Blue River Fish Barriers

Feasibility Study

for

Clifton Ranger District, U.S. Forest Service

Clifton, Arizona

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Prepared by the U.S. Bureau of Reclamation, Phoenix Area Office

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I. Introduction

This study was undertaken at the request of the Apache-Sitgreaves National Forest, Clifton Ranger District. Reclamation was asked to evaluate potential fish barrier sites on the Blue River in Greenlee County, Arizona and provide estimates and feasibility designs. The study focused on three sites upstream of the confluence with the San Francisco River. Time did not permit a detailed study of the sites but allowed for a general reconnaissance to describe general conditions and to identify issues that will require further investigation. A general description of each site is included. Since all of the sites are similar, they share common characteristics for design and construction. Conclusions and considerations are addressed at the end of the report.

This report provides the Clifton Ranger District with results of a three-day preliminary field investigation of the lower Blue River (see maps, attached). Potential fish barrier sites on the Blue River are evaluated and cost estimates and feasibility designs are presented. In addition, cost estimates, feasibility designs, and evaluation of stabilization of the Juan Miller crossing (located 8.8 miles upstream from the terminus of the Blue River) are included.

The Blue River, a tributary to the San Francisco River in Greenlee County, Arizona, presently supports six native fish species, including the federally-threatened loach minnow (*Tiaroga cobitis*), to the relative exclusion of nonnative forms. Numerous nonnative fishes that presently inhabit the San Francisco River present a serious threat to the continued integrity of the Blue River native ichthyofauna. The Apache-Sitgreaves National Forest, Clifton Ranger District, is developing the Blue River Native Aquatic Restoration Project, and proposes construction of a fish barrier near the terminus of the Blue River that would eliminate or substantially reduce the threat of nonnative fish contamination from the San Francisco River. Non-native species of concern in the area include red shiner, channel catfish, flathead catfish, carp, rainbow trout, mosquito fish, smallmouth bass, and fathead minnow. Besides the loach minnow, native species occurring in the Blue River drainage consist of Sonora sucker, speckled dace, longfin dace, desert sucker, the federally-threatened Apache trout, and possibly the federally-endangered razorback sucker.

The Forest Service has identified Juan Miller Crossing on the Blue River as a major contributor of sedimentation in the stream, which may impact native fishes. The Forest Service has requested the technical assistance of the Bureau of Reclamation, Phoenix Area Office, in the planning, design, and construction of a permanent low water crossing on the Blue River. An estimate for a low water crossing with fish barrier functionality is also included.

These actions should substantially enhance the future status of native fish populations in the Blue River, and will allow potential repatriation of other native fish species now absent from the drainage.

The site investigation was performed on October 15 through October 17, 1997. Those participating were Bob Csargo and Terry Myers of the U.S. Forest Service, Sally Stefferoud of the U.S. Fish and Wildlife Service, Paul Marsh of Arizona State University, and Rob Clarkson, Mike Pryor, and Jeff Riley of the U.S. Bureau of Reclamation.

The first day we drove from Phoenix, met with Forest Service personnel in Clifton, and continued on to fish barrier site 1. The second day, after engineering and geologic evaluations were completed at site 1 and site 2, we drove to Juan Miller Crossing. The third day we looked the crossing site and site 3. Site 4 was not physically attended, but is located at an intriguingly narrow part of the canyon, and is evaluated in this report as a potential barrier site to be constructed with helicopter support.

What follows is our analysis containing field evaluations, feasibility cost estimates, feasibility designs and sketches, and recommendations.

II. Fish Barrier Site 1

A. General - This site is approximately one-half mile upstream of the confluence of the Blue River and the San Francisco River (see Photos 1-5). The width of the channel is 246 feet and is bounded by near vertical rock on each bank. The channel bottom is alluvium of unknown depth. The site is in Township 2 S, Range 31 E, Section 31 (NW1/4 of SW1/4 of SW1/4).

It tentatively appears that the 100-year instantaneous peak flow in the San Francisco River will back water up the Blue River to a depth about 2.5 feet above the top of the fish barrier (assuming a 5-foot high barrier). Although this information presents some concerns, several considerations should be weighed before this site is dismissed:

1. The 100-year instantaneous peak flow is a short-lived event, perhaps 1 or 2 hours.

2. The 100-year instantaneous peak flow is a rare event that has not yet been recorded to date. This report used a 100-year flow of 105,000 cfs (adjusted from 109,000 cfs because of the location of the site within the watershed), which is based on US Geologic Survey data. Over the period of record (1891, 1905-1907, 1911 to present), the high flow of 90,900 cfs (not adjusted) occurred in 1983. The next highest flow occurred in 1907 at 70,000 cfs. The low probability of the 100-year event may suggest designing to a lower frequency flood.

2. If the San Francisco River is experiencing a major flood, the close proximity of the Blue River watershed makes it probable that the Blue River would also have high flows. Fish would likely have difficulty moving upstream during these events.

3. An accurate survey of the fish barrier's elevation with respect to the drop in elevation to the confluence is required.

4. Accurate cross-sections of the confluence area are necessary to perform a final hydraulic analysis to evaluate the effect of the San Francisco River on the barrier with a higher degree of confidence.

B. Construction Access - After leaving State Highway 78, we traveled about 12 miles of reasonably well maintained road (Forest Service Road 212) that would present no problems to construction equipment. However, the last 2 miles to the San Francisco River are steep and challenging. It is our opinion that a concrete mixer truck would be unable to climb the steep grades involved at one section of this last 2 miles. The problem section is a steep 1/4 mile section of road near Dix Mesa that loaded concrete trucks would need to climb to deliver concrete. Pickup trucks and small to medium flatbed trucks can negotiate the road. Earth moving equipment (dozer, backhoe) may have to be unloaded at the steep section and walked up the hill. One option is to pioneer a road with a flatter grade to bypass this steep section of road. However, our estimates do not reflect this activity, which would cost about $20,000. This approach would ultimately generate cost savings, but the Forest Service would need to evaluate the impact of the new section of road on aesthetics, maintenance, and public use. The road could be used as a temporary construction road, then scarified, seeded, and abandoned upon completion of work, although its outline may be visible for some years.

The road reaches the San Francisco River at the Martinez ranch. The 2.5-mile road from the ranch to the confluence is rough and overgrown in places and the San Francisco River must be forded several times. At the time of our site visit the San Francisco River was crossable, however higher flows could prevent entry. Over the last 0.5 mile from the confluence to the barrier, no travelway is obvious, but a road could be bladed in with little effort.

C. Geology

Right Abutment - The rock at the right abutment (Photo 2) centerline is massive light-pinkish gray lithic tuff that forms a steep 18-foot high cliff. The massive tuff is overlain by bedded tuff. Within 50 feet downstream of centerline is an exposure of underlying bedded tuff that is two feet thick, strikes N30EE and dips 10ENW (upstream). The bedded tuff is separated from the massive tuff by a 1/8 inch-thick soft, slightly cemented bed of sand and contains alternating beds, one to two inches thick of light red and gray fine-grained tuff separated by coarser lithic tuff that is two to seven inches thick. Approximately 100 feet downstream of centerline is an exposure of basaltic andesite below the tuff. At the contact, which strikes N40EE and dips 13ENW (upstream), is a two-foot thick transition zone. This zone contains about 30 percent basaltic andesite fragments from three to twelve inches in diameter in the upper half and basaltic andesite with tuff-filled fractures up to one-inch thick in the lower half. The basaltic andesite is hard. The tuff at centerline is moderately soft to moderately hard, predominantly moderately hard on the surface, but is drummy in places and may be softer away from the exposed face. The massive tuff contains prominent fractures that strike and dip N30EW, 85ENE; N45EE, 75ENW; and N55EE, 60ENW. These are open approximately 1/4 inch at the surface. The river formed a pool four feet deep and ten feet wide. Several steel bars are installed into the rock but their original purpose is not clear.

Channel Section - The channel section is about 250 feet wide and is mostly filled with a cobble bar that diverted the flow to the west. The surface of the bar contains a trace of boulders with a maximum size of two feet, 30 percent cobbles, 30 percent coarse gravel, 20 percent fine gravel and 20 percent sand. The rock type is predominantly rounded to subrounded basaltic andesite. The gradation may become finer with depth.

Left Abutment - The left abutment is composed of massive lithic tuff that is approximately 18 feet high, benched and overlain by bedded tuff. The massive tuff is moderately soft to moderately hard, predominantly moderately soft, drummy and scales off in places on the cliff face. The rock gets harder toward the base of the cliff and is hard in the lower three feet. Near the proposed centerline is an undulating nearly vertical fracture in the rock that is open from six inches to one foot and extends about three feet into the cliff (Photo 3). About five feet upstream of centerline is a striated fault surface that is vertical and strikes N50EE with some calcite infilling. About 20 feet upstream of centerline is a dike of black basalt (Photo 4) that strikes N60EW and dips 80ENE. The basalt is moderately to intensely weathered, breaks with a moderate to light hammer blow, and can be penetrated about 1/4 inch with a pick. The dike is 1.1 feet wide and is finer grained and harder along the margins for about ½ inch. The dike may be offset by the fault because it did not appear where projected downstream of centerline. A little further downstream there was a soil zone filled with organic material that may have been formed by erosion of the dike, however digging into the soil only showed tuff fragments. There is a terrace of sandy material downstream of centerline that contains a growth of sycamore trees. Erosion protection may be required in this area.

D. Design

The primary challenge at this site is that a gravity-type structure "floating" on an alluvium foundation in a river channel is not an ideal situation. The main concern is that a portion of the river during flood flows would begin to pass under the structure due to scour and increased water pressures. This could lead to loss of material in the foundation and eventual structural failure.

One answer to these concerns is to tie the structure to bedrock. At this time we do not know the depth to bedrock, so bedrock is assumed to be 35 feet deep at all fish barrier sites discussed in this report. This depth makes tieing the structure to bedrock very costly.

Placing the structure on piles or caissons that tie into bedrock was considered. However, boring the holes generally requires a large drill rig or crane. Since equipment access is so difficult, this option was eliminated from consideration at Sites 1, 2, and 4.

If the structure is not tied to rock except at the abutments, the barrier must extend deep enough to prevent undercutting, must be massive enough not to be pushed downstream, and wide enough to effectively float on the alluvium.

A cross-section of the fish barrier at Site 1 is shown on Sketch No. 1. Preliminary sliding and overturning calculations have been performed, indicating a reasonable factor of safety. Until geologic investigations are performed, the assumptions made regarding the makeup of the alluvium for the sliding, overturning, and scour computations will dictate the results of these calculations.

Steel reinforcement is not shown on any of the cross-section sketches, but will be necessary. The vertical wall and apron of the barrier will be heavily reinforced, with less steel needed in the scour protection portion of the structure.

Two types of scour will occur; channel scour due to flooding, and downstream scour from erosive action created by the structure. River channel scour was computed to 15 feet below the channel surface during a 100-year flood event, hence the 15-foot deep upstream wall of the barrier. Downstream scour determined the depth of the 6-foot deep downstream key at the end of the concrete apron.

One possible cost reduction option is to provide scour protection only to 10 feet below the channel instead of 15 feet, since the upstream side of the barrier will eventually fill with sand, gravel, and cobbles to the top of the 5-foot barrier. Once the sediment is place, the full 15 feet of scour protection will exist. However, immediately after construction, the barrier is protected only to a 25-year storm scour depth. This risk may or may not be acceptable to the Forest Service and can be discussed further if this project enters a design phase.

Abutment rock will be excavated to key the structure into the canyon walls. In addition, steel anchor bars will be drilled and grouted into the rock, and extended into the fish barrier concrete.

