East Fork White River Fish Barrier

Feasibility Study

White Mountain Apache Reservation

near Fort Apache, Arizona

March 1999

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

By: Jeff Riley - Civil Engineer
Mike Pryor - Geologist
Rob Clarkson - Fisheries Biologist

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I. Introduction

This report summarizes the results of a one day field investigation of two potential fish barrier sites on the East Fork of the White River near Fort Apache. This study was undertaken at the request of the White River Apache Game and Fish Department in White River, Arizona. Reclamation was asked to evaluate potential fish barrier sites on the East Fork of the White River and provide estimates and feasibility designs. The study focused on two sites upstream of the confluence with the main stem of the White River. A general reconnaissance was conducted to perform preliminary surveys, look at the geology, evaluate site access, describe general conditions, and identify issues that will require further investigation.

This report provides the White River Apache Game and Fish Department with a narrative evaluation of the potential fish barrier sites, along with cost estimates and feasibility sketches. Conclusions are addressed at the end of the report.

The White River is a tributary of the Salt River (see map #1). The East Fork of the White River, which joins the White River about ½ mile below the study area, presently supports several native fish species, including the federally-threatened loach minnow (*Tiaroga cobitis*), to the relative exclusion of nonnative forms. Nonnative fishes that presently inhabit the White River present a serious threat to the continued integrity of the native ichthyofauna. The White River Apache Tribal Recreation Headquarters is proposing construction of a fish barrier near the terminus of the East Fork of the White River that would eliminate or substantially reduce the threat of nonnative fish contamination from the White River.

A fish barrier should substantially enhance the future status of native fish populations in the East Fork of the White River, and will allow potential repatriation of other native fish species now absent from the drainage.

The site investigation was performed on September 17, 1998. Those participating were Mark Nemeth of the Tribal Headquarters, Stewart Jacks of the U.S. Fish and Wildlife, and Rob Clarkson, Mike Pryor, and Jeff Riley of the U.S. Bureau of Reclamation.

We met at the tribal headquarters the morning of September 17 before continuing on to the potential fish barrier sites (see map #2). We first looked at Site 1 near the Apache village restoration. We then hiked upstream to Site 2, which is near the Fort Apache sewage lagoons.

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

II. Fish Barrier Site 1

A. General - Of the two sites investigated, this site is the furthest downstream on the East Fork, approximately 1/4 mile upstream of the confluence with the White River. The site is immediately upstream of the Apache village replica. The channel is characterized by a 25 to 30-foot wide stream channel bounded by alluvial terraces within a 100-foot deep canyon. The canyon walls are mostly covered by talus from the canyon rim. The terraces and the canyon walls are heavily vegetated with large trees and undergrowth. The rim of the canyon is primarily intact, exposed rock. A fish barrier constructed to the 100-year flood level would be approximately 200 feet long at this location. The site is in Township 5 N, Range 22 E, Section 35 (NE1/4 of NW1/4). The area is heavily vegetated and several large trees would need to be removed during construction.

B. Construction Access - Although we walked down to the site on the marked foot trail from Fort Apache, vehicular access would most likely be along the same road used to access the Apache village replica. This route involves an on-grade crossing through the East Fork flows. It appears that the route is actually a private road to some personal dwellings, whose concurrence to utilize the road would be necessary. In addition, the road runs through the middle of the Apache village replica, which may present concerns to the curators of the display. There are no existing roads the last few hundred feet to the proposed barrier site, so a road would need to be pioneered to the area. This would involve clearing of vegetation and grading to create a passable roadway.

Notwithstanding the concerns raised above, the access would present no difficulties for construction traffic unless the East Fork is experiencing high flows.

C. Geology

Right Abutment - The canyon rim, about 100 feet above the river, is comprised of intact basalt. Below the rim, intact basalt is overlain with basalt talus. The talus, generated by weathering of the rim, consists of large angular blocks generally ranging from 1 to 5 feet in diameter, with a maximum size of approximately 20 feet.

Stream Channel - The stream channel is about 25 feet wide and is filled primarily with rounded basalt cobbles with a maximum size of about 3 feet in diameter. There is an alluvial terrace about 5 feet above the main channel composed of sand and gravel. We estimate that the depth of alluvium to bedrock is about 20 feet.

Left Abutment - Same description as right abutment with a less steep slope and fewer pieces of large talus.

III. Fish Barrier Site 2

A. General - About 1/4 mile upstream of Site 1, was a narrow stretch of canyon. Site 2 was within this narrow section. The site is in Township 5 N, Range 22 E, Section 26 (NW1/4 of SE1/4). The channel is characterized by a 20 to 25-foot wide stream channel bounded by alluvial terraces within a 100-foot deep canyon. The canyon walls are mostly covered by talus from the canyon rim. The terraces and the canyon walls are heavily vegetated with large trees and undergrowth. The rim of the canyon is primarily intact, exposed rock. A fish barrier constructed to the 100-year flood level would be approximately 75 feet long at this location.

The stream channel is about 24 feet wide and is bounded by a 55-foot wide floodplain terrace. The slopes of the canyon are steep, with a slope of about 0.37 or 2.5:1 (run:rise).

The area is heavily vegetated and several trees would need to be removed during construction.

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

- Fish barrier at Site 2 would be more than 100 feet shorter.
- Site 2 has easier access for construction equipment.
- Site 2 probably has shallower bedrock.

The main disadvantage to Site 2 is that a fish barrier at Site 1 protects an additional 1/4 mile of the East Fork White River.

A cross-section at the proposed location of the fish barrier is provided (sketch #1).

Sketch #2 shows the channel cross-section with the barrier in place.

