Fossil Creek Fish Barrier

Phase 1

Conceptual Study

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Table of Contents

I. INTRODUCTION

The headwater reaches of Fossil Creek, a travertine-forming, spring-fed stream in Yavapai and Coconino Counties, Arizona, in the Coconino and Tonto National Forests (see Figure 1), retains five native fish species to the exclusion of non-indigenous forms. These native species include the headwater chub (*Gila nigra*), Sonora sucker (*Catostomus insignis*), desert sucker (*Pantosteus clarki*), specked dace (*Rhinichthys osculus*), and longfin dace (*Agosia chrysogaster*).

Approximately 0.2 miles below the headsprings, nearly all of the 43 cubic feet per second (cfs) of the base discharge is diverted to power the Irving and Childs hydroplants. Modal flow downstream from the upper diversion dam 3.5 miles to the Irving hydroplant is maintained from leakage through the dam, and averages 0.2 cfs. From the Irving plant downstream 11 miles to the confluence with Verde River, modal discharge rises to approximately 2.0 cfs, primarily due to travertine deposition within the pipeline that prevents conveyance of the full 43 cfs. Non-native fishes have contaminated Fossil Creek from below the upper diversion dam to its mouth at the Verde River, and the native ichthyofauna there is impoverished.

Arizona Public Service (APS), the operator of the Childs and Irving hydropower plants under a Special Use Permit with the U.S. Forest Service, has agreed to surrender its Federal Energy Regulating Commission hydropower operating license and return all 43 cfs of the baseflow of Fossil Creek to its streambed by December 31, 2004. This action will provide a unique opportunity to restore the instream and riparian biotic communities to lower Fossil Creek, including possible repatriation of native fishes that may have historically occupied the stream that are now absent (e.g., loach minnow *Tiaroga cobitis*, spikedace *Meda fulgida*). As restoration of the native fish community necessitates removal of non-native forms, the lower stream must be first renovated and then repatriated with natives. To prevent reinvasion of non-native fishes following chemical treatment, physical barriers must be emplaced in the stream prior to the renovation.

The U.S. Fish and Wildlife Service and U.S. Bureau of Reclamation (Reclamation), in cooperation with the Arizona and New Mexico Departments of Game and Fish, have identified barrier construction feasibility (Phase I) investigations on lower Fossil Creek as a project to be funded under provisions of a reasonable and prudent alternative of the 1994 biological opinion on transportation and delivery of Central Arizona Project water to the Gila River basin, Arizona and New Mexico. These parties mutually determined that Reclamation would undertake these studies, which were to include an initial site visit and evaluation of site characteristics (topography, geology, access, substrate, gradient, and other conditions necessary for engineering design and construction considerations of barrier configuration), preparation of a report that summarizes and discusses site description and design/construction considerations, preliminary conceptual design, hydrology, estimation of contract and non-contract costs for construction, consideration of construction prerequisites including National Environmental Policy Act (NEPA), Endangered Species Act (ESA), and Clean Water Act (CWA) compliance, right-of-way and permits acquisition, and recommendations for further action or nonaction. This report provides results of three, one-day field investigations of potential fish barrier sites on Fossil Creek.

The first field investigation was performed on April 6, 2000. Participants included representatives from the U.S. Forest Service, Gerry Stefferud (Tonto National Forest) and Mark Whitney (Coconino Nation Forest); Paul Marsh of Arizona State University; and Rob Clarkson, Jeff Riley and Michael Miller of the U.S. Bureau of Reclamation. Three sites were investigated (Figure 2) and have been designated as fish barrier site 1, (upper site), fish barrier site 2 (lower site) and fish barrier site 3 (deep pool site). A second investigation was performed on May 12, 2000, to evaluate the potential of sites near the confluence of Fossil Creek and the Verde River. No suitable sites were located during the May 12 investigation. Fish barrier site 1 (upper site) was revisited on August 11, 2000, to evaluate the potential for erosion on the left bank of the upper site.

II. FISH BARRIER SITE 1 (upper site)

A. General - The upper site is located about 4.6 miles upstream of the confluence of the Verde River at coordinates Northing 3,801,265 and Easting 438,865 (Figure 2). At this location, the active channel is approximately 60 feet wide and has carved three slots in the bedrock (Photo 8). The stream presently flows through the center slot and into a small pool downstream. The creek then flows around and through a number of very large boulders and drops into a deeper pool. The water surface in the deep pool is approximately 8 to 10 feet lower than the water surface upstream of the slot. The proposed fish barrier would be comprised of filling all three slots with separate concrete plugs.

B. Construction Access - There are no existing trails to the upper site. Access was achieved by hiking upstream from fish barrier site 2 (lower site). All construction materials would need to be brought in by helicopter or packed in by mule train. The canyon is narrow and offers no flat areas to deliver equipment. Travel along the stream channel may be difficult during periods of high stream flow.

C. Fish Barrier Structure - Illustrations of the concrete structures in each of the 3 slots are shown in figures 4 and 5. Figure 6 shows the barrier configuration and dimensions in the direction of the streamflow. The crest elevation of the center slot is shown as one foot lower than slots 1 and 3. This allows the entire 43 cfs to discharge through the center slot. This is done to keep stream flows centered within the channel and away from the abutments as much possible. Flows greater than 80 cfs will discharge from all three slots. Biologists will need to provide input as to whether this is a desirable situation.

D. Geology - The site for the fish barrier was selected at a natural break in the slope of the stream. Three slots have been carved into the rock by flowing water.

Right Abutment - The right abutment of the proposed fish barrier rises 7 feet vertically above the top of the right slot to a bench that slopes gently to the right (Photo 9). Profiles perpendicular to the stream and in the thalweg upstream of the proposed fish barrier site were conducted and are shown on Figure 3 as Profiles 3 and 4, respectively.

Stream Channel - Three slots have been carved into the bedrock. The right slot (slot #3) is approximately 2 feet deep and 5 feet wide (Photo 8). No alluvial material fills the slot. One foot downstream of centerline, the rock surface drops 5 feet (Photo 9). The center slot (slot #2) is approximately 8 feet wide and 7 feet deep. The sides of the slot are slightly undercut and irregularly shaped (Photos 8, 9 and 11). During the site investigation, water was flowing through the slot at a depth of about 7 inches. No alluvial material was observed, but large boulders are present upstream and downstream. The left slot (slot #1) is approximately 8 feet wide and may be up to 9 feet deep (Photos 8, 9 and 11). The total depth to rock is unknown since it is filled with sand- to boulder-size material, but the alluvium is thought to be no more than 3 feet deep.

Left Abutment - The bedrock of the left abutment slopes up from the top of the left slot until it is 1.5 feet higher than the lip of the slot. Beyond this point the bedrock is obscured by large boulders (Photos 9 and 10).

