Other sites upstream of B2 were rejected due to the amount of road improvements that would be necessary to accommodate the movement of construction equipment through the narrow confines of the canyon. Access to sites C and D would require blasting of canyon walls and other extensive earthwork to allow sufficient road widening and straightening.

Rights-of-entry to sites B1 and B2 for detailed site investigations were not granted by private property owners. Due to rights-of-entry refusals, Reclamation could not adequately evaluate these potential barrier sites. Reclamation also determined that acquisition of, or rights to, sites B1 and B2 for barrier construction could not willingly be obtained from property owners, effectively eliminating these sites from further consideration. Notably, the biological opinion emphasized procurement of sites from willing sellers and discouraged condemnation of land.

III. AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

This chapter describes the affected environment and analyzes the environmental consequences of the proposed action and the no action alternative. The analysis addresses the following resource topics: hydrology and geomorphology, biological resources, land use, water quality, cultural resources, environmental justice, and Indian trust assets (ITA). Potential project-related noise, air quality, and socioeconomic (except see environmental justice and ITA sections) impacts were determined by Reclamation to be negligible and thus are not analyzed in this EA. The following analysis examines possible maximum impacts of the project that are anticipated to occur.

A. Hydrology and Geomorphology

1. Affected Environment

Flow regimes within Aravaipa Creek are influenced by the size, shape, and gradient of the channel; roughness of the stream bottom; and amount of rainfall. Flows tend to be episodic, with higher volumes coinciding with runoff from storm events.

Stream gradient is generally less than 13.2 feet/mile (0.2 percent) near the source of perennial flow that begins approximately 3.7 miles northwest of the town of Klondyke. Gradient increases to greater than 132.0 feet/mile (2.5 percent) within the gorge, and again falls to near 26.4 feet/mile (0.5 percent) near the San Pedro River, where flows become ephemeral (Minckley 1981). Gradient in the proposed project area is 31.7 feet/mile (0.6 percent) (Reclamation data).

Mean channel width in the perennial reach below the gorge in 1976 was approximately 99.1 feet, mean stream width was 32.5 feet, mean depth was 3.0 inches, and mean maximum depth was 13.5 inches (Minckley 1981). These figures appear representative of the project area, except to note the local presence of a few peripheral scour pools that exceed 3 feet in depth.

Monthly mean discharges for Aravaipa Creek, measured 5.9 miles upstream from the mouth (immediately upstream from the project area), range from a low of 12 cfs in June to a high of 67 cfs in February, based on 64 years of record (U.S. Geological Survey (USGS) records). A record discharge of 70,800 cfs (300-year flood frequency) was estimated during an October 1, 1983, flood event. Flooding in 1993, which USGS records indicate peaked at 13,000 cfs, was particularly damaging because of its long duration. When floods originate in the upper Aravaipa Valley, large amounts of relatively fine-grained materials are transported downstream, often resulting in aggradation of the streambed and filling in of pools with fine material (Minckley 1981). Flood waters that are derived from higher elevation, bedrock-dominated canyon tributaries, however, have fewer sources for fine suspended loads and, therefore, have a higher probability for scour and degradation of channels downstream (Minckley 1981). Tributary floods also transport larger materials from high elevations that are often deposited in the form of alluvial fans that may temporarily block or impound mainstem flows.

Substrates in the project area range from fine sands and silts to boulders and bedrock (the latter being mudstone conglomerate along canyon walls). Erodible features potentially disturbed by the proposed action include:

- alluvial fans (silty sands, gravelly sand with gravel deposits)
- stream alluvium in active channel (sand, gravel, cobbles, and silt) and floodplains (silts, clays, and sand)
- colluvium (rock fragments and loose sand)

2. Environmental Consequences

a. Construction Impacts

Construction-related disturbances within the channel would result from site preparation (including trenching operations), equipment movement, and stockpiling of excavated alluvial material. Depending on the final design, as much as 15,000 cubic yards of material could be excavated at each barrier site for placement of structural elements such as the keys and apron. Most of the stockpiled material, however, would be returned to the excavation as backfill. Any "surplus" material would be disposed of within the sedimentation zone immediately upstream of each barrier, and eventually consolidate with sediment deposited by stream flow to form a new alluvial bed. Approximately 2 acres of soils and other geologic

features within the stream channel would be temporarily affected during construction. An additional 1.81 total acres of stream channel would fall within the permanent footprints of the barriers.

Other sites affected by construction include the contractor use area and two access roads. Preparation (blading and installation of a fence) and use of the temporary contractor yard would disturb approximately 2.1 acres of soils. The contractor use area would be revegetated with native plants following construction to stabilize disturbed soils and minimize erosion.

Access to both the upper and lower barrier sites would require utilization of two existing primitive roads. Both roads would be "improved" to accommodate the movement of construction equipment. Proposed road improvements include blading, filling, and trimming of vegetation. Approximately 0.3 acre would be disturbed by this action.

b. Surface Flows

Long-term operational impacts of the project include an incremental increase in upstream backwater flooding. The construction of barriers in the stream channel and the resulting deposition of sediment (aggradation) would raise the water surface profile upstream of the barriers. This backwater effect has been quantified in a preliminary river modeling study. The cross-sectional information for this study was obtained from aerial photogrammetry, and was mapped with 2-foot contour intervals. The hydraulic analysis was done using the U.S. Army Corps of Engineers' HEC-2 Water Surface Profile, which is an industry standard for this type of river modeling. The model estimates flow depth, flow velocity, and the width of flow for the stream channel with and without the barriers. The model accounts for channel slope, channel shape, channel roughness, and vegetation. A final river modeling analysis will be performed once all ground survey information is gathered to confirm engineering assumptions.

Frequency floods of 5, 10, 25, 50, and 100 years were run to compare the difference in the water surface profiles with the natural stream channel, and then with the barriers in place. The instantaneous peak flows associated with these frequency floods are 8.700, 13,500, 22,000, 30,000, and 40,000 cfs, respectively. Both profiles were plotted for the five frequency floods, and inundation areas were mapped (Figures 3-1, 3-2, 3-3, 3-4, and 3-5). The added backwater effects from the barriers would extend upstream a few hundred feet beyond the boundary of the allotted land onto private land. Less than 3 acres of allotted land and less than 1/4 acre of private land would be inundated by flooding attributable to the project (Table 2).

344-330-18857

Figure 3-1

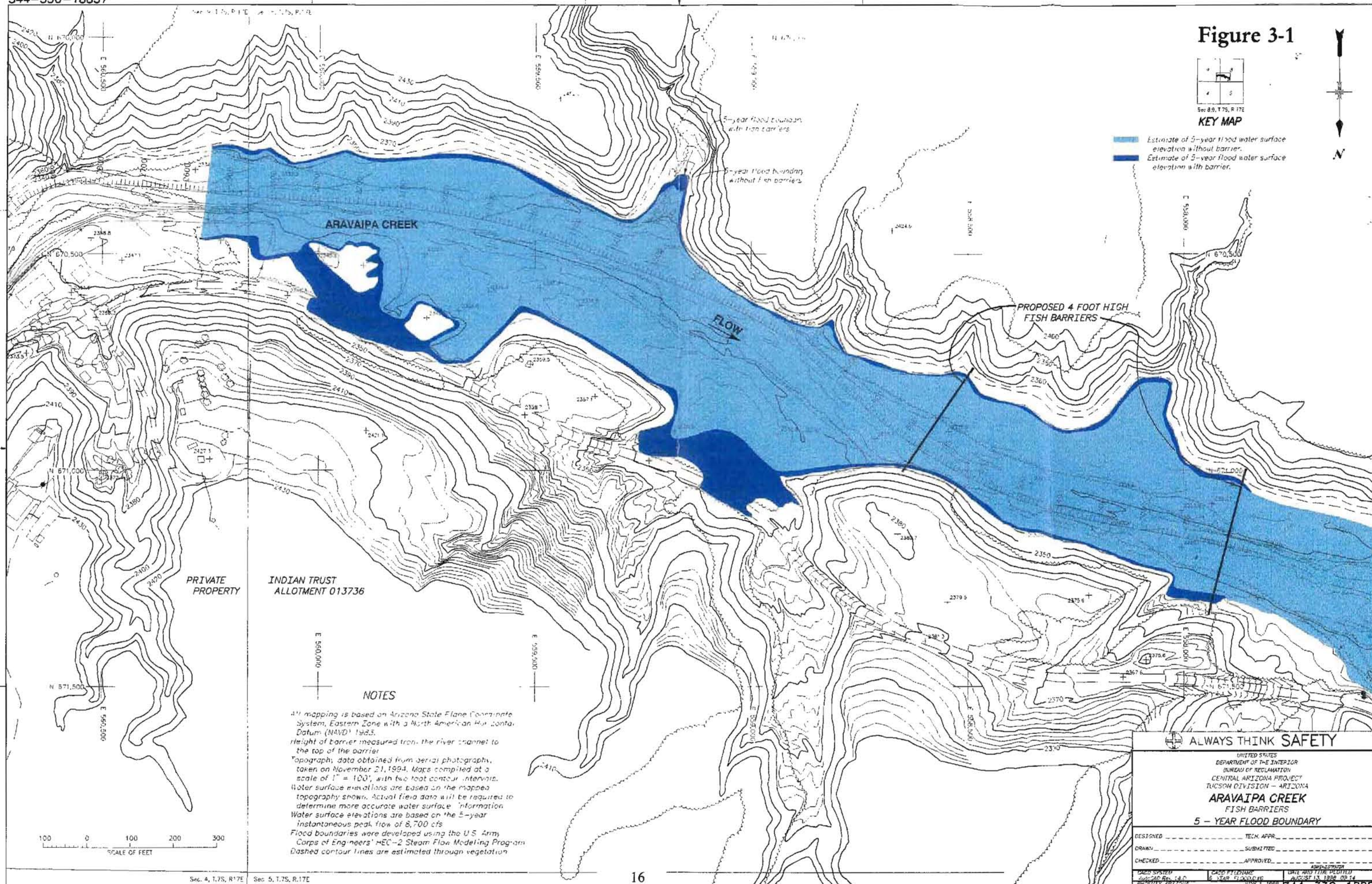
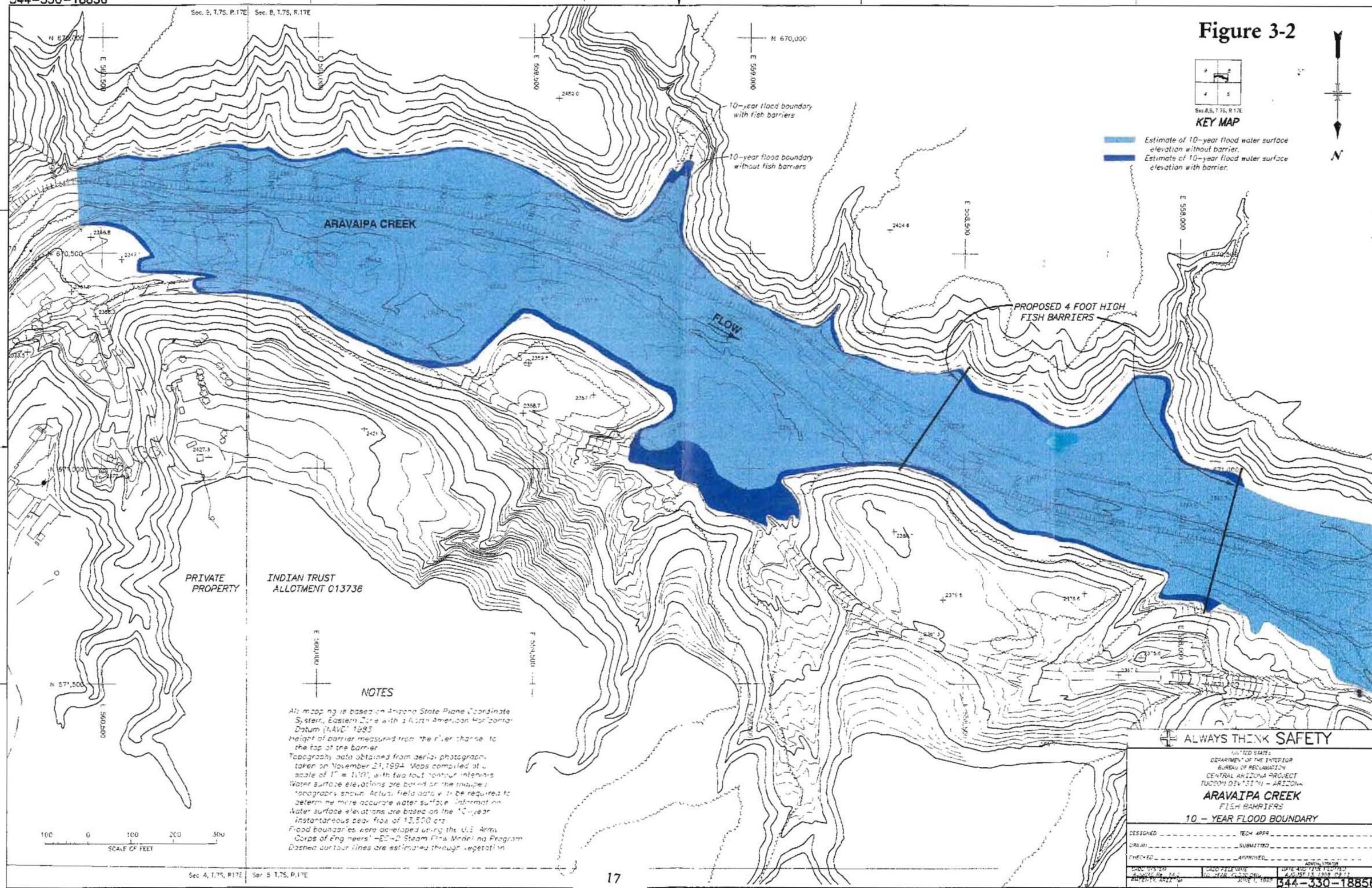


