Uncompahgre Valley Reclamation Project

AB Lateral Hydropower Facility

Draft Environmental Impact Statement

United States Department of the Interior

Bureau of Reclamation

DEPARTMENT OF INTERIOR

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

###

BUREAU OF RECLAMATION

The Bureau of Reclamation of the U.S. Department of the Interior is responsible for the development and conservation of the Nation's water resources in the Western United States.

The Bureau's original purpose "to provide for the reclamation of arid and semiarid lands in the West" today covers a wide range of interrelated functions. These include providing municipal and industrial water supplies; hydroelectric power generation; irrigation water for agriculture; water quality improvement; flood control; river navigation; river regulation and control; fish and wildlife enhancement; outdoor recreation; and research on water-related design, construction, materials, atmospheric management, and wind and solar power.

Bureau programs most frequently are the result of close cooperation with the U.S. Congress, other Federal agencies, States, local governments, academic institutions, water-user organizations, and other concerned groups.

DRAFT

ENVIRONMENTAL IMPACT STATEMENT

AB LATERAL HYDROPOWER FACILITY
UNCOMPAHGRE VALLEY HYDROPOWER PROJECT

Montrose and Delta Counties, Colorado

U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION

As Lead Agency in Cooperation With

U.S. DEPARTMENT OF THE INTERIOR, NATIONAL PARK SERVICE AND BUREAU OF LAND MANAGEMENT

This draft environmental impact statement describes four alternatives for the proposed construction and operation of a hydropower project using features of the existing Bureau of Reclamation Uncompahgre Valley Reclamation Project. The Bureau of Reclamation is considering executing a lease of power privilege (contract) with a private company to permit use of Federal facilities for this project. The alternatives described provide for additional diversions of water from the Gunnison River through the existing Gunnison Tunnel to a penstock and powerplant near Montrose, Colorado. A no-action alternative is also described. The significant issues addressed in the environmental impact statement include the impacts of reduced flows in the Gunnison River, increased flows in the Uncompahgre River, economic impacts in local counties, and impacts on endangered species.

For further information regarding this environmental impact statement, please contact the Regional Environmental Officer, Upper Colorado Region, U.S. Bureau of Reclamation, P.O. Box 11568, Salt Lake City, Utah 84147, (801) 524-5580 or FTS 588-5580.

Statement Number: DES 89-08

Filing Date: APR 19 1989

Comments should be received by: JUN 22 1989

SUMMARY

The purpose of this environmental impact statement is to present the environmental impacts that would occur if any of the alternatives of the AB Lateral Hydropower Facility were constructed and operated. The facility would be funded, built, and operated by the Uncompahgre Valley Water Users Association (UVWUA) and Montrose Partners (referred to as the "Sponsors"). These groups plan to construct the facility using existing features of the Uncompahgre Valley Reclamation Project (UVRP), a Bureau of Reclamation (Reclamation) irrigation project. They are seeking a lease of power privilege (contract) with Reclamation that would permit using facilities of the UVRP. Hydropower development in association with the UVRP was authorized by the Act of June 22, 1938 (Public Law 76-698, Stat. 941).

The purpose of the facility, located in Montrose County, Colorado, is to economically develop the energy potential of water flows from the Gunnison River through the Gunnison Tunnel to the Uncompahgre River. The large difference in elevations between the Gunnison Tunnel and the Uncompahgre River creates the potential for hydropower production. Power from the proposed facility would be sold to local utilities; for the first 15 years of project operation, capacity and energy would be sold to the Public Service Company of Colorado. After that period, a different power sales agreement would be arranged.

The developers cite the following needs for the proposed hydropower facility: (1) generating electrical power; (2) developing a renewable resource; (3) improving the existing irrigation system of the UVRP; and (4) enhancing the UVWUA's revenues for debt retirement and system improvement.

Alternatives

The alternatives in the environmental impact statement involve generating hydroelectric power using flows diverted from the Gunnison River and the elevation difference between the West Portal of the Gunnison Tunnel and the Uncompahgre River in Montrose. A portion of the flows that would be diverted would also be used to meet UVRP irrigation needs; the remaining flows would be diverted for power generation. Four economically feasible alternatives (designated alternatives B, C, E, and F) are presented in the environmental statement along with descriptions of plans that were studied but found infeasible. Alternative A is the no-action alternative.

Alternative A

Existing UVRP operating conditions would continue under alternative A. Water would continue to be diverted from the Gunnison and Uncompahgre Rivers to irrigate lands in Delta and Montrose Counties. Water diverted from the Gunnison River through the Gunnison Tunnel is delivered to the Uncompahgre River through the South Canal. After entering the Uncompahgre River, Gunnison River flows are combined with Uncompahgre River flows and diverted into six major canal systems. Mean annual diversions from the Gunnison River are 336,411 acre-feet.

Alternative B

Alternative B would divert water from the existing South Canal and AB Lateral into a penstock leading to a new powerhouse near Montrose. Discharges from the powerhouse would enter the Uncompahgre River through an excavated tailrace. New construction would include the powerhouse, penstock, transmission line, access roads, and tailrace. Modifications of existing facilities would include a portion of the existing AB Lateral, South Canal, and access roads.

The AB Lateral would be enlarged to a capacity of 1,235 cubic feet per second (ft^3/s) for 7,100 feet of its length. A penstock with an 1,135-ft^3/s capacity would be constructed to carry water from the lateral to a powerplant to be constructed north of Montrose. The other 100 ft^3/s would be used for irrigation purposes. The 38,380-foot penstock would be approximately 10 to 11 feet in diameter and would be buried. The powerplant would contain two Pelton turbines and generators designed to safely pass a maximum flow of 1,135 ft^3/s. Power would be transmitted through a new 115,000-volt (115 kilovolt [kV]) transmission line that would run 2.1 miles north to an existing substation.

Water for the powerplant would be diverted from the Gunnison River using a priority system for allocating flows to irrigation needs, instream flow needs, and power production needs. Irrigation demands and instream flow agreements would be given priority over hydropower needs. A minimum instream flow level of 300 ft^3/s would be met in the Gunnison River.

Environmental commitments in alternative B include protection of instream flows and irrigation supplies; acquisition and development of lands for wetland replacement; acquisition of lands to preserve an endangered plant species; deer escapes in the enlarged AB Lateral; protection of riverbanks along the Uncompahgre River downstream from the powerplant; monitoring of the endangered bald eagle; and restoration of areas disturbed during construction.

Alternative C

Alternative C, like alternative B, would divert water from the South Canal and AB Lateral into a penstock that would convey water to the powerplant near Montrose. To increase water supplies for hydropower production, alternative C includes enlarging the Gunnison Tunnel from its present capacity of 1,135 ft^3/s to 1,300 ft^3/s. However, the penstock and turbine capacity would still be limited to 1,135 ft^3/s. Other features and operational and environmental considerations are similar to alternative B.

Alternative E

The physical features of alternative E are similar to alternative B. The penstock and powerplant would be designed to a maximum capacity of 950 ft^3/s, rather than 1,135 ft^3/s. The penstock and enlarged AB Lateral would be scaled down from alternative B. Other features and operational and environmental considerations are similar to alternative B.

Alternative F

The location, dimensions, and physical features of alternative F would be the same as alternative B, including the powerplant flow capacity of 1,135 ft^3/s. This alternative would reduce diversions from the Gunnison River during periods of ice buildup and would deliver additional water to the Uncompahgre River upstream from Montrose during the summer.

Summary of Existing Environment and Environmental Consequences

General

The Uncompahgre Valley lies along the western flank of the Rocky Mountains with elevations ranging from 4,950 feet above sea level near Delta to 6,500 feet near Montrose. The Gunnison River flows east of the valley through the Black Canyon of the Gunnison National Monument and the Gunnison Gorge Recreation Area. The climate is typified by low precipitation and a wide range of daily and average annual temperatures. Native vegetation consists mostly of semidesert shrubs. Wetlands occur along the Gunnison and Uncompahgre Rivers.

About 505,000 acre-feet of water flow into the Uncompahgre Valley annually. Nearly two-thirds of this volume is imported for irrigation from the Gunnison River via the Gunnison Tunnel, and the remaining volume is derived from the Uncompahgre River and its tributaries.

The Uncompahgre River fishery is limited due to water quality and flow problems. However, the Gunnison River supports an excellent trout fishery between Crystal Reservoir and several miles downstream from the river's confluence with the North Fork of the Gunnison.

The total population in Montrose and Delta Counties is approximately 50,000 people. In addition to agriculture, tourism and recreation are important local industries.

Any of the four development alternatives would result in short-term construction-related impacts and long-term operational impacts. Short-term impacts include vegetation clearing, erosion, and construction disturbance, as well as short-term increases to the local economy. Long-term impacts would be related to the decreased flows in the Gunnison River and the increased flows in the Uncompahgre River and the long-term additions to the local economy resulting from power production.

Streamflows

Under the no-action alternative (alternative A), streamflows within the study area would continue to be affected by the operations of upstream reservoirs of the Aspinall Unit and Dallas Creek Project. The Gunnison River would be operated to maintain at least a minimum flow of 300 ft^3/s, except during extremely dry periods.

With alternatives B, C, E, and F, the Gunnison River would continue to be operated to maintain at least a minimum flow of 300 ft^3/s; however, diversions from the river would increase, with the greatest increase occurring during the nonirrigation season. On an annual basis, the volume of water in the Gunnison River downstream from the Gunnison Tunnel would be decreased by 45 percent for alternative B, 49 percent for alternative C, 41 percent for alternative E, and 44 percent for alternative F.

Average December through February flows entering the Black Canyon would be 1,392 ft^3/s for alternative A, 476 ft^3/s for B, 471 ft^3/s for C, 581 ft^3/s for E, and 499 ft^3/s for F. Average July through

September flows would be 897 ft^3/s for alternative A, 730 ft^3/s for B, 637 ft^3/s for C, 730 ft^3/s for E, and 730 ft^3/s for F. Minimum streamflows would be 300 ft^3/s for all alternatives, but the frequency of 300 ft^3/s flows would increase significantly with development alternatives.

A monitoring system would be operated to assure maintenance of instream flows as well as protection of irrigation supplies. In addition under alternative F, additional flows would be bypassed to the Gunnison River during winter operations if adverse icing conditions develop. Alternative F also would release up to 1,000 acre-feet of additional flow to the Uncompahgre River via the South Canal during the summer.

The operation of the facility would result in a decrease in Uncompahgre River flows in some reaches and increases in other reaches. Streamflows in the Uncompahgre River entering Montrose would be reduced by 75 percent for all of the development alternatives. Streamflows in the Uncompahgre River downstream from the proposed tailrace would be increased by 339 percent for alternative B, 364 percent for alternative C, 318 percent for alternative E, and 336 percent for alternative F.

Diversions from the Gunnison River would be curtailed under all alternatives, including no-action, during periods of flooding along the Uncompahgre River. Under the development alternatives, local flooding and severe local erosion would occur in case of catastrophic penstock failure.

Irrigation

Operation of the development alternatives would not affect the amount of water diverted for irrigation use within the study area, including private irrigation diversions as well as the UVRP. The Montrose and Delta Canal and the Loutzenhizer Canal would receive the majority of their water supply from the Uncompahgre River with development. Under the no-action alternative, about 59 percent of the water supplies delivered to these canals would be derived from the Gunnison River. Under any of the development alternatives, this figure would be reduced to about 35 percent. Senior water rights for private irrigation diversions along the Gunnison and Uncompahgre Rivers would continue to be honored.

River Morphology

Without development, the Gunnison River between the North Fork confluence and Delta would be expected to become narrower and more stable due to the effects of existing upstream water storage projects. Changes being caused by the Aspinall Unit on the Gunnison River upstream from the North Fork would continue.

With development, more of the riverbed would be exposed. Riparian vegetation would encroach during periods of low and intermediate flows but would be scoured during periods of high flows.

Without development, the Uncompahgre River upstream of the study area would become a narrower and more stable river under the influence of Ridgway Reservoir. Within the study area (downstream from the South Canal), the bank erosion that now occurs would continue.

With development, bank erosion in the Uncompahgre River between the South Canal and the proposed tailrace would decrease together with the river's potential to scour encroaching vegetation. Between the proposed tailrace and Delta, the river would become more unstable and significant additional bank erosion would occur unless bank protection was initiated. To minimize this erosion, bank stabilization would be performed in areas found to be most susceptible to erosion before development. Changes in erosion would be monitored during operations, and further bank stabilization would be completed where necessary.

Water Quality and Temperature

Under the no-action alternative, water quality in the Gunnison River would not change significantly. Water quality in the Uncompahgre River may improve as Ridgway Reservoir will settle out sediment and other pollutants.

Under the development alternatives, additional diversion from the Gunnison River would reduce the volume of high quality water available to dilute lesser quality tributary inflows. This reduction in water quality would occur primarily downstream from the North Fork. Temperatures in the Gunnison River would be slightly colder in the winter and warmer in the summer. The conditions under which ice forms in the Gunnison River would occur more frequently under the development alternatives. Ice accumulation would be most extensive below the North Fork confluence but would also increase above this tributary. Alternative F provides operational changes to decrease diversions and therefore increase flows when ice conditions create environmental problems.