E. Design and Construction Considerations (common to all sites)

Scour Depth - Although the surface of the channel appears to be armored with cobbles, the gradation may become finer with depth. Subsurface samples to determine gradation and maximum size material should be taken with a backhoe. This work could be done in conjunction with obtaining samples for concrete aggregate suitability. It is estimated that bedrock is 35 feet below the channel. Determination of depth to bedrock may be expensive due to the presence of cobbles and boulders that will make drilling difficult. Seismic surveys are an alternative to drilling to find bedrock. However, the seismic data may be difficult to interpret because the alluvial material may have a greater density than the underlying tuff. Dense alluvial material can reflect the sonic impulses before bedrock does, creating the appearance of a shallower depth to bedrock. Surveying is required at the proposed site and cross-sections will be required upstream and downstream of the structure. Soil samples need to be obtained to determine gradation of the alluvium.

Excavation - Excavation of alluvial materials can be performed by common means if it is properly drained. If the channel is not dewatered, there will be stability problems in the excavation and equipment travel will be difficult. The excavated material can be side cast away from the trench and reused as backfill. The backfill may require removal of large cobbles and boulders to prevent damage to the structure. It may be advantageous to stockpile oversize material (larger than five inches) separately so that it can be used downstream of the structure for additional erosion protection.

Dewatering and Diversion - Dewatering will be required to maintain an open excavation in the alluvial material. Although upstream and downstream deep wells would be the most effective means, they will be difficult and expensive to drill. A sump system upstream and downstream of the excavation may be an alternative. These sumps will require excavation to a depth of at least five feet below the proposed excavation. A perforated corrugated metal pipe may be used to protect the pump. Pumps will also be required within the barrier excavation during excavation and concrete placement. Ideally, the site investigations should include the installation of a well for pump testing to determine the level of effort required for dewatering. This well could also be used to confirm that bedrock will not be encountered in the excavation. Because of the difficult access to the site and the presence of cobbles and boulders in the alluvium, this hole will be expensive to bore, however the cost of delays due to inadequate dewatering information could increase construction costs substantially.

The above-ground stream flows will need to be diverted away from construction activities. To accomplish this, the river will be diverted as far to one side of the channel as possible, while work occurs on the other side. The flows will eventually be diverted to the other side to finish the work. A dozer will be used to create the diversion channels and associated berms.

Cofferdams consisting of mounded alluvial material should be constructed upstream and downstream of the excavation to protect the work from above-ground flow. During excavation and construction, water from dewatering wells should be diverted through a diversion pipe, which may require moving during construction. The pipe should be long enough to discharge in such a way to prevent the diverted water from entering the area being pumped.

<u>Aggregate Production</u> - Samples should be obtained during the scour investigation to determine the suitability of in-place material for use as concrete aggregate. The basaltic andesite material appears to be usable. If tuff is encountered, it should not be used. Processing will be required to remove oversize material. Because of the remoteness of the site, it will be expensive to import concrete aggregate materials. Assuming concrete mixers are unable to access the fish barrier location, concrete would be batched at the site. Cement would be trucked in. Sand and gravel would be processed at the site using channel material. Trailer mixers that are small enough to be hauled in would be used to mix concrete at the site.

<u>Abutment Shaping</u> - A key should be excavated in both abutments to a depth of at least three feet. This can be done using a hoe-ram. The rock may be softer than that exposed at the surface and may be subject to slaking. It is recommended that grouted bars also be drilled into the abutment to help key the structure. Additional analysis should be performed on the left abutment of Site 1 to insure that the basalt dike does not adversely affect slope stability during construction; removal of a block of bedded tuff near the top of the abutment should be considered for safety.

There is a potential for a wedge failure at the right abutment of Site 2; the excavation should performed upstream of this feature to prevent destabilization. Sealing of the vertical joints on the left abutment of Site 2 should be considered to prevent water flow and possible fish migration in the future if the joint filling washes out. This can be done by filling with concrete to the height of the barrier.

Downstream Protection - The canyon downstream of the right abutment of Site 1 is rock and generally does not require slope protection. However, there is a sandy area downstream of the left abutment that may require protection if keeping sycamore trees is important. There did not appear to be enough boulder size material within the alluvium to use for riprap. If protection is warranted, a riprap borrow source may be required. A potential source is the basaltic andesite exposed along the canyon. However, this would require blasting and may destabilize overlying rock. Other alternatives such as jetty jacks could be considered.

Major construction equipment needed at the sites:

Backhoe/hoe ram/front end loader
Small dozer
Dump truck
Trailer concrete mixer
Dewatering pumps
Drill rig

F. Estimate

Assumptions made for this estimate are as follows:

1. Concrete mixer trucks cannot access the site.
2. Cement will be hauled to the site.
3. Native materials at the site will be used for all concrete aggregate and sand.
4. The river can be channeled to divert flows during construction.
5. Pumps can be used to dewater the key trench.
6. No major floods occur during the construction period.

The total estimated cost for a fish barrier at Site 1 is $765,000. The breakdown of costs for all construction activities follows.

Other Considerations: This estimate shows costs using conventional excavation methods. Another possible construction alternative may be to use slurry wall construction techniques. This method would reduce the required alluvium excavation by allowing a narrow slot to be excavated, instead of a wide trench with slopes laid back on 1:1 slopes. The slot would be kept full of a bentonite slurry during excavation to keep the walls from collapsing inward. The slurry would be pumped out at the same rate that concrete is placed at the bottom of the trench. This method is not expected to be cost effective, especially at sites 1, 2, and 4, but may be able to be done for less than expected.

II. Fish Barrier Site 2

A. General - Site 2 is in T.2S., R.31E., Section 31, SW1/4 of NE1/4 of SW1/4, approximately 2000 feet upstream of Site 1. The sites are separated by a fault with the north-side up so that the rock at both sites is similar. A barrier at this site would be approximately 235 feet long and would trend east-west.

Site 2 and Site 1 are quite similar with respect to design and construction considerations. Advantages that Site 2 has over Site 1 are:

- 10 feet shorter.
- barrier would run straight across river resulting in a simpler structure.
- higher elevation may negate the effects of the San Francisco River flood flows.

The disadvantages are: 0.4 miles of river will be sacrificed below the barrier; and, 0.4-mile longer construction road.

It tentatively appears that the base of the fish barrier will be above the San Francisco River's 100-year flood water level, although further analysis of this issue is needed.

B. Construction Access - Access to Site 2 will be along the same route as Site 1, requiring an additional 0.4 miles of road grading in the river channel.

C. Geology

Right Abutment - The right abutment is 30 feet high, vertical and composed of massive lithic tuff above which is a bench approximately three to five feet wide and an overlying sequence of bedded tuff. The surface of the massive tuff is hard to very hard although it was drummy in places and scales off into pieces about 1/4 to ½ inch thick with a light hammer blow in some places. There are two prominent joints just downstream of centerline, one trends N55EE and dips about 80ESE (downstream) and the other trends N40EE and dips 80ENW (upstream). These joints are coated with some patches of calcite, have an irregular shape and probably intersect below the gravel bar in the channel. A small wedge about twelve feet high has been removed between the joints creating an overhang (photo 6). Upstream of the proposed centerline are two widely spaced joints that trend N60EW and are predominantly vertical except for short segments along the trace that dip 60EE upstream and downstream. These joints are open up to 1/8 inch.

Channel Section - The channel section is predominantly coarse gravel and cobbles on the surface but probably is finer with depth. The bar is about three feet high.

Left Abutment - The left abutment is sliver shaped and is ten feet wide at its upstream end to about 25 feet wide at the proposed centerline. It is nearly vertical, approximately 40 feet high and composed of massive lithic tuff. There are four prominent joints (Photo 7) spaced 10 to 30 feet apart and are open. These trend approximately N30EE to N40EE. The joints appeared to be continuous to the backside of the outcrop.

Site 2 Geologic Considerations - Similar to Site 1. There is a potential wedge failure downstream of centerline on the right abutment.

Open vertical joints downstream of centerline on left abutment should be sealed with concrete to the height of the barrier to insure that water cannot by-pass the structure through openings in the rock.

D. Construction Considerations - Same as Site 1.

E. Design - Same considerations as discussed for Site 1, see Sketch #1.

F. Estimate - For all intents and purposes, the cost estimate for Site 2 is the same as Site 1, $765,000.

III. Fish Barrier Site 3

A. General - Site 3 is about 400 feet downstream of the Juan Miller Crossing. The river channel is approximately 115 feet wide and bounded by near vertical rock walls.

The main advantages of this site are cost savings associated with a shorter fish barrier, and relatively easy construction access. The primary disadvantage is that eight miles of the Blue River to the confluence with the San Francisco River is unprotected by fish barriers.

B. Construction Access - Construction equipment should have no problems accessing this site. The 20 paved miles from Clifton on US Highway 666, although steep, curvy, and slow, presents no difficulties for concrete transit mixers. Likewise, the 13-mile gravel road (Forest Service Road 475) to the crossing is in reasonably good shape, and should not restrict hauling operations.

C. Geology

The abutments at Site 3 are composed of massive lithic tuff and contain open joints spaced about three feet apart perpendicular to the river on the right abutment. These joints are open one to several inches.

D. Construction Considerations

Concrete can be batched and delivered by commercial sources. There is ample space near the crossing for a contractor laydown area. A crane can be brought to the site, expanding the design and construction options. The USGS stream gage immediately upstream of the site will be affected by the barrier's influence on the river, and may result in some additional cost.

E. Design

One option at this site is to extend concrete to the full scour depth for a 100-year storm event, with the same cross-section as Sites 1 and 2 (see Sketch #1). An estimate is included for this configuration.

However, this relatively easy to reach site permits crane access, enabling the structure to be placed on caissons or piles (see Sketch #2). Advantages of a caisson option are: 1. Added stability by tieing the structure to bedrock; and, 2. Because the structure is supported, some undercutting may be acceptable, thereby lessening the need to construct to full scour depth.

A sketch and estimate for a caisson option are included. A depth to bedrock is assumed and scour protection is reduced to 8 feet below the channel (protection depth needed for a 25-year storm).

F. Estimate

Assumptions made for this estimate are as follows:

1. Concrete obtained from commercial sources.
2. The river can be channeled to divert flows during construction.
3. Pumps can be used to dewater the key trench.
4. No major floods occur during the construction period.

The total estimated cost for a fish barrier built to full scour depth at Site 3 is $604,000. The total estimated cost for a fish barrier with caisson option is $549,000.

IV. Fish Barrier Site 4

A. General - This area was not visited during the site investigations because of its remoteness. From aerial photographs, this location appears to be the narrowest point on the 8 miles of river from the confluence with the San Francisco River to Juan Miller Crossing. The width of the channel is about 90 feet wide. The site is 4.5 miles upstream from the confluence with the San Francisco River. Another site about 100 feet wide is located 3.0 miles from the confluence. The river channel appears to be bounded by rock abutments and a barrier would be able to be placed straight across the channel.

The primary advantage to this site is that a shorter structure is needed, thereby reducing concrete quantities and disruptive effects on the river channel. Disadvantages include the unprotected river downstream of the barrier and access difficulties.

B. Construction Access - Although a road could be bladed up or down the river channel to the site, the assumption made in this report is that such a road would negatively impact the area and is not desirable. Therefore for this particular site, all equipment and cement would be flown in using helicopters, or brought in on horseback or by mule.

The contractor would probably set up a helipad and use area near Juan Miller Crossing. This results in a 3.5-mile flight line distance to the barrier site.