B. Construction Access - Access for construction equipment is excellent at this site. An existing gravel road to the sewage lagoons from Fort Apache has reasonable grades and is wide enough to accommodate the necessary equipment. The existing road is within 100 yards of Site #2. A road will need to be pioneered to the site from that point, but will not be a difficult activity.

C. Geology

Right Abutment - The canyon rim, about 100 feet above the river, is comprised of intact basalt. Below the rim, intact basalt is overlain with basalt talus. The talus, generated by weathering of the rim, consists of large angular blocks, most from 1 to 5 feet in diameter, with a maximum size of approximately 20 feet.

Stream Channel - The stream channel is about 25 feet wide and is filled primarily with rounded basalt cobbles with a maximum size of about 3 feet in diameter. There is an alluvial terrace about 5 feet above the main channel composed of sand and gravel. We estimate that the depth of alluvium to bedrock is about 20 feet.

Left Abutment - Same description as right abutment with a less steep slope.

IV. Design Considerations

We believe a reinforced concrete structure is appropriate at this site. The narrow canyon brings concrete quantities down to an affordable level and the shallow bedrock provides a stable tie-in. A cross-section of the barrier configuration is shown in Sketch #3. A 4-foot vertical drop will stop fish movement in the upstream direction. A 25-foot long concrete apron will prevent fish from gathering in scour holes immediately downstream of the barrier. Upstream and downstream keys extend into the stream channel alluvium to protect the structure from erosive forces. Other than the possibility of facing the exposed concrete with native basalt materials for aesthetics, the rest of the structure would be reinforced concrete. Lower strength concrete could be used in the lower portions of the keys to reduce cement costs. 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 keys.

A vital piece of information for the stability of the structure is knowledge of the potential for scour. Scour is a frequent cause of failure of structures in rivers and streams and needs to be thoroughly evaluated during the design phase. Two types of scour will occur; natural channel scour due to flooding, and downstream scour induced by the structure itself. Until geologic investigations are performed, our scour and stability calculations are based assumptions of the makeup of the alluvial material.

River channel scour is estimated to extend about 7 feet below the channel surface during a 100-year flood event. Downstream scour is expected to reach a depth of about 9-foot deep at the downstream end of the concrete apron. Sketch #2 shows the keys attached to bedrock for the full length. This may not be necessary, but is shown so estimates are conservative.

The location of bedrock is another critical piece of data. Depending where bedrock is could significantly affect concrete quantities, depth of scour keys, the shape of the structure, and whether other options like caissons are viable. Sketch #1 shows our best estimate of the location of bedrock at this time, prior to any investigations.

The design flood for fish barriers can be broken down in two categories. First is the frequency flood for which the barrier effectively blocks fish movement; second is the frequency flood related to engineering stability.

Fisheries biologists usually recommend constructing fish barriers such that the barriers are effective when experiencing flows up to a 100-year flood event. This can be readily achieved at this site. According to U.S. Geologic Survey stream gaging, the 100-year instantaneous peak flow is 1,090 cubic feet per second (cfs). The barrier crest shown in Sketch #2 meets this 100-

year flood criteria.

Scour, sliding and overturning forces, and abutment stress reach their maximum at the time of the instantaneous peak flow during a flooding event. Structures within a river or stream are usually designed to withstand at least a 100-year storm. The highest East Fork flow on record occurred in 1983 and was 2,700 cfs, which is more than double the 100-year event. Because of this extreme event and the short period of record (August 1957 to present), it may be prudent to engineer the structure to withstand a higher flow the 100-year event. In this case, we recommend designing the stability features of the barrier, for example scour keys and sliding resistance, for the highest flow on record. In heavily wooded, small watersheds like this one where the flooding peaks are not extreme, such a requirement is reasonable and will not increase the cost significantly.

After several flooding events, we expect sedimentation to fill on upstream side of the barrier, up to the low point of the crest. Sketch #4 shows the estimated slope of the sediment and how far the sediment zone will extend upstream. The barrier combined with the sediment aggredation will increase the water surface profile during runoff events, resulting in a wider flood inundation zone. A thorough understanding of these flooding changes is usually required to mitigate for potential upstream flood damages. Flooding effects downstream are expected to be minimal as the stream quickly returns to its normal flow regime once past the barrier.

Placing the structure on piles or caissons that tie into bedrock is a possible way to reduce concrete costs. Even with caissons the barrier must extend deep enough to prevent undercutting, and be massive enough not to be pushed downstream during flooding. This option should be looked at when the geology investigations results are available.

Preliminary sliding and overturning calculations have been performed, indicating a reasonable factor of safety. Assumptions regarding the gradation of the alluvium material were made to facilitate the these calculations.

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.

Abutment protection does not appear to be necessary. The canyon walls appear to be comprised of competent basalt overlain with large basalt blocks. Even if the underlying rock is more fractured than expected, the blocks will act as riprap to protect the abutments. The blocks should be moved back into position once the abutment work is complete. Also, any available extra blocks could be placed just downstream of the structure at invert level to resist downstream scour.

V. Site Investigations

Scour Depth - Although the surface of the channel appears to be armored with cobbles, the gradation may become finer with depth, increasing scour potential. Subsurface samples to determine material gradation at different depths should be taken with a backhoe.

It is estimated that bedrock is 12 feet below the channel at Site 2. If so, a backhoe test pit will be the most cost effective method to confirm the bedrock depth. However, a backhoe may have difficulty sampling to the full depth since the soils will be saturated and side slope sluffing may make visual confirmation of the bedrock level impossible.

If the test pit method is not effective, auger holes are recommended. Drawbacks to augering are cost and the presence of cobbles and boulders that can make drilling not only difficult, but hard to distinguish large boulders from bedrock. 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. Seismic surveys are relatively inexpensive compared to drilling and unobtrusive to the environment, but the results must be carefully interpreted.