Figure 3-2


Sec. 9, T.7S, R.17E
Sec. 8, T.7S, R.17E
N 670,000
E 559,000
10-year flood boundary with fish barriers
10-year flood boundary without fish barriers
ARAVAIPA CREEK
FLOW
PROPOSED 4 FOOT HIGH FISH BARRIERS
PRIVATE PROPERTY
INDIAN TRUST ALLOTMENT 013736
N 671,500
E 560,500
KEY MAP
Estimate of 10-year flood water surface elevation without barrier.
Estimate of 10-year flood water surface elevation with barrier.
N
NOTES
All mapping is based on Arizona State Plane Coordinate System, Eastern Zone with 1 North American Horizontal Datum (NAD) 1983
Height of barrier measured from the river channel to the top of the barrier
Topographic data obtained from aerial photogrammetry taken on November 21, 1994. Maps compiled at a scale of 1" = 100', with two foot contour intervals
Water surface elevations are based on the mapped topography shown. Actual field data will be required to determine more accurate water surface information
Water surface elevations are based on the 10-year instantaneous peak flow of 13,500 cfs
Flood boundaries were developed using the U.S. Army Corps of Engineers' HEC-2 Steady Flow Modeling Program
Dashed contour lines are estimated through vegetation
100 0 100 200 300
SCALE OF FEET
Sec. 4, T.7S, R.17E
Sec. 5 T.7S, R.17E
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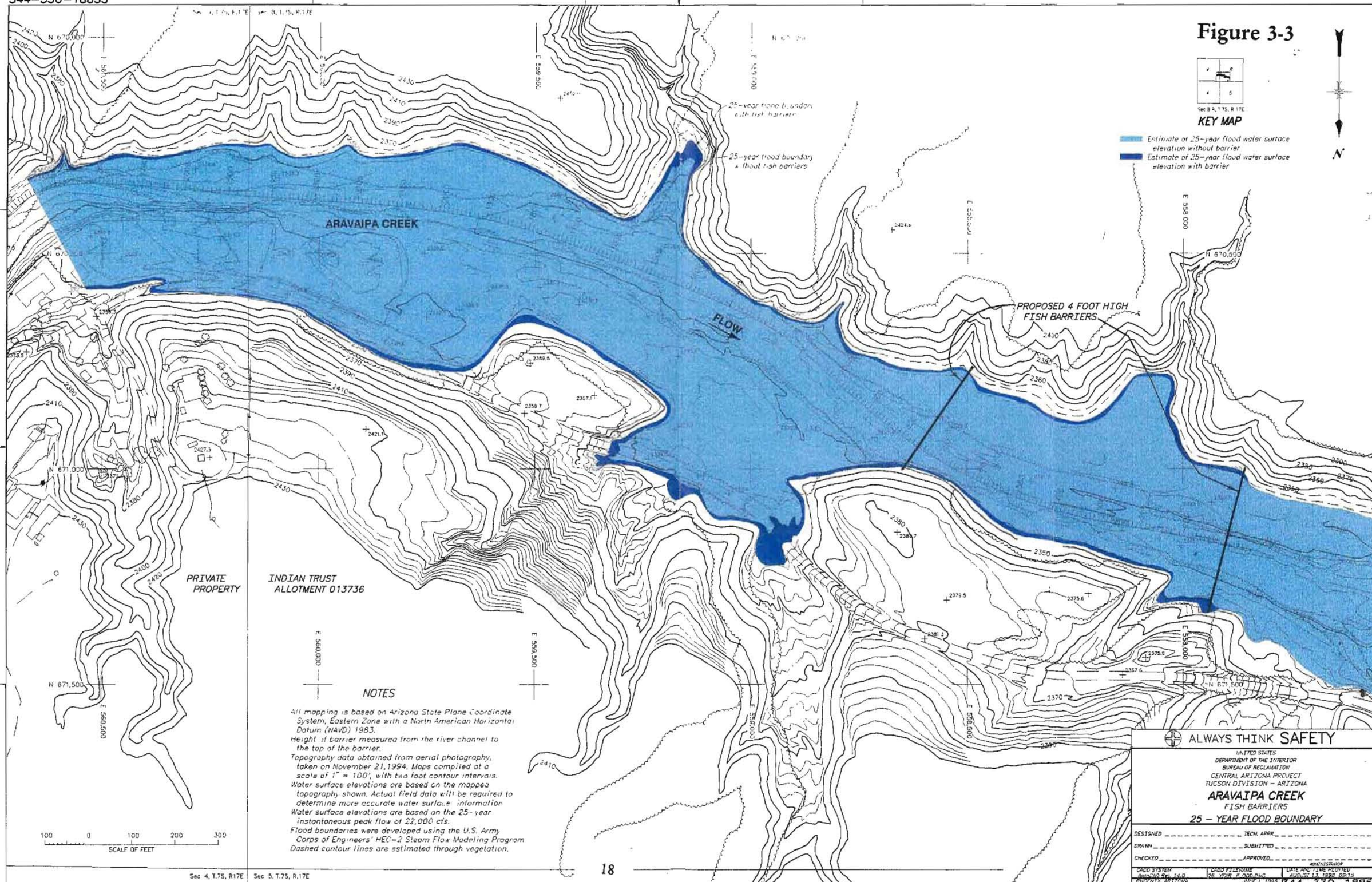
CENTRAL ARIZONA PROJECT
TUCSON DIVISION - ARIZONA
ARAVAIPA CREEK
FISH BARRIERS
10 - YEAR FLOOD BOUNDARY
DESIGNED
TECH APPR
DRAWN
SUBMITTED
CHECKED
APPROVED
ADMINISTRATOR
CADD SYSTEM
CADD FILE NAME
DATE ADMINISTRATOR APPROVED
AUGUST 13, 1998
JUNE 1, 1998
344-330-18856

344-330-18855

Figure 3-3

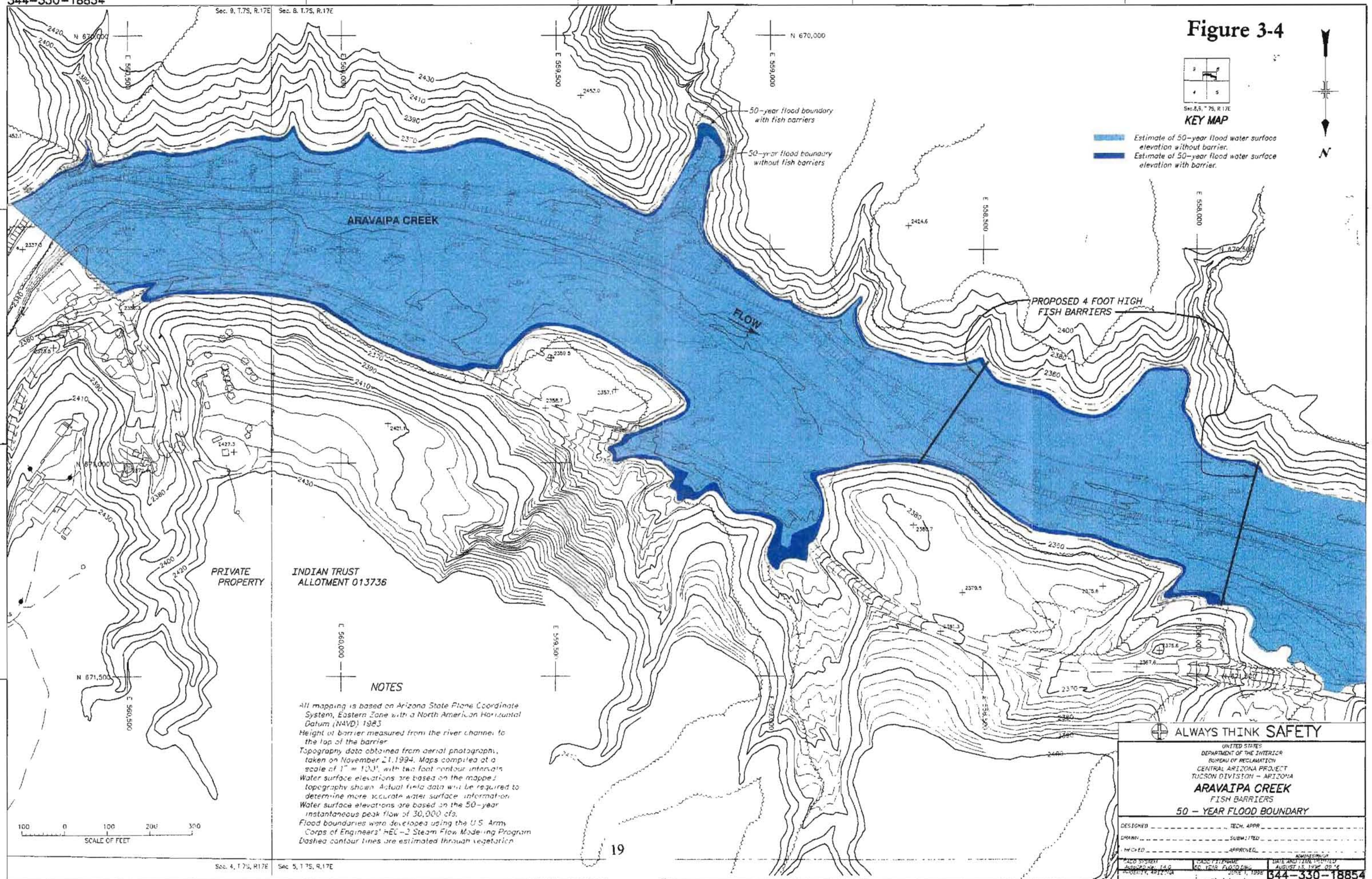


NOTES

All mapping is based on Arizona State Plane Coordinate System, Eastern Zone with a North American Horizontal Datum (NAVD) 1983.
Height of barrier measured from the river channel to the top of the barrier.
Topography data obtained from aerial photography, taken on November 21, 1994. Maps compiled at a scale of 1" = 100', with two foot contour intervals.
Water surface elevations are based on the mapped topography shown. Actual field data will be required to determine more accurate water surface information.
Water surface elevations are based on the 25-year instantaneous peak flow of 22,000 cfs.
Flood boundaries were developed using the U.S. Army Corps of Engineers' HEC-2 Steam Flow Modeling Program.
Dashed contour lines are estimated through vegetation.