A large helicopter, like a 58T, would be required during mobilization to fly equipment such as skip loaders, small backhoes, and concrete mixers into the site. This helicopter is capable of transporting 2,500 to 3,000 pounds without difficulty. There are a variety of small loaders and backhoes that fall into this weight category. A 58T would cost about $1,400/hour. "Llama" helicopters are capable of transporting about 2000 pounds, and cost about $1,200/hour.

After initial equipment mobilization a smaller, more standard size helicopter would provide support for the duration of the contact. Bell Long Rangers can carry about 1000 pounds and typically cost $900/hour. Bell Jet Rangers are smaller and carry about 700 pounds. A helicopter of this size could haul personnel, cement, pumps, and other small equipment.

The use of military helicopters could be investigated to reduce costs, but that option is not explored in this report.

C. Geology - Specific geology at the site is unknown, although it appears from aerial photos that the right abutment is primarily tuff and the left abutment is comprised of basalt. It is a reasonable assumption that the alluvium in the river channel is similar in makeup and depth as the other sites.

D. Construction Considerations

Concrete would be batched at the site. Sand and gravel would be processed at the site using channel materials. The largest equipment available at the site would be skip loaders. The canyon is narrowest at this location and may present some clearance problems for the pilots.

E. Design

For the estimate, the same design assumptions and cross-section was used for Site 4 as the other sites (see sketch #1). This approach may be conservative since the canyon is so much narrower than the other sites. The narrowness may allow a more site specific design using an arch shape across the river for additional strength, resulting in less concrete and lower costs. The strength of the arch design may also enable the structure to be built with shallower scour protection, again reducing costs. However, the lack of specific information about this site makes exploration of these possibilities inappropriate at this time.

F. Estimate

Assumptions made for this estimate are as follows:

1. All equipment will be brought in by helicopter, no vehicular access.
2. Cement, steel, forms will be flown in by helicopter.
3. Native materials at the site will be used for all concrete aggregate and sand.
4. The river can be channeled to divert flows during construction.
5. Pumps can be used to dewater the key trench.
6. No major floods occur during the construction period.

The total estimated cost for a fish barrier at Site 4 is $904,000. The breakdown of costs for all construction activities follows.

V. Juan Miller Crossing Upgrade

A. General - Juan Miller Crossing (Photos 15 through 17) is an existing unprotected low water crossing. This site is located 13 miles from Highway 666 on Forest Service Road 475. The crossing experiences erosion problems during high flows in the Blue River. The Forest Service attempted to stabilize the river bed by placing about six large rocks (three to four feet diameter) on the downstream side of the roadway. The water surface drops about 18 inches at the area where the rock was placed. The river channel is about 300 feet wide at this location. The original crossing as shown on the Fritz Canyon 7½' Quadrangle is approximately 350 feet upstream of the present crossing. The Forest Service has proposed that the road be regraded and a concrete slab be placed across the Blue River.

A concrete roadway section across the river would be constructed on the same alignment as the current crossing.

B. Construction Access - Construction equipment should have no problems accessing this site. The 20 paved miles from Clifton on US Highway 666, although steep, curvy, and slow, presents no difficulties for concrete transit mixers. Likewise, the 13-mile gravel road (Forest Service Road 475) to the crossing is in reasonably good shape, and should not restrict hauling operations.

C. Geology - The existing channel material at this location is fine sand to boulders, predominantly coarse sand and fine gravel. The cliff is at least 100 feet high; bedding trends N85EW and dips 10ENE. The most westerly 15 feet of the existing road is tuff and the rest of the distance to the river is predominantly sand. Near the river edge is a stand of cottonwood trees.

D. Construction Considerations - Concrete can be batched and delivered by commercial sources. There is ample space near the crossing for a contractor laydown area. A crane can be brought to the site, expanding the design and construction options.

E. Design - The implications of a portion of the crossing washing out are not as serious, from a biological or cost standpoint, as a fish barrier failure. For this reason, and in an effort to reduce costs, the scour protection features of the crossing were designed around a 25-year storm, instead of a 100-year storm. Many local, state, and federal agencies design crossings and culverts to the 25-year storm, so this is not without precedent. Using 25-year flood data, the scour protection can be reduced from a depth of 15 feet to 8 feet below the river channel.

The crossing would consist of a 16-foot roadway with upstream and downstream keys as shown in Sketch #3. The roadway surface would essentially match the existing profile across the river channel.

F. Estimate - Assumptions made for this estimate are as follows:

1. 16-foot wide roadway.
2. Designed for a 25-year storm.
3. Concrete obtained from commercial sources.
4. The river can be channeled to divert flows during construction.
5. Pumps can be used to dewater the key trench.
6. No major floods occur during the construction period.

The total estimated cost for an upgraded Juan Miller Crossing is $297,000.

VI. Juan Miller Crossing Upgrade/Fish Barrier

A. General - This structure would handle traffic and function as a fish barrier. The configuration of the structure would be identical to the fish barriers cross-section shown on Sketch #1. Since the crossing would be a fish barrier, the scour protection is designed for a 100-year storm. The alignment of the structure would coincide with the existing roadway.

B. Construction Access - Same as discussed for the crossing upgrade.

C. Geology - Same as discussed for the crossing upgrade.

D. Construction Considerations - Similar to those discussed for the crossing upgrade, with deeper excavation required.

E. Design - All design considerations are identical to those discussed in detail under Site 1 fish barrier.

F. Estimate - Used the same assumptions listed in the crossing upgrade, with the exception of a 15-foot wide roadway, instead of 16-foot wide. The roadway can be designed to any width, but 15 feet was convenient since the fish barriers have a 15-foot apron.

The cost of a combination crossing and fish barrier is estimated to be $775,000. The principle reason for the high cost is the width of the channel at this location. A caisson option similar to the one at site 3 would run about 20% less, or about $620,000.

VII. Conclusions and Closing Remarks

1. The emphasis of the cost estimates contained within this report are on construction contract costs. Some discussion of design costs, construction supervision costs, and site investigations are appropriate at this time.

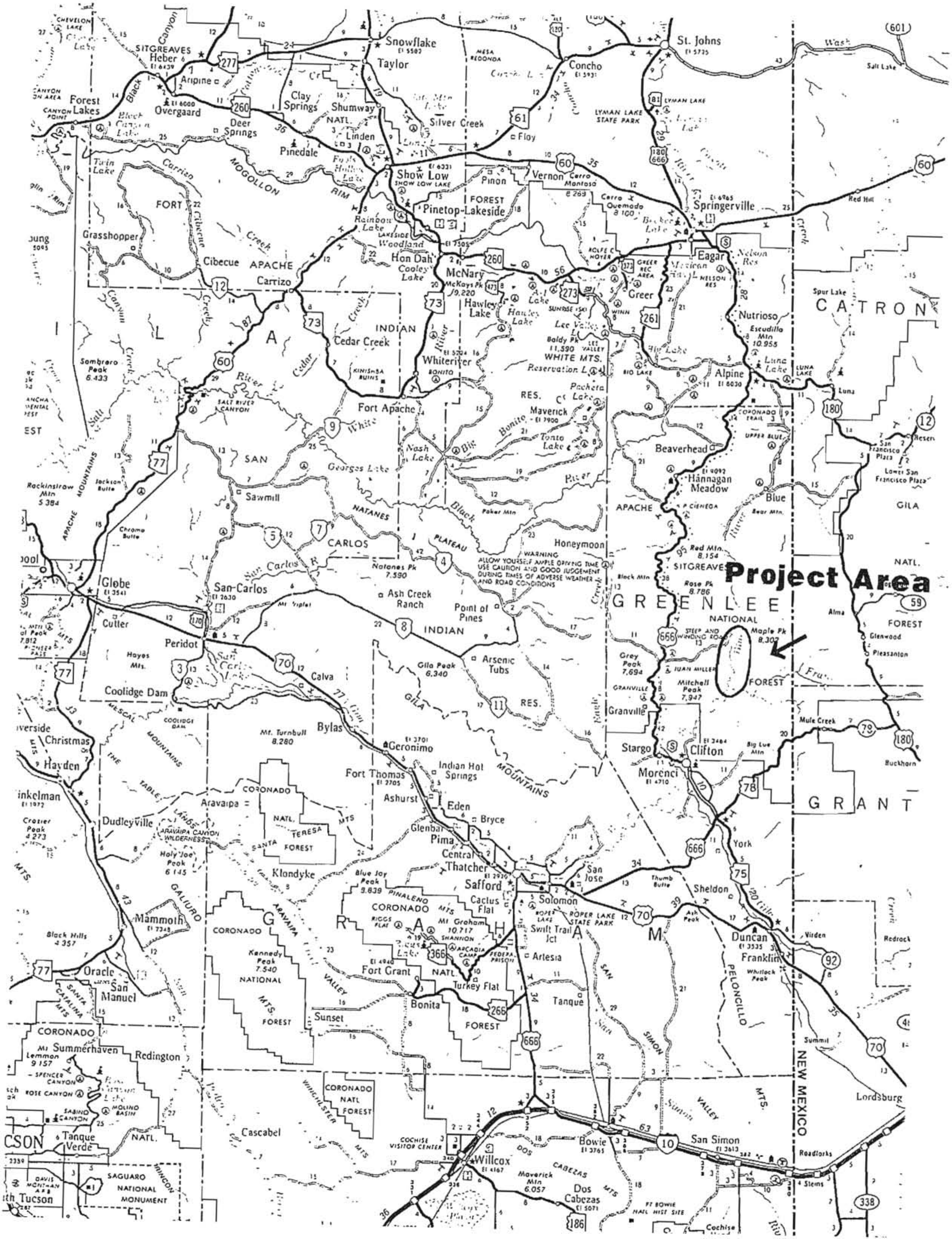
Design costs will depend partially on the actual site chosen. For example, Site 1 will probably need an accurate assessment of the effects of the San Francisco River 100-year flood, while the other sites would not be affected. This assessment would require a survey crew to provide cross-sections of the floodplain and a hydraulic analysis of the river channel, resulting in costs that would not be generated at the other sites. Design costs common to all the sites will include additional site visits, establishment of survey control, preparation of specification narrative and drawings, procurement of necessary NEPA permits and documents, and general coordination with involved entities. For general estimating purposes, though, it is probably reasonable to assume design costs will be approximately 15% of the cost of construction costs for an A&E firm or Reclamation engineering.

Construction management costs include inspection, construction safety enforcement, and contract administration, which involves payments to the contractor, handling modifications and contract disputes, and scheduling. Reclamation field forces have a constant presence on-site to ensure construction quality and they meet safety standards. These commitments result in construction management costs that are about 30% of the construction costs. Construction management can also be contracted out to a private firm. It may appear that these firms have substantially lower construction management costs than Reclamation. However, they frequently reduce costs by inspecting only once or twice a week. If it is important to you that inspection forces are at the site all the time, the contract with your construction management firm should specify such.

