MGD (5,000 AFY). Evaporation ponds are used for concentrate disposal.

***Conventional Treatment***

Conventional treatment begins with the addition of chemicals to enhance the flocculation of particles, followed by filtration and disinfection. The treatment train proposed in this study includes: untreated CAP water pumped to a raw water reservoir; screens; aeration; chemical pretreatment (disinfectants and coagulants); rapid and/or flash mixers; flocculation and sedimentation beds; filters; post-disinfection; corrosion control and a finished water reservoir for delivery to the potable water distribution system.

***Slowsand Filtration***

Slowsand filters (SSF) remove biological particles, such as Giardia cysts, Cryptosporidium oocysts, algae, bacteria, viruses, as well as turbidity. Slowsand filtration is attractive because it is passive, meaning that operator intervention is minimal; resulting in lower operating costs, and appears to be effective on CAP water. Slowsand filtration does not require expensive supplies and does not need chemical coagulation involving coagulant chemical feeders, rapid mixers, flocculators, or sedimentation basins with sludge removal equipment. Operation requires only the adjustment of flow to the plant, the monitoring of head loss and turbidity, and the scraping of the filter schmutzdecke (top thin layer). The filtration process is followed by disinfection and corrosion control prior to delivery into the potable distribution system.

An earlier report by Reclamation, Alternatives for Using CAP Water in the Northwest Tucson Area (Reclamation, 2000), identified a lack of operational experience treating Colorado River water using slowsand filtration as a stand alone treatment and as a pretreatment for reverse osmosis (RO). As a follow-up, Reclamation conducted a pilot study for the group of Northwest Tucson water providers to determine the efficacy and cost of slowsand filtration on CAP water. The pilot study was performed on CAP water in the Tucson area, which should be similar to water that the Sierra Vista Subwatershed would receive. The pilot study found that SSF could be used to treat water to Safe Drinking Water standards and was effective as a pretreatment to RO. The study also refined the costs for SSF and SSF/RO.

***Microfiltration and Ultrafiltration***

Microfiltration (MF) and ultrafiltration (UF) are barrier membrane filtration processes. In normal operation, feed water flows through the membrane module. Inside the module, water flows around the hollow membrane fibers. The flow passes through the walls of the membrane to the inside of the tubular fiber space. The membrane serves as a barrier that prevents the passage of solid particles that are larger than its pores. For microfiltration, particles greater than about 0.2 micron diameter are filtered out. Particles smaller than about 0.2 microns and most of the water pass into the tubular space inside. This filtered water, or filtrate, passes out of the membrane assembly as product water. The unfiltered feed water carries the solids out of the membrane assembly as wastewater.

Ultrafiltration removes even smaller solids down to about 0.01 micron diameter or 10 percent of the size of the particles removed by microfiltration, including viruses.

At some point, backwashing is needed to flush the accumulated particle solids to waste. This is usually done automatically based on pressure drop or the length of time the membrane system is in operation. The backwash water can be recovered and recycled back through the microfilter.

An important advantage of MF/UF over conventional filtration is that no filter-aid chemicals are usually required unless removal of some particular contaminant such as iron, manganese, or TOC is needed. Chemicals are used for occasional cleaning. In most cases, the cleaning chemicals can be discharged to the local sewer since they are approved for use in treating drinking water.

Because MF/UF provides absolute barriers to microorganisms, it serves as a "physical disinfectant" by removing protozoa (Giardia and Cryptosporidium) cysts, bacteria, and viruses.

MF/UF is very effective as a pretreatment to remove particulate material from water that may foul or plug the downstream reverse osmosis (RO) treatment process. Because of the very low particulate levels of MF/UF filtrate, a downstream RO plant can operate without particulate fouling at high flux rates.

***Reverse Osmosis Treatment***

Osmosis is a natural process in which water is transported through a semi-permeable membrane from a solution of low concentration to one of high concentration. For example, if fresh water and salty water are separated by a semi-permeable membrane, the fresh water will tend to move through the semi-permeable membrane in an attempt to equalize the salt concentrations of the waters on both sides of the membrane. This tendency produces a driving force that operates in a manner similar to pressure. The term "osmotic pressure" is used to describe it.

Reverse osmosis operates by applying sufficient pressure on the feedwater (salty) side of the membrane to force water through the membrane to the fresh water side (permeate), thus reversing the osmotic process. RO membranes permit very little passage of dissolved salts, so the RO product TDS is much lower than the feedwater TDS. The required pressure depends on several factors, but is primarily determined by the TDS concentration. Recovery is the percentage of feedwater recovered as permeate.

RO recovery is affected by two processes, “fouling” and “scaling”. Fouling is caused by suspended solids and high concentrations of iron and manganese that tend to plug RO elements. Some kind of pretreatment is necessary to prevent fouling. Both slowsand filtration and microfiltration/ultrafiltration provide effective pretreatment for RO. Scaling is caused by precipitates of sparingly soluble compounds that coat the RO membranes. The rate of scaling is controlled by the concentrations of these compounds.

RO systems consist of elements arranged in a series. Water which permeates through the first RO membrane travels through a spiral path and collects into a central product water tube. The feed water which does not permeate through the first element leaves the annular, or ring-shaped, space of the first element and enters the annular passages of the second element. This process continues through the series.

Because RO is a barrier process; it rejects other contaminants in the feedwater in addition to dissolved salts. RO rejects not only Giardia and Cryptosporidium, but also viruses, dissolved salts, and many organic solutes which are often measured as TOC. Because many organic solutes form disinfection by-products (DBPs) when free chlorine is used for disinfection, treatment methods that do not reduce TOC must use chloramine (a mix of chlorine and ammonia) instead. However, because chloramine is more persistent than free chlorine, the finished water may have chlorine concentrations that are too high for uses such as kidney dialysis and recreational fish tanks.

RO removal of these DBP precursors greatly reduces the levels of DBPs. The use of less persistent free chlorine then becomes an option for disinfection. Present and proposed regulations for tri-halomethanes (THM's), haloacetic acid and DBPs are readily met with RO treatment.

For treatment of CAP water with a TDS of 700 mg/L, low-pressure RO membranes appear to have the appropriate combination of low to moderate operating pressures and moderate salt rejection. A design water recovery of 85 percent appears feasible based on extensive operational experience and pilot testing at Tucson's Hayden-Udall Treatment Facility and at Reclamation's Water Quality Improvement Center (WQIC) in Yuma. Recovery appears to be limited by barium sulfate solubility.

RO treatment systems must dispose or manage the reject concentrate. Since the Sierra Vista Subwatershed is not located near any saline bodies of water, the recommended disposal method is the use of evaporation ponds. It is estimated that 900 acres of evaporation ponds will be required to dispose of the concentrate generated from the desalting of 30,000 AFY of CAP water at an 85% recovery rate. (This assumes an evaporation rate of 63 inches/year).

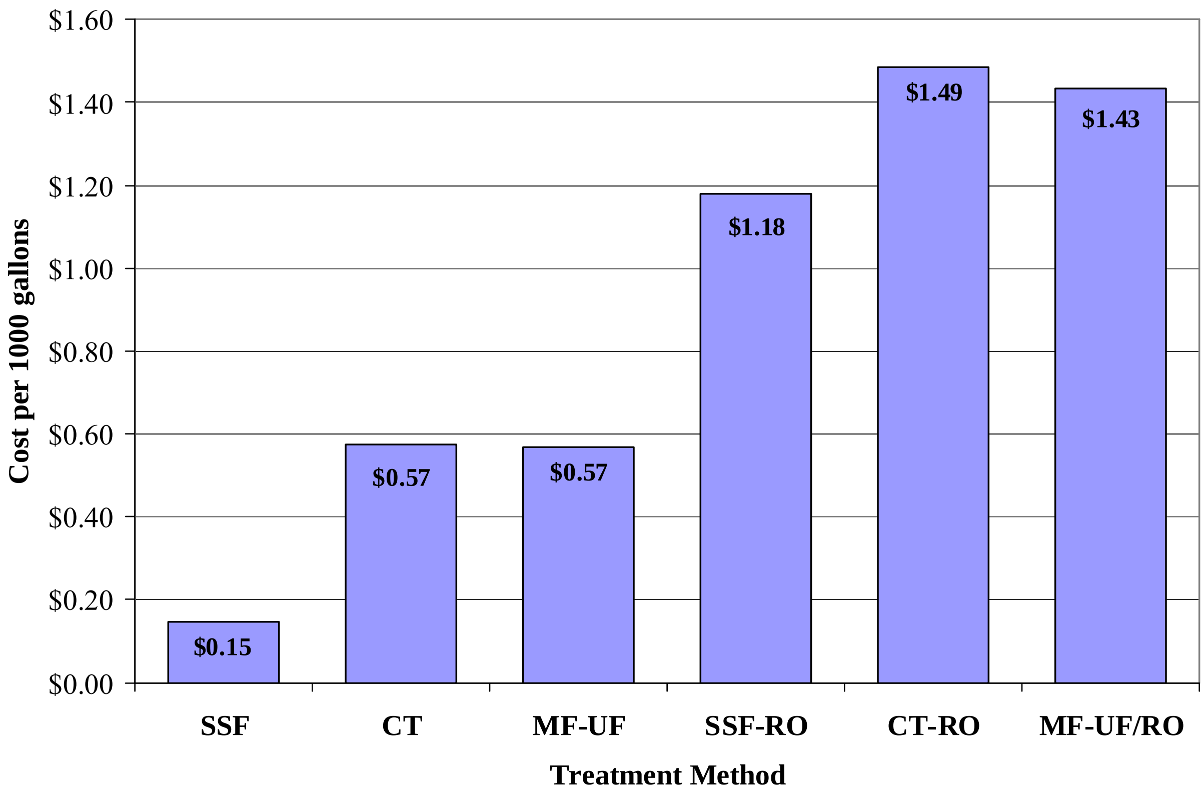
## Recommended Alternatives for Using CAP Water

Pilot studies conducted by the Bureau of Reclamation and a group of Northwest Tucson water providers found that slowsand filtration of CAP water can meet all primary drinking water standards at about one-fourth the cost of either conventional treatment or MF/UF. Therefore, SSF is the recommended treatment for domestic delivery of CAP without desalting.

In addition, SSF provides effective and cost-efficient pretreatment for RO. The previously mentioned pilot test showed that SSF is as effective as MF/UF for RO pretreatment at a much lower cost. A long-term pilot test of the effectiveness of slowsand filtration/reverse osmosis for treating CAP water is underway at the WQIC and a second pilot will begin in October in Marana, Arizona. Pending the positive outcome of the long-term pilots, the recommended treatment for desalting is SSF/RO.

**Potential for Cooperation**
Depending on the route, several entities that possess CAP allocations may be interested in cooperating in the construction of the pipeline. CAP subcontractors that have not had access to "wet" water from the CAP system include the Vail Water Co., Community Water Company of Green Valley, the Green Valley Domestic Water Improvement District and the Spanish Trails Water Company. If the I-10 route is selected, access to CAP water on the east side of the Tucson area may provide options for utilizing CAP water for other CAP subcontractors, like Tucson Water. Increasing the capacity of the pipeline increases the capital cost. However, the cost per acre-foot delivered would be reduced. Sharing the capital and operation and maintenance costs and adding support for the project could be beneficial.

**Chart 1 – Comparison of Direct Delivery Treatment Costs for CAP water**



## Table 4 –Water Quality Aspects of CAP Water Use Options

| | Recharge & Recovery | Conventional Treatment | Slowsand Filtration | Microfiltration/ Ultrafiltration | Reverse Osmosis |
|---|---|---|---|---|---|
| Meets SDWA Standards | N/A | Yes | Yes | Yes | Yes |
| Requires Chloramine Disinfection | Maybe | Yes | Yes | Yes | No |
| Suitable for RO pretreatment | Yes | No | Yes | Yes | N/A |
| Lowers Total Dissolved Solids | No | No | No | No | Yes |

## Table 5 – General Comparison of CAP Water Use Options

| | Environmental impacts | Environmental enhancement potential | Water quality | Other |
|---|---|---|---|---|
| Water Treatment and Distribution System | Mitigation will be required for Reservoir, WTP, and pipeline. | Mitigation will be required. | Depending on treatment option pursued, quality could range from poor (high TDS) to excellent (reverse osmosis). | Providers would control cost and water quality; some replacement of older pipelines may be required. |
| Continue Using Wells | Probable degradation of riparian areas. | Both basins and in-channel provide opportunities. | Good changing to fair over time | Potential for subsidence, increased pumping cost and new (deeper) wells. |
| Recharge and Recovery | Construction of pipelines and recharge basins. | Both basins and in-channel provide opportunities. | Fair changing to poor – higher TDS in a short time | Prevent or minimize subsidence potential; possible replacement of older pipelines. |

**Table 6- Summary of Costs, Including Utilization (I-10 Alignment)**

**$/Acre-Foot**

| Volume | Recharge and Recovery | SSF | CT | MF-UF | SSF-RO | CT-RO | MF-UF/RO |
|---|---|---|---|---|---|---|---|
| 20,000 AFY | $1,725 | $1,411 | $1,550 | $1,549 | $1,747 | $1,847 | $1,831 |
| 30,000 AFY | $1,594 | $1,281 | $1,420 | $1,418 | $1,617 | $1,717 | $1,700 |
| 40,000 AFY | $1,570 | $1,257 | $1,396 | $1,394 | $1,593 | $1,693 | $1,677 |

**$/1000 gallons**

| Volume | Recharge and Recovery | SSF | CT | MF-UF | SSF-RO | CT-RO | MF-UF/RO |
|---|---|---|---|---|---|---|---|
| 20,000 AFY | $5.29 | $4.33 | $4.76 | $4.75 | $5.36 | $5.67 | $5.62 |
| 30,000 AFY | $4.89 | $3.93 | $4.36 | $4.35 | $4.96 | $5.27 | $5.22 |
| 40,000 AFY | $4.82 | $3.86 | $4.28 | $4.28 | $4.89 | $5.20 | $5.15 |

## Issues and Concerns:

***Water Rights, Ownership***

- CAP water could be delivered to private water companies in the Sierra Vista area. The Arizona Corporation Commission typically does not allow the companies to buy more expensive water and pass the cost on to the consumer. However, the ACC has proposed a policy whereby "a water company would be allowed to recover CAP costs if it could demonstrate that it needed the CAP allocation to properly serve its customers". The water company would have to demonstrate that the need for the water will occur by 2025 and must use its full allocation by 2034.

***Available Capacity in Reach 6 Pipeline***

- Pump capacity of the Black Mountain Pumping Plant, which supplies water to Reach 6, the last section of the CAP aqueduct, is 200 cfs. The Reach 6 pipeline begins with a pipe diameter of 72 inches and decreases to a 54 inch diameter. Delivery capacity of the Reach 6 pipeline at the Terminus is about 160 cfs. Ultimately, delivery capacity depends on user's demands, pipeline size and design capacity, and Black Mountain pumping plant capacity. Current allocations, which affect the Terminus, require an estimated average maximum use of 120 cfs. Green Valley area water providers, the Pima Mine Road Recharge Facility and the San Xavier District of the Tohono O'odham Nation have allocations supplied from this segment of the CAP. The capacity required to deliver 30,000 AFY to Sierra Vista is about 45 cfs and is available.

***Storage, System and Long-term Reliability***

- A CAP system reliability reservoir providing 30 days of storage for the Tucson area has been authorized but has not been constructed. In addition, long-term reliability, typically associated with shortages on the Colorado River, is the responsibility of CAP subcontractors with allocations. A reservoir at the Sierra Vista terminus providing a 12 hour supply is included in the design. Entities in the Sierra Vista area will need to evaluate the amount of risk versus cost that will be acceptable to address the issues of short-term and long-term reliability.

***Effectiveness***

- Coordinated watershed-scale groundwater management planning and policy would be required in the future to ensure that the combined water demands placed on the aquifer did not result in negative consequences.

- Regardless of how an allocation of CAP water is obtained it will likely come with strings attached. There might be a parallel in the history of how the CAP system was constructed. An excerpt from the Arroyo publication (U of A WRRC):

> *1980 Groundwater Management Act*
>
> *Concern about groundwater overuse again made the legislative agenda when the Groundwater Management Act was passed in 1980. The Arizona Legislature passed the law at the urging - some claim it was in response to a threat - of the federal government. Whatever might have transpired between the two parties, a bargain was in fact struck: the state would take measures to control groundwater use and the federal government would complete the Central Arizona Project. The GMA was the result of political maneuvering, and water conservation became the law of the land. The GMA stands as the cornerstone of the state's water conservation efforts.*

To review the whole article one can visit the website at:
http://ag.arizona.edu/AZWATER/arroyo/104.html

From Jacobs and Holway, 2004, "Managing for sustainability in an arid climate: lessons learned from 20 years of groundwater management in Arizona, USA", Hydrogeology, Hydrogeology Journal (2004) 12:52–65:

> *"By the late 1970s there was growing recognition of the impacts of water level declines and resulting land subsidence in some areas. The U.S. Secretary of the Interior also declared that the long-desired Central Arizona Project would not be authorized unless Arizona took steps to reduce groundwater overdraft."*

***Financing***

- Financing – where the money comes from, how it is paid back and by who must be ascertained.

***Regulatory***

- Federal regulatory programs and issues are covered in the appendices. Two important issues are summarized below:

    - A Clean Water Act Section 404 permit is required for discharge of fill or dredged material into "waters of the United States" (washes, streams, rivers, lakes, and wetlands). Activities requiring a 404 permit also must obtain a 401 Water Quality Certification. Construction projects with a total area of one acre or more must be permitted in accordance with Arizona Pollutant Discharge Elimination System regulations (Section 402).

    - National Environmental Policy Act compliance (most likely an EIS) is required if project is partly or wholly funded by the Federal Government.

***Geology***

- Selection of preferred alignment will be impacted by excavation through bedrock and narrow existing roadways, topography, and cross drainage depression (siphons). In particular, the Santa Rita Alignment traverses three to four miles of narrow mountain roadway and bedrock excavation. This requires exceedingly large slope excavations to lay back existing cut slopes, expensive hard rock excavation, and importation of bedding and backfill material.

- Importation of water with quality different from the existing groundwater may have an effect on soil geochemistry, wastewater quality, surface water and ground water quality. These issues have been accepted by the existing users of CAP water.

- See the table in Appendix, summarizing geologic information for the apparently preferred route along I-10.

***Biological***

- Although the conveyance pipeline would use previously disturbed easements wherever possible, the pipeline route must be surveyed for species listed or proposed under the Endangered Species Act.

- Potential effects to the following federally listed, proposed, candidate species and/or designated/proposed critical habitat should be addressed in the NEPA document: Gila chub, Chiricahua leopard frog, jaguar, lesser long-nosed bat, northern aplomado falcon, cactus ferruginous pygmy-owl, Mexican spotted owl, Pima pineapple cactus, and any other species proposed or listed prior to project implementation.

- Critical habitat for both loach minnow and spikedace was vacated in September 2004. Prior to project initiation, the current status of this critical habitat designation should be ascertained.

- Endangered Species Act Section 7 consultation and subsequent mitigation may be required to offset impacts to native fish as a result of the importation of non-native fish via the CAP system. The San Pedro River occurs within the Gila River Watershed and has been consulted on. However, the San Pedro River fish barriers have not been constructed and delivery of water to Sierra Vista would be upstream of currently proposed barrier locations.

- Environmental issues of concern will be greater if CAP water is recharged, ponded or put into an open conveyance system. If CAP water is delivered directly to the end user (pipe to pipe), then impacts associated with transportation of non-native fish into the San Pedro River basin and effects to the San Pedro River water quality will be eliminated.

- Sensitive plants such as agaves and cacti located within the pipeline right-of-way should be salvaged pursuant to the Arizona Native Plant Law.

- Coordination with the Arizona Department of Transportation will be required to obtain a permit for construction near Highway 83, a designated Scenic Highway.

- Coordination should be conducted with the following land managers along the pipeline route: Department of Defense, Coronado National Forest, Bureau of Land Management, State of Arizona, Pima County Regional Flood Control and University of Arizona (for the Santa Rita Experimental Range) and any other affected agencies.

- See the attached Biological Appraisal for further information. Note that the information is very preliminary, based on a cursory review of the alignments. This information is provided to allow the reader to begin to formulate an understanding of the affected biology.

***Cultural Resources***

- A Class I survey (literature search) is needed to determine what areas along the potential CAP routes have been surveyed and what known cultural resources and Traditional Cultural Properties (TCPs) are located within the area of potential effect. This would include accessing site files at the Arizona State Museum as well as those of the Coronado National Forest (USFS), Bureau of Land Management, and Fort Huachuca (DOD).

- Should this alternative proceed to a feasibility level analysis, a Class III cultural resource (intensive) survey would be required to identify cultural resources and TCPs in the area of potential effect.

- As part of the Class III survey, tribal consultation regarding traditional cultural properties would need to be carried out. At a minimum, this includes the Hopi, Tohono O'odham, San Carlos and White Mountain Apache and the Gila River Indian Community. The Zuni and the Yavapai may also need to be consulted.

- If testing and/or data recovery are required to mitigate the effects of the project, additional tribal consultation would be conducted as part of the Section 106 process.

- Section 106 consultation with the State Historic Preservation Office must also be carried out. The Advisory Council on Historic Preservation would also be part of the consultation process, but it is likely they would opt not to be.

- Section 106 activities would be coordinated with the NEPA process

- See the attached draft of the Cultural Resources evaluation for further information. Note that the information is very preliminary, based on a cursory review of the alignments.

**Primary References:**

1) Central Arizona Project M & I Water Supply Pipeline for Sierra Vista and Fort Huachuca, Arizona. Appraisal Designs and Cost Estimates. U. S. Bureau of Reclamation, Arizona Projects Office, Phoenix, Arizona, November 1993

2 ) Preliminary Cost/Benefit Analysis for Water Conservation, Reclamation and Augmentation Alternatives for the Sierra Vista Sub-watershed, Fluid Solutions/BBC Research and Consulting Report, November 2003 (FS report).

3) CAP water allocations, water quality, users, deliveries, CAP web site, CAP-az.com

4) Central Arizona Project, Larry Dozier, 2005, Personal communications.

5) CAP, Tucson Aqueduct, Operational and Capacity Summary.

6) Ground-water Quality in the Sierra Vista Subbasin, Arizona, 1996-7. Coes, Alyssa, D.J. Gellenback and Douglas C. Towne. Water-Resources Investigations Report 99-4056, National Water Quality Assessment Program, USGS, 1999.

7) Alternatives for Using Central Arizona Project Water in the Northwest Tucson Area, Reclamation, 2000.

8) Pilot Investigation of Slowsand Filtration and Reverse Osmosis Treatment of Central Arizona Project Water, Reclamation, August, 2002.

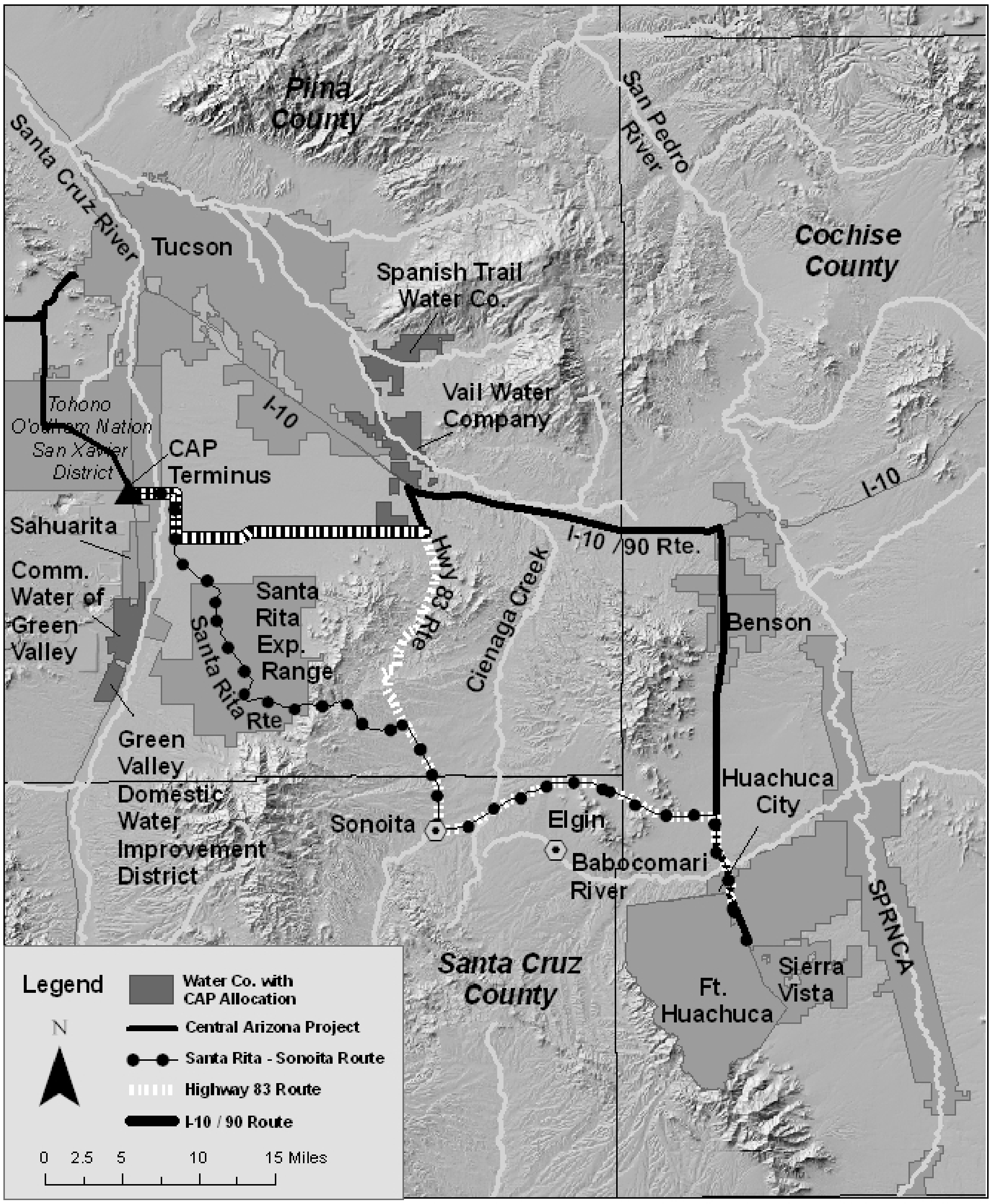
9) Arizona Corporation Commission Working Group Reports, Appendix D, Proposed Policy for Central Arizona Project (CAP) Cost Recovery, Attachment D, available at http://www.cc.state.az.us/working/wt-attachD.htm

10) EPA Secondary Drinking Water Regulations: Guidance for Nuisance Chemicals http://www.epa.gov/safewater/consumer/2ndstandards.html

11) Conversation with John Bodenchuk, ADWR staff, December 5, 2005.

12) Personal communication with Patricia McGraw, ADWR staff, November 1, 2005.

## Preliminary Appraisal Level Routes for Extension of CAP to Sierra Vista Area




U.S.B.R. Tucson Field Office, July 12, 2005

D. Preliminary Appraisal Study of CAP Water to Sierra Vista Alternative

*Appendix A: Final Biological Appraisal for CAP Water to Sierra Vista Alternative*

# Appendix A

## FINAL BIOLOGICAL APPRAISAL FOR CAP WATER TO SIERRA VISTA ALTERNATIVE

### INTERSTATE 10 (I-10) ALIGNMENT - EXISTING ENVIRONMENT

### Vegetation Resources

The I-10 alignment passes through three vegetative communities (Brown 1994): Sonoran Desertscrub, Semidesert Grassland and Chihuahuan Desertcrub. It also crosses numerous drainages including the major drainages of the Santa Cruz River, Cienega Creek, Davidson Canyon and the Babocomari River.

The **Sonoran Desertscrub** community occurs at the beginning of the pipeline route at Pima Mine Road in Tucson and continues east toward Highway 83. Two vegetation associations (paloverde-cacti-mixed scrub and creosotebush-bursage) occur within the Sonoran Desertscrub community. The paloverde-cacti-mixed scrub association occurs on the hills and bajadas. The primary plant species within this habitat type are foothill paloverde (*Parkinsonia microphylla*), blue paloverde (*Parkinsonia florida*), saguaro (*Cereus giganteus*), catclaw acacia (*Acacia greggii*), ocotillo (*Fouquieria splendens*), barrel cactus (*Ferocactus wislizenii*), brittlebush (*Encelia farinosa*), triangle-leaf bursage (*Ambrosia deltoidea*), and various cholla (*Opuntia*) species. This habitat type is noted for its rich diversity of bird species (Brown 1994).

The creosote-bursage association occupies the lower elevational gradients and is much simpler in structure than the paloverde-cacti-mixed scrub community. It is composed mainly of shrubs and dwarf shrubs such as creosotebush (*Larrea tridentata*), triangle-leaf bursage, and saltbush (*Atriplex* sp.) with a few cacti such as cholla and prickly pear (*Opuntia* sp).

The **Semidesert Grassland** community starts west of Highway 83 and is intermixed with the Chihuahuan Desertscrub community all the way to Sierra Vista. It primarily occurs along I-10 with the exception of an approximately 10 mile stretch around Cienega Creek. It also runs south on I-90 to Sierra Vista except around Huachuca City. The Semidesert Grassland community occurs between 3600 and 4600 feet in elevation, adjacent to the Chihuahuan Desertscrub and below the Madrean Evergreen Woodland communities. The Semidesert Grassland community is a perennial grass-shrub dominated landscape, where the grass cover has been reduced by encroachment of a wide variety of shrubs, trees, and stem succulents (Brown 1994). In some areas, Brown (1994) notes that trees, half-shrubs, cacti, and forbs may outnumber or completely replace the grasses. Such a "disclimax" grassland is often the result of natural or human-induced intervention into cyclic fire patterns. However, in this case, widespread livestock grazing and increasing aridity caused by a decrease in rainfall and an increase in temperature are considered to be the cause. Typical grass species include needle grama (*Bouteloua aristidoides*), grama grass (*Bouteloua* sp), bush muhly (*Muhlenbergia porteri*), and three awn (*Aristida* sp). Nongrass species are more typical of the paloverde, cacti-mixed scrub association and include mesquite (*Prosopis velutina*), catclaw acacia, foothill paloverde, burroweed (*Isocoma tenuisecta*), four-wing saltbush (*Atriplex canescens*), and triangle-leaf bursage.

The **Chihuahuan Desertscrub** occurs around Cienega Creek on I-10 and again around Huachuca City along Highway 90. The Chihuahuan Desertscrub community occurs primarily in southeastern Arizona. The landforms associated with the Chihuahuan desertscrub are primarily basins, outwash plains, low hills and bajadas. Plant composition is relatively homogenous consisting of three dominant shrub species: creosotebush, tarbush (*Flourensia cernua*) and white thorn acacia (*Acacia constricta*) (Brown 1994). Increased elevation brings in succulents such as banana yucca (*Yucca bacata*), shindagger (*Agave lechuguilla*), soaptree yucca (*Yucca elata*) and desert spoon (*Dasylirion wheeleri*).

The **Xero/Meso/Hydro-Riparian Community** vegetation varies by drainage and location. All streams are ephemeral (flowing only in response to rainfall events) at the alignment crossings. However, both Davidson Canyon and Cienega Creek have intermittent (seasonal flows) and perennial (year-round flows) flows upstream and downstream of the alignment crossings. Davidson Canyon and Cienega Creek are classified as Interior Riparian Deciduous Forests and Woodland (Brown 1994). This vegetation community is maintained along perennial or seasonally intermittent streams within the Chihuahuan biotic provinces. Both Davidson Canyon and Cienega Creek are vegetated with Fremont cottonwood (*Populus fremontii*) and Goodding willow (*Salix gooddingii*) trees at the crossing locations, indicating a shallow groundwater table.

Groundwater pumping has resulted in a lowering of the water table and subsequent downcutting of the Santa Cruz River channel. The lowered water table also resulted in the demise of the gallery forest of cottonwood and willow which helped to stabilize the channel banks, resulting in a widening of the channel. The existing vegetation consists primarily of mesquite, whitethorn acacia, and four-wing saltbush. The large mesquite bosques of the past no longer exist, having been replaced by smaller, scrubbier mesquite. The Babocomari River, at the Highway 90 pipeline crossing, is also vegetated with scrubby mesquite.

## Wildlife Resources

Wildlife species composition within the Sonoran Desert depends not only on adaptational biology but on cover, temperature, humidity and food availability (Crosswhite and Crosswhite 1982). The number of species showing biological adaptations to the desert is large, but the number with less-pronounced adaptations reflects the complexity of the habitat. Habitat factors are valuable to the species in ameliorating the basic environment. For example, were it not for cavities constructed in saguaros by the Gila woodpecker, the elf owl probably could not survive in the Sonoran Desert (Crosswhite and Crosswhite, 1982).

Riparian vegetation provides habitat for 60 to 75 percent of Arizona's resident wildlife, despite the fact that riparian areas occupy less than 0.5 percent of the state's total land area (Arizona Riparian Council 1994). The structural diversity of the vegetation creates numerous ecological niches for an abundance of wildlife species from raptors (hawks and owls), passerines (smaller birds), small mammals, snakes, and lizards to large mammals such as desert mule deer (*Odocoileus hemionus*), collared peccary (*Tayassu tajaca*), bobcat (*Felis rufus*), and mountain lion (*Puma concolor*).

The San Pedro River dominates the Sierra Vista/Fort Huachuca community. Preservation of the perennial flows in this system is the primary reasons this appraisal report has been prepared. Riparian areas provide critical habitat for neotropical migrants such as the summer tanager (*Piranga rubra*), Bell's vireo (*Vireo bellii*), yellow-billed cuckoo (*Coccyzus americanus*), and yellow warbler (*Dendroica petechia*). The San Pedro Riparian National Conservation Area (SPRNCA) is designated as a Globally Important Bird Area (AGFD unpublished). The San Pedro River is one of the West's main neotropical flyways (TNC unpublished); over 400 species of birds have been identified in the SPRNCA.

The presence of large blocks of undisturbed land in association with drainages provides critical movement corridors for large mammals. Drainages also provide important food, water, and cover for large mammals as they take advantage of seasonal food sources. Roadkill data (Personal Communication, Scott Richardson, Biologist, July 19, 2001) indicate that a number of large mammals travel between the Santa Rita Mountains and the Rincon Mountains. Cienega Creek and Davidson Canyon serve as potential movement corridors. Wildlife species likely to utilize Box Canyon Wash, Davidson Canyon, Cienega Creek and the Babocomari River for foraging or movement include mountain lion, bear (*Euarctos americanus*), bobcat, white-tailed deer (*Odocoileus virginianus*), white-nosed coati (*Nasua narica*), raccoon (*Procyon lotor*), coyote (*Canis latrans*), collared peccary, and gray fox (*Urocyon cinereoargenteus*).

Some wildlife species that are "characteristic" of each biotic community, but may also occur outside of those areas, are mentioned below.

**Sonoran Desertscrub** - This community is particularly noted for its rich bird life. Some characteristic species include the white-winged dove (*Zenaida macroura*), elf owl (*Micrathene whitneyi*), and pyrrhuloxia (*Cardinalis sinuatus*). Other wildlife species include: mule deer, collared peccary, white-throated woodrat (*Neotoma albigula*), regal horned lizard (*Phrynosoma solare*), western whiptail (*Cnemidophorus tigris*), Gila monster (*Heloderma suspectum*), Arizona coral snake (*Micruroides euryxanthus*), and the tiger rattlesnake (*Crotalus tigris*).

**Semidesert Grassland** - Generally, grassland species have fared less well than their scrub-adapted competitors. Antelope, for example, are now totally absent from large areas of their former range in semidesert grassland, whereas mule deer and collared peccary have extended their ranges (Brown 1994). Wildlife characteristic of the

Semidesert Grassland include: black-tailed jackrabbit (*Lepus californicus*), badger (*Taxidea taxus*), Swainson's hawk (*Buteo swainsoni*), poor-will (*Phalaenoptilus nuttallii*), Scott's oriole (*Icterus parisorum*), western yellow box turtle (*Terrapene ornata luteoloa*), and the Mexican hognose snake (*Heterodon nasicus kennerlyi*).

**Chihuahuan Desertscrub** - Because of its "recent origin", few warm-blooded vertebrates are restricted to Chihuahuan Desertscrub (Brown 1994). Most species are representative of a southeastern extension of general desert adapted species. Some "characteristic" species include the southern pocket gopher (*Thomomys umbrinus),* Southern grasshopper mouse (*Onychomys torridus*), scaled quail (*Callipepla squamata*), Chihuahuan raven (*Corvus cryptoleucus*), Texas banded gecko (*Coleonyx brevis*), round-tailed horned lizard (*Phrynosoma modestum*), whipsnakes (*Masticophis* sp.), and Chihuahuan hook-nosed snake (*Gyalopion canum*).

**Federally Proposed and Listed Species**

The following federally listed species occur in Pima and Cochise counties and may occur along the proposed pipeline alignments. Surveys and appropriate Endangered Species Act Section 7 consultation should be conducted where necessary.

| | |
|---|---|
| Lesser Long-nosed Bat | (*Leptonycteris curasoae yerbabuenae*) |
| Northern Aplomado Falcon | (*Falco femoralis septentrionalis*) |
| Cactus Ferruginous Pygmy-owl | (*Glaucidium brasilianum cactorum*) |
| Chiricahua Leopard Frog | (*Rana chiricahuensis*) |
| Gila Chub | (*Gila intermedia*) |
| Pima Pineapple Cactus | (C*oryphantha scheeri* var. *robustispina*) |

**Lesser long-nosed bat -** This species was listed as endangered on September 30, 1988 (FR Vol. 53 No. 190). The lesser long-nosed bat is one of three leaf-nosed bats in Arizona (Hoffmeister 1986). It is distinguished from nearly all other bats in Arizona by its elongated snout, tipped with a triangular leaf-shaped flap of skin. It is distinguished from the other two bats in this family by a greatly reduced tail membrane and lack of a tail (Arizona Game and Fish Department [AGFD] 1992).

Known threats to this species include disturbance of roost sites and loss of food resources through overharvesting of agaves in northern Mexico, spread of agriculture, wood cutting, and livestock grazing.

The lesser long-nosed bat feeds on nectar and pollen from saguaros and agaves, forming a mutualistic relationship with these plants (USFWS 1991). They cannot tolerate prolonged exposure to cold, do not hibernate, and spend winters in Mexico. Lesser long-nosed bats have been known to forage long distances from their roost sites. Bats from caves located in the Pinacate Mountains in Mexico forage at Organ Pipe Cactus National Monument, approximately 50 miles away. This long distance movement is necessary due to lack of foraging habitat near the roost site.

The current range of the lesser long-nosed bat is similar to the historic range. It extends from southern Maricopa County through Pinal, Pima, Cochise, and Santa Cruz counties and into Mexico. This species is found mainly in desertscrub habitat dotted with agaves (*Agave* sp.), mesquite, creosotebush, and columnar cacti. Daytime and maternity roosts are located in caves and abandoned mines.

**Northern Aplomado Falcon** - There are very few published records of the northern aplomado falcon after 1900 (Corman 2005). It is speculated that heavy grazing pressure combined with severe drought in the late 1880's resulted in a reduction in the prey base, leading the falcon's extirpation from Arizona (Corman 2005). Most records of this species were obtained in Cochise County north to Fort Bowie (Visher 1910). Five nesting records of the aplomado falcon were recorded in 1887; all were detected in the vicinity of Fort Huachuca (Bendire 1892).

Historically, the northern aplomado falcon inhabited open grassland terrain with scattered trees and relatively low ground cover with a supply of suitable nesting sites (primarily mesquite or yucca). There have been no confirmed sightings of this species in United States between 1952 and 1997.

The FWS proposes to establish a "nonessential experimental population" of aplomado falcons in Arizona and New Mexico (FR 70 6819). The proposal, published in the Federal Register on February 9, 2005 indicates that up to 150 aplomado falcons may be released until a self-sustaining population is established.

A "nonessential experimental population" is a reintroduced population whose loss would not be likely to appreciably reduce the likelihood of survival of the species in the wild. Any species encountered outside of a National Park or National Wildlife Refuge System unit would be treated as a "proposed species" under the Endangered Species Act. This means a "conference" with FWS would be conducted should any impact be expected as part of a Federal action. Since the designation indicates the population is not essential to the continued existence of the species, no proposed action could lead to a "jeopardy" determination.

**Cactus Ferruginous Pygmy-Owl** - The cactus ferruginous pygmy-owl (pygmy-owl) is similar in appearance to its relative, the northern pygmy-owl, which is also found in the state. This small 7-inch owl can be distinguished from other small owls in the State by its long tail and round earless head. The cactus ferruginous pygmy-owl can be identified from the northern pygmy-owl by the dark barring in the tail (northern pygmy-owl has light barring in the tail.) However, the best criterion for identification is its call.

According to the FWS (1993 and 1998), the primary threats to this species are the widespread loss and modification of riparian habitat. Additional impacts to the owl may result from harassment by birdwatchers, lack of management plans for this species on Federal and State lands, as well as competition for nest sites from introduced starlings. Recent increases in the loss of upland habitat, such as is occurring around the Tucson area, are also of concern (USFWS 1998).

Historic accounts indicate the pygmy-owl may have been more common and widespread in the state. Records show this species utilized cottonwoods and willows for nesting in riparian woodlands (Rea 1983). Records prior to 1971 indicate that this species was found as far north in the state as the Blue Point Cottonwoods near the confluence of the Salt and Verde Rivers (Millsap and Johnson 1988). Today, confirmed reports of pygmy-owls in Arizona are exclusively from Sonoran Desertscrub below 3000 ft in elevation and south of Picacho Peak (AGFD 1996).

The subspecies of pygmy-owl found in Arizona was listed as endangered with critical habitat on March 10, 1997 (62 FR 10730). Since then the status of this species and its critical habitat has been the subject of numerous court cases. On September 19, 2001, the critical habitat designation was remanded back to the FWS for further review. Consequently, the final rule designating critical habitat for the Arizona population was vacated. FWS reissued proposed critical habitat on November 27, 2002.

On August 19, 2003, the Ninth Circuit Court published an opinion finding that the FWS listing of the pygmy-owl was arbitrary and capricious. The Circuit Court reversed and remanded the issue back to the District Court for further proceedings consistent with the opinion. A petition filed with the Ninth Circuit for rehearing by the Defenders of Wildlife was denied on October 28, 2003. In December 2003, the FWS filed papers with the District Court indicating they were in agreement with the decision to vacate the listing. On June 28, 2004, the District Court ordered the FWS to reconsider the legal status of the pygmy-owl and prepare a report for the Court's review by January 31, 2005. On August 3, 2005, the FWS published in the Federal Register a Proposed Rule to Remove the Pygmy-owl from the Federal list of Endangered and Threatened Wildlife (70 FR 44547). To date, no final rule on delisting has been issued.

**Chiricahua Leopard Frog** - The Chiricahua leopard frog, described by Platz and Mecham (1979), had already suffered serious reduction in geographic range in Arizona by 1987 (Clarkson and Rorabaugh 1989). This species was listed as threatened on June 13, 2002 (67 FR 40790).

The Chiricahua leopard frog has two forms. The southern form is found in southeast Arizona, portions of southwest New Mexico, and a portion of Mexico. The Rim form is a disjunct population occurring along the southern edge of the Colorado Plateau, headwater drainages in the White Mountain, and on the Mogollon Rim in Arizona (Sredl et al. 1997). Chiricahua leopard frog habitat ranges from 3500 to 8890 feet. Chiricahua leopard frog distribution overlaps with the northern leopard frog (*Rana pipiens*) at higher elevations and lowland leopard frog (*Rana yavapaiensis*) at lower elevations. *Rana chiricahuensis* are the most aquatic of all the leopard frogs (Sredl 1998).

Habitat heterogeneity is important for leopard frogs. They prefer habitat with a variety of structure and cover, including emergent and submergent vegetation, overhanging banks and organic debris. Perimeter vegetation provides good cover and foraging habitat. Egg masses are usually laid in shallows and are attached to emergent vegetation or debris. Silt and organic debris are used for hiding from predators, as well as for hibernation during the winter months or for aestivation during periods of drought. In addition, organic sediments support a diversity of invertebrates that attract other food sources for frogs. Leopard frogs prefer a variety of water depths. Deep water provides protection from terrestrial predators and is used more often in the winter, while shallow water is important for foraging and egg site attachment.

Chiricahua leopard frogs are found in the upper tributaries to the San Pedro River and historically were found at Hereford and Palominas (personal communication, Rob Clarkson, Reclamation, August 30, 2005; Clarkson and Rorabaugh 1989).

**Gila Chub** - Gila chub was listed as endangered on November 2, 2005 [70 FR 66664] due to the extensive habitat loss and establishment of nonnative fishes throughout most of its range (USFWS 2002). A Gila River basin endemic, Gila chub is similar in many ways to the closely-related roundtail chub, but is smaller and thicker-bodied, and characteristic of deeper pools in small streams, cienegas, and springs (Minckley 1973). The species historically was widespread and common in suitable habitat throughout central and southeastern Arizona. Much of that habitat has been lost and only remnant populations restricted to tributaries persist today. The Gila chub commonly inhabit pools in smaller streams, springs, and cienegas and can survive in small artificial impoundments (USFWS 2005). Gila chub is reclusive, hiding in deep water among roots and other cover.

The Gila chub is found in upper Cienega Creek, which has the only stable-secure population in Santa Cruz River drainage. Two other populations in the Santa Cruz River drainage are considered unstable-threatened (USFWS 2005). The San Pedro River basin has three stable-threatened populations (Redfield, Hot Springs and Bass Canyons). The status of the Gila chub in O'Donnell Canyon (Babocomari River) is unstable-threatened (USFWS 2005).

**Pima Pineapple Cactus** - The Pima pineapple cactus (PPC) was listed as endangered on September 23, 1993, (58 FR 49875). This cactus is also known as the stout-needled mulee cactus or Sheer's strong-spined cory cactus. It is a low growing round cactus with finger-like projections called tubercles extending outward from the stem. The tubercles are marked with a prominent groove on the upper side, a characteristic of the genus Coryphantha. The spine cluster has one slightly hooked central spine and 10 - 15 straight strawberry colored radial spines. The large yellow flowers have a narrow floral tube; the fruit is green (Ecosphere 1992).

Ecosphere (1992) documented the current distribution of the cactus as west to the Baboquivari Mountains, east to the Santa Rita and Patagonia Mountains, north to Tucson, and south into Sonora, Mexico. In general, PPC is found in open patches of habitat within the semidesert grassland and Sonoran desertscrub vegetation communities, from 2300 ft to 5000 ft elevation (Ecosphere 1992). PPC appears to be most abundant in the ecotonal boundary between these two communities (FWS, draft recovery plan, unpublished). This species seems to prefer deep alluvial soils of granitic origin

(Ecosphere 1992a). They are most often found on south or east facing slopes (with less than 5 percent slope) between 2500 ft and 3800 ft elevation (Ecosphere 1992a). Associated vegetation includes primarily mesquite, triangle-leaf bursage, burroweed, chain fruit cholla (*Opuntia fulgida*), barrel cactus (*Ferocactus wislizeni*), cane cholla (*Opuntia spinosior*), and purple-fruited prickly pear (*Opuntia phaeacantha*). Few grasses are associated with this species (Mills 1991).

The main threat affecting this cactus is habitat loss from construction associated with a rapidly growing human population (FWS, draft recovery plan, unpublished). The second cause is the introduction of nonnative species such as Lehman's lovegrass (*Eragrostis lehmanniana*) which outcompete native grasses and forms monotypic stands (Rutman 1992, FWS draft recovery plan, unpublished). The spread of nonnative grasses has modified the patchy distribution of grass to contiguous stands resulting in increased losses of cacti as a result of fire. Other potential impacts include grazing and illegal collection of this species.

## I-10 ALIGNMENT - AFFECTED ENVIRONMENT

**Vegetation -** Impacts from the proposed project will occur as a result of construction of the following features: conveyance pipeline, booster pump stations, transmission lines, storage tanks and recharge basins. The proposed alignment follows the highly disturbed I-10 and Highway 90 corridors and would be located adjacent to or within previously disturbed habitat, thereby reducing overall impacts to vegetation. If the pipeline cannot be attached to the highway bridges at the major channel crossings, then additional habitat disturbance would occur along the Santa Cruz and Babocomari Rivers, Davidson Canyon, and Cienega Creek. Both Davidson Canyon and Cienega Creek contain high quality habitat values. Pima County Regional Flood Control has expressed concern over construction activities in these drainages and should be consulted prior to project implementation (personal communication, Julia Fonseca, Hydrologist, June 2005).

Existing transmission lines are available along this alignment; however an additional five miles of line would be required to supply the substations. On the ground clearances will need to be completed and site specific impacts determined prior to project construction.