Surveying - Surveying is required at the proposed site to develop an accurate cross-section for engineering. If the flooding effects caused by the barriers need to be understood and mitigated for, surveys will be required upstream and downstream of the structure for channel hydraulic analysis.

Use of on-site materials - Because access to the site is fairly easy and the quantity of concrete is not great (280 cubic yards), ready-mix concrete suppliers are probably the most cost effective sources of concrete. However, in case the local basalt is used for aesthetic facing on the exposed concrete, samples of the rock should be obtained during the gradation sampling to determine compatibility with concrete.

VI. Construction Considerations

Excavation - Excavation of alluvial materials can be performed by common means if the alluvium is properly drained. If the channel is not dewatered, there will be stability problems in the walls of the excavated area. 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 2 feet) 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. Dewatering and pumping costs are including in the estimate. A sump system upstream and downstream of the excavation would probably be the best method for dewatering. These sumps will require the installation of pumps within a perforated corrugated metal pipe, at or below the proposed excavation. 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. Because of 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 discharged below the excavation via pipelines which may require moving during construction.

Abutment Shaping - A key should be excavated in both abutments to a depth of at least three feet. This can be done using a hoe-ram attachment on a backhoe or blasting. It is recommended that grouted anchor bars also be drilled into the abutment to help key the structure.

Equipment - Major construction equipment needed for construction: Backhoe/hoe ram, front end loader, dozer, dewatering pumps, generators, drill rig.

VII. Cost Estimates - Feasibility estimates were prepared for Sites 1 and 2. Assumptions made for these estimates are as follows:

1. Concrete mixer trucks can access the sites.
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 estimated cost for a fish barrier at Site 2 is $214,000. For Site 1, the cost is estimated to be $418,000. The primary reason for the cost difference between the two sites is the wider canyon at Site 1, requiring 420 cy more concrete than Site 2.

VIII. Conclusions and Closing Remarks

- Site 2 offers an excellent location to construct and maintain a fish barrier. The canyon at the site is narrow with hard rock abutments making possible a low cost, stable barrier. Existing roads provide good access to within 100 yards of the site. Site 1 is at a wider point in the canyon, resulting in a more expensive fish barrier.

- The cost estimates for the two sites show construction costs. Some discussion of design costs, construction supervision costs, and site investigations are appropriate at this time.

Design costs include additional site visits, establishment of survey control, preparation of specification narrative and drawings, engineering calculations, hydraulic analysis (if necessary), procurement of NEPA permits and documents, and general coordination with involved entities. For general estimating purposes, though, it is reasonable to assume design costs will be approximately 20% of the cost of construction, 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 enforce 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. Some of these private firms appear to have lower construction management costs. 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.

Cost Estimate for East Fork White River Fish Barrier, Site No. 1

The contract is estimated to take 2.5 months to complete. The stream has perennial flow at the project site.

1. Mobilization - 5% of subtotal of work = $16,600

2. Contractor costs

   Office Trailer - $2,000
   Air compressor @ $350/mo for 2.5 months = $900
   Misc. Equipment - $2,000
   Subtotal = $4,900
   Maintenance (15%) = $700
   Total = $5,600

3. River Diversion

   Dozer, 75 hp - $3000/mo for 2.5 months = $7,500
   Operator - ($26/hr)(8 hr/day)(21 work days/mo)(2.5 mo) = $10,900
   Total diversion = $18,400

4. Dewatering - Install upstream and downstream sumps using the 6" pumps. The 4" pumps will be placed in the excavation. Install sumps in 3-foot diameter, 15-foot long corrugated metal pipes.

   Generators (5), 1.5-3 kW; - ($300/mo)(5 units)(1.5 mo) = $2,300
   Pumps (2), 4", 560 gpm - $600/mo for 1.5 month = $1,800
   Pumps (5), 6", 1590 gpm - $1700/mo for 1.5 month = $12,800
   Sump CMP liners - ($35/ft)(15 ft)(5 pipes) = $2,600
   Install 5 CMP liners 15 feet deep - $2,000
   Misc. piping - $500
   Laborer - ($20/hr)(8 hr/day)(21 work days/mo)(1.5 mo) = $5,000
   Total dewatering cost = $27,000

5. Excavation in alluvium (assuming 2:1 side slopes)

   4,700 cy @ $10 cy = $47,000

6. Excavating rock for abutment keys

   Avg. 10 cy/abutment, 20 cy @ $300/cy = $6,000

7. Drill and install anchors in abutment.

    2 drillers - $25/hr for 10 days = $4,000
    Drill rig - $1500/day for 10 days + $500 mobilization = $15,500
    Total drilling = <u>$19,500</u>

8. Furnish, form, reinforce, place concrete - Haul concrete from White River (5 miles).

    700 cy @ $250/cy = <u>$175,000</u>

9. Backfill - 4,700 cy @$4/cy = $<u>18,800</u>

10. Other costs

    Foreman - $29/hr for 53 days = $12,300
    Equipment depreciation - $2,000
    Total = <u>$14,300</u>

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

Subtotal of activities 2-12	= $331,600
Mobilization (5%)	= <u>$ 16,600</u>
	$348,200
Contingencies (20%)	= <u>$ 69,600</u>

Total estimated cost at Site 1 = <u>$418,000</u>

Cost Estimate for East Fork White River Fish Barrier, Site #2

The contract is estimated to take 2 months to complete. The stream has perennial flow at the project site.