Water supplies in the Uncompahgre River in the 12-mile reach between the South Canal and Montrose would receive less high quality water from the Gunnison River during the irrigation season and thus less dilution capability would exist. Downstream from Montrose, additional Gunnison River water would be present to dilute sediments and other pollutants. Salt loading to the river would be reduced with development.

Soils and Vegetation

No significant changes in soils or vegetation are projected under the no-action alternative. Under the development alternatives, vegetation and soil disturbance would occur in construction areas. Disturbed areas would be restored and reseeded. A total of approximately 12 acres of wetlands would be lost due to construction. This acreage would be replaced by creation of a wetland area near the powerplant.

Lower flows in the Gunnison River would allow the establishment of additional riparian vegetation. However, the scouring of vegetation would occur during high flow periods as now occurs under the no-action alternative. Along the Uncompahgre River, bank stabilization efforts would be required to protect riparian areas.

Less than one percent of the total known population of the endangered clay-loving wild buckwheat (Erigonum pelinophilum) would be eliminated during construction of the penstock. Special construction techniques in this area would be imposed to reduce impacts, and off-site mitigation to protect other populations would be implemented.

Fisheries

Without development, the Gunnison River would be expected to keep its status as a Gold Medal fishery maintained by natural reproduction. This fishery has been maintained under a large range of flows over the last decade, and no significant habitat or water quality changes would be expected from this range.

Development alternatives would divert additional flows from the river, with the largest change occurring in the nonirrigation season. Studies on the fish populations and fish habitat over the last decade indicate that the fishery would be maintained under development conditions.

Additional diversions through the Gunnison Tunnel may increase the loss of fish from the Gunnison River to the South Canal.

Under the no-action alternative, the fishery in the Uncompahgre River between Ridgway Dam and the Montrose and Delta Canal would be expected to improve due to better flow patterns and water quality. With development, habitat conditions may improve between the South Canal and the Loutzenhizer Diversion (approximately 7 miles) and decline between the Loutzenhizer Diversion and Montrose (approximately 4 miles). Flow conditions and water quality should improve downstream from Montrose, but other habitat conditions may preclude development of a significant fishery.

River flows downstream from Delta would not be affected, and therefore the endangered fishes that occur in the lower Gunnison and Colorado Rivers would not be affected.

Wildlife

Significant changes are not projected under the no-action alternative. Land use changes in the Uncompahgre Valley may gradually reduce wildlife habitat and numbers. Land management plans for lands along the Gunnison River, however, provide for long-term preservation of habitat. Possible impacts to wildlife under development alternatives include loss of habitat in construction areas and loss of 12 acres of wetland. These losses would be offset by a wetland replacement plan and restoration and revegetation plans. Reduced flows in the Gunnison River should not significantly affect wildlife resources. Increased hike-in fishing, however, could lead to wildlife disturbance. Features of development alternatives include deer escape ramps along the AB Lateral and raptor-proofing of transmission lines to reduce impacts to wildlife.

Endangered bald eagles are common winter residents along rivers in the area, with the greatest concentrations occurring along the Gunnison River. Changes in river flows and accompanying ice conditions could affect use by eagles. A monitoring program has been recommended by the Fish and Wildlife Service and adopted by the Sponsors.

Land Use and Recreation

Significant land use changes are not projected under the no-action alternative. Construction of development alternatives would disturb approximately 234 acres of land, the majority of which is now used for livestock grazing or irrigated agriculture. Approximately 127 acres of land would be needed for operation of the facility. However, permanent land use changes would occur on only about 30 acres. This includes 24 acres of grazing land between the powerplant and the Uncompahgre River. The remaining

6 acres would be used for the operation and maintenance of the enlarged AB Lateral and its associated structures.

Under the no-action alternative, recreational use along the Gunnison River would be affected by management plans of the Bureau of Land Management and the National Park Service. With development, river flows would decline, leading to a decrease in private and commercial rafting and an increase in hikers and anglers. The recreational value of the Uncompahgre River would continue to be limited from a public standpoint because of the limited public land along the river. However, groups have developed public trails and other use areas along the river in recent years and this trend would be expected to continue. River flow changes in the Uncompahgre River would not deter from such developments except in the 4-mile reach between the Loutzenhizer Diversion and Montrose, where flows would be significantly reduced by the development alternatives. As indicated previously, alternative F would provide additional flows to this reach as compared to other development alternatives.

A portion of the Gunnison River downstream from the Gunnison Tunnel has been determined eligible as a wild river under the Wild and Scenic Rivers System, and a wilderness study area borders the river downstream from the Black Canyon of the Gunnison National Monument. Under the no-action alternative, these areas may be designated by Congress as a wild river and a wilderness area. These areas would remain eligible under development conditions according to the National Park Service and the Bureau of Land Management, although some resources would be adversely affected according to these agencies.

Social and Economic Conditions

Without development, the economy of the Montrose-Delta area would continue to be dependent upon agriculture, tourism, and light industry. With the development alternatives, local employment opportunities would increase during construction. Operation of the facility would be expected to produce annual tax revenues to Montrose County of $400,000. Operating revenues to the UVWUA would be expected to range between $150,000 and $300,000 in the first year of operation, escalating each year thereafter to over $1 million in the year 2008.

Without development, rafting use along the Gunnison River would be expected to average approximately $311,000 of direct expenditures annually. With development of alternatives B, E, or F, these expenditures would be reduced to about $274,000 annually, or to $237,000 with development of alternative C.

Without development, the estimated expenditures attributed to hike-in fishing to the Gunnison River would be about $446,000. This value would increase to about $507,000 with development of alternatives B, E, or F, and to about $541,000 with development of alternative C.

Air Quality and Noise

Operation of the facility would have little, if any, adverse impact on the air quality of the region. Activities during construction would generate fugitive dust emissions and mobile source air emissions. Dust may be generated during certain phases of construction; motor vehicles and other construction equipment would emit exhaust pollutants.

Operation of the facility would offset emissions of SO2, NOx, and CO2. For alternative C, these offsets are anticipated to average 825; 1,375; and 412,500 tons per year, respectively. For other alternatives, the offsets would be slightly lower.

Within the operational areas of the powerplant, the noise levels would conform to safe levels as established by Occupation and Health Administration (OSHA) regulations. Outside the plant, the only constant and appreciable noise source would be the transformers. Vehicular traffic would be infrequent. Construction noise would result but would be short term and restricted to the period between 7:00 a.m. and 7:00 p.m.

Cumulative Impacts

To more accurately describe impacts of the development alternatives, future river operations have been projected under the no-action alternative. The effects of upstream reservoirs of the Aspinall Unit and the Dallas Creek Project have been estimated so that total impacts of the AB Lateral Facility on the river systems can be seen.

Cumulatively, the impacts of reduced flows in the Gunnison River and the resultant increased opportunity for hike-in human use would result in both the reduction and increase of some of the values that make the area attractive. This could result in more restrictive management practices being instituted by the National Park Service and the Bureau of Land Management.

A number of other projects upstream from the Aspinall Unit are being considered. These include transmountain diversions to the eastern slope of Colorado. The feasibility of these proposals is directly affected by Colorado water law. If any of the development alternatives proposed in this report would be implemented, the available water supply for those projects could be reduced if their water rights are junior to those of the AB Lateral Facility. The water rights granted to the AB Lateral Facility would reserve more water available for use in the Gunnison River Basin.

Public Involvement

Public involvement activities are described in this draft environmental statement. Various proposals for hydropower development on the Uncompahgre Valley Reclamation Project have been considered since 1979. In 1986, Reclamation began issuing news releases and consulting with agencies on the AB Lateral proposal. Reclamation began preparing an environmental assessment and conducted environmental scoping meetings in 1987. Following public review of the assessment, Reclamation determined that an environmental impact statement should be prepared. Significant issues were determined throughout the public involvement process, and studies were completed to answer issues and concerns. A final environmental impact statement and a record of decision will also be prepared.

Summary

The following tables (S-1 through S-4) summarize information on the facility, including alternative costs, benefits, energy production, river flows, irreversible and irretrievable impacts, as well as other environmental parameters. A benefit/cost ratio has been computed for each of the development alternatives. Only the sale of power generation has been included in the benefits calculation. Costs include the cost of constructing and operating the alternatives, environmental mitigation costs, as well as property taxes. The project sponsor's preferred plan is alternative C, which maximizes the benefit/cost ratio.

Summary Table 1.--Short- and long-term impacts resulting from alternatives[1]

Resource	Irre- versible impact	Irre- trievable impact	Relationship of short-term use of environmental and long-term productivity
Streamflows	No	No	Streamflows in the Gunnison River would be reduced by diversions to proposed development. Streamflows in Uncompahgre River would be increased. Largest decreases and increases occur during the winter months.
Irrigation	No	No	Water supplies to irrigated lands would not be affected. Development would be operated to provide required demands to irrigation system before meeting hydropower demands.
River mechanics	Yes	No	Without mitigation, development would increase bank erosion along the Uncompahgre River downstream from proposed tailrace.
Water temperature	No	No	Periodic ice acccumulation would occur during severely cold periods. During summer months, water temperatures in the Gunnison River below the North Fork confluence would increase during low flow periods. Temperatures in the Uncompahgre River would decrease in the summer below the powerplant.
Water quality	No	No	Water quality in the Uncompahgre River would improve below proposed tailrace. Water quality would degrade in the Uncompahgre River between the South Canal and tailrace. Water quality in the Gunnison River would degrade downstream of Smith Fork confluence.
Fisheries	No	No	Significant impacts to Gunnison River fishery would not occur. Uncompahgre River fishery below the tailrace would improve as result of increased flows.

[1] An irreversible impact to a resource is one that cannot be changed once it occurs; an irretrievable impact means that the resource cannot be recovered or reused.

Summary Table 1.--Short- and long-term impacts resulting from alternatives (continued)

Resource	Irre-versible impact	Irre-trievable impact	Relationship of short-term use of environmental and long-term productivity
Soils & vegetation	Yes	Yes	Less than one percent of the populations of clay-loving wild buckwheat and adobe penstemon would be eliminated during construction of the penstock. Widening and lining of the AB Lateral would result in the loss of 4 acres of wetland. Bank stabilization along the Uncompahgre River would result in the loss of about 8 acres of wetland.
Terrestrial wildlife	No	No	Significant impacts to terrestrial wildlife would not occur.
Land use & recreation	No	No	Significant land use changes are not expected with development. Recreational rafting usage of the Gunnison River would decrease. Hike-in angler use of the Gunnison River Gorge would increase.
Social and economic	No	No	Short-term employment opportunities would increase as a result of construction. Long-term employment could also change due to increased revenues to Montrose County and the UVWUA. Development would decrease employment in the rafting industry and increase employment related to fishing.
Cultural resources	No	No	No impacts would occur to cultural resources except under alternative C, which includes enlarging the Gunnison Tunnel.
Air quality	No	No	Short-term degradation of air quality resulting from construction equipment would occur. Development would reduce emissions of air pollutants from fossil-fueled powerplants.

Summary Table 2.--Summary comparison of alternatives

Item	A	B	C	E	F
	Alternative				
WATER FLOW DATA (in ft^3/s)					
Gunnison River:					
Entering Canyon (average annual)	1,103	613	563	654	618
Average December through February flows	1,392	476	471	581	499
Average July through September flows	897	730	637	730	730
Minimum flows	300	300	300	300	300[1]
Below Delta (all periods)	No change	No change	No change	No change	No change
Uncompahgre River:					
Below South Canal (average annual)	540	342	342	342	343
Average December through February flows	89	88	88	88	88
Average July through September flows	910	579	579	579	585
Below Montrose & Delta Canal (average annual)	312	113	113	113	115
Average December through February flows	61	60	60	60	60
Average July through September flows	471	140	140	140	145
Entering Montrose (average annual)	269	65	65	65	67
Average December through February flows	50	48	48	48	48
Average July through September flows	392	58	58	58	63
Below Cedar Creek (average annual)	202	684	735	643	679
Average December through February flows	40	956	960	850	932
Average July through September flows	279	442	536	442	442
Through turbines (average annual)	- NA -	702	751	661	695
Average December through February flows	- NA -	918	922	812	894
Average July through September flows	- NA -	527	621	527	522
PRODUCTION DATA					
Rated capacity (HP)	- NA -	66,240	66,240	54,650	66,240
Average annual energy production (MWh)	- NA -	261,006	274,911	247,264	258,619
Design flow capacity (ft^3/s)	- NA -	1,135	1,135	950	1,135
Net head at maximum capacity (feet)	- NA -	580	580	603	580
PHYSICAL DATA					
Pipeline diameter[2] (inches)	- NA -	120	120	114	120
Tunnel modifications	None	None	Enlarged	None	None

[1] The minimum flow for Alternative F would be increased as necessary during winter months for purging ice buildup in the Gunnison River downstream of the Tunnel.

[2] Penstock diameters are preliminary and subject to change.