At this time, no locations for the potential recharge basins have been identified. Therefore, impacts associated with this feature cannot be determined. On the ground clearances will need to be completed and site specific impacts determined prior to project construction.

**Wildlife -** Wildlife values adjacent to these highly traveled roads are minimal. There are numerous small mammal, reptile and amphibian species that occur within the diverse vegetation communities along the proposed alignment. This appraisal analysis does not warrant a detailed discussion of all the potential species that could be impacted. Suffice to say there will be loss of small mammal and herpetefaunal species from construction activities. Impacts to avian species and large mammals, outside of the drainage crossings, would be relatively minor. Impacts to wildlife species from construction of transmission lines and recharge basins will be evaluated once the alignments are delineated.

**Federally Listed Species -** If CAP water is recharged or ponded, there will be additional impacts to native fish and frogs from the transfer of non-native fish species into the San Pedro River basin. The Bureau of Reclamation consulted with the Fish and Wildlife Service (USFWS 1994 and USFWS 2001) on the effects to native fish from inter-basin water transfers to the Gila River Basin in 1994, and again in 2001. The San Pedro River was included in this consultation. However, the San Pedro River fish barriers have not been constructed and water deliveries to Sierra Vista would occur upstream of any proposed fish barrier location. Therefore re-initiation of Section 7 consultation would be required for any Federal action.

Impacts to non-aquatic federally listed species would likely be fewer with this alignment. Surveys for Pima pineapple cactus would be required when suitable habitat is crossed at the beginning of the proposed alignment.

Few impacts are anticipated to the lesser long-nosed bat, northern aplomado falcon or cactus ferruginous pygmy-owl from this project. Listing status for the cactus ferruginous pygmy-owl should be checked prior to project implementation.

## SANTA RITA MOUNTAINS ALIGNMENT - EXISTING ENVIRONMENT

### Vegetation

The Santa Rita Mountains Alignment passes through five vegetative communities (Brown 1994): Sonoran Desertscrub, Semidesert Grassland, Chihuahuan Desertcrub, Plains Grassland and Madrean Evergreen Woodland. This alignment crosses numerous drainages including the Santa Cruz and Babocomari Rivers, and parallels Box Canyon Wash through the Santa Rita Mountains.

The **Sonoran Desertscrub** community occurs at the beginning of pipeline route at Pima Mine Road and continues southeast toward the Santa Rita Experimental Range. See habitat description under I-10 alignment.

The **Semidesert Grassland** community occurs along the alignment as it traverses the Santa Rita Experimental Range to the foothills of the Santa Rita Mountains. The Semidesert Grassland community also occurs west of Elgin along a small stretch of the Babocomari River and around the city of Sierra Vista. See habitat description under I-10 alignment.

The **Madrean Evergreen Woodland** community occurs along the pass through the Santa Rita Mountains. The Santa Rita Mountains is one range in a system known as the "Sky Islands". These mountains are surrounded by desert, effectively isolating the species that occur there. The Sky Islands extend from Sierra Madre Occidental in

Mexico, north to the Mogollon Rim in Arizona. The Madrean Evergreen Woodland community consists primarily of Emory oak (*Quercus emoryi*) Arizona white oak (*Quercus arizonica*) and Mexican blue oak (*Quercus oblongifolia*). Portions of this habitat, especially in the lower elevations, are very open.

The **Plains Grassland** community occurs east of the Santa Rita Mountains roughly from Sonoita to Elgin, Arizona. The Plains Grassland community was formerly an open, grass-dominated landscape in which grasses formed a continuous or nearly uninterrupted cover. Grazing and the subsequent reductions in fire have altered the habitat allowing more shrubs to coexist in the system. The Plains Grassland is composed of mixed or short-grass communities of which the principal species are blue grama (*Bouteloua gracilis*), side-oats grama (*B. curtipendula*), buffalo grass (*Buchloe dactyloides*), Indian rice grass (*Oryzopsis hymenoides*) and galleta grass (*Hilaria jamesii*).

The **Chihuahuan Desertscrub** occurs along the Babocomari River at Huachuca City and extends approximately 10 miles to the west. See habitat description under the I-10 alignment.

The **Xero/Meso/Hydro-Riparian Community** vegetation varies by drainage and location. Conditions along the Santa Cruz and the Babocomari Rivers were discussed previously. The Box Canyon pass through the Santa Rita Mountains is an intermittent stream vegetated with Fremont cottonwood, ash (*Fraxinus velutina*), walnut (*Juglans major*), and sycamore (*Platanus wrightii*). Oak and juniper (*Juniperus* sp.) vegetation on the steep hillsides nearly encroaches into the channel. Vegetation falls within the Interior Riparian Deciduous forest and Woodland community (Brown 1994). This vegetation community is maintained along perennial or seasonally intermittent streams within the Chihuahuan biotic provinces.

**Scenic Highway Designation -** Highway 83 was designated by the Arizona Department of Transportation (ADOT) as a Scenic Highway under Arizona Revised Statute (ARS R-17-3-809). A permit from ADOT is required prior to authorization of any construction activity along this highway. Construction activities must conform to the "Landscape and Irrigation Design Guidelines for ADOT Encroachment Permit Applications".

**Wildlife Resources**

General wildlife resources have been discussed previously, with the exception of the identification of some characteristic species from the Plains Grassland and Madrean Evergreen Woodland communities.

**Plains Grassland** - Because the center of the Plains Grassland habitat is well outside of the boundaries of the Southwest, the most characteristic birds are peripheral as nesting species: Cassin's sparrow (*Aimophila cassinii*), lark bunting (*Calamospiza melanocorys*), and grasshopper sparrow (*Ammodramus savannarum*). Other species include the Plains harvest mouse (*Reithrodontomys montanus*), corn snake (*Elaphe guttata*), Plains blackhead snake (*Tantilla nigriceps*), Great Plains toad (*Bufo cognatus*), and Southern Prairie lizard (*Sceloporus undulatus consobrinus*).

**Madrean Evergreen Woodland** - has a varied and interesting faunal diversity resulting in part from the influence of Mexico. The Madrean Evergreen Woodland is the principal biotic community for the white-tailed deer and the white-nosed coati in the southwest (Brown 1994). This habitat is well known for three small rattlesnakes: the banded rock (*Crotalus lepidus*), twin-spotted (*Crotalus pricei*), and the ridgenosed rattlesnake (*Crotalus willardi*). But it is the avian world which has the richest assortment of species, including the elegant trogon (*Trogon elegans*), magnificant hummingbird (*Eugenes fulgens*), Montezuma quail (*Cyrtonyx montezumae*), whiskered screech owl (*Megascops trichopsis*), and Mexican jay (*Aphelocoma ultramarina*).

**Federally Proposed and Listed Species**

The following federally listed species occur within Pima, Santa Cruz and Cochise counties and may occur along the proposed Santa Rita Mountains pipeline alignment. Surveys and appropriate Endangered Species Act Section 7 consultation should be conducted where necessary.

| | |
|---|---|
| Lesser Long-nosed Bat | (*Leptonycteris curasoae yerbabuenae*) |
| Jaguar | (*Panthera onca*) |
| Northern Aplomado Falcon | (*Falco femoralis septentrionalis*) |
| Cactus Ferruginous Pygmy-owl | (*Glaucidium brasilianum cactorum*) |
| Mexican Spotted Owl | (*Strix occidentalis lucida*) |
| Chiricahua Leopard Frog | (*Rana chiricahuensis*) |
| Gila Chub | (*Gila intermedia*) |
| Pima Pineapple Cactus | (*Coryphantha scheeri* var. *robustispina*) |

For discussions on the lesser long-nosed bat, northern aplomado falcon, cactus ferruginous pygmy-owl, Chiricahua leopard frog, Gila chub and Pima pineapple cactus please refer to previous sections.

**Mexican Spotted Owl** - The Mexican spotted owl (MSO) was listed as threatened on March 16, 1993 [58 FR 14248] with critical habitat listed on August 31, 2004 [69 FR 53182]. The MSO occupies mixed conifer and ponderosa pine/gambel oak (*Quercus gambelii*) vegetation types, usually characterized by high canopy closure, high stem density, multi-layered canopies within the stand, numerous snags and downed woody material. Much of the time, suitable nesting and roosting habitat are located on steep slopes or in canyons with rocky cliffs, where dense vegetation, crevices or caves provide cool moist microsites for nests and roosts.

The MSO has nested in riparian gallery forests (USFWS 1995). However, they have not been documented breeding in these forests in recent times (Ganey and Dick 1995). Because MSO's use canyon bottoms extensively, it is important to preserve and increase the quality of these habitats (USFWS 1995).

While many MSO's stay on their breeding areas throughout the year, in winter some birds migrate to lower, warmer elevations and more open woodland or scrub habitats (Ganey and Dick 1995). The adjacent pinion-juniper woodlands and desert scrub habitats provide suitable wintering and possibly dispersal habitat for MSO's. The Box Canyon route through the Santa Rita Mountains traverses potential wintering habitat.

**Jaguar** - The jaguar was listed as endangered in 1997 (62 FR 39147). Its historic range in the United States included the southwestern states from California to Louisiana. These big cats were never common in Arizona. Recent sightings of the jaguar in Arizona, New Mexico and Texas have been isolated occurrences of individuals which traveled up from Mexico. Since 1900, 62 jaguars have been reportedly killed or captured in the American Southwest (Brown and Gonzalez 2000). In 1986, a male jaguar was illegally killed in the Dos Cabezas Mountains (Brown and Gonzalez 2000). In 1996, the first recent photographic documentation of a jaguar was made by two local hunters. More recent sightings were documented by remote-sensing cameras in 2001, 2003 and 2004 (AGFD/USFWS news release). Approximately 50% of records for this species are from the Madrean Evergreen Woodland habitat.

## SANTA RITA MOUNTAINS ALIGNMENT - AFFECTED ENVIRONMENT

**Vegetation** - The proposed Santa Rita Mountains alignment would be placed within existing road rights-of-way where possible. However, the alignment is significantly more undeveloped than the I-10 route, and consequently more environmentally sensitive. If the pipeline cannot be attached to the highway bridges at the major channel crossings, then additional habitat disturbance will occur along the Santa Cruz and Babocomari Rivers. However, habitat quality at these two crossings is considered low.

This alignment passes through the Santa Rita Experimental Range, which has been protected from major development. The Semidesert Grassland habitat has experienced significant development pressure over the past years. This alignment would result in new impacts to a previously protected community from the pipeline, transmission line and booster pump station construction. This alignment would also parallel Box Canyon through the mountain pass. The canyon road is very narrow and bordered by the drainage on one side and steep rocky cliffs on the other. Construction of the pipeline through this section would result in significant vegetative and viewshed impacts.

Existing transmission lines are not available along this alignment. It is estimated that 24 miles of line would need to be constructed for the substations. On the ground clearances will need to be completed and site specific impacts determined prior to project construction. The large length of line to be constructed would compound the vegetation impacts associated with this alignment.

At this time, no locations for the potential recharge basins have been identified; therefore impacts associated with this feature cannot be determined. On the ground clearances will need to be completed and site specific impacts determined prior to project construction.

**Scenic Highway Designation -** The Santa Rita Mountains alignment follows a portion of Highway 83, a State designated Scenic Highway. A permit from the ADOT must be obtained prior to construction (personal communication, Cheryl Banta, Manager, August 31, 2005). Projects must comply with the following restrictions 1) cause the least damage to existing vegetation, 2) cause least visual impact from traveled roadway 3) require the least amount of earthwork, 4) cause minimal amount of erosion, 5) provide adequate safety standards for traffic and 6) include revegetation of disturbed areas and appropriate mitigation.

**Wildlife -** Large portions of this route cross isolated and undisturbed habitats within the Santa Rita Experimental Range and the Santa Rita Mountains, both of which exhibit high value for wildlife. This alignment parallels Box Canyon within the Santa Rita Mountains, which may provide a travel corridor for large mammals. Construction activities may cause temporary disturbances to large mammals utilizing the corridor.

There is significant potential habitat for nesting raptors, which could be impacted depending upon the timing of construction. The relatively narrow width of the alignment may reduce the impact to smaller avian species.

There are numerous small mammal, reptile and amphibian species that occur within the diverse vegetation communities along the proposed alignment. As previously mentioned, this appraisal analysis does not warrant a detailed discussion of all the potential species that could be impacted. Due to the undisturbed nature of the habitat and the length of the proposed pipeline, there will be considerable loss of small mammal and herpetefaunal species from any construction activity.

Impacts to wildlife species from construction of transmission lines and recharge basins will be evaluated once the alignments are delineated.

**Federally Listed Species -** If CAP water is recharged or ponded, there will be additional impacts to native fish and frogs from the transfer of non-native fish species into the San Pedro River, as discussed previously.

The Santa Rita Experimental range contains high densities of the Pima pineapple cactus. Surveys for this species along the pipeline, electric transmission line and pump station locations would be required. Consultation with the FWS would be required if cacti are located within any right-of-way (ROW). Permits to cross the Santa Rita Experimental Range must be acquired from the University of Arizona, which has a lease on the property.

This alignment traverses potential winter habitat for the Mexican spotted owl; consultation with the FWS may be required. Coordination with the Coronado National Forest is recommended to determine potential effects to the Mexican spotted owl.

The majority of this route travels through prime lesser long-nosed bat habitat. The AGFD Heritage Management Data Base records should be checked to determine roost locations along the proposed alignment. Important food resources (agaves and yuccas) may be impacted as a result of construction activities.

Few impacts are anticipated to the northern aplomado falcon or cactus ferruginous pygmy-owl from this project. Listing status for the cactus ferruginous pygmy-owl should be checked prior to project implementation. Few impacts are expected to the jaguar due to their irregular occurrences in Arizona.

## HIGHWAY 83 ALIGNMENT - EXISTING ENVIRONMENT

### Vegetation

The Highway 83 alignment follows the I-10 alignment until it reaches Highway 83. At Highway 83, it turns south to Sonoita. From Sonoita, the alignment follows the Santa Rita Mountains alignment east to Sierra Vista. This alignment passes through five vegetation communities (Brown 1994): Sonoran Desertscrub, Semidesert Grassland, Madrean Evergreen Woodland, Plains Grassland and Chihuahuan Desertscrub. It also crosses numerous drainage corridors, including the major drainages of the Santa Cruz and the Babocomari Rivers and parallels Davidson Canyon.

**Sonoran Desertscrub** community occurs at the same location as described for the I-10 alignment. See I-10 alignment for the habitat description.

**Semidesert Grassland** community starts west of Highway 83 and continues south along Highway 83, ending just north of Sonoita. See I-10 alignment for habitat description.

**Madrean Evergreen Woodland** community occurs along the middle portion of Highway 83 where it intersects the foothills of the Santa Rita Mountains. See Santa Rita alignment for the habitat description.

**Plains Grassland** community location occurs along the same route as the Santa Rita Mountains alignment. See Santa Rita Mountains alignment for the habitat description.

**Chihuahuan Desertscrub** community occurs at the same location as described for the Santa Rita Mountains alignment. See the Santa Rita Mountains alignment for the habitat description.

**Xero/Meso-Riparian Community** vegetation varies by drainage and location. All the stream crossings are ephemeral (flowing only in response to rainfall events) at the alignment crossings. See I-10 alignment for discussion of Santa Cruz and Babocomari Rivers. Highway 83 also crosses Gardner Canyon, which is vegetated with mesquite and desert willow (*Chilopsis linearis*). Davidson Canyon parallels a large portion of Highway 83 and is vegetated primarily with mesquite at this location.

**Scenic Highway Designation -** See previous discussion for information.

**Wildlife Resources -** See previous discussions.

**Federally Proposed and Listed Species**

The following federally listed or proposed species occur within Pima, Santa Cruz and Cochise counties and may occur along the proposed Highway 83 pipeline alignment. Surveys and appropriate Endangered Species Act Section 7 consultation should be conducted where necessary.

| | |
|---|---|
| Lesser Long-nosed Bat | (*Leptonycteris curasoae yerbabuenae*) |
| Jaguar | (*Panthera onca*) |
| Northern Aplomado Falcon | (*Falco femoralis septentrionalis*) |
| Cactus Ferruginous Pygmy-owl | (*Glaucidium brasilianum cactorum*) |
| Mexican Spotted Owl | (*Strix occidentalis lucida*) |
| Chiricahua Leopard Frog | (*Rana chiricahuensis*) |
| Gila Chub | (*Gila intermedia*) |
| Pima Pineapple Cactus | (*Coryphantha scheeri* var. *robustispina*) |

See previous discussion for information on federally listed and proposed species.

## HIGHWAY 83 ALIGNMENT- AFFECTED ENVIRONMENT

**Vegetation -** The proposed alignment would be placed within existing road ROW's where possible. The Highway 83 alignment is less developed than the I-10 route and therefore more environmentally sensitive. If the pipeline cannot be attached to the highway bridges at the major channel crossings, additional habitat disturbance will occur along the Santa Cruz and Babocomari Rivers, and Gardner Canyon. This alignment also parallels Davidson Canyon for several miles. Meso-riparian habitat along Gardner and Davidson Canyons contains higher wildlife values.

Highway 83 is designated as a Scenic Highway and impacts associated with construction activities would affect the scenic value of the highway. Approximately 10 miles of the highway traverses the foothills of the Santa Rita Mountains where the road is narrow and windy. In this same area Highway 83 is bounded by hills on one side and Davidson Canyon on the other, leaving little room for pipeline construction.

Existing transmission lines are not available along this alignment. It is estimated that 12 miles of line would need to be constructed for the substations. On the ground clearances will need to be completed and site specific impacts determined prior to project construction. The large length of line to be constructed would compound the vegetation impacts associated with this alignment.

At this time, no location for the potential recharge basins has been identified; therefore impacts associated with this feature cannot be determined. On the ground clearances will need to be completed and site specific impacts determined prior to project construction.

**Scenic Highway Designation -** The Santa Rita Mountains alignment follows Highway 83, a State designated Scenic Highway, from I-10 to Sonoita. See previous discuss under Santa Rita Mountains alignment-Affected Environment.

**Wildlife -** Portions of Highway 83 are relatively undisturbed, including the section that parallels Davidson Canyon. Construction of the proposed facilities may temporarily impact the travel corridor for large mammals.

There is potential habitat for nesting raptors which could be impacted by construction activities, depending upon the timing of construction. The relatively narrow width of the alignment may reduce the impact to smaller avian species.

There are numerous small mammal, reptile and amphibian species that occur within the diverse vegetation communities along the proposed alignment. As previously mentioned, this appraisal analysis does not warrant a detailed discussion of all the potential species that could be impacted. Due to the undisturbed nature of the habitat and the length of the proposed pipeline, there will be considerable loss of small mammal and herpetefaunal species from any construction activity.

Impacts to wildlife species from construction of transmission lines and recharge basins will be evaluated once the alignments are delineated.

**Federally Listed Species -** If CAP water is recharged or ponded there will be additional impacts to native fish and frogs from the transfer of non-native fish species into the San Pedro River, as discussed previously.

This alignment crosses potential winter habitat for the Mexican spotted owl; consultation with the FWS may be required. Coordination with the Coronado National Forest is recommended to determine potential effects to the Mexican spotted owl.

The majority of this route travels through prime lesser long-nosed bat habitat. The AGFD Heritage Management Data Base records should be checked to determine roost locations along the proposed alignment. Important food resources (agaves and yuccas) will be impacted as a result of construction activities.

Surveys for Pima pineapple cactus would be required when suitable habitat is crossed at the beginning of the proposed alignment.

Few impacts are anticipated to the northern aplomado falcon or cactus ferruginous pygmy-owl from this project. Listing status for the cactus ferruginous pygmy-owl should be checked prior to project implementation. Few impacts are expected to the jaguar due to their irregular occurrences in Arizona.

## SUMMARY OF IMPACTS

This appraisal level review consisted of (1) a one day drive along the proposed alignments, (2) literature review, and (3) limited personal contacts. Analysis is therefore limited to a general discussion of potential impacts. Thorough on-the-ground surveys will be required to adequately assess impacts for a feasibility level study.

The route which utilizes the greatest amount of previously disturbed land will have the fewest environmental impacts. The I-10 alignment follows existing major highway rights-of way for its entire length. Although it crosses more major drainages than the other alternatives, far fewer miles of transmission lines must be constructed. There will be less impact to high quality vegetative habitats along this alignment, and as a result, less impact on any associated wildlife species. Although this alignment crosses habitat for six federally listed species, impacts to the lesser long-nosed bat, cactus ferruginous pygmy-owl and jaguar are expected to be minimal. Potential impacts to the Gila chub and Chiricahua leopard frog would only occur if CAP water is recharged or ponded. Potential impacts would be primarily associated with the Pima pineapple cactus. See Table 1 for summary of impacts.

The Santa Rita Mountains alignment, on the other hand, traverses large tracts of relatively undisturbed, high quality habitat. Transmission line construction would impact approximately 24 miles; twice the distance for the Highway 83 alternative and nearly 5 times the distance for the I-10 alternative. Transmission lines would likely be constructed along the shortest route to the substations and therefore would not follow existing roads. Although the pipeline alignment does follow existing roads, habitat within the Santa Rita Experimental Range is sparsely developed and contains high densities of Pima pineapple cactus.

Likewise, construction of the pipeline and transmission lines through the narrow Box Canyon in the Santa Rita Mountains would result in disturbance to vegetation, local wildlife and potential disruption to use of the Box Canyon wildlife corridor. This alignment also parallels portions of Highway 83, which is a designated Scenic Highway. It also traverses habitat for eight federally listed species. Potential impacts to the Gila chub and Chiricahua leopard frog would only occur if CAP water is recharged or ponded. Impacts to the jaguar, northern aplomado falcon and cactus ferruginous pygmy-owl are expected to be minimal. Potential impacts would be primarily associated with the Pima pineapple cactus, lesser long-nosed bat and Mexican spotted owl. See Table 1.

The Highway 83 route combines portions of both the I-10 and Santa Rita Mountain alignments; consequently the impacts are a combination of the two. The overall environmental impact appears to lie midway between those of the two routes. It traverses environmentally sensitive habitat along Davidson Canyon and parallels Highway 83, a Scenic Highway, for its entire length. It would require construction of approximately 12 miles of transmission lines. Wildlife values along this alignment range from moderate to high. It traverses habitat for the same eight federally listed species as described under the

Santa Rita Mountains alignment. Impacts to federally listed species would be similar. See Table 1.

## Table 1. Summary of Impacts by Alternative

| | I-10 | SANTA RITA | HIGHWAY 83 |
|---|---|---|---|
| **VEGETATION** | low environmental sensitivity<br>4 major drainage crossings<br>5 miles of transmission lines<br>follows major highway corridors<br>unquantified losses for recharge basins | high environmental sensitivity<br>2 major drainage crossings<br>24 miles of transmission lines<br>follows relatively undeveloped route<br>unquantified losses for recharge basins<br>Scenic Highway impacts<br>Santa Rita Experimental Range impacts<br>Box Canyon impacts | mod to high environmental sensitivity<br>3 major drainage crossings<br>12 miles of transmission lines<br>follows moderately developed route<br>unquantified losses for recharge basins<br>Scenic Highway impacts<br>Davidson Canyon impacts |
| **WILDLIFE** | low wildlife value<br>highly disturbed habitat along ROW<br>loss of small mammal and herpetefauna | high wildlife value<br>large portions of undisturbed habitat<br>loss of small mammal and herpetefauna<br>potential impact to breeding raptors<br>potential impact to movement corridors | moderate to high wildlife value<br>sections of undisturbed habitat<br>loss of small mammal and herpetefauna<br>potential impact to breeding raptors<br>potential impact to movement corridor |
| **T&E SPECIES** | potential impacts to native fish and frog<br>crosses Pima pineapple cactus habitat<br>crosses lesser long-nosed bat habitat<br>crosses northern aplomado falcon habitat<br>crosses cactus ferrug. pygmy-owl habitat | potential impacts to native fish and frog<br>crosses Pima pineapple cactus habitat<br>crosses lesser long-nosed bat habitat<br>crosses northern aplomado falcon habitat<br>crosses cactus ferrug. pygmy-owl habitat<br>crosses jaguar habitat<br>crosses Mexican spotted owl habitat | potential impacts to native fish and frog<br>crosses Pima pineapple cactus habitat<br>crosses lesser long-nosed bat habitat<br>crosses northern aplomado falcon habitat<br>crosses cactus ferrug. pygmy-owl habitat<br>crosses jaguar habitat<br>crosses Mexican spotted owl habitat |

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D. Preliminary Appraisal Study of CAP Water to Sierra Vista Alternative

*Appendix B: CAP Water Delivery to Sierra Vista – I-10 Alignment Anticipated Geology and Estimated Excavation Characteristics*

| APPENDIX B –<br>CAP WATER DELIVERY TO SIERRA VISTA – I-10 ALIGNMENT<br>ANTICIPATED GEOLOGY AND ESTIMATED EXCAVATION CHARACTERISTICS | | | | |
|---|---|---|---|---|
| **PIPELINE LEG**<br>(Approximate mileage from CAP Reach 6 Terminus at Pima Mine Road) | **GEOLOGIC UNIT**<br>(AGS, Maps 26/35) | **GEOLOGIC DESCRIPTION** | **EXCAVATION** (Estimated)<br>Cm = Common w/ mech. Assist | **COMMENTS** |
| 1.) 0 - 1.5 miles | Q | Surficial deposits; sand, gravel, & cobbles; variably cemented; valley fill | Common | Along Pima Mine Road ROW to Santa Cruz River (SCR) floodplain |
| 2.) 1.5 – 4.5 miles | Qy | Young alluvium; sand, gravel, clay, silt, cobbles and boulders | Common | SCR floodplain/channel deposits |
| 3.) 4.5 – 6 miles | Q | Surficial deposits; sand, gravel, & cobbles; variably cemented; valley fill | Common | Along Santa Rita Road ROW south to Sahuarita |
| 4.) 6 – 21 miles | Q | Surficial deposits; sand, gravel, & cobbles; variably cemented; valley fill and alluvial fan (bajada), piedmont terraces; rockier w/ cobbles and caliche | Common | East along Sahuarita Road ROW to Hwy 83; possible rock at Wentworth Rd. |
| 5.) 21 – 22.5 miles | Jv | Jurassic Volcanics; weathered rock | Cm - rock | Hwy. 83 to I-10 spur |
| 6.) 22.5 – 24.5 miles | Q | Surficial deposits; variably cemented to cemented alluvial-fan (fanglomerate) | Cm | Fanglomerate cuts, hummocky |
| 7.) 24.5 – 26.5 miles | Qo | Older Surficial deposits; cemented alluvium, fanglomerate deposits | Rock - Cm | Along I-10 east; possible hard digging, cross washes |
| 8.) 26.5 – 27.5 miles | KJs | Mesozoic Sedimentary Rocks w/ minor volcanics – undiff.; predom. Sandstone & conglomerate | Rock | Along I-10 east; cross major fault |
| 9.) 27.5 – 31.0 miles | Tsm | Tertiary Sedimentary rocks; faulted conglomerate, sandstone, mudstone | Rock | Along I-10 east |
| 10.) 31.0 – 36.5 miles | Tsy | Tertiary Sedimentary rocks; conglomerate, sandstone, dissected fanglomerate | Cm - rock | Along I-10 east, railway crossings |

**APPENDIX B**
**CAP Water Delivery to Sierra Vista – I-10 Alignment**
**Anticipated Geology and Estimated Excavation Characteristics – (Continued)**

| **PIPELINE LEG** (Approximate mileage from CAP Reach 6 Terminus at Pima Mine Road) | **GEOLOGIC UNIT** (AGS, Maps 26/35) | **GEOLOGIC DESCRIPTION** | **EXCAVATION** (Estimated) Cm = Common w/ mech. Assist | **COMMENTS** |
|---|---|---|---|---|
| 11.) 36.5 – 37.5 miles | KJs | Mesozoic Sedimentary Rocks w/ minor volcanics – undiff.; predom. Sandstone & conglomerate | Rock | Along I-10 east, cross washes |
| 12.) 37.5 – 39.0 miles | Tsy | Tertiary Sedimentary rocks; conglomerate, sandstone, dissected fanglomerate | Cm - rock | Along I-10 east; Pima and Cochise County Line |
| 13.) 39.0 – 47.0 miles | Q | Surficial deposits; sand, gravel, cobbles, variably cemented; dissected alluvial fan (bajada), fanglomerate, piedmont terraces, possible pediment/shallow rock | Cm | Along I-10 north of Whetstone Mountains and then south along Route 90 towards Sierra Vista |
| 14.) 47.0 – 48.5 miles | Tsy | Tertiary Sedimentary rocks; conglomerate, sandstone, dissected fanglomerate | Cm - rock | South along Route 90, wash crossings |
| 15.) 48.5 – 51.5 miles | Q | Surficial deposits; sand, gravel, cobbles, variably cemented; dissected alluvial fan (bajada), fanglomerate, piedmont terraces, probable pediment/shall. rock | Cm - rock | South along Route 90, wash crossings |
| 16.) 51.5 – 53.0 miles | Yg/YXg | Precambrian granitics, plutons, mod.-int. weathered; some Paleozoic sandstone, shale, carbonates possible | Rock - Cm | South along Route 90, wash crossings, Kartchner Caverns area |
| 17.) 53.0 – 66.0 miles | Q | Surficial deposits; sand, gravel, cobbles, dissected alluvial fan (bajada), cemented fanglomerate, conglomerate, piedmont terraces | Cm | South along Route 90, wash crossings; Hwy. 82 at 63 miles |

| APPENDIX B<br>CAP Water Delivery to Sierra Vista – I-10 Alignment<br>Anticipated Geology and Estimated Excavation Characteristics – (Continued) | | | | |
|---|---|---|---|---|
| **PIPELINE LEG**<br>(Approximate mileage from CAP Reach 6 Terminus at Pima Mine Road) | **GEOLOGIC UNIT**<br>(AGS, Maps 26/35) | **GEOLOGIC DESCRIPTION** | **EXCAVATION** (Estimated)<br>Cm = Common w/ mech. Assist | **COMMENTS** |
| 18.) 66.0 – 69.0 miles | Tsy | Tertiary Sedimentary rocks; conglomerate, sandstone, dissected fanglomerate, alluvium channel deposits and terrace deposits, minor floodplain, loose cobbles to cemented alluvium | Cm | South along Route 90, wash crossings; dropping down into Babocomari River valley and Huachuca City; Old Railroad Grade. |
| 19.) 69.0 – 72.0 miles | Q | Surficial deposits; sand, gravel, & cobbles; variably cemented; valley fill and some fan deposits; cemented gravel and caliche possible | C - Cm | South along Route 90 into Ft. Huachuca |
| | | | | |

**APPENDIX B**
**CAP WATER DELIVERY TO SIERRA VISTA –HIGHWAY 83 ALIGNMENT**
**ANTICIPATED GEOLOGY AND ESTIMATED EXCAVATION CHARACTERISTICS**

| **PIPELINE LEG**<br><br>(Approximate mileage from CAP Reach 6 Terminus at Pima Mine Road) | **GEOLOGIC UNIT**<br><br>(AGS, Maps 26/35) | **GEOLOGIC DESCRIPTION** | **EXCAVATION** (Estimated)<br><br>Cm = Common w/ mech. Assist | **COMMENTS** |
|---|---|---|---|---|
| 1.) 0 - 1.5 miles | Q | Surficial deposits; sand, gravel, & cobbles; variably cemented; valley fill | Common | Along Pima Mine Road ROW to Santa Cruz River (SCR) floodplain |
| 2.) 1.5 – 4.5 miles | Qy | Young alluvium; sand, gravel, clay, silt, cobbles and boulders | Common | SCR floodplain/channel deposits |
| 3.) 4.5 – 6 miles | Q | Surficial deposits; sand, gravel, & cobbles; variably cemented; valley fill | Common | Along Santa Rita Road ROW south to Sahuarita |
| 4.) 6 – 21 miles | Q | Surficial deposits; sand, gravel, & cobbles; variably cemented; valley fill and alluvial fan (bajada), piedmont terraces; rockier w/ cobbles and caliche | Common | East along Sahuarita Road ROW to Hwy 83; possible rock at Wentworth Rd. |
| 5.) 21 – 22.5 miles | Yg/YXg | Precambrian granitics, plutons, mod.-int. weathered; porphyritic; some volcanics possible | Rock | Begin Hwy. 83 south from I-10 |
| 6.) 22.5 – 23.5 miles | KJs | Mesozoic Sedimentary Rocks w/ minor volcanics – undiff.; predom. sandstone & conglomerate | Rock - Cm | South along Hwy. 83; |
| 7.) 23.5 – 24.5 miles | Pz/MzPz | Paleozoic Sedimentary and Metasedimentary rocks, deformed and metamorphosed (hard quartzites, marbles, etc.), possibly including some fractured volcanics, carbonates, and softer clastics | Rock | South along Hwy. 83; in mining district |
| | | | | |

**APPENDIX B**
**CAP Water Delivery to Sierra Vista - Highway 83 Alignment**
**Anticipated Geology and Estimated Excavation Characteristics – (Continued)**

| **PIPELINE LEG** (Approximate mileage from CAP Reach 6 Terminus at Pima Mine Road) | **GEOLOGIC UNIT** (AGS, Maps 26/35) | **GEOLOGIC DESCRIPTION** | **EXCAVATION** (Estimated) Cm = Common w/ mech. Assist | **COMMENTS** |
|---|---|---|---|---|
| 8.) 24.5 – 26 miles | TKg | Laramide granitic rocks; porphyritic, plutons, intrusives; granite to dioritic composition, copper-bearing depending on weathering profile, maybe use Cm; | Rock | South along Hwy. 83, Empire Mountains and Davidson Canyon. |
| 9.) 26 – 31 miles | Kv | Laramide volcanic rocks; fractured rhyolite to andesitic composition, some welded tuff; intrusives; depending on fracturing, maybe use Cm | Rock - Cm | South along Hwy. 83, some canyon crossings |
| 10.) 31 – 35.5 miles | Tsy | Tertiary Sedimentary rocks; sandstone, conglomerate, fanglomerate, some finer clastics and evaporites; generally well lithified forming ridges/bluffs, etc. | Cm - rock | South along Hwy. 83 about three miles north of the Pima and Santa Cruz Co. line; near Empire Gulch |
| 11.) 35.5 – 37.5 miles | Qo | Older Surficial deposits; variably cemented alluvium, sand, gravel, cobbles, possible shallow, weathered rock (regolith)/pediment between Whetstone and Mustang Mountains. | Cm - common | Along Hwy.82 (Rain Valley) east towards Route 90; cross Cienaga Creek; then south along Route 90 towards Sierra Vista |
| 12.) 37.5 – 49 miles | Q | Surficial deposits; sand, gravel, cobbles, dissected alluvial fan (bajada), cemented fanglomerate, conglomerate, terraces | Cm - common | Intersects Hwy. 90 at 47 miles |

**APPENDIX B**
**CAP Water Delivery to Sierra Vista - Highway 83 Alignment**
**Anticipated Geology and Estimated Excavation Characteristics – (Continued)**

| **PIPELINE LEG** (Approximate mileage from CAP Reach 6 Terminus at Pima Mine Road) | **GEOLOGIC UNIT** (AGS, Maps 26/35) | **GEOLOGIC DESCRIPTION** | **EXCAVATION** (Estimated) Cm = Common w/ mech. Assist | **COMMENTS** |
|---|---|---|---|---|
| 13.) 49 – 52 miles | Tsy | Tertiary Sedimentary rocks; conglomerate, sandstone, dissected fanglomerate, alluvium channel deposits and terrace deposits, minor floodplain, loose cobbles to cemented alluvium | Cm | South along Route 90, wash crossings; dropping down into Babocomari River valley and Huachuca City; Old Railroad Grade. |
| 14.) 52 – 55 miles | Q | Surficial deposits; sand, gravel, & cobbles; variably cemented; valley fill and some fan deposits; cemented gravel and caliche possible | C - Cm | South along Route 90 into Ft. Huachuca |
| | | | | |

**APPENDIX B**
**CAP WATER DELIVERY TO SIERRA VISTA – SANTA RITA MOUNTAINS ALIGNMENT**
**ANTICIPATED GEOLOGY AND ESTIMATED EXCAVATION CHARACTERISTICS**

| **PIPELINE LEG**<br>(Approximate mileage from CAP Reach 6 Terminus at Pima Mine Road) | **GEOLOGIC UNIT**<br>(AGS, Maps 26/35) | **GEOLOGIC DESCRIPTION** | **EXCAVATION** (Estimated)<br>Cm = Common w/ mech. Assist | **COMMENTS** |
|---|---|---|---|---|
| 1.) 0 - 1.5 miles | Q | Surficial deposits; sand, gravel, & cobbles; variably cemented; valley fill | Common | Along Pima Mine Road ROW to Santa Cruz River (SCR) floodplain |
| 2.) 1.5 – 4.5 miles | Qy | Young alluvium; sand, gravel, clay, silt, cobbles and boulders | Common | SCR floodplain/channel deposits |
| 3.) 4.5 – 6 miles | Q | Surficial deposits; sand, gravel, & cobbles; variably cemented; valley fill | Common | Along Santa Rita Road ROW south to Sahuarita |
| 4.) 6 – 17 miles | Q | Surficial deposits; sand, gravel, trace cobbles; predom. unconsolidated to moderately cemented; rockier and more cobbly towards alluvial fan (bajada) and piedmont mountain front deposits near Santa Rita toe, grading into basin fill/SCR valley fill deposits towards I-19; estimated to be sandier near the surface and coarser-grained at depth | Common - Cm | Southeast along several miles of the Santa Rita Road, then nearly due south across the Santa Rita Experimental Range and Wildlife Area; uniform topographic relief across well-drained bajada with shallow arroyos. |
| 5.) 17 – 20 miles | Yg/YXg | Precambrian granitics, plutons, commonly porphyritic and cross-cut with siliceous dikes, intrusives; mod.-intensely weathered; some Paleozoic sandstone, shale, carbonates possible and local younger volcanics | Rock | Narrow, winding roads and high relief through Box Canyon/Santa Rita Mtns.; deep cuts/tunneling poss. w/ raveling, talus, rockfall, differing rock properties probable; changing pipe directions, etc. |

**APPENDIX B**
**CAP Water Delivery to Sierra Vista – Santa Rita Mountains Alignment**
**Anticipated Geology and Estimated Excavation Characteristics (Continued)**

| **PIPELINE LEG**<br>(Approximate mileage from CAP Reach 6 Terminus at Pima Mine Road) | **GEOLOGIC UNIT**<br>(AGS, Maps 26/35) | **GEOLOGIC DESCRIPTION** | **EXCAVATION** (Estimated)<br>Cm = Common w/ mech. Assist | **COMMENTS** |
|---|---|---|---|---|
| 6.) 20 – 20.5 miles | Pz/MzPz | Paleozoic Sedimentary and Metasedimentary rocks, deformed and metamorphosed (hard quartzites, marbles, etc.), possibly including some fractured volcanics, carbonates, and softer clastics | Rock | High-angle fault at 20.5 miles; likely steeply dipping strata, talus, rockfall, etc. |
| 7.) 20.5 – 40.5 miles | Tsy | Tertiary Sedimentary rocks; sandstone, conglomerate, dissected fanglomerate, alluvial fan; loose to strongly cemented alluvium in channel/wash crossings; foothills & piedmont morphology with mixed soil/rock conditions; generally well lithified forming ridges/bluffs, etc. | Cm - rock | 25 miles to Route 83, Pima and Santa Cruz County line at about 30 miles, 34 miles south along Route 83 to Sonoita; then either along Route 82 (Rain Valley) or Babocomari River/Old Railroad Grade legs, to SV |
| 8.) 40.5 – 42.5 miles | Qo | Older Surficial deposits; variably cemented alluvium, sand, gravel, cobbles, possible shallow, weathered rock (regolith)/pediment between Whetstone and Mustang Mountains. | Cm - common | Along Hwy.82 (Rain Valley) east towards Route 90; cross Cienaga Creek; then south along Route 90 towards Sierra Vista |
| 9.) 42.5 – 52 miles | Q | Surficial deposits; sand, gravel, cobbles, dissected alluvial fan (bajada), cemented fanglomerate, conglomerate, piedmont terraces | Cm - common | Intersects Hwy. 90 at 52 miles |
| | | | | |

**APPENDIX B**
**CAP Water Delivery to Sierra Vista – Santa Rita Mountains Alignment**
**Anticipated Geology and Estimated Excavation Characteristics (Continued)**

| **PIPELINE LEG**<br><br>(Approximate mileage from CAP Reach 6 Terminus at Pima Mine Road) | **GEOLOGIC UNIT**<br><br>(AGS, Maps 26/35) | **GEOLOGIC DESCRIPTION** | **EXCAVATION** (Estimated)<br><br>Cm = Common w/ mech. Assist | **COMMENTS** |
|---|---|---|---|---|
| 10.) 52 – 55 miles | Tsy | Tertiary Sedimentary rocks; conglomerate, sandstone, dissected fanglomerate, alluvium channel deposits and terrace deposits, minor floodplain, loose cobbles to cemented alluvium | Cm | South along Route 90, wash crossings; dropping down into Babocomari River valley and Huachuca City; Old Railroad Grade. |
| 11.) 55 – 58 miles | Q | Surficial deposits; sand, gravel, & cobbles; variably cemented; valley fill and some fan deposits; cemented gravel and caliche possible | Common - Cm | South along Route 90 into Ft. Huachuca |
| | | | | |

D. Preliminary Appraisal Study of CAP Water to Sierra Vista Alternative

*Appendix C: Appraisal Level Overview of Cultural Resources along the Proposed Extension of the Central Arizona Project to Sierra Vista*

# APPENDIX C

# Appraisal Level Overview of Cultural Resources along the Proposed Extension of the Central Arizona Project to Sierra Vista

## Introduction

This document provides an overview of the cultural resources that may be affected by the extension of the Central Arizona Project from its current terminus by I-19 and Pima Mine Road in Tucson, to the Sierra Vista area. The extension would utilize a 36 - 42 inch buried pipeline with associated pumping stations, operational reservoir and other associated facilities. The proposed right-of-way (ROW) for the pipeline would be about 100 feet wide, increasing to larger areas around pumping plants and reservoirs. Three potential routes for the pipeline extension have been proposed. The "I-10" alignment follows I-10 to Route 90. The "Santa Rita Mountains" route goes through the Santa Rita Mountains and into Sonoita. The third, "Highway 83" route, includes portions of the first two alignments, with a connecting segment along the northern portion of Highway 83. A map of the three alignments is included in the main body of the Draft Report.

The following is a Class I Survey, or Cultural Resources Overview, of the area covered by the three alignments. The overview is basically a literature search of previous archaeological investigations in the area, and is a compilation of what is currently known about the cultural resources. This is meant to be a "big picture" view of the cultural resources, and is not intended to define specific resources that might be impacted by the CAP extension alternative.

While an overview can supply a general understanding of the cultural resources that may be impacted, it is limited by the extent of the current data about the cultural resources of the area. Archaeological surveys and projects are abundant in the Tucson area, and are associated with the rapid development of the area. The number of projects declines in the other areas, however. Existing projects are associated mainly with the development of various kinds of rights-of-way (highways, utility lines, fiber optic lines, etc.) or projected residential developments. In addition, large parts of the alignments cross public lands. Only a portion of these have been intensively surveyed.

This review will approach the cultural resources by looking at three main geographic areas that the alignments will cross: the Santa Cruz Valley, the Cienega Basin, and the San Pedro Valley. All three of these are typical of the Basin and Range geological province and are characterized by a major drainage surrounded by roughly north-south trending mountain ranges.

**Santa Cruz Valley**: In the project area, the Santa Cruz River is a seasonal stream flowing north toward the Gila River. South of Tucson it is flanked by extensive bajadas that extend from the Sierrita Mountains on the west and the Santa Rita Mountains to the east. Prior to extensive stream entrenchment in the early 1900s, the Santa Cruz was a braided stream that supported riparian areas and mesquite *bosques* along the river channel, with Sonoran desert scrubland on the bajada. The alignments that cross this area will span the Santa Cruz River and cross the extensive bajada to the Santa Rita Mountain foothills. Elevations along the alignments range between approximately 2650’ to 3800’ at Highway 83 (I-10 and Highway 83 alignments); up to 4350’ at the west end of Box Canyon in the Santa Rita Mountains (Santa Rita Mountains alignment).

**Cienega Basin**: The Cienega Basin is a small high basin centered on the north-flowing Cienega Creek drainage and surrounded by the Santa Rita Mountains to the west, the Whetstone Mountains to the east, the Canelo Hills to the south and the Empire Mountains to the north. The Santa Rita Mountains and Highway 83 alignments pass through the foothills of the Santa Ritas and then cut across the open plains of the basin. Vegetation includes open desert grasslands in the upper basin, open oak woodland in the Santa Rita foothills, desert scrub in the lower basin, and riparian areas along Cienega Creek and its major tributaries. Elevation ranges between about 3800’ where Highway 83 joins I-10, to a maximum of about 5200’ in the Rosemont area, and down to about 4900’ in the Sonoita and Rain Valley areas.

**San Pedro Valley**: The San Pedro is a north-flowing stream that is perennial in the southern portion of the valley, becoming seasonal as it approaches Benson. The Whetstone and Huachuca Mountains form the western boundary of the valley and the Dragoon and Mule Mountains form the eastern edge. The river is flanked by extensive bajadas that reach from the mountains to the stream. The I-10 alignment would pass along the base of the Whetstone Mountains and onto the open bajada on the southeastern shoulder. All routes would cut across the Babocomari River, a major tributary to the San Pedro River flowing eastward from the Sonoita area. Riparian areas are found along sections of the Babocomari, open grassland and desert scrub cover the bajadas, and oak woodlands cover the lower Whetstone foothills. Elevation ranges from about 4000’ near I-10 to a maximum of about 4600’ for most of the alignment, falling to about 4260’ where it crosses the Babocomari.

## Cultural History

### Paleoindian (10,500-8,500 BC)

The Paleoindian period represents the very earliest known human occupation of southern Arizona. The culture was characterized by a mobile hunting and gathering economy followed by small bands that focused on hunting now-extinct megafauna, including mammoths and giant sloths. Paleoindian camps are often associated with megafauna kill sites. To date, no Paleoindian sites have been identified in the Tucson Basin, although isolated diagnostic points have been recovered from the Valencia Site (Doelle 1985), the Tucson Basin (Huckell 1982) and other areas. Similarly, evidence of a Paleoindian occupation of the Cienega Valley is extremely sparse and limited to isolated finds.

In contrast, the middle San Pedro Valley has a relatively high density of Paleoindian sites. The sites were located by fossil springs and include abundant megafauna remains with associated Clovis period lithic tools and nearby campsites. Evidence collected from sites such as Lehner

Ranch (Haury et al. 1959), indicates a cooler and wetter environment prevailed at that time. The sites are generally located near the river in former spring areas now buried in the lower bajada. The sites are covered by several meters of alluvium and associated with dark organic spring deposits (algal mats) that were exposed in the sides of actively eroding arroyos. Paleoindian, mostly Clovis, points have been found on the surface in other parts of the valley, but no sites are known away from the river.

The paucity of Paleoindian sites in southern Arizona does not necessarily indicate that occupation of the time was limited to the San Pedro Valley. Rather, the scarcity of sites probably reflects a combination of several factors. First, small mobile populations create a limited number of sites. Second, the greater age of Paleoindian sites makes them more prone to being destroyed through erosion. Finally, most known open-air Paleoindian sites have been deeply buried and are evident only when exposed through erosion.

## Archaic (8,500-200 BC)

**The Early Archaic** (8500-5000 BC) is often considered to be a transitional stage between the megafauna hunting cultures of the Paleoindian period, and the later more gathering-focused cultures of the later Archaic. The Early Archaic is poorly represented in most of Southern Arizona, and is best known from the Whitewater Draw area of the Sulphur Springs Valley southeast of the study area. It is characterized by an assemblage including simple milling stones and chipped stone tools. Projectile points are rare, but generally display high shoulders and a tapering stem (Sayles 1983). The culture is thought to have been a mobile hunting and gathering society, with small family-based bands forming the primary social unit. Most known Early Archaic sites are located along major drainages and often deeply buried in alluvium. Those in upland situations can be shallow and consist of artifact scatters with diagnostic points as the only indicator of time period.

**The Middle Archaic** (5000-1500 BC) is slightly better known than the preceding period, largely because it is more widespread and is represented by a number of different sites and site types. Some archaeologists suggest that different point styles indicate the presence of two different Archaic culture, the Cochise of southeastern Arizona and the Armagosa in the Colorado River Valley and Papagueria. During this period, a hunting and gathering economy appears to have exploited a number of environmental zones. Ground stone artifacts become more numerous and varied in function, and plant resources appear to have gained a greater importance. As noted by Gregory (1999a), Stevens (2001) and many others, our knowledge of this time period is severely limited because most sites in floodplain locations have been deeply buried by post-occupation flooding events, covering the sites with up to 30 feet of fill in some cases. Contemporary sites in upland situations, while less likely to be deeply buried, are more prone to erosion and often difficult to identify unless diagnostic artifacts, mostly projectile points, are present.