344-330-18854

Figure 3-4



344-330-18852

Figure 3-5

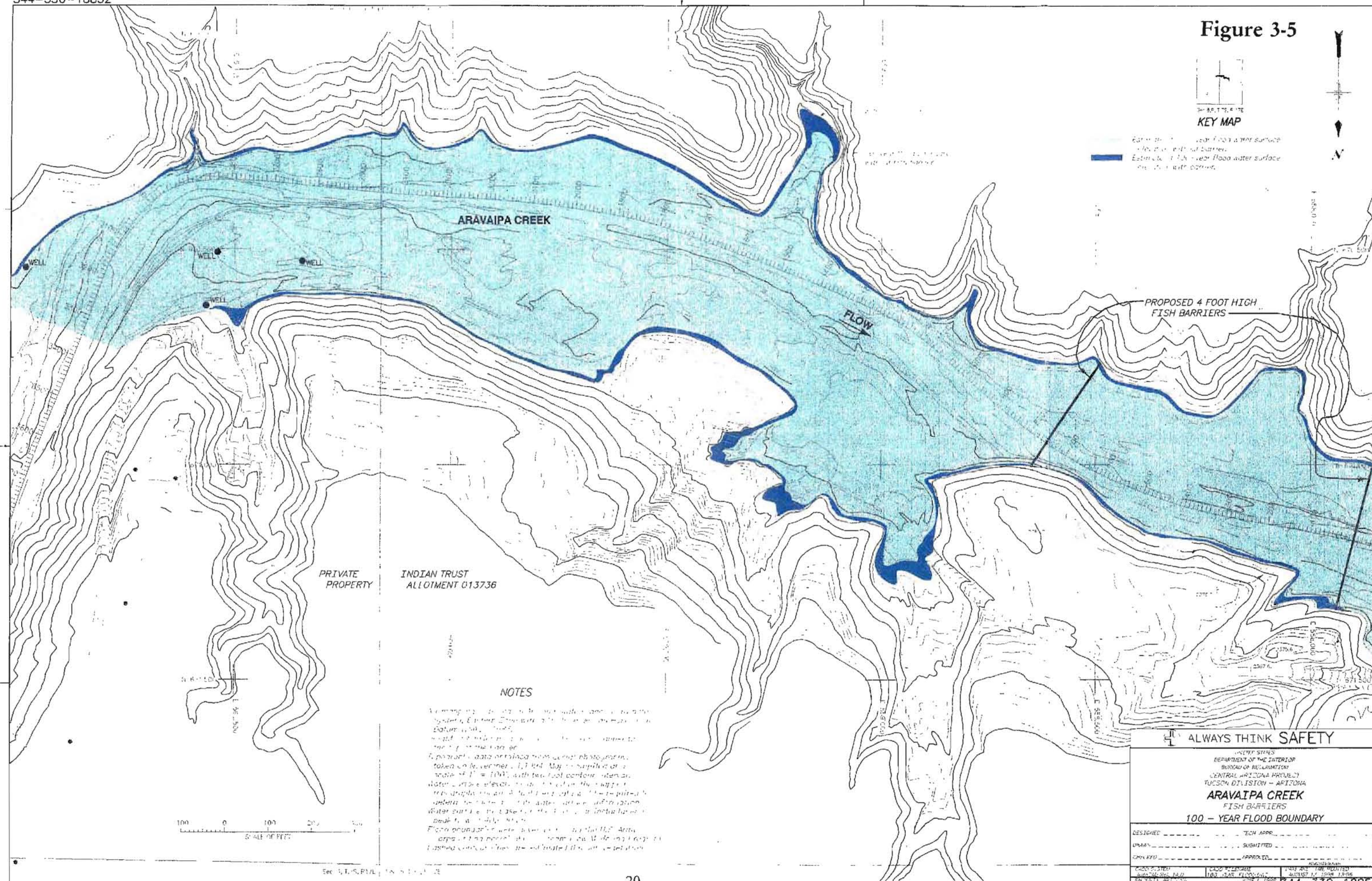


Table 2. Estimated project-related flood effects

ADDITIONAL IMPACTS (ACRES)					
Affected Property	5-Year Flood	10-Year Flood	25-Year Flood	50-Year Flood	100-Year Flood
Allotment	2.50	1.70	1.30	1.30	1.30
Private	0.04	0.16	0.13	0.16	0.19

Downstream effects beyond the barrier aprons would be relatively minor. Stream flow would return to its natural hydraulic regime within 100 feet of each barrier. Beyond 100 feet, the hydraulic effects of normal flow and flood would not be influenced by the barriers.

c. Subsurface Flows

The depth to bedrock would be determined when the right-of-entry is obtained from BIA to allow detailed geologic investigations. Examination of the alluvial base would necessitate several test drillings within the stream channel. Information derived from these field investigations would be used to develop the final project design and engineer any features that might be required to minimize possible impacts to hydrology at the barrier sites.

Currently, the depth of alluvium in the center of the channel is believed to be 60 to 80 feet. If this assumption proves to be accurate, a permeable alluvial zone with a hydraulic height of 40 to 60 feet will exist between bedrock and the concrete barrier. Assuming a height of 50 feet with a stream width of 270 feet, the permeable area is 6,750 square feet. Based on these assumptions, the barriers would interrupt approximately 0.16 cfs of subsurface flows. These flows are relatively minor and should pass below the barrier with undetectable effects on the ground-water table or above ground flows.

If the channel bedrock proves to be closer to the surface than estimated, the barriers may be tied directly to the rock or attached by means of caissons. Caissons would allow subsurface flows to pass beneath the barrier. In the case of the structure being tied to bedrock, large portals would be placed through the barrier to allow ground water to pass through the concrete.

d. Public Road Impacts

Hydraulic modeling of Aravaipa Creek shows that backwater flooding currently begins to affect Aravaipa Road at about a 12-year frequency flood. With the fish barriers in place, the same situation occurs with a 4-year flood. Reclamation would modify affected sections of Aravaipa Road to conform with the Pinal County all-weather road standards. Two low-lying sections of Aravaipa Road would be raised approximately 3 to 4 feet to improve drainage and prevent road closures caused by project-related backwater flooding. Almost 1,250 feet (500 feet and 750 feet, respectively) of Aravaipa Road above the upper barrier would be modified. Road improvements would include installation of culverts and placement of 6 inches of aggregate base course on the driving surface. Fill material would be imported from a commercial off-site source and compacted to Pinal County standards. Aravaipa Road would remain open while road construction is underway and all traffic would be accommodated, although there could be some minor traffic delays. Flagmen would be provided by the contractor if traffic volumes and construction activities warrant this additional measure to ensure safe passage through the work zone. The volume of construction traffic generated by the fish barrier project would not be expected to interfere with traffic flow on public roads.

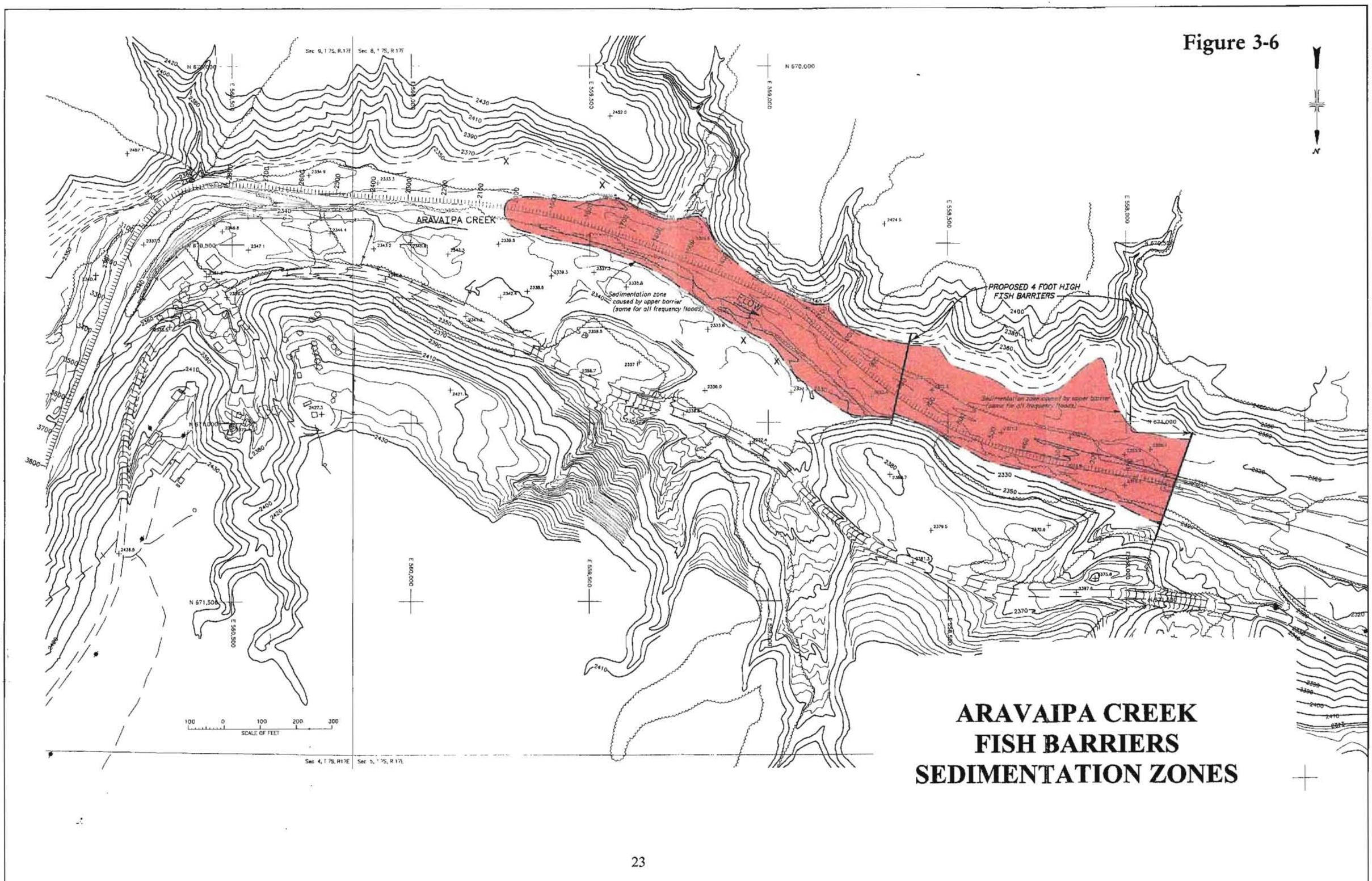
e. Sediment Deposition (Aggradation)

Any impediment placed in flowing water will momentarily disrupt flow velocity and allow opportunities for sediment deposition. This same dynamic relationship between stream velocity and sediment deposition would occur at the barrier sites. Immediately following construction, the fish barriers would become effective sediment traps. Silt transporated by normal stream flow and flood would quickly collect upstream of each barrier to form "sedimentation zones" (Figure 3-6). At the barrier's center, the sediment would accumulate (aggrade) to a depth of 4 feet, raising the stream channel to the same height as the barrier. Temporary pools formed by barrier construction would eventually fill with silt.

The extent of the sedimentation is expected to reach approximately 1,200 feet upstream of the upper barrier, where the raised stream channel would converge with the existing stream channel grade. The lower barrier would experience the same type of sedimentation, but since the barriers would be separated by about 800 feet, the sediment aggradation would be interrupted by the upper barrier. This may lead to sediment partially burying the downstream face of the upper barrier by 3 to 5 inches. Aggradation of sediment to more than a few inches at the base of the upper barrier could seriously compromise the barrier's effectiveness as an impediment to fish movement. Thus, 800 feet is the minimum acceptable distance for barrier separation.