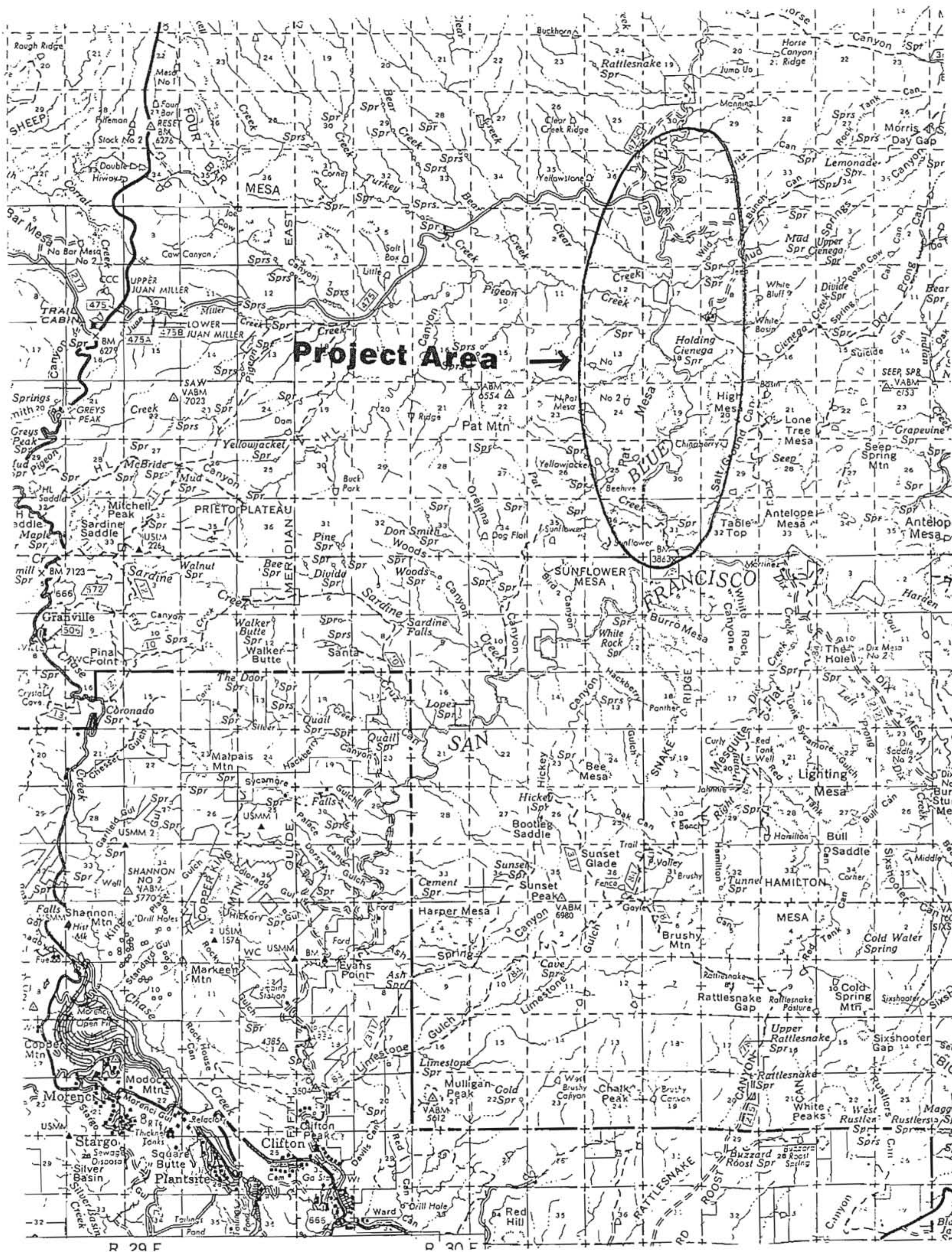
Site investigations that need to be performed include: determining depth to bedrock; soil gradation analysis for scour computations; analyze aggregate for suitability in concrete; and possibly a test well for dewatering calculations.

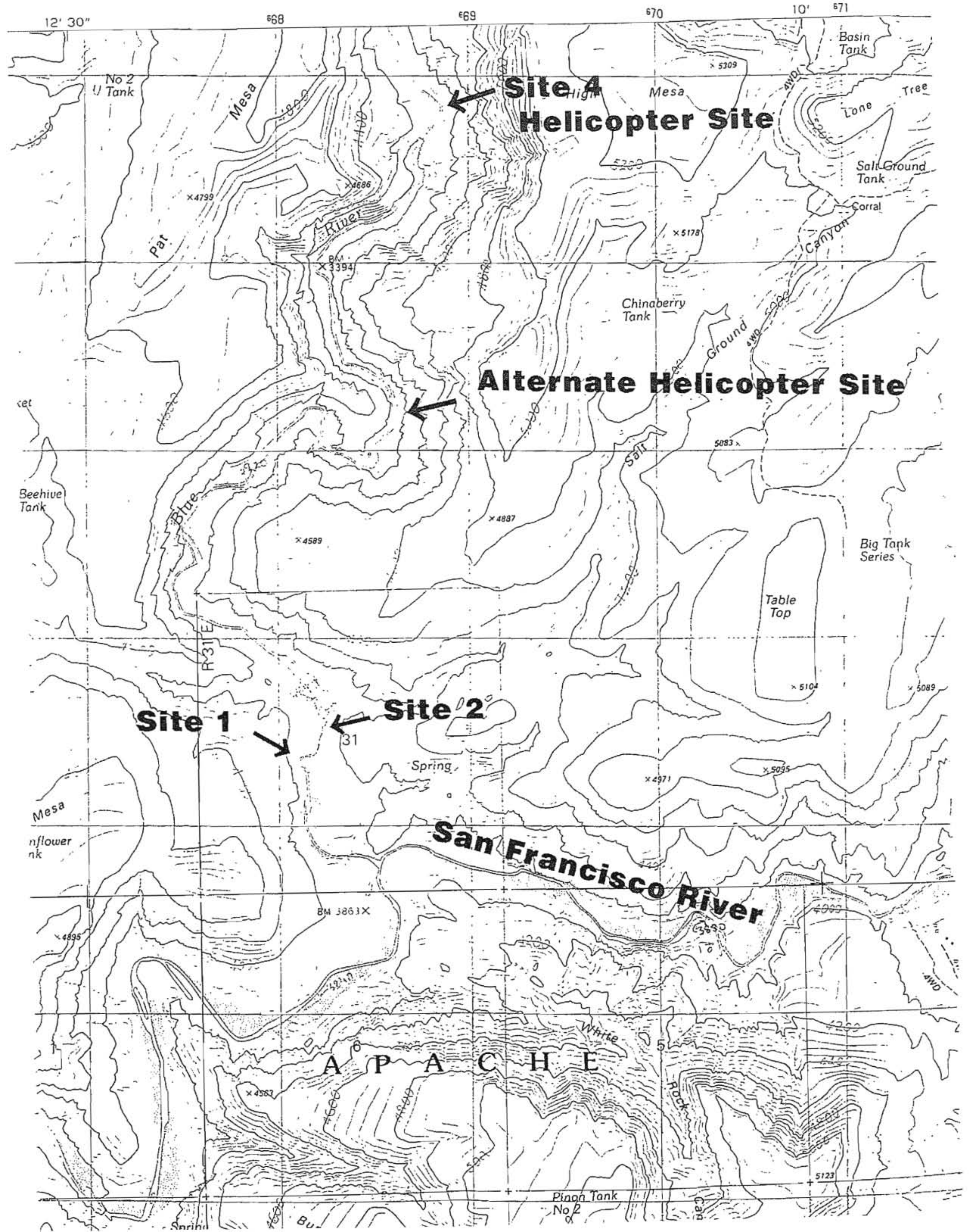
2. Engineering calculations for scour, sliding and overturing, and the San Francisco River 100-year flood level are not included in this report, but can be furnished upon request. Because of the lack of specific geologic and survey information, the calculations were based on visual observations rather than hard data and will likely change slightly with actual data.

3. The Juan Miller Crossing design in this report has a fairly conservative design, with scour protection to a 25-year level. A much less expensive concrete structure could be constructed if the Forest Service is willing accept some risk and periodic repair of the structure.

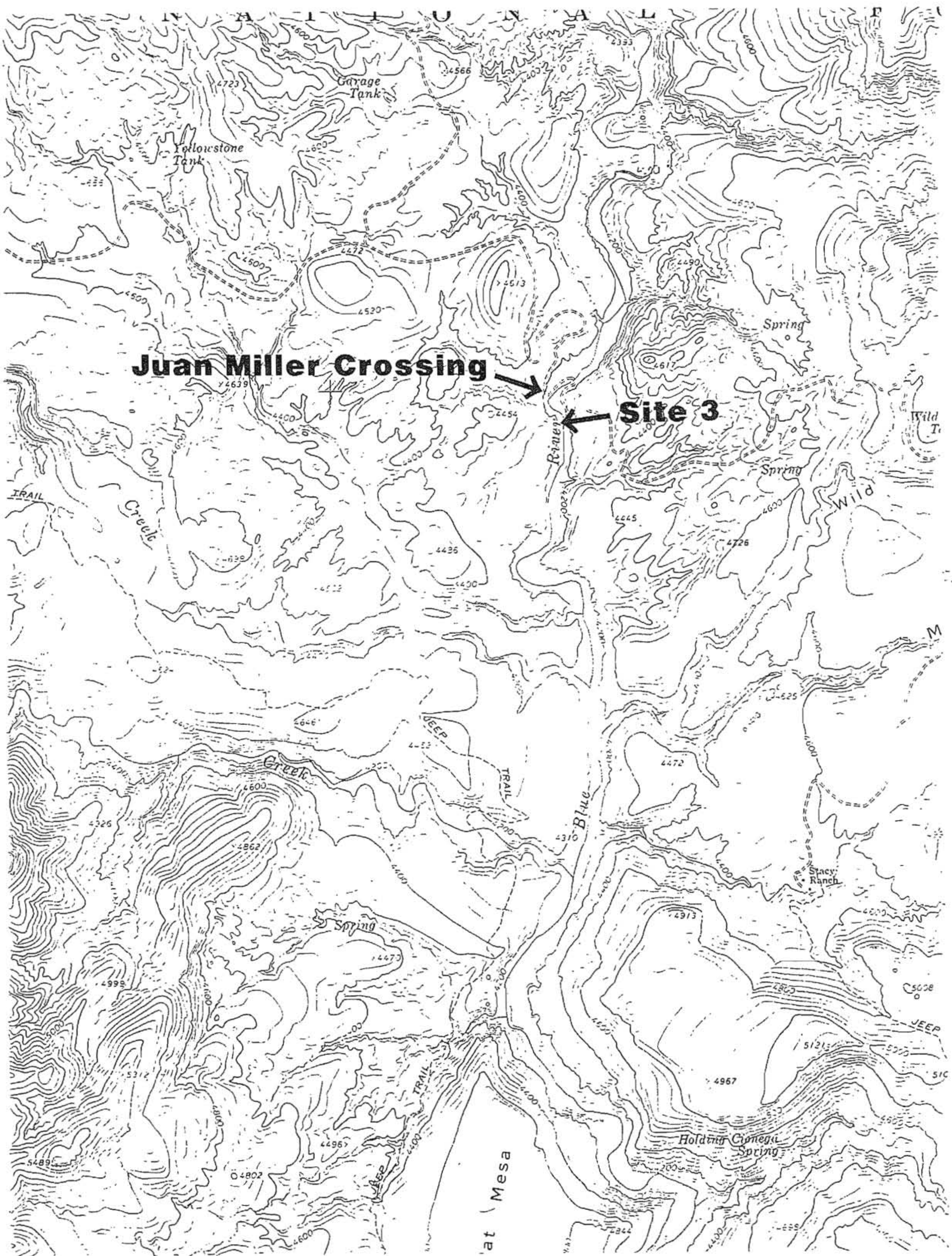


Project Area
Snowflake
Taylor
St. Johns
Concho
Heber
Forest Lakes
Overgaard
Clay Springs
Shumway
Silver Creek
Linden
Pinedale
Show Low
Pinetop-Lakeside
Vernon
Springerville
Eagar
MOGOLLON RIM
FORT APACHE INDIAN RES.
Cibecue
Carrizo
McNary
Hon Dah
Greer
Nutrioso
Alpine
Whiteriver
Cedar Creek
Fort Apache
WHITE MTS.
Maverick
Beaverhead
Hannagan Meadow
Blue
CATRON
APACHE SITGREAVES NATIONAL FOREST
GREENLEE
Maple Pk 8,302
Honeymoon
SAN CARLOS INDIAN RES.
Globe
San Carlos
Peridot
Coolidge Dam
Point of Pines
Ash Creek Ranch
Arsenic Tubs
Calva
Bylas
Geronimo
Fort Thomas
Granville
Stargo
Clifton
Morenci
York
Sheldon
Duncan
Franklin
Virden
Mule Creek
Alma
Glenwood
Pleasanton
GRANT
GILA MOUNTAINS
Pima
Central
Thatcher
Safford
Solomon
San Jose
Eden
Bryce
Glenbar
Ashurst
Klondyke
Aravaipa
Dudleyville
Hayden
Christmas
Winkelman
Mammoth
Oracle
San Manuel
CORONADO NATIONAL FOREST
Mt. Graham 10,717
Swift Trail Jct
Artesia
Fort Grant
Bonita
Turkey Flat
Sunset
Tanque
Cascabel
Redington
Summerhaven
Mt Lemmon 9,157
Tanque Verde
SAGUARO NATIONAL MONUMENT
Willcox
Bowie
San Simon
Dos Cabezas
Lordsburg
Steins
Road Forks
NEW MEXICO
ALLOW YOURSELF AMPLE DRIVING TIME USE CAUTION AND GOOD JUDGEMENT DURING TIMES OF ADVERSE WEATHER AND ROAD CONDITIONS