Middle Archaic sites have been identified in floodplain settings in the Santa Cruz Basin, Cienega Basin, and the San Pedro Valley. Many of these are deeply buried and have been identified in exposed bank cuts. Sites in the upland areas of these basins appear to be associated with springs and upper portions of tributaries in mountain foothills/upper bajadas (Huckell 1984; Stevens 2001). These upland areas often contain lithic material sources and include a variety of different biotic communities. The limited botanical material recovered from sites of this period indicates intense collection of wild seed crops combined with hunting.

**Late Archaic/Early Agricultural** (1500-200 BC): This period is a transitional stage between the hunting and gathering way of life followed during the earlier Archaic periods and the intensive agricultural economies of the Ceramic period. The introduction of cultivated crops appears to have been integrated into the existing pattern of hunting combined with the intensive collection of wild seed crops. Investigations in several different areas of southern Arizona show an increasing trend toward a more settled way of life, with pit houses clustered in communities, large storage pits, and the beginning of ditch irrigation (Gregory 1999b, Huckell 1995, Mabry 1998). Although sedentism increases along the river valleys at this time, the identification of small contemporary camp sites and limited activity sites in the bajadas and foothills indicates that mobility was maintained either seasonally, or by a different populations within the area.

In the Tucson Basin, a number of Late Archaic/Early Agricultural sites have been investigated in the Santa Cruz floodplain (Gregory 1999b, Haynes and Huckell 1986, Mabry 1998). For example, the recently excavated Los Pozos community includes numerous circular pithouses with large interior storage pits, a variable material culture, ample evidence of agriculture, and the remains of a possible irrigation ditch system (Gregory 1999b). Sites from this period have also been located on the bajada (Buttery 1987; Huckell et al. 1987), although they are generally smaller and seem to represent limited activity sites focused on resource procurement and perhaps limited flood-water farming. The larger sites away from the floodplain tend to cluster at the toe of the bajada and the base of mountains along major streams.

The Cienega Valley also contains a considerable number of sites from this period. They tend to occur along Cienega Creek, where entrenched streams have exposed buried sites in arroyo sides (Huckell 1995; Stevens 2001). They also appear in the upper bajadas and foothills of the Santa Rita Mountains, where occupations occurred mostly on ridges near water and arable land (Huckell 1984, Stevens 2001). Investigated sites often include a few circular structures and evidence of agriculture, but the sites do not tend to get as large as those on the Santa Cruz River floodplain.

A similar situation is present in the San Pedro Valley, where Late Archaic sites have been identified in the banks of the San Pedro and its major tributaries (Sayles and Antevs 1941) and along the base of the neighboring mountains (Whalen 1971). Work in this area has been more limited and has not included much in the way of excavation. No direct evidence of agriculture has been recovered.

## CERAMIC PERIOD (200 BC-AD 1450)

The Early Ceramic period (200 BC- AD 700) can be viewed as a continuation of the cultural development that occurred in the previous period. The number and size of settled communities increased in areas where farming was possible (floodplains, alluvial fans, base of mountains), the diversity of cultural material increased, and ceramics became an integral part of daily life. A progression in the use of ceramics during this period can be seen as the technology became more accepted. The earliest ceramic vessels, such as those from Coffee Camp, lacked temper and represent limited forms that do not appear to be associated with use at a household level (Halbirt and Henderson 1993). During the Agua Caliente phase, sand-tempered plain ware vessels became more common household objects. The plainwares appear to represent a widespread proto-Mogollon style that was widespread at this time (Deaver and Ciolek-Torrello 1995). In the Tucson Basin it was be joined by red wares in the Tortolita phase.

Sites of this period are best known from data recovery projects in the Santa Cruz Valley, including investigations along the I-10 corridor on the north side of Tucson (Mabry et al 1997) and at the Valencia Viejo Site on Tucson's south side (Wallace 2003). El Arbolito, an early ceramic period site in the Corona de Tucson project area, included ceramics and characteristics that indicate a Mogollon influence (Huckell et al. 1987). The results of these investigations support the case for increased sedentism, a generalized Mogollon-influenced cultural make-up, and expansion into areas away from the main floodplains. Surveys in the Cienega Basin and Rosemont area indicate that the expanding early Ceramic period populations began to establish communities along major washes in those areas. Use of higher upland areas was probably limited to resource collection. Limited evidence from the San Pedro Valley indicates a relatively low occupation level at this time, or have the sites just not been found.

**Late Ceramic Period** (AD 700-1450) This period includes the Hohokam culture that so often characterizes our perceptions of the prehistoric period of southern Arizona. The Hohokam developed distinctive decorated ceramics in a variety of forms, lived in communities that often clustered around communal ceremonial areas, participated in a wide-ranging exchange system that brought in exotic materials, manufactured shell jewelry, and practiced irrigation and floodwater farming. Large communities were located along rivers and larger tributaries, while smaller hamlets and farmsteads were established in a variety of settings. This period is a time of increasing population growth in southern Arizona, with an increase in the number of sites and site size in the Preclassic period (AD 700-1100), the spread of Tucson Basin populations into neighboring areas, such as the Cienega Basin and the lower stretches of the San Pedro Valley, an increased participation in long-distance trade with other regions, and greater community integration through the use of ballcourts and other community structures. The upper San Pedro Valley is often seen as supporting a more localized culture that interacted with the Hohokam to the west and Mogollon communities to the east as well as Chihuahuan groups.

Preclassic sites reach their greatest distribution in the Rincon period, when settlements of various sizes were located at the bajada bases along the Santa Cruz River floodplain, and along the mountain bases and foothills. Small farming communities were located on ridgetops in the Santa Rita foothills (Ferg et al 1984) and along the lower bajada (Stephen et al.1997; Buttery 1987) while large communities were established along the Santa Cruz River (Doelle 1985, Doelle et al. 1985; Cultural and Environmental Services 1987; Greenleaf 1975) and its major tributaries. The San Pedro Valley supported large communities along its floodplain as well as along the base of the Huachuca Mountains where large tributaries emerged from their canyons (Altshul and Jones

1990). Limited activity sites from this period reflect the continued procurement of natural resources, while rock pile features appear to indicate the increased cultivation of agave on the bajadas, a pattern repeated in the Santa Cruz River valley and the San Pedro Valley.

In the Classic period, populations in the Tucson Basin appear to have coalesced into larger communities along the Santa Cruz and larger drainages. The upper San Pedro valley maintained a more localized culture, though trade wares from sites indicate interaction with the Tucson Basin as well as communities to the south and east. The higher elevations in the Santa Rita foothills appear to have been abandoned at this time, with smaller communities continuing for a while in the Cienega Valley.

## Post-Contact/Historic

The Hohokam culture is generally seen as ending around AD 1450; very few pre-contact sites have been dated between about AD 1450-1600. Evidence from southern Arizona and elsewhere in the Southwest indicate that there were many population shifts in the centuries preceding European contact in1540. The decline in numbers of late ceramic period sites suggests there was a population decline in southern Arizona, a pattern seen elsewhere in the Southwest. A shift in settlement patterns is suggested by Doelle (1984), though whether this was a response to environmental, social, or a combination of factors is not known. Some have suggested that the area was totally abandoned, with O'odham groups from the south filling in the vacant areas. O'odham traditions indicate that the O'odham have been living in the deserts and along the river of southern Arizona for many generations. They were firmly established by the time that Spanish explorers and missionaries entered the scene in the late 1600s.

O'odham groups were living in communities along major rivers and in the desert areas of southern Arizona when the Spanish first visited in the 1690s. Kino, Manje, and others noted that the Sobaipuri were living and farming in the San Pedro Valley and the upper Santa Cruz Valley. The village of Bac (W:ak), where the San Xavier Mission was later established, supported a large farming community utilizing irrigation ditches to water agricultural fields in the Santa Cruz floodplain. Other early Spanish missions such as Tumacacori, Guevavi and Calabasas were established in the 1690s near O'odham communities in the upper Santa Cruz valley. The Tohono O'odham were primarily living in small desert communities in the Papagueria at that time, while the Akimel O'odham had farming communities along the Gila River near present day Sacaton.

Initial Spanish missionary efforts began in the 1690s, and after a hiatus were renewed in the mid-1700s. The missionaries introduced old-world crops such as wheat and barley, and also brought livestock and horses to the Sobaipuri and other groups in Sonora and Arizona. Missions and visitas were usually established in or near O'odham villages, and local populations were encouraged to settle year-round at the mission, contributing to the mission through their labor. The early mission period coincided with the increased attacks by Apache groups on both mission and secular settlements in Sonora and what is now southern Arizona. The Chiricahua Apache often made their home in the Dragoon Mountains bordering the east edge of the Santa Cruz Mountain. Hunting, collecting and raiding parties reached into the Huachuca, Santa Rita, and

Santa Catalina Mountains. The Presidio of Tubac was established in 1752 to protect the Tumacacori Mission and Spanish settlers that had begun to settle in the area. A re-alignment of presidios saw the establishment of the Tucson presidio in the Santa Cruz Valley and Terrenate in the San Pedro Valley in 1776. Throughout the Spanish and Mexican periods (AD 1700-1854), most non-indigenous populations concentrated in the Santa Cruz Valley with ranches, farms, and mines established in nearby valleys.

The Apache threat caused the Sobaipuri to abandon the San Pedro Valley in the early 1700s, and the presidio of Terrenate was relocated back to Sonora in 1781 after only five years in the San Pedro Valley. Apache raids restricted the use of outlying valleys and mountain areas by O'odham and Spanish, making the collection of wild foods and other resources difficult. Spanish efforts to pacify the Apaches saw the establishment of Apache settlements outside major Spanish communities, including Tucson, where the Spanish provided supplies and foodstuffs to prevent raiding on communities in Sonora and Chihuahua.

Following the Gadsden Purchase in 1854, southern Arizona became part of the United States. The influx of Americans, first begun during the California Gold Rush (1849), increased following the Civil War and the establishment of the railroads in the 1880s. Starting in the 1880s, farms were expanded along the Santa Cruz River and major drainages, and ranches established in nearby valleys and basins. Mining exploration expanded as well, with claims and development occurring in the Santa Rita, Arivaca, and Huachuca Mountains. The introduction of the Southern Pacific Railroad was a boon to the mining companies. Small spur lines such as the New Mexico and Arizona Railroad soon connected mines and smelters with the main rail lines.

## Previous Work:

## Santa Cruz Valley

**Southern Tucson Basin Survey (Doelle, Dart, and Wallace 1985)**

This survey concentrated in areas along the east side of the Santa Cruz floodplain, east of the San Xavier District and north of Sahuarita. It focused on recording pre-contact archaeological sites. The investigators found evidence of buried Archaic sites (e.g. Joe Ben Site) along the Santa Cruz and mouths of major tributaries. Many of these early sites were first located and discussed by Haynes and Huckell (1986). Early Hohokam (Pioneer and early Colonial) occupation appears to have been light in the survey area, though later investigations have shown settlements along the Santa Cruz farther to the north (Wallace 2003). Large primary villages and hamlets of the Rillito and early Rincon Phase are situated largely on the west bank of the Santa Cruz Floodplain, at the toe of the extensive Sierrita Mountain bajada. A population shift in the beginning of the Middle Rincon first saw an increase of hamlets on the west bank shifting to an increased occupation of hamlets on the east bank by the Late Rincon. The transition from west to east continued in the Tanque Verde phase, with increased numbers of primary villages and hamlets on the east bank, as well as numerous roasting pits and seasonal camps up the bajada to the east.

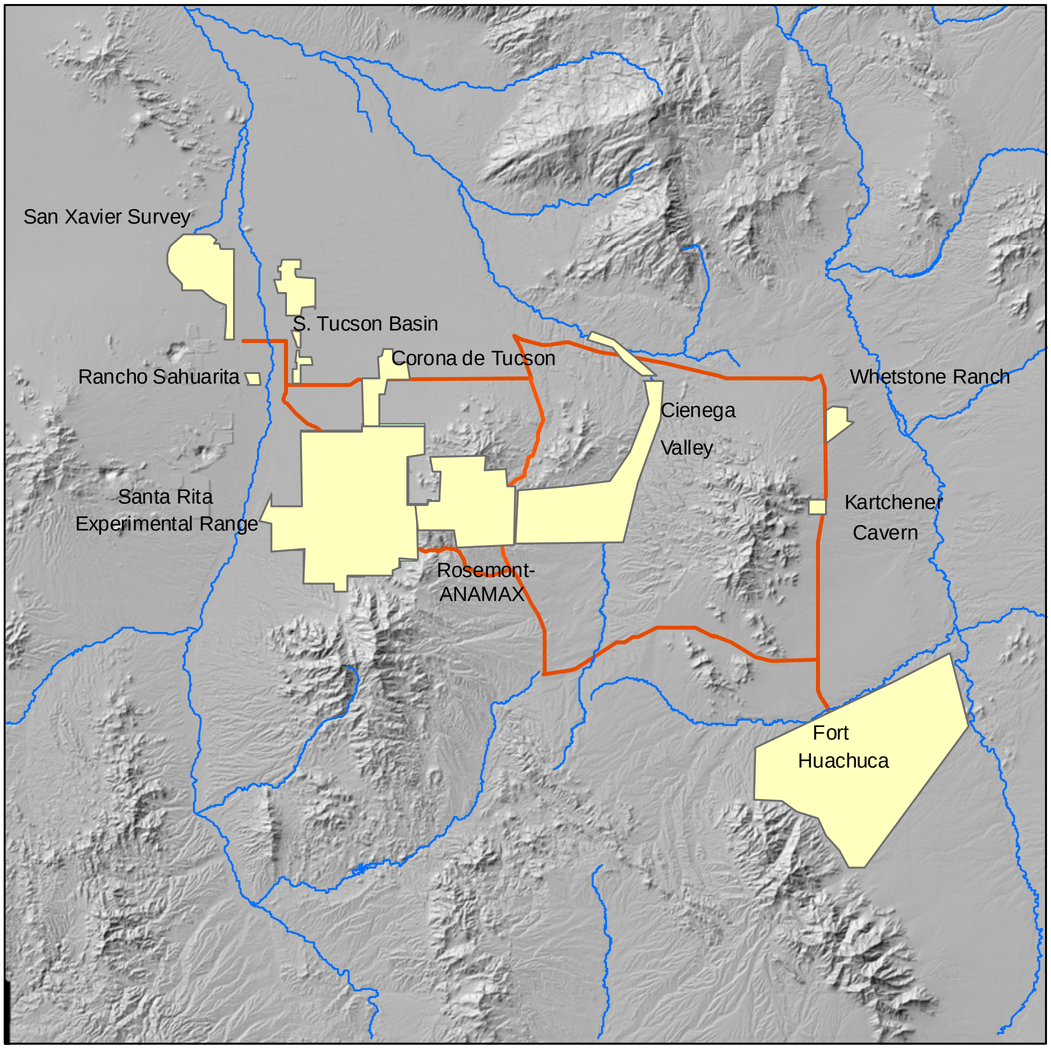


**Figure 1 Large Block Archaeological Surveys**

Throughout the Hohokam period, larger habitation sites concentrated along the Santa Cruz River, with seasonal camps and roasting pit sites distributed on the bajadas, usually near larger washes. The survey encountered widespread agricultural features and rock piles along the base of the Santa Rita bajada, most of which do not include diagnostic artifacts but appear to be associated with the increase in the east bank population in the Rincon and Tanque Verde phases. A similar association of rock pile agricultural features was found with the Late Sedentary-Early Classic Marana Community in the northern Tucson Basin (Fish, Fish and Madsen 1992). The survey also recorded numerous small habitation sites on the bajada, usually along larger washes, suggesting that small-scale floodwater farming may have been carried out in that area.

**San Xavier Project Survey (Cultural and Environmental Systems 1987)**
This project included the survey of a large area of the San Xavier District south of Black Mountain and west of the Santa Cruz River, including a portion of the Santa Cruz River floodplain. Survey results indicate a series of large Hohokam habitation sites, including several with ballcourts, at the toe of the bajada extending from the Sierrita Mountains, on the west bank of the Santa Cruz floodplain. This series of sites includes the large Punta de Agua Site (Greenleaf 1975), excavated prior to construction of I-19. While most large sites cluster along the edge and upper portion of the floodplain, smaller sites on the lower bajada were located around larger washes that may have been used for floodwater farming or resource procurement. Sites also cluster around the base of Black Mountain, and a trincheras site is located at the eastern end of Black Mountain.

A Late Archaic presence is indicated by isolated diagnostic projectile points and the presence of deeply buried features in the Santa Cruz River bank. Although there is evidence of a light Colonial period occupation, the peak of Hohokam occupation occurred mostly along the river and on the lower bajada in the Rillito and Rincon Phases. A population shift in the Late Rincon Phase saw a decrease in the use of the southern portion of the west bank during the Tanque Verde phase, although communities closer to the historic Bac community continued to be occupied. Although little is known about Tucson Phase occupations, protohistoric and early historic O'odham sites tend to cluster along the west bank of the river. The community of Bac was thriving when visited by Kino and company in the 1690s. These early Spanish visitors noted the presence of ditch irrigation and the quality of the area for farming and grazing.

**Santa Rita Experimental Range (Buttery 1987)**
The Santa Rita Experimental Range is located on the northwestern bajada of the Santa Rita Mountains about 30 miles southeast of Tucson. Buttery (1987) completed a 15% sample survey of the area (a total of approximately 53,000 acres) and encountered a total of 46 archaeological sites. Over 60% of the sites were located in the upper bajada at the base of the mountains, while the other sites occurred within the lower bajada less than a mile from the Santa Cruz River. Buttery noted that most of the 25 habitation sites are clustered along major drainages in the upper bajada, particularly along Box Canyon, where soils and water availability favored agriculture. The upper bajada was also used for procuring plant and stone resources, as indicated by the presence of bedrock mortar sites and lithic scatters. The lower bajada supported scattered habitation sites as well as agricultural sites characterized by rock pile fields probably used for agave cultivation. Buttery's sample survey encountered very few sites in the middle bajada zone.

The survey did not find any evidence of a Paleoindian occupation and an Archaic presence was represented by isolated Archaic style projectile points. The great majority of sites appear to be related to the Hohokam period, especially the Rincon Phase (AD 900-1200). Many of the rock pile fields and limited activity sites lacked diagnostic artifacts and so are difficult to place in a specific time period. Buttery also found evidence of a light historic occupation of the area, many sites appearing to be related to early mining claims and tests.

**Corona de Tucson (Huckell et al. 1987)**
The Corona de Tucson survey located 27 sites including 22 Hohokam, 2 Archaic, 2 historic, and 1 protohistoric occurrences. The project area is located on the broad northwestern bajada extending from the Santa Rita Mountains, and is an area of dissected alluvial deposits and washes. Data recovery included both Archaic sites, which were composed of lithic scatters and fire-cracked rock (FCR) concentrations (probably eroded roasting pits) that suggest short term occupations and resource procurement. The recovery of a San Pedro Point indicates a probable Late Archaic occupation. Four investigated Rincon phase sites included at least one pithouse each, as well as associated features, while two sites included just small, informal structures with abundant FCR features. Five hearth sites were also investigated. The largest site, El Arbolito, was a large early Ceramic period farmstead with abundant artifacts, several structures and associated features.

The area is heavily dissected, and most sites are located along washes that would be appropriate for floodwater farming. The abundance of hearths and fire-cracked rock features is suggestive of plant resource processing. Isolated hearths and FCR features are abundant in the northern project area, and much less common in the southern, where the bajada slope becomes steeper.

**Rancho Sahuarita Survey (Stephen et al. 1997)**
This large block survey of about 2800 acres is situated near the Helmet Peak/Pima Mine Road Interchange south of Tucson, in the area of the Sahuarita High School. Though located largely on the west bank of the Santa Cruz, the location of the 25 sites within the area reflects the settlement pattern common in other areas of the Santa Cruz Valley: Larger prehistoric habitation sites tend to be located on the toe of the bajada and along the edges of the floodplain, while smaller procurement and possible agricultural sites are located across the bajada and to a lesser degree on the floodplain. The survey encountered only a few historic trash scatters from the 1920s-1930s in the bajada. Many of the larger Hohokam sites appear to represent a Rincon phase occupation, while smaller scatters often lacked diagnostic artifacts.

**Sahuarita Corridor Survey (Hesse 2001)**
This survey for the projected 18 mile highway bypass from I-19 east to I-10 represents a 300 foot corridor across the lower bajada extending northwest from the Santa Rita Mountains. The corridor runs parallel to a portion of the I-10 alignment. The proposed alignment crosses thirteen sites, including two historic transportation rights-of-way and an historic house foundation with associated trash. Most of the prehistoric occurrences appear to represent resource procurement sites that include a number of thermal rock features, or eroded roasting pits, with an associated artifact scatter. The great majority of these sites are from the ceramic period, but some represent a Late Archaic occupation. On the surface they are quite similar to the sites excavated in the nearby Corona de Tucson project and probably have similar sub-surface features and deposits.

## Sonoita Basin

**Rosemont Anamax Project (Debowski 1980)**
The Rosemont area is located in the foothills of the Santa Rita Mountains at quite a high elevation, with most sites occurring between 4400-5200 feet above sea level. A proposal to develop the area for a copper mine supported the survey of a large block of land that extended from the western foothills to the edge of the Cienega Valley. Although project boundaries shifted through time, over 600 archaeological sites were located in the maximum surveyed area of about 30 square miles. These represented Archaic, Ceramic period, and historic occupations, and many sites that could not be placed in a particular time period because of the lack of diagnostics. A sample of the sites was excavated by Arizona State Museum, and the Upper Davidson Canyon Archaeological District eventually nominated to, and placed on, the National Register of Historic Places. The high number of sites recorded by the survey was surprising, given the generally high elevation of the project area.

Twenty-six probable Archaic sites were located within the most extensive project area boundaries; twelve of these received further investigation. Several excavated Late Archaic sites included pit houses with associated roasting pits and other features, and abundant lithic and ground stone tools. These habitation sites were generally located in the headwaters of larger drainages and their locations correlated with water sources. Limited activity sites, particularly those associated with lithic procurement and reduction, were often located on ridges with large cobbles on the surface (Huckell 1984).

The survey also located 102 Ceramic period sites, with an additional 571 sites that were termed “unknown aboriginal” because no ceramics were noted on the surface, though many could still date from that time period. The predominance of Tucson Basin Hohokam ceramics in Ceramic period sites suggested to the investigators that the Rosemont area was settled by groups originating from the Tucson Basin. At least three initial sites have a Canyon del Oro phase occupation, with the number of sites increasing through the Rillito and Rincon phases. The Rosemont Hohokam community appears to have been abandoned after this period, with no Classic period sites located during the survey (Ferg et al. 1984). Classic period sites are located in the Cienega Valley just east of, and lower than, the Rosemont area.

Phillips (1984) found that most Ceramic period habitation sites were located on ridges and other raised situations near major drainages with a gradient of less than 3.5%. He attributes this to a correlation of site location with valley areas most appropriate for flood-water farming, the capture and distribution of flood waters to agricultural fields. Many of the undated “unknown aboriginal” are similarly distributed, and may represent limited use sites associated with the main habitation loci. Phillips (1984) also notes the presence of over 90 rock pile sites in the survey area. These are generally located in higher elevations in xeric grassland settings and are often associated with agave cultivation. Ferg et al (1984) notes that most Ceramic Period sites are also largely located within the mosaic woodlands of the area, rather than in the lower, open grasslands.

Ayres (1984) investigated about 30 historic sites in the Rosemont area. The bulk of these are associated with the numerous mining activities that took place between the 1870s-1920s, including the town sites of Old and New Rosemont. Ranching peaked in the area prior to the establishment of the Coronado National Forest in the early 1900s. Farms were uncommon in the area, given the higher elevation and lack of substantial water sources.

**State Route (Highway) 83**: Archaeological surveys of Highway 83 encountered 23 archaeological sites between Sonoita and I-10 (Bilsbarrow 1995; Wright 1996). Five historic sites included several segments of the historic Highway 83 highway as well as the New Mexico and Arizona Railroad, a historic cemetery (1920s), and possible Civilian Conservation Corps check dams. No historic habitations were encountered along the road right-of-way. Eighteen prehistoric sites consisted primarily of lithic and artifact scatters, often associated with cobble clusters or roasting pits. These sites tended to cluster near larger drainages where arable land is available for floodwater farming, and appear to represent both Late Archaic and Ceramic Period occupations. Few of these sites included diagnostic artifacts, preventing a more detailed temporal determination.

**State Route 82:** Archaeological surveys of portions of State Route 82 between Sonoita and Mustang Corners (Intersection of SR 82 and 90) encountered only historic sites, including portions of the historic highway built before 1948, a portion of the New Mexico and Arizona Railroad, and a historic cobble foundation for an adobe structure (Stone 1992, 1993). Very few archaeological surveys have taken place in this area. Route 82 passes through rolling grassy plains in this portion of the Cienega Basin, an area that does not appear to have been used for more than low-impact uses prehistorically.

**Cienega Valley Survey (Stevens 2001)**

The Cienega Valley survey included almost 44 square miles of area in the Empire-Cienega Resource Conservation Area administered by the Bureau of Land Management (BLM). While Stevens focused on the Late Archaic and Early Agricultural periods in her dissertation analysis, the survey recorded sites from all time periods. The survey recorded 422 sites, many of them with multiple components. The majority of components represent Ceramic Period sites (353), with Archaic (70) and Early Agricultural (42) occupations also well-represented. Many prehistoric components lacked diagnostic materials, and so could not be assigned to a particular time period (190). Only one protohistoric site was located, and 58 sites had an historic component.

Visibility of early sites along the basin interior was affected by the up to 30 feet of alluvial deposits that have accumulated within the Cienega floodplain since the Archaic occupation. The effects of alluviation are much reduced in the upper bajada/foothills areas, where early sites tend to be on flattened sections of ridge lines. Stevens found that multiple- and limited-activity sites from all periods tended to be located on the uplands bajadas and in the valley bottoms, with the middle bajada areas used less consistently. Multiple activity sites are generally associated with longer-term occupations, while limited activity sites generally indicate a short-term use focused on procuring a resource or having a limited function.

## San Pedro Valley

**State Route 90:**

An archaeological survey was completed on either side of SR 90 prior to a road widening project; the right-of-way varied between 100-450 feet in width (Wright 1992). The survey encountered seven sites including three historic rights-of-way (El Paso and Southwestern Railroad, two historic Highway 90 segments), three other historic sites, and one prehistoric lithic scatter. An earlier survey (Fedick 1986) recorded the remains of an historic gas station at the intersection of State Routes 82 and 90. Another previously recorded historic railroad right-of way (New Mexico and Arizona Railroad) is crossed by Highway 90 near Huachuca City.

**Whetstone Ranch:**

Several archaeological surveys have been completed for various Whetstone Ranch development projects on the east side of Route 90 near Benson. Prehistoric sites encountered on these large parcels include several agricultural sites with rock piles and artifact scatters representing the Late Archaic and Ceramic periods. Historic sites include historic El Paso & Southwestern Railroad (EP&SW RR), Blackwell watering station, several trash scatters, a lime kiln and the historic McGrew Spring habitation site (Dart 2001, Jones 2000). Of the 16 sites reviewed by Dart (2001), there was an even division between historic and prehistoric occupations. Other than the historic railroad and McGrew Spring site, most sites indicate a seasonal or short term use of the bajada area east of State Route 90 in this area.

**Kartchner Caverns State Park (Madsen and Bayman 1989)**

Madsen and Bayman (1989) surveyed the 550 acres that make up Kartchner Caverns State Park prior to park development. The survey area overlapped with a portion of Whalen's (1971) earlier reconnaissance of approximately 100 square miles in the Middle San Pedro River Valley between the river and the Whetstones. Whalen identified 90 prehistoric sites, 82 of which were non-ceramic and thought to be Archaic. Nine of these were located within the park boundaries. Madsen and Bayman (1989) defined two historic and eleven prehistoric sites within the boundaries. Only some of their sites corresponded with Whalen's. Eight of the prehistoric sites are lithic scatters that range from small sites with light densities to extensive, high density sites with a high diversity of artifacts and surface features. More specialized activity sites included two bedrock mortar sites and one lithic quarry. Data recovery by SWCA (Phillips et al. 1993) in the portion of the park destined for visitor facilities indicated that cultural materials and features were limited to the surface and tended to cluster in different areas. Rather than representing a possible base camp, SWCA suggests that the extensive lithic scatter is the result of frequent short term use of the area by small groups over a long period of time. The area appears to have been visited repeatedly because of the high grade chert that is available in the nearby limestone outcrops, and because of the availability of water.

**Fort Huachuca Survey (Altschul and Jones 1990)**
Altschul and Jones (1990) summarized the archaeological surveys that have taken place on the Fort Huachuca Military Reservation, mostly as sample surveys of the entire reservation. Eighty-four archaeological sites were located within 8,600 surveyed acres that were distributed across the Fort's land. Fifty-eight of these sites were prehistoric and thirty-one were historic. Recorded sites range in age from the Archaic to the Ceramic Period and into the Protohistoric and historic periods. They found two over-arching settlement pattern trends: 1) sites cluster along the major rivers (San Pedro and Babocomari) resulting in heavy use of the bajada's edge, particularly by the San Pedro, and 2) there are numerous sites at the base of the mountain, particularly where major drainages debouch from the narrow mountain canyons.

Two buried Archaic sites were noted during the survey, but prehistoric use of the area seems to have peaked in the late Ceramic period. Large village sites were distributed at even intervals at the base of the mountains, with smaller hamlets scattered between them. Recovered ceramics are largely local wares and suggest that the upper San Pedro was not an extension of the Tucson Basin Hohokam. The Garden Canyon Site, a large Babocomari phase site situated at the mouth of Garden Canyon, is an excellent example of these village sites. Resource procurements sites are generally located on the bajada within 5-7 miles of the river. Interestingly, few of these were found on the highly dissected bajada just south of the Babocomari within the fort lands. Although the occupation of the area by the Sobaipuri is known from early Spanish documents from the late 17th century as well as archaeological investigations (Di Peso 1951, 1953), no Sobaipuri sites were found during the survey. The historic sites are a mix of military, ranching and farming, mining, and transportation rights-of-way.

## Cultural Resources and the CAP Extension Alignments

## Santa Cruz River Valley

All proposed alignments cross the Santa Cruz River, an area where high densities of prehistoric habitation sites and agricultural features are clustered on the lower bajada above the floodplain. The floodplain often supports historic properties (eg. Canoa Ranch) and has a high probability of buried Archaic or early Ceramic period sites. Later Ceramic period sites may also be located on the surface.

Two alignments cross the bajada that extends west and northwest from the Santa Rita Mountains. The middle bajada areas contain lower densities of both prehistoric and historic sites. These include resource procurement sites (plant collecting and processing, hunting, temporary farming, etc.), small habitation sites, and some agricultural features (rock piles, check dams) that may represent both Late Archaic and Ceramic period occupations. A historic occupation is represented by scattered structure foundations, some representing early 20th century homesteads, historic rights of way (roads, railroads), and trash dumps.

The I-10 and Highway 83 alignments tend to stay on the middle bajada in the Tucson Basin, while the Santa Rita Mountains alignment angles to the southeast to enter the Box Canyon area of the Santa Rita Mountains. Prehistoric site density rises on the upper bajada/mountain base, especially along major drainages that would be appropriate for floodwater farming. Buttery (1987) found that many large prehistoric sites concentrated along the Box Canyon Wash, a major drainage that is followed by the Santa Rita Mountains alignment. Historic sites also increase at the mountain base where habitation sites were located near water sources and resource procurement (logging, charcoal manufacture, hunting) camps are scattered about. The ANAMAX-Rosemont survey located numerous Archaic and Ceramic period and historic sites in the area just north of Box Canyon, particularly on ridges overlooking the larger, more gently sloped drainages that drain to the east.

## Cienega Valley

The I-10 alignment passes to the north of the main portion of the Cienega Valley, paralleling I-10 as it crosses Cienega Creek and its major tributaries. The area is quite dissected with steep valley sides and gravelly ridges. Many sites are located on low terraces along the drainages, where site density is high. Impact to natural and cultural resources could be lessened by hanging the extension pipe from the I-10 bridge. After crossing the drainages, the alignment then rises to a high open bajada area where site density once again is quite low. The Highway 83 alignments splits from the I-10 route to follow Highway 83 south along the western edge of the Davidson Canyon drainage until it reaches the west edge of the Cienega Valley, where it joins the Santa Rita Mountains alignment near Empire Gulch. The northern stretch of this route crosses an area with relatively low site densities, but densities rise in the upper Davidson-Barrel Canyon area. The alignment passes through the Upper Davidson Canyon Archaeological District.

There is a very high potential of encountering buried Archaic or Early Ceramic period sites in larger floodplains. Large block surveys have shown a surprisingly high prehistoric site density along the upper bajada and in the foothills, where habitation sites tend to cluster on ridges above valleys with arable land. The middle bajada appears to have supported a variety of smaller resource procurement sites. While the northern portion of the basin appears to have a moderately high density of prehistoric sites, very few sites have been encountered in the open grasslands that dominate the southern basin.

Historic sites in the Cienega Valley largely consist of mining-related communities and structures, ranches, and transportation-related sites. Within the Cienega Basin, prehistoric sites cluster along Cienega Creek and its major tributaries.

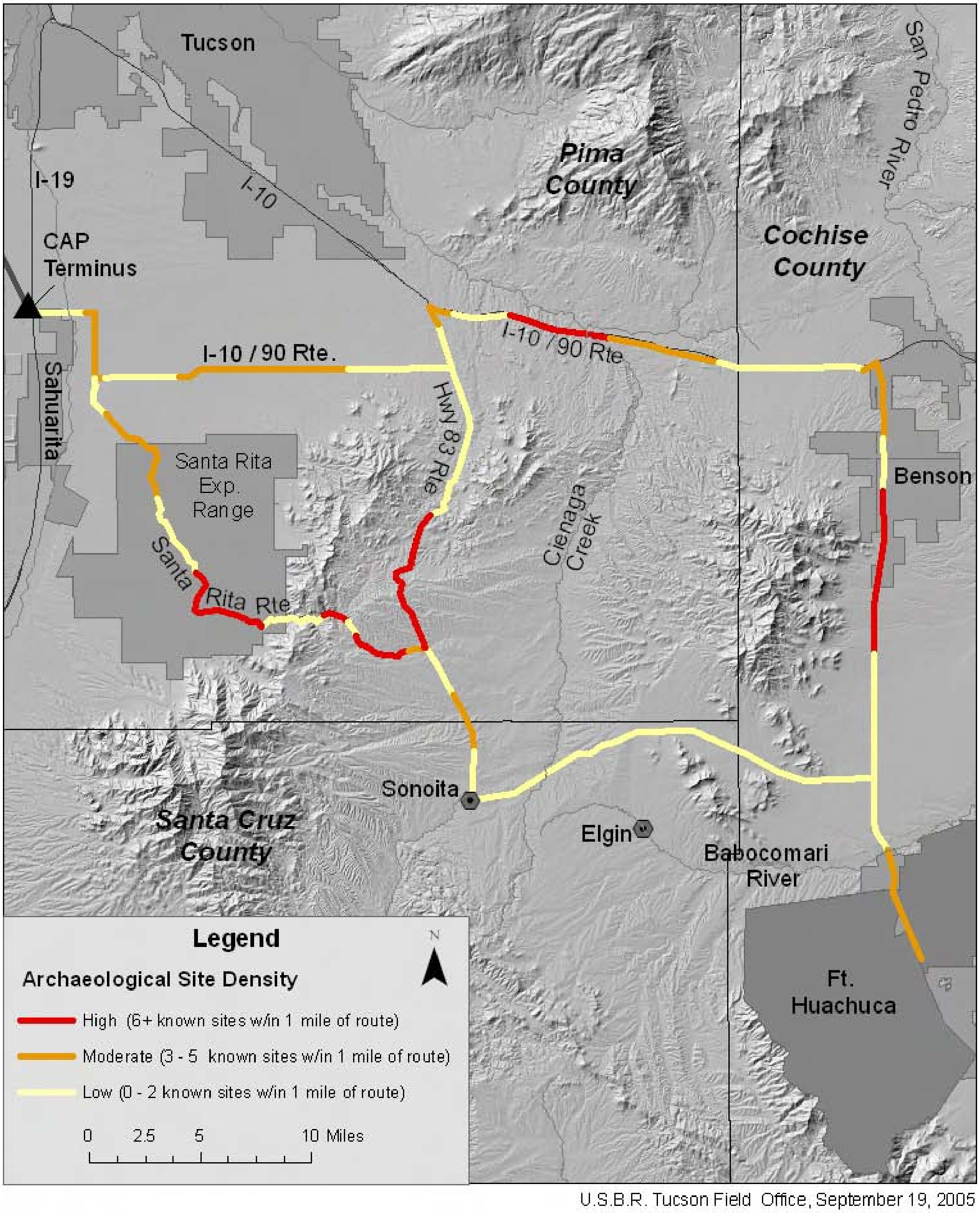


**Figure 2 Densities of known cultural resources along the proposed CAP routes**

## San Pedro Valley

The San Pedro Valley is sometimes seen as having been on the periphery of major prehistoric cultures of southern Arizona, but in many aspects it provides unique information on past cultures that is found in few other places. The valley has an unusually high concentration of Paleoindian sites, mostly located in the lower bajada near old springs. It also has a relatively high number of Archaic sites, as well as Ceramic and Protohistoric period sites.

The I-10 alignment parallels State Route 90 down the west edge of the San Pedro Valley. It crosses bajada areas that support moderate to high prehistoric site densities. Sites in this area include many agricultural and resource procurement camps. Site density increases in the Kartchner Cavern area, where Route 90 passes closer to the Whetstone Mountains. The bajada areas along the northern portion of the Whetstone Mountains supported a rather low density of prehistoric sites, a pattern that continues much of the way to the gate at Fort Huachuca. One exception to this would be the area around Babocomari Creek, a major tributary to the San Pedro, where site densities have the potential to be high.

Basins created for the recharge of CAP water to the local aquifer cover considerable acreage and have a severe impact on the land. Impacts to cultural resources would probably be greatest near the San Pedro and in the upper bajada area. The use of washes for recharge would have the potential for impacting buried Archaic and Paleoindian deposits that may be exposed in arroyo walls.

## Recommendations

**I-10 to Route 90 as preferred alignment**:
This alignment has the least potential to affect significant cultural resources. It follows several established rights-of-way and so includes areas that have already been disturbed. Much of the alignment crosses the bajada in the Santa Cruz Valley, an area where prehistoric cultural resources are sparsely distributed and mostly consist of limited activity sites and camp sites. Historic sites are also rather limited in this area. Cultural resources are relatively dense along the Davidson Canyon, Cienega Creek and other large drainages north of the Empire Hills. Because the alignment would cross these valleys, there is a greater potential to avoid sites by altering its placement. When the alignment proceeds to the open bajada on the north and south sides of the Whetstone Mountains, the cultural resources are again largely represented by dispersed, limited activity sites.

**Less preferred alignments:** The Santa Rita Mountains alignment would parallel the Santa Cruz River for several miles, and could potentially encounter the higher site densities that are found at the base of the bajada. It would then cross the bajada, where site densities are low and largely consist of limited activity sites. Higher site densities would be expected in the upper bajada on the west side of the mountains, and in the more gently sloping valleys of the east side where the alignment passes through portions of the ANAMAX-Rosemont project, an area with numerous known prehistoric and historic sites. It then proceeds to the upper bajada of the Cienega Valley, another area with high site densities, before moving into the open grasslands of the basin and into Rain Valley, both areas with low site densities. This alignment is relatively undisturbed and has the potential to encounter higher site densities as it parallels the Santa Cruz and in the Santa Rita foothills and upper bajada of the Cienega Basin.

The Highway 83 alignment shares the lengthy bajada stretch of the Santa Cruz Valley with the I-10 alignment. It then turns south along Highway 83, which initially follows portions of Davidson Canyon before crossing into the Cienega Basin. Few sites have been recorded along the northern stretch of Highway 83, but the site density rises rapidly as it enters the Cienega Valley. Here it enters portions of the ANAMAX-Rosemont project and the Cienega Valley survey. Numerous sites have been recorded along major tributaries and on ridges in the Santa Rita foothills and the upper bajada of the Cienega Valley. This alignment joins that of the Santa Rita Mountains alignment in the Greaterville area and passes through the open grasslands of the upper basin where low site densities have been recorded.

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D. Preliminary Appraisal Study of CAP Water to Sierra Vista Alternative

*Appendix D: Federal and State Regulatory Programs and Issues for the CAP to Sierra Vista Alternative*

# Appendix D

# Federal and State Regulatory Programs and Issues for the CAP to Sierra Vista Alternative

Federal activities affecting the water supply alternatives being evaluated under this study include compliance with sections 401, 402, and 404 of the Clean Water Act. Under section 401, the project proponents would need to obtain Arizona State Water Quality Certification. Under section 402, a National Pollutant Discharge Elimination System Requirements (NPDES) permit would be required. Under section 404, a Department of Army permit would be required to address dredge and/or fill material affecting waters of the United States. The Endangered Species Act (ESA) and the National Historic Preservation Act must also be addressed.

## Clean Water Act

### *National Pollutant Discharge Elimination System Requirements*

Pursuant to section 402 of the Clean Water Act, the Arizona Department of Environmental Quality (ADEQ) administers the certification of NPDES permits for EPA (know as AZPDES). The AZPDES permit for Point Sources of Pollution, as defined by ADEQ, protects the waters of the State from pollutants discharged from a point source. The waters of the State include all perennial or intermittent streams, lakes, ponds, impounding reservoirs, marshes, water courses, waterways, wells, aquifers, springs, irrigation systems, drainage systems, and other bodies or accumulations of surface, underground, natural, artificial, public, or private water situated wholly or partly in or bordering on the State.

A NPDES storm water permit is also required for certain industrial and construction activities that discharge storm water. NPDES permits are usually required for effluent or industrial wastewater being disposed of by discharge to the waters of the State. This includes storm water discharges from golf courses if they are being irrigated with effluent or reclaimed water. However, when effluent is proposed for a reuse application, such as recharge, the ADEQ wastewater reuse and APP rules are applied.

Prior to the issuance of either a NPDES or section 404 permit, the applicant must obtain a section 401 certification. This declaration states that any discharge complies with all applicable effluent limitations and water quality standards.

### *Section 404 Clean Water Act Dredge and Fill Permits*

Section 404 of the Clean Water Act requires that the Army Corps of Engineers, with the concurrence of EPA, issue or deny permits for activities that result in the discharge of dredge or fill material into the waters of the United States. For the purposes of this section, waters of the United States include most streams, stream channels, and wetlands in Arizona. It should be noted that the section 404 permit also pertains to disturbance activities in wetlands and riparian areas. Intended to prevent the unlawful filling of wetlands, this section would apply to most channel modifications made for in-channel recharge projects. A 404(b)1 analysis (alternative analysis) must be completed to determine the least damaging practicable alternative. Under section 401 of the Clean Water Act, section 404 permits must be certified by ADEQ.

### *Endangered Species Act*

Section 7 of the ESA requires Federal agencies to ensure that their activities do not jeopardize the continued existence of a listed species or adversely modify "critical" habitat for a listed species. Federal activities include actions authorized, funded, or carried out by the agency, including any regulatory action such as issuance of section 404 permits of the Clean Water Act. When listed or proposed species are present, the action agency must evaluate whether the Federal action may affect any listed, threatened, or endangered species. If the agency determines that the project may affect a listed species or adversely modify critical habitat, then a formal section 7 consultation with the Fish and Wildlife Service (FWS) is initiated. FWS will issue a "biological opinion" that will determine whether the Federal action will "jeopardize the continued existence" of any listed species and, if so, will include reasonable and prudent alternatives" to remove any jeopardy to the species.

An Incidental Take permit would be issued to cover impacts to species "incidental" to the project action. Section 9 of the ESA prohibits the "take" of any federally listed or proposed species (except plants on private land). Consequently, non-Federal entities may be subject to enforcement of the ESA without any Federal connection, if their activity results in the take of a species.

*"Take" is defined under the ESA as "harass, harm, pursue, hunt, shoot, kill, wound, trap, capture, or collect." Harm is further defined to include significant habitat modifications or degradations that result in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering.*

Section 10 of the ESA provides a method for non-Federal entities to avoid take through completion of a Habitat Conservation Plan (HCP) or Safe Harbor Agreement. Until a non-Federal entity has a section 10 permit, potential section 9 liability exists, regardless of the status of habitat designation or FWS protocol standards. When a non-Federal entity receives its section 10 permit under the ESA, the biological opinion developed for the HCP would include an incidental take permit. The permit would authorize any incidental take of a listed species by the section 10 permittee, pursuant to implementation of the required reasonable and prudent alternatives.

The ESA may also affect projects if a federally listed species occurs in habitat created or sustained by a project. If a project operator is required to protect habitat incidentally created or sustained by the project, then the design and operation of some projects may be legally constrained for endangered species protection. Injection recharge projects and basin recharge projects operated to maximize recharge through wet/dry cycles and discing are less likely to create incidental habitat than multipurpose projects incorporating in-stream riparian features and recreation.

### *National Environmental Policy Act Compliance*

The National Environmental Policy Act (NEPA) was signed in 1969. NEPA is our basic national charter for protection of the environment. The policy contains action-forcing provisions to ensure Federal agencies follow the letter and spirit of the act, which is to protect the environment. The main purposes of NEPA are:

- To declare a national policy that will encourage productive and enjoyable harmony between man and his environment
- To promote efforts that will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man
- To enrich the understanding of the ecological systems and natural resources important to the Nation

***The NEPA Process*** — Federal agencies are required to “adopt procedures to ensure that decisions are made in accordance with the policies and purposes of the Act.” Agencies are to designate the major decision points in their principal programs and ensure that the NEPA process corresponds with them. This process cannot be a last-minute consideration if it is to be applied appropriately. Whenever Reclamation is considering an action, the NEPA process will be integrated in to all planning and decision-making processes from the earliest discussion of the need for and type of action to be taken.

***What NEPA Does*** — Compliance with NEPA requires participation of Federal, State, and local agencies, and concerned and affected public in the planning process. The act requires full disclosure about actions, alternatives, impacts, and possible mitigation for actions taken by Federal agencies. This act allows environmental concerns and impacts to be expressed and considered while an action is being planned. During planning, steps can be taken to correct or mitigate the impacts of an action. It is usually too late to correct errors after a project's planning phase without a substantial increase in the cost and the manageability of the project. Properly applying NEPA results in better decision-making.

***Types of Compliance*** — NEPA compliance documentation is triggered by a Federal action. If there is no Federal action being taken, there is no NEPA document required. The nature of the Federal action may be constructing a project, granting a permit or approval to a third party, providing Federal funding in a third-party project, or any other action where a Federal decision is required.

Once it has been established that there is a Federal action, the next step is to determine relevant environmental issues and the potential magnitude of environmental impacts. Once these have been identified, the appropriate level of NEPA documentation can be determined. After the environmental effects have been evaluated, the appropriate level of documentation can be selected. These levels are:

- *Categorical Exclusions.* – The first type of compliance documentation is the categorical exclusion (CE). A CE applies to actions that do not individually or cumulatively have a significant effect on the human environment. A CE excludes certain Federal actions from further NEPA documentation because the action has been shown to have no significant effect on the environment or unresolved conflicts concerning alternative uses of available resources. There may be cases where a CE appears to apply, but because of particular circumstances, a different type of NEPA compliance documentation may be appropriate.

- *Environmental Assessment/Finding of No Significant Impact.* – The next type of compliance documentation is an environmental assessment (EA). The EA process may be used for evaluation of any action at any time to assist in planning and decision-making. The EA should provide sufficient evidence and analysis to determine that an environmental impact statement (EIS) is not required for the project. If it is determined the EA is adequate for the project, a finding of no significant impact (FONSI) is issued, and preparation of an EIS is not required.

Obviously, the conclusion in issuing a FONSI cannot be reached without having knowledge of what the issues are, as determined by appropriate Federal and State agencies, as well as the general public. Note that the choice to conduct the next level of compliance (an EIS) can be made any time there is enough information to indicate that significant impacts may occur or that sufficient controversy (factual disputes) about the impacts exists. A statement from someone stating that they "hate the project" does not necessarily mean there is sufficient controversy. The choice of doing an EA does not guarantee the conclusion that a FONSI will be prepared.

- *Environmental Impact Statement.* – An EIS is normally required for a major Federal action in which environmental effects are potentially significant. The Council on Environmental Quality regulations point out that "major," in the term "major action," reinforces, but does not have a meaning independent of, "significant." A major action is one that significantly affects the quality of the environment. The nature of an action and its resulting significant environmental effects may be apparent from the beginning of the study. For actions of this sort, an EIS is needed, and an EA need not be prepared.