Left of the boulders, the ground surface rises to 9 feet above the stream channel, then descends about 3 feet into a dry channel filled with alluvium and vegetation. It is not known how deep bedrock is in the channel left of the boulders. The dry channel is approximately 6 feet above the current water surface of the stream. Where the dry channel splits off from the active stream, the elevation difference from the stream up to the dry channel is 9 feet, the same as at the barrier site. Therefore, flood flows need to be running about 9 feet above normal before water enters the dry channel. During a large enough flood, the dry channel may offer an avenue upstream for fish. This frequency flood will be determined and evaluated during the design phase. If deemed necessary, two small (9 feet across) gabion fish barrier drop structures can be installed where the channel runs between 20-foot diameter boulders to prevent upstream fish movement.

Volcanics consisting of alternating layers of basalt and agglomerate ranging from 1 to 4 feet thick form the exposed stream channel and abutments of the upper site (Photos 9 and 12). The basalt is moderately to slightly weathered, moderately hard to hard and possesses amygdaloidal texture. Amygdules are 1/4 to 1 inch in diameter and are filled with calcium carbonate. The basalt also contains numerous, irregular fractures, 1 to 3 feet long and filled with 1/4 to 2 inches of calcium carbonate. The agglomerate is composed of 65 percent 1/2 to 3 inch diameter scoriaceous basalt fragments in a fine-grained, tuffaceous matrix. The agglomerate is moderately weathered and moderately soft to moderately hard (soft at the surface). Alluvium consisting of sand, gravel, cobbles and boulders up to 3 feet in diameter fill slots #1 and #2 to an unknown depth.

D. Foundation Cleanup - Most of the proposed site is free of alluvium and would require minimum foundation cleanup prior to concrete placement. Excavation of the alluvium in the bottom slot #1 will be required.

III. FISH BARRIER SITE 2 (lower site)

A. General - Fish barrier site 2 (lower site) is located about 1500 feet downstream of fish barrier site 1 (Figure 2), near the base of a small terrace (Photo 1) at coordinates Northing 3,800,855 and Easting 438,772. The stream channel abutments are composed entirely of rock. The stream channel itself contains alluvial materials to an estimated depth of 8 to 9 feet. The site is located at the upstream end of a pool, which will make an apron necessary.

B. Construction Access - There are no existing trails from the road to Fossil Creek, so access was obtained by hiking down a steep slope, utilizing cow paths when possible. The slope flattens out into a terrace, approximately 20 feet higher than the stream. The terrace is upstream of the site and is the only flat area of any size that could be used as a delivery point for equipment and materials brought in by helicopter. All construction materials would need to be brought in by helicopter or packed in by mule train. Travel along the stream channel may be difficult during periods of high stream flow.

C. Fish Barrier Structure - Figure 7 shows a cross-section of the current stream channel and indicates our approximation of depth of alluvium to rock. Figures 8 and 9 show the barrier configuration and dimensions.

D. Geology - The site for the fish barrier was selected at a point where the creek narrows to about 30 feet wide (Photo 2). Profiles perpendicular to the stream and in the thalweg upstream of the proposed fish barrier site were conducted and are shown on Figure 3 as Profiles 1 and 2, respectively.

Right Abutment - The right abutment rises in a smooth slope to about 12 feet above the water surface. At the break in slope, a few large boulders sit on the bedrock surface (Photo 4).

Stream Channel - The stream channel is about 22 feet wide and is filled primarily by basalt boulders up to 4 by 4 by 3 feet in size. Bedrock is exposed on both sides of the channel and is estimated to be less than 8 feet below the water surface in the channel.

Left Abutment - A 5- to 7-foot wide rib of bedrock extends 6 to 10 feet above the water surface on the left bank and would form the left abutment of the fish barrier (Photo 3).

Basalt forms the abutments and channel. The basalt is moderately to slightly weathered and very intensely fractured at the surface, but becomes slightly weathered to fresh and moderately to slightly fractured a few inches into the body of the rock (Photo 5). When struck with a hammer, the surface of the basalt commonly breaks into coarse gravel-size fragments. The rock beneath is usually hard and rings with a hammer blow. The basalt contains numerous, irregular fractures, 6 inches to 3 feet long and filled with 1/4 to 2 inches of calcium carbonate. The fractures tend to be oriented perpendicular to the stream channel.

E. Foundation Cleanup - The abutments of the proposed fish barrier would require minimum foundation cleanup and removal of weathered, very intensely fractured rock prior to concrete placement. Excavation of the alluvium in the channel would be required.

IV. FISH BARRIER SITE 3 (deep pool)

A third site was investigated downstream of fish barrier site 2, but was later rejected due to the presence of a deep pool directly downstream (Photo 7). According to the fish biologists, high flows could form standing wave hydraulics which could assist fish trying to negotiate past the barrier. Construction of an apron could negate this concern.

V. ENGINEERING AND DESIGN CONSIDERATIONS

The primary challenge at both the upper site and the lower site is anchoring the structures adequately to rock to prevent movement of the structure during high flows. The two sites were selected in large part because of the exposed rock outcrops, which will allow for excellent anchoring and provide good rock to concrete bonding.

In addition to the forces from the water during high flow events, the barriers will sustain severe impact loads from rolling and bouncing boulders and vegetative debris being carried by the flows. These lòads will need to be evaluated during the design phase.

It is anticipated that the boulders will mar and chip the concrete barrier, especially the upstream face of the barrier and the apron of the lower site barrier. On the upstream face of the barriers, this damage will be obscured by the sediment level, and should cause no structural damage. The apron of the lower barrier, however, will sustain visible damage unless efforts are undertaken to mitigate these effects. Large rocks tumbling off the crest of the barrier and falling 4 feet onto the apron will chip pieces of concrete out. A hole could develop creating an area for fish to gather at the base of the drop, negating the function of the apron. This erosion could be controlled with steel plates to protect the apron, additional rebar in the concrete at the impact area to arrest the development of the hole, or sacrificial concrete which could be eroded without resulting in a low spot. Steel apron plates were used on the Tule Creek fish barrier north of Lake Pleasant in Arizona. Additional rebar was installed in the aprons of the Aravaipa Creek fish barriers near Dudleyville, Arizona.

Because of the difficulty in getting rock excavating equipment to either site, anchorage will probably rely entirely on anchor bars, not an excavated key. Chipping keys into the rock at either site would require a hoe-ram or much costly hand work. It is our belief that adequate anchorage can be achieved with anchor bars. Calculations will be performed during the design phase to verify this assumption.

Steel reinforcement is not shown on the figures, but will be necessary. All exposed surfaces will need to be heavily reinforced.

Because Fossil Creek is not gauged, frequency flood magnitudes and hydrographs will need to be created empirically. The barrier will be designed to withstand at least the 100-year frequency flood.

If concrete is to be batched at the site using the water from Fossil Creek, the chemistry of the water should be evaluated. This is necessary to determine if the chemical makeup of the water is compatible with the cement. Incompatible water and cement can cause cracking of the concrete.