Project Area
BLUE RIVER
SAN FRANCISCO
Pat Mesa
High Mesa
Holding Cienega Spr
Pat Mtn
Pat Creek
Sunflower Mesa
Table Top
Antelope Mesa
Lone Tree Mesa
Seep Spring Mtn
FOUR BAR MESA
EAST GUIDE MERIDIAN
PRIETO PLATEAU
Mitchell Peak
Sardine Saddle
Granville
Pinal Point
Coronado Spr
Malpais Mtn
Sycamore
Shannon Mtn
Markeen Mtn
Evans Point
Morenci
Modoc Mtn
Stargo
Square Butte
Plantsite
Clifton
Clifton Peak
Silver Basin
Harper Mesa
Mulligan Peak
Sunset Peak
Sunset Glade
Bootleg Saddle
Bee Mesa
Brushy Mtn
Rattlesnake Gap
Cold Spring Mtn
Sixshooter Gap
HAMILTON MESA
Lighting Mesa
Bull Saddle
Chalk Peak
White Peaks
Red Hill
Buzzard Roost Spr
SNAKE RIDGE
RATTLESNAKE
ROOST
Black Jack
R. 29 E
R. 30 E



Site 4
Helicopter Site
Alternate Helicopter Site
Site 1
Site 2
San Francisco River
12' 30"
668
669
670
10'
671
Basin Tank
No 2 U Tank
Mesa
High Mesa
Lone Tree
Salt Ground Tank
Corral
Canyon
Pat
Blue River
BM 3394
Chinaberry Tank
Salt Ground
4WD
Beehive Tank
Big Tank Series
Table Top
R31E
31
Spring
Mesa
BM 3863
APACHE
White Rock
Pinon Tank No 2

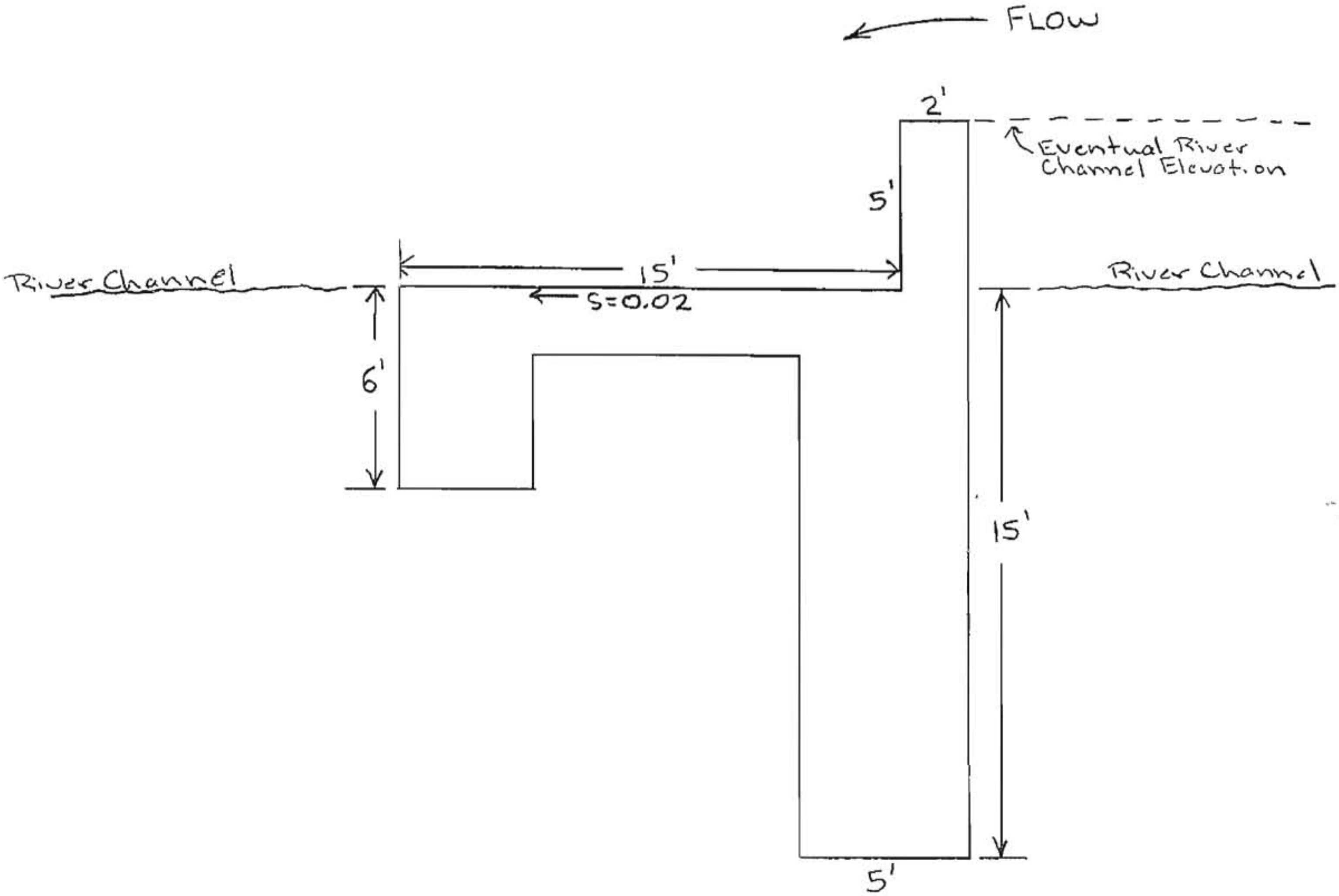


N A T I O N A L
Garage Tank
Yellowstone Tank
Juan Miller Crossing
Site 3
River
Spring
Creek
TRAIL
Wild
JEEP TRAIL
Blue
Stacy Ranch
Holding Cienega Spring
Mesa
JEEP