The prevailing stream gradient through the project area is approximately 0.6 percent. For a short distance upstream of the lower barrier, stream gradient increases to almost 0.9 percent before returning to 0.6 percent near the upper barrier site. Due to

Figure 3-6


ARAVAIPA CREEK
FLOW
Sedimentation zone caused by upper barrier (same for all frequency floods)
PROPOSED 4 FOOT HIGH FISH BARRIERS
N 670,000
N 671,000
N 671,500
E 560,500
E 559,500
E 559,000
SCALE OF FEET
ARAVAIPA CREEK
FISH BARRIERS
SEDIMENTATION ZONES

the steeper gradient, sediment aggradation between the two barriers would be less than above the upper barrier. The acreage affected by sediment deposition is projected to be 7.5 acres (4.5 acres upstream of the upper barrier and 3.0 acres between the barriers). The volume of this sediment would be 15,000 cubic yards (10,000 cubic yards upstream of the upper barrier and 5,000 cubic yards between the barriers).

f. Scour

In the zone of sedimentation upstream of the barriers, the slope of the stream channel would become flatter as sediment accumulates. This would result in lower velocities through this section, which in turn should decrease scour and encourage additional aggradation until such time that natural sediment deposition and transport processes reach equilibrium. Upstream of the sedimentation zone, the scour should be similar to conditions without the barriers. Immediately downstream of the barriers, velocities will be higher as the water falls over the drop. Most of this turbulent scour will lose its energy at the apron. At the abutments, the higher velocities will increase erosion potential. Since the abutment rock is a soft mudstone conglomerate, it is not expected to withstand erosive flows. These high velocity areas would be armored with concrete, riprap, or gabions. Beginning approximately 100 feet downstream of the barriers, flow characteristics and scour would be unaffected by barrier operation.

Protection of the abutments from natural erosional forces is extremely important. If flows can erode around the end of a barrier, the stream will simply shift laterally and render the barrier ineffective. For this reason, the stream banks would require stabilization with riprap or other means for up to 100 yards upstream of each barrier.

g. Impacts to Wells

The possible effects of barrier construction and operation on nearby private wells were examined. First, the local drawdown due to dewatering for key trench excavation was considered. The nearest well, 1,800 feet upstream of dewatering pumping, would be the most likely affected. The analysis, however, demonstrated that recharge from the stream would confine the drawdown cone of the dewatering pumping to the immediate project area and, thus, would not impact private wells. Next, the influence of the raised stream channel was investigated. The stream channel elevation would increase as a result of sedimentation behind the barrier. The sediment zone is expected to extend 1,200 feet upstream of the upper barrier. The upper end of the sediment falls approximately 600 feet down gradient of the nearest well. This distance would preclude any measurable influence normal stream flow regimes might have on the wells.

All of the wells are within the 100-year floodplain, and are already subject to inundation from the 100-year flood event (Figure 3-5). Consequently, the well sites would be affected by slightly deeper 100-year flood flows and briefly extended flood durations. A temporary slight increase in water levels in the wells may result from the expected incremental increase in flooding.

h. Effects of Structural Failure

Once the upstream side of the barriers have filled in with sediment, very little, if any, water will be stored or backed up by the barriers. A structural failure under this condition poses no additional flooding threat to downstream property.

A structural failure of either barrier prior to sediment build-up would result in water being released downstream of the lower barrier. Prior to sediment build-up, there would be about 4.5 acre-feet and 0.5 acre-feet capacity behind the upper and lower barriers, respectively, and the maximum depth of water behind each barrier would be 4 feet. In the unlikely event of a "clear-day" failure (a failure that does not occur as a result of storm run-off), assuming a 50-foot wide section (a common jointing distance) suddenly breached for the entire hydraulic height of 4 feet of the upper barrier (the worst case scenario), an initial surge of approximately 1,100 cfs would occur. This flow would immediately begin to decrease as the ponded water elevation falls. For example, after 1 minute approximately 30 percent of the stored water would be released, and the discharge would be around 800 cfs. This flow would steadily decrease over about 20 minutes, when the stream would resume its normal flow. The leading edge of the flood wave would begin to attenuate significantly within a mile of the barrier due to infiltration, dispersion over the wide floodplain, and reduced velocity because of vegetation. As the leading edge approached the vicinity of the creek's confluence with the San Pedro River, the flow would probably range from 100 to 400 cfs. The effects of a barrier failure during normal stream flow would be confined to the stream channel and portions of the floodplain subject to recurrent flooding. The temporary flow surge immediately below the barrier would be substantially less than a 2-year frequency flood, which is estimated by USGS to be 3,790 cfs.

A more likely failure would occur during a large flood event. The catastrophic loss of a barrier during a flood would erode sediment that may have already accumulated in the sedimentation zone, returning the channel in this section of stream to its original preconstruction elevation. Loss of the barrier, and any impounded sediment, would lower the flood surface at the barrier site. The volume of water released would be proportionately small relative to the overall flood volume and would not perceptively increase flows. Because the water behind the barrier is already moving with the flood, the collapse of the

barrier would not produce a flood wave. The only anticipated adverse effect of a barrier failure during a flood would be the possible slight increase in bank erosion on allotted land immediately downstream of the barrier. No measurable impact to public roads, residences, farm production, or cultural sites is expected.

i. No Action Alternative

Geomorphic and hydrologic effects resulting from construction and operation of the fish barriers would not occur. Periodic flooding on the allotment and upstream private properties would continue without project-related influences.

B. Biological Resources

1. Affected Environment

The lower reach of Aravaipa Creek above the project area is considered one of the premier examples of high-quality riparian vegetation, as well as one of the last remaining refugia for native fish in the Sonoran Desert. The unique values of Aravaipa Creek have been recognized by active protection of the central canyon as a wilderness area managed by the Bureau of Land Management (BLM), establishment of reserves by The Nature Conservancy, and conservation efforts of the Arizona Game and Fish Department (AGFD), Forest Service, and numerous private landowners.

The head of the Aravaipa Creek channel originates below the low divide bordering Sulphur Springs Valley in Graham County, from where it flows northwest in a narrowing valley between the Pinaleño and Turnbull-Santa Teresa ranges to the north and the Galiuro Mountains to the south. After entering an upper canyon section, the stream then cuts west through a gorge in the northern flanks of the Galiuros and enters Pinal County. It then turns southwest through a lower canyon, and heads west again as it leaves the lower canyon. Aravaipa Creek joins the San Pedro River in a broad valley south of the town of Winkelman (Minckley 1981). Maximum elevations in the basin exceed 10,000 feet in headwaters of the Pinaleños, and descend to 2,150 feet at the confluence with the San Pedro River.

Vegetation in the upper portion of the creek is best characterized as desert-grassland habitat (Minckley 1981). Desert grassland habitat is often transitional between evergreen woodland or chaparral above and desertscrub habitat below (Brown 1982). The stream is perennial through the BLM Wilderness Area and for several miles downstream. However, prior to the confluence with the San Pedro River, the flow becomes subsurface and the vegetation immediately along the channel changes from a cottonwood (*Populus fremontii*) and willow

(*Salix goodingii*) gallery forest to isolated pockets of trees, and finally to riparian scrub vegetation consisting primarily of seepwillow (*Baccharis salicifolia*) and burrobrush (*Hymenoclea monogyra*).

The project area is located in the lower portion of Aravaipa Creek, approximately 10 miles downstream from the Wilderness Boundary and approximately 5.5 miles upstream from the confluence with the San Pedro River. Surface flows are perennial in the project area; however, vegetation consists of scattered pockets of Sonoran Riparian Deciduous Woodland interspersed with Sonoran Riparian Scrubland habitat.

Terrestrial Resources

1. Vegetation - Vegetation within the project area is divided into four habitat types based on the vegetation classification system described by Brown (1982). The project area was cover mapped during June 1998, and the results are presented in Figure 3-7. The four community types include: Sonoran Riparian Deciduous Woodlands (cover mapped as mixed riparian, velvet mesquite and mixed mesquite); Sonoran Riparian Scrubland (cover mapped as mixed seepwillow/burrobrush); Sonoran Interior strand (included within the seepwillow/burrobrush cover type); and paloverde, cacti-mixed scrub community (cover mapped as Sonoran desertscrub). For a list of common plant species in Aravaipa Creek see Appendix B.

Following is a more detailed description of the vegetative community in the project area. The first paragraph describes the general vegetative community, while the indented paragraphs describe the actual project conditions.

The Sonoran Riparian Deciduous Woodlands community consists primarily of streamside vegetation such as Fremont cottonwood (*Populus fremontii*) and Goodding willow (*Salix goodingii*), but also includes saltcedar (*Tamarix ramosissima*) and velvet and/or honey mesquite (*Prosopis velutina* or *P. glandulosa*).

> This habitat is the dominant association in the river corridor, but habitat quality is considered moderate at best. The habitat is scattered in small pockets along the river corridor and consists of willow, cottonwood, sycamore (*Plantanus wrightii)*, saltcedar (*Tamarix ramosissima*), velvet mesquite (*P. velutina*), soapberry (*Sapindus saponaria*), Arizona walnut (*Juglans major*), and velvet Ash (*Fraxinus velutina*). The willow/cottonwood trees are either mature or decadent with little evidence of regeneration. There is one large (300 foot by 200 foot) mesquite bosque, while the remaining mesquite (more scrubby in stature) occurs in narrow stringers adjacent to the river. Saltcedar is interspersed within the corridor.

Figure 3-7

344-330-18860

Sec. 9, T.7S, R.17E | Sec. 8, T.7S, R.17E

Sec. 4, T.7S, R17E | Sec. 5, T.7S, R.17E

N 670,000 | N 671,000 | N 671,500 | N 670,500

E 560,500 | E 560,000 | E 559,500 | E 559,000 | E 558,500

Legend

- Private land not mapped
- Sonoran Desert Scrub
- Stream channel
- Mixed seepwillow/burrobrush
- Velvet mesquite
- Mixed mesquite (velvet mesquite, desert hackberry, elderberry, burrobrush, seepwillow, little-leaf paloverde, Arizona grape and Gooding willow)
- Mixed riparian (Fremont cottonwood, Gooding willow, Arizona ash, netleaf hackberry, soapberry and Arizona walnut)

Sec.8,9, T.7S, R.17E
KEY MAP

ARAVAIPA CREEK

FLOW

PROPOSED 4 FOOT HIGH FISH BARRIERS

Sedimentation zone caused by upper barrier (same for all frequency floods)

Construction Use Area A

Maximum extent of Construction Work Area

Construction Access Road

Sedimentation zone caused by upper barrier (same for all frequency floods)

Construction Use Area B

Construction Access Road

Construction Use Area C

100 0 100 200 300
SCALE OF FEET

NOTES

All mapping is based on Arizona State Plane Coordinate System, Eastern Zone with a North American Horizontal Datum (NAVD) 1983.

Height of barrier measured from the river channel to the top of the barrier.

Topography data obtained from aerial photography, taken on November 21,1994. Maps compiled at a scale of 1" = 100', with two foot contour intervals.

Water surface elevations are based on the mapped topography shown. Actual field data will be required to determine more accurate water surface information.

Water surface are based on the 100-year instantaneous peak flow of 40,000 cfs.

Flood boundaries were developed using the U.S. Army Corps of Engineers' HEC-2 Steam Flow Modeling Program.

Dashed contour lines are estimated through vegetation.