Engineering and design costs to develop complete construction specifications are estimated to be approximately 10 to 12% of the construction cost. However, this percentage would be higher if only the upper barrier is constructed because of the low cost of the upper barrier. Likewise, if both barriers are constructed, the design costs as a percentage of the total cost would go down. More detailed engineering and design costs estimates are included in the Cost Estimates section of this report.

VI. CONSTRUCTION CONSIDERATIONS

The remoteness and lack of vehicular access are the most notable characteristics of this project. Transporting materials and personnel from the road to the selected site will require helicopter or pack animals. Getting personnel to the site will involve horses or hiking. The closest commercial concrete batch plant is about one hour away, whether from Camp Verde or Payson. Concrete and materials will need to be trucked in to the Stehr Lake area, mostly on windy, gravel roads.

The site is situated within a designated wilderness area and therefore precludes the use of mechanized equipment without a waiver. It is our opinion that such a waiver must be obtained to properly perform certain key aspects of the work. For example, anchor bars will be installed in the rock to tie the concrete structure to the rock foundation. Without the ability to mechanically drill the holes for the anchor bars, we are concerned that it may not feasible to drill the holes to the required depth which will develop the full strength of the anchor. Power saws for forms and concrete vibrators need to run off generators. Concrete batched on-site will require gas powered mixers. Because of the importance of proper anchorage for these structures, the work described in this report is based on the assumption that a waiver will be obtained to allow the use of mechanized equipment. Hypothetically the project could be constructed without the use of mechanized equipment, although such a restriction would change certain aspects of the design and construction approach, and would substantially increase costs.

If helicopters are used to transport equipment and materials to the fish barrier, the contractor would probably set up a helipad near Stehr Lake. This would result in a 1.4 mile flight line distance to the lower site, and 1.1 miles to the upper site (one way). The actual load capacity of a specific helicopter is highly dependant on elevation. Load capacities are estimated below, but these figures should be used only as a general guide.

A large helicopter, like a Sikorsky S58T, may be required during mobilization to transport equipment such as concrete mixers, skip loader or small backhoe (if needed) to 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. Backhoes can also be disassembled, flown into the site in pieces, and reassembled at the work area. "Llama" helicopters are capable of transporting about 2,000 pounds and would be a cost effective way to haul ready-mix concrete to the site.

Hourly helicopter rates are dependant on the proximity of the craft to the project. There is a good chance that an S58T and a Llama would be stationed in the Phoenix area. The rates given assume the specific helicopters are located in Phoenix. An S58T would cost about $1,600/hour. The Llama would cost about $1,300/hour.

After initial equipment mobilization a smaller, more standard size helicopter would provide support for the duration of the contract. Bell Long Rangers can carry about 1,000 pounds and typically cost $900/hour. Bell Jet Rangers are smaller and carry about 700 pounds. A helicopter of this size could haul cement, pumps, and other small equipment.

Although helicopters are not allowed to land within wilderness areas without a waiver, we suggest requesting such a waiver for the lower site. There is a convenient terrace about 20 vertical feet above the stream which would provide an excellent landing site. Safety of personnel is the primary consideration for a waiver request. Attempting to detach loads swinging below an airborne helicopter increases the potential for injury, as opposed to unloading cargo from a grounded helicopter. Cost and efficiency are additional reasons to request landings. If allowed to land, personnel and equipment can be shuttled to the site on a daily basis. Without landings, personnel must access the site on foot or by horseback. The more inefficiencies created by landing restrictions, the higher the cost of the project. In addition, mule trains are more likely to impact the terrain than a helicopter. However, since helicopter landing waivers are difficult to obtain, our estimates assume that landings will not be allowed.

If pack animals are used instead of helicopters to haul equipment and materials, laydown areas at Stehr Lake and at the barrier site will need to be established. A trail would be created by the repeated passage of the animals. It is assumed that the pack animals used would be mules. They would be loaded with 100 to 200 pounds of materials. The cost runs about $200 per day per mule.

From Stehr Lake to the stream, the elevation difference is 740 feet. The ground distance to the lower site from the lake is 1.7 miles. The upper site is 2.0 miles from Stehr Lake and is accessed by traveling up the stream from the lower site. These distances can be hiked on foot or traveled on horseback. There is currently no trail. Because of the effort associated with getting people to the site, it is likely the contractor personnel will camp at the work site, coming out once or twice a week.

There are two ways to approach concrete transport to the fish barrier. The concrete could be batched at a commercial site, trucked to a site near Stehr Lake, transferred to a ¼ or ½ cy bucket, and flown via helicopter directly to the barrier structure. The concrete would be deposited directly from the bucket below the hovering helicopter to the structure formwork.

The other approach would be to transport the concrete materials (cement, sand, and gravel) to the site by helicopter or mule train. The materials would then be batched onsite using small mixers. This assumes that water from the stream can be used in the concrete mix. Mixers need to be portable, able to be lifted by a helicopter.

As discussed above, helicopters can deliver hydraulic equipment to break and remove alluvial boulders. However, if pack animals are used as the sole means of transport, boulders and cobbles at the lower site would be removed with labor intensive hand chipping or blasting. We assume in this report that blasting would be the contractor's preferred method to break boulders down to a size that can be excavated. Blasting would be limited to alluvial materials, and would probably involve about 5 individual blasts. A wilderness area waiver would likely be required in order to blast.

The contractor performing the construction will have several options regarding stream diversion. One option is to pump and siphon the entire current flow of 2 cfs around the job site. This method is heavily reliant on generators, but simplifies diversion channeling. Option 2 involves diverting the streamflow from one side of the channel to the other to allow concrete construction. This method will probably require a gap in the concrete or a culvert embedded in the concrete that will be filled in as a final activity. The third option would be to divert the stream into a culvert far enough upstream of the construction work that the culvert can pass over the crest of the barrier, thereby not interfering with the structure. This option is more feasible with a steep stream thalweg. A flatter stream slope requires a longer culvert run.

VII. NEPA, ESA, and CLEAN WATER ACT

Consideration of a Fossil Creek fish barrier(s) beyond the feasibility stage must include provisions for compliance with NEPA, ESA, and CWA. The U.S. Forest Service is ultimately the action agency for a potential fish barrier project on their land, but delegation of much of any compliance activities could be made to Reclamation or a private consultant. The NEPA process entails writing draft and final Environmental Assessments of the preferred project and its considered alternatives, and presenting the preferred and alternative projects at public meetings. The NEPA process can take 6-12 months to complete. Reclamation estimates that its performance of all NEPA-required activities would cost approximately $20,000.

The acquisition process for a 404 permit under requirements of CWA includes determining the impact footprint of the barriers (flooding, sedimentation, and construction zones), receiving a jurisdictional delineation from U.S. Army Corps of Engineers, further processing of a 404 permit application, and identification of possible mitigation for certain impacts to "waters of the US." Processing time for compliance with CWA can take 6-12 months. Reclamation estimates that compliance costs associated with CWA regulations would be an additional $20,000.