7-1654 (1-89)
Bureau of Reclamation

COMPUTATION SHEET

BY J. Riley	DATE	PROJECT	SHEET ____ OF ____
CHKD BY	DATE	FEATURE	
DETAILS Sketch #1			

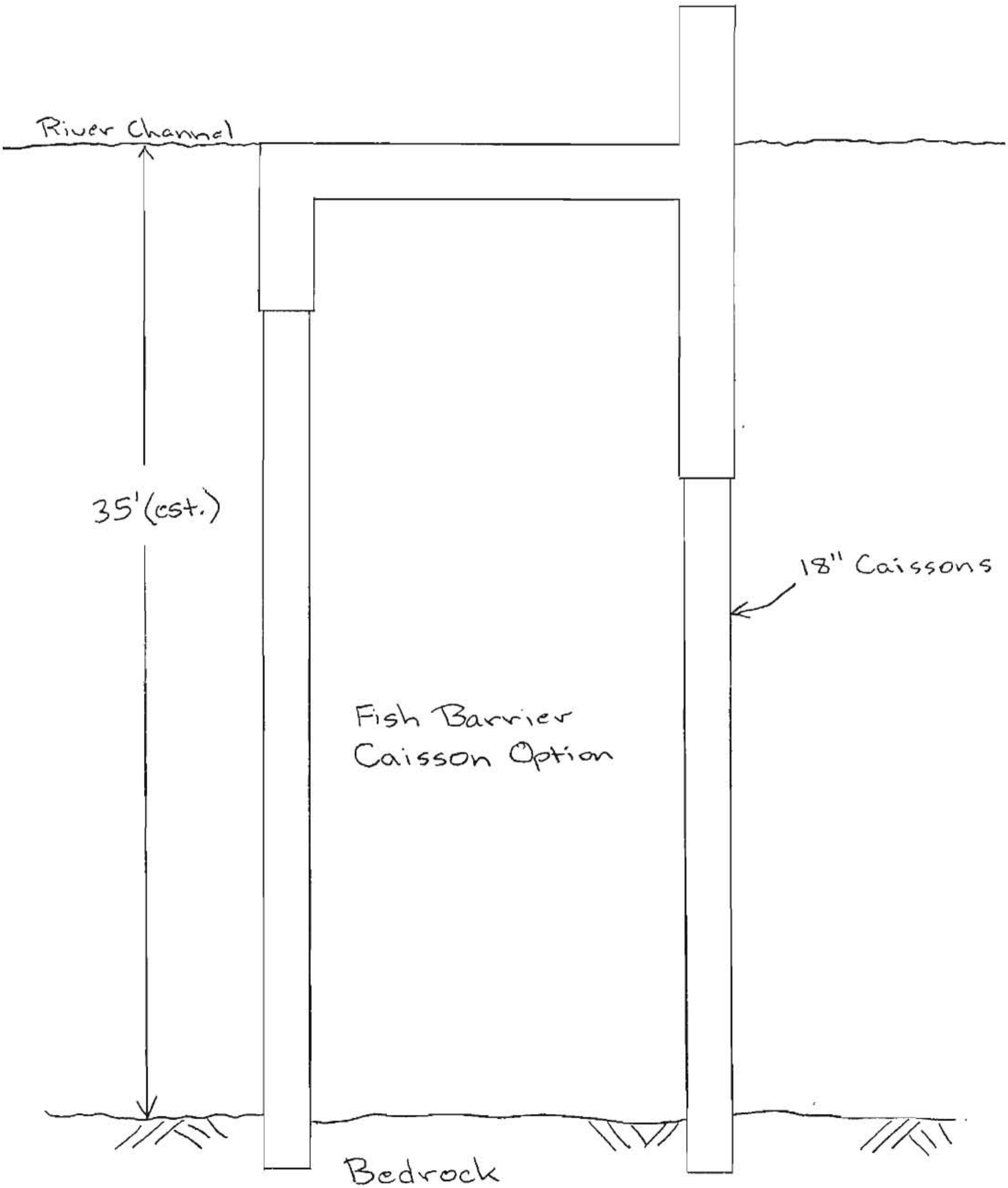


Fish Barrier Configuration
Cross- Section

7-1654 (1-89)
Bureau of Reclamation

COMPUTATION SHEET

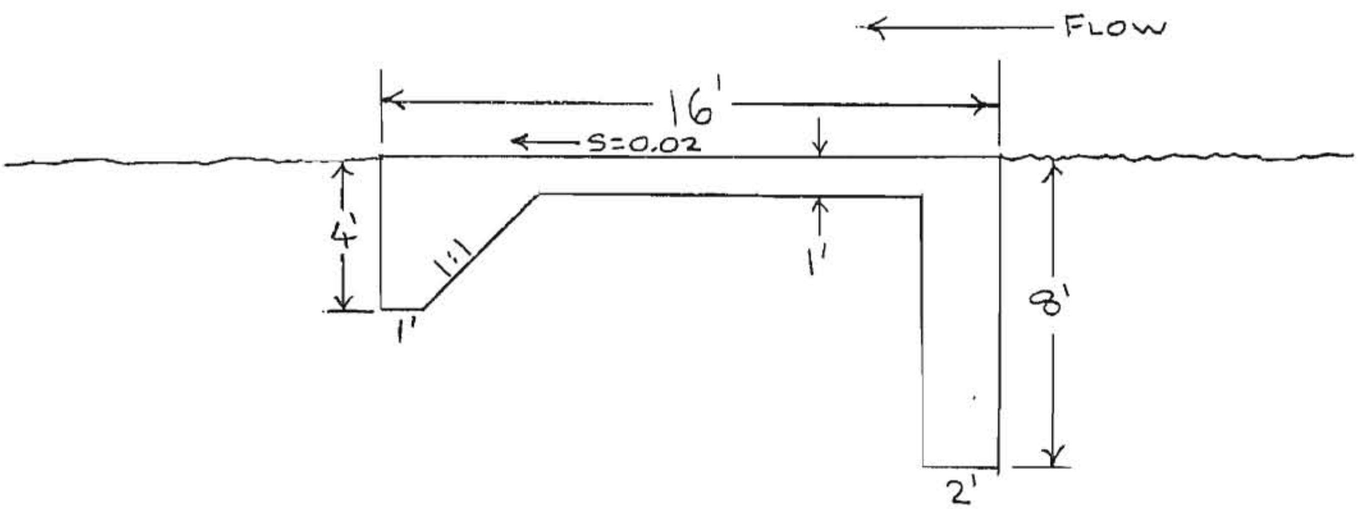
BY J. Riley	DATE	PROJECT	SHEET ___ OF ___
CHKD BY	DATE	FEATURE	
DETAILS Sketch #2			



7-1654 (1-89)
Bureau of Reclamation

COMPUTATION SHEET

BY J. Riley	DATE	PROJECT	SHEET ___ OF ___
CHKD BY	DATE	FEATURE	
DETAILS Sketch #3			



JUAN MILLER CROSSING

VEHICLE ONLY OPTION

Cost estimate for Fish Barrier Sites 1 and 2

The contract is estimated to take 5 months to complete. Most equipment and crew costs are taken from Means estimating guide for Heavy Construction.

1. Mobilization - 10% of subtotal of work = $55,600

2. Equipment

Dozer, 75 hp - $3000/mo for 5 months = $15,000
    Operator - ($26/hr)(8 hr/day)(21 work days/mo)(5 mo) = $22,000
Backhoe/loader, 45-60 hp, 3/4 cy - $2500/mo for 5 months = $12,000
    Operator - $25/hr for 5 months = $21,000
Grader, 25,000 lb - $5000/mo for 4 months = $20,000
    Operator - $26/hr for 4 months = $18,000
Dump truck, 12 ton - $3000/mo for 4 months = $12,000
    Operator - $21/hr for 4 months = $15,000
Concrete mixers, 2 cy, 2 mixers - $3000/mo for 2 months = $12,000
Generators (5), 1.5-3 kW; air compressor (1) - ($300/mo)(5 units)(5 mo) = $7,500
Pumps (2), 4", 560 gpm - $600/mo for 3 months = $4,000
Pumps (4), 6", 1590 gpm - $1700/mo for 3 months = $20,000
Office Trailer - $3,000
Misc. Equipment - $5,000
Equipment subtotal = $185,500
Maintenance (15%) = $28,000
Equipment Total = <u>$213,500</u>

3. River Diversion - Assume work done with dozer, so costs covered under Equipment.

4. Excavation of alluvium - Assume work done with dozer, backhoe, and dump truck, so costs covered under Equipment.

5. Dewatering - Pumps and generator costs covered under Equipment. Install upstream and downstream sumps using the 6" pumps. The 4" pumps will be placed in the excavation. Install sumps in 3-foot diameter, 20-foot long corrugated metal pipes.

    Sump CMP liners - ($35/ft)(20 ft)(4 pipes) = $3,000
    Misc. piping - $1,000
    Laborer - $20/hr for 3 months = $10,000
    Dewatering labor and pipe cost = <u>$14,000</u>

6. Excavating rock in key - Use hoe-ram attachment on backhoe, $1000 to deliver, attach, maint.

    Laborer - $20/hr for 10 days = $2000. Total rock exc = <u>$3,000</u>

7. Drill and install anchors in abutment.

   2 drillers - \$25/hr for 12 days = \$5000
   Drill rig - \$1500/day for 12 days + \$500 mobilization = \$19,000
   Total drilling = \$24,000

8. Hauling

   Cement - Assume 3 bags/cy x 1,282 cy = 3,846 bags = 361,500 lbs (94lb/bag) = 181 tons.
   Assume 3 tons/load, so 60 trips needed. 1 trip takes 1 day, so 60 trips is 85 calender days, or 3 months rent on truck.

   Trucks - \$1500/mo for 3 months = \$4,500
   Drivers - \$20/hr for 3 months = \$10,000

   Forms - 5 loads
   Rebar - 540 lbs/ft x 246 feet = 132,840 lb = 66 tons= 22 loads
   Anchors, misc. - 3 loads
   30 loads takes 1.5 months

   Trucks - \$1500/mo for1.5 months = \$2,500
   Drivers - \$20/hr for 1.5 months = \$5,000

Total hauling = \$22,000

9. Materials

   Cement - \$8/bag x 3,846 bags = \$31,000
   Reinf. steel - \$0.60/lb x 132,840 lbs = \$80,000
   Lumber, misc - \$20,000

Total materials = \$131,000

10. Forming and reinforcement - Cost of lumber and rebar covered under Materials

   2 carpenters - \$25/ hr for 40 days = \$16,000
   2 steel workers - \$27/hr for 30 days = \$13,000
   2 laborers - \$20/hr fof 40 days = \$13,000

Total forming and reinforcement labor = \$42,000

11. Mixing concrete - Mixers and loaders covered under Equipment.

   3 Laborers - \$20/hr for 30 days = \$15,000

12. Placing concrete - Cost of cement covered under Materials. Sand and aggregrate obtained at

no cost, processing costs under Equipment.

2 laborers - $20/hr for 30 days = $10,000
2 finishers - $24/hr for 30 days = $12,000

Total labor for placing concrete = $22,000

13. Backfilling - Most backfill work done with loader and dozer, those costs under Equipment.

Laborer - $20/hr for 17 days = $3,000

14. Other costs

Job superintendant - $30,000
Foreman - $29/hr for 105 days = $25,000
Equipment depreciation - $10,000
Total = $65,000

15. Summary of costs - Contingencies include minor construction activities and costs associated with runoff and flooding problems.

Subtotal of activities 2-14	= $556,000
Mobilization (10%)	= $ 55,600
	$611,600
Contingencies (25%)	= $152,900
	$764,500

Total estimated cost for a fish barrier at site No. 1 = $765,000

Cost estimate for Fish Barrier Site No. 3

The contract is estimated to take 4 months to complete. Most equipment and crew costs are taken from Means estimating guide for Heavy Construction.

1. Mobilization - 8% of subtotal of work = $35,760

2. Equipment

Dozer, 75 hp - $3000/mo for 4 months = $12,000
    Operator - ($26/hr)(8 hr/day)(21 work days/mo)(4 mo) = $18,000
Backhoe, 1 cy - $6000/mo for 3 months = $18,000
    Operator - $25/hr for 3 months = $13,000
Loader, 1-3/4 to 2 cy, 100 hp - $4000/mo for 3 months - $12,000
    Operator - $25/hr for 3 months = $13,000
Dump truck, 12 ton - $3000/mo for 4 months = $12,000
    Operator - $21/hr for 4 months = $15,000
Generators (5), 1.5-3 kW; air compressor (1) - ($300/mo)(5 units)(4 mo) = $6,000
Pumps (2), 4", 560 gpm - $600/mo for 3 months = $4,000
Pumps (4), 6", 1590 gpm - $1700/mo for 3 months = $20,000
Office Trailer - $3,000
Misc. Equipment - $5,000
Equipment subtotal = $151,000
Maintenance (15%) = $23,000
Equipment Total = <u>$174,000</u>

3. River Diversion - Assume work done with dozer, so costs covered under Equipment.

4. Excavation of alluvium - Assume work done with dozer, backhoe, and dump truck, so costs covered under Equipment.

5. Dewatering - Pumps and generator costs covered under Equipment. Install upstream and downstream sumps using the 6" pumps. The 4" pumps will be placed in the excavation. Install sumps in 3-foot diameter, 20-foot long corrugated metal pipes.

Sump CMP liners - ($35/ft)(20 ft)(4 pipes) = $3,000
Misc. piping - $1,000
Laborer - $20/hr for 3 months = $10,000
Dewatering labor and pipe cost = <u>$14,000</u>

6. Excavating rock in key - Use hoe-ram attachment on backhoe, $1000 to deliver, attach, maint.

Laborer - $20/hr for 6 days = $1000. Total rock exc = <u>$2,000</u>

7. Drill and install anchors in abutment.

2 drillers - $25/hr for 10 days = $4000
Drill rig - $1500/day for 10 days + $500 mobilization = $16,000
Total drilling = <u>$20,000</u>

8. Concrete - Cost of concrete includes transportation from a commercial source, materials, forming, reinforcement, placing, stripping forms, and curing.

($300/cy)(600 cy) = <u>$180,000</u>

9. Backfilling - Most backfill work done with loader and dozer, those costs under Equipment.

Laborer - $20/hr for 17 days = <u>$3,000</u>

10. Other costs

Job superintendant - $24,000
Foreman - $29/hr for 84 days = $20,000
Equipment depreciation - $10,000
Total = <u>$54,000</u>

11. Summary of costs - Contingencies include minor construction activities and costs associated with runoff and flooding problems.

Subtotal of activities 2-10	= $447,000
Mobilization (8%)	= <u>$ 35,760</u>
	$482,760
Contingencies (25%)	= <u>$120,690</u>
	$603,450

Total estimated cost for a fish barrier at site No. 1 = <u>$604,000</u>

Cost estimate for Fish Barrier Site No. 3, Caisson Option

The contract is estimated to take 4 months to complete. Most equipment and crew costs are taken from Means estimating guide for Heavy Construction.