Summary Table 3.--Alternative cost data, in $1,000, and benefit/cost analysis

Item	Alternative A	B	C	E	F
ALTERNATIVE COST DATA (in 1990 dollars)					
Construction costs[1]	- NA -	$52,959	$53,709	$48,454	$52,959
Development costs[2]	- NA -	$9,155	$9,245	$8,614	$9,155
Total capital costs	- NA -	$62,114	$62,954	$57,068	$62,114
Annual operation and maintenance costs	- NA -	$1,050	$1,050	$950	$1,050
ECONOMIC ANALYSIS (in 1992 dollars)[3]					
Discount rate = 13 percent					
Present value, fixed costs	- NA -	$68,870	$69,797	$63,269	$68,870
Present value, variable costs	- NA -	$8,551	$8,551	$7,737	$8,551
Present value, revenues from sale of power	- NA -	$78,549	$82,733	$74,405	$77,848
Benefit/cost ratio	- NA -	1.015	1.056	1.048	1.006
Discount rate = 14 percent					
Present value, fixed costs	- NA -	$66,037	$66,926	$60,666	$66,037
Present value, variable costs	- NA -	$8,174	$8,174	$7,396	$8,174
Present value, revenues from sale of power	- NA -	$75,106	$79,107	$71,144	$74,436
Benefit/cost ratio	- NA -	1.012	1.053	1.045	1.003
Discount rate = 15 percent					
Present value, fixed costs	- NA -	$63,419	$64,273	$58,261	$63,419
Present value, variable costs	- NA -	$7,827	$7,827	$7,081	$7,827
Present value, revenues from sale of power	- NA -	$71,933	$75,764	$68,138	$71,290
Benefit/cost ratio	- NA -	1.010	1.051	1.043	1.001

[1] Includes design/build costs, land acquisition and environmental mitigation costs.

[2] Includes financing, engineering design, licensing and legal fees, interest during construction, and administrative costs.

[3] Discount rates evaluated represent the range of financing rates expected by the Sponsors.

Summary Table 4.--Impacts of alternatives

Item	A	B	C	E	F
	Alternative				
WATER QUALITY AND QUANTITY					
Salt-loading reduction (tons)	0	3,044	3,256	2,866	3,014
Annual flow entering Black Canyon (Gunnison R.)(ft^3/s)	1,103	613	563	654	618
Annual flow entering Montrose (Uncompahgre R.)(ft^3/s)	269	65	65	65	67
Annual flow below Cedar Creek (Uncompahgre R.)(ft^3/s)	202	684	735	643	679
ENDANGERED SPECIES					
Clay-loving wild buckwheat affected by const. (acres)	0	<5	<5	<5	<5
Mitigation acreage provided by Sponsors (acres)	0	60	60	60	60
Endangered fisheries affected	None	None	None	None	None
Endangered wildlife affected	None	Bald eagle	Bald eagle	Bald eagle	Bald eagle
WETLANDS					
Acreage affected along AB Lateral (acres)	0	4	4	4	4
Acreage affected along Uncompahgre River (acres)	0	8	8	8	8
Mitigation acreage provided by Sponsors (acres)	0	12	12	12	12
LAND USE					
Permanent easement requirements (acres)	0	127	127	127	127
Temporary easement requirements (acres)	0	249	249	249	249
RECREATION					
Gunnison River Wild & Scenic eligibility retained	Yes	Yes	Yes	Yes	Yes
Rafting, user days	4,673	4,066	3,440	4,066	4,066
Present value, direct expenditures[1] ($1,000)	$4,454	$3,924	$3,480	$3,924	$3,924
Economic impacts ($1,000)	$0	-$530	-$974	-$530	-$530
Fishing, user days	17,680	20,078	21,414	20,063	20,078
Present value, direct expenditures[1] ($1,000)	$6,387	$7,261	$7,748	$7,261	$7,261
Economic impacts ($1,000)	$0	$874	$1,361	$874	$874
CULTURAL RESOURCES					
Cultural resources sites affected	0	0	1	0	0
AIR QUALITY					
Air pollutant emissions offset: SO_2 (tons/yr)	0	800	825	740	800
NO_x (tons/yr)	0	1,300	1,375	1,235	1,300
CO_2 (tons/yr)	0	390,000	412,500	370,000	390,000

[1] Direct expenditures for rafting and fishing shown as net present value. 1988 values inflated at 5 percent per year and discounted to 1992 dollars at 8.875 percent. Annual expenditures (in 1988 dollars) are shown in chapter 3.

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

Page

LIST OF TABLES

Page

LIST OF TABLES (cont'd)

LIST OF TABLES (cont'd)

LIST OF TABLES (cont'd)

LIST OF FIGURES

CHAPTER 1 PURPOSE AND NEED

CHAPTER 2 ALTERNATIVES INCLUDING PROPOSED ACTION

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

CHAPTER 1
PURPOSE AND NEED

Introduction

The purpose of this report is to present the environmental impacts that would occur if the alternatives of the AB Lateral Hydropower Facility were constructed and operated. The facility would be funded, built, and operated by the Uncompahgre Valley Water Users Association (UVWUA) and Montrose Partners, referred to as the "Sponsors" in this document.

The Sponsors plan to construct the AB Lateral Hydropower Facility using existing features of the Uncompahgre Valley Reclamation Project (referred to throughout this report as the UVRP), a Bureau of Reclamation (Reclamation) irrigation project. They are seeking a contract (lease of power privilege) with Reclamation that would permit using UVRP features for generating hydroelectric power.

In 1987 and 1988, Reclamation prepared an environmental assessment (EA) to address project related impacts. Public scoping meetings were held in November 1987, in Denver and Montrose, Colorado. Approximately 200 copies of the draft EA were distributed to agencies and interested members of the public in March and April 1988. Based largely on comments received in response to the EA, Reclamation determined that an environmental impact statement (EIS) for the facility should be prepared. Reclamation prepared this draft EIS using information provided by various agencies, organizations, and consultants.

Location

The facility, which would be located in west-central Colorado near the city of Montrose, would use the existing Gunnison Diversion Dam, Gunnison Tunnel, part of the South Canal, and an enlarged AB Lateral near Montrose to deliver water to a proposed penstock and powerplant.

Authorization

Hydropower development in association with the UVRP was authorized by the Act of June 22, 1938 (Public Law 76-698, Stat. 941) (the Act). Reclamation published a notice of intent to contract for hydropower development on the UVRP in the December 9, 1985, issue of the Federal Register (50 FR 50238). Reclamation received one proposal in response to the Federal Register notice, the proposal submitted by the Sponsors. Reclamation and the Sponsors subsequently signed an agreement on

June 6, 1986, to study the feasibility of developing hydroelectric power on the UVRP.

Under the Act, the hydropower facility would be constructed and operated under a lease of power privilege with Reclamation. Funding for the hydropower studies is provided by the Sponsors. Reclamation serves as the lead Federal agency responsible for ensuring compliance with the National Environmental Policy Act of 1969.

Participating Organizations

The UVWUA, a Colorado nonprofit corporation formed under the Colorado Non-Profit Corporations Act, was formed in part to repay the debt incurred to the Government during construction of the UVRP and in part to operate and maintain the UVRP. The construction repayment contract was renegotiated in 1948, and final payment is scheduled for the year 2048. In 1988, approximately $7 million of these loans were repurchased by the UVWUA and refinanced with $2 million of debt supplied by the State of Colorado.

The Act also allows a nonprofit corporation to carry out any lawful purpose for which it was established. According to the UVWUA's Articles of Incorporation, as amended in 1927, the UVWUA's lawful purposes include the development of hydroelectric power facilities.

The UVWUA's involvement in the AB Lateral Facility would include assistance in acquiring title to and/or the right to use lands necessary for construction and operation of the facility and in acquisition of the necessary water rights to operate the facility. The UVWUA would review and approve any plans that could affect the UVRP's operation including operation guidelines and canal and lateral modification designs. The UVWUA would operate and maintain the facility as part of normal operation and maintenance of the UVRP. The UVWUA would share the revenue from power sales but would not be at financial risk or liability for financing, constructing, or operating the facility. Revenues would be used for early debt retirement, for upgrading the irrigation system, or for reducing annual water users assessments.

Montrose Partners is a partnership formed under the Massachusetts Limited Partnership Act (limited partners consist of a group of private investors). Mitex, Inc., of Boston, Massachusetts, the general partner, is a developer, owner, and operator of small hydropower facilities and has participated in developing a number of hydroelectric projects.

Montrose Partners and the UVWUA would acquire all lands necessary for constructing and operating the facility. They would contract with engineering firms and others for studies and designs required to complete the facility, contract with equipment manufacturers to provide turbines and other electrical and mechanical equipment, and negotiate agreements for the sale of power. Montrose Partners would raise all funds needed to pay for the above activities and would be responsible for any financial risk for construction, operation, and maintenance of the facility. Revenues from power sales would be distributed among investors in the facility, the UVWUA, and the United States.

In addition to Reclamation's involvement in the facility, other Federal agencies are involved in various development stages. Approximately 1 acre of Federal land administered by the Bureau of Land Management (BLM) would be needed for enlarging the AB Lateral (described later); a Section 404 permit would be needed from the U.S. Army Corps of Engineers (COE); a Section 402 permit would be needed from the Colorado Department of Health; a Biological Opinion has been prepared by the Fish and Wildlife Service (FWS) under the Endangered Species Act; and coordination is ongoing with the FWS under the Fish and Wildlife Coordination Act. BLM and the National Park Service (NPS) are cooperating agencies in the National Environmental Policy Act (NEPA) process.

The Sponsors are also required to comply with applicable city, county, and State rules and regulations regarding land use, water quality protection, and construction.

Purpose of Project

The purpose of the AB Lateral Hydropower Facility is to economically develop the energy potential of water flows from the Gunnison Tunnel to the Uncompahgre River. The large difference in elevation between the West Portal of the Gunnison Tunnel and the Uncompahgre River creates the potential for hydropower production.

Need for Project

The Sponsors cite the following needs for the proposed hydropower facility: (1) generating electrical power; (2) developing a renewable resource; (3) improving the existing irrigation system; and (4) enhancing the UVWUA's revenues for debt repayment and system improvement.

Electrical Power

Power from the proposed facility would be sold to local utilities. For the first 15 years of project operation, capacity and energy would be sold to the Public Service Company of Colorado for resale to its customers. The 15-year power sales contract signed in 1988 would coincide with the financing term for project related debt. Beginning in year 16, the Sponsors would be free to select a different power purchaser for the balance of the lease term with Reclamation.

Under the Public Utilities Regulatory Policies Act of 1978 (PURPA), Sponsors are assured a market for project power at rates not to exceed the purchasing utility's "avoided cost." Avoided cost is generally defined as the cost a utility would incur to provide an equivalent amount of generation. The avoided cost standard was developed to ensure that electric rate payers would be indifferent to such purchases. Power sales from the project at rates less than or equal to avoided costs would thus be economical when compared to other alternatives.

Electrical power needs within specific service territories are forecast by individual utilities. Public Service Company of Colorado, in their 1987 forecast of loads and resources (PSCo, 1987), showed the need for 472 megawatts (MW) of additional capacity to meet minimum reserve criteria in 1992 (the facility's first year of operation), increasing to over 1,100 MW by 1996 (the last year in the 10-year forecast). The December 1988 version of this plan (PSCo, 1988) showed power needs to range from 500 MW in 1992 to 1,000 MW by 1998. Generation from the proposed project, as well as other independent small power producers, is expected to fill a portion of that need. In accordance with those forecasts and conditions, the project's power sales agreement was approved by the Colorado Public Utilities Commission in June 1988 (CPUC, 1988).

Demand forecasts for the larger Rocky Mountain Power Area (Colorado and parts of Wyoming and South Dakota) are published annually by the Western Systems Coordinating Council (WSCC). The 1988 WSCC forecast showed the need for 1,568 MW of new capacity in the area from 1988 to 1997 (WSCC, 1988). The Federal Energy Regulatory Commission (FERC) also provides independent assessments of power needs. Within Colorado in 1988, FERC has established the need for new power resources in environmental assessments for hydropower projects at Paonia Dam (44FERC 62,010 7/1/88), Lemon Dam (43FERC 62,305 6/16/88), and Maroon Creek (Project 10,441, 7/20/88). The proposed AB Lateral Facility, under a 40-year lease from Reclamation and with a potential 100-year project life, would be useful in meeting a portion of the immediate and future power needs within Colorado and the immediate region.

Integrating facility power into the local grid would supply additional benefits to local power quality and reliability. Operating the facility, with its proximity to the Montrose load center, would provide an alternate power source in case temporary outages occur at Colorado Ute Electric Association thermal plants or transmission lines. In addition, the facility would provide needed voltage support to the local system, alleviating a problem which usually occurs when load is separated from generators by long transmission lines.

Finally, operation of the facility would enhance the State of Colorado's electrical reliability by contributing to fuel diversity. Colorado and the rest of the Rocky Mountain power area rely heavily on coal to fuel major powerplants. Adding of hydroelectric generation to the system would help mitigate economic difficulties if the coal supply were interrupted, if coal prices were to increase substantially, or if acid rain legislation required installation of emissions reduction equipment at existing facilities.