Some latitude exists in determining those actions that require an EIS. The determination is the result of many factors, including controversy, environmental considerations, project history, and the language in the regulations.

While it is recognized that provision of water through a Federal water project may accommodate projected population growth, under current Reclamation policy, impacts associated with such growth need not be discussed under NEPA if Reclamation has no control over the subsequent growth. This policy is based on the U.S. Supreme Court decision in *Department of Transportation v Public Citizen, June 7, 2004*, which determined a Federal agency need not consider the environmental effects of the associated nonfederal action (growth and development) in its environmental assessments under NEPA if the Federal Agency has no ability (jurisdiction or control) to prevent the nonfederal action and associated effects from occurring. In this instance, Reclamation has no jurisdiction over the growth in the Sierra Vista area.

## Other Federal Laws

Federal laws that may apply to a proposed project are listed below.

### Executive Order 11988, Floodplain Management, May 24, 1977

Executive Order 11988 requires avoiding or minimizing harm associated with the occupancy or modification of a flood plain.

### Executive Order 11990, Protection of Wetlands, May 24, 1977

Executive Order 11990 provides for the protection of wetlands through avoidance or minimization of adverse impacts.

### Fish and Wildlife Coordination Act of 1934, as Amended

This act requires coordination with Federal and State wildlife agencies (FWS and Arizona Game and Fish Department) for the purpose of mitigating project-caused losses to wildlife resources.

### National Historic Preservation Act of 1966, as Amended

Federally funded undertakings that have the potential to affect historic properties are subject to Section 106 of the National Historic Preservation Act (NHPA). Under this act, Federal agencies are responsible for the identification, management, and nomination to the *National Register of Historic Places (National Register)* any significant cultural resources that would be affected by Federal actions. Consultation with the Advisory Council on Historic Preservation, the State Historic Preservation Officer, and affected Indian tribes is required when a Federal action may affect cultural resources on, or eligible for inclusion on, the *National Register*.

### Native American Graves Protection and Repatriation Act

The Native American Graves Protection and Repatriation Act (NAGPRA) became law in 1990 (P.L. 101-601). NAGPRA is intended to ensure that Native American human burials, associated and unassociated funerary objects, sacred objects, and items of cultural patrimony currently curated by Federal agencies, or by museums or institutions receiving Federal funding, are identified and inventoried for possible return to an appropriate tribe. NAGPRA provides regulations covering how the intentional excavation or accidental discovery of Native American human remains and associated cultural items on Federal or tribal lands must be handled. Furthermore, it provides information on determining ownership of Native American human remains and associated funerary offerings found on Federal or tribal land. The law sets fines for persons illegally trafficking in Native American human remains and cultural items. It also establishes a review committee to monitor the inventory and repatriation process and to assist in dispute resolutions arising from the law. Meeting the requirements of this act will be required if Federal funding for the project is provided.

**Clean Air Act of 1963, as Amended**

This act requires that any Federal entity engaged in an activity that may result in the discharge of air pollutants must comply with all applicable air pollution control laws and regulations including Federal, State, and local laws.

## *State Regulatory Issues – Recharge*

Recharge of groundwater is required to comply with Federal and State water quality standards. . If recharge is taking place along a stream channel, a Federal NPDES permit is required. Outside of a stream, recharge projects can either be done through an Aquifer Protection Permit (APP) or through Arizona's Title 45 process. Under Title 45, ADWR requires recharge facilities within Active Management Areas to obtain up to three permits. Although it is not strictly required to obtain ADWR permits in order to recharge water outside of Active Management Areas, Reclamation recommends that the USPP comply with State permit guidelines. The guidelines ensure that recharge is effective and does not cause harm to other entities. The required studies can also be used to implement a maintenance, monitoring, and operational regime that ensures optimum recharge efficiency.

An **Underground Storage Facility (USF) Permit** (A.R.S. § 45-811.01) allows the permit holder to operate a facility that stores water in the aquifer. The criteria a USF must meet in order to be permitted include:

1. The applicant must demonstrate financial and technical capability
2. The project must be hydrologically feasible
3. The project may not cause unreasonable harm to land or other water users within the area of impact
4. The applicant must agree in writing to obtain any required floodplain use permit from the county flood control district before beginning any construction activities
5. The director of environmental quality has determined that the facility is not in a location that will cause the migration of a contaminant plume or poor quality groundwater or will not cause pollutants to be leached, so as to cause unreasonable harm.

A Constructed Underground Storage Facility Permit allows for water to be stored in an aquifer by using some type of constructed device, such as an injection well or percolation basin.

A Managed Underground Storage Facility Permit allows for water to be discharged to a naturally water-transmissive area such as a streambed that allows the water to percolate into the aquifer without the assistance of a constructed device. All surface flows entering and exiting a managed underground storage facility must be measured at the facility boundaries in a manner consistent with the Department's measuring device rules (R12-15-905 & 906)

A **Water Storage (WS) Permit** (A.R.S. § 45-831.01) allows the permit holder to store water at a USF

A **Recovery Well (RW) Permit** (A.R.S. § 45-834.01) allows the permit holder to recover long-term storage credits or to recover stored water annually. The impact of recovering stored water in the proposed location must not damage other land and water users, as noted in the adopted well spacing and impact rules (R12-15-830 & 840). An impact analysis is required under certain circumstances

Although recharge of CAP water and other non-effluent waters is exempt from Arizona Aquifer Protection Permit requirements (A.R.S.§ 49-250(B)(12) and (13)), if a permit to operate a recharge facility is secured under Title 45, any discharge must still comply with Arizona Water Quality Standards. This exemption from the APP program should expedite recharge permitting of non-effluent water while still providing ample protection to the aquifer through permit and monitoring requirements.

## E. Preliminary Cost/Benefit Analysis for Water Conservation, Reclamation and Augmentation Alternatives for the Sierra Vista Sub-Watershed

# Preliminary Cost/Benefit Analysis for Water Conservation, Reclamation and Augmentation Alternatives for the Sierra Vista Sub-Watershed

## Volume 1: Report

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**Category:** WATER IMPORTATION/EXPORTATION

***Alternative Name: (WIE1) Move Municipal Wells to the Douglas INA***

This alternative involves moving municipal wells located in the Sierra Vista Subwatershed into the Douglas INA. This alternative has been subdivided into three sub-alternatives, namely: WIE 1a - Bisbee; WIE 1b - Tombstone; and WIE 1c - Sierra Vista/Fort Huachuca. General discussion and initial assumptions on these alternatives are collectively discussed in the section immediately following. More detailed discussion of each alternative and the results of subsequent evaluations then follow.

1. ***How might it function:***

   There are two possible alternatives for moving service area wells for Bisbee, Tombstone and Sierra Vista/Fort Huachuca wells into the Douglas INA: 1) Purchase existing irrigation wells located in the Douglas Basin and convert them to municipal use; or 2) Purchase/lease property on which to locate new wells to supply municipal needs in the Sierra Vista Subwatershed.

   Purchasing existing wells will require identifying wells that have sufficient capacity and adequate water quality to meet Sierra Vista Subwatershed's needs. Owners of the wells would have to be willing to sell and possibly go out of the agricultural business. Wells would likely require the installation of new surface seals and may need other retrofitting to be suitable for drinking water use.

   A professional judgement was made in not pricing out the purchase of existing agriculture wells, because of study team's prior experience in rehabilitating/converting agricultural wells. Items taken into consideration were the location of existing wells may not be convenient to access and could potentially drive up pipeline cost. Secondly, drinking water wells are screened to extract water of the best quality and many agricultural wells draw water from throughout the aquifer without regard to quality. Thirdly, finding the well design data is often impossible with older wells and these wells often have to be cleaned and videoed to find out screened intervals. Finally, once wells have been inspected, it is typical to find that the well casing is corroded and requires replacement. Newly constructed wells ensure that the target production zone is exploited.

   Locating a new well field(s) would require identifying areas where the aquifer was sufficiently productive and water quality was adequate. Exploration drilling would likely be required. Well locations would have to be sufficiently distant from other existing wells so as not to cause significant drawdown at the existing wells. The new wells would have to be designed, drilled, tested, and equipped.

   Either alternative will require the construction of conveyance pipelines from the new wells to the existing systems, as well as securing the rights-of-way for the pipeline. Several miles of the pipeline could have to be constructed in consolidated rock. Booster stations would be necessary to lift the water from the Douglas Basin to the municipalities of Bisbee, Tombstone, and Sierra Vista. The construction of any drinking water system would require approval by the Arizona Department of Environmental Quality.

These wells will need to be sited with consideration for impacts to existing users located in the contributing groundwater basin. The existing law on extending a service area to take in wells will also need to be taken into consideration or sought relief from.

Adjustments to the O&M costs of these alternatives have been made to account for savings that will accrue to water providers by not having to pump their existing wells.

2. ***How might it be implemented:***
Changes to Arizona statutes will be required if the proposed replacement well field is located outside of the Upper San Pedro Groundwater Basin. Much of the municipal water service of these communities is served by private water companies. With sufficient financial incentives and approval from the Arizona Corporation Commission, it is possible that their owners could be motivated to alter the system as proposed and limit or possibly terminate use of existing wells

It is also possible that an entity could be established that would develop the water supply and infrastructure and then either transfer the ownership in some fashion to the private water companies, or wholesale water to these utilities at a cost equivalent to their current well field production costs.

Water service in Tombstone is municipally controlled.

3. ***Who might be responsible:***
The Partnership or some sub-set thereof could serve as the negotiating entity. Then, the Partnership or a new entity could develop the required infrastructure to the delivery point of each water provider. The Partnership or the new entity may have to deal with water quality issues prior to its distribution of water from the pipeline.

4. ***Geographic area covered:***
Bisbee, Sierra Vista/Fort Huachuca, and Tombstone areas, either collectively or individually.

5. ***Who is conserving /contributing:***
All municipal customers whose water is imported would no longer be reliant on the Sierra Vista Subwatershed's groundwater system.

6. ***When implemented:***
Would require more than five years to implement.

7. ***Potential parties impacted/types of impacts:***
All municipal providers would be impacted by changes to their systems. Farmers within the Douglas INA could be impacted by additional pumping from the aquifer that they utilize. All municipal water users may see higher rates.

8. ***Comments and suggestions:***
There are efforts underway to recharge effluent throughout the Sierra Vista Subwatershed. Importation of the full supply and recharging the resultant effluent within the subwatershed would have a positive impact on the water budget.

Alternatively, to the extent these efforts are successful, the need to import the full volume of demands could be lessened by the volume of effluent recharged to balance the water budget of each large municipal user.

***Yield Estimates***

| | Alternative | Annual Yield for Year 2000 | Incremental Yields | Cumulative Yields as of Year 2010 |
|---|---|---|---|---|
| Bisbee | Composite WIE 1 | 8,600 | 1,560 | 10,160 |
| | WIE 1a | 1,000 | 10 | 1010 |
| Tombstone | WIE 1b | 250 | 20 | 270 |
| SV/Fort | WIE 1c | 7,350 | 1,530 | 8,880 |

***Cost Estimates in Constant 2000 Dollars***

| | Alternative | Annual C/Y Ratio ($/AF) | PV C/Y Ratio ($/AF) |
|---|---|---|---|
| Bisbee | Composite WIE 1 | $950 | $12,916 |
| | WIE 1a | $689 | $9,366 |
| Tombstone | WIE 1b | $1,072 | $14,556 |
| SV/Fort | WIE 1c | $976 | $13,270 |

| | Alternative | Annual Cost | Up-Front Capital | Present Value Cost |
|---|---|---|---|---|
| Bisbee | Composite WIE 1 | $9,656,384 | $99,300,264 | $131,229,000 |
| | WIE 1a | $696,060 | $6,465,760 | $9,460,000 |
| Tombstone | WIE 1b | $289,493 | $3,256,904 | $3,930,000 |
| SV/Fort | WIE 1c | $8,670,831 | $89,577,600 | $117,839,000 |

***Level of Uncertainty***

The cost and yield estimate for this alternative has an uncertainty level of about 50%.

### *Overlaps, Conflicts and Potential Synergies*

This alternative overlaps with the other water importation alternatives. To the extent reuse of wastewater alternatives are implemented, those alternatives may reduce the scale of the water importation alternatives.

### *Phase II Analysis*

Further analysis conducted for each alternative is presented below. Adjustments were made to the assumed volume of imported water in accordance with the following table.

## Water Importation Demands
## Used Overall Assumption-Water Use Baseline
## Sierra Vista Watershed
Baseline Projections — Arizona DES/SEAGO Population Forecast

| | 2000 | | | 2010 | | | 2020 | | |
|---|---|---|---|---|---|---|---|---|---|
| **Area** | **Demand** | **Effluent*** | **Importation Volume** | **Demand** | **Effluent*** | **Importation Volume** | **Demand** | **Effluent*** | **Importation Volume** |
| Sierra Vista City (excluding Ft. Huachuca)** | 5,100 | 2,464 | 2,636 | 6,880 | 3,360 | 3,520 | 7,910 | 3,793 | 4,118 |
| Tombstone City | 250 | 125 | 125 | 270 | 135 | 135 | 270 | 135 | 135 |
| Bisbee City | 1,000 | 605 | 395 | 1,010 | 633 | 377 | 1,100 | 550 | 550 |
| Huachuca City | 275 | 56 | 219 | 350 | 62 | 288 | 370 | 185 | 185 |
| Subtotal Municipal Population | 6,625 | 3,250 | 3,375 | 8,510 | 4,190 | 4,320 | 9,650 | 4,663 | 4,988 |
| Ft. Huachuca | 1,855 | 928 | 928 | 1,200 | 600 | 600 | 1,200 | 600 | 600 |
| Unincorporated Residents*** | 4,130 | | | 4,790 | | | 5,360 | | |
| Subbasin Total Water Use | 12,610 | 4,178 | | 14,500 | 4,790 | | 16,210 | 5,263 | |

*Effluent volumes based on reported flows escallated with growth in 2010 and 2020. (Ft. Huachuca and Tombstone flows based on 50% of demands.)
**Demands include PDS Golf Course use.
***Assumes no effluent available from unincorporated areas.

***Move all of Sierra Vista, Ft. Huachuca, Huachuca City, and Bisbee Pumping Demands to the Douglas Basin***

This alternative involves moving municipal wells that serve the Sierra Vista (SV), Ft. Huachuca (FH), Huachuca City (HC), and Bisbee areas into the Douglas Basin. The proposed location of the SV, FH, and HC well field will be in D(22-26)6; whereas the proposed location of the Bisbee well field will be in D(22-26)31. This could be accomplished by either purchasing existing wells or purchasing property to locate new wells in the Douglas Basin. A pipeline from the new Douglas Basin wells to Sierra Vista will need to be constructed, as will a pipeline from the new Bisbee well field to Bisbee.

In order to simplify the modeling effort, one model simulation will be run for the SV, FH, and HC well field, which includes the Bisbee demands. Two well locations are modeled using WINFLOW, a two-dimensional groundwater flow software package. The wells are located in D(22-20)6, and each well, based on the assumed water demands in 2020, pumped at a rate of 5,480 AF/Y (3,397 GPM) (Figure 1). The following assumptions are made:

a) the primary aquifer is assumed confined,
b) the static water level and the top of the aquifer is approximately 4,010 feet above mean sea level (MSL),
c) the base of the aquifer is at 3,280 feet above MSL,
d) the hydraulic conductivity is assumed to be 8 feet/day, and
e) the storage coefficient is assumed to be 0.0017.

It is interpreted that the inner diameter of the well casing required to pump at the required rate and head would be 0.892 feet (10.7 inches) in radius.

The resultant drawdown in either well is 316 feet below static water level or 3,694 feet above MSL. The groundwater level at the end of 100 years of continuous pumping will be 414 feet above the base of the aquifer, which demonstrates the physical availability of groundwater.

This modeling represents a simplified first cut at feasibility. It would likely require more wells than modeled to implement the alternative. This would have the effect of distributing pumping and its associated impacts and would likely result in drawdowns less than those predicted herein.

### *WIE 1a – Move Bisbee Wells to the Douglas Basin*

This alternative consists of moving the wells that serve the Town of Bisbee away from the Sierra Vista Subwatershed into the Douglas Basin. Current demands at Bisbee are estimated to be 1,000 acre-feet per year. Future demand (year 2010) of Bisbee is estimated to be 1,010 acre-feet per year. Under this alternative, this supply would be pumped from wells to be located in the Douglas Basin and transported to Bisbee via a newly constructed pipeline. An alternative assuming successful recharge of effluent at a rate of 50% of the base municipal demands has also been evaluated. Importation was reduced by the assumed volume of recharge.

#### Relative Advantages and Disadvantages of Moving Bisbee Wells to the Douglas Basin

Replacing Bisbee's Upper San Pedro Basin pumping with Douglas Basin pumping would have a direct and immediate impact on the water budget of the Sierra Vista Subwatershed. The water provider for the Town of Bisbee is the Arizona Water Company (AWC). The current AWC well field is located approximately 10 miles from the San Pedro River. Consequently, direct and appreciable changes to the River in response to this proposed elimination of pumping may not be immediately discernable.

In addition, if Bisbee's effluent, derived from base demands imported from the Douglas Basin, were to be either reused or recharged in the Sierra Vista Subwatershed, Bisbee's water use could actually augment the San Pedro's water supplies.

The Douglas Basin has proven itself capable of sustaining significant volumes of groundwater pumping to supply agricultural uses. ADWR (1994) estimated that an average of 110,000 acre-feet was pumped from the basin annually in the early 1970s. By 1986, pumping had been reduced to 38,000 acre-feet per year. ADWR predicted long-term agricultural pumping to be 49,000 acre-feet per year, although if current economic conditions in the agricultural sector do not change, the pumpage will likely not approach this level. Additional demands for Municipal and Industrial (M&I) and mining purposes are projected to be 8,000 and 1,000 acre-feet annually, respectively, in 2040. In 1990, M&I pumping was estimated at 4,000 acre-feet per year. Additional unquantified M&I demands exist on the Mexican side of the border, where local water supply issues are being experienced.

Bisbee sits on the divide between the Douglas and Upper San Pedro basins. A significant portion of the current demands for Bisbee are served from the Upper San Pedro Basin, but are located in the Douglas Basin and actually represent a transfer of water out of the Sierra Vista Subwatershed. This transfer has been occurring for over 50 years.

While there is significant wildlife habitat along Whitewater Draw, this community does not appear to be supported by a water supply in direct hydrologic connection with the Douglas Basin groundwater system. Whitewater Draw is classified as ephemeral along its entire reach. Depth to groundwater along Whitewater Draw is in excess of 50 feet below ground surface throughout the basin (Rascona, 1993).

In order to assist in the demonstration of the capability to serve the proposed exports, the study team has conducted groundwater modeling to evaluate the stresses imposed by serving the demands of Bisbee, Huachuca City, Fort Huachuca and Sierra Vista from the Douglas Basin. The results of this effort are presented in Appendix 2. The estimated aquifer drawdowns attributable to pumping to serve the entire demands of Bisbee, Huachuca City, Fort Huachuca and Sierra Vista are 414 feet in a simulated well field with 2 wells after 100 years of pumping. Accommodating just the Bisbee pumping from Douglas would result in far smaller water level declines. Further, splitting the pumping between recharge/recovery in the Sierra Vista Subwatershed and pumping in the Douglas Basin would further reduce the projected impact to the Douglas Basin.

## Cost Criteria

- Capital Intensity

  The following table summarizes the cost estimates for importing water from the Douglas Basin to the City of Bisbee. The costs are estimated under two alternatives: (1) full demand served from Douglas and (2) demands offset by assumed effluent recharge imported from Douglas. These importation costs are summarized in the table below and will be offset by savings that will accrue to water providers not pumping their wells that currently serve their customers.

**Bisbee from Douglas**

| Without Effluent Recharge | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Costs | | | | | | | |
| | Imported | | O&M | | | Total | Present | CY Ratio ($/AF) | |
| Year | Water (AF) | Capital | Annual | Saved | Net | Annual | Value | Annual | PV |
| 2000 | 1,000 | $ 6,465,760 | $ 416,000 | $ 199,000 | $ 217,000 | $ 692,880 | $ 9,416,000 | $ 693 | $ 9,416 |
| 2010 | 1,010 | $ 6,465,760 | $ 421,170 | $ 200,990 | $ 220,180 | $ 696,060 | $ 9,460,000 | $ 689 | $ 9,366 |
| With Effluent Recharge | | | | | | | | | |
| 2000 | 395 | $ 3,940,400 | $ 158,000 | $ 78,605 | $ 79,395 | $ 569,408 | $ 7,738,000 | $ 1,442 | $ 19,590 |
| 2010 | 377 | $ 3,940,400 | $ 151,177 | $ 75,023 | $ 76,154 | $ 566,167 | $ 7,694,000 | $ 1,502 | $ 20,408 |

- Cost Uncertainty

  At full importation, it is assumed that at least 2 wells would be constructed in the Douglas Basin to serve the Town of Bisbee and that a 10-inch, 17 mile pipeline would be needed to bring water to Bisbee. These cost estimates are based on producing and transporting all of Bisbee's demands from the Douglas Basin.

  The effluent recharge alternative reduces the numbers of wells to 1 and reduces the pipeline diameter from 10 inch to 8 inch. Even if effluent recharge was taken into account redundancy is still required in the water delivery system and existing wells in the Sierra Vista Subwatershed would still be required as backup for emergency situations.

The costs of importation are relatively certain and have been determined by current costs for materials and construction. Costs for the development of effluent recharge facilities are not included in the overall cost contained herein and would be necessary to implement the reduced importation scenario.

The O&M Saved column in the above table is a reflection of costs not incurred for pumping in the existing wells that were replaced for this alternative.

**Implementation/Administration Criteria**

- Ease of Implementation

  The Arizona Revised Statutes (A.R.S) §§ 45-544 and 45-545 govern groundwater transport between subwatersheds (outside of Active Management Areas).

  A.R.S. § 45-544 allows for the transportation of water between subwatersheds of the same groundwater basins, subject to the payment of damages. This statute does not allow for the transportation of water between groundwater basins, except in specific identified cases.

  A.R.S. § 45-545 defines the damage rules for the transportation of water. The statute states that neither injury nor impairment of water supply should be presumed by the transportation of water away from the subwatershed. In assessing whether damages and/or injuries have occurred because of the transportation of water, the court shall take into account actions the transporter of water has taken toward mitigation. These efforts include:

  - Retirement of land from irrigation,
  - Discontinuance of pre-existing uses of groundwater,
  - Water conservation techniques, and
  - Procurement of additional sources of water which benefit the subwatershed.

  While A.R.S. § 45-544 excludes the transportation of water between groundwater basins, significant portions of the developed portions of Bisbee are located in the Douglas Basin. It is likely that significant volumes of water could be transported from the water bearing portions of the Douglas Basin under current state law.

  As stated above, exemptions have been written into state law to allow for transportation of groundwater between basins. For the most part, these exemptions were adopted during passage of the transportation statutes to protect prior investments of parties (primarily Phoenix area municipalities) intending to transfer groundwater from a basin. It may be possible to get such an exemption to cover the transportation of groundwater from the Douglas Basin to augment the water supplies of the Sierra Vista Subwatershed.

- Ease of Administration

  Administration of this program would likely be relatively easy, likely consisting of metering well production and the filing of annual reports to the proper state agencies documenting pumping. If mitigation measures, such as those described under A.R.S. § 45-545 above are required, documenting efforts and the effectiveness of the measures may make reporting more burdensome.

**Summary of Pros and Cons**

This alternative likely represents a viable replacement supply for Bisbee. The necessary pumping to meet Bisbee's demands are a small portion of current pumping, and far less than the pumping experienced at the height of agricultural production in the Douglas Basin. The primary drainage in the Douglas Basin, Whitewater Draw, is an ephemeral stream. This is significant wildlife habitat along Whitewater Draw but it is not believed to be reliant on the regional groundwater system. As such, large scale groundwater pumping is not likely to have a significant impact on wildlife.

Freethy and Anderson (1986) estimated groundwater recharge for the Douglas Basin to be 22,000 acre-feet per year. More recent estimates limit recharge to 17,000 acre-feet per year (EEC, 2002). All current withdrawals in excess of these amounts could be considered to be groundwater mining. Imposing additional pumping to serve Bisbee would exacerbate that mining condition. The sustainability of this program would be a function of the volume of water in storage in the Basin and changes in long-term demands. Eventually, this supply would also need to be replaced. Additional poorly quantified demands exist in Agua Prieta on the Mexican side of the international border.

Capital costs are high for this alternative due to the necessary costs of the drilling of wells and construction of the pipeline. A portion of these costs may be offset to a degree by acquiring existing wells.

Local opposition and state law may present barriers to implementation.

***WIE 1b – Move Tombstone's Water Supply to the Douglas Basin***

This alternative consists of serving the City of Tombstone from the Douglas Basin. The alternative relies on use of the pipeline that is envisioned to serve Sierra Vista and Fort Huachuca in alternative WIE 1c that follows this discussion (Replacing the pipeline that serves Tombstone from springs in the Huachuca Mountains with groundwater from the Douglas Basin as a stand alone project is evaluated in alternative WIE 4). Current demands at Tombstone are estimated to be 250 acre-feet per year. Future demand (year 2010) of Tombstone is estimated to be 270 acre-feet per year. Under this alternative, this supply would be pumped from wells to be located in the Douglas Basin and transported to Tombstone via a newly constructed spur pipeline from the main pipeline that would serve Sierra Vista and environs from the Douglas Basin.

**Cost Criteria**

- Capital Intensity

  The following table summarizes the cost estimates for importing water from the Douglas Basin to the City of Tombstone. These importation costs are summarized in the table below and may be offset by savings that will accrue to the City by not having to operate its current wells or its surface water treatment plant. These offsets have not been quantified for this alternative.

**Tombstone from Douglas INA**

| Year | Yield Imported Water | Costs Capital | Costs O&M | Costs Total Annual Cost | Costs Present Value | CY Ratio ($/AF) Annual | CY Ratio ($/AF) Present Value |
|---|---|---|---|---|---|---|---|
| 2000 | 250 | $3,256,904 | $46,907 | $285,806 | $3,884,000 | $1,143 | $15,536 |
| 2010 | 270 | $3,256,904 | $49,785 | $289,493 | $3,930,000 | $1,072 | $14,556 |

- Cost Uncertainty

  At full importation, it is assumed that one well would be constructed in the Douglas Basin to serve the Town of Tombstone and that a 6-inch, 15 mile spur pipeline would be constructed from the Sierra Vista pipeline to bring water to Tombstone. Accommodating Tombstone's demands in this larger pipeline did not require upsizing. These cost estimates are based on producing and transporting all of Tombstone's demands from the Douglas Basin.

  The costs of importation are relatively certain and have been determined by current costs for materials and construction.

**Implementation/Administration Criteria**

- Ease of Implementation

  The Arizona Revised Statutes (A.R.S) §§ 45-544 and 45-545 govern groundwater transport between subwatersheds (outside of Active Management Areas). Implementation of this alternative would require changing existing law. More detailed discussion of implementation is found in WIE 1c, below.

- Ease of Administration

  Administration of this program would likely be relatively easy, likely consisting of metering well production, water quality, and the filing of annual reports to the proper state agencies documenting pumping. If mitigation measures, such as those described under A.R.S. § 45-545 above are required, documenting efforts and the effectiveness of the measures may make reporting more burdensome.

### *WIE 1c – Move Sierra Vista, Fort Huachuca and Huachuca City Wells to the Douglas Basin*

This alternative consists of moving the wells that serve the Sierra Vista, Fort Huachuca, and Huachuca City away from the Sierra Vista Subwatershed into the Douglas Basin. Replacement of all current and future demand is estimated to be 8,430 acre-feet per year and would then be brought to the area via pipeline. An alternative assuming successful recharge of effluent at a rate of 50% of the base municipal demands has also been evaluated. Importation was reduced by the assumed volume of recharge.

**Relative Advantages and Disadvantages of Moving Sierra Vista, Fort Huachuca and Huachuca City Wells to the Douglas Basin**

Replacing Sierra Vista, Fort Huachuca and Huachuca City's Upper San Pedro pumping with Douglas Basin pumping would have a large direct and immediate impact on the water budget of the Sierra Vista Subwatershed. There is not general agreement on the impact of withdrawals to serve these communities and the Fort, but any long-term threat to the baseflows of the San Pedro River would be eliminated for as long as the supplies came from elsewhere.

As with the Bisbee alternative, if these communities' effluent, derived from base demands imported from the Douglas Basin, were to be either reused or recharged in the Upper San Pedro, these water uses could actually augment the San Pedro's water supplies. Alternatively, the volume of water imported could be reduced by the volume recharged and achieve a zero net impact of the water budget of the Sierra Vista Subwatershed.

The Douglas Basin has proven itself capable of sustaining significant volumes of groundwater pumping to supply agricultural uses. ADWR (1994) estimated that an average of 110,000 acre-feet was pumped from the basin annually in the early 1970s. By 1986, pumping had been reduced to 38,000 acre-feet per year. ADWR predicted long-term agricultural pumping to be 49,000 acre-feet per year, although if current economic conditions in the agricultural sector do not change, the pumpage will likely not approach this level. Additional demands for M&I and mining purposes are projected to be 8,000 and 1,000 acre-feet annually, respectively, in 2040. In 1990, M&I pumping was estimated at 4,000 acre-feet per year. Additional unquantified M&I demands exist on the Mexican side of the border, where local water supply shortages are being experienced.

All of these water demands would be considered a trans-basin transfer, and would require a change in Arizona state law.

While there is significant wildlife habitat along Whitewater Draw, this community does not appear to be supported by a water supply in direct hydrologic connection with the Douglas Basin groundwater system. Whitewater Draw is classified as ephemeral along its entire reach. Depth to groundwater along Whitewater Draw is in excess of 50 feet below ground surface throughout the basin (Rascona, 1993).

In order to assist in the demonstration of the capability to serve the proposed exports, the study team has conducted groundwater modeling to evaluate the stresses imposed by serving the demands of Bisbee, Huachuca City, Fort Huachuca and Sierra Vista from the Douglas Basin. The results of this effort are presented in Appendix 2 The estimated aquifer drawdowns attributable to pumping to serve the entire demands of Bisbee, Huachuca City, Fort Huachuca and Sierra Vista are 414 feet in a simulated well field with 2 wells after 100 years of pumping. 414 feet of groundwater would remain above the assumed base of the aquifer. Accommodating just the Sierra Vista/Fort Huachuca/Huachuca City pumping from Douglas would result in smaller water level declines. Further, splitting the pumping between recharge/recovery in the Sierra Vista Subwatershed and pumping in the Douglas Basin would further reduce the projected impact to the Douglas Basin. Pumping from additional wells, as anticipated in the cost estimates, would distribute the impact of the pumping further and reduce the estimated drawdown than the simplified impact analysis. While more detailed evaluations are required, this preliminary analysis implies that the water resources are present in the Douglas Basin to implement this alternative.

**Cost Criteria**

- Capital Intensity

The following table summarizes the cost estimates for importing water from the Douglas Basin to serve Sierra Vista, Fort Huachuca and Tombstone. The costs are estimated under two alternatives: (1) full demand served from Douglas and (2) demands offset by assumed recharge imported from Douglas. These costs, summarized in the table below, will be offset savings that will accrue to water providers not pumping the wells that currently serve their customers.

**SV/FtH/HC Import from Douglas INA**

| Year | Imported Water (AF) | Costs: Capital | O&M: Annual | O&M: Saved | O&M: Net | Total Annual | Present Value | CY Ratio ($/AF): Annual | CY Ratio ($/AF): PV |
|---|---|---|---|---|---|---|---|---|---|
| Without Effluent Recharge | | | | | | | | | |
| 2000 | 7,230 | $88,877,600 | $2,154,540 | $ 542,250 | $1,612,290 | $8,153,681 | $ 110,811,000 | $1,128 | $15,327 |
| 2010 | 8,430 | $89,577,600 | $2,638,590 | $ 665,970 | $1,972,620 | $8,565,531 | $ 116,408,000 | $1,016 | $13,809 |
| With Effluent Recharge | | | | | | | | | |
| 2000 | 3,783 | $47,369,200 | $1,653,171 | $ 283,725 | $1,369,446 | $4,855,819 | $ 65,992,000 | $1,284 | $17,444 |
| 2010 | 4,148 | $54,847,200 | $1,746,308 | $ 311,100 | $1,435,208 | $5,471,962 | $ 74,366,000 | $1,319 | $17,928 |

- Cost Uncertainty

At full importation, it is assumed that at least 10 wells would be constructed in the Douglas Basin to serve Sierra Vista and Fort Huachuca and that a 24-inch, 54 mile pipeline would be needed to bring water to Sierra Vista. An additional well would be required for Tombstone, along with a 16 mile, 6-inch pipeline from the primary Sierra Vista pipeline to replace their supply. These cost estimates are based on producing and transporting all of the demands from the Douglas Basin.

The demands to serve Huachuca City have been included in the groundwater modeling. However, the cost of the pipeline from the transmission main to Huachuca City has not been included in the cost estimating for this alternative.

The effluent recharge alternative reduces the numbers of wells to 5 and reduces the pipeline diameter from 24 inch to 16 inch. The costs of effluent recharge have not been included in these costs.

The costs are relatively certain and have been determined by current costs for materials and construction.

The O&M Saved column in the above table is a reflection of costs not incurred for pumping in the existing wells that were replaced for this alternative.

**Implementation/Administration Criteria**

- Ease of Implementation

  The Arizona Revised Statutes (A.R.S) §§ 45-544 and 45-545 govern groundwater transport between subwatersheds (outside of Active Management Areas).

  While A.R.S. § 45-544 allows for the transportation of water between subwatersheds of the same groundwater basins, subject to the payment of damages, it does not does not allow for the transportation of water between groundwater basins, such as those proposed herein except in specific identified cases.

  While not directly applicable, A.R.S. § 45-545 defines the damage rules for the transportation of water. The statute states that neither injury nor impairment of water supply should be presumed by the transportation of water away from the sub-basin. In assessing whether damages and/or injuries have occurred because of the transportation of water, the court shall take into account actions the transporter of water has taken toward mitigation. These efforts include:

  - Retirement of land from irrigation,
  - Discontinuance of pre-existing uses of groundwater,
  - Water conservation techniques, and
  - Procurement of additional sources of water that benefit the subwatershed.

  Such measures may assist in gaining approval for the proposed trans-basin movement of water. State law would have to be amended to include delivery of water from the Douglas Basin to these communities for this transportation of groundwater between basins to occur.

- Ease of Administration

  Administration of this program would be relatively easy, likely consisting of metering well production, water quality sampling, and the filing of annual reports to the proper state agencies documenting pumping. Responsibility for water quality from the wells would be the responsibility of the implementing entity. If mitigation measures, such as those described under A.R.S. § 45-545 above are required, documenting efforts and the effectiveness of the measures may make reporting more burdensome.

**Summary of Pros and Cons**

This alternative may represent a viable replacement supply for Sierra Vista and Fort Huachuca. The hydrologic feasibility of long-term groundwater withdrawals to meet the needs of these communities will need to be explored in greater detail than the modeling presented in Appendix 2. The total groundwater pumping required to sustain this alternative is significantly less than the pumping experienced at the height of agricultural production in the Basin.

While there is significant wildlife habitat along Whitewater Draw, this community does not appear to be supported by a water supply in direct hydrologic connection with the Douglas Basin groundwater system. Whitewater Draw is classified as ephemeral along its entire reach. Depth to groundwater along Whitewater Draw is in excess of 50 feet below ground surface throughout the basin (Rascona, 1993).

Freethy and Anderson (1986) estimated groundwater recharge for the Douglas Basin to be 22,000 acre-feet per year. More recent estimates limit recharge to 17,000 acre-feet per year (EEC, 2002). All current withdrawals in excess of these amounts could be considered to be groundwater mining. Imposing additional pumping to serve Sierra Vista, et al. would exacerbate that mining condition. The sustainability of this program would be a function of the volume of water in storage in the Basin and changes in long-term demands. Eventually, this supply would also need to be replaced. Additional significant, but poorly quantified, demands exist in Agua Prieta on the Mexican side of the international border.

Capital costs are high for this alternative due to the necessary costs of the drilling of wells and construction of the pipeline. These costs may be offset to a degree by acquiring existing wells.

State law will need to be changed to implement this alternative. Local opposition is probable.

# Appendix 2

## INDIVIDUAL ALTERNATIVE ANALYSES

### Water Importation – Exportation

Assumptions for all WIE alternatives

Unit Costs

| | |
|---|---|
| Wells | $350,000 |
| 6” pipeline/ft | $ 35 |
| 10” pipeline/ft | $ 65 |
| 24” pipeline/ft | $ 225 |
| 30” pipeline/ft | $ 300 |

| | | |
|---|---|---|
| Assumptions | Well Capacity | 1,000 gpm |
| | Max Pipeline Velocity | 6 ft/sec |
| | Energy Costs | $0.09/KWH |

# Appendix 2

INDIVIDUAL ALTERNATIVE ANALYSES

## Water Importation – Exportation

### *WIE1 – Move Municipal Wells into Douglas INA*

WIE 1a) Move Bisbee Wells to Douglas Basin

Assumes Bisbee will require 2 new wells
Assumes pipeline length of 17 miles
Assumes pipe diameter of 10 inches

**Bisbee from Douglas**

| Without Effluent Recharge | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Costs | | | | | | CY Ratio ($/AF) | |
| | | | O&M | | | Total | Present | | |
| Year | Imported Water (AF) | Capital | Annual | Saved | Net | Annual | Value | Annual | PV |
| 2000 | 1,000 | $ 6,465,760 | $ 416,000 | $ 199,000 | $ 217,000 | $ 692,880 | $ 9,416,000 | $ 693 | $ 9,416 |
| 2010 | 1,010 | $ 6,465,760 | $ 421,170 | $ 200,990 | $ 220,180 | $ 696,060 | $ 9,460,000 | $ 689 | $ 9,366 |
| With Effluent Recharge | | | | | | | | | |
| 2000 | 395 | $ 3,940,400 | $ 158,000 | $ 78,605 | $ 79,395 | $ 569,408 | $ 7,738,000 | $ 1,442 | $ 19,590 |
| 2010 | 377 | $ 3,940,400 | $ 151,177 | $ 75,023 | $ 76,154 | $ 566,167 | $ 7,694,000 | $ 1,502 | $ 20,408 |

**Water Importation – Exportation**
***WIE1 – Move Municipal Wells into Douglas INA***
(Continued)

WIE 1b) Move wells into Douglas INA to serve Tombstone

Assumes Tombstone will require 1 well
Assumes pipeline length of 16 miles
Assumes pipe diameter of 6 inches

| Tombstone from Douglas INA | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Yield | Costs | | | | CY Ratio ($/AF) | |
| Year | Imported Water | Capital | O&M | Total Annual Cost | Present Value | Annual | Present Value |
| 2000 | 250 | $3,256,904 | $46,907 | $285,806 | $3,884,000 | $1,143 | $15,536 |
| 2010 | 270 | $3,256,904 | $49,785 | $289,493 | $3,930,000 | $1,072 | $14,556 |

# Appendix 2

INDIVIDUAL ALTERNATIVE ANALYSES

**Water Importation – Exportation**
***WIE1 – Move Municipal Wells into Douglas INA***
(Continued)
WIE 1c) Move Sierra Vista, Fort Huachuca and Huachuca City Wells into Douglas INA

Assumes SV/FH/HC will require 10 wells
Assumes pipeline length of 54 miles
Assumes pipe diameter of 24 inches

**SV/FtH/HC Import from Douglas**

| Year | Imported Water (AF) | Costs | | | | | | CY Ratio ($/AF) | |
|---|---|---|---|---|---|---|---|---|---|
| | | Capital | O&M Annual | O&M Saved | O&M Net | Total Annual | Present Value | Annual | PV |
| Without Effluent Recharge | | | | | | | | | |
| 2000 | 7,230 | $ 88,877,600 | $ 2,154,540 | $ 542,250 | $ 1,612,290 | $ 8,153,681 | $ 110,811,000 | $ 1,128 | $15,327 |
| 2010 | 8,430 | $ 89,577,600 | $ 2,638,590 | $ 665,970 | $ 1,972,620 | $ 8,565,531 | $ 116,408,000 | $ 1,016 | $13,809 |
| With Effluent Recharge | | | | | | | | | |
| 2000 | 3,783 | $ 47,369,200 | $ 1,653,171 | $ 283,725 | $ 1,369,446 | $ 4,855,819 | $ 65,992,000 | $ 1,284 | $17,444 |
| 2010 | 4,148 | $ 54,847,200 | $ 1,746,308 | $ 311,100 | $ 1,435,208 | $ 5,471,962 | $ 74,366,000 | $ 1,319 | $17,928 |

## E1. Summary of Data Gaps in the BBC / FS Douglas Water Importation Alternative

# Summary of Data Gaps in the BBC / FS Douglas Water Importation Alternative

Final
May 17, 2006

Introduction:
Reclamation personnel examined all alternatives considering importation of groundwater from the Douglas, Arizona watershed, discussed in the report, "Preliminary Cost/Benefit Analysis for Water Conservation, Reclamation and Augmentation Alternatives for the Sierra Vista Sub-Watershed". This report was prepared for the Upper San Pedro Partnership by Fluid Solutions and BBC Research and Consulting in November, 2003. This report shall subsequently be referred to as the "BBC/FS Report."

These alternatives were included in the BBC/FS report as part of the category of water importation/exportation (WIE). Alternatives describing importation of groundwater from the Douglas Basin are referred to as "WIE 1: Move Municipal Wells to the Douglas INA".

This alternative was further subdivided into three separate options:

WIE 1a: Move Bisbee Wells to the Douglas Basin
WIE 1b: Move Tombstone's Water Supply to the Douglas Basin
WIE 1c: Move Sierra Vista, Fort Huachuca and Huachuca City Wells to the Douglas Basin

The following analysis is based on the discussion of the three options in Volume 1, Chapter 4, pages 122 -136 and Appendix 2, pages 112 – 115. Unless specifically stated, the comments refer all three options.

The BBC/FS Report content is typical of what might be expected of a scoping or appraisal level analysis. The report was published prior to establishing a clear concise problem statement and criteria by which one could ascertain how well an alternative would address the problem. The report lacks a comparison that documents the evaluation process, as requested by the USPP.

Summary:

The BBC/FS Report significantly understates the cost of importing groundwater from the Douglas Basin to Bisbee, Tombstone and the Sierra Vista area. Essential elements of the project are not discussed, such as the required structures and routes the pipelines would take. The pipes for which costs are given are undersized and will not accommodate summer peak demand or emergency outages. The sites identified for new wells may be impractical, and longer pipelines may be required, depending on the hydrologic conditions in the Douglas Basin.

In addition, the report does not discuss the biological or cultural resources that would be impacted by the project, or the costs of investigating and mitigating them. The legal and institutional analysis is brief and does not discuss unsuccessful attempts by several municipalities to import groundwater from other basins.

The BBC/FS report presents two sets of numbers, one where all demand is served through importation of groundwater, and another where demand is reduced by assuming that 50% of effluent will be recharged. Demand is calculated from population estimates, and represents water use by consumers. If effluent is to be used to satisfy consumer demand and thereby reduce the amount of groundwater imported, there must be infrastructure included to recover, treat and deliver the effluent. However, these costs are not included in the cost estimates.

A map developed by Reclamation, showing the locations of elements of the Douglas alternative, is attached at the end of this document.

Engineering Data Gaps:

- The report lacks identification and descriptions of structures which would be required. This is typical of appraisal level reports. At a minimum, these should include well pumps, collection pipelines, storage tanks, booster pump systems and control equipment.

- Routes for Bisbee to Douglas (WIE 1a), Tombstone to Douglas (WIE 1b) and Sierra Vista, Fort Huachuca and Huachuca City to Douglas (WIE 1c) pipelines are not shown or discussed.

- No delivery points in the receiving towns were identified. It is necessary to do this so that alternative routes can be identified and the pipeline layout can be optimized.

- Pipeline transport hydraulics are needed to determine costs. (This requires the identification of a route.)

- In order to adequately evaluate the viability of this alternative, a report would need to address the hydrologic conditions in the Douglas Basin. Reclamation's cursory review of pumping in the Douglas basin, with information provided by ADWR, indicates there is a history of significant pumping demand and corresponding water level drops. Identifying a productive pumping site where drawdown would not interfere with flow would be essential. The pumping sites should also avoid degradation of environmentally sensitive locations, such as riparian areas. These factors may greatly influence the location of the wells, and therefore the length and cost of the pipelines.

- For the Bisbee to Douglas (WIE 1a) pipeline, a 10 inch diameter pipe would accommodate only 1.5 times the average annual flow. If local wells are not to be maintained, as is done in the BBC/FS report, the pipe will also have to accommodate emergency storage as well as summer peaking, and should be sized at 3 to 5 times average annual demand. A design that would allow peak demand and emergency storage to be served from local wells, and maintain the 10 inch pipe size would be preferable. Either way, the cost of the alternative will be higher than stated in the BBC/FS report.

- For the Tombstone and SV, Ft. Huachuca, Huachuca City option (WIE 1b and WIE 1c) the 24 inch pipe inch diameter pipe would accommodate only 1.5 times the average annual flow of 8,430 AFY. There is no capacity allowed for summer peaking and emergency storage. A pipe sized for 3 to 5 times average annual flow is required if these uses are to be accommodated, which will increase the cost of the project significantly. These expenses would need to be included in the cost estimate.

- No mention of environmental, cultural, biological and NEPA compliance issues and associated costs, except for a short comment on probable effects on Whitewater Draw.

- Pipe costs for delivery to Huachuca City were not included in cost estimates.

<u>Groundwater Modeling Discussion:</u>

- The model assumed a confined or semi-confined aquifer conditions, but did not look at the possibility of having an unconfined aquifer which would result in larger drawdowns.

  *Technical Explanation:* The stated aquifer parameter assumptions on page 127 appear to be reasonable for a confined or semi-confined aquifer. However, if the real aquifer will be dewatered due to pumping, then this "confined" assumption in the modeling portrays a more "rosy" situation (i.e., will understate the real pumping drawdown impacts).

- The report did not discuss how demand would be allocated among several wells, which could affect the predicted drawdown and increase the cost.

  *Technical Explanation*: The report states that the Bisbee alternative would develop two wells in the Douglas sub-basin, and that the Sierra Vista / Fort Huachuca alternative would require 5 to 10 wells, depending on whether effluent supplies are factored in. Page 127 is ambiguous on how the SV pumping demands were allocated to the wells in the model, as well as the inclusion of the Bisbee demands.

  If 3,397 gpm is being simulated in the model from each of two wells, when in fact that pumpage should be derived from several different wells at different locations (each at smaller pump rates), then the model could be over-predicting the 100-year drawdowns stated on page 127 <u>at the well.</u> The model should have used an observation grid (unless it did and it was not mentioned) that simulated drawdowns at some location away from the pumping well itself. This would convey a more reasonable drawdown projection 100 years in the future.

Note: The location D(22-20)6 for the SV well field seems to be a typo from the location given above on page 127 of D(22-26)6.

Additional data gaps:

- Unlike the BOR Benson alternative, the BBS/FS Douglas alternative does not attempt make up for exporting water by retiring an equal or greater amount of agricultural demand. It is likely that this will be necessary in order to make this alternative politically acceptable to residents of the Douglas Basin.

- The BBC/FS Report repeatedly states that the volume of water transported in the Douglas alternative can be reduced by reusing effluent. However, it does not include the costs for expanding for reusing effluent directly. This cost should be included in an alternative that includes effluent reuse.

Actions necessary to provide the same information as that provided in Reclamation reports:

Better data and analysis are necessary to identify delivery points and determine collection points. The following steps are required:

- Get a list of the local wells and examine well conditions and water levels to find a preliminary well location.

- Identify well locations and cost to run power to wells.

- Determine whether to rehabilitate existing wells or drill new ones, and all associated costs.

- Determine who owns the land and what rights are attached to the property to be acquired, as well as any property-related legal or regulatory issues. For the Reclamation Benson alternative this information was provided by TNC and ADWR.

- Identify additional agricultural land that could be retired to offset planned pumping, determine cost of land acquisition. For the Reclamation Benson alternative this information was provided by TNC.

- Layout pipe collection and distribution system. A fixed number of delivery points must be defined in order to figure out the number of routes and to optimize pipe sizes.

- Provide sizing and costs for individual or combined systems of collection and delivery points. Determine optimal configuration for the Douglas to Bisbee, Douglas to Tombstone, Douglas to Sierra Vista, Ft. Huachuca, and Huachuca City, and all possible combinations that would affect the cost per unit delivered.

- Identify type of pipe and layouts, pumps, other facilities, operation and personnel, maintenance and associate costs for all these factors.