1. Mobilization - 5% of subtotal of work = $8,500

2. Contractor costs

Office Trailer - $2,000
Air compressor @ $350/mo for 2 months = $700
Misc. Equipment - $2,000
Subtotal = $4,700
Maintenance (15%) = $700
Total = $5,400

3. River Diversion
   Dozer, 75 hp - $3000/mo for 2 months = $6,000
   Operator - ($26/hr)(8 hr/day)(21 work days/mo)(2 mo) = $8,800
   Total diversion = $14,800

4. Dewatering - Install upstream and downstream sumps using the 6" pumps. The 4" pumps will be placed in the excavation. Install sumps in 3-foot diameter, 15-foot long corrugated metal pipes.
   Generators (5), 1.5-3 kW; - ($300/mo)(5 units)(1 mo) = $1,500
   Pumps (2), 4", 560 gpm - $600/mo for 1 month = $1,200
   Pumps (5), 6", 1590 gpm - $1700/mo for 1 month = $8,500
   Sump CMP liners - ($35/ft)(15 ft)(5 pipes) = $2,600
   Install 5 CMP liners 15 feet deep - $2,000
   Misc. piping - $500
   Laborer - $20/hr for 1 month = $3,400
   Total dewatering cost = $19,700

5. Excavation in alluvium (assuming 2:1 side slopes)

   1,600 cy @ $10 cy = $16,000

6. Excavating rock for abutment keys

   Avg. 10 cy/abutment, 20 cy @ $300/cy = $6,000

7. Drill and install anchors in abutment.

   2 drillers - \$25/hr for 10 days = \$4,000
   Drill rig - \$1500/day for 10 days + \$500 mobilization = \$15,500
   Total drilling = \$19,500

8. Furnish, form, reinforce, place concrete - Haul concrete from White River (5 miles).

   280 cy @ \$250/cy = \$70,000

9. Backfill - 1,600 cy @\$4/cy = \$6,400

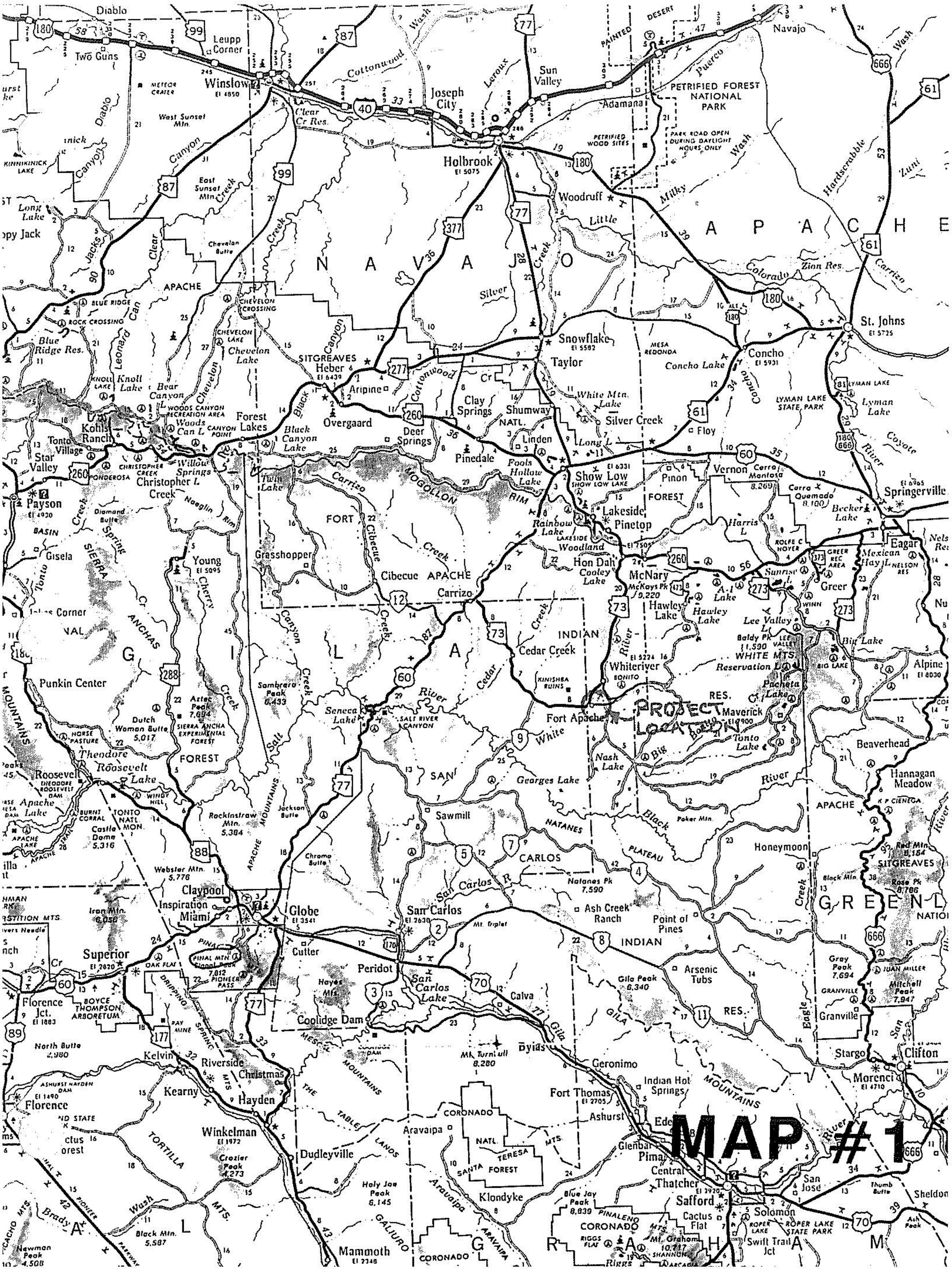
10. Other costs

   Foreman - \$29/hr for 42 days = \$9,700
   Equipment depreciation - \$2,000
   Total = \$11,700