Renewable Resources

In passing the National Energy Act of 1978, Congress found that:

> [T]he protection of the public health, safety, and welfare, the preservation of national security, and the proper exercise of congressional authority under the Constitution to regulate interstate commerce require...a program providing for increased conservation of electric energy, increased efficiency in the use of facilities and resources by electric utilities, and equitable retail rates for electric consumers, [and]...a program to provide for the expeditious development of hydroelectric potential at existing small dams to provide needed hydroelectric energy (PURPA, Section 2; Public Law 95-617).

One of Congress' key motivations in passing this bill was to reduce the national dependence on fossil fuels. Developing the AB Lateral Facility would eliminate the need to construct and (or) operate an equivalent amount (40 to 50 MW) of fossil-fueled generation, thus reducing dependence on fossil fuels.

Recently, emissions-related problems have been brought to the forefront of national attention. The principal smokestack gasses released from fossil-fueled powerplants include sulfur and nitrogen oxides and carbon dioxide. The sulfur and nitrogen oxides are thought to be major contributors to the phenomenon known as "acid rain." Carbon dioxide, and to a lesser extent, nitrogen oxides, are believed to be principal causes of the "greenhouse effect" (the slow warming of overall climate). Thus a strong need exists to reduce emissions of these gasses where economically feasible.

Operation of the proposed facility would result in emissions reductions from existing and/or future fossil-fueled plants in direct proportion to the facility's generation. The alternatives considered would result in emissions offsets (reductions) of sulfur oxides ranging from 750 tons per year to 825 tons per year. Nitrogen oxide emissions would be reduced by 1,235 to 1,375 tons per year. Offsets or reductions in carbon dioxide emissions, the major contributor to the "greenhouse effect," would range from 370,000 to 410,000 tons per year as a result of facility operation.

Irrigation System

Facility development would include installing automated stream gauges, gate control equipment, and remote telemetry devices at key locations on the UVWUA system. Information from these units would be fed directly to the UVWUA headquarters in Montrose. The instrumentation would allow the UVWUA to more efficiently control the flow of water needed to serve both irrigators and the hydropower facility.

The facility penstock would provide an alternate route for irrigation water to travel from the Gunnison Tunnel to the Selig, Ironstone, Garnet, and East Canals (see figure 1.1). If emergency repairs are ever necessary to the South Canal during the irrigation season, water flows could still be maintained over most of the UVRP, increasing irrigation system reliability.

UVWUA Revenues

The UVWUA currently has outstanding rehabilitation and betterment loans of approximately $2.1 million due to the State of Colorado and an additional debt of $3.5 million owed to the Federal Government under construction loans originally lent for the Uncompahgre Project. The principal source of revenue to meet these expenses is the sale of water to UVWUA irrigators. One impact of the project will be the assistance to the UVWUA in repayment of this debt. As currently planned, initial revenues would be used for debt retirement on an accelerated basis. Revenues from water charges could then be used for more comprehensive operations and maintenance activities. Overall

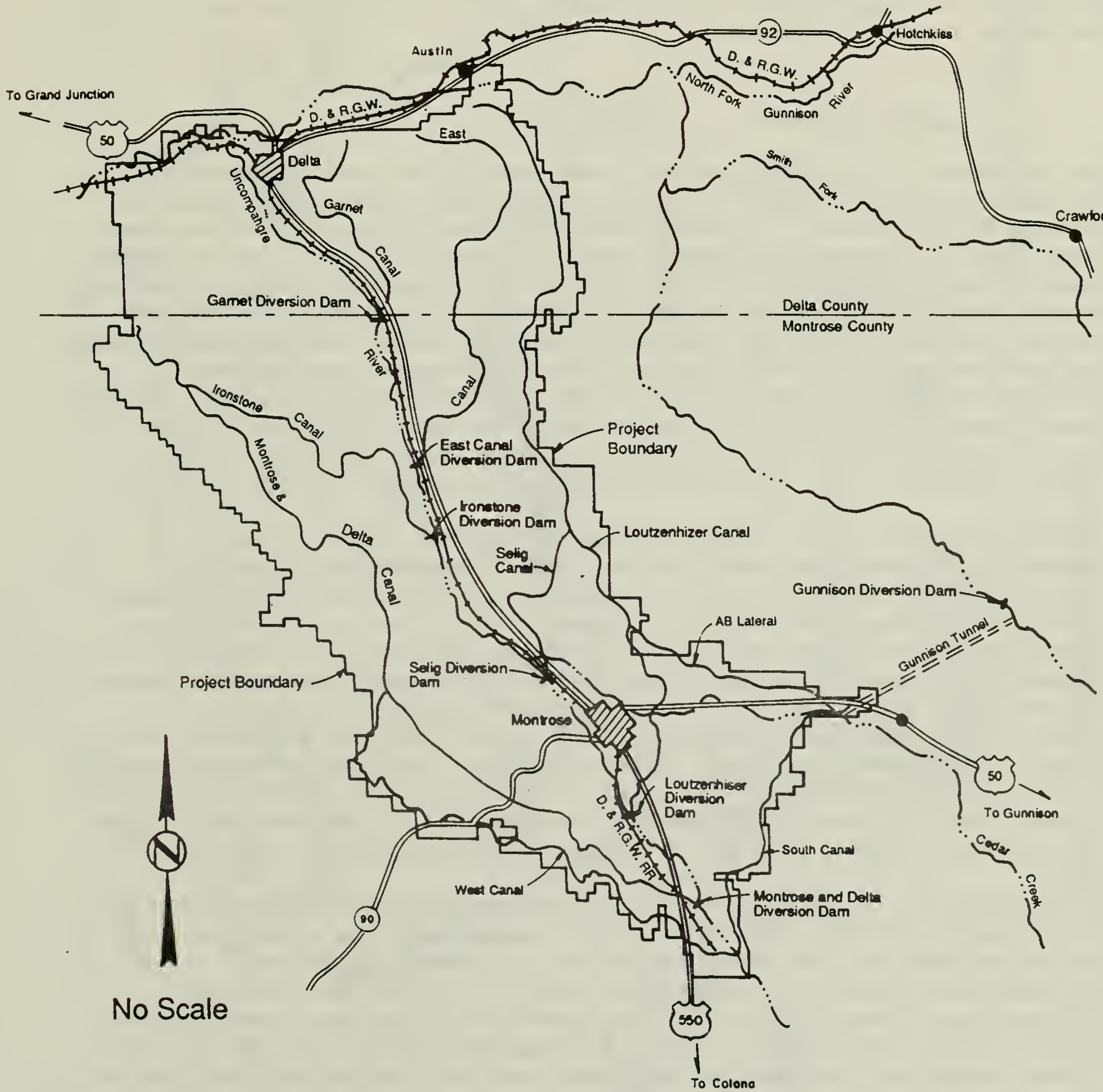


Figure 1.1. Uncompahgre Valley Reclamation Project.

charges to farmers could thus be held constant, or in the long run, possibly decrease, while greatly improving system efficiency. The Federal debt, which is not fully due until 2048, could be repaid by 2004.

Background

The proposed hydropower development would be located within the boundaries of the UVRP, which now supplies irrigation water to nearly 86,000 acres. The project includes Taylor Park Dam and Reservoir in Gunnison County, seven diversion dams, 152 miles of canals, and 414 miles of laterals in Montrose and Delta Counties. Water from the Gunnison River is diverted through the Gunnison Tunnel and delivered by the South Canal to the Uncompahgre River for rediversion to UVRP lands. The UVRP canal system and irrigated lands begin about 6 miles south of Montrose and extend downstream (northward) to Delta for 34 miles along both sides of the Uncompahgre River. Figure 1.1 shows the location of the major canals of the UVRP and other features of the study area.

Irrigation and water supply demands for the UVRP are met by diverting flows from the Gunnison and Uncompahgre Rivers. Historically, about 505,000 acre-feet of water annually flows into the Uncompahgre Valley. About two-thirds of this flow is supplied by the Gunnison River through the existing Gunnison Tunnel; the remaining supplies enter from the Uncompahgre River. The average annual flow in the Gunnison River is about 1,360 cubic feet per second (ft^3/s) upstream from the Gunnison Tunnel, which is over five times greater than the average annual flow of the Uncompahgre River near Colona, just upstream of UVRP boundaries. Historically, both rivers carry high natural flows during late spring and early summer resulting from snowmelt.

Natural flows on both rivers are now regulated by dams operated by Reclamation upstream from UVRP lands. Crystal, Morrow Point, and Blue Mesa on the Gunnison River together comprise Reclamation's Wayne N. Aspinall Unit. Ridgway Dam on the Uncompahgre River is part of Reclamation's Dallas Creek Project. Taylor Park Dam, which is part of the UVRP and operated by the UVWUA, provides irrigation storage and is located on the Taylor River upstream of Blue Mesa Dam. Figure 1.2 shows the location of these dams.

The two rivers have been linked by a network of canals and laterals since the early 1900s. The major features of this linkage are the Gunnison Tunnel and the South Canal, which convey diverted flows from the Gunnison River into the Uncompahgre River. Portions of these flows are diverted from the South Canal to meet demands along its length, including those of

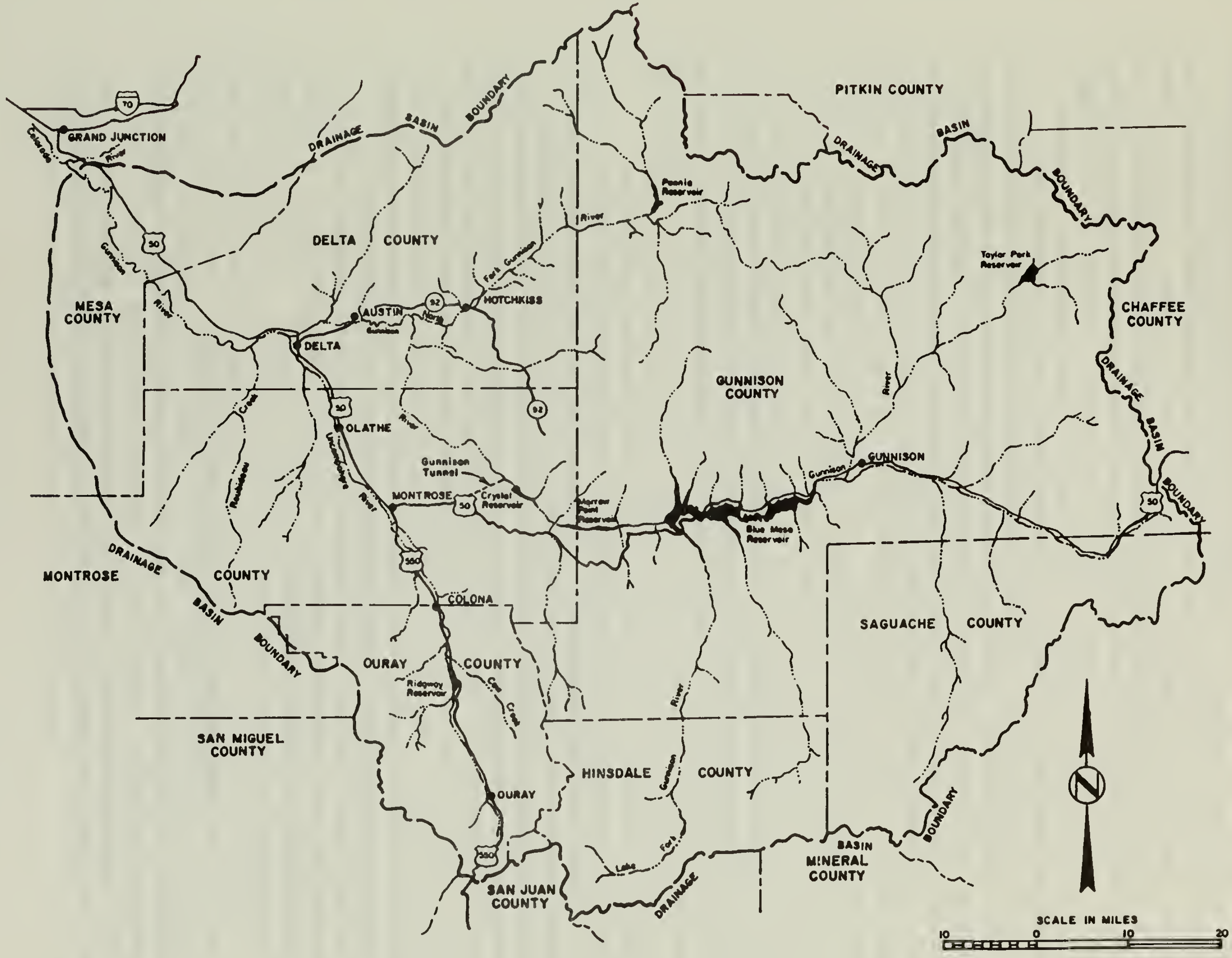


Figure 1.2. Gunnison River Basin

the AB Lateral and West Canal. However, the majority of the over 337,000 acre-feet annually diverted from the Gunnison River are combined with Uncompahgre River water to irrigate UVRP lands.