ESA compliance likely will involve writing a Biological Assessment that determines effects of the project to federally-listed species and designated critical habitat of loach minnow and spikedace. Although Fossil Creek is unoccupied by these latter species, the fish barrier project will certainly affect their critical habitat, and thus project impacts likely must be formally consulting on with U.S. Fish and Wildlife Service (FWS). As the project is for the benefit of native fishes, consultation with FWS should proceed smoothly, as it did recently with Reclamation's Aravaipa Creek fish barrier project. Reclamation estimates that ESA compliance activities should not take more than 3-6 months, depending on the priority it receives from FWS. Estimated costs for ESA compliance is approximately $10,000.

VIII. CONCLUSIONS AND RECOMMENDATIONS

Both the upper and lower sites provide good rock foundations for fish barrier structures to be constructed. The upper site requires less concrete and will be less costly to build than the lower site.

The only large concern we have with either site is the dry channel to the left of the upper barrier. This channel is discussed in detail in the upper barrier section of this report. This side channel will need to be discussed further to evaluate the risk of fish movement during high flows when the channel could be carrying water.

For purposes of estimating costs, we used a 10-foot long apron at the lower site. The apron is not necessary from a structural stability standpoint. However, since flows would discharge directly into a standing pool without an apron, fisheries biologists consider an apron to be necessary. The reason this issue is being mentioned here is that the apron makes up a large part of the concrete quantity (46%) of the lower barrier, and therefore the cost. The length of the apron could be shortened to reduce costs, or lengthened as necessary to prevent a hydraulic situation that could assist fish movement over the barrier. Fisheries biologists should be consulted to determine a suitable apron length.

There is no need for further geologic or materials site investigations if Reclamation is responsible for preparing the construction specification. One more site visit may be required after development of the specifications to confirm assumptions made during the design process.

It is our opinion that engineering and design costs would be similar whether Reclamation or a private engineering firm performs the work. Reclamation will be able to provide construction management services during the construction of the barriers, which involves inspection, construction safety enforcement, and contract administration (payments to contractor, handling modifications and contract disputes).

In conclusion, if the Forest Service wishes to proceed with this project, we believe there are no technical reasons to prevent this project from moving forward.

IX. CONSTRUCTION COST ESTIMATES

General - These cost estimates assume that there will be no waivers of wilderness area restrictions and that construction will be performed using wilderness techniques. Therefore, no roads will be constructed to the site; labor and equipment will access the site by foot, by helicopter, or by mule train; and helicopters will not be allowed to land.

Costs will be escalated by the inherent difficulties associated with constructing fish barriers at the identified locations. These difficulties include the remoteness of the sites, distance to commercial concrete batch plants, road conditions for hauling equipment and materials, lack of vehicular access to the barrier sites, and wilderness area restrictions. These costs are the primary reason for the high contingency figures (25%) shown in the estimates.

Whether the contractor elects to camp at the site or stay in town should not significantly affect costs. Any additional costs associated with camping are part of the contingencies costs.

Estimates for both the upper and lower fish barrier sites include the same three options; helicopters transporting ready mixed concrete, helicopters transporting concrete materials to batched on site, and using pack animals to transport concrete materials.

A discussion on helicopter considerations, costs, and load capabilities can be found in the Construction Considerations section of this report.

Most equipment costs are taken from Means Building Construction Cost Data, 2000. Labor costs are estimated using actual rates from recent Reclamation jobs.

A. <u>Cost Estimate for Upper Site - helicopter option using ready mixed concrete</u>

This estimate is based on the work being performed in 21 calendar days. Assume that the contractor will work 6 days per week, 10 hours per day, for 18 total working days, or 180 hours.

1. Mobilization - 10% of subtotal of work = $11,583

2. Equipment

Llama helicopter - Use to transport ready mixed concrete from the Stehr Lake area directly to the structure, haul equipment and materials. Assume concrete transported in ½ cy buckets. Total of 25 cy of concrete. Assume 7 minutes per round trip.

(25 cy/0.5 cy per trip)(7 minutes/trip)(1 hr/60 minutes) = 5.8 hours, say 6 hours

Assuming stream diversion is accomplished with pumps and siphons, all three concrete dams can be placed in one day. Considering flying time to a Phoenix hanger and refueling, assume a 10-hour day for the helicopter.

($1,300/hr)(10 hours) = $13,000

Bell Long Ranger helicopter - Use for transporting formwork, supplies, equipment, and tools.

Transporting materials into site - ($900/hour)(2 days)(10 hours/day) = $18,000
Demobilization - ($900/day)(2 days)(10 hours/day) = $18,000

Helicopter total cost = <u>$49,000</u>

Generator, 1.5-3 kW; air compressor
(2 units)($400/mo/unit)(1 mo) + ($1.50/hr)(180 hrs)(2 units) = $1,340
rent + hourly operating cost

Pumps (4), 4", 560 gpm
(4 pumps)($650/mo/pump)(1 mo) + ($2.50/hr)(100 hrs)(4 pumps) = $3,600

Siphons and siphon starter pumps - $2,000

Miscellaneous equipment - $2,000

Equipment Total (not including helicopters) = <u>$8,940</u>

3. Labor - Since helicopters will not be allowed to land, personnel will need to access the site on foot or by horseback. This estimate assumes 5 horses will need to be utilized for transportation for three weeks; 4 for the contractor and 1 for the cowboy who will provide rigging and care. Horse costs include food and corrals.

Superintendent/Foreman - ($30/hr)(180 hours) = $5,400
Carpenters (2) - ($17/hr)(180 hours)(2 carpenters) = $6,120
Laborers (3) - ($15/hr)(180 hours)(3 laborers) = $8,100
Cowboy - ($15/hr)(180 hours) = $2,700
Horses (5) - ($200/day/horse)(21 days)(5 horses) = $21,000

Labor total = $43,320

4. River Diversion - In the interest of placing all concrete in one day, thereby reducing helicopter time, the contractor will probably consider diverting all flows with pumps and siphons. This strategy eliminates the need to divert the stream from one slot to another slot, which would require concrete placements on at least 2 days. Pumps and siphon materials costs are included under Equipment.

5. Excavation of alluvium - Assume all work done by hand, so costs covered under Equipment and Labor.

6. Dewatering - Pumps and generator costs covered under Equipment. Discharge hoses - $400

7. Drill and install anchors in rock. Use jackleg drill setup. 2 rows of anchors at upstream end and 2 rows at downstream end. Anchor rows are 2 feet apart, anchors spaced 2 feet on centers. 100 bars required. Anchors are #8 bars, doweled into rock 8 feet. The drillers are accounted for as laborers under Labor. Anchors and grout are listed under materials.

Rent jackleg drills (2) - ($300/week/drill)(3 weeks)(2 drills) = $1,800

8. Materials - All materials will be transported by helicopter from a laydown area at Stehr Lake. Material costs include delivery to Stehr Lake.