IMPACTED AREAS IN ACRES

Sedimentation zone

Upper Barrier = 1.2
Stream Channel = 1.3
Mixed Seepwillow/Burrobrush = 3.2
Velvet Mesquite = .009

Lower Barrier = 1.1
Stream Channel = .71
Mixed Seepwillow/Burrobrush = 3.3
Velvet Mesquite = .18
Mixed Riparian = .007
Mixed Mesquite = 0.2

Sonoran Desert Scrub

Upper Barrier = .02
Lower Barrier = .01
Upper Construction work site = .002
Middle Construction work site = .0005

Construction Zones

Upper Barrier = 0.3
Lower Barrier = 0.1
Upper Construction work site = 0.3
Middle Construction work site = 0.5
Lower Construction work site = 0.2

Mixed Seepwillow/Burrobrush

Upper Barrier = 0.5
Lower Barrier = 0.9
Upper Construction work site = 0.8
Middle Construction work site = 1.6
Lower Construction work site = 1.0

Velvet Mesquite

Lower Barrier = .05
Middle Construction work site = .007
Lower Construction work site = .006

Mixed Riparian

Upper Barrier = .02
Middle Construction work site = .006

Total area = 0.1

Mixed Mesquite

Total area = .04

Upper Construction Access Road

Mixed Seepwillow/Burrobrush = .04
Velvet Mesquite = 0.2
Sonoran Desert Scrub = .01

Lower Construction Access Road

Total area = 2.1

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TUCSON DIVISION - ARIZONA

ARAVAIPA CREEK
FISH BARRIERS
VEGETATION MAPPING

DESIGNED _____ TECH. APPR. _____
DRAWN RONALD DONWAY SUBMITTED _____
CHECKED _____ APPROVED _____

CADD SYSTEM	CADD FILENAME	DATE AND TIME PLOTTED
AutoCAD Rel. 14.0 PHOENIX, ARIZONA	344330188600.DWG JUNE 1, 1998	SEPTEMBER 29, 1998 10:30

344-330-18860

The Sonoran Riparian Scrubland community has adapted to the successional situations that occur in the flood-prone areas they inhabit (Brown 1982). Vegetation typical of this community type consists of seepwillow, desert broom (*B. sarothroides*), arrowweed (*Pluchea* sp.), as well as more upland species such as lycium (*Lycium* sp.), acacia (*Acacia* sp.) and desert hackberry (*Celtis pallida*).

This portion of the river channel is predominantly seepwillow and burrobrush adjacent to the stream channel. Although not the dominant vegetation community in the project area, it is the major habitat type impacted by the project.

The Sonoran Interior Strand community is subject to greater scouring than the Sonoran Riparian Scrubland. This habitat consists primarily of open stands of shrubs and weeds such as seepwillow, tree tobacco (*Nicotiana glauca*), and nightshade (*Solanum* sp.). Some areas subject to frequent scour may only be populated with algae (Brown 1982).

In the project area, nearly one-half of the riverine channel consists of this open community. The vegetation consists primarily of seepwillow, burrobrush, bermuda (*Cynodon dactylon*), and Mediterranean grass (*Schismus barbatus*).

The paloverde, cacti-mixed scrub community occurs on the uplands and bajadas surrounding the river corridor. Plants are mainly comprised of small-leaved desert trees, shrubs, and numerous cacti. The primary plant species in this community type include foothill paloverde (*Cercidium microphyllum*), saguaro (*Cerceus giganteus*), ocotillo (*Fouqueria splendens*), barrel cactus (*Ferocactus* sp.), brittlebush (*Encelia farinosa*), triangle-leaf bursage (*Ambrosia deltoidea*), and various cholla (*Opuntia*) species.

The project area outside of the immediate river corridor is surrounded by this community type. All the representative vegetative species are present. The "hills" along the south side of the river are more sparsely vegetated with littleleaf paloverde and acacia, while the gently sloping north side has an abundance of saguaro, mesquite, and paloverde trees.

2. Wildlife - Riparian habitat supports 60 to 75 percent of Arizona's resident wildlife (Arizona Riparian Council 1994). In recent years, riparian areas have been recognized as critical habitat for neotropical migrants such as summer tanager, Bell's vireo, yellow warbler, and yellow-billed cuckoo. Small mammals such as woodrats, skunks, and bats, as well as large mammals such as coyotes, utilize riparian areas. They are also home to a diverse array of reptiles and amphibians.

Wildlife use of riparian habitat is disproportionate to the amount of habitat available (Ohmart and Anderson 1986). In other words, although 60 - 75 percent of Arizona's resident wildlife are dependent on riparian habitats, riparian areas occupy less than 0.5 percent of the State's total land area (Arizona Riparian Council 1994).

Although the few mammal species are not distinctive, riparian habitats have greater species richness (number of species) and total small mammal biomass than upland sites (Stamp and Ohmart 1979 *in* Ohmart and Anderson 1986). The same is probably true for herpetofauna; however, there are no indepth, long-term data from riparian ecosystems to substantiate this (Ohmart and Anderson 1986). On the other hand there has been considerable information generated on avian use of riparian habitat. Numerous studies have described the strong correlation between bird species diversity and vegetation structure and density (MacArthur and MacArthur 1961, Anderson and Ohmart 1977, and Anderson et al. 1983). Healthy mature stands of cottonwood-willow vegetation provide one of the most structurally diverse habitats in the Sonoran desert (Arizona Riparian Council 1994, Rosenberg et al. 1991).

No specific wildlife inventories were conducted (outside of threatened and endangered species surveys) in the project area. Consequently the following information is taken from literature reviews of similar habitat types. This section describes the wildlife species that typically occur within the different vegetative communities. Due to the degraded habitat quality and linear, disjunct distribution of habitat in the project area, species richness and species abundance (total number of individuals) is reduced when compared to higher quality habitats. Consequently, not all the species listed may be present in the area.

The mobility of birds and mammals in conjunction with the interspersion of habitat types results in overlap of species among habitat types. Although not restricted to the community type within which they are described, the following wildlife species are primarily dependent upon that community type for breeding purposes. For a list of wildlife species in Aravaipa Creek see Appendix C.

The Sonoran Riparian Deciduous Woodlands - The mixed riparian, mixed mesquite and mesquite habitat support a wide variety of neotropical migrants (small "perching" birds that winter in central and South America) such as yellow and Lucy's warbler, summer tanager, Bell's vireo, and yellow-billed cuckoo. Other avian species include white-winged dove, Vermillion flycatcher, cardinal, Abert's towhee, Cooper's hawk, great blue heron, Bewick's wren, and verdin. Although birds make up a more visible part of the community, this habitat type is home to many species of mammals, reptiles, and amphibians.

Large mammals such as javelina, coyote, and bobcat use riparian habitat as a movement corridors. The diversity of wildlife species is directly correlated to the complexity of vegetation structure. Consequently, the riparian habitat would have greater species diversity. Small mammals include several bat species (red, hoary, and pallid bats) as well as various rats and mice: white-throated woodrat, Arizona cotton rat, cactus mouse, desert pocket mouse, and western harvest mouse. Herpetofauna include common kingsnake, desert spiny lizard, tree lizard, and western whiptail lizards.

The Sonoran Riparian Scrubland - The close proximity of the seepwillow/burrobrush habitat to "riparian" habitat allows the movement of wildlife species between habitat types. Species diversity within this habitat type would be substantially different if riparian habitat was absent. Common birds include Gambel's quail, mourning dove, white-winged dove, Abert's towhee, Say's Phoebe, and black-tailed gnatcatcher. Common mammals include coyote, bobcat, desert cottontail, cactus mouse, deer mouse, white-throated wood rat, and western harvest mouse. Herpetofauna include zebra-tailed lizard, common kingsnake, gopher snake, western whiptail lizard, and western diamondback rattlesnake.

The Sonoran Interior Strand - Because this area is more open and provides little cover, it is utilized by species which prefer open, sparsely vegetated areas. Some common avian examples include killdeer and water pipit. Habitat is limited for small mammals and herpetofauna, although the lesser earless lizard (*Holbrookia maculata*) utilizes this habitat and was seen during field visits.

Paloverde, cacti-mixed scrub - The paloverde, cacti-mixed scrub community has the richest diversity of wildlife compared to other Sonoron Desertscrub communities. Wildlife species typical of the paloverde, cacti-mixed scrub habitat include common birds such as Harris hawk, roadrunner, mourning dove, verdin, cactus wren, black-tailed gnatcatcher, phainopepla, Gambel's quail, Costa's hummingbird, brown towhee, gilded flicker, and Gila woodpecker.

Common mammals include the California leaf-nosed bat, coyote, black-tailed jackrabbit, desert cottontail, Merriams's kangaroo rat, white-throated wood rat, round-tailed ground squirrel, and cactus mouse. Common reptiles include the desert spiny lizard, patch-nosed snake, glossy snake, western diamondback, desert tortoise, Gila monster, lesser earless lizard, and side-blotched lizard. Common amphibians include the Sonora toad, Great Plains toad, Couch's spadefoot toad, and western spadefoot toad.

Aquatic Resources

1. Physical Environment

Monthly mean discharges for Aravaipa Creek measured approximately 0.5 mile upstream of the project area range from an annual low of 12 cfs in June to a high of 67 cfs in February. The largest flow recorded was 70,800 cfs, on October 1, 1983.

During floods, complex interactions among stream discharge, sediment load, sediment size, local geomorphology, and other factors determine how sediments are transported, sorted, and deposited to form aquatic habitats. Except in areas where bedrock may form the stream bottom, aquatic habitats may be completely destroyed and reformed during a flood event, and are thus highly dynamic. In 1976, lower Aravaipa Canyon (upstream from the project area) was approximately 88 percent riffles and rapids (areas of water column with fast current velocity and steep gradient, considerable surface turbulence, often with large substrates) and 12 percent pools (area of water column with low current velocity and near-zero surface gradient and little or no surface turbulence, often with small substrates) (Minckley 1981). Reclamation is unaware of more recent data that quantitatively describe aquatic habitat conditions in the lower reach of Aravaipa Creek.

The stream reach within the project area contains aquatic features regulated by the U.S. Army Corps of Engineers (COE) under the CWA. Approximately 6.3 acres of habitat are COE-delineated jurisdictional waters of the United States. The majority of jurisdictional area consists of open channel habitat (described previously under terrestrial resources) and open water habitat. Open water habitat can be described as riffles, pools or runs. The percentage of each type depends on the physical characteristics of the stream such as slope, substrate size, and sediment load among other factors.

Pools within the project area are small and shallow in depth because of the gentle slope and heavy sediment load of the stream. Riffles are relatively indistinct, have a flat gradient, and consist of variable substrate size. The existing stream bed gradient is too flat to allow development of classically-defined rifle-pool complexes. This lowered quality of instream habitats is demonstrated by the sparsity of special status fish species in the project area.

2. Reptiles and Amphibians

Aquatic habitats of Aravaipa Creek may support several aquatic and semi-aquatic reptile and amphibian species, including the Federal candidate Chiricahua leopard frog (*Rana chiricahuensis*), State-listed species Mexican garter snake (*Thamnophis equis*) and lowland leopard frog (*Rana yavapaiensis*), along with the canyon tree frog (*Hyla arenicolor*), several species of true (*Bufo* spp.) and spadefoot (*Scaphiopus* spp.) toads,

Sonoran mud turtle (*Kinosternon sonoriense*), and other species of garter snake (*Thamnophis* spp.). Bullfrog (*Rana catesbeiana*) is the most successful nonnative amphibian in Arizona. Previous studies have not thoroughly examined the potential distribution of these species within the Aravaipa Creek drainage system.

All amphibian species are tied to the aquatic environment for reproduction and rearing of gill-breathing larvae. Following transformation from larvae, most amphibians develop lungs to breathe air. Thus, eggs and larvae of all of the amphibians listed above may be found in Aravaipa Creek, but some post-larval amphibians are also highly aquatic (e.g., leopard frogs). Conversely, most reptile reproduction occurs on land, and breathing is with lungs. Sonoran mud turtle is the most highly aquatic reptile on this list, where adults are nearly exclusively found in water. Mexican garter snake is usually found within 50 feet of water (Rosen and Schwalbe 1988).

3. Fishes

A considerable amount of monitoring and research has been directed toward the fishes of Aravaipa Creek, beginning in the 1960s and continuing today (Barber and Minckley 1966, 1983, Barber et al. 1970, Minckley and Barber 1971, Siebert 1980, Minckley 1981, Schrieber and Minckley 1981, Kepner 1982, Clarkson and Minckley 1988, Rinne 1989, 1991, 1992, Vives and Minckley 1990, Williams 1991, Douglas et al. 1994, Velasco 1997). The stream supports seven native species, including two threatened forms, loach minnow (*Tiaroga cobitis*), and spikedace (*Meda fulgida*) (both monotypic genera), and a State-listed species, roundtail chub (*Gila robusta*). These species, along with longfin dace (*Agosia chrysogaster*), and speckled dace (*Rhinichthys osculus*), are members of the Family Cyprinidae (minnows). The other two species, desert sucker (*Pantosteus clarki*), and Sonora sucker (*Catostomus insignis*), are members of the Family Catostomidae (suckers).