Water is diverted from the Uncompahgre River at six diversion dams and passed through several hundred miles of canals, laterals, and drains to meet irrigation needs. Moving downstream from the South Canal outfall, other major canal systems include the Montrose and Delta (M&D), Loutzenhizer, Selig, Ironstone, East, and Garnet Canals. Annual irrigation diversions for the UVRP and other private systems have averaged about 559,000 acre-feet per year. About half of the flow diverted to these canals is used consumptively (mainly for irrigation), and the remainder returns to the Uncompahgre River for downstream use and ultimately joins the Gunnison River near Delta.

Historic UVRP operations have been constrained by two major factors, the capacity of the Gunnison Tunnel and periodic flooding on the Uncompahgre River downstream of the South Canal. Presently, the capacity of the Gunnison Tunnel (the Tunnel) is 1,135 ft^3/s, based upon tests conducted by the UVWUA and the Colorado State Engineer in September 1987 (Colorado State Engineer).

The Gunnison Tunnel is 5.8 miles long and crosses under the hydrologic divide between the Gunnison and Uncompahgre River Basins. Construction on the Tunnel was started by private interests before 1900 but was stopped due to financial problems. Construction began again in 1904, shortly after the development efforts were assumed by Reclamation (then known as the Reclamation Service). The Tunnel was completed in 1909, but full operation did not begin until 1912, when the Gunnison Diversion Dam was completed. Because of its significance to the historical development of the region and because of the history surrounding the actual construction, the Tunnel has been placed on the National Register of Historic Places. It has also been registered by the American Society of Civil Engineers as a National Engineering Landmark.

Relationship with Other Projects

The Gunnison and Uncompahgre River Basins have been the subject on numerous projects, plans and programs discussed below. The proposed development would operate in concert with existing projects and become part of future management plans for the two basins.

Uncompahgre Valley Reclamation Project

The Gunnison Tunnel, the South Canal, and the AB Lateral of the UVRP would be used by the proposed development to deliver water for hydropower generation. A detailed description of the modifications to these features is presented in chapter 2 of this report.

The Gunnison Tunnel is now operated during the irrigation season, with periodic use during the winter months for purposes of providing water to Fairview Reservoir. With development, the Tunnel would be operated year round, although periodic inspection and maintenance would be performed. Year round operation would not impact the integrity or life expectancy of the Tunnel. Physical modifications to the Tunnel would not occur in three of the four development alternatives. For alternative C, the Tunnel would be modified to increase its hydraulic capacity to 1,300 ft^3/s.

The South Canal would be modified to incorporate a larger diversion structure to the AB Lateral. These modifications would be constructed at times which would least disrupt irrigation deliveries. The construction work would include temporary provisions for water delivery downstream from the modifications.

A portion of the AB Lateral would be modified to provide greater discharge capacity in the lateral. The modifications would include concrete lining of the affected length, estimated to be approximately 7,100 feet from its diversion at the South Canal to the proposed penstock intake structure. Irrigation deliveries would not be impaired during construction of the modifications or operation of the proposed facility.

Operation of the proposed development would not reduce deliveries of irrigation water to UVWUA members under any circumstances. Irrigation water for the Selig, Ironstone, Garnet, and East Canals would be passed through the proposed facility rather than the South Canal. Flows in the Uncompahgre River in combination with Gunnison River water would be used to meet the demands of the M&D and the Loutzenhizer Canals. However, these systems would not place a call on the river that would prevent Ridgway Reservoir from storing water at times when the Gunnison Tunnel direct flow right could be utilized to meet irrigation demands.

Operation of the proposed development would provide some insurance against a failure of the South Canal. Acreage irrigated under the project would not increase.

Wild and Scenic Rivers Act

Section 5(a) of the Wild and Scenic Rivers Act identified the Gunnison River as a "Candidate River" for designation (Public Law 93-621; January 3, 1975). The NPS completed a study and concluded that 26 miles of the river from the upstream boundary of the Black Canyon of the Gunnison National Monument downstream to the Smith Fork confluence are eligible for designation as a wild river. The eligibility was based upon five criteria: (1) it is free-flowing; (2) its length is sufficient to provide a meaningful experience to the recreation users; (3) it has adequate volumes of high quality water; (4) its watershed and shoreline are primitive and relatively inaccessible; and (5) its environs possess outstanding scenic, geologic, recreational, and wildlife values (NPS, 1979b).

Development of any of the proposed alternatives would primarily affect criterion 5, recreation use, and criterion 3, volume of water, as discussed in detail in chapter 3. The river would remain eligible for "wild and scenic" status under all alternatives.

Wilderness Areas

Both a wilderness area and a wilderness study area exist along the Gunnison River downstream from the Gunnison Tunnel. An area of 11,180 acres in the Black Canyon of the Gunnison National Monument has been designated as a wilderness, and 21,038 acres of public land managed by the BLM downstream from the monument have been designated the Gunnison Gorge Wilderness Study Area.

Operation of alternative hydropower plans would affect river flows through these areas and this in turn would affect recreation use. These impacts are discussed in chapter 3.

Black Canyon of the Gunnison National Monument

The Black Canyon of the Gunnison National Monument was established in 1933 and borders the Gunnison River immediately downstream from the Gunnison Tunnel. River flows through the monument are regulated by the upstream Aspinall Unit Reservoirs and by diversions through the Gunnison Tunnel. Alternatives being considered under the project would further alter these flows. The flow changes and their effects are discussed in chapter 3.

Wayne N. Aspinall Unit

The Aspinall Unit Reservoirs--Blue Mesa, Morrow Point, and Crystal--were completed in 1966, 1970 and 1976, respectively. The Aspinall Unit along with Glen Canyon Dam in Arizona, Flaming Gorge Dam in Utah, and Navajo Dam in New Mexico comprise the four major storage units of the Colorado River Storage Project (CRSP). The CRSP was authorized in 1956 to provide storage to ensure that water commitments to the Lower Basin States are met and to allow the Upper Basin States to develop water for hydroelectric power, irrigation, and municipal and industrial use. The Aspinall Unit, located in Gunnison and Montrose Counties, provides water storage and hydroelectric power generation along the 40-mile section of the Gunnison River between the city of Gunnison and the Gunnison Diversion Dam at the Gunnison Tunnel.

Flows in the river are largely controlled by Blue Mesa Reservoir, the largest and most upstream of the three Aspinall Reservoirs. Water released through the Blue Mesa Powerplant receives short-term reregulation by Morrow Point and Crystal Reservoirs, immediately downstream. Blue Mesa Reservoir has a storage capacity of 940,700 acre-feet, while Morrow Point and Crystal Reservoirs have capacities of 117,000 and 26,000 acre-feet, respectively. At Blue Mesa storage allocations are 748,430 acre-feet for active conservation and flood control; 81,071 acre-feet inactive storage; and 111,200 acre-feet dead storage (Reclamation, 1981). The reservoir is normally drawn down in the late summer, fall, and winter period; and major filling occurs between April and August. Water releases through Blue Mesa and Morrow Point are primarily for peaking power while releases through Crystal Powerplant are uniform to satisfy downstream water rights and to maintain a minimum flow of 300 ft^3/s downstream from the Gunnison Tunnel. Background on the 300 ft^3/s figure is found in chapter 3.

Operation of the proposed development would not affect the operation or purposes of the Aspinall Unit Reservoirs. The proposed hydropower plant would be operated as a "run-of-the-river" facility, meaning that water would be diverted as it is available in the streambed without placing water rights calls on upstream storage. Consequently, the proposed development would not result in reduced storage or lower water levels in the Blue Mesa Reservoir.

Dallas Creek Project

Ridgway Dam and Reservoir, part of the Dallas Creek Project, were completed in 1988 on the Uncompahgre River approximately 25 miles upstream (south) of Montrose. The reservoir includes

55,000 acre-feet of storage to be used for municipal, industrial, and irrigation purposes in the Uncompahgre Valley.

Reclamation's proposed operation of this reservoir has been incorporated into the Sponsors' water supply studies. The analysis was based upon projected operating schedules and releases from the reservoir over a 32-year period. Development of the AB Lateral alternatives would not affect water levels in the Ridgway Reservoir, nor would it increase the amounts of water withdrawn for irrigation or other purposes.

Smith Fork Project

The Smith Fork Project was constructed by Reclamation in the early 1960's and is located in Delta and Montrose Counties about 25 miles east of Delta. Using flows of the Smith Fork and Iron, Muddy, and Alkalai Creeks, the project provides supplemental irrigation water to 8,924 acres and a full service supply to 1,423 acres of land. The principal feature is Crawford Dam about a mile south of Crawford on Iron Creek. The 14,395-acre-foot Crawford Reservoir stores the direct surplus flows of Iron, Muddy, and Alkalai Creeks as well as flows of the Smith Fork through the Smith Fork Feeder Canal. Water from the reservoir is supplied to project lands by Aspen and Clipper Canals.

The Crawford Water Conservancy District operates and maintains the project while the Colorado Division of Parks and Outdoor Recreation administers the recreation at Crawford Reservoir which includes fishing, boating, and camping. The Smith Fork Project would not be affected by operation of the AB Lateral alternative.

Uncompahgre Rehabilitation and Betterment Program

Although maintenance and rehabilitation has been regularly performed during UVRP operation, by the 1970's much of the UVRP system needed repair and modernization. In 1979 at UVWUA's request, Reclamation began a detailed inspection of UVRP facilities to determine the extent and nature of needed improvements. In 1981, the study was completed. A rehabilitation and betterment (R&B) report was approved that authorized a R&B loan from the United States to the UVWUA. Work was begun on the R&B program in 1982.

Completed rehabilitation work include: (1) replacement of the needle valves and associated structures at Taylor Park Dam with jet flow valves; (2) replacement of the wooden flume through Olathe with buried concrete pipe; (3) reconstruction of the wooden flume section on the Ironstone Canal with a concrete-lined section; (4) installation of new concrete-lined sections on the West Canal to prevent leakage and slippage; (5) repair of the lining along the South Canal; (6) repair of the Gunnison Tunnel and tunnels along the South Canal; and (7) capping the downstream apron on the Ironstone and M&D Diversion Dams and replacing the sluice gate on the Selig Diversion Dam. Completion of the R&B program would not be affected by AB Lateral alternatives.

Colorado River Water Quality Improvement Program

The Lower Gunnison Basin Unit of the Colorado River Water Quality Improvement Program was authorized for construction in 1984 under Public Law 98-569. The winter water portion of the unit provides for replacing winter livestock water in the UVRP system with delivery through the rural domestic systems. Also part of the overall plan is to concrete-line approximately 60 miles of canals and 195 miles of laterals on the east side of the Uncompahgre Valley. The winter water component of the plan will be implemented as the initial phase of development. Construction and operation of the unit would not be affected by alternatives being considered for the hydropower project.

Shavano Falls Hydropower Facility

The Sponsors also propose to develop a 2.9-MW hydroelectric station at Shavano Falls on the M&D Canal about 6 miles west of Montrose. Power and energy from the Shavano Falls Facility would be sold to the Public Service Company of Colorado. Reclamation prepared an environmental assessment for the development in 1986 and issued a finding of no significant impact in 1987 (Reclamation, 1986 and 1987b).

Developing the AB Lateral Facility would reduce the amount of hydropower water that would be diverted to this unit. This action would reduce the energy production at Shavano Falls; however, developing the AB Lateral Facility would not diminish the quantity of water in the M&D Canal for irrigation purposes.

Other Water Projects

The Colorado Water Resources and Power Development Authority is presently conducting a study of water and related resources of the Upper Gunnison and Uncompahgre Basins. The primary objective of this study has been to identify and evaluate water resource development plans to enhance the water-based economy of the study area in an environmentally sound manner with the goals to provide adequate future water supplies; to improve fisheries and recreational opportunities, and to provide greater public access for these activities. The authority has included development of alternative B in its hydrologic modeling studies.

Several entities, some of which propose to divert water from the Gunnison Basin and transfer it to the east slope of the Rocky Mountains for purposes of municipal and industrial use, have filed competing water rights applications for use of upper Gunnison Basin water. Because these projects are still in the conceptual stage, the impacts of their development cannot be assessed. However, such diversions would be made in accordance with Colorado Water Law--water would be diverted in priority subject to the provision of adequate water supplies to senior water rights within the Gunnison Basin.

CHAPTER 2
ALTERNATIVES INCLUDING PROPOSED ACTION

Summary of Alternatives

Under present conditions, water is diverted from the Gunnison River to meet agricultural, domestic, municipal and industrial, and other needs in the Uncompahgre Valley. As mentioned previously, the Uncompahgre Valley Water Users Association (UVWUA) and Montrose Partners (referred to as the Sponsors) of the proposed development intend to use a portion of the Gunnison River diversions to generate hydroelectric power. Additional diversions from the Gunnison River during the winter months and to a lesser extent during the irrigation season are proposed.

The purpose of this chapter is to describe the various alternatives for developing Uncompahgre Valley Reclamation Project's (UVRP) hydropower potential. The Sponsors have performed detailed technical and economic analyses for numerous development alternatives which involve various design flow options, different penstock routes, development of the South Canal power potential, and different locations for the powerplant.