Concrete - ($120/cy)(25 cy) = $3,000
Rebar - ($0.65/lb)(110 lb/cy)(25 cy) = $1,788
Anchor bars - ($0.65/lb)(6,500 lb) = $4,225
Anchor bar grout - (18 cu ft bags)($20/bag) = $360
Forming lumber - $1,500
Miscellaneous materials - $1,500

Total materials = $12,373

9. Backfilling will be done by hand, so costs are covered under Labor.

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

Subtotal of activities 2-9	= $115,833
Mobilization (10%)	= $ 11,583
	$127,416
Contingencies (25%)	= $ 31,854
	$159,270

Total cost at the upper site, using ready mixed concrete transported by helicopter = $159,000

B. Cost Estimate for Upper Site - helicopter transporting materials, mix concrete at the work site

This estimated assumes the work will be performed in 28 calendar days. Assume that the contractor will work 6 days per week, 10 hours per day, for 24 total working days, or 240 hours.

1. Mobilization - 10% of subtotal of work = $16,389

2. Equipment

Bell Long Ranger helicopter - Use for transporting all materials, formwork, supplies, equipment, and tools to the site.

Weight of materials:

Cement - (25 cy concrete)(450 lb/cy) = 11,250 lbs
Sand - (25 cy)(1,000 lb) = 25,000 lbs
Aggregate - (25 cy)(2,000 lb) = 50,000 lbs
Water will be obtained from the stream = 0 lbs

Subtotal concrete materials = 86,250 lbs. Specify that on-site cobbles be liberally added within the forms during concrete placement to reduce concrete quantity by 10%. Therefore reduce materials quantities by 10%:

Concrete materials = 78,000 lbs
Rebar and anchor bars = 10,000 lbs
Total concrete materials = 88,000 lbs

Bell Long Ranger can transport about 1000 pounds per load. Assume actual weight of 800 pounds per load.

Transporting concrete materials - 88,000 lb / 800 lb per load = 110 loads.

Assuming round trip every 15 minutes and 8 hours of hauling each day:

(98 loads)(0.25 hours/load)(1 day/8 hours) = 3.4, say 4 days of helicopter time.

Transporting all other materials into site - 1 day

Assume 10 hour helicopter days, which will include flying time from hanger and refueling.

($900/hour)(4 days + 1 day)(10 hours/day) = $45,000
Demobilization - ($900/hr)(2 days)(10 hours/day) = $18,000

Helicopter total cost = $63,000

Generator, 1.5-3 kW; air compressor

(2 units)($400/mo/unit)(1 mo) + ($1.50/hr)(240 hrs)(2 units) = $1,520

rent + operating costs

Pumps (4), 4", 560 gpm

(4 pumps)($650/mo/pump)(1mo) + ($2.50/hr)(200 hrs)(4 pumps) = $4,600

Concrete mixers (2), 6 cu ft, 7 hp

(2 mixers)($510/mo/mixer) + ($1/hr)(240 hrs)(2 mixers) = $1,500

Siphons and siphon starter pumps - $2,000

Miscellaneous equipment - $2,000

Equipment Total (not including helicopters) = $11,620

3. Labor - Since helicopters will not be allowed to land, personnel will need to access the site on foot or by horseback. This estimate assumes 7 horses will need to be utilized for transportation for 4 weeks; 6 for the contractor and 1 for the cowboy in charge of rigging and care. Horse costs include food and corrals.

Superintendent/Foreman - ($30/hr)(240 hours) = $7,200
Carpenters (2) - ($17/hr)(240/hours)(2 carpenters) = $8,160
Laborers (5) - ($15/hr)(240 hours)(5 laborers) = $18,000
Cowboy - ($15/hr)(240 hours) = $3,600
Horses (7) - ($200/day/horse)(27 days)(7 horses) = $37,800

Labor total = $74,760

4. River Diversion - In the interest of placing all concrete in one day, thereby reducing helicopter time, the contractor will probably consider diverting all flows with pumps and siphons. This strategy eliminates the need to divert the stream from one slot to another slot, which would require concrete placements on at least 2 days. Pumps and siphon materials costs are included under Equipment.

5. Excavation of alluvium - Assume all work done by hand, so costs covered under Equipment and Labor.

6. Dewatering - Pumps and generator costs covered under Equipment. Discharge hoses - $400

7. Drill and install anchors in rock. Use jackleg drill setup. 2 rows of anchors at upstream end and 2 rows at downstream end. Anchor rows are 2 feet apart, anchors spaced 2 feet on centers.

100 bars required. Anchors are #8 bars, doweled into rock 8 feet. The drillers are accounted for as laborers under Labor. Anchors and grout are listed under materials.

Rent jackleg drills (2) - ($300/week/drill)(3 weeks)(2 drills) = <u>$1,800</u>

8. Materials - All materials will be transported by helicopter from a laydown area at Stehr Lake. Material costs include delivery to Stehr Lake.

Cement - ($10/bag)(108 bags (@94 lbs/bag)) = $1,080
Sand - (22,500 lbs)(1 ton/2000 lbs)($45/ton) = $507
Aggregate - (45,000 lbs)(1 ton/2000 lbs)($60/ton) = $1,350
Rebar - ($0.65/lb)(110 lb/cy)(25 cy) = $1,788
Anchor bars - ($0.65/lb)(6,500 lb) = $4,225
Anchor bar grout - (18 cu ft bags)($20/bag) = $360
Forming lumber - $1,500
Miscellaneous materials - $1,500

Total materials = <u>$12,310</u>

9. Backfilling will be done by hand, so costs are covered under Labor.

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

Subtotal of activities 2-9	= $ 163,890
Mobilization (10%)	= <u>$ 16,389</u>
	$ 180,279
Contingencies (25%)	= <u>$ 45,070</u>
	$ 225,349

Total cost at the ~~lower~~ upper site, helicopter transporting materials, mixing concrete at site = <u>$225,000</u>

C. Cost Estimate for Upper Site - pack animal option, no helicopters

This estimate is based on the work being performed in 35 calendar days. Assume that the contractor will work 6 days per week, 10 hours per day, for 30 total working days, or 300 hours.

1. Mobilization - 10% of subtotal of work = $14,746

2. Equipment

Pumps (4), 4", 560 gpm

(4 pumps)($650/mo/pump)(1 month) + ($2.50/hr)(240 hrs)(4 pumps) = $5,000
rent + operating costs

Siphons and siphon starter pumps - $2,000

Miscellaneous equipment - $2,000

Equipment Total = $9,000

3. Labor - Materials and equipment will be transported to the site via pack animals. Personnel will access the site on foot or by mule. This estimate assumes that mules will need to be utilized for 35 calendar days. Mule costs include food and corrals. Assume mules will require a cowboy with horse for rigging and care. Assume contractor personnel can utilize the mules for access to site.