Introduced species that permanently reside in or periodically invade Aravaipa Creek include green sunfish (*Lepomis cyanellus*), yellow bullhead (*Ameiurus natalis*), mosquitofish (*Gambusia affinis*), largemouth bass (*Micropterus salmoides*), common carp (*Cyprinus carpio*), fathead minnow (*Pimephales promelas*), and red shiner (*Cyprinella lutrensis*) (Bettaso et al 1995). A single specimen of black bullhead (*Ameiurus melas*) was taken from the lower stream in 1990 (W.L. Minckley, unpublished data). Another nonnative species collected from the lower San Pedro River but never taken from Aravaipa Creek is channel catfish (*Ictalurus punctatus*).

Only yellow bullhead and green sunfish have been consistently collected from the stream since monitoring began in 1963 (W.L. Minckley, unpublished data; Bettaso et al. 1995). The other species started appearing in collections beginning in the early 1980s (a single largemouth bass was also taken in 1963), and most are now routinely encountered in the creek below the project area. Red shiner, a species of considerable concern because of its documented negative effects on populations of spikedace and other native species (Minckley and Deacon 1968, Abarca 1989, Marsh et al. 1990, Rinne 1991, Douglas et al. 1994), first appeared in Aravaipa Creek in 1990. It disappeared in 1991 following an Aravaipa Creek flood that exceeded 3000 cfs, but reappeared in 1997 following a long period of flow stability (Clarkson 1998).

Special Status Species

The FWS utilizes a county-wide list (Table 3) to indicate listed species in a project area, consequently the majority of species do not actually occur in the project area. There is no suitable habitat in the project area for the following species: Arizona hedgehog cactus, Nichol's turk's head cactus, desert pupfish, Gila topminnow, razorback sucker, bald eagle, Mexican spotted owl, southwestern willow flycatcher, Yuma clapper rail and Acuna cactus. The AGFD has designated 17 species of wildlife of special concern in Arizona, which have been included in Table 3 (1996a).

Table 3. Federally-listed species for Pinal County, and State of Arizona wildlife of special concern.

LIST OF SPECIAL STATUS SPECIES		
STATUS	SPECIES	PRESENCE IN PROJECT AREA
E	Arizona hedgehog cactus *(Echinocereus triglochidiatus arizonicus)*	-
E	Nichol's turk's head cactus *(Echinocereus horizonthalonius* var. *nicholii)*	-
E,S	Lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*)	+
E,S	Desert pupfish *(Cyprinodon macularius)*	-
E,S	Gila topminnow (*Poeciliopsis occidentalis occidentalis)*	-
T,S	Loach minnow *(Tiaroga cobitis)*	+
E,S	Razorback sucker *(Xyrauchen texanus)*	-
T,S	Spikedace (*Meda fulgida*)	+

LIST OF SPECIAL STATUS SPECIES		
STATUS	SPECIES	PRESENCE IN PROJECT AREA
E	American peregrine falcon (*Falco peregrinus anatum*)	+
T,S	Bald eagle (*Haliaeetus leucocephalus*)	-
E,S	Cactus ferruginous pygmy-owl *(Glaucidium brasilianum cactorum)*	-
T	Mexican spotted owl (*Strix occidentalis lucida)*	-
E,S	Southwestern willow flycatcher (*Empidonax traillii extimus*)	-
E	Yuma clapper rail (*Rallus longirostris yumanensis*)	-
C	Acuna cactus (*Echinomastus erectocentrus acunensis*)	-
C,S	Chiricahua leopard frog (*Rana chiricahuensis*)	?
S	Mexican garter snake (*Thamnophis eques*)	?
S	Lowland leopard frog (*Rana yavapaiensis)*	?
S	Roundtail chub (*Gila robusta)*	+
S	Western red bat (*Lasiurus borealis)*	?
S	Greater western mastiff bat (*Eumops perotis*)	-
S	Townsends' big-eared bat (*Plecotis townsendii*)	-
S	Mesquite mouse (*Peromyscus merriami)*	-
S	Western yellow-billed cuckoo (*Coccyzus americanus occidentalis*)	-
S	Desert tortoise (*Gopherus agassizii*)	-

E=Endangered; T=Threatened; C=Candidate; S=Wildlife of special concern in the State of Arizona; -=Absent; +=Present; ?=Undetermined

Specific descriptions of special status species and known occurrences are found in Appendix D.

2. Environmental Consequences

The information presented in Tables 4 and 5 was derived from a GIS based cover map of the project area. Construction zones were overlaid onto the habitat map and the areas of impact digitized and quantified. The areas of impact represent maximum disturbance estimates.

a. Fish Barrier Sites

Terrestrial Habitat - Less than 2 acres of habitat would be permanently altered (Table 4) as a result of barrier emplacement. Approximately 1.51 acres of terrestrial habitat, predominately (93 percent) seepwillow and burrobrush, would be lost. Approximately 0.08 acre of terrestrial habitat would be impacted consisting of a mosaic of riparian species (mesquite, desert hackberry, Fremont cottonwood, Gooding willow, Arizona ash, netleaf hackberry, soapberry, and Arizona walnut). The remaining 0.03 acre consists of Sonoran desertscrub habitat. Impacts to "riparian" habitat would be limited due to the small acreage involved, and linear nature of the habitat.

The remaining 0.3 acre consists of open water habitat which will be described in the wildlife section.

Table 4. Permanent habitat impacts (acres by vegetation type) from construction of Aravaipa Creek fish barriers.

FEATURE	TOTAL IMPACT							
	TOTAL ACRES	OPEN WATER	TERRESTRIAL					
			TOTAL	seep/ burro	mes-quite	mixed riparian	mixed mes-quite	sonoran desert scrub
FISH BARRIERS	1.81	0.30	1.51	1.4	0.06	0.02	0.0	0.03
TOTAL ACRES IMPACTED	1.81	0.30	1.51	1.4	0.06	0.02	0.0	0.03

Table 5. Temporary (long/short term) habitat impacts (acres) (by vegetation type) from construction of Aravaipa Creek fish barriers.

FEATURE	TOTAL IMPACT							
	TOTAL ACRES	OPEN WATER	TERRESTRIAL					
			TOTAL	seep/ burro	mes-quite	mixed riparian	mixed mesquite	sonoran desert scrub
CONTRACTOR USE AREA B	2.10	0.00	2.10	0.00	0.00	0.00	0.00	2.10
ACCESS ROADS (Total does not include 0.16 ac of existing road)	0.30	0.00	0.30	0.05	0.20	0.00	0.04	0.01
CONSTRUCTION ZONES (exclusive of sedimentation zone)	1.30	0.20	1.10	1.08	0.01	0.010	0.00	0.002
SEDIMENTATION ZONE (exclusive of barrier overlap)	7.51	2.01	5.50	5.10	0.19	0.007	0.20	0.00
TOTAL ACRES IMPACTED	11.21	2.21	9.00	6.23	0.4	0.017	0.24	2.11

Wildlife - Due to the limited area required for placement of the barriers, minimal impacts to wildlife would occur. The barrier placement would result in minor loss of small mammal and herpetofaunal (reptile and amphibian) habitat.

Aquatic Habitat - Approximately 0.3 acre of aquatic habitat would be permanently altered by the fish barriers (Table 4). In Aravaipa Creek, the concrete fish barriers would behave as bedrock during 100-year or more-frequent floods, and the habitats they form would become highly stabilized. At lower flows, fishes and most other aquatic animals would be excluded from the shallow, swift-flowing habitats formed over the concrete aprons. Barrier faces would become waterfalls that are also unavailable to fishes and most other macroorganisms. The crests of the barriers likely would be used by species that are tolerant of swift water such as filter-feeding black fly larvae, and many forms of algae. Movements of aquatic organisms upstream past the barriers would become difficult or impossible.

There would be negligible effects to the functions and values of riffle and pool complexes resulting from the lessening of local stream slope. Classic riffle-pool complexes (which provide higher quality macroinvertebrate and fish habitat) do not exist within the project reach. The riffles in the project area consist of variable-sized substrate and extremely shallow water depths. Riffle habitat favored by the threatened loach minnow (a riffle obligate species present upstream of the project area) is composed of very uniform cobble-sized substrate. The formation of uniform cobbles within a riffle is slope dependent, meaning that the steeper slope helps to sort the substrate. The slight gradient in the project reach is insufficient to permit proper sorting of substrate. In fact, the difference in stream velocity between riffle and non-riffle areas is barely discernable within the project reach. This reach of the stream is not likely to develop high quality riffle-pool complexes due to the low gradient.

Special Status Species - No impacts to terrestrial special status species would occur from barrier placement. For aquatic species, placement of fish barriers would result in the genetic isolation of spikedace, loach minnow, and roundtail chub populations upstream of the barrier from those downstream. The length of perennial stream below the barriers lost in this manner represents only a very small percentage of the total length of the perennial waters of Aravaipa Creek. No genetic effects to the much larger upstream populations are anticipated.

In addition, habitats in the project area appear suboptimal for these species, as evidenced by their preference for upstream areas (Minckley 1981) (Bettaso, et al. 1995). For example, surveys conducted near the proposed fish barrier sites by the AGFD during 1992-1994 showed that median relative abundances of spikedace, loach minnow, and roundtail chub did not exceed 1 percent (Bettaso et al. 1995). Further, long-term (1963-1997) fish survey data from Aravaipa Creek (W.L. Minckley, Arizona State University, unpublished data) show that the presence and abundance of spikedace, loach minnow, and roundtail chub in the lower (western) reach is highly variable (Figure 3-8). When relative abundance of these species exceeds 4.5 - 5.0 percent of the total fish population in the lower reach, it is likely that some or all will be present in the vicinity of the proposed fish barriers. For loach minnow, this occurred four times in 32 years of sampling (12.5 percent of sampling years), and for spikedace, 12 times (37.5 percent). Roundtail chub relative abundance never exceeded 4.5 percent in the lower reach, and their occurrence near the project area sporadically consists of a few young-of-year individuals. Data for spikedace are strongly influenced by a surge in its relative abundance between 1983 and 1990. There is no doubt that substantial numbers of spikedace would pass over the fish barriers and be lost to the system during periods of such high abundance; numbers of loach minnow and roundtail chub would be substantially less. When the species are relatively abundant, however, such losses would have no influence on upstream populations of Aravaipa Creek, since evidence exists that the lowermost segments of the population are lost when portions of the stream naturally become isolated and dry up, or become too warm for the species to survive (W.L. Minckley, Arizona State University, personal communication).