The economically feasible alternatives were given detailed environmental consideration. Alternatives that were not economically feasible were eliminated from detailed environmental study but are discussed in this chapter. The purpose of each alternative is to develop the power potential of discharges as they fall from the Gunnison Tunnel (the Tunnel) to the Uncompahgre River. As such, alternative methods of generating electricity, such as thermal or combustion powerplants, were not considered.

The alternatives involve generating hydroelectric power using flows diverted from the Gunnison River and the elevation difference between the West Portal of the Gunnison Tunnel and the Uncompahgre River in Montrose. A portion of the flows that would be diverted would also be used to meet UVRP irrigation needs; the remaining flows would be diverted solely for power generation.

Alternative A

Alternative A is the no-action alternative and represents the conditions of the affected area without development. It establishes the baseline for evaluating environmental impacts of hydropower development. It also establishes anticipated conditions in the affected areas without development and assumes that irrigation diversions made to the various canals would be made according to historic use.

Alternative B

The AB Lateral Facility would be developed to a capacity of 1,135 cubic feet per second (ft^3/s). Irrigation demands were assumed to equal historically recorded diversions. Minimum instream flow in the Gunnison River was assumed to be 300 ft^3/s during all months of the year.

Alternative C

The AB Lateral Facility capacity and minimum flow for this alternative are the same as those values for alternative B (1,135 ft^3/s and 300 ft^3/s, respectively). However, the Gunnison Tunnel capacity would be increased to 1,300 ft^3/s.

Alternative E

This alternative proposes developing of the AB Lateral Facility to a capacity of 950 ft^3/s, without alteration of the Gunnison Tunnel. The minimum instream flows were assumed to be 300 ft^3/s for all months of the year.

Alternative F

This alternative would have a design configuration identical to alternative B; however, it would be operated differently. During winter months, if ice buildups occurred at locations which would threaten existing structures or habitat, diversions would be reduced to increase flows in the Gunnison River. For purposes of modeling water flows, this amount has been assumed to equal 600 ft^3/s for 7 days each month, which is an average monthly increase of 68 ft^3/s in January and 75 ft^3/s in February.

A further operational change included in alternative F is represented by providing through the South Canal an additional 1,000 acre-feet of water in the Uncompahgre River upstream from the tailrace in the months of August and September. This flow would be used in the river as directed by the Colorado Division of Wildlife (CDOW), should a fishery be developed in the Uncompahgre River. For purposes of modeling water flows, this amount has been estimated at an average of 8 ft^3/s in each of the 2 months.

Detailed Description of Alternatives

Alternative A (No Action)

Existing UVRP operating conditions would continue under alternative A. Water diverted from the Gunnison River through the Gunnison Tunnel is delivered to the Uncompahgre River through the South Canal and, to a lesser extent, Cedar Creek. Cedar Creek is used because of capacity limitations in the South Canal (see chapter 3). After entering the Uncompahgre River, Gunnison River flows are combined with Uncompahgre flows and diverted into six major canal systems -- the Montrose and Delta (M&D), Loutzenhizer, Selig, Ironstone, East, and Garnet. Water supplies are delivered to the West Canal via a direct diversion from the South Canal. (Each of these systems are described in detail in chapter 3).

In addition to the West Canal, flows are diverted from the South Canal into the AB Lateral and several other small laterals along its 11.6-mile length. Project 7, which also diverts a portion of its water supplies from the South Canal, is a rural water supply system which provides domestic supplies to three area water conservancy districts as well as for Montrose, Olathe, and Delta. Project 7 water diverted from the South Canal is stored in Fairview Reservoir, which is adjacent to the canal about 1 mile downstream from the West Portal of the Tunnel.

Average annual historical supplies and diversions for the UVRP are presented in table 2.1. Values shown in this table are based upon a 32-year period of record used as the basis for analysis of the remaining development alternatives.

Periodic flooding on the Uncompahgre River has caused the UVWUA to reduce diversions through the Tunnel to prevent additional flows from being introduced to the Uncompahgre River. In general, flooding conditions occur annually along the Uncompahgre, although the severity of flooding has varied greatly. Ridgway Dam is not specifically operated for flood control, but its operation will reduce flooding along the Uncompahgre. Flood conditions are described in chapter 3.

Before the Aspinall Unit was constructed, it was not uncommon for Gunnison River flows to fall below 100 ft^3/s. However, the Aspinall Unit has helped to stabilize flows in the Gunnison River which in turn has allowed the establishment of a Gold Medal fishery in the river between the tunnel portal and the North Fork of the Gunnison River. To protect this fishery and to meet

Table 2.1.-- Estimated supplies and historical demands for the Uncompahgre Valley Reclamation Project

Location	Mean annual volume (acre-feet)
Water available to system[1]	
Diverted from Gunnison through Tunnel	336,411
Uncompahgre River at Colona	168,685
Total supplies	505,096
Water diverted for irrigation[2]	
AB Lateral (existing conditions)	18,112
Cedar Creek wasteway	11,077
West Canal	49,177
Other South Canal laterals	22,453
Non-UVRP demands above South Canal[3]	10,955
Montrose & Delta Canal	163,326
Non-UVRP demands below South Canal[3]	11,482
Loutzenhizer Canal	42,925
Selig Canal	60,081
Ironstone Canal	102,309
East Canal	45,868
Garnet Canal	21,307
Total diversion demands	559,072

[1] Source: Reclamation simulation models for Uncompahgre and Gunnison Rivers.
[2] Source: UVWUA historical records of daily diversions.
[3] Source: See chapter 3 for description.

downstream water rights, the Bureau of Reclamation (Reclamation) has controlled releases from Blue Mesa Dam to meet irrigation demands at the Tunnel as well as to allow a minimum instream flow of 200 ft^3/s. In recent years the goal has been increased to 300 ft^3/s when available.

The cornerstone of the UVRP is the Gunnison Tunnel, which is 5.8 miles long and crosses under the hydrologic divide between the Gunnison and Uncompahgre River basins. Tunnel dimensions vary throughout its length; it was designed to have a rectangular section 11 feet wide and 12 feet high with an arched roof, having a slope of approximately 10 feet per mile. In some sections, the Tunnel is completely lined with reinforced concrete, whereas in others only the tunnel floor is lined. In the unlined portions, the tunnel floor is relatively smooth, but occasional rock outcrops protrude outward from the walls and ceiling which restrict the tunnel's hydraulic capacity. Tunnel sections and dimensions are described in table 2.2.

The UVWUA has been engaged for the past several years in a Rehabilitation and Betterment (R&B) Program to repair and

Table 2.2.--Description of Gunnison Tunnel sections

Section	Percent of tunnel length	Description
A	38.5	Floor lined, walls and ceiling unlined. Width varies from 11.0' to 14.5', and height varies from 11.3' to 14.3'. Walls are generally rough with numerous projections into flow area.
B	6.7	Floor and walls lined to Tunnel spring line. Width varies from 9.3' to 11.5'; height to spring line varies from 7.0' to 11.5', as constructed. Some sections showing evidence of erosion behind walls.
C	8.0	Floor and walls lined to Tunnel ceiling. Height and width are same as section A.
D	21.1	Floor and walls lined to ceiling. Vertical walls, with partially lined arch ceiling. Width varies from 9.0' to 11.5', and wall height varies from 11.0' to 11.7'. Timber beams exposed in some sections.
E	15.6	All surfaces are lined. Sidewalls are sloping and flat, and ceiling is arched. Width varies from 9.0' to 11.5', and height varies from 11.0' to 11.7'.
F	10.1	All surfaces are lined and smooth. Section is horseshoe-shaped with an arched floor. Maximum height of section is 10.0 feet.

modernize UVRP facilities. Included in this program have been construction activities to repair and replace Tunnel lining. This work is expected to continue in the near future.

Under the no-action alternative, other individuals or corporations may attempt to proceed with similar developments. Reclamation approval of such development would be required.

Alternative B

Alternative B would divert water from the South Canal and AB Lateral into a penstock that would convey water to a new powerhouse located in north Montrose. Discharges from the powerhouse would enter the Uncompahgre River through an excavated tailrace. The location of these features is shown in figure 2.1.

Features of Alternative B.--Certain physical facilities would be constructed for this alternative. Other facilities that currently exist and are operated by the UVWUA would be modified. New construction would include the powerhouse, penstock, transmission line, access roads, and tailrace. Modifications of existing facilities would include a portion of the existing AB Lateral, South Canal, and access roads. No modifications would occur to the Gunnison Tunnel.

Each of these features is described in detail below. The description offered in the following paragraphs is based upon conceptual development studies. Further studies of geotechnical, hydraulic, equipment, and other design parameters may result in minor changes.

Canal Modifications.--The development begins at the AB Lateral diversion works on the South Canal. Presently, flows are diverted into the lateral by two sluice gates located on the South Canal right wall. Alternative B modifies this diversion by removing the sluice gates, replacing them with a single radial gate, and widening the AB Lateral to accommodate the increased flows.

Under alternative B, the present diversion works would be modified on the South Canal to restrict the amount of water flowing down the South Canal during project operation. This diversion is presently accomplished by a narrow restriction in the South Canal channel located a few yards downstream of the AB Lateral sluice gates. This restriction creates a backwater effect, allowing water to divert into the AB Lateral.

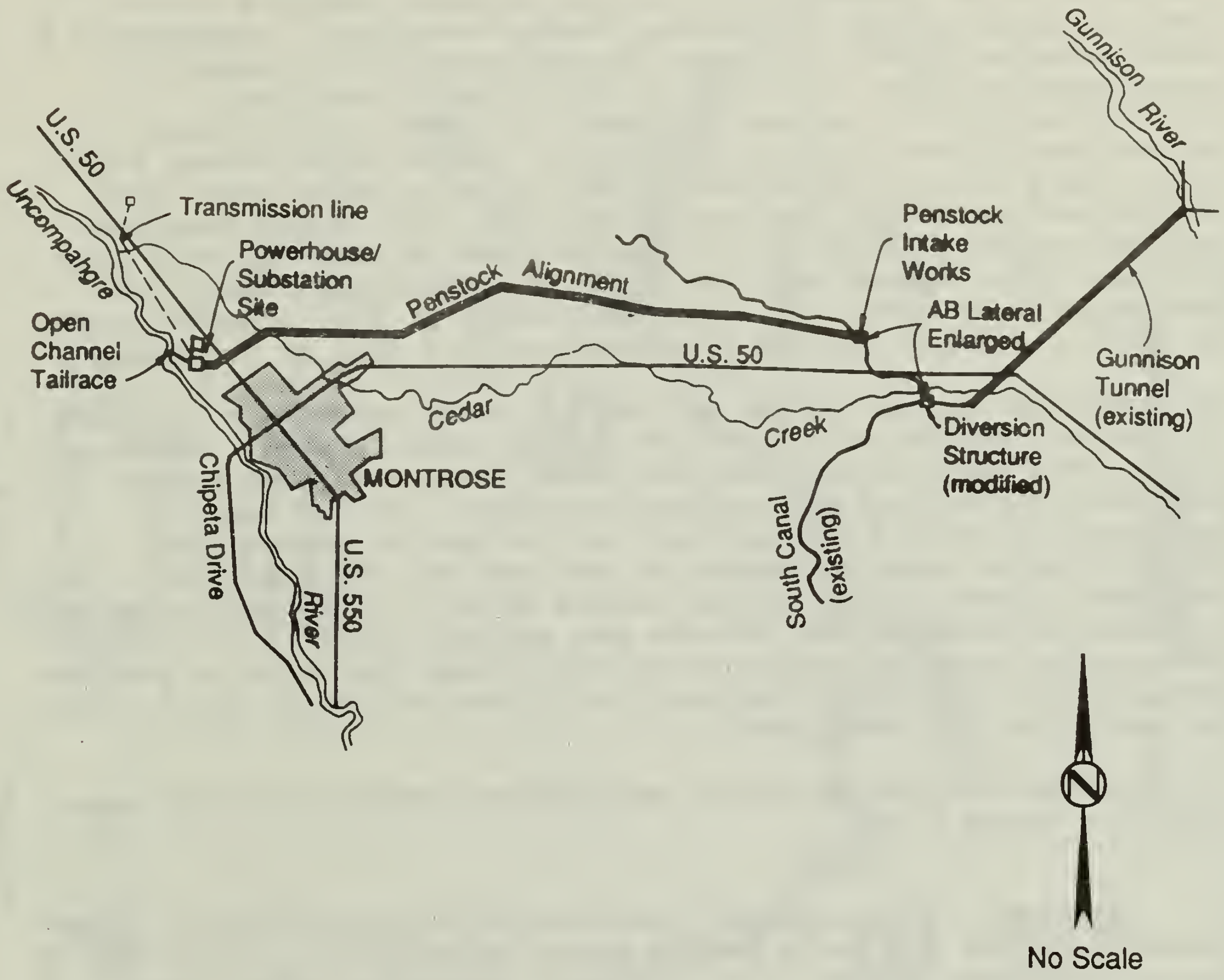


Figure 2.1. Location of project features, Alternative B.

Alternative B would replace the narrow channel gate with a single radial gate. This gate, together with the gate proposed for the AB Lateral, would be opened or closed by a hydraulic operator and remotely controlled from the UVWUA's Montrose headquarters.