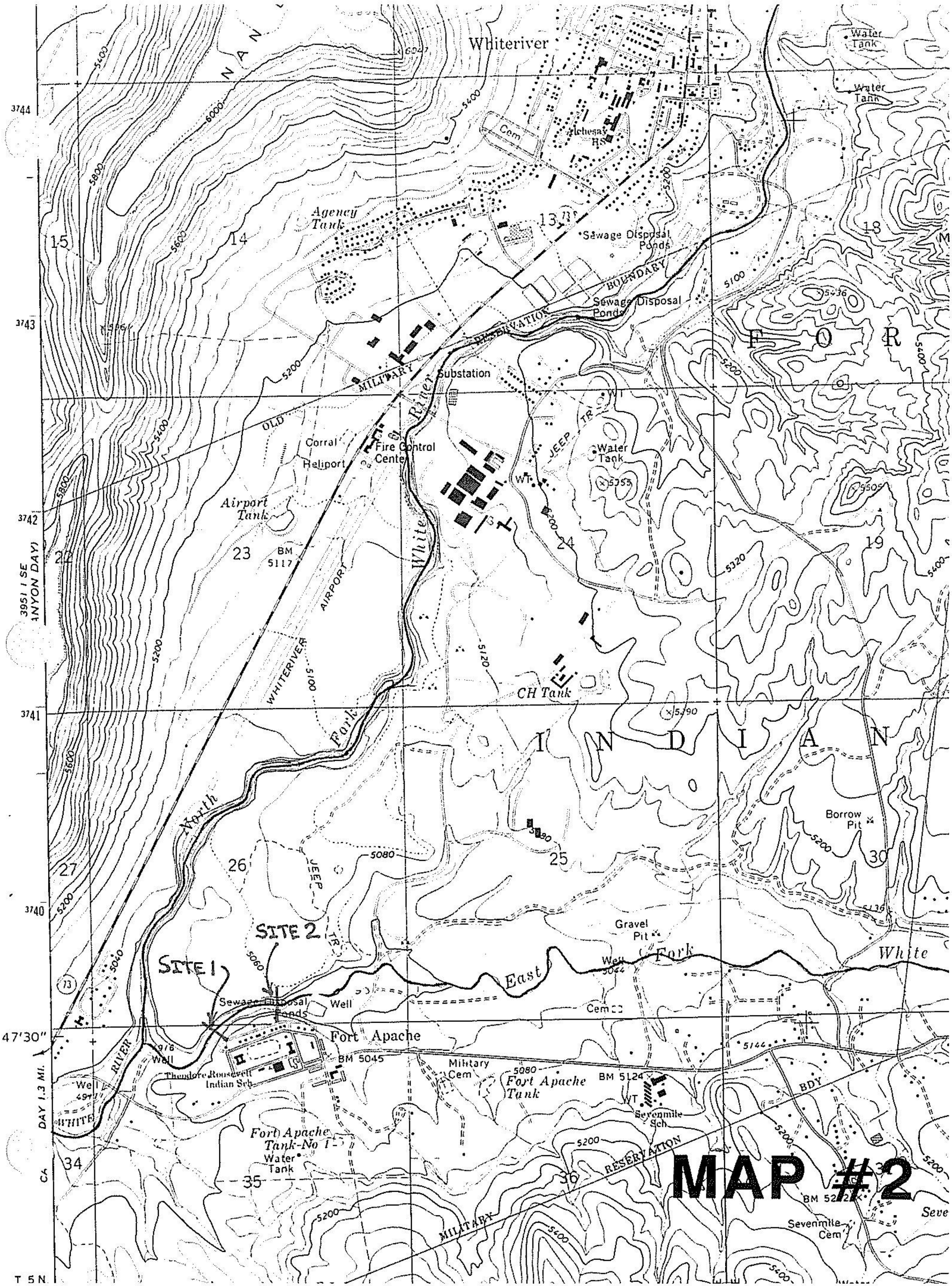
11. Summary of costs - Contingencies include minor construction activities, small equipment, and costs associated with runoff and flooding problems.

Subtotal of activities 2-12	= \$169,500
Mobilization (5%)	= \$ 8,500
	\$178,000
Contingencies (20%)	= \$ 35,600
	\$213,600

Total estimated cost at Site 2 = \$214,000



MAP # 1
PROJECT LOCATION
Winslow
Holbrook
Joseph City
Leupp Corner
Two Guns
Diablo
Sun Valley
Adamana
PETRIFIED FOREST NATIONAL PARK
PAINTED DESERT
Navajo
Woodruff
N A V A J O
A P A C H E
Snowflake
Taylor
Concho
St. Johns
Heber
SITGREAVES
Aripine
Overgaard
Clay Springs
Shumway
Linden
Pinedale
Show Low
Silver Creek
Floy
Vernon
Springerville
Eagar
Lakeside
Pinetop
McNary
Hon Dah
Greer
Forest Lakes
Kohls Ranch
Tonto Village
Star Valley
Payson
Christopher Creek
Young
Grasshopper
Cibecue
FORT APACHE INDIAN
Carrizo
Cedar Creek
Whiteriver
Fort Apache
Maverick
Alpine
Beaverhead
Hannagan Meadow
Honeymoon
Punkin Center
Roosevelt
Theodore Roosevelt Lake
SIERRA ANCHAS
G I L A
SAN CARLOS INDIAN RES.
Claypool
Miami
Globe
Inspiration
Superior
San Carlos
Cutter
Peridot
San Carlos Lake
Coolidge Dam
Calva
Bylas
Geronimo
Fort Thomas
Ashurst
Point of Pines
Ash Creek Ranch
Arsenic Tubs
Granville
Stargo
Clifton
Morenci
Florence Jct.
Florence
Kelvin
Riverside
Christmas
Kearny
Hayden
Winkelman
Dudleyville
Aravaipa
Klondyke
Mammoth
Pima
Central
Thatcher
Safford
Solomon
San Jose
Sheldon
Eden
Glenbar
Swift Trail Jct