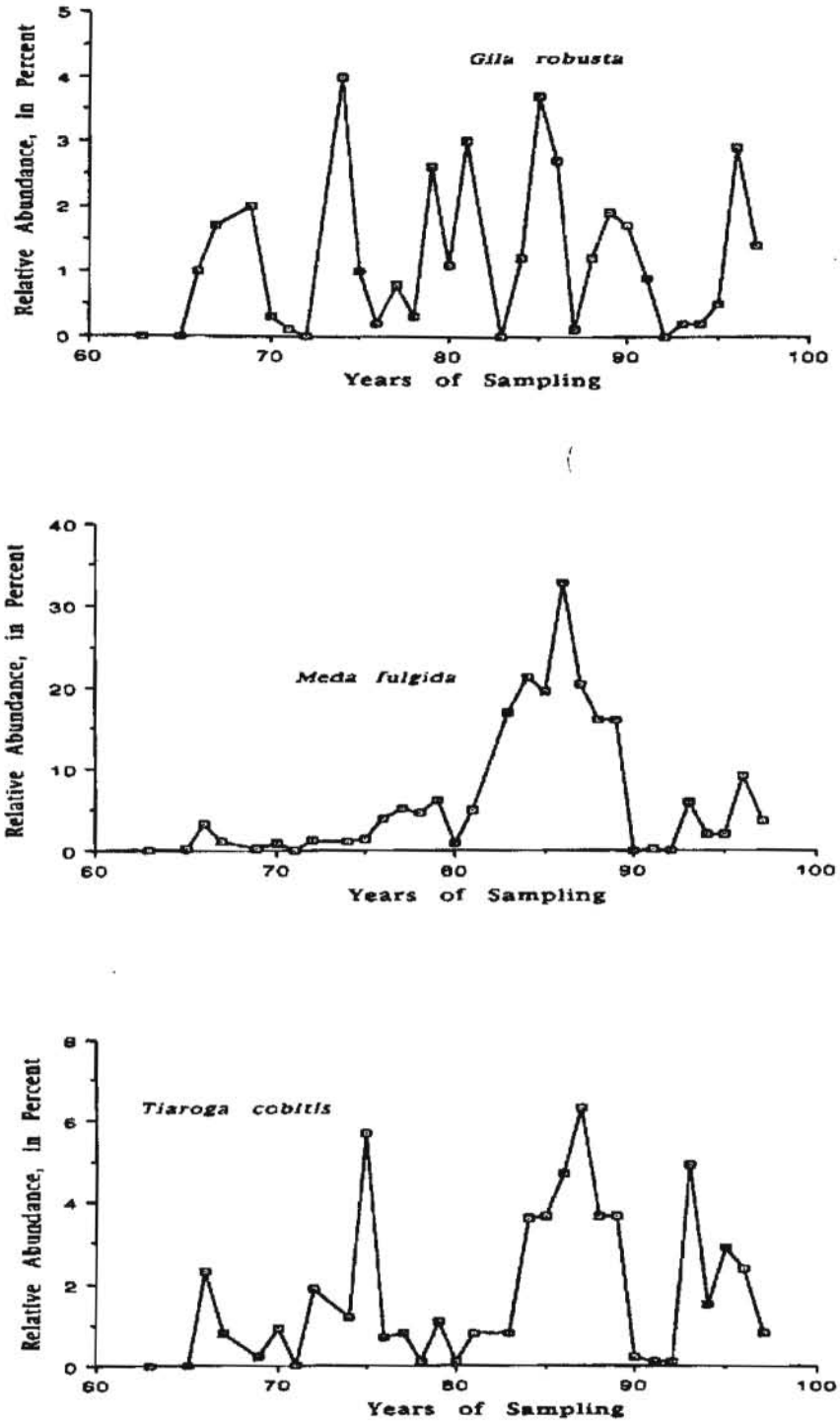

FIGURE 3-8. Relative abundance (percent) of roundtail chub (*Gila robusta*), spikedace (*Meda fulgida*), and loach minnow (*Tiaroga cobitis*) in the lower (western) segment of Aravaipa Creek, Pinal County, Arizona, 1963-1997. all sampling stations combined. Note the differences in the scale of the vertical axis.

Placement of fish barriers on Aravaipa Creek would also result in genetic isolation of the upstream populations from others in the greater Gila River basin. Over an extended period of time (perhaps hundreds or thousands of years), such isolation could result in decreased genetic variability and loss of rare alleles of Aravaipa Creek populations, and thus possibly decrease their ability to adapt to changing environments. Fragmentation of native fish populations, however, is already so extensive due to water development, presence of nonnative predators, climatic trends, and other factors, that gene flow among isolated stocks already is unlikely. The immediate protection afforded the populations by fish barriers far outweigh possible long-term genetic effects. The high probability of near-term loss of Aravaipa Creek fishes to alien competitors and predators in the absence of fish barriers further outweighs these considerations. If nonnative fishes are not brought under control in the near-term, the prognosis for persistence of native fishes, except perhaps in rare refugia, is bleak.

Downstream drift of larva of spikedace, loach minnow, and roundtail chub past the barriers would result in some losses to upstream populations, as they would be unable to move back upstream past the barriers once below. Distances drifted by spikedace, loach minnow, and roundtail chub larvae, or for that matter virtually any other native fish species, have not been determined, but two lines of evidence suggest that drift losses over the fish barriers would be negligible under the proposed project. First, drift of larval stages of these species has not been shown to be a significant feature of their life histories, and most drift that occurs is during daylight when drift distances are short (Bestgen et al. 1985). Second, spikedace, loach minnow, and roundtail chub adults only sporadically occur near the project area, and little reproduction in the lower reach is expected. Therefore, unless drift transport distances are relatively long (several kilometers or more), large losses from this avenue are not expected.

Downstream transport of older life stages of fishes during flood or by other avenues of dispersal would also result in some losses of fishes below the barriers, although native fishes in general are adapted to avoid the worst hydraulic conditions of flood events and resist downstream transport (Minckley and Meffe 1987). However, entire year classes of native fishes can be destroyed from floods that occur during larval rearing periods (Robinson et al. In press.). For reasons similar to those explained for genetic isolation impacts (above), losses of spikedace, loach minnow, and roundtail chub from flood transport are expected to be minimal and of no significance to upstream populations.

As with early life stages of native fishes, the passage of ill-timed floods that occur during larval development of Chiricahua and lowland leopard frog has the potential to decimate a given year's cohort. Such effects would occur with or without the presence of fish barriers, however. In the absence of flooding during larval development, downstream losses of larvae of Chiricahua and lowland leopard frogs over the barriers should be minor, since sites of oviposition and larval rearing are in areas of slack water with relatively little potential for entrainment in currents that could transport larvae downstream. Significant downstream drift of amphibian larvae in streams has not been noted in the literature.

No substantial impacts to later life stages (juvenile and adult metamorphs) of Chiricahua and lowland leopard frogs are expected from emplacement of fish barriers. Fish barriers should not be a complete barrier to upstream movements by terrestrially-mobile adult frogs, nor to Mexican garter snake, although movements would be hindered.

Benefits - The barriers are expected to have positive benefits to spikedace, loach minnow, roundtail chub, and other native fish populations by preventing or hindering upstream invasions of nonnative fishes and other undesirable aquatic organisms into the upper reaches of Aravaipa Creek. If Chiricahua and lowland leopard frogs persist in the area, these effects should also benefit their populations, in that they have also been shown to be negatively impacted by presence of nonnative fishes (Rosen et al. 1995). A similar benefit resulting from control of nonnative organisms should accrue to populations of Mexican garter snake (Rosen and Schwalbe 1988).

b. Bank Protection

Minor habitat loss would result from the placement of bank protection (rip-rap/concrete or gabion) upstream and downstream from each barrier. However, initial assessment indicates that bank protection may not be necessary on the south side tie-in for the upper barrier due to competency of the rock. Estimates indicate that approximately 0.30 acre of seepwillow/burrobrush, mesquite, and Sonoran desertscrub habitat would be affected. Appropriate mitigation would be included when effects are quantified during final design.

c. Temporary (Long/Short Term) Impacts

1. Alternative Contractor Use Area A

Terrestrial Habitat - This alternative use area is located east of the upper barrier between the Aravaipa Road and the creek (Figure 2-3). The habitat consists of a remnant mature mesquite bosque that has been heavily impacted by existing trails, grazing, and recreational use. Cattle utilize this area primarily for shade on a frequent basis. Numerous small mesquite bosques are located throughout Aravaipa canyon on BLM and The Nature Conservancy properties, but few bosques remain outside of these protected areas.

Although there is very little ground cover and few shrubs, development of the staging area of this habitat would result in substantial pruning of trees to provide adequate vehicular clearance as well as removal of some mature mesquite trees. It is anticipated that most of the pruned trees would survive.

Wildlife - Use of this area would result in disturbance to avian, small mammal, and herpetofaunal species. The Lucy warbler in particular prefers the mesquite habitat (Brandt 1951, Terres 1991, and Johnson et al. 1997). Other species which utilize mesquite include: Bewick's wren, Bell's vireo, northern cardinal, and yellow-breasted chat. Use of this area would result in temporary loss of 2.1 acres of small mammal and hepetofaunal habitat. Impacts to large mammals would be minimal.

Aquatic Habitat - No impacts would occur to aquatic habitat.

Special Status Species - No impacts would occur to special status species.

2. Alternative Contractor Use Area B (Preferred Site)

Terrestrial Habitat - A total of 2.10 acres of Sonoran desertscrub habitat would be disturbed for construction staging (Table 5). This site is located atop a small knoll overlooking the project area. A portion of the area has been previously disturbed, and the staging area would be centered around this location, but would extend into previously undisturbed habitat.

Wildlife - Use of the staging area would result in the temporary disturbance and/or loss to small mammal and herpetofaunal species.

Aquatic Habitat - No aquatic habitat would be impacted.

Special Status Species - No special status species would be impacted.

3. Alternative Contractor Use Area C

Terrestrial Habitat - Use of this alternate site would impact approximately 2.1 acres of mixed mesquite habitat. This site is located immediately west of the lower barrier location between Aravaipa Road and Aravaipa Creek. Habitat is generally dense with a mixture of mesquite, burrobrush, acacia, little-leaf paloverde, and desert hackberry vegetation. The mesquite ranges from scrubby trees less than 7 feet high to mature bosque type trees. The dense vegetation would require nearly complete removal of all vegetation to accommodate the staging activities. Both long and short term impacts would occur. The short term impacts would result from loss of shrubs and grasses which would recover fairly rapidly, but impacts to mature trees would require a greater length of time to restore lost values.

Wildlife - The dense vegetation supports a wider variety of wildlife than found in the upland desertscrub habitat. Clearance of vegetation would result in temporary loss of habitat for nesting birds, small mammals, and herpetofaunal species. Temporary noise disturbances from use of the area would be minimal. Impacts to large mammals would be minimal and mainly amount to noise disturbance.

Aquatic Habitat - No impacts would occur to aquatic habitat.

Special Status Species - No special status species would be impacted.

4. Construction Zones

Terrestrial Habitat - Use of construction zones would result in temporary impacts to a total of 1.3 acres of habitat (Table 5). Ninety-eight percent of these impacts would occur in the seepwillow/burrobrush habitat type. Only 0.01 acre each of mesquite and mixed riparian habitat, along with 0.002 acre of Sonoran desertscrub habitat, would be impacted. The majority of seepwillow/burrobrush habitat is distributed along the center of the river corridor and subjected to loss during flooding. Approximately 85 percent of this habitat was lost during 1993 flood events and has since reestablished. It is expected that upon completion of the construction activities this habitat would quickly reestablish with similar vegetation species and densities. In addition, a portion of the construction zones upstream of each barrier coincides with the impact area for the sedimentation zones (Figure 3-7) which will be described below.

Approximately 0.2 acre of open water habitat would be impacted (impacts will be described under aquatic section below.)

Wildlife - This portion of the river receives minimal use by wildlife species due to the frequency with which it is inundated. Avian use is sporadic, with limited nesting potential outside of killdeer and seasonal use by shorebirds. Likewise, mammalian use is limited, increasing in direct proportion to the distance from main channel (or frequently inundated area). Herpetofaunal use represents the primary terrestrial wildlife value in this habitat type. Use of this area for construction would result in a temporary loss of use for wildlife species. It is expected that vegetation (and, therefore, wildlife habitat) would begin to reestablish upon completion of construction until the next flood event eliminated it.

Aquatic Habitat - Impacts to aquatic habitat from construction zones would be overshadowed by the impacts from the sedimentation zone (with the exception of the area downstream of the lower barrier site). Impacts below the downstream barrier are expected to be minimal. Construction traffic would predominately operate on the gravel bars and habitat adjacent to the stream (with the exception of a single creek crossing site).

Special Status Species - If present in the area during construction activities, some individuals of spikedace, loach minnow, and roundtail chub might be killed when heavy equipment moves across or through the streambed. Such losses are expected to be minor. The 1994 biological opinion on the transportation and delivery of CAP water included "take" provisions for activities necessary to implement reasonable and prudent alternatives, such as the fish barrier project.