- Identify capacity for emergency outages, whether in the form of a reservoir requiring larger pipe sizes, or by keeping existing SVSW groundwater pumps operational in case of an emergency outage. These costs must be included as part of the total project costs.

- Perform area geological investigation for construction cost factors.

- Investigate environmental, permitting and legal issues with transporting the water from Douglas area. The same types of issues will need to be examined with regard to delivering the water to the Sierra Vista Subwatershed.

- Address legal issues in more in depth. Existing water laws that allow or restrict agreements to transfer water between basins should be investigated. So should the results of attempts by Scottsdale and Tucson to acquire water outside of their basins.

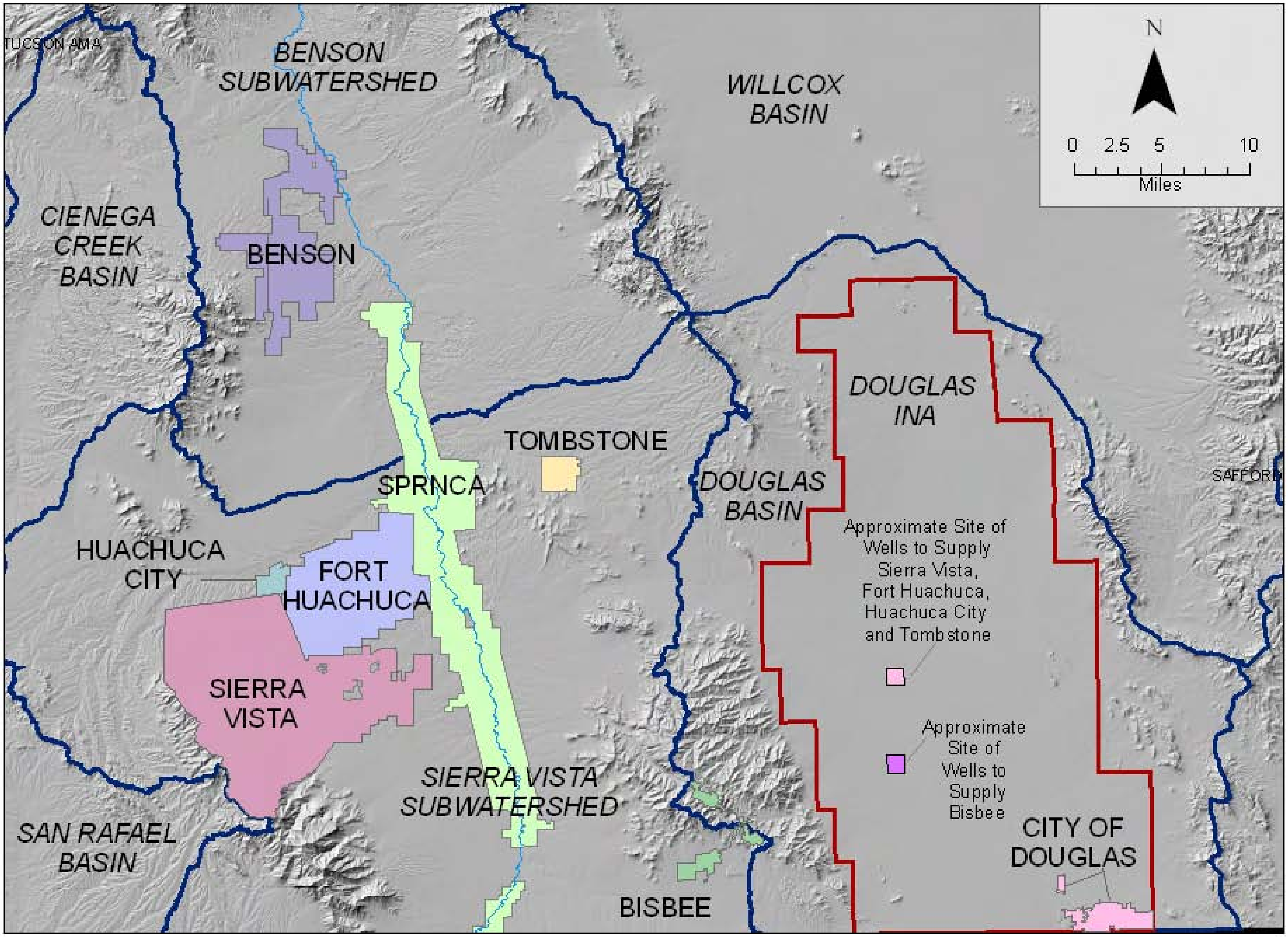
- Identify possible impacts to habitat for threatened and endangered species as well other environmentally sensitive areas and necessary mitigation measures

- Identify cultural resources that may be impacted by pipeline construction and necessary mitigation measures.

- Investigate all necessary permits, reviews and other actions needed to comply with the National Environmental Policy Act, which is required if Federal funding is provided for the project.

Note: Data for the Douglas basin is not as easily available and would require more work to obtain than more developed areas of the state.

Location Map for BBC/FS Douglas to Sierra Vista, Tombstone and Bisbee Augmentation Alternatives




May 16, 2006

# F. Appraisal Study of the Water Development Potential of Rainwater Collection for New Residential Communities and New Commercial/Industrial Businesses

# Appraisal Study of the Water Development Potential of Rainwater Collection for New Residential Communities and New Commercial/Industrial Businesses

**Final**

**September 25, 2006**

**This is a draft working document being developed by the Bureau of Reclamation for use by the Upper San Pedro Partnership in describing a preliminary conceptual design. It is intended to initiate a dialogue with all interested parties affected by this alternative. The contents are conceptual and preliminary in nature.**

**The Bureau of Reclamation defines an appraisal study as a brief investigation to determine whether to proceed with an in-depth "feasibility" study. The appraisal study uses existing data and information to identify plans to meet current and projected goals. It evaluates an array of options and identifies at least one solution to justify potential federal involvement. Typical duration of an appraisal study is one year or less.**

**The feasibility study is a detailed investigation and must be authorized by an Act of Congress. It is used to determine the desirability of seeking Congressional authorization for the implementation of a project. All feasibility studies contain a detailed environmental impact statement pursuant to the National Environmental Policy Act (NEPA) and other related statutes.**

**Description:** This alternative investigates the possibility of recovering rainwater through rooftop and ground level collection processes. The collection process would involve typical building components such as rooftops, gutters, and downspouts. It would also include items which are not typical building components, such as collection pipes, pumps, filters, common water storage areas, and return water delivery pipes. This water will take minimal treatment to be used for toilet flushing, clothes washing or landscape irrigation.

**Analysis and Discussion:** Two scenarios have been reviewed for rainwater collection:

- One - a new residential subdivision of 50 homes
- Two - a new commercial/industrial development

**Scenario One:** This scenario evaluates collecting rainwater for toilet flushing within a new, 50 home residential subdivision. The water can be used for other non-potable water needs if toilets are not the selected use of the water. A water budget was created to compare the volume of collectable water with the subdivision's toilet water demand. This was done using and Excel spreadsheet and historical rainfall data for Sierra Vista from the Western Regional Climate Center. The Sierra Vista area receives an average of 1.22 feet per year. Toilet flushing demand was estimated at 14.9 gallon per day per capita, or 59.6 gallons per home per day, for a four person family. The quantity used in the calculation is slightly reduced from the US EPA standard of 16.2 gallons per capita. A four person per home estimation may be high, however, this allows for visitors. Water usage for toilet flushing of 50 homes can be calculated at 1,100,000 gallons or 3.4 acre feet per year.

An average home rooftop of 2,000 square feet and an additional contribution per home of 1,000 square feet of roadway, driveway, or patio collection area were assumed. Runoff efficiency for rooftop catchments and pavement/patios was set at 90 percent and 80 percent respectively. With these levels of efficiency, 1,200,000 gallons or 3.7 acre feet of rainwater can be anticipated on an annual basis.

In an average rainfall year, enough rainwater can be captured to provide an alternate water supply for toilet flushing in a new residential subdivision. However, it would take about three years to accumulate the necessary 300,000 gallons storage

Below are the tables used to provide this analysis, a detail to demonstrate the layout of equipment and an estimate of the costs to provide a system of this size.

**Table 1. Rooftop Capture Potential for a 50 Home Subdivision**

| Month | Sierra Vista rainfall in feet | Rooftop collection at 90% efficiency (gal.) | Pavement collection at 80% efficiency (gal.) | Total (gal) | Total (af) |
|---|---|---|---|---|---|
| January | 0.101 | 67,993 | 30,219 | 98,212 | 0.3 |
| February | 0.056 | 37,699 | 16,755 | 54,454 | 0.2 |
| March | 0.039 | 26,255 | 11,669 | 37,924 | 0.1 |
| April | 0.032 | 21,542 | 9,574 | 31,117 | 0.1 |
| May | 0.024 | 16,157 | 7,181 | 23,338 | 0.1 |
| June | 0.034 | 22,889 | 10,173 | 33,062 | 0.1 |
| July | 0.263 | 177,052 | 78,690 | 255,741 | 0.8 |
| August | 0.332 | 223,502 | 99,334 | 322,837 | 1.0 |
| September | 0.11 | 74,052 | 32,912 | 106,964 | 0.3 |
| October | 0.101 | 67,993 | 30,219 | 98,212 | 0.3 |
| November | 0.04 | 26,928 | 11,968 | 38,896 | 0.1 |
| December | 0.084 | 56,549 | 25,133 | 81,682 | 0.3 |
| **Annual** | **1.216** | **818,611** | **363,827** | **1,182,438** | **3.6** |

**Table 2. Appraisal Level Costs of Rooftop Capture and Reuse within a 50 Home Subdivision**

| Item | Capital cost ($1000) | Annualized Capital Cost ($1000) | O&M Cost ($1000) | Total Annual Cost ($1000) | Cost per Acre-Foot | Cost per 1000 gallons |
|---|---|---|---|---|---|---|
| **House Collection System** (materials and installation of gutters, downspouts, Kerb system) | $247 | $18.18 | | $18.18 | $4,913 | $15.08 |
| **Neighborhood Collection System** (piping & storage)) | $719 | $52.89 | | $52.89 | $14,294 | $43.87 |
| **Treatment and Pumping** | $60 | $4.43 | $4.60 | $9.03 | $2,440 | $7.49 |
| **Delivery & Distribution Piping** | $107 | $7.89 | | $7.89 | $2,133 | $6.55 |
| **Total** | **$1,133** | **$83.39** | **$4.60** | **$87.99** | **$23,780** | **$72.98** |

**Model Subdivision**

**Scenario Two:** This scenario evaluates the capture and reuse of rainwater for a new commercial/industrial business rooftop. A rooftop of 400,000 square feet has been selected for analysis. No water usage has been determined.

The table below shows a 3,274,445 gallons or 10.05 acre-feet of rainwater collection annually that can be used for any non-potable water use. A 1.5 million gallon tank would be filled by August of the first year and end up bypassing 1.7 million gallons for the remainder of the year. This scenario would provide approximately 271,000 gallons or 0.8 acre feet per month of water to offset municipal water usage.

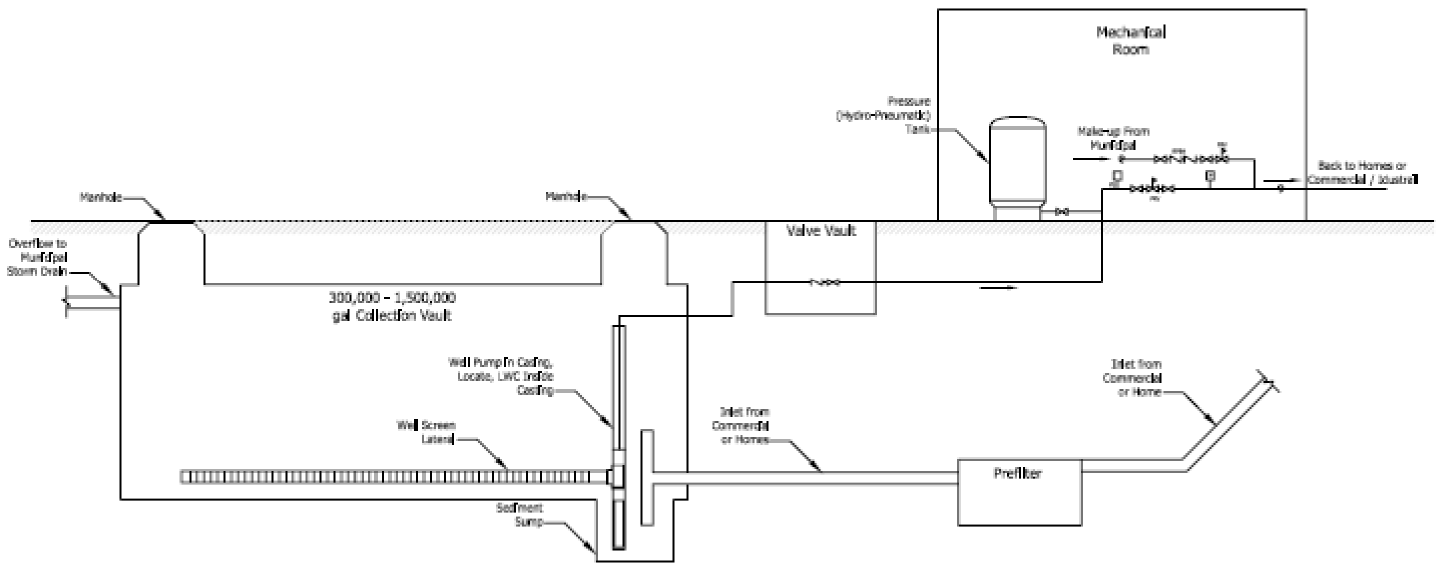
***Table 3. Rooftop Capture Potential for Commercial Building***

| Month | Sierra Vista rainfall in feet | Rooftop collection at 90% efficiency (gal.) | Total (gal) | Total (af) |
|---|---|---|---|---|
| January | 0.101 | 271,973 | 271,973 | 0.8 |
| February | 0.056 | 150,797 | 150,797 | 0.5 |
| March | 0.039 | 105,019 | 105,019 | 0.3 |
| April | 0.032 | 86,170 | 86,170 | 0.3 |
| May | 0.024 | 64,627 | 64,627 | 0.2 |
| June | 0.034 | 91,555 | 91,555 | 0.3 |
| July | 0.263 | 708,206 | 708,206 | 2.2 |
| August | 0.332 | 894,010 | 894,010 | 2.7 |
| September | 0.11 | 296,208 | 296,208 | 0.9 |
| October | 0.101 | 271,973 | 271,973 | 0.8 |
| November | 0.04 | 107,712 | 107,712 | 0.3 |
| December | 0.084 | 226,195 | 226,195 | 0.7 |
| **Annual** | **1.216** | **3,274,445** | **3,274,445** | **10.0** |

**Table 4. Appraisal Level Costs of Rooftop Capture for a Commercial Building**

| Item | Capital cost | Annualized Capital Cost | O&M Cost | Total Annual Cost | Cost per Acre-Foot | Cost per 1000 gallons |
|---|---|---|---|---|---|---|
| **Rooftop Collection System** (materials and installation) | $22,880 | $1,684 | | $1,684 | $168 | $0.51 |
| **Storage & Treatment** | $978,250 | $71,999 | $4,474 | $76,473 | $7,610 | $23.35 |
| **Total** | **$1,001,130** | **$73,683** | **$4,474** | **$78,157** | **$7,778** | **$23.87** |

## Schematic Community Residential Subdivision tank or Commercial / Industrial below grade tank

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Appendix A: Water Balance Calculations for Rainwater Capture and Reuse for Toilet Flushing, 50 Home Subdivision

| | Month | Total toilet req. for 50 residences | Available runoff supply (from table 2) | Runoff minus toilet req. | Excess runoff to storage (not used each month) | Accumulative storage* | Household req. from storage (required to supplement toilet flushing) | Req. from municipal supply (no rainwater in storage tank) | Excess runoff to overflow |
|---|---|---|---|---|---|---|---|---|---|
| Year One | Jan. | 92,400 | 98,212 | 5,812 | 5,812 | 5,812 | 0 | 0 | 0 |
| | Feb. | 83,450 | 54,454 | -28,996 | 0 | -23,184 | 28,996 | 23,184 | 0 |
| | March | 92,400 | 37,924 | -54,476 | 0 | -77,660 | 54,476 | 77,660 | 0 |
| | April | 89,400 | 31,117 | -58,283 | 0 | -135,943 | 58,283 | 135,943 | 0 |
| | May | 92,400 | 23,338 | -69,062 | 0 | -205,005 | 69,062 | 205,005 | 0 |
| | June | 89,400 | 33,062 | -56,338 | 0 | -261,343 | 56,338 | 261,343 | 0 |
| | July | 92,400 | 255,741 | 163,341 | 163,341 | -98,002 | 0 | 98,002 | 0 |
| | Aug. | 92,400 | 322,837 | 230,437 | 230,437 | 132,435 | 0 | 0 | 0 |
| | Sept. | 89,400 | 106,964 | 17,564 | 17,564 | 149,999 | 0 | 0 | 0 |
| | Oct. | 92,400 | 98,212 | 5,812 | 5,812 | 155,811 | 0 | 0 | 0 |
| | Nov. | 89,400 | 38,896 | -50,504 | 0 | 105,307 | 50,504 | 0 | 0 |
| | Dec. | 92,400 | 81,682 | -10,718 | 0 | 94,589 | 10,718 | 0 | 0 |
| Year Two | Jan. | 92,400 | 98,212 | 5,812 | 5,812 | 100,401 | 0 | 0 | 0 |
| | Feb. | 83,450 | 54,454 | -28,996 | 0 | 71,405 | 28,996 | 0 | 0 |
| | March | 92,400 | 37,924 | -54,476 | 0 | 16,929 | 54,476 | 0 | 0 |
| | April | 89,400 | 31,117 | -58,283 | 0 | -41,354 | 58,283 | 41,354 | 0 |
| | May | 92,400 | 23,338 | -69,062 | 0 | -110,416 | 69,062 | 110,416 | 0 |
| | June | 89,400 | 33,062 | -56,338 | 0 | -166,754 | 56,338 | 166,754 | 0 |
| | July | 92,400 | 255,741 | 163,341 | 163,341 | -3,413 | 0 | 3,413 | 0 |
| | Aug. | 92,400 | 322,837 | 230,437 | 230,437 | 227,024 | 0 | 0 | 0 |
| | Sept. | 89,400 | 106,964 | 17,564 | 17,564 | 244,588 | 0 | 0 | 0 |
| | Oct. | 92,400 | 98,212 | 5,812 | 5,812 | 250,400 | 0 | 0 | 0 |
| | Nov. | 89,400 | 38,896 | -50,504 | 0 | 199,896 | 50,504 | 0 | 0 |
| | Dec. | 92,400 | 81,682 | -10,718 | 0 | 189,178 | 10,718 | 0 | 0 |
| Year Three | Jan. | 92,400 | 98,212 | 5,812 | 5,812 | 194,990 | 0 | 0 | 0 |
| | Feb. | 83,450 | 54,454 | -28,996 | 0 | 165,994 | 28,996 | 0 | 0 |
| | March | 92,400 | 37,924 | -54,476 | 0 | 111,518 | 54,476 | 0 | 0 |
| | April | 89,400 | 31,117 | -58,283 | 0 | 53,235 | 58,283 | 0 | 0 |
| | May | 92,400 | 23,338 | -69,062 | 0 | -15,827 | 69,062 | 15,827 | 0 |
| | June | 89,400 | 33,062 | -56,338 | 0 | -72,165 | 56,338 | 72,165 | 0 |
| | July | 92,400 | 255,741 | 163,341 | 163,341 | 91,176 | 0 | 0 | 0 |
| | Aug. | 92,400 | 322,837 | 230,437 | 230,437 | 300,000 | 0 | 0 | 0 |
| | Sept. | 89,400 | 106,964 | 17,564 | 17,564 | 300,000 | 0 | 0 | 0 |
| | Oct. | 92,400 | 98,212 | 5,812 | 5,812 | 300,000 | 0 | 0 | 0 |
| | Nov. | 89,400 | 38,896 | -50,504 | 0 | 249,496 | 50,504 | 0 | 0 |
| | Dec. | 92,400 | 81,682 | -10,718 | 0 | 238,778 | 10,718 | 0 | 0 |
| Year Four | Jan. | 92,400 | 98,212 | 5,812 | 5,812 | 244,590 | 0 | 0 | 0 |
| | Feb. | 83,450 | 54,454 | -28,996 | 0 | 215,594 | 28,996 | 0 | 0 |
| | March | 92,400 | 37,924 | -54,476 | 0 | 161,118 | 54,476 | 0 | 0 |
| | April | 89,400 | 31,117 | -58,283 | 0 | 102,835 | 58,283 | 0 | 0 |
| | May | 92,400 | 23,338 | -69,062 | 0 | 33,773 | 69,062 | 0 | 0 |
| | June | 89,400 | 33,062 | -56,338 | 0 | -22,565 | 56,338 | 22,565 | 0 |
| | July | 92,400 | 255,741 | 163,341 | 163,341 | 140,776 | 0 | 0 | 0 |
| | Aug. | 92,400 | 322,837 | 230,437 | 230,437 | 300,000 | 0 | 0 | 0 |
| | Sept. | 89,400 | 106,964 | 17,564 | 17,564 | 300,000 | 0 | 0 | 0 |
| | Oct. | 92,400 | 98,212 | 5,812 | 5,812 | 300,000 | 0 | 0 | 0 |
| | Nov. | 89,400 | 38,896 | -50,504 | 0 | 249,496 | 50,504 | 0 | 0 |
| | Dec. | 92,400 | 81,682 | -10,718 | 0 | 238,778 | 10,718 | 0 | 0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year Five | Jan. | 92,400 | 98,212 | 5,812 | 5,812 | 244,590 | 0 | 0 | 0 |
| | Feb. | 83,450 | 54,454 | -28,996 | 0 | 215,594 | 28,996 | 0 | 0 |
| | March | 92,400 | 37,924 | -54,476 | 0 | 161,118 | 54,476 | 0 | 0 |
| | April | 89,400 | 31,117 | -58,283 | 0 | 102,835 | 58,283 | 0 | 0 |
| | May | 92,400 | 23,338 | -69,062 | 0 | 33,773 | 69,062 | 0 | 0 |
| | June | 89,400 | 33,062 | -56,338 | 0 | -22,565 | 56,338 | 22,565 | 0 |
| | July | 92,400 | 255,741 | 163,341 | 163,341 | 140,776 | 0 | 0 | 0 |
| | Aug. | 92,400 | 322,837 | 230,437 | 230,437 | 300,000 | 0 | 0 | 0 |
| | Sept. | 89,400 | 106,964 | 17,564 | 17,564 | 300,000 | 0 | 0 | 0 |
| | Oct. | 92,400 | 98,212 | 5,812 | 5,812 | 300,000 | 0 | 0 | 0 |
| | Nov. | 89,400 | 38,896 | -50,504 | 0 | 249,496 | 50,504 | 0 | 0 |
| | Dec. | 92,400 | 81,682 | -10,718 | 0 | 238,778 | 10,718 | 0 | 0 |
| Year Six | Jan. | 92,400 | 98,212 | 5,812 | 5,812 | 244,590 | 0 | 0 | 0 |
| | Feb. | 83,450 | 54,454 | -28,996 | 0 | 215,594 | 28,996 | 0 | 0 |
| | March | 92,400 | 37,924 | -54,476 | 0 | 161,118 | 54,476 | 0 | 0 |
| | April | 89,400 | 31,117 | -58,283 | 0 | 102,835 | 58,283 | 0 | 0 |
| | May | 92,400 | 23,338 | -69,062 | 0 | 33,773 | 69,062 | 0 | 0 |
| | June | 89,400 | 33,062 | -56,338 | 0 | -22,565 | 56,338 | 22,565 | 0 |
| | July | 92,400 | 255,741 | 163,341 | 163,341 | 140,776 | 0 | 0 | 0 |
| | Aug. | 92,400 | 322,837 | 230,437 | 230,437 | 300,000 | 0 | 0 | 0 |
| | Sept. | 89,400 | 106,964 | 17,564 | 17,564 | 300,000 | 0 | 0 | 0 |
| | Oct. | 92,400 | 98,212 | 5,812 | 5,812 | 300,000 | 0 | 0 | 0 |
| | Nov. | 89,400 | 38,896 | -50,504 | 0 | 249,496 | 50,504 | 0 | 0 |
| | Dec. | 92,400 | 81,682 | -10,718 | 0 | 238,778 | 10,718 | 0 | 0 |
| Year Seven | Jan. | 92,400 | 98,212 | 5,812 | 5,812 | 244,590 | 0 | 0 | 0 |
| | Feb. | 83,450 | 54,454 | -28,996 | 0 | 215,594 | 28,996 | 0 | 0 |
| | March | 92,400 | 37,924 | -54,476 | 0 | 161,118 | 54,476 | 0 | 0 |
| | April | 89,400 | 31,117 | -58,283 | 0 | 102,835 | 58,283 | 0 | 0 |
| | May | 92,400 | 23,338 | -69,062 | 0 | 33,773 | 69,062 | 0 | 0 |
| | June | 89,400 | 33,062 | -56,338 | 0 | -22,565 | 56,338 | 22,565 | 0 |
| | July | 92,400 | 255,741 | 163,341 | 163,341 | 140,776 | 0 | 0 | 0 |
| | Aug. | 92,400 | 322,837 | 230,437 | 230,437 | 300,000 | 0 | 0 | 0 |
| | Sept. | 89,400 | 106,964 | 17,564 | 17,564 | 300,000 | 0 | 0 | 0 |
| | Oct. | 92,400 | 98,212 | 5,812 | 5,812 | 300,000 | 0 | 0 | 0 |
| | Nov. | 89,400 | 38,896 | -50,504 | 0 | 249,496 | 50,504 | 0 | 0 |
| | Dec. | 92,400 | 81,682 | -10,718 | 0 | 238,778 | 10,718 | 0 | 0 |
| Year Eight | Jan. | 92,400 | 98,212 | 5,812 | 5,812 | 244,590 | 0 | 0 | 0 |
| | Feb. | 83,450 | 54,454 | -28,996 | 0 | 215,594 | 28,996 | 0 | 0 |
| | March | 92,400 | 37,924 | -54,476 | 0 | 161,118 | 54,476 | 0 | 0 |
| | April | 89,400 | 31,117 | -58,283 | 0 | 102,835 | 58,283 | 0 | 0 |
| | May | 92,400 | 23,338 | -69,062 | 0 | 33,773 | 69,062 | 0 | 0 |
| | June | 89,400 | 33,062 | -56,338 | 0 | -22,565 | 56,338 | 22,565 | 0 |
| | July | 92,400 | 255,741 | 163,341 | 163,341 | 140,776 | 0 | 0 | 0 |
| | Aug. | 92,400 | 322,837 | 230,437 | 230,437 | 300,000 | 0 | 0 | 0 |
| | Sept. | 89,400 | 106,964 | 17,564 | 17,564 | 300,000 | 0 | 0 | 0 |
| | Oct. | 92,400 | 98,212 | 5,812 | 5,812 | 300,000 | 0 | 0 | 0 |
| | Nov. | 89,400 | 38,896 | -50,504 | 0 | 249,496 | 50,504 | 0 | 0 |
| | Dec. | 92,400 | 81,682 | -10,718 | 0 | 238,778 | 10,718 | 0 | 0 |
| | **Ave. Annual gallons** | **1,087,850** | **1,182,438** | **94,588** | **422,967** | **300,000** | **328,378** | **165,488** | |
| | | | | | | **Storage Provided in Harvesting Tanks** | | | |

Appendix A: General Comments on Individual Rooftop Capture Systems

Submitted by Tom Runyon, Fort Huachuca

One of the principle arguments against individual rainwater harvesting systems is that they would rapidly fall into a state of disrepair. It seems to me that the implementation of widespread individual rainwater harvesting systems would create an industry for supplying and servicing such systems. One could imagine that if individual residential rainwater harvesting systems were mandated on new homes, businesses for supplying and servicing these systems would quickly emerge similar to the emergence of service stations following the widespread availability/use of motor vehicles. This emergence of businesses for supplying/servicing these systems would create competition, which would ultimately lower costs.

The cost of an individual residential rainwater harvesting system for meeting landscape water needs would obviously vary depending on the size of the yard and plant composition but a 3,000 gallon system would probably meet the majority of landscape water needs for a yard with a modest amount of turf (300 square feet per City of Sierra Vista proposed code changes) and low water use plants. Such a system incorporating a 2,500 main storage tank and smaller feeder tanks at each gutter downspout with piping, pumps, and cartridge filtration would probably cost about $4000 and would achieve water savings of about 10,000 gallons per year based on 1,200 square feet of total landscaping (Bermuda grass and low water use plants). This assumes that the gutters are already in place. The cost of the system would add approximately $27/month to a 30-year mortgage with a fixed rate of 7%. Although the acre-foot cost of individual systems would still be quite high (over $10,000/acre-ft), the individual homeowner cost would be quite modest when added to the mortgage payment. Many of the larger augmentation options under consideration have lower costs per acre-ft but it is doubtful that such options could be financed locally given the capital investment required. Will the Federal Government subsidize large water mitigation projects in the Sierra Vista subwatershed? If the answer is likely to be no or not in the foreseeable future, then the widespread use of rainwater harvesting at the residential scale should be either mandated or incentivized.

Another aspect of individual rainwater systems that are under the control of the homeowner is that the homeowner gets to actively participate in water conservation. This will likely raise the overall awareness of water issues and will likely lead to increased water conservation in other areas. Although this indirect benefit of individual rainwater harvesting systems cannot be quantified, it could arguably be quite significant.

# G. Appraisal Study of the Water Recharge Potential of Collected Urban Runoff In the Sierra Vista Area

# Appraisal Study of the Water Recharge Potential of Collected Urban Runoff In the Sierra Vista Area

Prepared by the Bureau of Reclamation in Cooperation with the Upper San Pedro Partnership

September 25, 2006
FINAL

**This is a draft working document being developed by the Bureau of Reclamation for use by the Upper San Pedro Partnership in describing a preliminary conceptual design. It is intended to initiate a dialogue with all interested parties affected by this alternative. The contents are conceptual and preliminary in nature.**

**The Bureau of Reclamation defines an appraisal study as a brief investigation to determine whether to proceed with an in-depth "feasibility" study. The appraisal study uses existing data and information to identify plans to meet current and projected goals. It evaluates an array of options and identifies at least one solution to justify potential federal involvement. Typical duration of an appraisal study is one year or less.**

**The feasibility study is a detailed investigation and must be authorized by an Act of Congress. It is used to determine the desirability of seeking Congressional authorization for the implementation of a project. All feasibility studies contain a detailed environmental impact statement pursuant to the National Environmental Policy Act (NEPA) and other related statutes.**

**Description:** This alternative investigates the recovery and recharge of stormwater runoff from impervious surfaces in the Sierra Vista area. Runoff from a highly urbanized eight square mile area would be collected in an underground pipeline system. The stormwater would then be treated, stored and recharged using constructed basins.

One option is to recharge in an area close to the San Pedro River (SPR). The basin sites for this option have been selected using information from the USGS "Capture Map", which shows how much recharge is likely to be "captured" by the SPR in a given location. Recharging water near the river is meant to create a groundwater mound to enhance surface water flow in the SPR and sustain alluvial groundwater levels during low flow periods.

A second option involves recharge between the City of Sierra Vista and the SPR, in the area of hydrologic impact (AHI), where pumping is taking place. The hydrological effects on the SPR from the recharge will not be immediate as in option one, however, the overall cost is less. An exact location has not been identified.

## Analysis and Discussion:

The information required to analyze this alternative is the amount of water which can be collected, the size and type of collection facilities, the routing of the conveyance pipeline, the method of recharge and corresponding costs. In addition, the quality of the recovered water, appropriate treatment level and associated costs have been incorporated. Reclamation believes that enough information is available to complete this appraisal-level analysis.

*End Use of Water*

Under Option 1, all water collected will be used for recharge, specifically for mounding immediately adjacent to the alluvial aquifer of the SPR. The intent is to mimic bank storage and pre-development groundwater elevations. By providing storage in the recharge area and down-gradient, the project will provide contributing flows to the river during non-storm periods.

Under Option 2, the recharge location is sited to have a direct hydrological effect on areas where pumping demand is high.

*Estimates of Runoff*

The process of urbanization increases impermeable area within a watershed, which in turn increases runoff. Studies by the USDA Agricultural Research Service (USDA-ARS) and GeoSystems Analysis, Inc. (GSA) indicate that recharge has increased due to urbanization within the Sierra Vista Subwatershed, creating additional stormwater flow. This has been termed the "differential" in runoff due to development. Recently, GSA and Stantec Consulting Engineers have examined the possibility of recharging this differential using flood control infrastructure. Estimates of "differential runoff" from the Stantec/GSA Cochise County Flood Control Urban Runoff Recharge Plan, March 2006 Draft, were used as a source for this report.

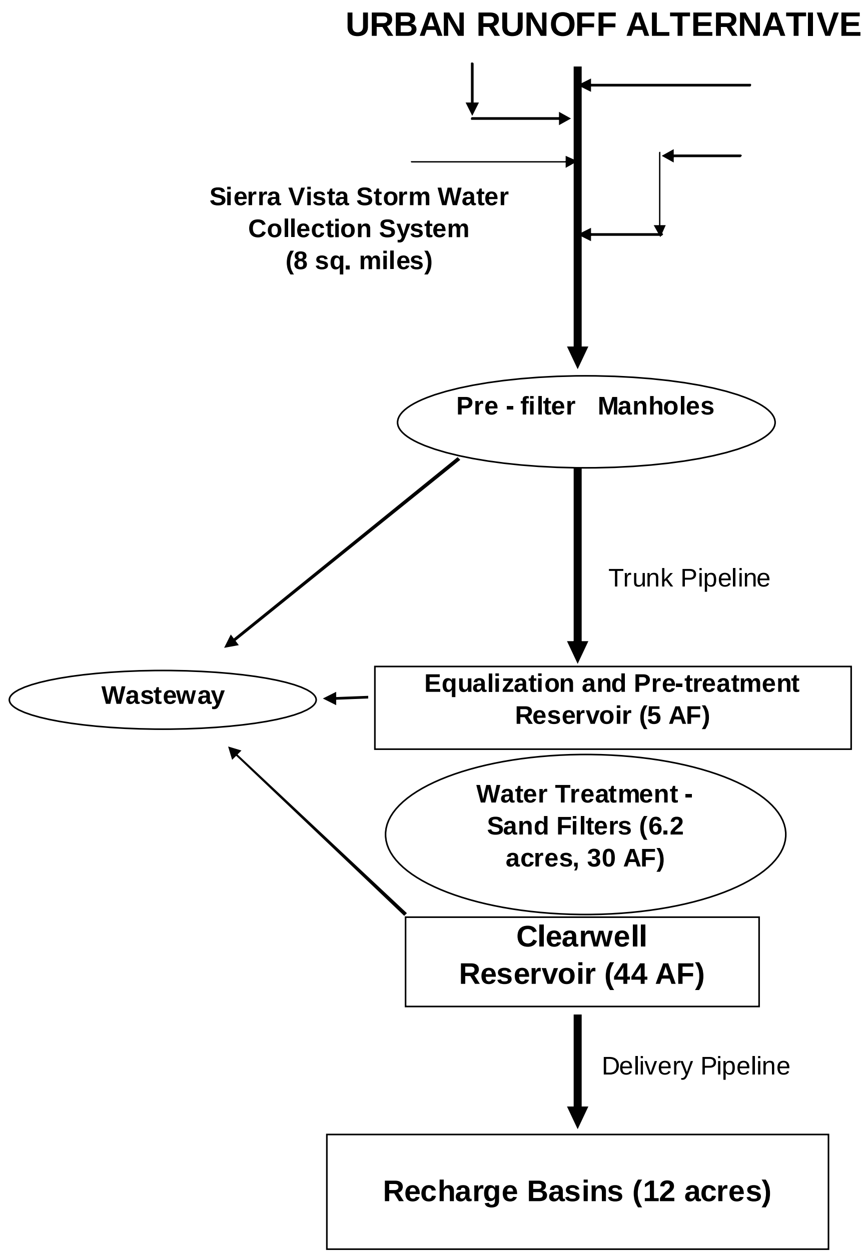
Analysis of rainfall data from the Western Regional Climate Center showed that on average, Sierra Vista experiences 60 rainfall events annually, 40 in summer and 25 in winter. However, on average, only 30 storms provide collectable stormwater. Storms of less than 0.2 inches do not generate enough runoff to enter into the collection system, and are high in "first flush" pollutants. Major runoff periods include short duration, high intensity, thunderstorms in the summer and long duration, low intensity, storms in the winter. For this proposal, approximately 70% of the differential in runoff within the study area would be captured.

To size the system, the ability to capture large runoff events has been balanced against the relative frequency of runoff events, the cost of storage and the recharge basin capacity. The facilities have been sized to maximize the stormwater capture area and reservoir storage, while minimizing the overall cost. Note that because of the local rainfall patterns, the facilities will be dry a majority of the time between storms. Bypass of peak flows and events exceeding the two year storm are part of the facilities sizing criteria, as a larger system would be considerably more costly and dry a greater portion of the year.

The collection system focuses on the highly urbanized areas of Sierra Vista located within Soldier's, Graveyard, Woodcutter's and Coyote Wash Watersheds. The system will collect stormwater from an eight square mile area, capturing runoff from storms greater than 0.2 inches, with a recharge volume of 1,800 ac-ft per year.

*Collection System*

Since the pipeline system is located in an urbanized area, excavation of existing streets and drainage ways will be necessary. Pipeline routing will follow existing roads and easements. Curbs and gutters will be installed at 500 to 750 foot intervals to gather stormwater off of streets, parking lots and other impervious areas. The water will be conveyed into a piping system consisting of 30 inch diameter laterals and 60 inch diameter pressure trunk lines and then transported to the treatment plant. Manholes and collector basins will be located at 1,000 foot intervals to enable required system maintenance. Cost estimates include materials and installation of laterals, trunk lines, manholes, and treatment features.



*Quality of Recovered Water*

The system will gather storm water from streets and other impermeable areas high in refuse and street pollutants, including hydrocarbons, pesticides and animal waste. Typical concentrations of pollutants found in urban stormwater are shown below in Tables 1 and 2.

Wasting of the first flush from storms will be required to maintain water quality. (Otherwise, additional facilities would be required to treat the poor water quality of the first flush.)

Low intensity storms following dry spells will yield small quantities of water and provide poorer water quality. Conversely, larger storms will provide flushing of pollutants and higher quality water. Treatment facilities have been incorporated into the system to remove trash, sand and grit, fine particles and pollutants that attach to them, as well as biological contaminants. In addition, the basin recharge process will provide additional treatment as the stormwater filters through the soil (soil aquifer treatment).

**Table 1** Typical Urban Areas and Pollutant Yields (Burton & Pitt, 2002)

| POLLUTANT | LAND USE (lb/acre/yr)[a] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Com-mercial | Parking Lot | Residential - Density High | Residential - Density Medium | Residential - Density Low | High-ways | Ind-ustry | Parks | Shop-ping Center |
| Total Solids | 2100 | 1300 | 670 | 450 | 65 | 1700 | 670 | NA[c] | 720 |
| SS | 1000 | 400 | 420 | 250 | 10 | 880 | 500 | 3 | 440 |
| Cl | 420 | 300 | 54 | 30 | 9 | 470 | 25 | NA | 36 |
| TP | 1.5 | 0.7 | 1 | 0.3 | 0 | 0.9 | 1.3 | 0.03 | 0.5 |
| TKN | 6.7 | 5.1 | 4.2 | 2.5 | 0.3 | 7.9 | 3.4 | NA | 3.1 |
| $NH_3$ | 1.9 | 2 | 0.8 | 0.5 | 0 | 1.5 | 0.2 | NA | 0.5 |
| $NO_3 + NO_2$ | 3.1 | 2.9 | 2 | 1.4 | 0.1 | 4.2 | 1.3 | NA | 0.5 |
| $BOD_5$ | 62 | 47 | 27 | 13 | 1 | NA | NA | NA | NA |
| COD | 420 | 270 | 170 | 50 | 7 | NA | 200 | NA | NA |
| Pb | 2.7 | 0.8 | 0.8 | 0.1 | 0 | 4.5 | 0.2 | 0 | 1.1 |
| Zn | 2.1 | 0.8 | 0.7 | 0.1 | 0 | 2.1 | 0.4 | NA | 0.6 |
| Cr | 0.15 | NA | NA | 0 | 0 | 0.09 | 0.6 | NA | 0.04 |
| Cd | 0.03 | 0.01 | 0 | 0 | 0 | 0.02 | 0 | NA | 0.01 |
| As | 0.02 | NA | NA | 0 | 0 | 0.02 | 0 | NA | 0.02 |

[a] The difference between lb/acre/yr and kg/ha/yr is less than 15%, and the accuracy of the values shown in this table cannot differentiate between such close values
[b] The monitored low-density residential areas were drained by grass swales
[c] NA = Not available

*Treatment – Stormwater Treatment Plant*

Treatment of the stormwater may be necessary to eliminate bacterial contaminants, hydrocarbons and other pollutants. Treatment processes may include debris screening, pre-settlement detention, grit and sand removal, hydrocarbon absorption, settling and rapid sand filtration. Facilities would include a five acre-foot pre-treatment reservoir, a treatment plant and a 6.2 acre rapid sand filter. The treatment facilities will require personnel on-site for operation and maintenance, especially during storm events.

**Table 2** Median Event Mean Concentrations for All Sites by Land Use Category (EPA, 1983)
Source: Stormwater Best Management Practice Design Guide, EPA/600/R-04/121, Office of Research and Development, Environmental Protection Agency, September, 2004, Appendix D, p.2. Accessed August 18, 2006.

| Constituents | Land Uses | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Residential | | Mixed Land Use | | Commercial | | Open/ Non-urban | |
| | Median | COV[a] | Median | COV | Median | COV | Median | COV |
| BOD5, mg/L | 10 | 0.41 | 7.8 | 0.52 | 9.3 | 0.3 | -- | -- |
| COD, mg/L | 73 | 0.55 | 65 | 0.58 | 57 | 0.4 | 40 | 0.78 |
| TSS, mg/L | 101 | 0.96 | 67 | 1.14 | 69 | 0.9 | 70 | 2.92 |
| Total Pb, µg/L | 144 | 0.75 | 114 | 1.35 | 104 | 0.7 | 30 | 1.52 |
| Total Cu, µg/L | 33 | 0.99 | 27 | 1.32 | 29 | 0.8 | -- | -- |
| Total Zn, µg/L | 135 | 0.84 | 154 | 0.78 | 226 | 1.1 | 195 | 0.66 |
| TKN, µg/L | 1900 | 0.73 | 1289 | 0.5 | 1179 | 0.4 | 965 | 1 |
| $NO_2$+$NO_3$(as N), µg/L | 736 | 0.83 | 558 | 0.67 | 572 | 0.5 | 543 | 0.91 |
| TP, µg/L | 383 | 0.69 | 263 | 0.75 | 201 | 0.7 | 121 | 1.66 |
| Soluble P, µg/L | 143 | 0.46 | 56 | 0.75 | 80 | 0.7 | 26 | 2.11 |
| [a] COV: coefficient of variation = standard deviation/mean | | | | | | | | |

Available at: http://www.epa.gov/ORD/NRMRL/pubs/600r04121/600r04121appd.pdf

Treated water would then be stored in a 44 acre-foot "clearwell" reservoir, designed to hold water for up to 30 days. (This size of reservoir can hold runoff from a 0.2 inch/hour rainfall over a four hour interval. However, peak flows and larger events will bypassed.) Chlorination may be required to provide disinfection and vector control. Water may need to be dechlorinated immediately before recharge.

*Recharge System*
A 60 inch diameter pipeline, capable of conveying 150 cubic feet per second (cfs) from the clearwell reservoir, will convey treated water to the recharge basins. This size pipe will ensure rapid filling of the basin at start of storm runoff.

The treated stormwater would be recharged using twelve acres of constructed basins, with additional acreage for berms and amenities. For option 1, the basins are located within one mile of the SPR. For Option 2, the basins are located approximately four miles east of the City, reducing the length of the pipeline by about two miles.

The basins are designed to recharge the full 1,800 AFY collected. They are designed for an infiltration rate of one foot per day, a ponding depth of two feet and a 50-percent wet to 50-percent dry cycle. Assuming an open water evaporation rate of 3.6 ft/year, approximately 18 afy would be lost from the basins. However, this can be offset by capturing slightly more water in the covered reservoir and conveying this additional amount to the recharge basins. Evaporation is considered a relatively insignificant percentage compared to the total water collected.

To avoid the fine-grained soils typically found at ground surface, which impede recharge rates, the basins would be excavated to a depth of five feet. Long-term maintenance consists of disking and/or excavation of the top layer to remove fine sediments. A 44 acre ft event will typically recharge within seven days. A detailed evaluation including geomorphology, hydrogeology, water quality, and geochemistry will be necessary to determine the technical feasibility of recharge at any site.

A network existing production wells and new monitoring wells would be used to monitor groundwater levels and quality in the regional aquifer during recharge operations. Existing wells would be used for data acquisition whenever possible.

In addition to the engineered treatment, water quality standards will likely be improved through "soil-aquifer treatment" which occurs during the recharge process. Soil-aquifer treatment is effective at removing pathogens and dissolved organic carbon.

**Issues and Concerns:**

***Effectiveness***

- This alternative has the advantage of capturing stormwater that might otherwise evaporate or recharge far away from the SPR and transporting it to a location where it should have the greatest benefit to the river. However, it is dependent on the occurrence of storms greater than 0.2 inches. It cannot effectively offset groundwater pumping during a long-term drought.

***Water Rights and Ownership***

- Stormwater flow to the SPR would remain at or above pre-development levels.

- Collecting stormwater into a pipeline before it flows into natural channels avoids the issue of acquiring surface water rights to the stormwater.

***Financing***

- Financing – where the money comes from, how it is paid back and by who must be ascertained.

***Regulatory***

- Recharge of groundwater is required to comply with Federal and State water quality standards. Basin recharge projects can either be permitted through an Aquifer Protection Permit (APP) or through Arizona's Title 45 process. Under Title 45, ADWR requires recharge facilities within Active Management Areas to obtain up to three permits. Although it is not strictly required to obtain ADWR permits in order to recharge water outside of Active Management Areas, Reclamation recommends that the USPP comply with State permit guidelines. The guidelines ensure that recharge is effective and does not cause harm to other entities. The required studies can also be used to implement a maintenance, monitoring, and operational regime that ensures optimum recharge efficiency.

- National Environmental Policy Act compliance (most likely an EIS) is required if project is partly or wholly funded by the Federal Government.

- CWA Section 404 permit coverage is needed for fills associated with pipeline crossings of washes and streams.

***Biological***

- Although the conveyance pipeline would use previously disturbed easements wherever possible, the pipeline route must be surveyed for species listed or proposed under the Endangered Species Act.

- Potential effects to the following federally listed, proposed, candidate species and/or designated/proposed critical habitat should be addressed in the NEPA document: Gila chub, Chiricahua leopard frog, jaguar, lesser long-nosed bat, northern aplomado falcon, cactus ferruginous pygmy-owl, Mexican spotted owl, Pima pineapple cactus, and any other species proposed or listed prior to project implementation.

- Sensitive plants such as agaves and cacti located within the pipeline right-of-way should be salvaged pursuant to the Arizona Native Plant Law.

***Cultural Resources***

- A Class I survey (literature search) is needed to determine what areas along the potential routes have been surveyed and what known cultural resources and Traditional Cultural Properties (TCPs) are located within the area of potential effect. This would include accessing site files at the Arizona State Museum as well as those of the Bureau of Land Management, and Fort Huachuca (DOD).

- Should this alternative proceed to a feasibility level analysis, a Class III cultural resource (intensive) survey would be required to identify cultural resources and TCPs in the area of potential effect. It should be noted that a plethora of cultural resources, ranging from Paleoindian to historical, are located near the SPR where recharge basins under option 1 are planned. This will significantly affect environmental (NEPA) clearances and will require extensive mitigation prior to project implementation as part of the National Historic Preservation Act (NHPA), Section 106 process.

- If testing and/or data recovery are required to mitigate the effects of the project, additional tribal consultation would be conducted as part of the Section 106 process.

- Section 106 consultation with the State Historic Preservation Office must also be carried out. The Advisory Council on Historic Preservation would also be part of the consultation process, but it is likely they would opt not to be.