Whiteriver
Water Tank
Water Tank
Cem
Alchesay HS
Agency Tank
Sewage Disposal Ponds
BOUNDARY
Sewage Disposal Ponds
RESERVATION
MILITARY
Substation
OLD
Corral
Fire Control Center
Heliport
Airport Tank
BM 5117
AIRPORT
White River
JEEP TR
Water Tank
CH Tank
WHITERIVER
North Fork
F O R
I N D I A N
Borrow Pit
Gravel Pit
SITE 2
SITE 1
East Fork
White
Well
Sewage Disposal Ponds
Well
Cem
Fort Apache
BM 5045
Military Cem
Fort Apache Tank
BM 5124
Sevenmile Sch
Theodore Roosevelt Indian Sch
Well
RIVER
WHITE
BDY
Fort Apache Tank-No 1
Water Tank
RESERVATION
MILITARY
BM 5227
Sevenmile Cem
MAP #2

7-1654 (1-89)
Bureau of Reclamation

COMPUTATION SHEET

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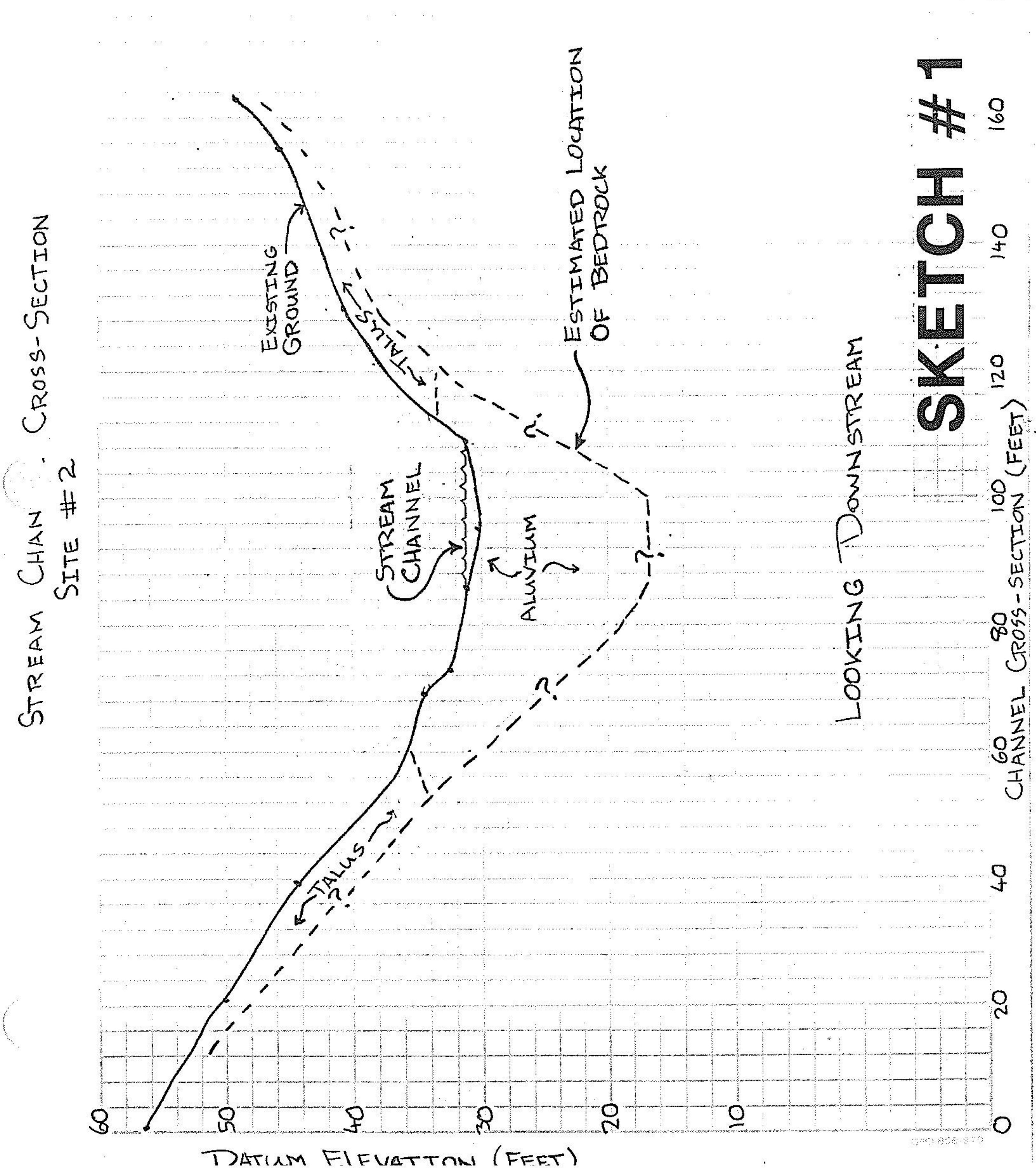
DETAILS			