Time required to haul materials and equipment:

Concrete materials, rebar, and lumber weighs 88,250 pounds. Assume equipment adds another 1,000 pounds, for a total of 90,000 pounds. Assuming average mule load is 150 pounds means 600 loads are necessary. Assuming 2 round trips per day over 30 working days, 10 mules are needed each working day to haul the materials.

Superintendent/Foreman - ($30/hr)(300 hours) = $9,000
Carpenters (2) - ($17/hr)(300/hours)(2 carpenters) = $10,200
Laborers (5) - ($15/hr)(300 hours)(5 laborers) = $22,500
Cowboy - ($15/hr)(300 hours) = $4,500
Horse - ($200/day)(35 days) = $7,000
Mules (10) - ($200/day/mule)(35 days)(10 mules) = $70,000

Labor total = $123,200

4. River Diversion - Unlike the option that delivers concrete via helicopter directly to the forms, mixing concrete on-site will require more than one day to place concrete. Therefore, diverting the entire stream with pumps and siphons is probably not a cost effective option. One approach to the problem would be to divert the stream into a culvert at some point upstream of the work that would allow the elevation of the culvert to remain above the barrier crest. Based on the stream profile, this approach would require about 130 feet of culvert. The second method would be to embed a culvert during the placement of slot 1, during which the stream is diverted through slot 2. The stream would then be diverted through the culvert during the placement of slots 2 and 3, and then filled with concrete at the end of the job. A third method would be to place slots 2 and 3 while the stream is diverted through slot 1. Then construct a coffer dam upstream of slot 1, high enough to spill water over the slot 2 concrete. A final option would be to combine partial placements and coffers, alternating flows between slot 1 and slot 2. The following figures assume a culvert is embedded in the slot 1 placement.

24" corrugated metal pipe - (\$25/ft)(30 ft) = \$750

All other costs are covered under Labor and Equipment.

5. Excavation of alluvium - Assume all work done by hand, so costs covered under Equipment and Labor.

6. Dewatering - Pumps and generator costs covered under Equipment. Discharge hoses - \$400

7. Drill and install anchors in rock. Use jackleg drill setup. 2 rows of anchors at upstream end and 2 rows at downstream end. Anchor rows are 2 feet apart, anchors spaced 2 feet on centers. 100 bars required. Anchors are #8 bars, doweled into rock 8 feet. The drillers are accounted for as laborers under Labor. Anchors and grout are listed under materials.

Rent jackleg drills (2) - (\$300/week/drill)(3 weeks)(2 drills) = \$1,800

8. Materials - All materials will be transported by mule train from a laydown area at Stehr Lake. Material costs include delivery to Stehr Lake.

Cement - (\$10/bag)(108 bags (@94 lbs/bag)) = \$1,080
Sand - (22,500 lbs)(1 ton/2000 lbs)(\$45/ton) = \$507
Aggregate - (45,000 lbs)(1 ton/2000 lbs)(\$60/ton) = \$1,350
Rebar - (\$0.65/lb)(110 lb/cy)(25 cy) = \$1,788
Anchor bars - (\$0.65/lb)(6,500 lb) = \$4,225
Anchor bar grout - (18 cu ft bags)(\$20/bag) = \$360
Forming lumber - \$1,500
Miscellaneous materials - \$1,500

Total materials = \$12,310

9. Backfilling will be done by hand, so costs are covered under Labor.

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

Subtotal of activities 2-9	= $147,460
Mobilization (10%)	= $ 14,746
	$162,206
Contingencies (25%)	= $ 40,552
	$202,758

Total cost at the ~~lower~~ upper site, using pack animals, and mixing concrete at site = $203,000

D. Cost Estimate for Lower Site - helicopter option using ready mixed concrete

This estimate is based on the work being performed in 31 calendar days. Assume that the contractor will work 6 days per week, 10 hours per day, for 26 total working days, or 260 hours.

1. Mobilization - 10% of subtotal of work = $22,695

2. Equipment

58T helicopter - Use only for mob and demob of backhoe and other large equipment.

$1,600/hr for 2 days (1 day to mob and 1 to demob, 10 hr days) = $32,000

Llama helicopter - Use to transport ready mixed concrete from the Stehr Lake area directly to the structure, haul equipment and materials. Assume concrete transported in ½ cy buckets. Total of 95 cy of concrete, say 100 cy for estimate. Assume 7 minutes per round trip.

(100 cy/0.5 cy per trip)(7 minutes/trip)(1 hr/60 minutes) = 23.3 hours

With flying time to Phoenix each day, say three 10-hour days required:

($1,300/hr)(30 hours) = $39,000

Bell Long Ranger helicopter - Use for transporting formwork, supplies, equipment, and tools.

Transporting materials into site - ($900/hour)(2 days)(10 hours/day) = $18,000
Demobilization - ($900/day)(2 days)(10 hours/day) = $18,000

Helicopter total cost = $107,000

Small backhoe for cleaning alluvial rubble from the channel

($2,000/month)(1 mo) + ($8.00)(260 hours) = $4,080
rent + hourly operating cost

Generator, 1.5-3 kW; air compressor

(2 units)($400/mo/unit)(1 mo) + ($1.50/hr)(260 hrs)(2 units) = $1,580

Pumps (4), 4", 560 gpm

(4 pumps)($650/mo/pump) +($2.50/hr)(200 hrs)(4 pumps) = $4,600

Miscellaneous equipment - $3,000

Equipment Total (not including helicopters) = $13,260

3. Labor - Since helicopters will not be allowed to land, personnel will need to access the site on foot or by horseback. This estimate assumes 6 horses will need to be utilized for transportation for one month; 5 for the contractor and 1 for the cowboy who will provide rigging and care. Horse costs include food and corrals.

Superintendent/Foreman - ($30/hr)(260 hours) = $7,800
Backhoe operator - ($27/hour)(260 hours) = $7,020
Carpenters (2) - ($17/hr)(260/hours)(2 carpenters) = $8,840
Laborers (3) - ($15/hr)(260 hours)(3 laborers) = $11,700
Cowboy - ($15/hr)(260 hours) = $3,900
Horses (6) - ($200/day/horse)(30 days)(6 horses) = $36,000

Labor total = $75,260

4. River Diversion - The stream will need to be shifted over to one bank to enable anchor bar and concrete work to be performed in the deepest part of the channel first. Assume the stream flows are diverted into a corrugated metal pipe through the barrier site. The equipment used to install the pipe will be the backhoe accounted for under Equipment.

36" corrugated metal pipe - ($50/ft)(60 ft) = $3,000

5. Excavation of alluvium - Assume all work done with the backhoe, so costs covered under Equipment and Labor.

6. Dewatering - Pumps and generator costs covered under Equipment. Discharge hoses - $400

7. Drill and install anchors in rock. Use jackleg drill setup. 2 rows of anchors at upstream end and 2 rows at downstream end. Anchor rows are 2 feet apart, anchors spaced 2 feet on centers. 80 bars required. Anchors are #8 bars with a 90-degree bend, doweled into rock 8 feet. The drillers are accounted for as laborers under Labor. Anchors and grout are listed under materials.