1. Mobilization - 8% of subtotal of work = $32,480

2. Equipment

Dozer, 75 hp - $3000/mo for 3 months = $9,000
    Operator - ($26/hr)(8 hr/day)(21 work days/mo)(3 mo) = $14,000
Backhoe, 1 cy - $6000/mo for 3 months = $18,000
    Operator - $25/hr for 3 months = $13,000
Loader, 1-3/4 to 2 cy, 100 hp - $4000/mo for 3 months - $12,000
    Operator - $25/hr for 3 months = $13,000
Dump truck, 12 ton - $3000/mo for 3 months = $9,000
    Operator - $21/hr for 3 months = $11,000
Generators (5), 1.5-3 kW; air compressor (1) - ($300/mo)(5 units)(4 mo) = $6,000
Pumps (2), 4", 560 gpm - $600/mo for 3 months = $4,000
Pumps (4), 6", 1590 gpm - $1700/mo for 3 months = $20,000
Office Trailer - $3,000
Misc. Equipment - $5,000
Equipment subtotal = $137,000
Maintenance (15%) = $21,000
Equipment Total = <u>$158,000</u>

3. River Diversion - Assume work done with dozer, so costs covered under Equipment.

4. Excavation of alluvium - Assume work done with dozer, backhoe, and dump truck, so costs covered under Equipment.

5. Dewatering - Pumps and generator costs covered under Equipment. Install upstream and downstream sumps using the 6" pumps. The 4" pumps will be placed in the excavation. Install sumps in 3-foot diameter, 20-foot long corrugated metal pipes.

Sump CMP liners - ($35/ft)(20 ft)(4 pipes) = $3,000
Misc. piping - $1,000
Laborer - $20/hr for 3 months = $10,000
Dewatering labor and pipe cost = <u>$14,000</u>

6. Caisson installation - 40 ton crane and auger required. 18-inch diameter caissons, an average of 25 feet deep. 10 feet apart below upstream wall, 20 feet apart on downstream key.

($60/vertical ft)(25 ft)(15 caissons) = $23,000

7. Excavating rock in key - Use hoe-ram attachment on backhoe, $1000 to deliver, attach, maint.

Laborer - $20/hr for 6 days = $1000. Total rock exc = $2,000

8. Drill and install anchors in abutment.

2 drillers - $25/hr for 10 days = $4000
Drill rig - $1500/day for 10 days + $500 mobilization = $16,000
Total drilling = $20,000

9. Concrete - Cost of concrete includes transportation from a commercial source, materials, forming, reinforcement, placing, stripping forms, and curing. The caissons make undercutting the structure less of an issue, so scour protection extends only 8 feet below the channel (25-year scour depth).

($300/cy)(440 cy) = $132,000

10. Backfilling - Most backfill work done with loader and dozer, those costs under Equipment.

Laborer - $20/hr for 17 days = $3,000

11. Other costs

Job superintendant - $24,000
Foreman - $29/hr for 84 days = $20,000
Equipment depreciation - $10,000
Total = $54,000

12. Summary of costs - Contingencies include minor construction activities and costs associated with runoff and flooding problems.

Subtotal of activities 2-11	= $406,000
Mobilization (8%)	= $ 32,480
	$438,480
Contingencies (25%)	= $109,620
	$548,100

Total estimated cost for a fish barrier at site No. 1 = $549,000

Cost estimate for Fish Barrier Site No. 4

The contract is estimated to take 4 months to complete. Most equipment and crew costs are taken from Means estimating guide for Heavy Construction.

1. Mobilization - 10% of subtotal of work = <u>$65,700</u>

2. Equipment

58T helicopter - $1,400/hr for 4 days (2 days to mob and 2 to demob) = $45,000 (includes pilot)
Bell Long Ranger helicopter = $900/hr for 30 days = 216,000
Skip loaders/backhoes (3) - $1000/mo for 4 months = $12,000
Operators (3) - ($26/hr)(8 hr/day)(21 work days/mo)(4 mo) = $54,000
Generators (5), 1.5-3 kW; air compressor (1) - ($300/mo)(5 units)(4 mo) = $6,000
Pumps (2), 4", 560 gpm - $600/mo for 3 months = $4,000
Pumps (4), 6", 1590 gpm - $1700/mo for 3 months = $20,000
Office Trailer - $3,000
Misc. Equipment - $5,000
Equipment subtotal = $365,000
Maintenance (15%) = $55,000
Equipment Total = <u>$420,000</u>

3. River Diversion - Assume work done with skip loaders, so costs covered under Equipment.

4. Excavation of alluvium - Assume work done with skip loaders, so costs covered under Equipment.

5. Dewatering - Pumps and generator costs covered under Equipment. Install upstream and downstream sumps using the 6" pumps. The 4" pumps will be placed in the excavation. Install sumps in 3-foot diameter, 20-foot long corrugated metal pipes.

Sump CMP liners - ($35/ft)(20 ft)(4 pipes) = $3,000
Misc. piping - $1,000
Laborer - $20/hr for 3 months = $10,000
Dewatering labor and pipe cost = <u>$14,000</u>

6. Excavating rock in key - Use hoe-ram attachment on skip loader, $1000 to deliver, attach, maint.

Laborer - $20/hr for 10 days = $2000. Total rock exc = <u>$3,000</u>

7. Drill and install anchors in abutment.

2 drillers - $25/hr for 12 days = $5000

Drill rig - $1500/day for 12 days + $500 mobilization = $19,000
Total drilling = $24,000

8. Hauling materials by helicopter

Cement - Assume 3 bags/cy x 470 cy = 1,410 bags = 132,540 lbs (94lb/bag).
Assume 800 lbs/load, so 166 trips needed. 10 trips per day, so 166 trips takes 17 working days.

Forms - 15 trips
Rebar - 540 lbs/ft x 94 feet = 50,760 lb = 64 trips
Anchors, misc. - 9 trips
88 trips takes 9 days

Total Bell Long Ranger helicopter days required = 26 days

9. Materials

Cement - $8/bag x 1,410 bags = $12,000
Reinf. steel - $0.60/lb x 48,700 lbs = $30,000
Lumber, misc - $18,000
Total materials = $60,000

10. Forming and reinforcement - Cost of lumber and rebar covered under Materials

2 carpenters - $25/ hr for 40 days = $16,000
2 steel workers - $27/hr for 30 days = $13,000
2 laborers - $20/hr fof 40 days = $13,000

Total forming and reinforcement labor = $42,000

11. Mixing concrete - Mixers and loaders covered under Equipment.

3 Laborers - $20/hr for 30 days = $15,000

12. Placing concrete - Cost of cement covered under Materials. Sand and aggregrate obtained at no cost, processing costs under Equipment.

2 laborers - $20/hr for 30 days = $10,000
2 finishers - $24/hr for 30 days = $12,000

Total labor for placing concrete = $22,000

13. Backfilling - Most backfill work done with loader and dozer, those costs under Equipment.

Laborer - \$20/hr for 17 days = \$3,000

14. Other costs

Job superintendant - \$24,000
Foreman - \$29/hr for 84 days = \$20,000
Equipment depreciation - \$10,000
Total = \$54,000

11. Summary of costs - Contingencies include minor construction activities and costs associated with runoff and flooding problems.

Subtotal of activities 2-14	= \$657,000
Mobilization (10%)	= \$ 65,700
	\$722,700
Contingencies (25%)	= \$180,675
	\$903,375

Total estimated cost for a fish barrier at site No. 1 = \$904,000

Cost estimate for Juan Miller Crossing Upgrade

The contract is estimated to take 3 months to complete. Most equipment and crew costs are taken from Means estimating guide for Heavy Construction.

1. Mobilization - 8% of subtotal of work = $18,320

2. Equipment

Dozer, 75 hp - $3000/mo for 2.5 months = $8,000
    Operator - ($26/hr)(8 hr/day)(21 work days/mo)(2.5 mo) = $11,000
Backhoe, 1 cy - $6000/mo for 2.5 months = $15,000
    Operator - $25/hr for 2.5 months = $11,000
Generators (4), 1.5-3 kW; - ($300/mo)(4 units)(2.5 mo) = $3,000
Pumps (4), 4", 560 gpm - $600/mo for 2.5 months = $6,000
Office Trailer - $2,000
Misc. Equipment - $4,000
Equipment subtotal = $60,000
Maintenance (15%) = $6,000
Equipment Total = <u>$66,000</u>

3. River Diversion - Assume work done with dozer, so costs covered under Equipment.

4. Excavation of alluvium - Assume work done with dozer, backhoe, and dump truck, so costs covered under Equipment.

5. Dewatering - Pumps and generator costs covered under Equipment. Install upstream and downstream sumps and place pumps in the excavation. Install sumps in 3-foot diameter, 10-foot long corrugated metal pipes.

Sump CMP liners - ($35/ft)(10 ft)(4 pipes) = $2,000
Misc. piping - $1,000
Laborer - $20/hr for 1 months = $3,000
Dewatering labor and pipe cost = <u>$6,000</u>

6. Concrete - Cost of concrete includes transportation from a commercial source, materials, forming, reinforcement, placing, stripping forms, and curing.

($250/cy)(470cy) = <u>$120,000</u>

7. Backfilling - Most backfill work done with loader and dozer, those costs under Equipment.

Laborer - $20/hr for 10 days = <u>$2,000</u>

8. Other costs

Job superintendant - $15,000
Foreman - $29/hr for 53 days = $13,000
Equipment depreciation - $3,000
Total = $31,000

9. Summary of costs - Contingencies include minor construction activities and costs associated with runoff and flooding problems.

Subtotal of activities 2-8	= $229,000
Mobilization (8%)	= $18,320
	$247,320
Contingencies (20%)	= $ 49,464
	$296,784

Total estimated cost for a fish barrier at site No. 1 = $297,000

Cost estimate for Juan Miller Crossing Upgrade with Fish Barrier Components

The contract is estimated to take 4 months to complete. Most equipment and crew costs are taken from Means estimating guide for Heavy Construction.

1. Mobilization - 8% of subtotal of work = $45,920

2. Equipment

Dozer, 75 hp - $3000/mo for 3 months = $9,000
    Operator - ($26/hr)(8 hr/day)(21 work days/mo)(3 mo) = $14,000
Backhoe, 1 cy - $6000/mo for 3 months = $18,000
    Operator - $25/hr for 3 months = $13,000
Loader, 1-3/4 to 2 cy, 100 hp - $4000/mo for 3 months - $12,000
    Operator - $25/hr for 3 months = $13,000
Generators (4), 1.5-3 kW; - ($300/mo)(4 units)(4 mo) = $5,000
Pumps (2), 4", 560 gpm - $600/mo for 3 months = $4,000
Pumps (4), 6", 1590 gpm - $1700/mo for 3 months = $20,000
Office Trailer - $3,000
Misc. Equipment - $5,000
Equipment subtotal = $116,000
Maintenance (15%) = $17,000
Equipment Total = <u>$133,000</u>

3. River Diversion - Assume work done with dozer, so costs covered under Equipment.

4. Excavation of alluvium - Assume work done with dozer, backhoe, and dump truck, so costs covered under Equipment.

5. Dewatering - Pumps and generator costs covered under Equipment. Install upstream and downstream sumps using the 6" pumps. The 4" pumps will be placed in the excavation. Install sumps in 3-foot diameter, 10-foot long corrugated metal pipes.

    Sump CMP liners - ($35/ft)(10 ft)(4 pipes) = $2,000
    Misc. piping - $1,000
    Laborer - $20/hr for 2 months = $7,000
    Dewatering labor and pipe cost = <u>$10,000</u>

6. Concrete - Cost of concrete includes transportation from a commercial source, materials, forming, reinforcement, placing, stripping forms, and curing.

    ($250/cy)(1,500cy) = <u>$375,000</u>

7. Backfilling - Most backfill work done with loader and dozer, those costs under Equipment.

Laborer - \$20/hr for 10 days = <u>\$2,000</u>

8. Other costs

Job superintendant - \$24,000
Foreman - \$29/hr for 63 days = \$20,000
Equipment depreciation - \$10,000
Total = \$54,000

9. Summary of costs - Contingencies include minor construction activities and costs associated with runoff and flooding problems.