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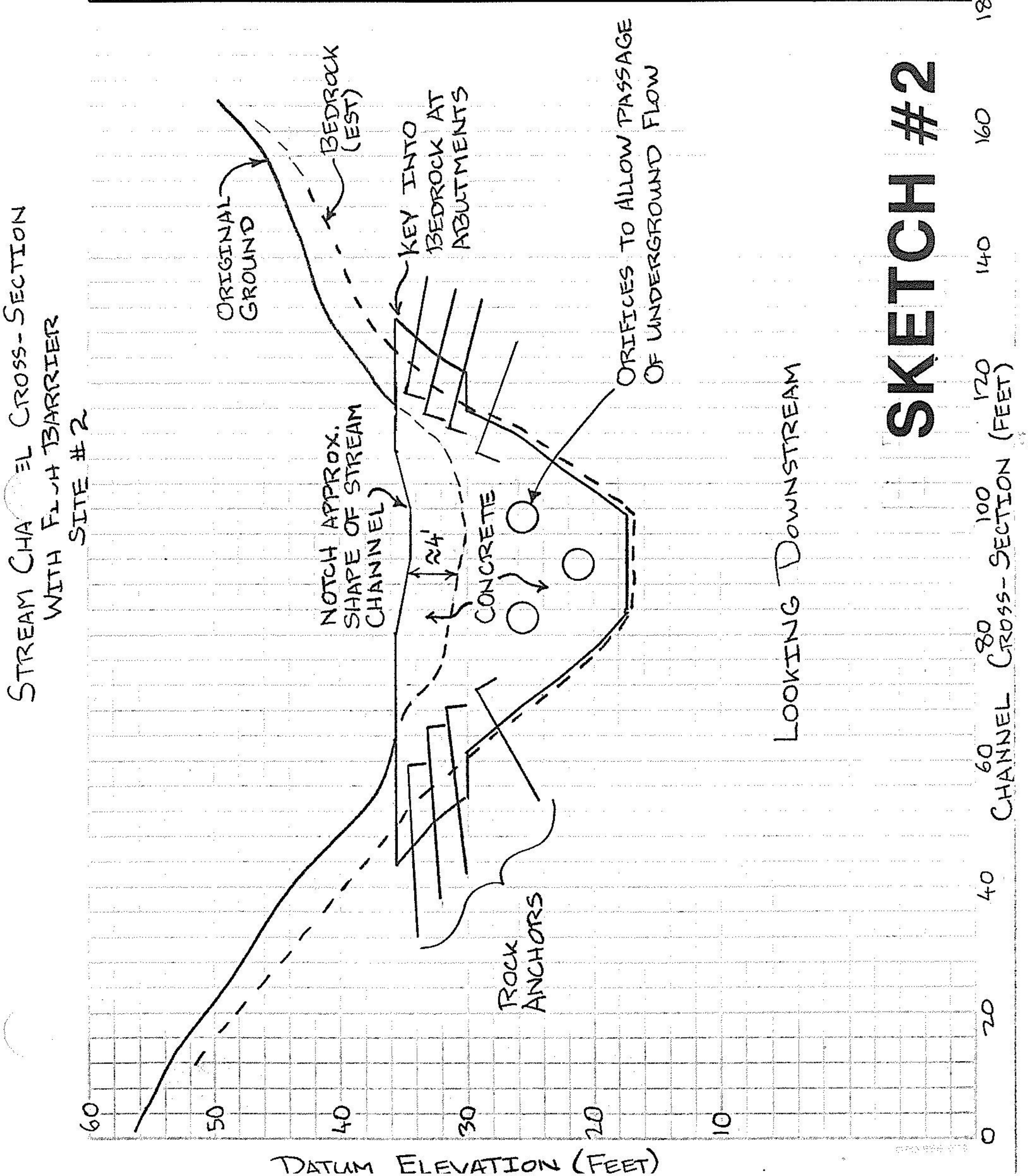
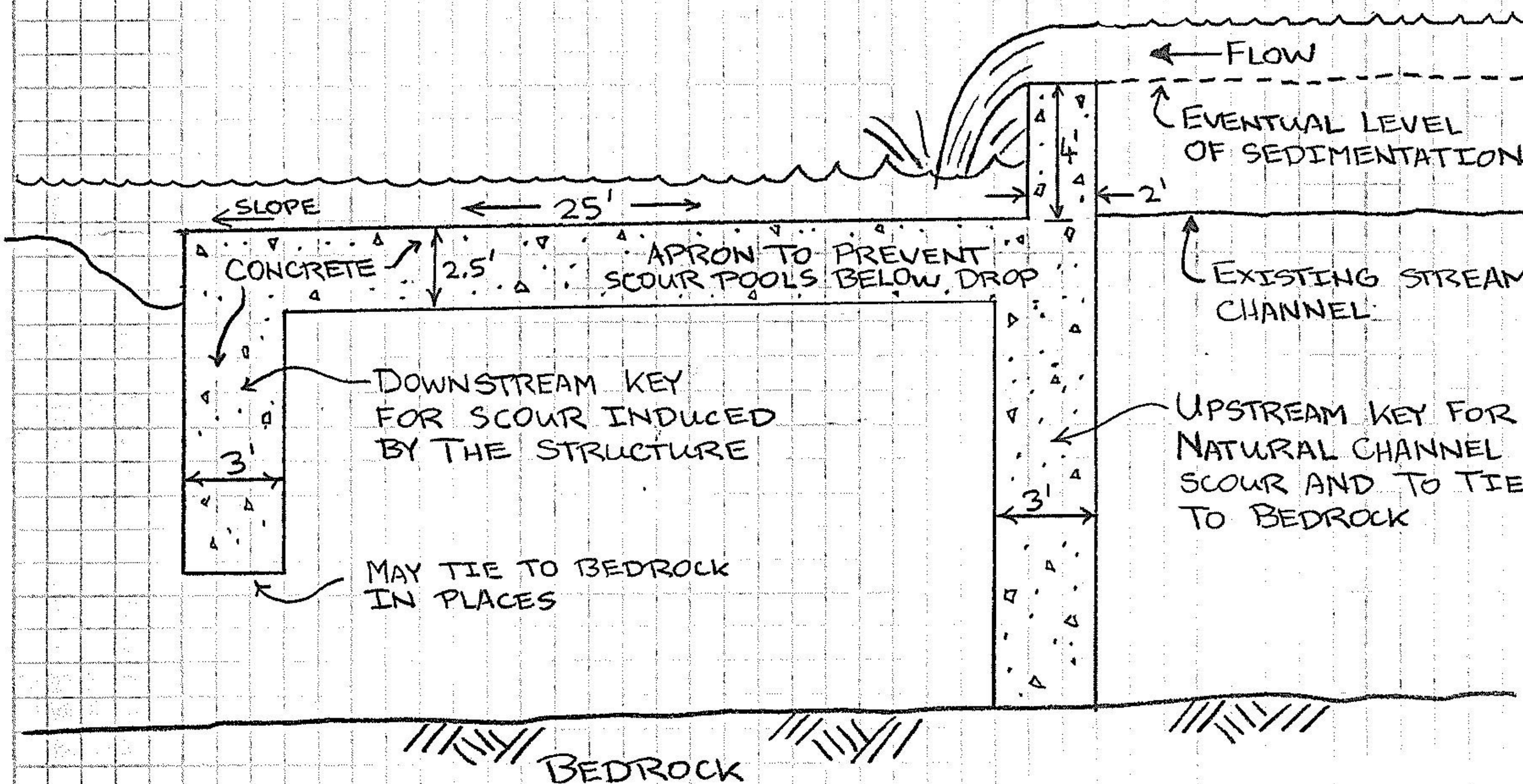