Rent jackleg drills (2) - ($300/week/drill)(2 weeks)(2 drills) = $1,200

8. Materials - All materials will be transported by helicopter from a laydown area at Stehr Lake. Material costs include delivery to Stehr Lake.

Concrete - ($120/cy)(100 cy) = $12,000
Rebar - ($0.65/lb)(110 lb/cy)(100 cy) = $7,150
Anchor bars - ($0.65/lb)(5200 lb) = $3,380
Anchor bar grout - (15 cu ft bags)($20/bag) = $300
Forming lumber - $2,000
Miscellaneous materials - $2,000
Total materials = $26,830

9. Backfilling will be done with the backhoe, so costs are covered under equipment and labor.

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

Subtotal of activities 2-9	= $226,950
Mobilization (10%)	= $ 22,695
	$249,645
Contingencies (25%)	= $ 62,411
	$312,056

Total cost at the lower site, using ready mixed concrete transported by helicopter = $312,000

E. <u>Cost Estimate for Lower Site - helicopter transporting materials, mix concrete at the work site</u>

This estimated assumes the work will be performed in 35 calendar days. Assume that the contractor will work 6 days per week, 10 hours per day, for 30 total working days, or 300 hours.

1. Mobilization - 10% of subtotal of work = $28,492

2. Equipment

Bell Long Ranger helicopter - Use for transporting all materials, formwork, supplies, equipment, and tools to the site. Weight of materials:

Cement - (100 cy concrete)(450 lb/cy) = 45,000 lbs
Sand - (100 cy)(1,000 lb) = 100,000 lbs
Aggregate - (100 cy)(2,000 lb) = 200,000 lbs
Water will be obtained from the stream = 0 lbs

Subtotal concrete materials = 345,000 lbs. Specify that on-site cobbles be liberally added within the forms during concrete placement to reduce concrete quantity by 10%. Therefore reduce materials quantities by 10%:

Concrete materials = 310,500 lbs
Rebar and anchor bars = <u>16,000 lbs</u>
326,500 lbs

Bell Long Ranger can transport about 1000 pounds per load. Assume actual weight of 800 pounds per load.

Transporting concrete materials - 326,500 lb / 800 lb per load = 408 loads.

Assuming round trip every 15 minutes and 8 hours of hauling each day:

(408 loads)(0.25 hours/load)(1 day/8 hours) = 12.8, say 13 days of helicopter time.

Transporting all other materials into site - 2 days

Assume 10 hour helicopter days, which will include flying time from hanger and refueling.

($900/hour)(13 days + 2 days)(10 hours/day) = $135,000
Demobilization - ($900/day)(2 days)(10 hours/day) = $18,000

Helicopter total cost = <u>$153,000</u>

Generator, 1.5-3 kW; air compressor

(2 units)($400/mo/unit)(1.25 mo) + ($1.50/hr)(280 hrs)(2 units) = $1,840

rent + hourly operating cost

Pumps (4), 4", 560 gpm

(4 pumps)($650/mo/pump) +($2.50/hr)(240 hrs)(4 pumps) = $5,000

Concrete mixers (2), 6 cu ft, 7 hp

(2 mixers)($510/mo/mixer) + ($1/hr)(280 hrs)(2 mixers) = $1,580

Miscellaneous equipment - $3,000

Equipment Total (not including helicopters) = $11,420

3. Labor - Since helicopters will not be allowed to land, personnel will need to access the site on foot or by horseback. This estimate assumes 7 horses will need to be utilized for transportation for 33 days; 6 horses for the contractor and 1 for the cowboy in charge of rigging and care. Horse costs include food and corrals.

Superintendent/Foreman - ($30/hr)(300 hours) = $9,000
Carpenters (2) - ($17/hr)(300/hours)(2 carpenters) = $10,200
Laborers (5) - ($15/hr)(300 hours)(5 laborers) = $22,500
Cowboy - ($15/hr)(300 hours) = $4,500
Horses (7) - ($200/day/horse)(30 days)(7 horses) = $42,000

Labor total = $88,200

4. River Diversion - The stream will need to be shifted over to one bank to enable anchor bar and concrete work to be performed in the deepest part of the channel first. Assume the stream flows are diverted into a corrugated metal pipe through the barrier site. The laborers performing the work are accounted for under Labor.

36" corrugated metal pipe - ($50/ft)(60 ft) = $3,000

5. Excavation of alluvium - Alluvium, boulders, and cobbles will need to be cleaned from the channel to provide solid contact between concrete and rock. Alluvium and cobbles can be removed by hand. Several boulders will need to be broken down into smaller pieces to be removed. This estimate assumes boulders will be reduced by blasting.

Blasting materials - $1,000

6. Dewatering - Pumps and generator costs covered under Equipment. Discharge hoses - $400

7. Drill and install anchors in rock. Use jackleg drill setup. 2 rows of anchors at upstream end and 2 rows at downstream end. Anchor rows are 2 feet apart, anchors spaced 2 feet on centers. 80 bars required. Anchors are #8 bars with a 90-degree bend, doweled into rock 8 feet. The drillers are accounted for as laborers under Labor. Anchors and grout are listed under materials.

Rent jackleg drills (2) - ($300/week/drill)(2 weeks)(2 drills) = $1,200

8. Materials - All materials will be transported by helicopter from a laydown area at Stehr Lake. Material costs include delivery to Stehr Lake.

Cement - ($10/bag)(440 bags (@94 lbs/bag)) = $4,440
Sand - (90,000 lbs)(1 ton/2000 lbs)($45/ton) = $2,025
Aggregate - (180,000 lbs)(1 ton/2000 lbs)($60/ton) = $5,400
Rebar - ($0.65/lb)(110 lb/cy)(100 cy) = $7,150
Anchor bars - ($0.65/lb)(5200 lb) = $3,380
Anchor bar grout - (15 cu ft bags)($20/bag) = $300
Forming lumber - $2,000
Miscellaneous materials - $2,000

Total materials = $26,695

9. Backfilling will be done by hand, so costs are covered under Labor.

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

Subtotal of activities 2-9	= $284,915
Mobilization (10%)	= $ 28,492
	$313,407
Contingencies (25%)	= $ 78,352
	$391,759

Total cost at the lower site, helicopter transporting materials, mixing concrete at site = $392,000

F. <u>Cost Estimate for Lower Site - pack animal option, no helicopters</u>

This estimate is based on the work being performed in 50 calendar days. Assume that the contractor will work 6 days per week, 10 hours per day, for 42 total working days, or 420 hours.