- Section 106 activities would be coordinated with the NEPA process

**Primary Reference:**
Stantec and GeoSystems Analysis, Inc., Cochise County Flood Control Urban Runoff Recharge Plan, March 2006 Draft

**Appraisal Costs of Urban Runoff Collection and Recharge Near the San Pedro River**

| Item | Capital cost ($M) | Annualized Capital Cost ($M) | O&M Cost ($M) | Total Annual Cost ($M) | Cost per Acre-Foot | Cost per 1000 gallons |
|---|---|---|---|---|---|---|
| **Collection System** (materials and installation of laterals, trunklines, curbs, gutters, manholes) | $40.98 | $3.02 | $0.22 | $3.23 | $1,795 | $5.51 |
| **Treatment System** (includes 5 acre pre-treatment reservoir, treatment train, 6.2 acre rapid sand filter) | $2.61 | $0.19 | $0.06 | $0.25 | $141 | $0.43 |
| **"Clearwell" Reservoir**, covered, 44 af, with pipeline to basins | $15.87 | $1.17 | included above | $1.17 | $649 | $1.99 |
| **Recharge Basins** (12 acres) | $0.86 | $0.06 | $0.04 | $0.10 | $55 | $0.17 |
| **Land costs for treatment plant, reservoir, basins** | $0.84 | $0.06 | $0.00 | $0.06 | $34 | $0.11 |
| **Total** | **$61.16** | **$4.50** | **$0.31** | **$4.81** | **$2,675** | **$8.21** |

**Appraisal Costs of Urban Runoff Collection and Recharge Near the AHI**

| Item | Capital cost ($M) | Annualized Capital Cost ($M) | O&M Cost ($M) | Total Annual Cost ($M) | Cost per Acre-Foot | Cost per 1000 gallons |
|---|---|---|---|---|---|---|
| **Collection System** (materials and installation of laterals, trunklines, curbs, gutters, manholes) | $34.20 | $2.52 | $0.18 | $2.70 | $1,499 | $4.60 |
| **Treatment System** (includes 5 acre pre-treatment reservoir, treatment train, 6.2 acre rapid sand filter) | $2.61 | $0.19 | $0.06 | $0.25 | $141 | $0.43 |
| **"Clearwell" Reservoir**, covered, 44 af, with pipeline to basins | $13.22 | $0.97 | included above | $0.97 | $541 | $1.66 |
| **Recharge Basins** (12 acres) | $0.86 | $0.06 | $0.04 | $0.10 | $55 | $0.17 |
| **Land costs for treatment plant, reservoir, basins** | $0.84 | $0.06 | $0.00 | $0.06 | $34 | $0.11 |
| **Total** | **$51.73** | **$3.81** | **$0.28** | **$4.09** | **$2,271** | **$6.97** |

## H. No Action Description associated with Augmenting Groundwater Use or to Recharge the Aquifer within the Sierra Vista Sub-watershed

# No Action Description associated with Augmenting Groundwater Use or to Recharge the Aquifer within the Sierra Vista Sub-watershed

The Upper San Pedro Partnership has developed a strategy with alternatives to reduce groundwater dependence or to recharge the groundwater supply. The no action alternative is described as follows:

The no action alternative would consist of not constructing some or all of the projects under BOR study. The no action alternative would also consist of other factors of the regional environment, such as project population growth, to continue as currently projected. In the no action alternative the annual regional groundwater pumping deficit is anticipate to be approximately 2025* acre feet by 2011.

**<u>Impacts</u>**

A no action alternative would result in a continued declining groundwater levels that would jeopardize the Upper San Pedro Partnerships ability to meet the goal of sustainable yield of the regional aquifer by 2011. Projects yielding between 1,800 (26,052 is the low yield for all projects) to 58,171 acre feet of water would not be implemented to either augment existing or replace existing groundwater use. This would potential result in failure to the goals of Section 321.

There is not another equivalent slate of potential projects to be studied for implementation if these projects are not implemented.

Not constructing some or all of the projects would result in fewer disturbances of soil and geology, no short term impacts to air and water quality, and no short term increases in wages associated with construction.

Given the growth projections in the region, the current state of the aquifer and the riparian area, and the other minor projects under study by the USPP:

With respect to the regional aquifer and the San Pedro River, failure to offset approximately 8,000 AF per year with either recharge or replacement of current groundwater pumping will result in diminished flows to the river and preclude recovery of the Huachuca water umbel, an endangered species. These are unacceptable consequences under both Section 321 and the Endangered Species Act.

With respect to other direct and indirect consequences of the no-action alternative, failure to offset the burden on groundwater use may also lead to closure or significant mission reductions at Fort Huachuca. The cost of moving these missions, in those cases where it is even possible to find suitable relocation, will greatly exceed the cost of the actions.

With respect to other economic impacts, the no action alternative has the potential to result in up to $1 billion in economic reduction within Cochise County from loss of income from Fort Huachuca. Additional losses from nature based tourism reductions attributed to both the Fort Huachuca and San Pedro Riparian National Conservation Area would lead to an overall loss of a $2 billion annually to the state of Arizona.

With respect to the San Pedro Riparian National Conservation Area, the no action alternative would impact the BLM's ability to meet the requirements to protect, conserve and enhance the NCA as directed under P.L. 100-696. Continued declining groundwater level would impact the necessary hydrologic conditions to manage a diversity of riparian species (including T/E species). Impact and potential loss of this globally important migratory bird habitat would be significant not only to the United State but to Mexico and Canada.

* The 2006 321 analysis has a storage deficit of 2,025 acre feet in 2011 assuming only the current 321 projects (no BOR projects) are put into action. Current 321 projects include things like the wastewaster recharge, detention basins, conservation, reuse etc. Courtesy of Jim Leenhouts, USGS.

Appendix B

# Summary of Ratings

# Table of Contents

JOINT SWG, TECHNICAL & GAC COMMITTEE MEETING

Topic: BOR Problem Statement and Screening Criteria

August 3, 2005 Prepared by Lynn Slagle

**MEETING RESULTS:**

**PROBLEM STATEMENT**

Water levels in parts of the regional aquifer of the Sierra Vista Sub-watershed are declining. A set of water augmentation solutions is desired that would add approximately 38,500* acre-feet per year to negate the potential impact of pumping on the aquifer and the San Pedro Riparian Conservation Area thru 2050—given current projections. Water augmentation would supplement existing and future recharge, reuse and conservation solutions implemented in the Sub-watershed.

*C*alculation assumptions include:*

- *2050 sub-watershed population of 170,000 people--based on 321 Report projections extrapolated out to 2050.*
- *Actual GPCD for 2004, which includes all water uses—population, recreation, industrial, agricultural.*
- *All figures are estimates based on current available information for planning purposes only. They will need to be refined over time as new information becomes available.*

**EVALUATION CRITERIA**

The criteria noted below will be used to help the Partnership compare and contrast various water augmentation options to determine which ones should receive further scrutiny and which ones can be moved to the back burner.

**Cost**

- Capital requirements
- Operating and maintenance expenses
- Total annual cost *(sum of capital cost amortized over life of project plus O&M)*
- Cost/yield ratio
- Timing of when dollars would be needed
- Availability of State or Federal funding

**Effectiveness**

Effectiveness of the alternative in terms of alleviating the problem identified in the problem statement.

- Yield in terms of acre-feet
- Likelihood that project magnitude and location of yields will benefit the regional aquifer, or the river.
    - Ability to help sustain natural range of alluvial groundwater levels in their current spatial distribution. *("Natural range of alluvial groundwater levels" is defined as the groundwater levels and gradients within the Sierra Vista Sub-watershed that existed at or about the time of the establishment of the SPRNCA.)*
    - Ability to help sustain natural baseflows within their general spatial distribution. *("Natural baseflows" is defined as the range of baseflows experienced in the river between 1954 and 1988)*
    - Ability to help sustain floodflows within their natural range of variability in terms of timing, frequency, and magnitude. *("Natural range of floodflows" is defined as the range of floodflows experienced in the river between 1954 and 1988)*
    - Ability to help maintain existing (or better) water quality within the river
- Ability of strategy to continue addressing problem during periods of extended drought, and over long periods of time (50 years+)
- Estimated yields are adequate to meet future projected population and SPRNCA needs.
- Can project reliably produce water every year or is it dependent on rainfall?
- Complements current or planned USPP projects.
- Timing of benefits
- Length of time to work through the regulatory requirements
- Will project replace or reduce groundwater demand?
- Potential for unintended environmental consequences at the source location of the water or within the Sierra Vista Sub-watershed.

**IMPLEMENTABILITY**

The proposed criteria will help the Partnership assess the ease with which the alternative can be implemented.

- Spatial, geologic and hydrologic constraints
- Environmental impact issues
- State of technology (i.e. proven method or pilot)
- Legal and regulatory issues at the local, state (e.g. ACC, ADWR, ADEQ, Land Department) and federal levels
- Current land ownership, right of way, water rights, etc.
- Current ownership of water utility
- Current land use and zoning
- Compatibility of project with adjacent uses
- Does project cross jurisdictional boundaries?
- Likely community support or opposition

- Impacts on area where water is being transferred from—political, environmental, economic

| | |
|---|---|
| Meeting attendees: | Eve Halper, BOR<br>Tom Runyon, Fort Huachuca<br>Carl Robie, Cochise County<br>George Michael, City of Sierra Vista<br>Chuck Potucek, City of Sierra Vista<br>Holly Richter, The Nature Conservancy<br>Dan Moore, BLM<br>Jason Douglas, US Fish and Wildlife Service<br>Jim Leenhouts, USGS<br>Tricia Gerrodette, Audubon Arizona<br>Rich Burtell, ADWR<br>Russ Scott, ARS<br>MaryAnn Black, Hereford NRCD<br>Jody Klein, Cochise County<br>Pat Call, Cochise County<br>Judy Gignac, Bella Vista Ranches<br>Maynard Kreps, City of Bisbee<br>Bob Strain, City of Sierra Vista<br>Gretchen Kent, Fort Huachuca<br>Paul Newman, Cochise County<br>Tom Whitmer, ADWR<br>Mike Nicholson |
| Non-member attendees: | Mary McCool<br>Cado Daily |
| USPP Program Administrator: | Mike Nicholson |
| Meeting facilitator: | Lynn Slagle |

JOINT SWG, TECHNICAL & GAC COMMITTEE MEETING

Augmentation Planning Problem Statement

November 16, 2006

**USPP MISSION** *(excerpted from the USPP Strategic Plan, dated 9-13-06)*

To meet the long-term water needs of the Sierra Vista Sub-watershed by achieving sustainable yield* of the regional aquifer by 2011 and beyond to: 1) preserve the San Pedro Riparian National Conservation Area (SPRNCA), and 2) ensure the long-term viability of Fort Huachuca.

** Sustainable yield is defined as the management of groundwater in a way that it can be maintained for an indefinite period of time, without causing unacceptable environmental, economic, or social consequences. (detailed sustainability criteria next page).*

**AUGMENTATION PLANNING PROBLEM STATEMENT --DRAFT**

- Water levels in parts of the regional aquifer of the Sierra Vista Sub-watershed are declining, with the potential to impact the hydrologic conditions of the San Pedro Riparian National Conservation Area.

- A set of water augmentation solutions is needed that would work toward sustainable yield by adding approximately 10,000 acre-feet a year (af/yr) by 2011 and 26,000 af/yr by 2050, to negate a portion of the 38,500 af/yr total demand** projected by 2050.

- Water augmentation would supplement existing and future recharge, reuse, conservation and other water resource management solutions implemented in the Sub-watershed.

**REFERENCES NEXT PAGE**

## REFERENCES

*** Initial criteria for sustainability (from 2005 Section 321 report)**

| Social and economic | Environmental |
|---|---|
| • Sufficient water quantity for human needs<br>• Fort Huachuca remains operational unless for reasons unrelated to water<br>• Cost of living, specifically affordable housing and the cost of doing business, remains within the means of a diverse population<br>• Maintain local participation in water management<br>• Sustain water quality | • Ground-water levels in alluvial aquifer within the SPRNCA maintained<br>• Stream base flow and flood flows maintained<br>• Accrete aquifer storage<br>• Riparian habitat and ecologic diversity maintained<br>• Water quality sustained in SPRNCA<br>• Overall riparian condition maintained<br>• Springs in the SPRNCA continue to flow |

**Demand c*alculation assumptions include:*

- *2050 sub-watershed population of 170,000 people--based on 321 Report projections extrapolated out to 2050.*
- *Actual GPCD for 2004, which includes all water uses—population, recreation, and industrial, agricultural.*
- *All figures are estimates based on current available information for planning purposes only. They will need to be refined over time as new information becomes available.*

November 28, 2006

**Overarching assumption to add to the CAP Recharge & Recovery Option:**

"This option could include recharge sites that would enhance conditions in the SPR's recent alluvium, which would support base flows in the river. This would benefit the river more quickly than recharging only in the area of hydrologic impact."

Criteria for which this assumption is likely to change ratings:

2b) Benefits River (< 50 years)
3a) Sustains SPRNCA alluvial gw levels (< 50 years)
4a) Sustains SPRNCA base flows (< 50 years)
6) Maintains or improves river water quality
10) Complementary w/ other USPP projects
11) Short lead time for benefits to river
16) Environmental Impact Issues
24) Likely Community Support

## Augmentation Alternatives Screening Process

April 7, 2006

1. Review the report for each alternative.

2. Review the screening criteria.

3. A sheet (summary sheet) has been created that allows information from individual reports that concerns rating criteria to be extracted and summarized.

4. How to fill out the summary sheet should be determined:
    a. Reclamation could take a "first cut" at filling in information for each criterion. The group then discusses the content.
    b. Reclamation fills in factual information only. Criteria that require interpretation are filled in by each Partnership representative.
    c. Each Partnership representative fills out a sheet for each alternative. The information is collected and presented to the group for discussion.

5. Review and comment on summary sheet that needs to be prepared for each alternative.

6. There is a need to develop a summary sheet for a "no Federal action" alternative.
    a. The lead Federal agency will either be the Fort or BLM
    Use the Fort's Biological Opinion and SPRNCA background

7. Complete "acceptance" or "consensus" on information contained on each summary sheet.

8. Using information in the summary sheets, fill out the matrix showing alternatives along one axis and criteria along the other axis. A rating system, preferably concise, should be discussed and agreed upon. Example: Good, Fair, Poor

9. Rate and rank alternatives based upon information in the matrix.

10. Select alternative(s) that will be analyzed in more detail (feasibility level).

The entire process described above and the individual reports will be documented in an appraisal report. The basis for moving forward with the more promising alternatives and the reasons for dropping alternatives from further consideration will have been documented. The "no Federal action" alternative is automatically included in any future actions.

Things to remember:

A. During the evaluation there will always be some uncertainty. Get comfortable with this fact. What needs to be considered is whether the uncertainty will lead to situation where an alternative can't go forward. Very few issues will fall into this category.

B. The process is meant to allow policy makers and stakeholders to evaluate the range of future actions against each other.
   a. Screening too early does not allow comparison with alternatives that have not been completely analyzed.
   b. Reclamation told the partnership it would review information on alternatives analyzed in the BBC/Fluid Solutions report to determine whether they can be screened using the criteria developed. There are data gaps that must be filled.

C. Selecting alternatives doesn't mean you're done - we have merely trimmed the number.

D. Selected alternatives will be evaluated in greater detail during the next phase – trying to answer the uncertainty mentioned in item A.

**A1. Intra-basin transfer: Tombstone Mine to Fort Huachuca Reclaimed Water System**

| Criterion | Relevant aspects of alternative with respect to criterion | Rating (good, fair, poor) |
|---|---|---|
| **Ratings based on yield of 500 acre-feet per year** | | |
| **EFFECTIVENESS** | | |
| 1. Yield in terms of acre-feet | Range of 500 acre-feet per year (estimated rate of natural recharge + 112 acre-feet per year effluent) to 1,322 acre-feet per year (sustainable for about 20 years, includes 112 acre-feet per year effluent) | Poor |
| 2. Likelihood that project magnitude and location of yields will benefit:<br><br>1) The regional aquifer<br><br>2) The river | <br><br><br>Regional aquifer: highly likely<br><br>River: Not likely over shorter timeframes (decades). Could eventually impair river's health by decreasing discharge to SPRNCA downstream of Charleston gage | <br><br><br>Regional aquifer: good<br><br>River:<br>< 50 years: poor<br>> 50 years: fair |
| 3. Ability to help sustain natural range of alluvial ground water levels in their current spatial distribution. ("Natural range of alluvial ground water levels" is defined as the ground water levels and gradients within the Sierra Vista Sub-watershed that existed at or about the time of the establishment of the SPRNCA.) | Short term (years - decades): low, due to distance from the river<br><br>Long term (decades - centuries): high, but still dependent upon no additional interception of ground water by other users between the Fort and the river. Will eventually degrade alluvial ground water levels in downstream areas | Short term: poor<br><br>Long term: fair |
| 4. Ability to help sustain natural base flows within their general spatial distribution. ("Natural base flows" is defined as the range of base flows experienced in the river between 1954 and 1988) | Short term (years - decades): low, due to distance from the river<br><br>Long term (decades - centuries): high, but still dependent upon no additional interception of ground water by other users between the Fort and the river | Short term: poor<br><br>Long term: fair |
| 5. Ability to help sustain floodflows within their natural range of variability in terms of timing, frequency, and magnitude. ("Natural range of flood flows" is defined as the range of floodflows experienced in the river between 1954 and 1988) | Little to no impact on floodflows | N/A |
| 6. Ability to help maintain existing (or better) water quality within the river | Little to no impact on water quality at the river | N/A |

**A1. Intra-basin transfer: Tombstone Mine to Fort Huachuca Reclaimed Water System**

| Criterion | Relevant aspects of alternative with respect to criterion | Rating (good, fair, poor) |
|---|---|---|
| **Ratings based on yield of 500 acre-feet per year** | | |
| 7. Ability of strategy to continue addressing problem during periods of extended drought and over long periods of time (50 years+) | Yield not directly subject to influences from drought. | Fair |
| 8. Estimated yields are adequate to meet future projected population and SPRNCA needs. | Insufficient as "stand alone" strategy to address 38,500 acre-foot goal through 2050 | Poor |
| 9. Reliably produces water every year, not dependent on rainfall | Not imminently rainfall dependent. Will reliably produce effluent, but the aquifer that supplies the mine area and wells around Tombstone (from which demand is satisfied for eventual conversion to effluent) is ultimately dependent on rainfall/drought. | Fair |
| 10. Complements current or planned USPP projects. | Compliments and does not conflict with other projects | Fair |
| 11. Timing of benefits (quick benefit to river) | Benefits to river not likely realized for several decades | Poor |
| 12. Length of time to work through the regulatory requirements | Less time than CAP, likely more than stormwater capture alternative | Fair |
| 13. Replaces or reduces ground water demand? | This option spatially transfers ground water that would eventually reach the San Pedro River. It does not reduce total demand within the sub-watershed or retire any existing uses, nor does this alternative augment the amount of water in the SV Sub-watershed. | Poor |
| 14. Low potential for unintended environmental consequences at the source location of the water or within the Sierra Vista Sub-watershed. | This option transfers water that would have eventually flowed toward the river. It will decrease natural discharge rates in downstream reaches over longer time periods. There may be impacts to other wells in the Tombstone area, and effects on aging mine works, causing settlement and subsidence. Could possibly improve water quality by cleaning up effluent. | Poor |

**A1. Intra-basin transfer: Tombstone Mine to Fort Huachuca Reclaimed Water System**

| Criterion | Relevant aspects of alternative with respect to criterion | Rating (good, fair, poor) |
|---|---|---|
| **IMPLEMENTABILITY** | | |
| **Ratings based on yield of 500 acre-feet per year** | | |
| 15. Spatial, geologic, and hydrologic constraints | The complex geology of the Tombstone area would necessitate additional detailed studies to address subsidence and settling issues. A better estimate of long-term yield will be difficult to ascertain. Unintended impacts on natural discharge rates to the San Pedro will also be difficult to predict. | Fair |
| 16. Environmental impact issues | The impacts to removing effluent from Walnut Gulch need to be assessed, along with the potential impacts to bats using the Tombstone mine. There are potential impacts with developing a pipeline across the riparian area (SPRNCA). | Fair |
| 17. State of technology (i.e., proven method or pilot) | Conventional technology | Good |
| 18. Legal and regulatory issues at the local, State (e.g. ADWR, ADEQ, Land Department), and Federal levels | ADWR, EPA issues would be minimal | Good |
| 19. Current land ownership, right of way, water rights, etc. | ROW, ADOT, county, private, possible interference with existing mining claims | Poor |
| 20. Current ownership of water utility | | Good |
| 21. Current land use and zoning | Mix of agricultural, RU-4 rural residential | Good |
| 22. Compatibility of project with adjacent uses | Subsidence/settlement may impact wells in area | Poor |
| 23. Complexity of crossing jurisdictional boundaries | Federal, county, city | Poor |
| 24. Likely community support | Likely there will be opposition | Poor |
| 25. Impacts on area where water is being transferred from—political, environmental, economic | Possible environmental impacts including: subsidence, settling, removal of effluent from Walnut Gulch, bats | Poor |
| **COST** | | |
| 26. Capital requirements | 500 acre-feet per year: $6.35 million, 1,322 acre-feet per year: $9.19 million | To be determined at a later stage |
| 27. Operating and maintenance expenses | 500 acre-feet per year: $0.26 million, 1,322 acre-feet per year: $0.66 million | To be determined at a later stage |

**A1. Intra-basin transfer: Tombstone Mine to Fort Huachuca Reclaimed Water System**

| Criterion | Relevant aspects of alternative with respect to criterion | Rating (good, fair, poor) |
|---|---|---|
| **Ratings based on yield of 500 AFY** | | |
| 28. Total annual cost (sum of capital cost amortized over life of project plus operation and maintenance) | 500 acre-feet per year: $0.72 million; 1,322 acre-feet per year: $1.34 million | To be determined at a later stage |
| 29. Cost/yield ratio | 500 acre-feet per year: $1,449 per acre-foot, $4.45 per thousand gallons | Fair |
| 30. Timing (when dollars would be needed) | Two years | To be determined at a later stage |
| 31. Availability of State or Federal funding | Unknown | To be determined at a later stage |

**A2. Intra-basin transfer: Tombstone Mine to Recharge at the SPRNCA**

| Criterion | Relevant aspects of alternative with respect to criterion | Rating (good, fair, poor) |
|---|---|---|
| **Ratings based on 500 acre-feet per year of yield** | | |
| **EFFECTIVENESS** | | |
| 1. Yield in terms of acre-feet | Range of 500 acre-feet per year (natural recharge plus 112 acre-feet per year of effluent) to 1,322 acre-feet per year (sustainable for about 20 years, also includes 112 acre-feet of effluent) | Poor |
| 2. Likelihood that project magnitude and location of yields will benefit:<br><br>1) The regional aquifer<br><br>2) The river | <br><br>1) Regional aquifer: not likely<br><br>2) River: highly likely over shorter timeframes (decades). Could eventually impair river's health by decreasing discharge to SPRNCA downstream of Charleston gage | <br><br>1) Regional aquifer: poor<br><br>2) River:<br>< 50 years: good<br>> 50 years: poor |
| 3. Ability to help sustain natural range of alluvial groundwater levels in their current spatial distribution. ("Natural range of alluvial groundwater levels" is defined as the groundwater levels and gradients within the Sierra Vista Sub-watershed that existed at or about the time of the establishment of the SPRNCA.) | Short term (years - decades): high, due to distance from the river. Small sustainable quantity. | < 50 years: good<br>> 50 years: poor |
| 4. Ability to help sustain natural baseflows within their general spatial distribution. ("Natural baseflows" is defined as the range of baseflows experienced in the river between 1954 and 1988). | Short term (years - decades): high, due to distance from the river. Small sustainable quantity | < 50 years: good<br>> 50 years: poor |
| 5. Ability to help sustain floodflows within their natural range of variability in terms of timing, frequency, and magnitude. ("Natural range of floodflows" is defined as the range of floodflows experienced in the river between 1954 and 1988). | Little to no impact on floodflows. | NA |
| 6. Ability to help maintain existing (or better) water quality within the river | Slow sand filtration would address fecal coliform bacteria in this alternative; however, other slight exceedences of drinking water standards in terms of arsenic, fluoride, and nitrates may exist. Water quality data have not been consistent, and additional treatment needs remain uncertain. | Fair |

**A2. Intra-basin transfer: Tombstone Mine to Recharge at the SPRNCA**

| Criterion | Relevant aspects of alternative with respect to criterion | Rating (good, fair, poor) |
|---|---|---|
| **Ratings based on 500 acre-feet per year of yield** | | |
| 7. Ability of strategy to continue addressing problem during periods of extended drought and over long periods of time (50 years+) | Yield not directly subject to influences from drought. Sustainability depends upon annual yield, highest estimate of yield sustainable for about 20 years | Fair |
| 8. Estimated yields are adequate to meet future projected population and SPRNCA needs. | Insufficient as "stand alone" strategy to address 38,500-acre-foot goal thru 2050 | Poor |
| 9. Reliably produces water every year; not dependent on rainfall | Not imminently rainfall dependent, but ultimately dependent on rain | Fair |
| 10. Complements current or planned USPP projects. | Complements, does not conflict | Good |
| 11. Timing of benefits (quick benefit to river) | Benefits to river realized in short term | Good |
| 12. Length of time to work through the regulatory requirements | Less than CAP and more than storm-water capture alternative | Fair |
| 13. Replaces or reduces ground water demand | This option spatially transfers ground water that would eventually reach the San Pedro River. It does not reduce total demand within the sub-watershed or retire any existing uses, nor does this alternative augment the amount of water in the SV Sub-watershed. | Poor |
| 14. Low potential for unintended environmental consequences at the source location of the water or within the Sierra Vista Sub-watershed. | This option intercepts water that would have eventually flowed toward the river - it will decrease natural recharge rates over longer time periods. There may be impacts to other wells in the Tombstone area and effects on aging mine works, causing settlement and subsidence. | Poor |
| **IMPLEMENTABILITY** | | |
| 15. Spatial, geologic, and hydrologic constraints | The complex geology of the Tombstone area would necessitate additional detailed studies to address subsidence and settling issues. A better estimate of long-term yield will be difficult to ascertain. Unintended impacts on natural recharge rates to the San Pedro will also be difficult to predict. | Fair |

| | | |
|---|---|---|
| 16. Environmental impact issues | The impacts to removing effluent from Walnut Gulch need to be assessed, along with the potential impacts to bats using the Tombstone mine and impacts associated with developing a pipeline to the river (through the SPRNCA). | Fair |
| 17. State of technology (i.e., proven method or pilot) | Conventional technology, aside from the specific design of recharge facilities near the river that will be adequate to sustain the riparian ecosystem | Fair |
| 18. Legal and regulatory issues at the local, State (e.g., ADWR, ADEQ, Land Department) and Federal levels | ADWR and EPA/ADEQ issues would be minimal. Interference with existing mining claims**.** | Fair |
| 19. Current land ownership, right of way, water rights, etc. | ROW: ADOT, BLM Southern Pacific, private. Significant problems with land ownership and water rights because of the many land owners and interests. | Poor |
| 20. Current ownership of water utility | N/A | N/A |
| 21. Current land use and zoning | Mix of agricultural and RU-4 residential | Good |
| 22. Compatibility of project with adjacent uses | Subsidence/settlement may impact wells in area | Poor |
| 23. Complexity of crossing jurisdictional boundaries**.** | Federal lands and county | Poor |
| 24. Likely community support | Unknown | Poor |
| 25. Impacts on area where water is being transferred from—political, environmental, economic | Possible environmental impacts include subsidence, settling, impacts to Walnut Gulch, and bats | Poor |
| **COST** | | |
| 26. Capital requirements | 500 acre-feet per year: $8.09 million, 1,322 acre-feet per year: $10.91 million | Fair |
| 27. Operating and maintenance expenses | 500 acre-feet per year: $0.14 million, 1,322 acre-feet per year: $0.27 million | To be determined at a later stage |
| 28. Total annual cost (sum of capital cost amortized over life of project plus operation and maintenance) | 500 acre-feet per year: $0.73 million, 1,322 acre-feet per year: $1.07 million | To be determined at a later stage |
| 29. Cost/yield ratio | 500 acre-feet per year: $1,466 per acre-foot, $4.50 per thousand gallons; 1,322 acre-feet per year: $809 per acre-foot, $2.48 per thousand gallons | To be determined at a later stage |
| 30. Timing (when dollars would be needed) | Two years | To be determined at a later stage |
| 31. Availability of State or Federal funding | Unknown | To be determined at a later stage |

| **B. Intra-basin transfer: North of Benson Retired Ag to Fort Huachuca/Sierra Vista** | | |
|---|---|---|
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| **Ratings assume that net amount of water transferred would be 75 percent of the amount that was pumped in that same area in 2002. Under that assumption the yield (amount of water transferred) would be 3,375 acre-feet per year.** | | |
| **EFFECTIVENESS** | | |
| 1. Yield in terms of acre-feet | Costs estimated for 3,375 acre-feet per year. Range is between 500 and 7,400 acre-feet per year (500 acre-feet represents 50 percent of 2002 pumping, 7,400 acre-feet represents 100 percent of historic maximum pumping). | Fair |
| 2. Likelihood that project magnitude and location of yields will benefit:<br><br>1) The regional aquifer<br><br>2) The river | <br><br>1) Regional aquifer: highly likely<br><br>2) River: not likely over shorter timeframes (decades) | <br><br>Regional: good<br><br>River:<br>Short term: poor<br>Long term: good |
| 3. Ability to help sustain natural range of alluvial ground water levels in their current spatial distribution. ("Natural range of alluvial ground water levels" is defined as the ground water levels and gradients within the Sierra Vista Sub-watershed that existed at or about the time of the establishment of the SPRNCA.) | Short term (years - decades): low, due to distance from the river<br><br>Long term (decades - centuries): high, but still dependent upon no additional interception of ground water by other users between the Fort/SV and the river | Short term: poor<br><br>Long term: good |
| 4. Ability to help sustain natural base flows within their general spatial distribution. ("Natural base flows" is defined as the range of base flows experienced in the river between 1954 and 1988.) | Short term (years - decades): low, due to distance from the river<br><br>Long term (decades - centuries): high, but still dependent upon no additional interception of ground water by other users between Fort/SV and the river | Short term: poor<br><br>Long term: good |
| 5. Ability to help sustain floodflows within their natural range of variability in terms of timing, frequency, and magnitude. ("Natural range of flood flows" is defined as the range of floodflows experienced in the river between 1954 and 1988.) | No impact on floodflows within SV Sub-watershed | N/A |

Appendix B:
B. Intra-basin transfer: North of Benson Retired Ag to Fort Huachuca/Sierra Vista

| **B. Intra-basin transfer: North of Benson Retired Ag to Fort Huachuca/Sierra Vista** | | |
|---|---|---|
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| **Ratings assume that net amount of water transferred would be 75 percent of the amount that was pumped in that same area in 2002. Under that assumption the yield (amount of water transferred) would be 3,375 acre-feet per year.** | | |
| 6. Ability to help maintain existing (or better) water quality within the river | Arsenic and fluoride levels are above drinking water standards but would be addressed with activated alumina treatment, resulting in no negative impacts to water quality within SV Sub-watershed | N/A |
| 7. Ability of strategy to continue addressing problem during periods of extended drought and over long periods of time (50 years+) | Surface water regulations may prohibit or reduce use of water if pumped from subflow zone according to priority of surface flow rights; future/additional water users in the Benson Sub-watershed may reduce local water availability. Long-term drought will affect regional water levels. | Poor |
| 8. Estimated yields are adequate to meet future projected population and SPRNCA needs. | Insufficient as "stand alone" strategy to address 38,500-acre-foot goal through 2050 | Poor |
| 9. Reliably produces water every year; not dependent on rainfall**.** | Not rainfall dependent over shorter (annual) time intervals | Fair |
| 10. Complements current or planned USPP projects. | No apparent conflict or competition with other projects; could complement other projects | Fair |
| 11. Timing of benefits (quick to the river) | Retiring pumping near SV/Fort Huachuca would benefit the San Pedro over longer timeframes but benefits not realized for decades at the river | Short term: poor<br>Long term: fair |
| 12. Length of time to work through the regulatory requirements | ADWR expects that it will take several years to resolve subflow zone issues | Fair |
| 13. Replaces or reduces ground water demand | Ground water demand would be reduced in the SV Sub-watershed, but, depending upon the yield, either partially reduced or replaced in the Benson Sub-watershed (agricultural for municipal). Potential maximum pumping would be reduced; however, current pumping isn't near the maximum allowed. | In Benson - fair<br>In SV - good |
| 14. Low potential for unintended environmental consequences at the source location of the water or within the Sierra Vista Sub-watershed. | Effects on endangered species downstream uncertain but likely, partially dependent upon the amount of pumping retired versus the amount transferred | Good |

| **B. Intra-basin transfer: North of Benson Retired Ag to Fort Huachuca/Sierra Vista** | | |
|---|---|---|
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| **Ratings assume that net amount of water transferred would be 75 percent of the amount that was pumped in that same area in 2002. Under that assumption the yield (amount of water transferred) would be 3,375 acre-feet per year.** | | |
| | upstream, and the combined effects of pumping by all water users. | |
| **IMPLEMENTABILITY** | | |
| 15. Spatial, geologic, and hydrologic constraints | Yield may be constrained in the future from competing water uses in the Benson Sub-watershed | Fair |
| 16. Environmental impact issues | The effects of continued ground water withdrawal near Benson would need to be evaluated in terms of both local impacts and on downstream reaches of the San Pedro where critical habitat exists, Federal mitigation projects are in place, and effects on endangered species must be evaluated. | Fair |
| 17. State of technology (i.e., proven method or pilot) | Conventional technology | Good |
| 18. Legal and regulatory issues at the local, State (e.g., ACC, ADWR, ADEQ, Land Department), and Federal levels | Complex, involving many agencies – ADEQ, ADWR, USFWS, EPA. Major regulatory issues with ACC. | Fair |
| 19. Current land ownership, right of way, water rights, etc. | Water rights: subflow and adjudication process; availability of parcels uncertain; easement would follow existing public roads | Fair |
| 20. Current ownership of water utility | Bella Vista Water Co., Arizona Water Co., PDS Water Co. Major regulatory issues with ACC. | Poor |
| 21. Current land use and zoning | Mixed land use: primarily agricultural and residential | Good |
| 22. Compatibility of project with adjacent uses | Effects on Benson area wells must be addressed. Reduced long-term pumping is good for adjacent uses. | Fair |
| 23. Complexity of project crossing jurisdictional boundaries. | County-City of Benson County | Fair |
| 24. Likely community support | Very low community support. If used as SV drinking water, there will be no support in source community. | Poor |

| **B. Intra-basin transfer: North of Benson Retired Ag to Fort Huachuca/Sierra Vista** | | |
|---|---|---|
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| **Ratings assume that net amount of water transferred would be 75 percent of the amount that was pumped in that same area in 2002. Under that assumption the yield (amount of water transferred) would be 3,375 acre-feet per year.** | | |
| 25. Impacts on area where water is being transferred from—political, environmental, economic | Environmental impacts dependent upon multiple factors listed above, political impacts high | Poor |
| **COST** | | |
| 26. Capital requirements | $31.6 million | To be determined at a later stage |
| 27. Operating and maintenance expenses | $2 million per year | To be determined at a later stage |
| 28. Total annual cost (sum of capital cost amortized over life of project plus operation and maintenance) | $2.3 million per year over 20 years. Present value (4 percent, 20 years, 0.0736) | To be determined at a later stage |
| 29. Cost/yield ratio | $1,282 per acre-foot, $3.93 per 1,000 gallons | Fair |
| 30. Timing of when dollars would be needed | Within 2 years | To be determined at a later stage |
| 31. Availability of State or Federal funding | Unknown | To be determined at a later stage |

**C1. Intra-basin transfer: Copper Queen Mine to Fort Huachuca / Sierra Vista**

| Criterion | Relevant aspects of alternative with respect to criterion | Rating (good, fair, poor) |
|---|---|---|
| **Ratings assume a project timeline of greater than 25 years. Also, uncertainty regarding mine water connectivity to the aquifer was considered** | | |
| **EFFECTIVENESS** | | |
| 1. Yield in terms of acre-feet | Yield dependent upon water quality: 45-percent recovery: 1,800 acre-feet per year, 65-percent recovery, 2,600 acre-feet per year (over a 21- to 25-year period) | Fair |
| 2. Likelihood that project magnitude and location of yields will benefit:<br>1) The regional aquifer<br>2) The river | 1) Regional aquifer: highly likely<br>2) River: not likely over shorter timeframes (decades). The poor rating for river is appropriate since there would be no “excess” water to recharge in Greenbush/injection well (even winter). Biggest diff. from CQ Mine to Bisbee suboption is probably less immediate benefit to river with this option. Virtually all other aspects are same between the two suboptions. | 1) Regional aquifer: good<br>2) River: poor |
| 3. Ability to help sustain natural range of alluvial ground water levels in their current spatial distribution. (“Natural range of alluvial ground water levels” is defined as the ground water levels and gradients within the Sierra Vista Sub-watershed that existed at or about the time of the establishment of the SPRNCA.) | Short term (years - decades): low, due to distance from the river<br>Long term (decades-centuries): high, but still dependent upon no additional interception of ground water by other users between Naco and the river | < 50 years: poor<br>> 50 years: fair |
| 4. Ability to help sustain natural base flows within their general spatial distribution. (“Natural base flows” is defined as the range of base flows experienced in the river between 1954 and 1988.) | Short term (years - decades): low due to distance from the river<br>Long term (decades - centuries): high, but still dependent upon no additional interception of ground water by other users between Naco and the rive | < 50 years: poor<br>> 50 years: fair |
| 5. Ability to help sustain floodflows within their natural range of variability in terms of timing, frequency, and magnitude. (“Natural range of flood flows” is defined as the range of flood flows experienced in the river between 1954 and 1988.) | Little to no impact on floodflows | N/A |

**C1. Intra-basin transfer: Copper Queen Mine to Fort Huachuca / Sierra Vista**

| Criterion | Relevant aspects of alternative with respect to criterion | Rating (good, fair, poor) |
|---|---|---|
| **Ratings assume a project timeline of greater than 25 years. Also, uncertainty regarding mine water connectivity to the aquifer was considered** | | |
| 6. Ability to help maintain existing (or better) water quality within the river | A wide range of constituents would be addressed through reverse osmosis, resulting water quality would be high | N/A |
| 7. Ability of strategy to continue addressing problem during periods of extended drought and over long periods of time (50 years+) | Drought does not directly affect this strategy, but sustainability for this option only defined as 21 to 25 years | Good |
| 8. Estimated yields are adequate to meet future projected population and SPRNCA needs. | Insufficient as a stand alone strategy to address 38,500 acre-feet per year goal through 2050 | Poor |
| 9. reliably produces water every year, not dependent on rainfall | Not directly rainfall dependent, but ultimately dependent on rainfall | Good |
| 10. Complements current or planned USPP projects. | Does not conflict with other projects; is complementary; competes for funds due to high cost | Good |
| 11. Timing of benefits | Benefits to river not likely realized for several decades | Poor |
| 12. Length of time to work through the regulatory requirements | Less time required than CAP, likely more than storm water capture alternative. Also, the APP and water rights issues with PD | Fair |
| 13. Will project replace or reduce groundwater demand? | This project will partially replace groundwater demand | Good |
| 14. Potential for unintended environmental consequences at the source location of the water or within the Sierra Vista Sub-watershed | A very small amount of water in the mine reaches of the San Pedro River, due to geologic flow barriers, so natural recharge to the river would only minimally be affected. This alternative augments the amount of water in the SV Sub-watershed (not just a transfer), at least in part. | Good |
| **IMPLEMENTABILITY** | | |
| 15. Spatial, geologic, and hydrologic constraints | Variation in water quality makes water treatment cost estimates difficult. PD may begin mining operations in the future, which may affect project yields. Integrity of mining shafts is also a potential issue. Disposal of concentrate is challenging. | Fair |
| 16. Environmental impact issues | Evaporation ponds concentrate toxic pollutants, so "bird-free" design and operation would be required. Approximately 310 to 490 acres of evaporation pond area is required for facilities. Disposal of dried salts from evaporation ponds is not addressed in the study. | Fair |

**C1. Intra-basin transfer: Copper Queen Mine to Fort Huachuca / Sierra Vista**

| Criterion | Relevant aspects of alternative with respect to criterion | Rating (good, fair, poor) |
|---|---|---|
| **Ratings assume a project timeline of greater than 25 years. Also, uncertainty regarding mine water connectivity to the aquifer was considered** | | |
| 17. State of technology (i.e., proven method or pilot) | Reverse osmosis is proven method, but customization of methods needed due to the variability on water quality | Fair/poor |
| 18. Legal and regulatory issues at the local, State (e.g., ACC, ADWR, ADEQ, Land Department), and General levels | Several ACC issues may be extremely problematic: under State law, this proposal cannot be done, NEPA clearance, ADEQ, 404 permits | Poor |
| 19. Current land ownership, right of way, water rights, etc. | Private: Phelps Dodge owner Because PD has the long-term operation of the mine is in question, the negotiation for water rights will be difficult, at best, given that water is being moved further away from the mine. | Poor |
| 20. Current ownership of water utility | Many private water providers; could be insurmountable | Poor |
| 21. Current land use and zoning | Industrial/ PD, residential | Good |
| 22. Compatibility of project with adjacent uses | Likely no significant negative impact on adjacent water levels; assumes evaporative ponds on PD lands | Good |
| 23. Does project cross jurisdictional boundaries? | | Fair |
| 24. Likely community support or opposition | Some opposition | Fair/poor |
| 25. Impacts on area where water is being transferred from—political, environmental, economic | Environmental: impacts minimal, helpful for PD operations, some cultural issues | Good |
| **COST** | | |
| 26. Capital requirements | 1,800 acre-feet per year: $51.9 million, 2,600 acre-feet per year: $54.0 million | To be determined at a later stage |
| 27. Operating and maintenance expenses | 1,800 acre-feet per year: $1.3 million, 2,600 acre-feet per year: $1.4 million | To be determined at a later stage |
| 28. Total annual cost (sum of capital cost amortized over life of project plus O&M) | 1800 acre-feet per year: $5.1 million, 2,600 acre-feet per year - $5.4 million | To be determined at a later stage |
| 29. Cost/yield ratio | 1,800 acre-feet per year: $2,860 per acre-foot, $8.78 per thousand gallons; 2,600 acre-feet per year: $2,062 per acre-feet, $6.33 per thousand gallons | Poor |
| 30. Timing of when dollars would be needed | Unknown | To be determined at a later stage |
| 31. Availability of State or Federal funding | unknown | To be determined at a later stage |

| **C2. Intra-basin transfer: Copper Queen Mine to Bisbee/Naco** | | |
|---|---|---|
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| **EFFECTIVENESS** | | |
| 1. Yield in terms of acre-feet | Yield dependent upon water quality: 45-percent recovery: 1,800 acre-feet per year; 65-percent recovery, 2,600 acre-feet per year (over a 21- to 25-year period). | Fair |
| 2. Likelihood that project magnitude and location of yields will benefit:<br><br>1) The regional aquifer<br><br>2) The river | <br><br><br>1) Regional aquifer: highly likely<br><br>2) River: not likely over shorter time frames (decades) | <br><br><br>1) Aquifer: good<br><br>2) River:<br>Short term: poor<br>Long term: good |
| 3. Ability to help sustain natural range of alluvial ground water levels in their current spatial distribution. ("Natural range of alluvial ground water levels" is defined as the ground water levels and gradients within the Sierra Vista Sub-watershed that existed at or about the time of the establishment of the SPRNCA.) | Short term (years - decades): low, due to distance from the river<br><br>Long term (decades - centuries): high, but still dependent upon no additional interception of ground water by other users between Naco and the river | Short term: poor<br><br><br>Long term: fair |
| 4. Ability to help sustain natural base flows within their general spatial distribution. ("Natural base flows" is defined as the range of base flows experienced in the river between 1954 and 1988) | Short term (years - decades): low, due to distance from the river<br><br>Long term (decades - centuries): high, but still dependent upon no additional interception of ground water by other users between Naco and the river | Short term: poor<br><br><br>Long term: fair |
| 5. Ability to help sustain floodflows within their natural range of variability in terms of timing, frequency, and magnitude. ("Natural range of flood flows" is defined as the range of flood flows experienced in the river between 1954 and 1988.) | Little to no impact on floodflows | N/A |
| 6. Ability to help maintain existing (or better) water quality within the river | A wide range of constituents would be addressed through reverse osmosis; resulting water quality would be high | N/A |
| 7. Ability of strategy to continue addressing problem during periods of extended drought, and over long periods of time (50 years+) | Drought does not directly affect this strategy, but sustainability for this option only defined as 21 to 25 years | Good |
| 8. Estimated yields are adequate to meet future projected population and SPRNCA needs. | Insufficient as a "stand alone" strategy to address 38,500 acre-feet per year goal thru 2050 | Poor |

Appendix B:
C2. Intra-basin transfer: Copper Queen Mine to Bisbee/Naco

| **C2. Intra-basin transfer: Copper Queen Mine to Bisbee/Naco** | | |
|---|---|---|
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| 9. Reliably produces water every year; not dependent on rainfall | Not directly rainfall dependent. Ultimately dependent on rain | Good |
| 10. Complements current or planned USPP projects. | Does not conflict with other projects; is complementary; competes for funds due to high cost | Good |
| 11. Timing of benefits (quick to the river) | Benefits to river not likely realized for several decades | Poor |
| 12. Length of time to work through the regulatory requirements | Less time required than CAP, likely more than storm water capture alternative | Fair |
| 13. Replaces or reduces ground water demand | This project will partially replace ground water demand | Good |
| 14. Low potential for unintended environmental consequences at the source location of the water or within the Sierra Vista Sub-watershed. | A very small amount of water in the mine reaches the San Pedro River, due to geologic flow barriers, so natural recharge to the river would only minimally be affected. This alternative augments the amount of water in the SV Sub-watershed (not just a transfer), at least in part. | Good |
| **IMPLEMENTABILITY** | | |
| 15. Spatial, geologic and hydrologic constraints | Variation in water quality makes water treatment cost estimates difficult. PD may begin mining operations in the future which may affect project yields. Integrity of mining shafts also a potential issue. | Fair |
| 16. Environmental impact issues | Evaporation ponds concentrate toxic pollutants so would require "bird-free" design and operation. Approximately 310-490 acres of evaporation pond area is required for facilities. Disposal of dried salts from evaporation ponds is not addressed in study. | Fair |
| 17. State of technology (i.e. proven method or pilot) | Reverse osmosis is a proven method; however, the huge variability in water quality make piloting to verify treatment and associated cost; at least 1 year for pilot | Technology - fair<br>Customizing - poor |
| 18. Legal and regulatory issues at the local, State (e.g. ACC, ADWR, ADEQ, Land Department), and Federal levels | NEPA clearance, ADEQ, 404 permits. Cannot be done under current State law. | Poor |
| 19. Current land ownership, right of way, water rights, etc | Private: Phelps Dodge owner. Long-term operation of mine in question | Fair |

| **C2. Intra-basin transfer: Copper Queen Mine to Bisbee/Naco** | | |
|---|---|---|
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| 20. Current ownership of water utility | Arizona Water Co., Inc., and Naco Water Co., Inc., ownership; would assume that AWC will not be willing to take this water; uncertain about Naco | Poor |
| 21. Current land use and zoning | Phelps Dodge and residential. | Good |
| 22. Compatibility of project with adjacent uses | Likely no significant negative impact on adjacent water levels, assuming ponds are on Phelps Dodge land. | Good |
| 23. Complexity of project crossing jurisdictional boundaries | | Fair |
| 24. Likely community support or opposition | Mild opposition | Fair |
| 25. Impacts on area where water is being transferred from—political, environmental, economic | Environmental: impacts minimal, some cultural issues. Helpful for Phelps Dodge | Good |
| **COST** | | |
| 26. Capital requirements | 1,800 acre-feet per year: $41.6 million, 2,600 acre-feet per year: 40.4 million | To be determined at a later stage |
| 27. Operating and maintenance expenses | 1,800 acre-feet per year: $1.3 million, 2,600 acre-feet per year: $1.3 million | To be determined at a later stage |
| 28. Total annual cost (sum of capital cost amortized over life of project plus operation and maintenance) | 1,800 acre-feet per year: $4.3 million, 2,600 acre-feet per year: $4.3 million | To be determined at a later stage |
| 29. Cost/yield ratio | 1,800 acre-feet per year: $2,397 per acre-foot, $7.36 per thousand gallons; 2,600 acre-feet per year: $1,635 per acre-foot, $5.02 per thousand gallons | Poor |
| 30. Timing of when dollars would be needed | Unknown | To be determined at a later stage |
| 31. Availability of State or Federal funding | Unknown | To be determined at a later stage |