The existing AB Lateral is an unlined channel having a bottom width of about 8 feet and uneven channel sections. Alternative B would enlarge about 7,100 feet of the lateral to a capacity of approximately 1,235 ft^3/s. Between the South Canal and U.S. Highway 50, a distance of about 650 feet, the modified lateral would have a rectangular cross section with 8-foot high walls and a 20-foot bottom width and would be constructed with reinforced concrete. The remaining 6,450 feet of the modified lateral would be widened to a bottom width of slightly more than 20 feet. The channel sections would be trapezoidal and lined with reinforced shotcrete. The flow depth at full capacity would be about 6.5 feet, leaving approximately 1.5 feet of freeboard.

The enlarged portion of the AB Lateral would continue to provide irrigation deliveries to areas served by this lateral. Construction of the enlargements would be made, to the maximum extent possible, during the non-irrigation season. To the extent construction would infringe upon the irrigation season, the Sponsors would make provisions to deliver the required flow. The enlarged lateral would include sluice gates to deliver irrigation supplies to Cedar Creek, and the ABB and ABC laterals. A fourth sluice gate would be installed in the intake structure to provide deliveries to the remaining portion of the AB Lateral which would be unaffected by development.

The proposed lateral alignment and typical lateral sections are shown in figure 2.2.

Penstock.--The penstock intake would be constructed of reinforced concrete and would have a total capacity of 1,135 ft^3/s. It would include a rock lip to prevent cobbles or other large rocks from entering the penstock and turbine. A steel trash rack would be equipped with a motorized hoist to allow removal of trash and other debris. The intake would also include stop-logs to be used to isolate the penstock from water flows during annual maintenance and inspection periods. The intake would also include a square-to-round transition section to funnel water into the penstock with minimum hydraulic disruptions. The structure would also include a gate or valve mechanism that would prevent flows from entering the penstock in case of an emergency. Options include a radial-type gate located in the intake flume upstream of the trashracks and a butterfly or gate valve located within the penstock immediately downstream of the transition piece.

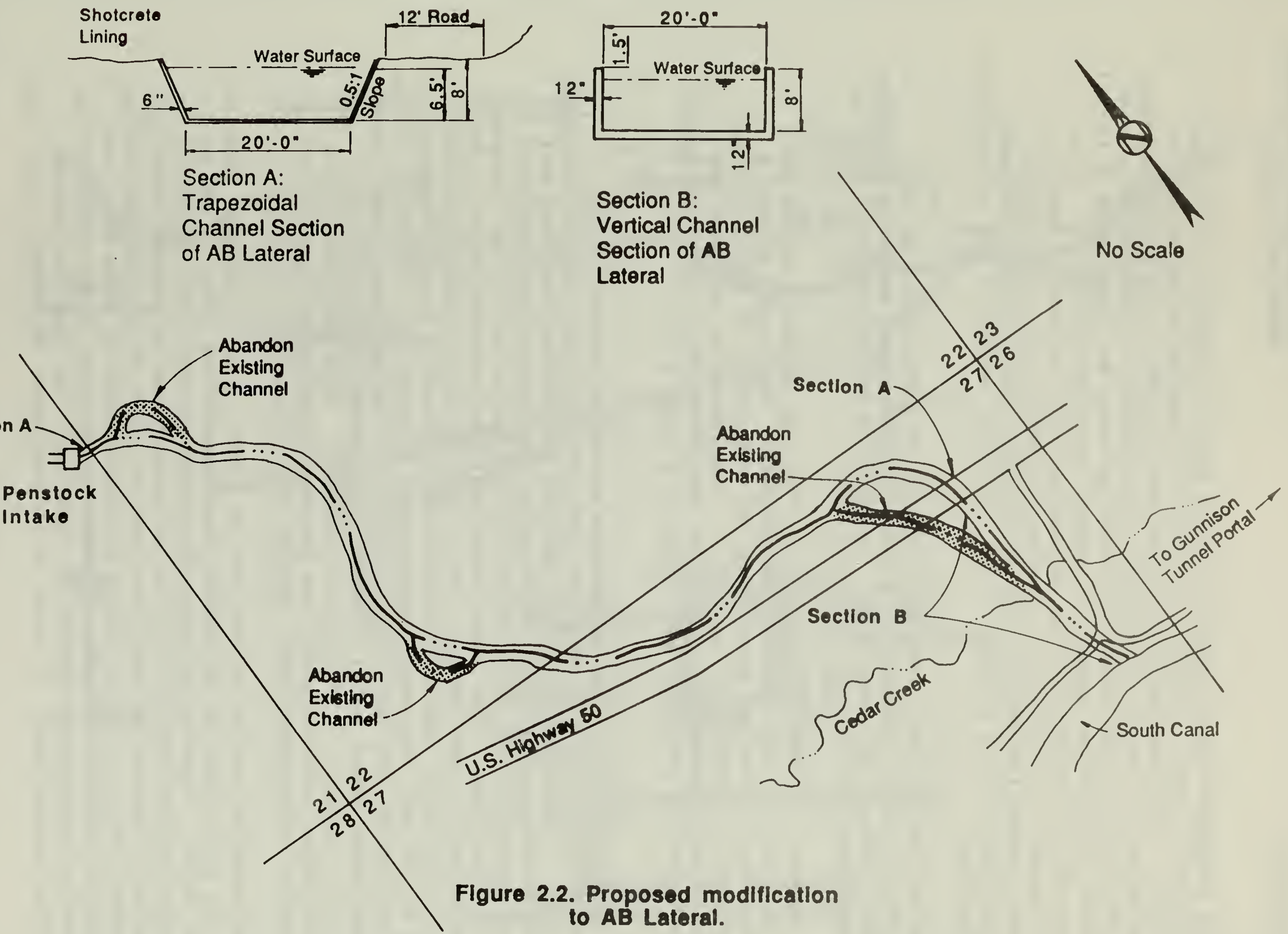


Figure 2.2. Proposed modification to AB Lateral.

The proposed steel penstock would have a diameter of between 10 and 11 feet, installed in 40-foot lengths in an excavated trench. Bell-and-spigot joints would probably be used and would be welded in the field during installation to assure watertight conditions. The inside of the pipe would be lined with a 16-mill layer of coal-tar epoxy to prevent rust deterioration. The outside of the pipe would be wrapped with polyvinyl tape to a thickness of 80 mills to further inhibit rust. As a final rust-preventive measure and to prevent electrolysis, cathodic protection would be used along the full length of the 38,380-foot pipeline.

During preliminary and final design of alternative B, the Sponsors would consider the use of prestressed concrete cylinder pipe instead of steel pipe. Final pipe diameters would also be determined during the design phase.

A number of potential alignments for the penstock route were considered in the concept development. Selection of the preferred route was based upon an evaluation of hydraulic and production parameters as well as consideration of land use. The proposed alignments, along with the preferred route and typical construction details, are shown in figure 2.3.

Powerhouse.--The powerhouse would be located in the northwestern part of Montrose near an abandoned sewage treatment plant. The structure would contain two Pelton turbines and synchronous generators, along with the appurtenant equipment necessary for the safe and efficient operation of the turbines and generators. The powerhouse would be constructed both above and below current ground level. The portion below grade would be constructed of reinforced concrete. It would be approximately 52 by 54 feet and would contain the turbine and generator floors. Above grade, the powerhouse would be constructed of steel and fabricated sheet metal; however, in the final design phase this may be changed to reinforced concrete. This portion of the powerhouse would contain the generator, station service control panels, and conventional support facilities.

The turbines would be designed to safely pass a maximum flow of 1,135 ft^3/s with an estimated lower operating limit of 50 to 100 ft^3/s. Water flow into the turbines would be controlled by globe valves located outside the powerhouse in buried valve vaults. The valves would be remotely controlled and operated hydraulically. These valves would probably be used only for turbine isolation during maintenance periods; they would not be used to control the amount of flow into the turbines during normal operations. In case of an unplanned shutdown, water would

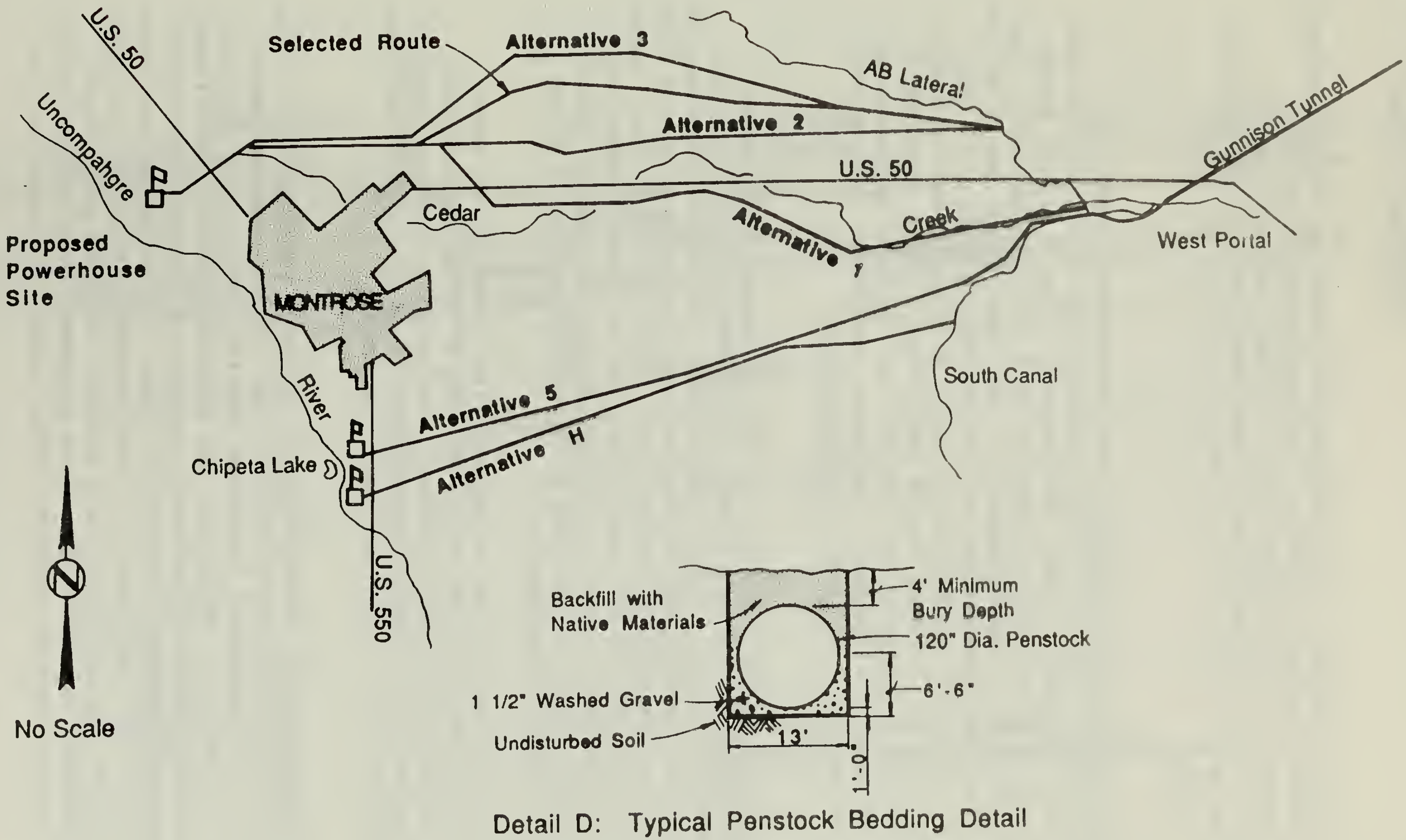


Figure 2.3. Selected and alternative penstock alignments, Alternative B.

continue to pass through the turbines but would be deflected away from the turbine runner, allowing the continuous flow of irrigation water to downstream canal systems and preventing sudden water level fluctuations in the Gunnison and Uncompahgre Rivers. Figure 2.4 shows the conceptual facilities at the powerhouse site.

Stilling Basin and Tailrace.--As the water leaves the powerhouse it would enter a stilling basin designed to slow the water velocity to about 5 feet per second. The stilling basin would be lined with riprap to prevent bank and bed erosion. An earth-lined tailrace, approximately 1,600 feet long, would convey water away from the powerhouse to the Uncompahgre River. The channel shape would be trapezoidal, with a 25-foot bottom width and 2:1 side slopes. Riprap would be placed at its confluence with the river to prevent bank erosion and channel degradation. Figure 2.5 shows the alignment, sections, and bank stabilization details to be used for tailrace construction.

Transmission Line.--Power from the proposed development would be transmitted through a new 115,000-volt (115 kilovolts [kV]) transmission line. This three-phase, wood pole line would begin at the new powerhouse substation and run generally 1/2 mile northwest to tap into an existing line. The existing line, which is currently rated at 46 kV, runs from the Bullock Substation in southwestern Montrose, north to Garnet Mesa. It passes approximately 1,000 feet east of the North Mesa Substation, 2 miles north of the Project powerhouse.