CROSS-SE[illegible]ON OF
FISH BARRIER



NOTE: ROCK FROM THE SURROUNDING AREA COULD BE USED TO FACE ALL EXPOSED CONCRETE TO BETTER BLEND THE STRUCTURE VISUALLY

SKETCH #3

7-1654 (1-89)
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COMPUTATION SHEET

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COMPUTATION SHEET

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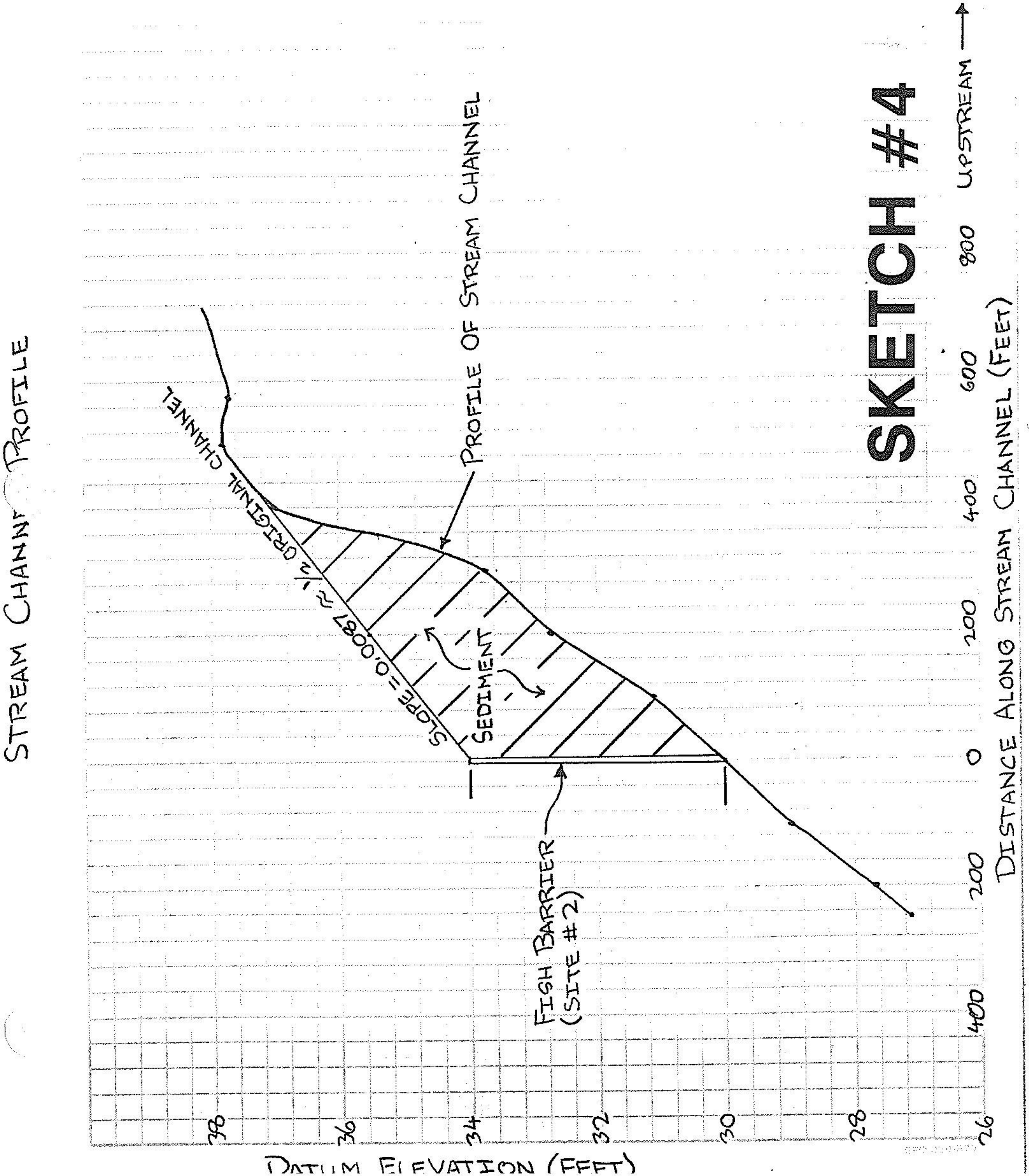
DETAILS			



Site No. 2
Looking Downstream

Site No. 2, Looking Upstream

Site No. 2, Right Abutment

Site No. 1, Example of
Basalt Talus on Canyon Wall