**D1. Inter-basin import: CAP recharge and recovery**

| Assumes recharge and recovery would take place in Sierra Vista city limits and/or near the SPR | | |
|---|---|---|
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| **EFFECTIVENESS** | | |
| 1. Yield in terms of acre-feet | Three options were assessed: 20,000 acre-feet, 30,000 acre-feet, 40,000 acre-feet. The larger volumes would result in net excess recharge temporarily. | Good |
| 2. Likelihood that project magnitude and location of yields will benefit:<br><br>1) The regional aquifer<br><br>2) The river | <br><br>1) Regional aquifer: highly likely<br><br>2) River: Recharge to the SPR could benefit the river within a year of operation. | <br><br>1) Regional aquifer: good<br><br>2) River:<br>< 50 years: poor<br>Change to good<br><br>> 50 years: fair<br>Change to good |
| 3. Ability to help sustain natural range of alluvial ground water levels in their current spatial distribution. ("Natural range of alluvial ground water levels" is defined as the ground water levels and gradients within the Sierra Vista Sub-watershed that existed at or about the time of the establishment of the SPRNCA.) | Short term: (years - decades): Recharge to the SPR could benefit the river within a year of operation<br><br>Long term: (decades - centuries): high, recharge at the SPR would mitigate interception of ground water between Sierra Vista/Fort Huachuca and the river | < 50 years: poor<br>Change to good<br><br>> 50 years: fair<br>Change to good |
| 4. Ability to help sustain natural baseflows within their general spatial distribution. ("Natural baseflows" is defined as the range of baseflows experienced in the river between 1954 and 1988.) | Short term: (years - decades): Recharge to the SPR could benefit the river within a year of operation<br><br>Long term: (decades - centuries): high, recharge at the SPR would mitigate the interceptions of ground water between Sierra Vista/Fort Huachuca and the river.<br><br>**USGS-** Would be good rating if upstream uses mitigated as well. **Reclamation** – Same as above. This alternative will have a significant, immediate impact on the river – and will not be affected by users (pumpers) between SV/FH and the river. | < 50 years: poor<br>Change to good<br><br>> 50 years: fair<br>Change to good |

**D1. Inter-basin import: CAP recharge and recovery**

| Assumes recharge and recovery would take place in Sierra Vista city limits and/or near the SPR | | |
|---|---|---|
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| 5. Ability to help sustain floodflows within their natural range of variability in terms of timing, frequency, and magnitude. ("Natural range of floodflows" is defined as the range of floodflows experienced in the river between 1954 and 1988) | Little to no impact on floodflows | N/A |
| 6. Ability to help maintain existing (or better) water quality within the river | CAP water has higher levels of total organic carbon (TOC), algae, and higher concentrations of suspended and dissolved solids than native ground water, which may affect soil geochemistry, wastewater quality, and surface and ground water quality. However, basic water quality standards would likely be met through "soil-aquifer treatment' during recharge, aside from removal of dissolved solids. CAP water will have an immediate effect on water quality for people and the river. TDS level will reflect blending CAP water at 700 parts per minute with SPR ground water at 265 parts per minute. | Fair |
| 7. Ability of strategy to continue addressing problem during periods of extended drought and over long periods of time (50 years+) | Allocation issues/seniority of water rights will be important during drought periods. Indian and non-Indian municipal and industrial allocations have highest priority, while non-Indian agricultural water is lower allocation priority during times of shortage. Duration of water availability uncertain. Properly used and/or allocated, CAP water will be less prone to long-term drought. | Good |
| 8. Estimated yields are adequate to meet future projected population and SPRNCA needs. | Yields up to 40,000 acre-feet per year were assessed by Reclamation. | Good |
| 9. Reliably produces water every year, not dependent on rainfall | Not rainfall dependent over shorter (annual) time intervals, but still contingent upon allocation issues. Good rating assumes excess capacity recharged when available and banked for dry years. | Good |

**D1. Inter-basin import: CAP recharge and recovery**

| Assumes recharge and recovery would take place in Sierra Vista city limits and/or near the SPR | | |
|---|---|---|
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| 10. Complements current or planned USPP projects. | | Good |
| 11. Timing of benefits (quick to the river) | Recharge of CAP water near Sierra Vista/ Fort Huachuca would benefit the San Pedro within a year of operation. | Poor<br>Change to good |
| 12. Length of time to work through the regulatory requirements | Numerous regulatory requirements would require considerable time: Clean Water Act-404 permitting, ESA Section 7, NEPA compliance, APP requirements or Arizona title 45, recovery well permit, others. | Poor |
| 13. Project replaces or reduces ground water demand | Ground water supply would be augmented in the SV Sub-watershed but would proportionately increase surface water demands in the Colorado River Basin. | Good |
| 14. Low potential for unintended environmental consequences at the source location of the water or within the Sierra Vista Sub-watershed. | Endangered Species Act consultation and subsequent mitigation measures may be required to offset impacts of importation of non-native fish. Environmental issues would be greater for the recharge alternatives than for direct delivery. Several federally listed proposed, candidate species would need to be addressed through NEPA. Possible ecological consequences due to increase in SPR's total dissolved solids concentration. See Reclamation's biological appraisal for additional ecological consequences.<br><br>Potential for environmental consequences to Colorado River system poorly defined.<br>Project involves buried pipelines, which have less long-term impacts than a canal. | Poor |
| **IMPLEMENTABILITY** | | |
| 15. Spatial, geologic, and hydrologic constraints | Water quality issues previously described. Longest proposed pipeline of all augmentation alternatives may make implementability issues more | Fair |

**D1. Inter-basin import: CAP recharge and recovery**

| Assumes recharge and recovery would take place in Sierra Vista city limits and/or near the SPR | | |
|---|---|---|
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| | complex and would require excavation through bedrock and large slope excavations. Approximately 12 to 14 miles of suitable natural channel will have to be identified for recharge at the river. | |
| 16. Environmental impact issues | See “potential for unintended environmental consequences” above. Raising the TDS concentration at the river may have an impact on the SPR ecosystem. | Poor |
| 17. State of technology (i.e., proven method or pilot) | Conventional technology | Good |
| 18. Legal and regulatory issues at the local, State (e.g. ACC, ADWR, ADEQ, Land Department), and Federal levels | Significant issues associated with multiple private water companies and the ACC. Other numerous regulatory issues: Clean Water Act 404 permits, ESA Section 7, National Historic Preservation Act, APP requirements or Arizona Title 45, recovery well permit(s), other Federal laws. | Poor |
| 19. Current land ownership, right of way, water rights, etc. | There is no current allocation for CAP water. ADWR cannot make reallocation recommendations prior to January 2010, and the process will be very competitive. Right of way: public roads, highways, and interstates; need ADOT construction permits for designated scenic highway alignment. Many different landowners involved. Competition for the CAP allocations will be extreme. Approximately 12 to 14 miles of suitable natural channel will have to be identified for recharge at the river. | Poor |
| 20. Current ownership of water utility | Central Arizona Project, many different local water providers | Poor |
| 21. Current land use and zoning | Variable land uses and zoning | Fair |
| 22. Compatibility of project with adjacent uses | Recharge operations could benefit water users in the vicinity of recharge location(s) | Good |
| 23. Complexity of crossing jurisdictional boundaries | Many jurisdictional boundaries/basins would be crossed | Poor |

**D1. Inter-basin import: CAP recharge and recovery**

| Assumes recharge and recovery would take place in Sierra Vista city limits and/or near the SPR | | |
|---|---|---|
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| 24. Likely community support | Community support would likely be low. Education could change level of support. This alternative offers the opportunity for recreational benefits associated with recharging in natural channels. | Poor |
| 25. Impacts on area where water is being transferred from—political, environmental, economic | | |
| **COST** | | |
| 26. Capital requirements | 20,000 acre-feet: $ 171.0<br>30,000 acre-feet: $ 224.9<br>40,000 acre-feet: $ 294.0 | To be determined at a later stage |
| 27. Operating and maintenance expenses | 20,000 acre-feet: $ 19.0<br>30,000 acre-feet: $ 28.4<br>40,000 acre-feet: $ 38.4 | To be determined at a later stage |
| 28. Total annual cost (sum of capital cost amortized over life of project plus operation and maintenance) | 20,000 acre-feet: $ 31.5<br>30,000 acre-feet: $ 44.8<br>40,000 acre-feet: $ 59.8 | To be determined at a later stage |
| 29. Cost/yield ratio | 20,000 acre-feet: $ 1,725<br>30,000 acre-feet: $ 1,594<br>40,000 acre-feet: $ 1,570 | Fair |
| 30. Timing of when dollars would be needed | After reallocation processes in 2010 | To be determined at a later stage |
| 31. Availability of State or Federal funding | Unknown | To be determined at a later stage |

| D2. Inter-basin import: CAP Recharge and Recovery | | |
|---|---|---|
| **Assumes recharge and recovery would take place in Sierra Vista city limits and/or near the SPR** | | |
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| **EFFECTIVENESS** | | |
| 1. Yield in terms of acre-feet | Three options were assessed: 20,000 acre-feet, 30,000 acre-feet, 40,000 acre-feet. The larger volumes would result in net excess recharge temporarily. | Good |
| 2. Likelihood that project magnitude and location of yields will benefit:<br><br>1) The regional aquifer<br><br>2) The river | <br><br><br>1) Regional aquifer: highly likely<br><br>2) River: Recharge to the SPR could benefit the river within a year of operation. | <br><br><br>1) Regional aquifer: good<br><br>2) River:<br>< 50 years: poor<br>Change to good<br><br>> 50 years: fair<br>Change to good |
| 3. Ability to help sustain natural range of alluvial ground water levels in their current spatial distribution. ("Natural range of alluvial ground water levels" is defined as the ground water levels and gradients within the Sierra Vista Sub-watershed that existed at or about the time of the establishment of the SPRNCA.) | Short term: (years - decades): Recharge to the SPR could benefit the river within a year of operation<br><br>Long term: (decades - centuries): high, recharge at the SPR would mitigate interception of ground water between Sierra Vista/Fort Huachuca and the river | < 50 years: poor<br>Change to good<br><br>> 50 years: fair<br>Change to good |
| 4. Ability to help sustain natural baseflows within their general spatial distribution. ("Natural baseflows" is defined as the range of baseflows experienced in the river between 1954 and 1988.) | Short term: (years - decades): Recharge to the SPR could benefit the river within a year of operation<br><br>Long term: (decades - centuries): high, recharge at the SPR would mitigate the interceptions of ground water between Sierra Vista/Fort Huachuca and the river.<br><br>**USGS-** Would be good rating if upstream uses mitigated as well.<br>**Reclamation** – Same as above. This alternative will have a significant, immediate impact on the river – and will not be affected by users (pumpers) between SV/FH and the river. | < 50 years: poor<br>Change to good<br><br>> 50 years: fair<br>Change to good |

| D2. Inter-basin import: CAP Recharge and Recovery | | |
|---|---|---|
| **Assumes recharge and recovery would take place in Sierra Vista city limits and/or near the SPR** | | |
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| 5. Ability to help sustain floodflows within their natural range of variability in terms of timing, frequency, and magnitude. ("Natural range of floodflows" is defined as the range of floodflows experienced in the river between 1954 and 1988.) | Little to no impact on floodflows | N/A |
| 6. Ability to help maintain existing (or better) water quality within the river | CAP water has higher levels of total organic carbon (TOC), algae, and higher concentrations of suspended and dissolved solids than native ground water, which may affect soil geochemistry, wastewater quality, and surface and ground water quality. However, basic water quality standards would likely be met through "soil-aquifer treatment' during recharge, aside from removal of dissolved solids. CAP water will have an immediate effect on water quality for people and the river. TDS level will reflect blending CAP water at 700 parts per minute with SPR ground water at 265 parts per minute. | Fair |
| 7. Ability of strategy to continue addressing problem during periods of extended drought and over long periods of time (50 years+) | Allocation issues/seniority of water rights will be important during drought periods. Indian and non-Indian municipal and industrial allocations have highest priority, while non-Indian agricultural water is lower allocation priority during times of shortage. Duration of water availability uncertain. Properly used and/or allocated, CAP water will be less prone to long-term drought. | Good |
| 8. Estimated yields are adequate to meet future projected population and SPRNCA needs. | Yields up to 40,000 acre-feet per year were assessed by Reclamation. | Good |
| 9. Reliably produces water every year; not dependent on rainfall | Not rainfall dependent over shorter (annual) time intervals, but still contingent upon allocation issues. Good rating assumes excess capacity recharged when available and banked for dry years. | Good |

| **D2. Inter-basin import: CAP Recharge and Recovery** | | |
|---|---|---|
| **Assumes recharge and recovery would take place in Sierra Vista city limits and/or near the SPR** | | |
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| 10. Complements current or planned USPP projects. | | Good |
| 11. Timing of benefits (quick to the river) | Recharge of CAP water near Sierra Vista/ Fort Huachuca would benefit the San Pedro within a year of operation. | Poor<br>Change to good |
| 12. Length of time to work through the regulatory requirements | Numerous regulatory requirements would require considerable time: Clean Water Act-404 permitting, ESA Section 7, NEPA compliance, APP requirements or Arizona title 45, recovery well permit, others. | Poor |
| 13. Replaces or reduces ground water demand | Ground water supply would be augmented in the SV Sub-watershed but would proportionately increase surface water demands in the Colorado River Basin. | Good |
| 14. Low potential for unintended environmental consequences at the source location of the water or within the Sierra Vista Sub-watershed. | Endangered Species Act consultation and subsequent mitigation measures may be required to offset impacts of importation of non-native fish. Environmental issues would be greater for the recharge alternatives than for direct delivery. Several federally listed proposed, candidate species would need to be addressed through NEPA. Possible ecological consequences due to increase in SPR's total dissolved solids concentration. See Reclamation's biological appraisal for additional ecological consequences.<br><br>Potential for environmental consequences to Colorado River system poorly defined.<br>Project involves buried pipelines, which have less long-term impacts than a canal. | Poor |

| **D2. Inter-basin import:  CAP Recharge and Recovery** | | |
|---|---|---|
| **Assumes recharge and recovery would take place in Sierra Vista city limits and/or near the SPR** | | |
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| **IMPLEMENTABILITY** | | |
| 15.  Spatial, geologic and hydrologic constraints | Water quality issues previously described.  Longest proposed pipeline of all augmentation alternatives may make implementability issues more complex and would require excavation through bedrock and large slope excavations. Approximately 12 to 14 miles of suitable natural channel will have to be identified for recharge at the river. | Fair |
| 16.  Environmental impact issues | See “potential for unintended environmental consequences” above.  Raising the TDS concentration at the river may have an impact on the SPR ecosystem. | Poor |
| 17.  State of technology (i.e., proven method or pilot) | Conventional technology | Good |
| 18.  Legal and regulatory issues at the local, State (e.g. ACC, ADWR, ADEQ, Land Department) and Federal levels | Significant issues associated with multiple private water companies and the ACC.  Other numerous regulatory issues:  Clean Water Act 404 permits, ESA Section 7, National Historic Preservation Act, APP requirements or Arizona Title 45, recovery well permit(s), other Federal laws. | Poor |
| 19.  Current land ownership, right of way, water rights, etc. | There is no current allocation for CAP water.  ADWR cannot make reallocation recommendations prior to January 2010, and the process will be very competitive. Right of way:  public roads, highways, and interstates; need ADOT construction permits  for designated scenic highway alignment.  Many different landowners involved. Competition for the CAP allocations will be extreme. Approximately 12 to 14 miles of suitable natural channel will have to be identified for recharge at the river. | Poor |
| 20. Current ownership of water utility | Central Arizona Project, many different local water providers | Poor |
| 21.  Current land use and zoning | Variable land uses and zoning | Fair |

| **D2. Inter-basin import: CAP Recharge and Recovery** | | |
|---|---|---|
| **Assumes recharge and recovery would take place in Sierra Vista city limits and/or near the SPR** | | |
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| 22. Compatibility of project with adjacent uses | Recharge operations could benefit water users in the vicinity of recharge location(s) | Good |
| 23. Complexity of crossing jurisdictional boundaries | Many jurisdictional boundaries/basins would be crossed | Poor |
| 24. Likely community support or opposition | Community support would likely be low. Education could change level of support. This alternative offers the opportunity for recreational benefits associated with recharging in natural channels. | Poor |
| 25. Impacts on area where water is being transferred from—political, environmental, economic | Impacts to Colorado River system poorly defined | Unknown |
| **COST** | | |
| 26. Capital requirements | 20,000 acre-feet: $ 171.0<br>30,000 acre-feet: $ 224.9<br>40,000 acre-feet: $ 294.0 | To be determined at a later stage |
| 27. Operating and maintenance expenses | 20,000 acre-feet: $ 19.0<br>30,000 acre-feet: $ 28.4<br>40,000 acre-feet: $ 38.4 | To be determined at a later stage |
| 28. Total annual cost (sum of capital cost amortized over life of project plus operation and maintenance) | 20,000 acre-feet: $ 31.5<br>30,000 acre-feet: $ 44.8<br>40,000 acre-feet: $ 59.8 | To be determined at a later stage |
| 29. Cost/yield ratio | 20,000 acre-feet: $ 1,725<br>30,000 acre-feet: $ 1,594<br>40,000 acre-feet: $ 1,570 | Fair |
| 30. Timing (when dollars would be needed) | After reallocation processes in 2010 | To be determined at a later stage |
| 31. Availability of State or Federal funding | Unknown | To be determined at a later stage |

| **E1. Inter-basin import: Douglas Basin to Bisbee** | | |
|---|---|---|
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| **EFFECTIVENESS** | | |
| 1. Yield in terms of acre-feet | 1,010 acre-feet (2010)<br>(Bisbee future demand estimated in BBC/FS report) | Poor |
| 2. Likelihood that project magnitude and location of yields will benefit:<br><br>1) The regional aquifer<br><br>2) The river | <br><br><br>1) Regional aquifer: highly likely<br><br>2) River: not likely over shorter time frames (decades)<br><br>BBC report states that a significant portion of Bisbee's demand is actually met (and has been for some time) from the Douglas basin. With the relatively small 1,000-acre-foot yields, the aquifer probably will not see much effect from this alternative. | <br><br><br>1) Regional aquifer: fair<br><br>2) River:<br>< 50 years: poor<br>> 50 years: fair |
| 3. Ability to help sustain natural range of alluvial ground water levels in their current spatial distribution. ("Natural range of alluvial ground water levels" is defined as the ground water levels and gradients within the Sierra Vista Sub-watershed that existed at or about the time of the establishment of the SPRNCA.) | Short term: (years - decades): low, due to distance from river<br><br>Long term: (decades - centuries): high, but still dependent upon no additional interception of ground water by other users between Naco and the river | < 50 years: poor<br><br>> 50 years: fair |
| 4. Ability to help sustain natural baseflows within their general spatial distribution. ("Natural baseflows" is defined as the range of baseflows experienced in the river between 1954 and 1988.) | Short term: (years - decades): low, due to distance from river<br><br>Long term: (decades - centuries): high, but still depends on no additional interception of ground water by other users between Naco and the river | < 50 years: poor<br><br>> 50 years: fair |
| 5. Ability to help sustain floodflows within their natural range of variability in terms of timing, frequency, and magnitude. ("Natural range of floodflows" is defined as the range of floodflows experienced in the river between 1954 and 1988.) | Little to no impact on floodflows | N/A |
| 6. Ability to help maintain existing (or better) water quality within the river | Little to no impact on water quality at the river | N/A |

| **E1. Inter-basin import: Douglas Basin to Bisbee** | | |
|---|---|---|
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| 7. Ability of strategy to continue addressing problem during periods of extended drought and over long periods of time (50 years+) | Estimated aquifer drawdowns attributable to pumping to serve the entire demands of Bisbee, Huachuca City, Fort Huachuca, and Sierra Vista are 414 feet in a simulated well field after 100 years of pumping. Accommodating just Bisbee would result in far smaller water level declines over this same time period. | Good |
| 8. Estimated yields are adequate to meet future projected population and SPRNCA needs. | Demand estimated by Partnership of 38,500 acre-feet through 2050 not modeled, but yield of 1010 acre –feet to meet Bisbee's 2010 estimated demand in BBC/FS report was met. | Poor |
| 9. Reliably produces water every year, not dependent on rainfall | Not rainfall dependent over shorter (annual) time intervals, but ultimately dependent on rainfall | Fair |
| 10. Complements current or planned USPP projects | | Fair |
| 11. Timing of benefits (quick to the river) | Retiring pumping near Naco would benefit the San Pedro over longer timeframes but benefits not realized for decades at the river | Poor |
| 12. Length of time to work through the regulatory requirements | Issues related to Arizona Water Company and ACC would require significant amounts of time | Poor |
| 13. Replaces or reduces ground water demand | Ground water demand would be reduced in the SV Sub-watershed, but would proportionately increase demands in the Douglas Basin. | Fair |
| 14. Potential for unintended environmental consequences at the source location of the water or within the Sierra Vista Sub-watershed. | Effects on endangered species and/or sensitive habitats within the Douglas Basin dependent upon the amount of pumping and the combined effects of pumping by all users. However, impacts to threatened and endangered species and environmentally sensitive areas were not directly addressed in the BBC/FS report. | Fair |

| IMPLEMENTABILITY | | |
|---|---|---|
| 15. Spatial, geologic, and hydrologic constraints | A confined aquifer is assumed for the Douglas Basin but, if the aquifer is unconfined, there would be smaller drawdowns than estimated. Geologic factors need additional research to estimate construction costs. The modeling was done using a two-dimensional model so the drawdown projections may be way off. | Fair |
| 16. Environmental impact issues | The significant habitat at Whitewater Draw does not appear to be directly connected with the ground water system and is ephemeral along its entire reach. However, the BBC report does not address impacts to biological resources, threatened and endangered species or other environmentally sensitive areas, or necessary mitigation measures. | Unknown |
| 17. State of technology (i.e., proven method or pilot) | Conventional technology | Good |
| 18. Legal and regulatory issues at the local, State (e.g. ACC, ADWR, ADEQ, Land Department), and Federal levels | While ARS 45-544 excludes the transportation of water between ground water basins, significant portions of Bisbee are located in the Douglas Basin. It is likely that significant volumes of water could be transported from the Douglas Basin to Bisbee under current State law. | Fair |
| 19. Current land ownership, right of way, water rights, etc. | Land ownership and rights of way not defined. | Unknown |
| 20. Current ownership of water utility | Arizona Water Company (private water provider) Issues with private water companies, and ACC may present major problems. | Poor |
| 21. Current land use and zoning | Rural, RU-4, agricultural | Good |
| 22. Compatibility of project with adjacent uses | Possible negative impacts to existing ground water users in Douglas Basin | Fair |
| 23. Complexity of project crossing jurisdictional boundaries | Parts of Bisbee within same ground water basin | Fair |
| 24. Likely community support | Unknown; local opposition probable | Poor |

| | | |
|---|---|---|
| 25. Impacts on area where water is being transferred from—political, environmental, economic | Environmental impacts addressed above - political and economic impacts uncertain. It appears unrealistic to assume moving water out of the Douglas watershed will be accepted positively by Douglas area residents. | Poor |
| **COST** | | |
| 26. Capital requirements | $6.47 million | To be determined at a later stage |
| 27. Operating and maintenance expenses | $220,000 | To be determined at a later stage |
| 28. Total annual cost (sum of capital cost amortized over life of project plus operation and maintenance) | $696,000 | To be determined at a later stage |
| 29. Cost/yield ratio | $689 | Good |
| 30. Timing (when dollars would be needed) | | To be determined at a later stage |
| 31. Availability of State or Federal funding | | To be determined at a later stage |

**E2. Inter-basin import: Douglas Basin to Sierra Vista/Fort Huachuca/Huachuca City**

| Criterion | Relevant aspects of alternative with respect to criterion | Rating (good, fair, poor) |
|---|---|---|
| **EFFECTIVENESS** | | |
| 1. Yield in terms of acre-feet | 8,880 acre-feet (2010) (SV/Fort Huachuca/Huachuca City demand estimated in BBC/FS report) | Fair |
| 2. Likelihood that project magnitude and location of yields will benefit:<br><br>1) The regional aquifer<br><br>2) The river | <br><br>1) Regional aquifer: highly likely<br><br>2) River: Relatively small volume with imperceptible river stress responses (especially short term) by not having to pump that amount in the SV sub-basin | <br><br>Regional aquifer: fair<br><br>River:<br>< 50 years: poor<br>> 50 years: fair |
| 3. Ability to help sustain natural range of alluvial ground water levels in their current spatial distribution. ("Natural range of alluvial ground water levels" is defined as the ground water levels and gradients within the Sierra Vista Sub-watershed that existed at or about the time of the establishment of the SPRNCA.) | Short term: (years - decades): low, due to distance from river<br><br>Long term: (decades- centuries): high, but still dependent upon no additional interception of ground water by other users between Sierra Vista/Fort Huachuca and the river | < 50 years: poor<br><br>> 50 years: fair |
| 4. Ability to help sustain natural baseflows within their general spatial distribution. ("Natural baseflows" is defined as the range of baseflows experienced in the river between 1954 and 1988.) | Short term: (years-decades): low, due to distance from river<br><br>Long term: (decades - centuries): high, but still dependent upon no additional interception of ground water by other users between Sierra Vista/Fort Huachuca and the river | < 50 years: poor<br><br>> 50 years: fair |
| 5. Ability to help sustain floodflows within their natural range of variability in terms of timing, frequency, and magnitude. ("Natural range of floodflows" is defined as the range of floodflows experienced in the river between 1954 and 1988.) | Little to no impact on floodflows | N/A |
| 6. Ability to help maintain existing (or better) water quality within the river | Little to no impact on water quality at the river | N/A |

**E2. Inter-basin import: Douglas Basin to Sierra Vista/Fort Huachuca/Huachuca City**

| Criterion | Relevant aspects of alternative with respect to criterion | Rating (good, fair, poor) |
|---|---|---|
| 7. Ability of strategy to continue addressing problem during periods of extended drought and over long periods of time (50 years+) | Estimated aquifer drawdowns attributable to pumping to serve the entire demands of Bisbee, Huachuca City, Fort Huachuca, and Sierra Vista are 414 feet in a simulated well field after 100 years of pumping. Accommodating just the Sierra Vista/Fort Huachuca/Huachuca City pumping from Douglas would result in somewhat smaller water level declines. | Good |
| 8. Estimated yields are adequate to meet future projected population and SPRNCA needs. | Demand estimated by partnership of 38,500 acre-feet through 2050 not modeled, but yield of 8,880 acre-feet of demand was met. | Poor |
| 9. Reliably produces water every year; not dependent on rainfall | Not rainfall dependent over shorter (annual) time intervals but ultimately dependent on rainfall. | Fair |
| 10. Complements current or planned USPP projects. | Does not appear to conflict with other projects or redirect limited resources | Fair |
| 11. Timing of benefits (quick to river) | Retiring pumping near Sierra Vista/Fort Huachuca would benefit the San Pedro over longer timeframes but benefits not realized for decades at the river | Poor |
| 12. Length of time to work through the regulatory requirements | Interbasin transfer would require a change in ARS 45-544 that governs transport of water between basins. This would require a considerable amount of time to address (more than 5 years). | Poor |
| 13. Replaces or reduces ground water demand | Ground water demand would be reduced in the SV Sub-watershed, but would proportionately increase demands in the Douglas Basin. | Good |
| 14. Low potential for unintended environmental consequences at the source location of the water or within the Sierra Vista Sub-watershed. | Effects on endangered species and/or sensitive habitats within the Douglas Basin dependent, in part, upon the amount of pumping and the combined effects of pumping by all users. However, impacts to threatened and endangered species and environmentally sensitive areas were not directly addressed in the BBC/FS report. | Poor |

| IMPLEMENTABILITY | | |
|---|---|---|
| 15. Spatial, geologic and hydrologic constraints | A confined aquifer is assumed for the Douglas Basin but, if the aquifer is unconfined, there would be smaller drawdowns than estimated. Geologic factors need additional research to estimate construction costs. The modeling was done using a two-dimensional model so the drawdown projections may be way off. | Fair |
| 16. Environmental impact issues | The significant habitat at Whitewater Draw does not appear to be directly connected with the ground water system and is ephemeral along its entire reach. However, the BBC report does not address impacts to biological resources, threatened and endangered species or other environmentally sensitive areas, or necessary mitigation measures. | Unknown |
| 17. State of technology (i.e., proven method or pilot) | Conventional technology | Good |
| 18. Legal and regulatory issues at the local, State (e.g., ACC, ADWR, ADEQ, Land Department), and Federal levels | Inter-basin transfer would violate ARS 45-544; INA interaction. | Poor |
| 19. Current land ownership, right of way, SURFACE water rights, etc. | Land ownership, rights of way not defined; INA interaction. | Unknown |
| 20. Current ownership of water utility | Many different water providers involved | Poor |
| 21. Current land use and zoning | Rural, RU-4, agricultural | Good |
| 22. Compatibility of project with adjacent uses | Possible negative impacts to existing ground water users | Poor |
| 23. Complexity of project crossing jurisdictional boundaries | Jurisdictional boundaries/basins would be crossed | Poor |
| 24. Likely community support | Unknown, but local opposition probable | Poor |
| 25.Impacts on area where water is being transferred from—political, environmental, economic | Environmental impacts addressed above; political and economic impacts uncertain. It appears unrealistic to assume moving water out of the Douglas watershed will be accepted positively by Douglas area residents. | Poor |

| COST | | |
|---|---|---|
| 26. Capital requirements | $89.6 million | To be determined at a later stage |
| 27. Operating and maintenance expenses | $1.97 million | To be determined at a later stage |
| 28. Total annual cost (sum of capital cost amortized over life of project plus operation and maintenance) | $8.57 million | To be determined at a later stage |
| 29. Cost/yield ratio | $1,016 | Good |
| 30. Timing (when dollars would be needed) | | To be determined at a later stage |
| 31. Availability of State or Federal funding | | To be determined at a later stage |

# Stormwater Capture: Rainwater Collection for Residential Use

Assumes 2,000 square feet of rooftop for collection plus 1,000 square feet of roadway, driveway, or patio collection from each home. Runoff efficiency set at 90 percent for rooftop and 80 percent for pavement—yielding 3.6 acre-feet per year per **50-home** subdivision. Calculations for total yield based on an 80-percent participation rate for new homes projected to 2050—based on current DES population growth rates **and 2.5 people per household. The total yield through 2050 has been annualized to give an average yearly value.**

**F1. Stormwater Capture: Rainwater Collection for Residential Use**

| Criterion | Relevant aspects of alternative with respect to criterion | Rating (good, fair, poor) |
|---|---|---|
| **EFFECTIVENESS** | | |
| 1. Yield in terms of acre-feet | 1,095 acre-feet per year (see assumptions above) | Poor |
| 2. Likelihood that project magnitude and location of yields will benefit:<br>1) The regional aquifer<br>2) The river | Not likely; low yield would reduce pumping away from river by small percentage. | Poor |
| 3. Ability to help sustain natural range of alluvial ground water levels in their current spatial distribution. ("Natural range of alluvial ground water levels" is defined as the ground water levels and gradients within the Sierra Vista Sub-watershed that existed at or about the time of the establishment of the SPRNCA.) | Low, due to magnitude and location | Poor |
| 4. Ability to help sustain natural baseflows within their general spatial distribution. ("Natural baseflows" is defined as the range of baseflows experienced in the river between 1954 and 1988.) | Low due to magnitude and location | Poor |
| 5. Ability to help sustain floodflows within their natural range of variability in terms of timing, frequency, and magnitude. ("Natural range of floodflows" is defined as the range of floodflows experienced in the river between 1954 and 1988.) | Could play role in engineering system to predevelopment flood flows | Fair |
| 6. Ability to help maintain existing (or better) water quality within the river | Little to no impact on water quality at the river | N/A |
| 7. Ability of strategy to continue addressing problem during periods of extended drought and over long periods of time (50 years+) | Yield directly subject to influences from drought | Poor |
| 8. Estimated yields are adequate to meet future projected population and SPRNCA needs. | Insufficient as "stand alone" strategy to address 2050 goal | Poor |

**F1. Stormwater Capture: Rainwater Collection for Residential Use**

| Criterion | Relevant aspects of alternative with respect to criterion | Rating (good, fair, poor) |
|---|---|---|
| 9. Reliably produces water every year; not dependent on rainfall | Directly dependent on rainfall | Poor |
| 10. Complements current or planned USPP projects. | | Fair |
| 11. Timing of benefits (quick to river). | Benefits to river not likely realized for several decades | Poor |
| 12. Length of time to work through the regulatory requirements. | Relatively minor regulatory requirements | Good |
| 13. Replaces or reduces ground water demand. | This option would reduce the amount of ground water pumped by the amount of rainfall captured. It does not reduce total demand within the sub-watershed, or retire any existing uses, but augments the amount of water in the SV Sub-watershed by reducing evaporative losses. | Good |
| 14. Low potential for unintended environmental consequences at the source location of the water or within the Sierra Vista Sub-watershed. | Risk of unintended environmental consequences minimal | Good |
| **IMPLEMENTABILITY** | | |
| 15. Spatial, geologic, and hydrologic constraints | No apparent hydrologic or geologic constraints | Good |
| 16. Environmental impact issues | Minimal environmental impact issues | Good |
| 17. State of technology (i.e., proven method or pilot) | Conventional technology | Good |
| 18. Legal and regulatory issues at the local, State (e.g. ACC, ADWR, ADEQ, Land Department), and Federal levels | No issues identified | Good |
| 19. Current land ownership, right of way, SURFACE water rights, etc. | No issues identified | Good |
| 20. Current ownership of water utility | No issues identified | Good |
| 21. Current land use and zoning | No issues identified | Good |
| 22. Compatibility of project with adjacent uses | No issues identified | Good |
| 23. Complexity of project crossing jurisdictional boundaries | No issues identified | Good |
| 24. Likely community support | Support likely | Good |
| 25. Impacts on area where water is being transferred from—political, environmental, economic | No issues identified | Good |
| **COST** | | |
| 26. Capital requirements | $1,133,000 | To be determined at a later stage |
| 27. Operating and maintenance expenses | $4,600 | To be determined at a later stage |
| 28. Total annual cost (sum of capital cost amortized over life of project plus operation and maintenance) | $87,990 | To be determined at a later stage |

**F1. Stormwater Capture: Rainwater Collection for Residential Use**

| Criterion | Relevant aspects of alternative with respect to criterion | Rating (good, fair, poor) |
|---|---|---|
| 29. Cost/yield ratio | $23,780 per acre-foot | Poor |
| 30. Timing of when dollars would be needed | | To be determined at a later stage |
| 31. Availability of State or Federal funding | | To be determined at a later stage |

# F. Stormwater Capture: Rainwater Collection for Commercial Use

Calculations for total yield based on current DES population growth rates with proportional increases in new commercial buildings. Percentage of impervious area for commercial districts was estimated with data from the Sierra Vista Planning Division. The total yield through 2050 has been annualized to give an average yearly value.

**F2. Stormwater Capture: Rainwater Collection for Commercial Use**

| Criterion | Relevant aspects of alternative with respect to criterion | Rating (good, fair, poor) |
|---|---|---|
| **EFFECTIVENESS** | | |
| 1. Yield in terms of acre-feet | 331 acre-feet per year | Poor |
| 2. Likelihood that project magnitude and location of yields will benefit:<br>1) The regional aquifer<br>2) The river | Not likely; low yield would reduce pumping away from river by small percentage. | Poor |
| 3. Ability to help sustain natural range of alluvial ground water levels in their current spatial distribution. ("Natural range of alluvial ground water levels" is defined as the ground water levels and gradients within the Sierra Vista Sub-watershed that existed at or about the time of the establishment of the SPRNCA.) | Low, due to magnitude and location | Poor |
| 4. Ability to help sustain natural baseflows within their general spatial distribution. ("Natural baseflows" is defined as the range of baseflows experienced in the river between 1954 and 1988.) | Low, due to magnitude and location | Poor |
| 5. Ability to help sustain floodflows within their natural range of variability in terms of timing, frequency, and magnitude. ("Natural range of floodflows" is defined as the range of floodflows experienced in the river between 1954 and 1988.) | Could play a part in engineering flood flows back to predevelopment levels | Fair |
| 6. Ability to help maintain existing (or better) water quality within the river | Little to no impact on water quality at the river | N/A |
| 7. Ability of strategy to continue addressing problem during periods of extended drought and over long periods of time (50 years+) | Yield directly subject to influences from drought | Poor |
| 8. Estimated yields are adequate to meet future projected population and SPRNCA needs. | Insufficient as "stand alone" strategy to address 2050 goal | Poor |
| 9. Reliably produces water every year; not dependent on rainfall | Directly dependent on rainfall | Poor |
| 10. Complements current or planned USPP projects. | | Fair |
| 11. Timing of benefits (quick to river) | Benefits to river not likely realized for several decades | Poor |

**Stormwater Capture: Rainwater Collection for Commercial Use**

| Criterion | Relevant aspects of alternative with respect to criterion | Rating (good, fair, poor) |
|---|---|---|
| 12. Length of time to work through the regulatory requirements | Relatively minor regulatory requirements | Good |
| 13. Replaces or reduces ground water demand | This option would reduce the amount of ground water pumped by the amount of rainfall captured. It does not reduce total demand within the sub-watershed, or retire any existing uses, but augments the amount of water in the SV Sub-watershed by reducing evaporative losses and decreasing pumping rates. | Good |
| 14. Low potential for unintended environmental consequences at the source location of the water or within the Sierra Vista Sub-watershed | Risk of unintended environmental consequences minimal | Good |
| **IMPLEMENTABILITY** | | |
| 15. Spatial, geologic, and hydrologic constraints | No apparent hydrologic or geologic constraints | Good |
| 16. Environmental impact issues | Minimal environmental impact issues | Good |
| 17. State of technology (i.e., proven method or pilot) | Conventional technology | Good |
| 18. Legal and regulatory issues at the local, State (e.g. ACC, ADWR, ADEQ, Land Department), and Federal levels | No issues identified | Good |
| 19. Current land ownership, right of way, SURFACE water rights, etc. | No issues identified | Good |
| 20. Current ownership of water utility | No issues identified | Good |
| 21. Current land use and zoning | No issues identified | Good |
| 22. Compatibility of project with adjacent uses | No issues identified | Good |
| 23. Complexity of project crossing jurisdictional boundaries | No issues identified | Good |
| 24. Likely community support | Support likely | Good |
| 25. Impacts on area where water is being transferred from—political, environmental, economic | No issues identified | Good |
| **COST** | | |
| 26. Capital requirements | $1,001,130 | To be determined at a later stage |
| 27. Operating and maintenance expenses | $4,474 | To be determined at a later stage |
| 28. Total annual cost (sum of capital cost amortized over life of project plus operation and maintenance) | $78,157 | To be determined at a later stage |
| 29. Cost/yield ratio | $7,778 per acre-foot | Poor |

**Stormwater Capture:  Rainwater Collection for Commercial Use**

| Criterion | Relevant aspects of alternative with respect to criterion | Rating (good, fair, poor) |
|---|---|---|
| 30. Timing (when dollars would be needed) | | To be determined at a later stage |
| 31. Availability of State or Federal funding | | To be determined at a later stage |

**G. Stormwater Capture: Recharge Urban Runoff near the SPRNCA**

| Assumes recharge and recovery would take place in Sierra Vista city limits and/or near the SPR | | |
|---|---|---|
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| **EFFECTIVENESS** | | |
| 1. Yield in terms of acre-feet | Collect stormwater from an eight square mile area, capturing runoff from storms greater than 0.2 inches with a recharge volume of 1,800 AF/YR<br>(Note: This option could be expandable to areas not originally covered in the report including the Fort, additional development in and around Sierra Vista. New development might be required to tie in to this system as well) | POOR |
| 2. Likelihood that project magnitude and location of yields will benefit:<br>1) The regional aquifer<br>2) The river | 1) Regional aquifer: not likely<br>2) River: likely over shorter time frames < 50yrs.<br>(Note: Final River rating will depend on the location of recharge, based on the USGS capture map) | REGIONAL: POOR<br>RIVER: FAIR |
| 3. Ability to help sustain natural range of alluvial ground water levels in their current spatial distribution. (“Natural range of alluvial ground water levels” is defined as the ground water levels and gradients within the Sierra Vista Sub-watershed that existed at or about the time of the establishment of the SPRNCA.) | Short term (<50 yrs.) high due to distance from the river<br>(Note: As written, recharge is at a single location so option only has the ability to influence conditions over a small spatial area. Final rating will depend on the amount and location of recharge, based on the USGS capture map | FAIR |
| 4. Ability to help sustain natural baseflows within their general spatial distribution. (“Natural baseflows” is defined as the range of baseflows experienced in the river between 1954 and 1988.) | Short term (<50 yrs.) high due to distance from the river<br>(Note: As written, recharge is at a single location so option only has the ability to influence conditions over a small spatial area. Final rating will depend on the amount and location of recharge, based on the USGS capture map | FAIR |

**G. Stormwater Capture: Recharge Urban Runoff near the SPRNCA**

| **Assumes recharge and recovery would take place in Sierra Vista city limits and/or near the SPR** | | |
|---|---|---|
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| 5. Ability to help sustain floodflows within their natural range of variability in terms of timing, frequency, and magnitude. ("Natural range of floodflows" is defined as the range of floodflows experienced in the river between 1954 and 1988) | This option would help engineer flood flows back to pre-development levels. | FAIR |
| 6. Ability to help maintain existing (or better) water quality within the river | Treatment facilities in this option would remove trash, sand, grit, fine particles and pollutants that attach to them, as well as biological contaminants. Chlorination may be required for disinfection and water may need to be de-chlorinated before recharge. Treatment of water to discharge standards could improve WQ | GOOD |
| 7. Ability of strategy to continue addressing problem during periods of extended drought and over long periods of time (50 years+) | Yield is subject to influences from drought. However, assuming there is some precipitation each year producing runoff in some amount, it can be banked, stored or recharged. | FAIR |
| 8. Estimated yields are adequate to meet future projected population and SPRNCA needs. | Insufficient as "stand alone" strategy to address 2050 goal | POOR |
| 9. Reliably produces water every year, not dependent on rainfall | Dependent on rainfall. However, rainfall can be banked in good years. Even in poor periods of poor precipitation, evapotranspiration losses are prevented. Where precipitation is insufficient (less than .2 storm events) to produce collected runoff d this option would suffer | FAIR |
| 10. Complements current or planned USPP projects. | Given the expandability of storm water collection efforts and the potential for additional sources of water to be added to the system (treated effluent, ground water, water from other augmentation initiatives, this project is potentially complementary to other USPP efforts. | FAIR |
| 11. Timing of benefits (quick to the river) | Benefits to river realized in the short term | GOOD |

**G. Stormwater Capture: Recharge Urban Runoff near the SPRNCA**

| Assumes recharge and recovery would take place in Sierra Vista city limits and/or near the SPR | | |
|---|---|---|
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| 12. Length of time to work through the regulatory requirements | Moderate length of time to work through requirements | FAIR |
| 13. Project replaces or reduces ground water demand | This option does not reduce the total demand within the sub-watershed or retire any existing uses, but it does augment the amount of water in the SV Sub-watershed by reducing evaporative losses and decreasing pumping rates. | POOR |
| 14. Low potential for unintended environmental consequences at the source location of the water or within the Sierra Vista Sub-watershed. | The potential for unintended environmental consequences is primarily associated with water quality issues at or near the river. Treatment to discharge standards could improve water quality. | GOOD |
| **IMPLEMENTABILITY** | | |
| 15. Spatial, geologic, and hydrologic constraints | No apparent hydrologic or geologic constraints. Potential constraints can likely be overcome through careful site selection. | GOOD |
| 16. Environmental impact issues | Section 404 for pipeline crossings of washes, NEPA. Generally minor EIS issues relative to other alternatives. | GOOD |
| 17. State of technology (i.e., proven method or pilot) | The technology of recharge facilities is known, however its application adjacent to the river in a way that will sustain the riparian ecosystem is relatively new. | FAIR |
| 18. Legal and regulatory issues at the local, State (e.g. ACC, ADWR, ADEQ, Land Department), and Federal levels | APP or Title 45 permitting process required for recharge facilities. | FAIR |
| 19. Current land ownership, right of way, water rights, etc. | Collecting stormwater before it flows into natural channels avoids the issue of acquiring surface water rights. | GOOD |
| 20. Current ownership of water utility | N/A | GOOD |
| 21. Current land use and zoning | Mix of agricultural and RU4 residential. | GOOD |
| 22. Compatibility of project with adjacent uses | No issues identified | GOOD |

**G. Stormwater Capture: Recharge Urban Runoff near the SPRNCA**

| Assumes recharge and recovery would take place in Sierra Vista city limits and/or near the SPR | | |
|---|---|---|
| **Criterion** | **Relevant aspects of alternative with respect to criterion** | **Rating (good, fair, poor)** |
| 23. Complexity of crossing jurisdictional boundaries | City of SV and County | GOOD |
| 24. Likely community support | Likely as it is a renewable source of new water, not importation from another political jurisdiction. | GOOD |
| 25. Impacts on area where water is being transferred from—political, environmental, economic | No issues identified. Positive from political and environmental perspectives. | GOOD |
| **COST** | | |
| 26. Capital requirements | $51,730,000 | TO BE DETERMINED AT LATER STAGE |
| 27. Operating and maintenance expenses | $280.000 | TO BE DETERMINED AT LATER STAGE |
| 28. Total annual cost (sum of capital cost amortized over life of project plus operation and maintenance) | $4,090,000 | TO BE DETERMINED AT LATER STAGE |
| 29. Cost/yield ratio | $2,675 /AF (for recharge in area of hydrologic impact) | POOR |
| 30. Timing of when dollars would be needed | | TO BE DETERMINED AT LATER STAGE |
| 31. Availability of State or Federal funding | | TO BE DETERMINED AT LATER STAGE |

Appendix C

# Regulatory and Institutional Issues

# Appendix C – Regulatory and Institutional Issues

## *Local Permits*

### Floodplain Ordinances:

Activities that modify the flood plain require permits from the appropriate local government. Most recommended alternatives are located within Cochise County. Permits could be required from the cities of Sierra Vista, Tombstone or Bisbee, or the Cochise County Flood Control Department (CCFCD). These entities would review design plans for constructed facilities to ensure that no adverse impacts occur to adjacent land owners. Any improvements made on unincorporated lands must comply with CCFCD flood plain ordinances.

In the case of the CAP alternatives, the pipeline would originate in Pima County. Permits would be required from Pima County Regional Flood Control District and possibly from the cities of Tucson and Sahuarita. Any improvements made on unincorporated lands must comply with the PCFCD flood plain and riparian habitat ordinance. This ordinance requires steps to reduce impacts to designated riparian areas. The 1-10 route for a CAP pipeline would go through Benson and would be subject to its city regulations.

Furthermore, ground disturbance within Pima County would require compliance with Chapter 18.72 of the Pima County Zoning Code (Native Plant Preservation). Reclamation would be required to prepare and submit a Native Plant Preservation Plan to Pima County Development Services. Compliance with Arizona's Native Plant Law is described under State Regulatory Issues, below.

# State Regulatory Issues

## *Central Arizona Water Conservation District Policies*

Alternatives involving the extension of the CAP to the SVS will require the cooperation and support of the Central Arizona Water Conservation District (CAWCD). The CAWCD was established to contract with the Federal Government to repay the reimbursable costs of the CAP. The CAWCD is directed by an elected 15-member board with representatives from the three member counties (Pima, Pinal, and Maricopa). The board sets CAP policy, which the CAWCD implements. CAWCD policies regarding water pricing and delivery scheduling priorities will affect the use of CAP water.

The CAWCD charges a "postage stamp rate" for all CAP water delivered to subcontractors in the CAP service area. This pricing policy is critical, since higher delivery costs in the SVS would make CAP utilization far less attractive. The CAWCD has established an annual schedule for setting capital charges for agricultural, municipal, and industrial CAP allocations.

## Delivery Policy

The CAWCD has established an administrative system to take orders, schedule deliveries, collect charges, and handle delivery contingencies for CAP water. Each year, the CAWCD estimates the amount of water that will be available to customers and accepts orders on the basis of that estimate. As long as more CAP water exists than is ordered by subcontractors, the CAWCD will schedule orders for excess water. Orders for scheduled water deliveries must be made by October 1 for the next calendar year. Additional water may be purchased on demand, as long as excess CAP water supplies and excess canal capacity exist. The CAWCD maintains an informal working relationship with its CAP water customers for flexibility in meeting system needs.

Priorities for delivery of CAP water, as established in law, assign the highest priority to Indian and municipal subcontractors. The lowest priority is assigned to non-Indian agriculture. If scheduled deliveries must be curtailed, those to non-Indian agricultural subcontractors are cut first. CAWCD has not applied this schedule of priorities to daily deliveries and has so far curtailed deliveries considering the operational flexibility of their customers. As currently implemented, daily operating priorities place direct municipal uses first, but place agricultural uses before municipal recharge projects. The rationale for this policy is that timing of deliveries is more important to agriculture than to recharge. This policy may be revisited due to the concerns of some municipal subcontractors that it shifts the burden of reliability towards municipal and industrial users.