Subtotal of activities 2-8	= \$574,000
Mobilization (8%)	= \$ 45,920
	\$619,920
Contingencies (25%)	= \$154,980
	\$774,900

Total estimated cost for a fish barrier at site No. 1 = \$775,000

A caisson option similar to the one at site 3 would run about 20% less, or about \$620,000.

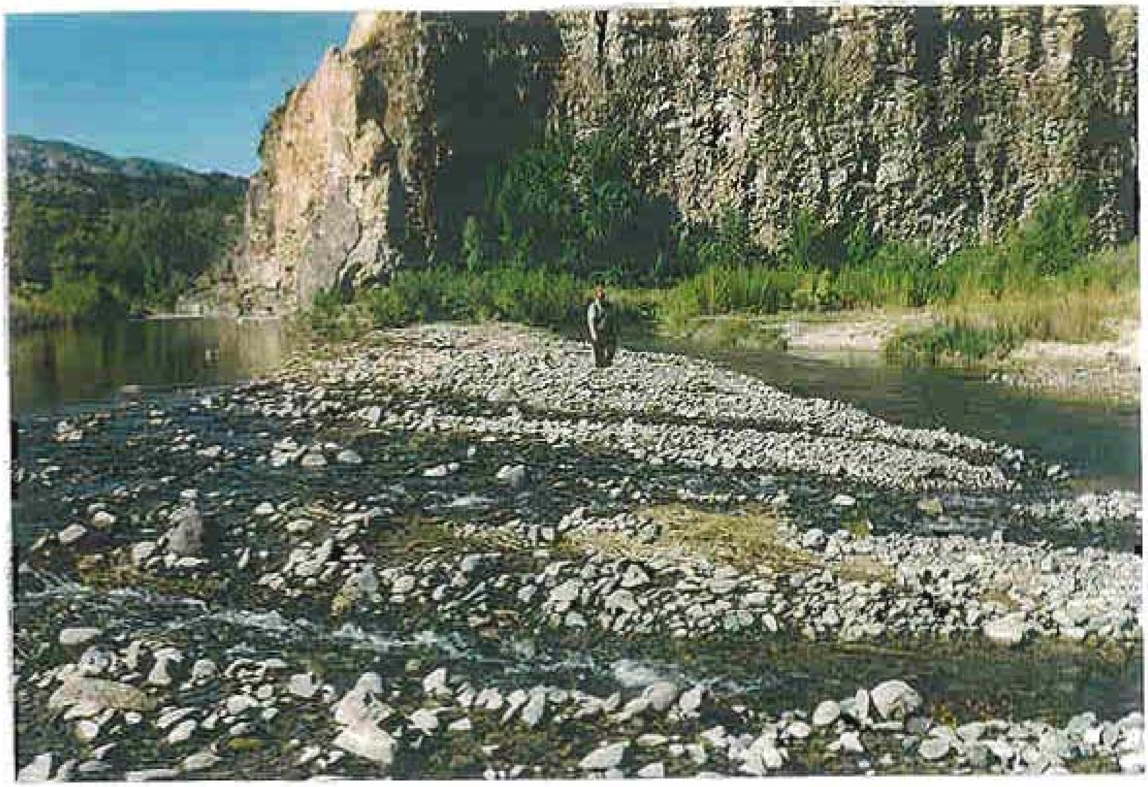


Photo 1 Blue River Fish Barrier October 16, 1997

View looking north (upstream) along the Blue River at the confluence with the San Francisco River. The east -west canyon wall is andesitic basalt with evidence of a fault-surface on the east side of the Blue River. A cobble-gravel bar at the center of the photo resembles other bars further upstream.

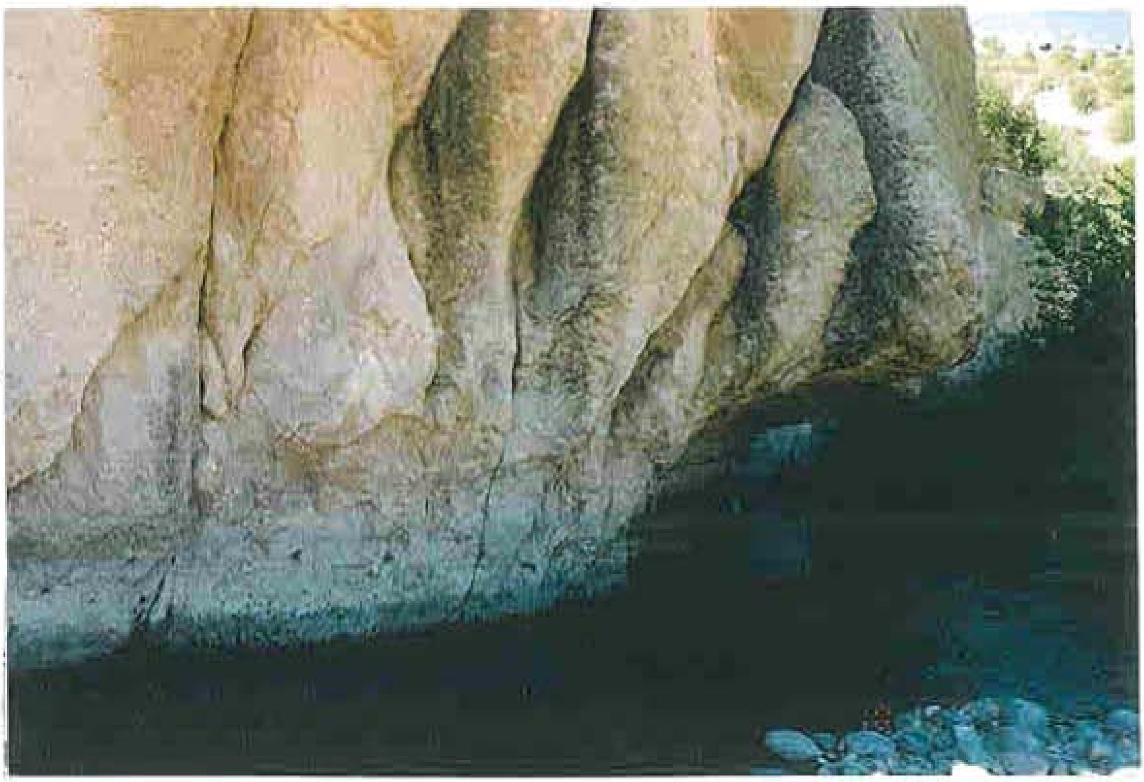


Photo 2 Blue River Fish Barrier October 16, 1997

Right abutment of Site 1 located approximately ½ mile upstream of the San Francisco River. The rock is massive lithic tuff with steep fractures.

Photo 3 Blue River Fish Barrier October 16, 1997

Left Abutment of Site 1 showing massive lithic tuff overlain by bedded tuff. Near the proposed centerline is an irregular eroded fracture that extends about three feet into the abutment.

Photo 4 Blue River Fish Barrier October 16, 1997

Left abutment of Site 1 upstream of centerline. At the center of the photo is a 1.1 foot wide basalt dike. Above the dike exposure, part of the bedded tuff is separated from the main outcrop and may require removal for safety.

Photo 5 Blue River Fish Barrier October 16, 1997

Close up of massive lithic tuff exposed along the Blue River. This tuff is underlain by basaltic andesite and overlain by bedded tuff and is typical of all of the sites examined. The rock is generally moderately hard to hard on the surface but is drummy in places.

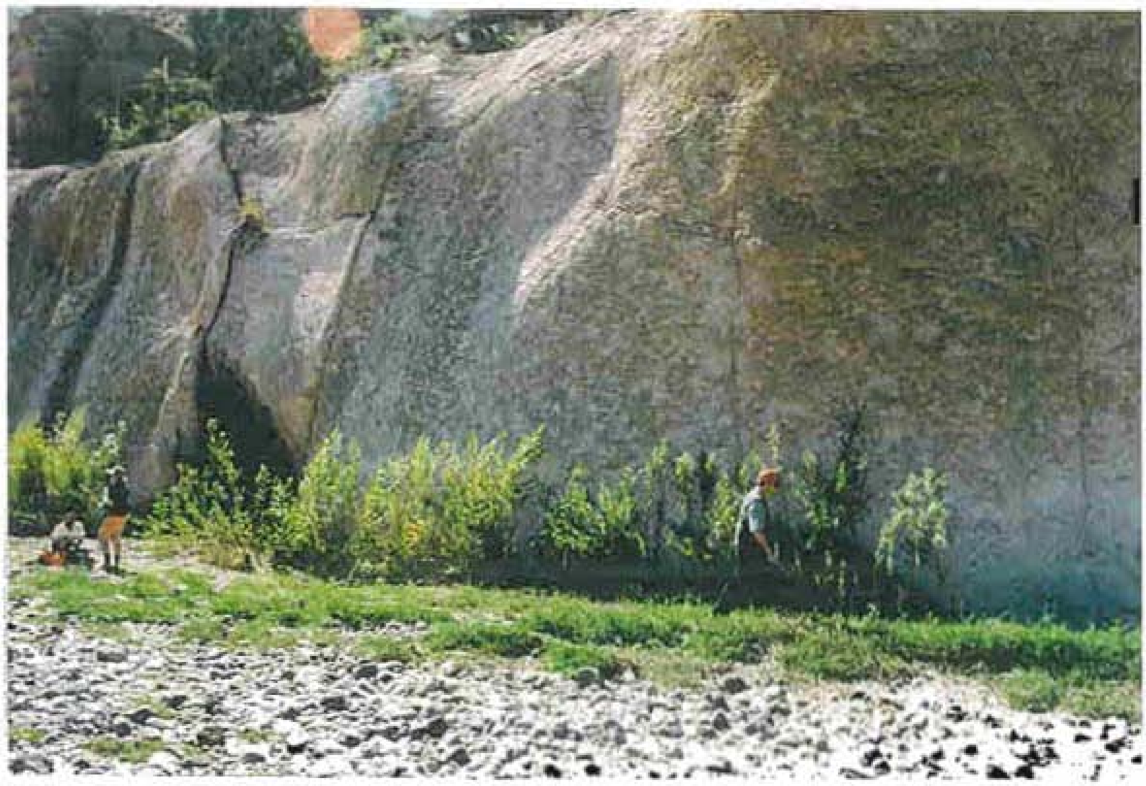


Photo 6 Blue River Fish Barrier October 16, 1997

Right abutment of Site 2. Rock is massive lithic tuff and photo shows two steep fractures and overhang near the proposed centerline. The centerline could be shifted upstream to avoid a potential slope movement along the fractures.

Photo 7 Blue River Fish Barrier October 16, 1997

Left Abutment of Site 2 showing narrow abutment at centerline and steep joints spaced about 10 to 30 feet apart.

Photo 8 Blue River Fish Barrier October 17, 1997

Blue River in the vicinity of Site 3 approximately 400 feet downstream of Juan Miller Crossing. There is a gaging station near the right abutment.

Photo 9 Blue River Fish Barrier October 17, 1997
View looking west of Juan Miller Crossing. The existing trail to the crossing curves to the right of the bedded tuff bedrock in the background. The flat area between the rock and the river is sand except for about 15 feet of tuff at the base of the cliff.

Photo 10 Blue River Fish Barrier October 17, 1997
View of Juan Miller Crossing looking westward across the Blue River. The channel is predominantly sand and gravel. Two large boulders are visible in the upper right of the photo. These were placed by the Forest Service to control the grade of the channel.

Photo 11 Blue River Fish Barrier October 17, 1997
View looking eastward of Juan Miller Crossing from the Blue River. Bedded tuff is in the background.