5. Access Roads

Terrestrial Habitat - Access to both the upper and lower barrier locations would utilize existing roads to the maximum extent practicable. The 0.30 acre of impact displayed in Table 5, represents the entire access area, of which almost one-half is occupied by existing roads. Impacts from construction of the lower access road would result primarily from widening of the road. Minor tree trimming on a mesquite and removal of several small desert hackberry shrubs would occur. Access to the upper barrier location would occur through the western portion of the mesquite bosque. This portion of the bosque is more open, and less vegetation clearing would be required to access the barrier site. Access would follow the existing road and then veer toward the creek through the seepwillow/burrobrush habitat. Branch removal/trimming would be required on several mature mesquite trees. Two small mesquite trees would be removed near the entrance off the county road. Complete clearance would be required for approximately 20 feet through desert hackberry, seepwillow, and burrobrush.

Wildlife - Due to the disturbed nature of the areas utilized for access, minimal impacts to wildlife species would occur

Aquatic Habitat - No impacts would occur to aquatic habitat.

Special Status Species -No impacts would occur to special status species.

6. Sedimentation Zones

Terrestrial Habitat - The majority of terrestrial habitat loss would result from the accumulation of sediment behind each barrier. Sedimentation would eliminate the development of certain instream habitats immediately upstream of the barriers.

Vegetation in the sedimentation zone is primarily (93 percent) composed of seepwillow/burrobrush habitat (Table 5). The majority of seepwillow/burrobrush habitat is located in the center of the river channel and subjected to repeated loss from flooding. Approximately 85 percent of this habitat was lost during the 1993 flood events (13,000 cfs peak flow). It is expected that upon completion of the construction activities, this habitat would reestablish with similar vegetation mimicking a regenerative process which is repeated after every flood event.

The remaining 0.40 acre of terrestrial habitat occurs in mesquite, mixed mesquite, and mixed riparian habitat. Since these areas are generally located on terraces adjacent to the channel bottom, the sedimentation impacts would be minimal. It is expected that 6 inches or less of sediment would be deposited in these habitat types, resulting in no adverse impacts.

Wildlife - This portion of the river receives minimal use by wildlife species due to the frequency of inundation and lack of cover. Avian use is sporadic, with limited nesting potential outside of killdeer and seasonal use by shorebirds. Likewise, mammalian use is limited, increasing in direct proportion to the distance from main channel (or frequently inundated area). Herpetofaunal use represents the primary terrestrial wildlife value in this habitat type. Upon completion of the barriers, this habitat would be partially inundated, forming a temporary pool that would eventually be filled with sediment. Following stabilization of the sediment zone, it is anticipated that a channel similar to preconstruction activities would become established.

The wildlife values within the sedimentation zone would change over time from the current seepwillow/burrobrush habitat to an open pool. The open pool habitat would eventually be completely filled in with sediment at which time seepwillow/burrobrush habitat would begin to reestablish. The seepwillow/burrobrush community is common along Aravaipa Creek. Loss of 5.6 acres of habitat of which nearly 50 percent is less than 3 feet high would not adversely impact wildlife in the area. There would be a short term loss of function/values between the complete sedimentation phase and the reestablishment of the habitat.

Aquatic Habitat - Instream habitats in the sedimentation zones would be altered primarily as a result of lessening of the local stream gradient. Thus, certain habitat types, such as steep-gradient riffles and rapids, would be less likely to form after construction of the barriers and resulting sedimentation. Decreases in mean sediment size, and

increases in channel sinuosity and braiding, are other possible effects associated with lower gradient. Small, shallow scour pools may form at the downstream ends of the aprons. Approximately 2.01 acres of impact would occur in the open water habitat.

At high (flood) discharges, swift current velocities and high sediment loads render most main-channel habitats largely unsuitable for aquatic organisms, which either move to lateral habitats to avoid some of the flood effects, or become entrained in the flood and either perish or get flushed downstream (Minckley and Meffe 1987). This fact would remain equally true with the presence of fish barriers.

Special Status Species - No impacts to terrestrial special status species would occur. Spikedace, loach minnow, and roundtail chub have very specific habitat preferences (flowing pools over fine substrates; shallow, well-defined riffles; and deep pools with cover, respectively), and they do not reliably inhabit the project area because of a lack of these habitats. Lessening of stream gradient in the sedimentation zones would perhaps make it less likely that habitats important for these species would ever form. These potential impacts are considered minor, however, relative to the length of unimpacted stream above the sedimentation zone.

No negative impacts to Chircahua leopard frog, lowland leopard frog, or Mexican garter snake are anticipated in the sedimentation zones.

7. Flood Inundation Effects

In addition to construction features, impacts were analyzed comparing the difference in inundation zones with and without the barriers for the following flood frequencies.

5-10 year flood impacts

Terrestrial Habitat - The difference in flood effects from the 5 and 10 year storms is predominately in the length of time low-lying portions of the county road would remain inundated. The affected areas would be limited to bare ground (dirt road), Sonoran desertscrub habitat, and a small portion of the mesquite bosque. The flow velocities would not be great enough to impact the mesquite bosque or Sonoran desertscrub habitat. No adverse impacts to any vegetation would result from the 5 - 10 year flood event.

Wildlife - The difference between impacts to wildlife with or without the barriers is negligible.

Aquatic Habitat - No aquatic habitat would be impacted.

Special Status Species - No special status species would be impacted.

25-year flood impacts

Terrestrial Habitat - Additional effects from the presence of the barriers during the 25-year flood event would be minimal. Small portions of the Sonoran desertscrub habitat would be affected along with a small portion of the road. Visual inspections of the habitat revealed no evidence of scour effects from past flood disturbances. No adverse impacts would occur to habitat.

Wildlife - No additional substantial impacts to wildlife would occur.

Aquatic Habitat - No aquatic habitat would be impacted.

Special Status Species - No special status species would be impacted.

50-100 year flood impacts

Terrestrial Habitat - Additional effects from the barriers during the 50 and 100-year flood events would be nearly undetectable. The flood flows would simply reach a few feet higher up the floodplain. On the south side of Aravaipa Creek, this habitat is a steep wall approximately 25 feet high. Slopes are gentler on the north side of the Creek and the 100-year flood zone would only inundate Sonoran desertscrub habitat. Based on visual inspections of the habitat to ascertain past flood effects, no adverse impacts to the area are expected to occur.

Wildlife - No quantifiable impacts to wildlife would occur.

Aquatic Habitat - No aquatic habitat would be impacted.

Special Status Species - No special status species would be impacted.

8. Nonnative Fishes Management

Fish populations in the stream reach between the fish barriers would be monitored at least annually, and following passage of large floods. Should undesirable nonnative fishes (or other nonnative aquatic organisms) be found in this "fish management zone," they would be aggressively removed to prevent possible transgression of the upper barrier and infestation of upstream reaches. Because this management zone would be only approximately 800 feet in length, attempts at fish removal would first consider traditional fish collection techniques using nets or electrofishing. Small losses of nontarget species (including perhaps loach minnow, spikedace, and roundtail chub) could occur from stresses associated with repeated handling and disturbance. These would be inconsequential to the larger, upstream populations, for reasons similar to those previously discussed.

Should traditional fish capture methods be considered inadequate to remove all individuals of undesirable species, chemical renovation of the management zone using an approved fish toxin would be undertaken. Prior to application of a toxin, as many native fishes as possible that were present in the management zone would first be captured, transported, and released alive above the upper barrier.

The toxin that would most likely be used to remove nonnative fish is sold under the brand name Fintrol®, with the active ingredient antimycin A. Fintrol® carries antimycin A in an acetone base, and the mixture is typically applied in streams in diluted form using multiple drip stations. Fintrol® is toxic only to aquatic animals that breathe with gills and, therefore, is not toxic to humans, domesticated animals, terrestrial wildlife, or plants. It is not a "poison" in the sense of a chemical like cyanide, but is actually an antibiotic produced in cultures of streptomycenes. It inhibits electron transport to cellular oxidative pathways, interfering with the ability of animals with gills to breathe (i.e., to uptake oxygen across a gill membrane). It kills fish rapidly and irreversibly through suffocation. Toxicity to aquatic insects with gill membranes is variable, and effects on amphibian larvae have not been reported.

Fintrol® is widely used and techniques for controlling its application are well worked out. It is applied in very small amounts - the recommended treatment level is 5-25 parts of Fintrol® to each billion parts of water. It deteriorates rapidly in water turbulence, sunlight, and warm temperatures, usually remaining active only for about 1/4 mile of stream. Although natural decay of the Fintrol® would detoxify it a short distance below the point of application, a detoxification station that would drip potassium permanganate into the stream at the lower barrier would ensure complete neutralization of the Fintrol. No adverse effect to aquatic life below the lower barrier is anticipated.

Repopulation of the management zone by aquatic invertebrates, fishes, and amphibians, following treatment would occur in a short period of time via emigration from upstream populations (fishes, amphibians, and many invertebrates) or aerial recolonization (many insects).

Human consumption of fish killed by Fintrol® is not approved by the Food and Drug Administration (FDA), although this lack of approval is due to the expense of conducting studies rather than to any suggestion of danger from human consumption. During common use over the last 20 years, no adverse effects to wildlife (or humans) have been observed from the consumption of fish killed by Fintrol®.

9. Summary of Biological Effects

Terrestrial - Construction of the Aravaipa Creek fish barriers would result in the permanent loss of less than 2 acres of terrestrial habitat (Table 6). Temporary impacts, primarily resulting from the deposition of sediments behind each barrier, would impact a total of 9 acres of terrestrial habitat. It is anticipated that after the sedimentation zones fill in, vegetation would begin to reestablish on the site.

The major impacts to wildlife species would be loss of habitat and temporary disturbances to small mammal and herpetofaunal species. Minimal impacts are expected for avian and large mammal populations.

There would be no adverse impacts to any terrestrial special status species. No federally-listed species occur in the project area on a permanent basis. No habitat for any federally-listed species occurs in the project area.

Aquatic - Specifically, 2.51 acres of aquatic resources would be impacted (0.3 acre permanent and 2.21 acres of temporary). The majority of temporary impacts would occur from the deposition of sediment. It is expected that the aquatic habitat in the sedimentation zone would reestablish once sediments levels have stabilized, although habitats characteristic of steeper gradients would be less likely to form in the lower-sloped sedimentation zone.

Approximately 0.3 acre of aquatic habitat would be permanently lost to use by fishes and other large aquatic organisms due to the presence of the fish barriers. Populations of fishes below the barriers would become reproductively (and genetically) isolated from those above, but no detrimental effects to the larger upstream populations are expected. Individuals of spikedace, loach minnow, and roundtail chub that become displaced below the barriers would likely fail to reproduce, and thus populations there would perish if they were not replaced by new immigrants from upstream.

There would be benefit to all of the special status aquatic organisms resulting from the control of invasion of new nonnative aquatic organisms.

Table 6. Summary of impacts to biological resources.

BIOLOGICAL RESOURCES	IMPACT
HABITAT	permanent loss of less than 2.0 acres of terrestrial habitat
	temporary impact to approximately 9.0 acres of terrestrial habitat
WILDLIFE	permanent loss of less than 2.0 acres of habitat for small mammals and herpetofaunal species
	loss of slow moving species (small mammals and herpetofauna) in construction zone
	temporary disturbance to wildlife species adjacent to construction areas
AQUATIC RESOURCES	permanent loss of 0.3 acre of open water habitat
	temporary impact to approximately 2.0 acres of open water habitat
	losses of drifting fish larvae and displaced juveniles and adults
	loss of fishes due to chemical or mechanical treatment of the stream between the barriers
	potential loss of certain instream habitat types in the sedimentation zones
SPECIAL STATUS SPECIES	no impacts to terrestrial special status species
	long-term beneficial impacts (increased protection) to native fishes; potential loss of individual fish during construction and periodic chemical treatment
	no adverse impacts to frogs or garter snakes

C. Mitigation

Table 7 summarizes the total acreage affected within each habitat type impacted by various construction activities and the proposed mitigation.