# *Arizona Department of Water Resources*

ADWR oversees the use of surface and groundwater resources under State jurisdiction and negotiates with external political entities to protect Arizona's Colorado River water supply. Other responsibilities include groundwater management, well permitting, administration of groundwater rights, evaluation of adequate water supply, and regulating the transportation of groundwater. Title 45 also establishes a mechanism for underground water storage, groundwater savings, and replenishment. This includes a program that provides for storage of Arizona's unused CAP allocation by the AWBA.

## Underground water Storage, Savings, and Replenishment Act

The Underground water Storage, Savings, and Replenishment (UWS) program has two sets of goals. The first set is to encourage the use of renewable water supplies to satisfy existing needs, to allow for effective and flexible storage of renewable water supplies not currently needed, and to preserve nonrenewable groundwater supplies. The UWS program, consistent with the Arizona Groundwater Management Act of 1980, encourages the direct use of renewable water over the use of groundwater.

The second set of goals facilitates the efficient and cost-effective management of water supplies by allowing storage of water in one location and recovery in a different location. Therefore, water may be stored near its source (such as the CAP Canal) and recovered where it is needed (a well field, for example). Although the UWS program contains some restrictions on this "transportation" of water, the program may be used to legally deliver water to a user without the expensive construction of canals and pipelines that physically convey the water. However, this allowance does not address the “wet” water needed to address problems associated with groundwater level decline, such as subsidence.

Recharge projects using CAP water as a source are regulated through Arizona’s Title 45 process. Under Title 45, ADWR requires recharge facilities within Active Management Areas to obtain up to three permits. Although it is not strictly required to obtain ADWR permits in order to recharge water outside of Active Management Areas, Reclamation recommends that the USPP comply with State permit guidelines. The guidelines ensure that recharge is effective and does not cause harm to other entities. The required studies can also be used to implement a maintenance, monitoring, and operational regime that ensures optimum efficiency. State regulations regarding the recharge of CAP water are described below.

## Program Description

An entity that wishes to store, save, replenish, or recover water through the UWS program must apply for permits through ADWR. Two types of recharge facilities are recognized by the UWS program. These are the groundwater savings facility (GSF) and the underground storage facility (USF). A GSF allows a water provider to supply renewable water to a facility (such as a farm) that would otherwise have pumped groundwater. The recipient (farm) uses this renewable water in place of pumping groundwater. The renewable water supplier earns credits to recover the water supplied to the recipient and can use them at a later date.

A USF facility allows water to be physically added to and stored in an aquifer. Examples of common USFs are listed below:

- *Off-channel constructed shallow spreading basins* are designed to maintain high infiltration and are operated in a wet-dry cycle mode. During the dry cycle, sediments and biological film that impede the movement of water can be removed or treated.

- *In-channel constructed facilities* are operated within the active flood plain of a water course. These may include inflatable dams, gated structures, levees, basins, and compound channels.

- *Managed in-channel recharge facilities* require no construction other than monitoring devices. The natural stream channel is used for recharge.

- *Injection wells* allow water to be injected directly into the aquifer. This type of facility generally requires that the source water meets drinking water standards.

- *Deep basins or pits* are constructed such that coarse-grained sediments of the vadose zone are exposed, thereby facilitating recharge.

Depending on what the applicant wishes to accomplish, up to three types of UWS permits may be required: (1) a facility permit, (2) a water storage permit, and (3) a recovery well permit.

A facility permit allows an entity to operate a recharge facility at which water is stored, saved, or replenished. The storage permit allows storage of a specific amount of water at a specific facility. Multiple parties may hold water storage permits for a single facility. A recovery well permit allows the permittee(s) to recover water stored in accordance with the UWS program.

### Uses of the Stored Water

Under the UWS program, stored water may be used and accounted for by annual recovery, long-term recovery, or replenishment. Almost any water stored under the program may be recovered within the same calendar year. Recovery within the same year as storage is called recovery on an annual basis and is considered to be equivalent to direct use of the water. Therefore, water stored and recovered within the same year is not subject to the same restrictions as long-term storage.

If water is to be stored for use in later years, as recommended, it must meet the eligibility requirements for long-term storage and recovery. These eligibility requirements focus on whether the water could have reasonably been used directly (as defined by A.R.S. 45-801.01(21)). This provision is designed to discourage storage when groundwater is still being used to supply its immediate needs. If the storage does qualify for long-term storage, a credit is made to the storer's long-term storage account and will be available for use at any time the storer wishes to call on it. Credits may also be assigned to other entities so long as the recipient also meets the definition of water that can not reasonably be used directly.

### Recovery Locations

Under the UWS program, the locations available for recovery of stored water are the same whether the water is recovered on an annual or a long-term basis. The water stored pursuant to the UWS program generally does not have to be recovered from the same area in which it was stored. Stored water may always be recovered (by the entity that stored the water) from within the area of impact of the storage. If the water is stored outside of an AMA, recovery must occur in the same irrigation non-expansion area, groundwater basin, or sub-basin in which the storage occurs.

### Water Protection Fund Grants

Established in 1994, the Arizona Water Protection Fund (AWPF) provides an annual source of funds to develop and implement measures to protect water of sufficient quality and quantity to maintain, enhance, and restore rivers and streams and associated riparian habitat. Funds may be granted to any person or entity, State or Federal agency, or political subdivision. All projects or programs must be located in Arizona, be consistent with State water law and water rights, and respond to the overall goals of the legislation. Grants from the fund may be used to:

- Develop and implement capital projects or specific measures to maintain, enhance, and restore rivers and streams and associated riparian resources

- Acquire effluent or CAP water for the purpose of protecting or restoring rivers and streams

- Develop, promote, and implement water conservation programs outside of the five AMAs

- Support research and data collection, compilation, and analysis

Manmade water resource projects may be funded if the project benefits a river or stream and creates or restores riparian habitat. A commission administers the expenditure of funds. Priority is given to projects that include matching contributions from other sources, provide continued project maintenance, include broad-based local support, and directly benefit perennial or intermittent streams. Successful applicants include municipalities, Indian tribes, agencies, universities, Natural Resource Conservation Districts, nonprofit organizations, and individuals.

AWPF grants could impact future augmentation activities in the SVS by providing funds to recharge stormwater or treated mine water, as well as to develop riparian enhancement projects with CAP water.

## *Arizona Department of Environmental Quality Regulations*

Arizona Department of Environmental Quality (ADEQ) activities and regulations that concern augmentation in the SVS include aquifer protection permits, aquifer water quality standards (AWQS), groundwater under the direct influence of surface water and the Water Infrastructure Finance Authority (WIFA).

### Aquifer Protection Permits

ADEQ is responsible for protecting the quality of water resources in the State. The Environmental Quality Act of 1986 (A.R.S. Title 49) established the requirements for the Aquifer Protection Permit Program. An APP is required if a pollutant is discharged directly into an aquifer, the land surface, or the vadose zone, in such a manner that there is reasonable probability that the pollutant will reach an aquifer.

Unless exempted, a waste discharge with the potential to degrade water quality in an aquifer must receive an APP, certifying that measures have been, or will be taken, to prevent pollution of the aquifer. Facilities proposed in this study that would require an APP include the recharge basins for the Recharge of Urban Runoff Alternative and the Copper Queen Mine to SPRNCA Recharge alternative. An APP is not required for recharge projects using CAP water. However, ADEQ is statutorily required to review applications for USF permits, regardless of their exemption from APP requirements.

ADEQ assesses whether a facility's location will promote the migration of a contaminant plume or poor quality groundwater, or will result in pollutants being leached to the groundwater table, so as to cause unreasonable harm (A.R.S. § 45-811.01(C)(5)). The rules also require ADEQ to advise ADWR of any APP applications for recharge facilities. ADWR, after consultation with ADEQ, may include any requirements deemed necessary to protect aquifer water quality in its permit.

## AZPDES Permits

On Dec. 5, 2002, Arizona became one of 45 states with authorization from EPA to operate the National Pollutant Discharge Elimination System permit program pursuant to Section 402 of the Clean Water Act (CWA). Under the Arizona Pollutant Discharge Elimination System (AZPDES) permit program, all facilities that discharge pollutants from any point source into waters of the United States are required to obtain or seek coverage under an AZPDES permit. The focus of the AZPDES permitting program is process and stormwater discharges from industrial facilities, construction sites, publicly owned treatment works, and urban areas. Stormwater runoff from construction sites one acre or greater in size are subject to the requirements of the AZPDES Construction General Permit.

In addition to the AZPDES program, there are ADEQ review requirement for activities subject to permitting under Section 404 of the CWA. These requirements are discussed under the Federal regulatory section.

## Aquifer Water Quality Standards

The APP rules include numeric and narrative water quality standards (AWQSs). Under Title 49, ADEQ has adopted rules (A.A.C.R18-11-401, et seq.) which set both types of AWQSs, as well as Health-Based Guidance Levels (HBGL). There are numeric AWQSs, equivalent to the Federal primary drinking water standards, for certain inorganic and organic chemicals, radio nuclides, and microbiological pollutants within the aquifer. Narrative standards may be set on a "case-by-case" basis utilizing HBGLs or other technical information, to protect human health or current and future aquifer use.

The ADEQ narrative standards state that a discharge shall:

- Not cause a pollutant to be present in an aquifer classified for a drinking water protected use in a concentration which endangers human health
- Not cause or contribute to a violation of a surface water quality standard established for a navigable water of the State
- Not cause a pollutant to be present in an aquifer which impairs existing or reasonably foreseeable uses of water in an aquifer

Changes or additions to the numeric standards list and interpretation of the narrative standards could significantly affect future augmentation activities in the SVS.

Although recharge of CAP water and other non-effluent waters is exempt from APP requirements (A.R.S.§ 49-250(B)(12) and (13)), if a permit to operate is secured under Title 45, any discharge must still comply with AWQSs. This exemption from the APP program should expedite permitting, while still providing ample protection to the aquifer through permit and monitoring requirements.

## Groundwater under the Direct Influence of Surface Water Disinfection Requirements

As the State agency designated to administer the Federal Safe Drinking Water Act, ADEQ promulgated rule A.A.C. R18-4-301.01, Groundwater Under the Direct Influence of Surface Water. This rule, which became effective on April 19, 1999, requires that groundwater under the direct influence (GUDI) of surface water must be treated according to drinking water rules that apply to surface water. Groundwater that is determined not to be influenced by surface water is not required to be treated unless it fails to meet primary drinking water standards (see A.A.C. R18-4-304). The GUDI rule may affect how proposed groundwater recharge projects are sited, especially if wells that pump groundwater for drinking purposes are located nearby and are determined to be under direct surface water influence.

ADEQ's Drinking Water Program currently regards recharge basins, in-channel recharge facilities, injection wells, or virtually any other mode of discharge of CAP water into wells or an aquifer as a "surface water body." Thus, if a recharge facility is designed with recovery wells within 500 feet, testing would be necessary to determine if the groundwater is under the influence of surface water. Testing would also be necessary for any existing wells within 500 feet of a newly installed recharge facility. If water recovered from a recharge project is determined to be under the direct influence of surface water, filtration and disinfection could be required before the water enters the drinking water distribution system. This treatment could add significantly to project costs.

The EPA issued guidance in October 1992 as the Consensus Method for Determining Groundwater Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA). As part of this method, a microscopic examination is made of the groundwater to determine whether insect fragments, plant debris, protozoa, etc., and other material associated with the surface or near surface environment are present.

Rule A.A.C. R18-4-301.01 includes criteria for MPA monitoring. The water supplier is responsible for collecting the samples and MPA testing. ADEQ is responsible for scheduling MPA monitoring at a time when the groundwater source is most susceptible to direct surface water influence. ADEQ assigns a risk rating to the sample after receiving the test results. The sample is rated high or moderate risk of direct surface water influence, or low risk of direct surface water influence. A second sample is collected for MPA at the same location on a date scheduled by ADWR. Collection and testing of a third sample may be required based on the results of the first two tests. The following table shows how GUDI is determined based on the results of the MPA monitoring.

| Test ratings | | | |
|---|---|---|---|
| First test | Second test | Third test | Determination |
| High or moderate | High or moderate | Not needed | GUDI |
| High or moderate | Low | High or moderate | GUDI |
| High or moderate | Low | Low | Not GUDI |
| Low | Low | Not needed | Not GUDI |
| Low | High or moderate | High or moderate | GUDI |
| Low | High or moderate | Low | Not GUDI |

For example, if the first test was rated as “high or moderate,” and the second test rated as “high or moderate,” a third test would note be needed since ADEQ would determine that the groundwater is under the direct influence of surface water. Likewise, if the first test was rated as high or moderate,” the second test rated as “low,” a third test would be required. If the third test were also rated as “low,” the ADEQ would determine that the groundwater is not under the direct influence of surface water.

## Water Infrastructure Finance Authority of Arizona

The WIFA is authorized to finance the construction, rehabilitation, or improvement of drinking water, wastewater, wastewater reclamation, and other water quality-related facilities and projects. WIFA can offer borrowers below market loans for 100 percent of the eligible project costs. Eligible projects may include:

- Conveyance systems for the transport of water from the CAP aqueduct to a treatment facility
- Treatment facilities required for water transported by the CAP aqueduct, Salt/Verde system water, and Aqua Fria system water, including recharge systems

WIFA administers three main programs: the Drinking Water Revolving Fund for eligible publicly and privately held drinking systems, the Clean Water Revolving Fund for eligible publicly held wastewater facilities and the Technical Assistance Program for pre-design and design grants and loans. Since there are more projects than funding available, WIFA maintains a Project Priority List (PPL) guide its selection process. To assist in its selections, WIFA reviews the technical and financial capability of the applicants.

WIFA can provide financial assistance for constructing, acquiring, or improving drinking water facilities, non-point source projects, and other related water quality facilities and projects.

It can guarantee debt obligations to political subdivisions that are issued to finance drinking water facilities. WIFA may also issue negotiable water quality bonds to generate the match required by the Safe Drinking Water Act for the drinking water revolving fund.

## *Summary of Water Treatment Regulations*

There are numerous federal regulations, promulgated under the Safe Drinking Water Act (SDWA), that govern the use of surface water, or groundwater under the influence of surface water, for domestic supplies. These regulations include the Surface Water Treatment Rule (SWTR), the Enhanced Surface Water Treatment Rules (ESWTRs), the Total Coliform Rule (TCR) and the Disinfection/ Disinfectant By-Products Rules (D/DBPRs).

### The Safe Drinking Water Act

The SDWA was enacted in 1974. In 1976, the SDWA set Maximum Contaminant Levels (MCLs) for drinking water and established treatment techniques. The SDWA was amended in 1986 and 1996, and requires many actions to protect drinking water and its sources: rivers, lakes, reservoirs, springs, and groundwater wells. The SWTR was included as a substantial part of the 1986 amendments. The TCR has since been included, as have the Long Term 1 and 2 ESWTR, and the Stage 1 and 2 D/DBPRs.

A.R.S. 49-201 through 225 provides the statutes by which ADEQ governs drinking water quality standards. ADEQ is proposing to modify its current drinking water rules to incorporate EPA's safe drinking water regulations by reference. The proposed revised regulations are available at: http://www.azsos.gov/aar/2004/50/proposed.pdf .

Current regulations covering drinking water standards from surface water and groundwater under the influence of surface water are described below. Unlike the Upper Santa Cruz Basin, the San Pedro Basin has not been designated as a sole-source aquifer, reference: http://www.epa.gov/safewater/sourcewater/pubs/qrg_ssamap_reg9.pdf

### Surface Water Treatment Rules

The Surface Water Treatment Rules apply to water systems that serve surface water or groundwater under the direct influence of surface water (GWUDI). CAP water is a surface water.

#### *The Surface Water Treatment Rule*

Under the SWTR, a treatment system must remove or inactivate 99.9 percent (equivalent to a 3 log reduction) of Giardia lamblia and 99.99 percent (equivalent to a 4 log reduction) of viruses. This is accomplished through a combination of barrier removal and deactivation through disinfection.

### *The Enhanced Surface Water Treatment Rule*

The ESTWR mandated sanitary surveys for all water systems. The initial survey was required within five years of promulgation, with a survey every five years thereafter. Surface water systems were required to provide at least a 99% (2-log) removal of Cryptosporidium oocysts.

The Interim Enhanced Surface Water Rule applied these conditions to water systems serving more than 10,000 people. The Long Term 1 Enhanced Surface Water Rule applied it to systems serving more than 25, but fewer than 10,000 people.

### Long Term 2 Enhanced Surface Water Rule

The Long Term 2 Enhanced Surface Water Rule was promulgated in June, 2006. Systems must monitor their water sources to determine treatment requirements. This involves two years of monthly sampling for Cryptosporidium. Filtered water systems will be classified in one of four treatment categories (bins) based on their monitoring results. Most systems are expected to be classified in the lowest bin and will face no additional requirements. Systems classified in higher bins must provide additional water treatment to further reduce Cryptosporidium levels by 90 to 99.7 percent (1.0 to 2.5-log), depending on the bin. All unfiltered water systems must provide at least 99 or 99.9 percent (2 or 3-log) inactivation of Cryptosporidium, depending on the results of their monitoring.

## The Total Coliform Rule

This regulation sets compliance with the MCL for total coliform (TC). For systems that collect 40 or more samples from the distribution system per month, no more than five percent of the samples may be TC positive. For those that collect fewer than 40 samples, no more than one sample may be TC positive.

## Disinfection/Disinfectant By-Product Rule

This rule applies to surface water systems and groundwater systems of any size that use a chemical disinfectant. The D/DBPR limits the amount of certain by-products formed during the treatment of drinking water, especially surface water from lakes, rivers, and impounds, due to the presence of organic matter. These by-products are formed when organic precursors and other chemical compounds present in the source water are exposed to disinfectants. The primary DBPs that are regulated include trihalomethanes (THMs) and haloacetic acids (HAAs).

The MCLs for DBPRs are given in the table below.

| Disinfection byproduct | MCL (mg/L) |
|---|---|
| Total trihalomethanes (TTHM) | 0.080 |
| Haloacetic acids (five) (HAA5) | 0.060 |
| Bromate | 0.010 |
| Chlorite | 1.0 |

Under the Stage I D/DBPR, water systems with conventional filtration treatment that use surface water, or groundwater under the direct influence of surface water, are required to remove specified percentages of total organic carbon (TOC) that may react with disinfectants to form DBPs.  CAP water contains approximately 4.5 mg/L of TOC and 143 mg/L of alkalinity. Therefore, 25 percent TOC removal is required for the CAP water conventional treatment plant.

EPA promulgated Stage 2 D/DBPR rule in January, 2006.  This rule requires water systems to meet MCLs as an average at each compliance monitoring location (instead of as a system-wide average as in previous rules) for two groups of DBPs: trihalomethanes (TTHM) and five haloacetic acids (HAA5). The Stage 2 DBPR was released simultaneously with the Long Term 2 Enhanced Surface Water Treatment Rule to address concerns about risk tradeoffs between pathogens and DBPs.

## Lead and Copper Rule

The LCR was promulgated by EPA on June 7, 1991.  The MCLs (action levels) are 0.015 mg/L for lead and 1.3 mg/L for copper.  Public water systems (PWSs) consisting of community water systems and non-transient, non-community water systems are subject to compliance with the LCR.  These PWSs must either demonstrate that optional treatment has been installed to control lead and copper or that the existing levels in consumers' tap water are below Federal action levels.  Lead and copper action levels are compared with the 90th percentile level, which is the 90th highest sample result.  For a system collecting 10 samples, this would be the 9th highest lead or copper sample result obtained during a monitoring period.  90th percentile values are calculated using all valid samples collected during a compliance period.  These values are then compared to the Federal action levels to determine compliance.  Public education and lead service line replacement provisions are also part of the lead and copper national primary drinking water regulations.

Corrosion control treatment alternatives to address values above the action levels for the LCR include:

- Alkalinity and pH Adjustments—uses passivation as the mechanism for corrosion control by inducing the formation of less soluble compounds with the targeted pipe materials (iron, lead, and copper).

- Calcium Hardness Adjustment—uses precipitation of calcium carbonate as the mechanism to protect pipe systems.  This is accomplished by adjusting the calcium-carbonate system equilibrium such that a tendency for calcium carbonate precipitation is encouraged to line the interior of pipes.

- Corrosion Inhibitors—uses passivation of the metal surface as the mechanism for corrosion control.  This is accomplished by feeding corrosion inhibitors such as orthophosphates to form metal complexes which coat the pipe surface.

## *Arizona Corporation Commission*

The following statute describes the Arizona Corporation Commission's requirements for allowing surcharges to water utility bills.

**ARS 40-370. Water utility surcharges to recover operating costs; notice; definition**

A. Subject to the limitations provided in subsection D, the commission shall authorize water utilities to recover increases in specific operating costs by means of a surcharge on water sales and to reduce rates when those specific operating costs decrease. The operating costs that may be considered in this procedure are limited to specific, readily identifiable costs that are subject to the control of another person, including the cost of purchasing electricity or gas, the cost of purchasing water from another utility, municipality or district and the payment of ad valorem taxes or any similar tax or assessment levied on the water utility. The surcharge shall not exceed ten per cent of current rates.

B. The water utility shall file written notice of a surcharge or rate decrease pursuant to this section with the commission, clearly advising the commission of:

1. The specific operating cost being considered for the rate decrease or recovery by the surcharge.

2. The amount of the operating cost being considered for the rate decrease or recovery by the surcharge.

3. The timing and method of cost recovery or rate reduction.

C. The water utility shall also deliver to each customer with the customer's next bill for service a notice of the proposed surcharge or rate reduction. This notice to customers shall include the following information:

1. The information prescribed by subsection B.

2. The customer's right to comment on the proposed surcharge or rate reduction.

3. The address and telephone number of the commission.

D. A surcharge imposed by this section is effective thirty days after the date on which the water utility files the written notice with the commission, unless within that time the commission in its discretion adjusts or denies the surcharge or determines that further investigation of the surcharge is required. The commission shall notify the water utility in writing of a decision to adjust or deny the surcharge or to further investigate the appropriateness of the surcharge. If the commission determines that further investigation of the surcharge is required, the commission may conduct a hearing regarding the appropriateness of the surcharge. If the commission does not issue a decision within one hundred twenty days after the date the water utility files the written notice, the surcharge is effective without further action.

E. For purposes of this section, “water utility” means a public service corporation that is subject to the commission’s jurisdiction and that engages in supplying water utility service in this state.

### State Historic Preservation Act

Arizona State Law (A.R.S. § 41-841 through § 41-847) prohibits excavation of historic or pre-historic sites on lands owned or controlled by the State of Arizona, except by permit from the Director of the Arizona State Museum. It also requires a person in charge of construction or other activities on lands owned or controlled by a State agency, or any town, city, or county to report the discovery of archaeological or historic sites or artifacts to the Director of the Arizona State Museum.

Under Arizona’s State Historic Preservation Act, an archaeological survey is required wherever the land surface will be excavated and/or inundated for a storage project. The survey is done to ensure that either no historic or prehistoric sites will be disturbed during construction, or that proper mitigation occurs before and during construction. If no surficial archaeological remains are found, a clearance is issued. If archaeological or paleontologic items are found during construction on State, county, or municipal lands, it is necessary to contact the director of the Arizona State Museum for proper mitigation.

Under A.R.S. 41-865, anyone discovering or disturbing human remains or funerary objects on privately owned land in Arizona is required to notify the Director of the Arizona State Museum and to protect those remains while the Director consults with Native American groups and other interested parties.

### Arizona Native Plant Law

Rules and regulations pertaining to Arizona’s Native Plant Law can be found in A.R.S. §3-901 through A.R.S. §3-934 and rules A.A.C. R3-4-601 through A.A.C. R3-4-611. A list of the protected native plants can be found in Appendix A of the rules cited above.

Protected native plants cannot be disposed of, salvaged, or removed from any lands without the permission from the owner and a permit or written confirmation notice from the Arizona Department of Agriculture. The owner or owner’s agent must provide the department with adequate notification 20 to 60 days prior to the intended destruction of protected native plants, depending on the area of the affected lands. For lands with an area of less than one acre, this notification may be oral or in writing. For areas of more than one acre, this notification must be in writing. The landowner may sell or give away any plant growing on his land. However, protected native plants may not be transported from the growing site without a permit from the department.

## Federal Regulatory Programs and Issues

Federal laws relevant to the water augmentation alternatives include the CWA, the Endangered Species Act (ESA), Colorado River Law, the Arizona Water Settlement Act, the National Historic Preservation Act and the Reclamation Reform Act (RRA).

The EPA has delegated compliance with sections 401 and 402 of the CWA, which regulate discharges into the waters of the United States, to ADEQ.  Under Section 401, proposed activities or facilities that require a federal Section 404 permit to discharge dredged or fill material into waters of the United States also need to obtain State Water Quality Certification from ADEQ, certifying that the action will not contribute to a violation of State water quality standards

## Section 404 Clean Water Act Dredge and Fill Permits

Section 404 of the Clean Water Act requires that the United States Army Corps of Engineers, with the concurrence of EPA, issue or deny permits for activities that result in the discharge of dredged or fill material into the waters of the United States.  For the purposes of this section, waters of the United States include most streams, stream channels, and wetlands in Arizona.  The 404 permit also pertains to disturbance activities in wetlands and riparian areas.  Intended to prevent the unlawful filling of wetlands, this section would apply to most channel modifications made for in-channel recharge projects.  A 404 (b)1 analysis (alternative analysis) must be completed in order to determine the least environmentally damaging practicable alternative.

## Endangered Species Act

Section 7 of the Endangered Species Act requires Federal agencies to ensure that their activities do not jeopardize the continued existence, or adversely modify, “critical” habitat for listed or proposed species.  Federal activities include actions authorized, funded, or carried out by the agency, including any regulatory action, such as issuance of Section 404 permits of the Clean Water Act.  When federally listed or proposed species, or designated or proposed critical habitat is present, the action agency must evaluate whether the Federal action has any effect on listed species or critical habitat.

If the action agency determines that the project will have no effect on a listed species or critical habitat, no consultation with the U.S. Fish and Wildlife Service (FWS) is required.  If the action agency determines that the project may affect, but is not likely to adversely affect, a listed species or critical habitat, informal consultation is initiated with the FWS.  If FWS agrees, written concurrence is provided.

If the action agency determines that the project may adversely affect a listed species, or adversely modify critical habitat, or if FWS does not concur that the action is not likely to adversely affect the species, then formal consultation with FWS is initiated.  Formal consultation culminates with the FWS’s issuance of a “biological opinion”, which determines whether the Federal action will “jeopardize the continued existence” of any listed species and/or destroy, or adversely modify, critical habitat.

A biological opinion serves to authorize the action agency’s incidental take of listed species.  “Take” is defined under the ESA as:  “harass, harm, pursue, hunt, shoot, kill, wound, trap, capture, or collect”.  “Incidental” refers to take that is associated with an otherwise lawful action.  An Incidental Take Statement would be included in the Biological Opinion to cover impacts to species “incidental” to the project action.

If the biological opinion determines that the Federal action will "jeopardize the continued existence" of any listed species and/or destroy, or adversely modify, critical habitat, it will include "Reasonable and Prudent Alternatives" to remove any jeopardy to the species, or adverse modification of critical habitat. A non-jeopardy finding may include Reasonable and Prudent Measures and nondiscretionary Terms and Conditions required to minimize "take or the effects of "take".

If the action agency determines that the project is likely to jeopardize a proposed species or adversely modify proposed critical habitat, then a conference is required. Note that there is a difference in the level of effect between listed and proposed species (or critical habitat). While consultation is required when a project "may affect" a listed species, conference is required for a proposed species only when the action is likely to jeopardize its continued existence, or adversely modify proposed critical habitat. A conference opinion is conducted like a formal consultation. An incidental take statement is produced but does not become effective unless the FWS adopts the opinion as final once the species is listed and/or critical habitat is designated.

Section 9 of the ESA prohibits the "take" of any federally listed or proposed species (except plants on private land). Consequently, non-Federal entities may be subject to enforcement of the ESA without any Federal nexus if their activity results in "take" of a species. Sections 10(a)(1)(A) and (B) of the ESA provides a method for non-Federal entities to legally and incidentally "take" a listed species through the completion of a Habitat Conservation Plan (HCP) or Safe Harbor Agreement (SHA). Until a non-Federal entity has a section 10 permit, potential Section 9 liability exists, regardless of the status of habitat designation or FWS protocol standards. When a non-Federal entity receives its section 10 permit under the ESA, the biological opinion developed for the HCP would include an analysis of the effects of the issuance of an Incidental Take permit. The permit would authorize any incidental take of a listed species by the section 10 permittee, pursuant to implementation of the required reasonable and prudent measures.

(Note: Non-Federal recharge projects are still subject to ESA regulation through compliance with Section 9 ("take" provision) for terrestrial species (e.g., the lesser long-nosed bat and southwestern willow flycatcher). If a non-Federal entity expects that "take" will occur as a result of construction and operation of a groundwater recharge project, the entity may apply for a Section 10 permit which would authorize the "take" (see above paragraph on section 10).

Consultation under the ESA may also be required for projects if a federally-listed species occurs on habitat created or sustained by a project. If a project operator is required to protect habitat incidentally created or sustained by the project, then the design and operation of some projects may be legally constrained for endangered species protection. An SHA for the project operator is one avenue to address this situation. Injection recharge projects and basin recharge projects operated to maximize recharge through wet/dry cycles and disking are less likely to create incidental habitat than multipurpose projects incorporating in-stream riparian features and recreation.

## Consultation with U.S. Fish and Wildlife Service (FWS) on CAP fish transfers to the Gila River basin

Reclamation reinitiated consultation in late 2006 on the 2001 Biological Opinion on CAP fish transfers to the Gila River basin to cover newly-listed species and incorporate the Santa Cruz River subbasin portion of the CAP. The new consultation should resolve old issues concerning the Santa Cruz River sub-basin portion of the CAP, and bring Reclamation into ESA compliance regarding newly-listed species.

The original 1994 FWS biological opinion on transport and delivery of CAP water to the Gila River basin in Arizona and New Mexico concluded that long-term CAP water deliveries were likely to introduce additional nonnative fish to central Arizona via the CAP aqueduct system, jeopardizing the continued existence of four species of endangered native fish.

The 1994 BO did not consider CAP impacts to most of the Santa Cruz River (SCR) sub-basin, however, because planning for all CAP water deliveries in the Tucson, Arizona, area was not complete at that time. Reclamation initiated formal consultation with FWS in 1997, for the Santa Cruz River sub-basin. FWS issued a draft biological opinion for the Santa Cruz sub-basin in 1999. That consultation was been delayed due to unresolved issues, and was never finalized.

Since 2001, new aquatic species were federally listed under ESA, and resolution of issues regarding conservation measures for the uncompleted consultation on the Santa Cruz River subbasin portion of the CAP prompted a re-initiation of consultation. The biological assessment submitted by Reclamation to FWS in December 2006 proposes addition of three fish barriers in the Santa Cruz River sub-basin, increases the amount of funding transfers from Reclamation to FWS for native fish recovery and nonnative fish control activities, and adds a one-time infusion of funding to assist with a recovery program for Chiricahua leopard frog. The other conservation measures (long-term monitoring of fish populations and implementation of a public information and education program) remain largely unchanged from the 2001 biological opinion. However, the consultation does address recharge projects downstream of the proposed fish barriers in the Santa Cruz River subbasin portion of the CAP delivery area. If the CAP system is extended to the Sierra Vista subwatershed, re-initiation of formal consultation, especially on recharge projects, will be required.

## National Environmental Policy Act

The National Environmental Policy Act (NEPA) was signed in 1969. NEPA is our basic national charter for protection of the environment. The policy contains action-forcing provisions to ensure Federal agencies follow the letter and spirit of the act, which is to protect the environment. The main purposes of NEPA are:

- To declare a national policy which will encourage productive and enjoyable harmony between man and his environment

- To promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man

- To enrich the understanding of the ecological systems and natural resources important to the Nation

NEPA establishes that before federally funded or sponsored actions are implemented, the responsible Federal agency must assess the significance of impacts to the human environment that will occur if the action is taken. Alternative ways of meeting the purpose and need for the action must be considered, and the impacts that would occur with these alternatives must be compared to the impacts of the proposed action. The Council on Environmental Quality's (CEQ) regulations for implementing NEPA further explain:

> *The NEPA process is intended to help public officials make decisions that are based on understanding of environmental consequences, and take actions that protect, restore, and enhance the environment. (CEQ Regulations for Implementing the Procedural Provisions of the NEPA, 40 CFR Part 1500.1)*

*The NEPA Process*. Federal agencies are required to "adopt procedures to ensure that decisions are made in accordance with the policies and purposes of the Act." Agencies are to designate the major decision points in their principal programs and ensure that the NEPA process corresponds with them. This process cannot be a last-minute consideration if it is to be applied appropriately. Whenever Reclamation is considering an action, the NEPA process will be integrated into all planning and decisionmaking processes from the earliest discussion of the need for and type of action to be taken.

*What NEPA Does*. Compliance with NEPA requires participation of Federal, State, and local agencies, and concerned and affected public in the planning process. The act requires full disclosure about actions, alternatives, impacts, and possible mitigation for actions taken by Federal agencies. This act allows environmental concerns and impacts to be expressed and considered while an action is being planned. During planning, steps can be taken to correct or mitigate the impacts of an action. It is usually too late to correct errors after a project's planning phase without a substantial increase in the cost and the manageability of the project. Properly applied, NEPA results in informed and better decisions.

For this project, the Reclamation is coordinating the investigation of water supply augmentation alternatives in the SVSW. NEPA compliance during this phase involves the identification of concerns, constraints, and potential impacts that could affect the viability of a proposed project. It also entails the development of a reasonable range of alternatives to meet the need for the project, in the event the project is federally funded.

In the feasibility level analysis, an environmental team should perform on-the-ground reconnaissance-level surveys of the proposed features, to determine potential impacts to resources of concern. At this time, it is anticipated that the following resources would be of particular interest: biological, geological, cultural, water quality, air quality, land use, visual, and socioeconomic effects. Based on existing information, the number of components involved (reservoir, water treatment plant [WTP], pumping plants, pipelines, and turnouts, etc.), and the likelihood that the project would be constructed over a period of a few years, it is anticipated that a programmatic environmental impact statement (EIS) covering the entire project would be appropriate.

Follow-up NEPA compliance could be required if on-the-ground conditions or design features change significantly as the various features are constructed over time. It is recommended that environmental staff assess the project as early as possible once the plans are in place, to allow enough time to prepare an EIS. The following issues could be of concern:

- Endangered species
- Development of previously undisturbed land
- Transmission line alignments (length, width)
- Cultural resources
- Visual resources
- Socio-economic issues

Analysis of impacts to biological and cultural resources are important parts of any NEPA document. The biological analysis includes a discussion of the existing resources, impacts, and proposed mitigation. Reclamation must also comply with the ES), which requires a determination of effects to listed species. Surveys of threatened and endangered species would be conducted and a biological assessment prepared. Consultation with the FWS under section 7 of the ESA would be conducted if appropriate. In addition, the Fish and Wildlife Coordination Act (FWCA) requires coordination with local resource agencies (i.e. Arizona Game and Fish Department). The FWS would prepare an FWCA report to recommend measures for the mitigation of fish and wildlife resources.

A cultural resource analysis includes preparation of the cultural resource portion of the NEPA document. This contains a description of previous investigations, existing cultural resources, and recommendations for future investigations. Reclamation would also consult with the State Historic Preservation Office (SHPO) as required by Federal law. Class 3 surveys, intensive on-the-ground surveys with 100-percent coverage of the project area, would be conducted.

Another major component of the NEPA process is coordination with local, State, and Federal agencies. This coordination is primarily carried out through compliance with the various Federal laws mentioned above, as well as the Clean Air Act and Clean Water Act.

## NEPA Compliance

*Types of Compliance*. NEPA compliance documentation is triggered by a Federal action. If there is no Federal action being taken, there is no NEPA document required. The nature of the Federal action may be constructing a project, granting a permit or approval to a third party, providing Federal funding in a third-party project, or any other action where a Federal decision is required. It is likely that any water augmentation alternative undertaken in the SVS will involve a Federal action and therefore be required to comply with NEPA.

Once it has been established that there is a Federal action, the next step is to determine relevant environmental issues and the potential magnitude of environmental impacts. Once these have been identified, the appropriate level of NEPA documentation can be determined. After the environmental effects have been evaluated, the appropriate level of documentation can be selected. These levels are:

- Categorical Exclusions — A CE applies to actions that do not individually or cumulatively have a significant effect on the human environment. A CE excludes certain Federal actions from further NEPA documentation because the action has been shown to have no significant effect on the environment or on unresolved conflicts concerning alternative uses of available resources. There may be cases where a CE appears to apply, but because of particular circumstances, a different type of NEPA compliance documentation may be appropriate.

- Environmental Assessment/Finding of No Significant Impact — The EA process may be used for evaluation of any action, at any time, to assist in planning and decisionmaking. The EA should provide sufficient evidence and analysis to determine that an environmental impact statement (EIS) is not required for the project. If it is determined in the course of the EA that this level of analysis is adequate, a finding of no significant impact (FONSI) is issued and preparation of an EIS is not required. However, the choice to prepare an EA does not guarantee that a FONSI will be reached. Note that the choice to conduct the next level of compliance (an EIS) can be made any time there is enough information to indicate that significant impacts may occur or that sufficient controversy (factual disputes) about the impacts exists.

- Environmental Impact Statement.—An EIS is normally required for a major Federal action with potentially significant environmental effects. The nature of an action and its resulting significant environmental effects may be apparent from the beginning of the study. For actions of this sort, an EIS is needed, and an EA will not be prepared.

## Other Federal Laws

A review of Federal laws that may apply to the proposed alternatives are listed below.

**Executive Order 11988, Floodplain Management, May 24, 1977**

Executive Order 11988 requires avoiding or minimizing harm associated with the occupancy or modification of a flood plain.

**Executive Order 11990, Protection of Wetlands, May 24, 1977**

Executive Order 11990 provides for the protection of wetlands through avoidance or minimization of adverse impacts.

**Fish and Wildlife Coordination Act of 1934, as Amended**

This act requires coordination with Federal and State wildlife agencies (FWS and Arizona Game and Fish Department) for the purpose of mitigating project-caused losses to wildlife resources.

**National Historic Preservation Act of 1966, as Amended**

Federal agencies are responsible for the identification, management, and nomination of cultural resources that would be affected by Federal actions to the National Register of Historic Places (National Register). When a Federal action may affect cultural resources on, or eligible for inclusion in, the National Register, consultation with the Advisory Council on Historic Preservation, the State Historic Preservation Officer and affected Indian tribes is required.

**Native American Graves Protection and Repatriation Act**

The Native American Graves Protection and Repatriation Act (NAGPRA) became law in 1990 (Public Law [P.L] 101-601). NAGPRA is intended to ensure that Native American human burials, all associated funerary offerings, and items of cultural patrimony currently curated by Federal agencies, or by museums or institutions receiving Federal funding, are identified and inventoried for possible return to an appropriate tribe. NAGPRA regulates the intentional or accidental excavation of Native American human remains on Federal or tribal lands. It also provides information on determining ownership of Native American human remains and associated funerary offerings found on Federal or tribal land. The law sets fines for persons illegally trafficking in Native American human remains and cultural items and establishes a review committee to monitor the inventory and repatriation process and to assist in dispute resolutions arising from the law. Compliance with this act will likely be required if Federal funding for the project is provided.

**Clean Air Act of 1963, as Amended**

This act requires that any Federal entity engaged in an activity that may result in the discharge of air pollutants must comply with all applicable air pollution control laws and regulations (Federal, State, or local).

**Indian Water Rights Settlements**

Southern Arizona Water Rights Settlement Act (SAWRSA) was the result of a 1975 lawsuit by the United States on behalf of the Tohono O'odham Nation against the City of Tucson and other major groundwater users in the Upper Santa Cruz basin to protect water resources of the San Xavier District, Schuk Toak District, and the Nation. SAWRSA (P.L. 97-293, as amended), enacted in 1982, provides that a total of 66,000 acre-feet of water is to be delivered to the Nation and that irrigation systems be constructed to allow for use of the water. Reclamation is responsible for executing the Federal Government's responsibilities in SAWRSA. Major provisions of SAWRSA include:

- The Secretary of the Interior is required to provide the following quantities of water suitable for irrigation use:

    - San Xavier District, 27,000 afy of CAP water and 23,000 AFY of CAP water with an agricultural priority
    - Schuk Toak District, 10,800 AFY of CAP water and 5,200 AFY of water with an agricultural priority

- The Tohono O'odham Nation must limit its groundwater pumping beneath the San Xavier District to 10,000 AFY and to 1980 volumes pumped beneath the eastern Schuk Toak District.

- The Secretary of the Interior is authorized to enter into a contract with the City of Tucson for 28,200 AFY of secondarily treated effluent to be used for SAWRSA purposes. SAWRSA specifically prohibits the construction of a separate conveyance system to deliver the effluent to the Nation, effectively precluding the ability to provide this water to the Nation.

- A Cooperative Fund of $10.5 million was established through 50-percent Federal and 50-percent local funding. The non-Federal cost sharing is $2.75 million from the State of Arizona, $1.5 million from the City of Tucson, and $1.0 million collectively from Anamax Mining Company, the Cyprus-Pima Mining Company, the American Smelting and Refining Company (ASARCO), the Duval Corporation, and the Farmers Investment Company (FICO). The fund, which has grown to about $25 million, will be used to fund delivery of the 66,000 AFY to the San Xavier and Schuk Toak Districts.

- The Tohono O'odham Nation agrees to dismiss the lawsuit against local groundwater users and to release water rights claims against them other than those provided in SAWRSA.

The 108th Congress of the United States enacted the Arizona Water Settlements Act of 2004 (P.L. 108-451) to provide for adjustments to the Central Arizona Project, to authorize the Gila River Indian Community water rights settlement, and to reauthorize and amend the Southern Arizona Water Rights Settlement Act of 1982.

Section 105 of the Act obligates the Secretary of Interior and the State to develop a firming program to ensure that 60,648 acre-feet of the non-Indian Agricultural priority water made available pursuant to the CAP master agreement and reallocated to Arizona Indian tribes, shall for a 100 year period, be delivered during water shortages in the same manner as water with a municipal and industrial delivery priority in the Central Arizona Project (CAP) system is delivered during water shortages."

The non-Indian Agricultural priority water has the lowest priority on the CAP system. Therefore, in times of water shortage on the Colorado River this supply would will be reduced or eliminated before municipal, industrial and Indian priority supplies are impacted. Accordingly, the parties to the AWSA agreed, as a result of the settlement provision to reallocate non-Indian Agricultural priority water to the tribes, to firm this block of water to increase its reliability in times of shortage.

## REFERENCES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Alternatives for Using Central Arizona Project Water in the Northwest Tucson Area Appraisal Study, August 2000, Reclamation.

Aquifer Protection Permits, Application Guidance Manual (modified March 10, 1997), Arizona Department of Environmental Quality.

Appendix D

# Section 321

# H.R.1588

**National Defense Authorization Act for Fiscal Year 2004 (Enrolled as Agreed to or Passed by Both House and Senate)**

## SEC. 321. COOPERATIVE WATER USE MANAGEMENT RELATED TO FORT HUACHUCA, ARIZONA, AND SIERRA VISTA SUBWATERSHED.

(a) LIMITATION ON FEDERAL RESPONSIBILITY FOR CIVILIAN WATER CONSUMPTION IMPACTS-

(1) LIMITATION- For purposes of section 7 of the Endangered Species Act of 1973 (16 U.S.C. 1536), concerning any present and future Federal agency action at Fort Huachuca, Arizona, water consumption by State, local, and private entities off of the installation that is not a direct or indirect effect of the agency action or an effect of other activities that are interrelated or interdependent with that agency action, shall not be considered in determining whether such agency action is likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of designated critical habitat.

(2) VOLUNTARY REGIONAL CONSERVATION EFFORTS- Nothing in this subsection shall prohibit Federal agencies operating at Fort Huachuca from voluntarily undertaking efforts to mitigate water consumption.

(3) DEFINITION OF WATER CONSUMPTION- In this subsection, the term `water consumption' means all water use off of the installation from any source.

(4) EFFECTIVE DATE- This subsection applies only to Federal agency actions regarding which the Federal agency involved determines that consultation, or reinitiation of consultation, under section 7 of the Endangered Species Act of 1973 (16 U.S.C. 1536) is required with regard to an agency action at Fort Huachuca on or after the date of the enactment of this Act.

(b) RECOGNITION OF UPPER SAN PEDRO PARTNERSHIP- Congress hereby recognizes the Upper San Pedro Partnership, Arizona, a partnership of Fort Huachuca, Arizona, other Federal, State, and local governmental and nongovernmental entities, and its efforts to establish a collaborative water use management program in the Sierra Vista Subwatershed, Arizona, to achieve the sustainable yield of the regional aquifer, so as to protect the Upper San Pedro River, Arizona, and the San Pedro Riparian National Conservation Area, Arizona.

(c) REPORT ON WATER USE MANAGEMENT AND CONSERVATION OF REGIONAL AQUIFER-

(1) IN GENERAL- The Secretary of the Interior shall prepare, in consultation with the Secretary of Agriculture and the Secretary of

Defense and in cooperation with the other members of the Partnership, a report on the water use management and conservation measures that have been implemented and are needed to restore and maintain the sustainable yield of the regional aquifer by and after September 30, 2011. The Secretary of the Interior shall submit the report to Congress not later than December 31, 2004.

(2) PURPOSE- The purpose of the report is to set forth measurable annual goals for the reduction of the overdrafts of the groundwater of the regional aquifer, to identify specific water use management and conservation measures to facilitate the achievement of such goals, and to identify impediments in current Federal, State, and local laws that hinder efforts on the part of the Partnership to mitigate water usage in order to restore and maintain the sustainable yield of the regional aquifer by and after September 30, 2011.

(3) REPORT ELEMENTS- The report shall use data from existing and ongoing studies and include the following elements:

(A) The net quantity of water withdrawn from and recharged to the regional aquifer in the one-year period preceding the date of the submission of the report.

(B) The quantity of the overdraft of the regional aquifer to be reduced by the end of each of fiscal years 2005 through 2011 to achieve sustainable yield.

(C) With respect to the reduction of overdraft for each fiscal year as specified under subparagraph (B), an allocation of responsibility for the achievement of such reduction among the water-use controlling members of the Partnership who have the authority to implement measures to achieve such reduction.

(D) The water use management and conservation measures to be undertaken by each water-use controlling member of the Partnership to contribute to the reduction of the overdraft for each fiscal year as specified under subparagraph (B), and to meet the responsibility of each such member for each such reduction as allocated under subparagraph (C), including--

(i) a description of each measure;

(ii) the cost of each measure;

(iii) a schedule for the implementation of each measure;

(iv) a projection by fiscal year of the amount of the contribution of each measure to the reduction of the overdraft; and

(v) a list of existing laws that impede full implementation of any measure.

(E) The monitoring and verification activities to be undertaken by the Partnership to measure the reduction of the overdraft for each fiscal year and the contribution of each member of the Partnership to the reduction of the overdraft.

(d) ANNUAL REPORT ON PROGRESS TOWARD SUSTAINABLE YIELD-

(1) IN GENERAL- Not later than October 31, 2005, and each October 31 thereafter through 2011, the Secretary of the Interior shall submit, on behalf of the Partnership, to Congress a report on the progress of the Partnership during the preceding fiscal year toward achieving and maintaining the sustainable yield of the regional aquifer by and after September 30, 2011.

(2) REPORT ELEMENTS- Each report shall include the following:

(A) The quantity of the overdraft of the regional aquifer reduced during the reporting period, and whether such reduction met the goal specified for such fiscal year under subsection (c)(3)(B).

(B) The water use management and conservation measures undertaken by each water-use controlling member of the Partnership in the fiscal year covered by such report, including the extent of the contribution of such measures to the reduction of the overdraft for such fiscal year.

(C) The legislative accomplishments made during the fiscal year covered by such report in removing legal impediments that hinder the mitigation of water use by members of the Partnership.

(e) VERIFICATION INFORMATION- Information used to verify overdraft reductions of the regional aquifer shall include at a minimum the following:

(1) The annual report of the Arizona Corporation Commission on annual groundwater pumpage of the private water companies in the Sierra Vista Subwatershed.

(2) The San Pedro base flow monitoring record of the Charleston flow gauge of the United States Geological Survey.

(3) Current surveys of the groundwater levels in area wells as reported by the Arizona Department of Water Resources and by Federal agencies.

(f) SENSE OF CONGRESS- It is the sense of Congress that any future appropriations to the Partnership should take into account whether the Partnership has met its annual goals for overdraft reduction.

(g) DEFINITIONS- In this section:

(1) The term `Partnership' means the Upper San Pedro Partnership, Arizona.

(2) The term `regional aquifer' means the Sierra Vista Subwatershed regional aquifer, Arizona.

(3) The term `water-use controlling member' has the meaning given that term by the Partnership.