1. Mobilization - 10% of subtotal of work = $26,728

2. Equipment

Pumps (4), 4", 560 gpm

(4 pumps)($650/mo/pump)(1.5 months) + ($2.50/hr)(320 hrs)(4 pumps) = $7,100
rent + operating costs

Miscellaneous equipment - $4,500

Equipment Total = <u>$11,600</u>

3. Labor - Materials and equipment will be transported to the site via pack animals. Personnel will access the site on foot or by mule. This estimate assumes that mules will need to be utilized for 40 calendar days. Mule costs include food and corrals. Assume mules will require a cowboy with horse for rigging and care. Assume contractor personnel can utilize the mules for access to site.

Time required to haul materials and equipment:

Concrete materials, rebar, and lumber weighs 330,000 pounds. Assume equipment adds another 1,000 pounds, for a total of 331,000 pounds. Assuming average mule load is 150 pounds means 2,207 loads are necessary. Assuming 3 round trips per day over 42 working days, 18 mules are needed each working day to haul the materials.

Superintendent/Foreman - ($30/hr)(420 hours) = $12,600
Carpenters (2) - ($17/hr)(420/hours)(2 carpenters) = $14,280
Laborers (5) - ($15/hr)(420 hours)(5 laborers) = $31,500
Cowboy - ($15/hr)(420 hours) = $6,300
Mules (18) - ($200/day/mule)(42 days)(18 mules) = $151,200
Horse - ($200/day)(42 days) = $8,400

Labor total = <u>$224,280</u>

4. River Diversion - The stream will need to be shifted over to one bank to enable anchor bar and concrete work to be performed in the deepest part of the channel first. Assume the stream flows are diverted into a corrugated metal pipe through the barrier site. The laborers performing the work are accounted for under Labor.

24" corrugated metal pipe - ($25/ft)(60 ft) = <u>$1,500</u>

5. Excavation of alluvium - Alluvium, boulders, and cobbles will need to be cleaned from the channel to provide solid contact between concrete and rock. Alluvium and cobbles can be removed by hand. Several boulders will need to be broken down into smaller pieces to be removed. This estimate assumes boulders will be reduced by blasting.

Blasting materials - $1,000

6. Dewatering - Pumps and generator costs covered under Equipment. Discharge hoses - $400

7. Drill and install anchors in rock. Use jackleg drill setup. 2 rows of anchors at upstream end and 2 rows at downstream end. Anchor rows are 2 feet apart, anchors spaced 2 feet on centers. 80 bars required. Anchors are #8 bars with a 90-degree bend, doweled into rock 8 feet. The drillers are accounted for as laborers under Labor. Anchors and grout are listed under materials.

Rent jackleg drills (2) - ($300/week/drill)(3 weeks)(2 drills) = $1,800

8. Materials - All materials will be transported by mule train from a laydown area at Stehr Lake. Material costs include delivery to Stehr Lake.

Cement - ($10/bag)(440 bags (@94 lbs/bag)) = $4,440
Sand - (90,000 lbs)(1 ton/2000 lbs)($45/ton) = $2,025
Aggregate - (180,000 lbs)(1 ton/2000 lbs)($60/ton) = $5,400
Rebar - ($0.65/lb)(110 lb/cy)(100 cy) = $7,150
Anchor bars - ($0.65/lb)(5200 lb) = $3,380
Anchor bar grout - (15 cu ft bags)($20/bag) = $300
Forming lumber - $2,000
Miscellaneous materials - $2,000

Total materials = $26,695

9. Backfilling will be done by hand, so costs are covered under Labor.

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

Subtotal of activities 2-9	= $267,275
Mobilization (10%)	= $ 26,728
	$294,003
Contingencies (25%)	= $ 73,501
	$367,504

Total cost at the lower site, using pack animals, and mixing concrete at site = $368,000

X. ENGINEERING AND DESIGN COST ESTIMATES

The following cost estimates are for the Phase 2 (Design) portion of the Fossil Creek Barriers project. Phase 2 is comprised of engineering and design work, geologic work, and coordination with interested parties. The end product will be complete and final construction specifications.

A. Phase 2 cost estimate for lower barrier site:

1. Engineering and design work

Engineer	Preparing drawings -	80 hours
	Hydrology -	10 hours
	Writing specifications -	100 hours
	Site visit (if necessary) -	12 hours
	NEPA assistance -	20 hours
	Total =	222 hours

(222 hours)($87/hour) = $19,314

Technician Drafting drawings - (60 hours)($70/hr) = $4,200

Total = $23,514

2. Geologic work

Geologist	Preparing drawings -	20 hours
	Writing specifications -	40 hours
	Site visit (if necessary) -	12 hours
	Total =	72 hours

(72 hours)($85/hr) = $6,120

3. Coordination with interested parties and miscellaneous activities

Concept meeting - (4 Reclamation staff)(4 hours)($85/hr) = $1,360
Specifications review - (5 Reclamation staff)(8 hours)($85/hr) = $3,400
Subtotal = $4,760

4. Lower Site Phase 2 total cost = $34,394, say $35,000

B. Phase 2 cost estimate for upper barrier site:

1. Engineering and design work

Engineer	Preparing drawings -	75 hours
	Hydrology -	10 hours
	Writing specifications -	95 hours
	Site visit (if necessary) -	12 hours
	NEPA assistance -	20 hours
		Total = 212 hours

(212 hours)($87/hour) = $18,444

Technician Drafting drawings - (55 hours)($70/hr) = $3,850

Subtotal = $22.294

2. Geologic work

Geologist	Preparing drawings -	20 hours
	Writing specifications -	35 hours
	Site visit (if necessary) -	12 hours
		Total = 67 hours

(67 hours)($85/hr) = $5.695

3. Coordination with interested parties and miscellaneous activities

Concept meeting - (4 Reclamation staff)(4 hours)($85/hr) = $1,360
Specifications review - (5 Reclamation staff)(8 hours)($85/hr) = $3,400
Subtotal = $4.760

4. Upper Site Phase 2 total cost = $32,749, say $33.000

C. Phase 2 cost estimate if barriers are built at both sites:

1. Engineering and design work

Engineer	Preparing drawings -	110 hours
	Hydrology -	10 hours
	Writing specifications -	120 hours
	Site visit (if necessary) -	16 hours
	NEPA assistance -	30 hours
	Total =	286 hours

(286 hours)($87/hour) = $24,882

Technician Drafting drawings - (100 hours)($70/hr) = $7,000

Subtotal = $31,882

2. Geologic work

Geologist	Preparing drawings -	30 hours
	Writing specifications -	60 hours
	Site visit (if necessary) -	16 hours
	Total =	106 hours

(106 hours)($85/hr) = $9,010

3. Coordination with interested parties and miscellaneous activities

Concept meeting - (4 Reclamation staff)(6 hours)($85/hr) = $2,040
Specifications review - (5 Reclamation staff)(10 hours)($85/hr) = $4,250
Subtotal = $6,290

4. Both sites Phase 2 total cost = $47,182, say $48,000