Approximately 3 miles of the existing line (Bullock to North Mesa) would be upgraded from 46 kV to 115 kV. An additional 1,000 feet of new line would connect the upgraded line to North Mesa (see figure 2.6). The transmission line, including both new and upgraded sections, would be raptor-proofed.

Bank Stabilization.--According to studies performed for this report, the Uncompahgre River channel bed is well-armored with cobbles and is not expected to erode significantly once operation of the facility begins. However, the introduction of additional flow to the Uncompahgre River would result in lateral erosion of the existing channel banks downstream from the proposed tailrace. Bank instability in this reach of the Uncompahgre River has been a problem in the past during flood events, and the additional volumes introduced as a result of the proposed development would accelerate erosion unless measures were taken to stabilize the

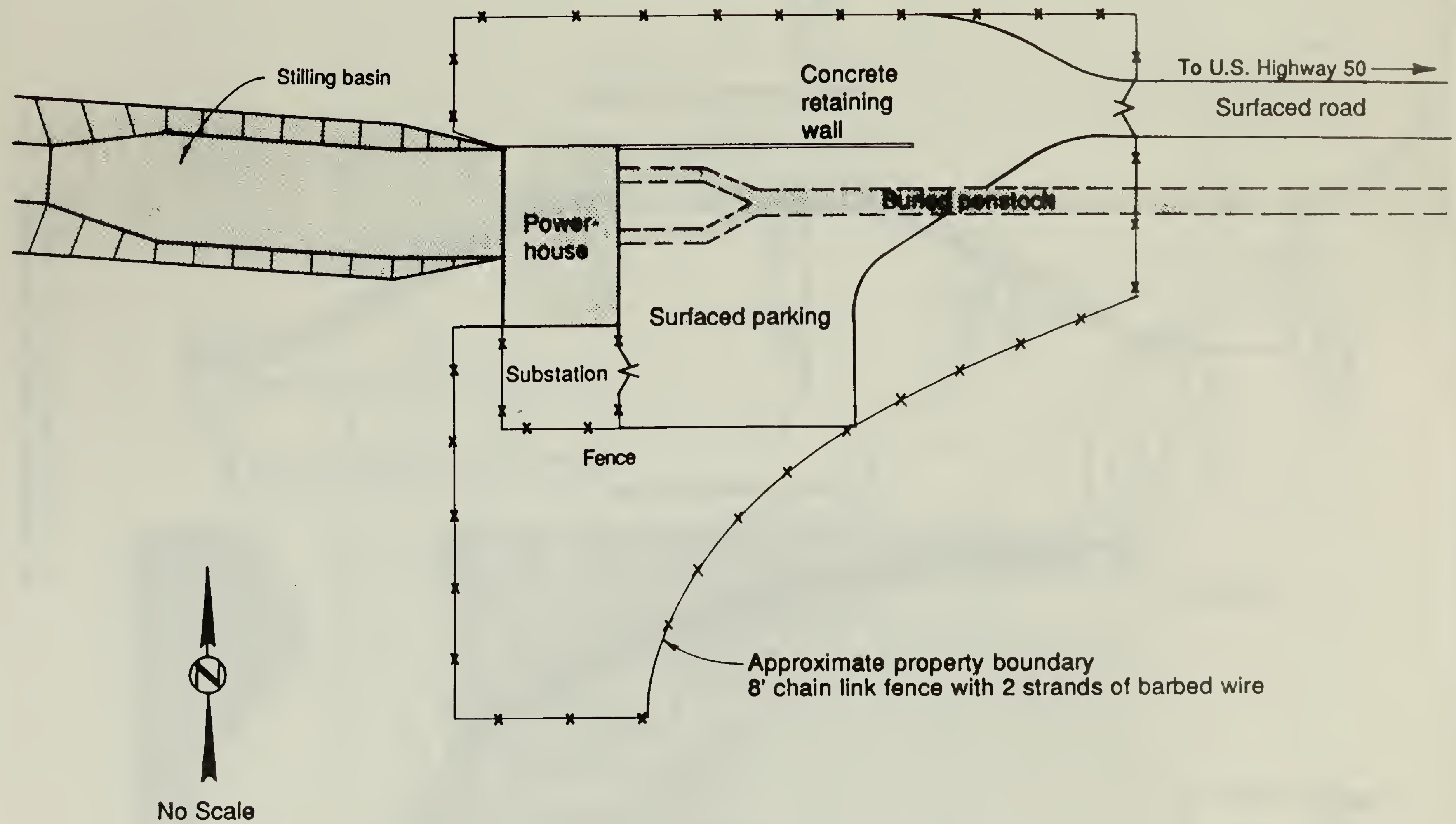
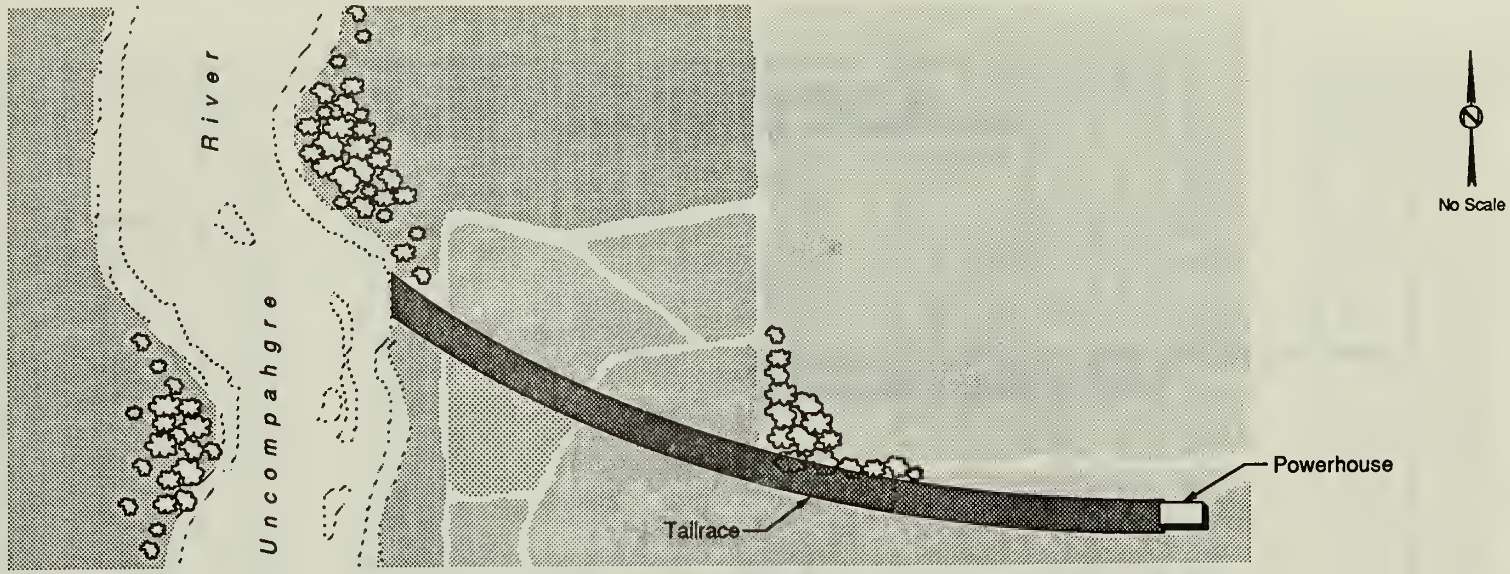
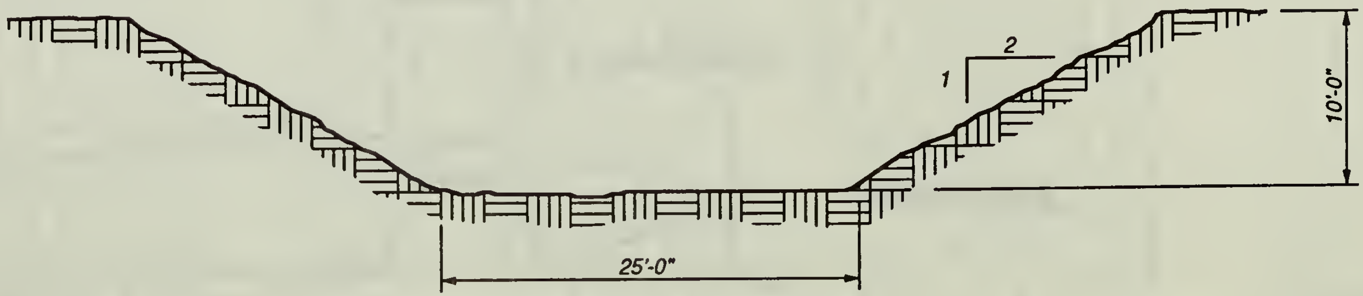


Figure 2.4. Plan of powerhouse site, Alternative B.



Plan for tailrace (no scale).



Typical section of tailrace (no scale).

Figure 2.5. Tailrace details.

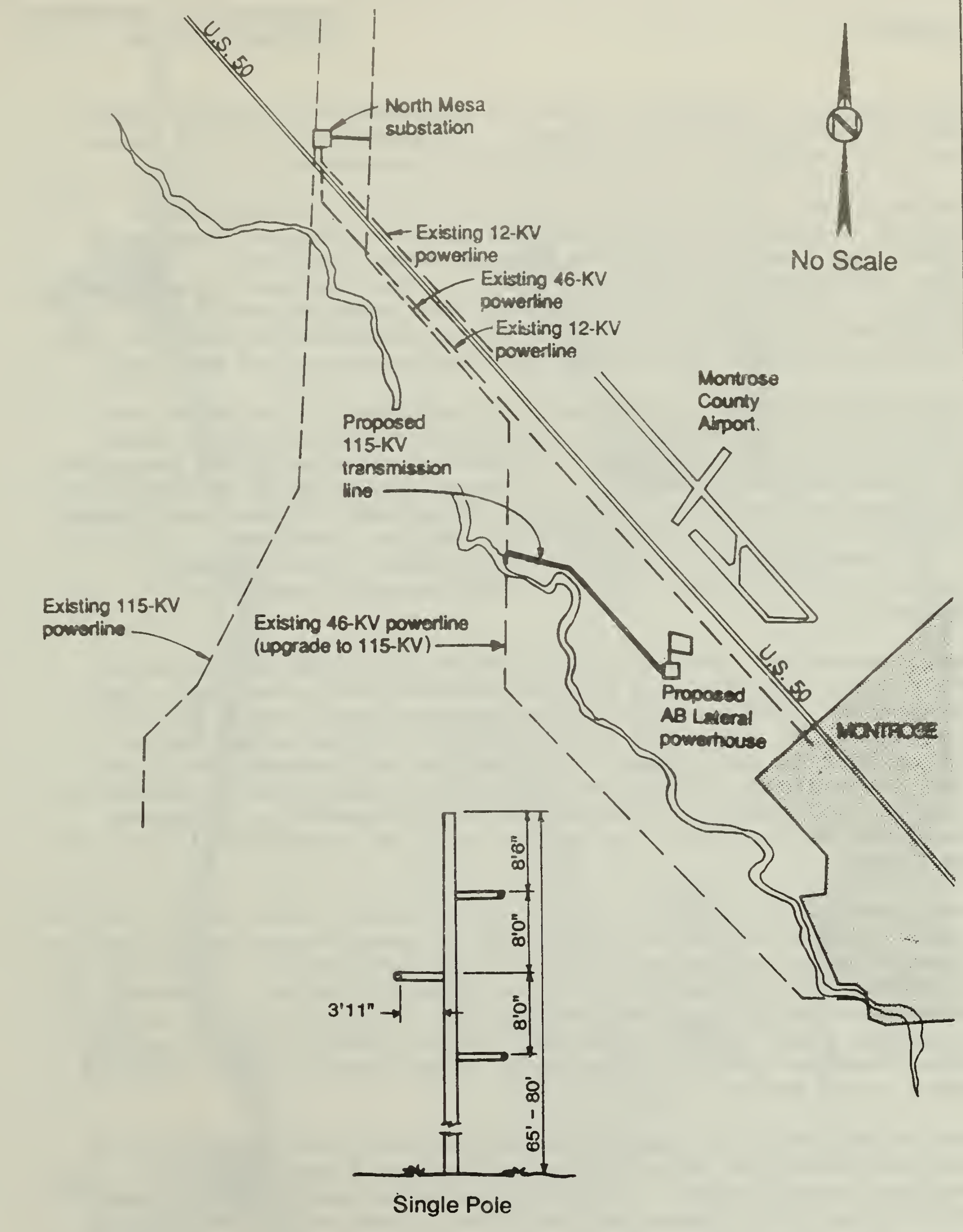


Figure 2.6. Proposed location of transmission line, Alternative B.

river banks. Presently, there are approximately 37,000 linear feet of bank protection in place. An additional 70,000 linear feet are estimated to be needed with development.

Design of the stabilization measures would be accomplished through coordination with Reclamation, the Corps of Engineers (COE), the Fish and Wildlife Service (FWS), and the CDOW, and would be prepared as part of the Section 404 permitting process. Once approved by the COE, the measures would be installed during construction of other development features and would be in place before beginning operation of the facility.

The design process would identify riverbanks in the affected reach which are particularly vulnerable to erosion, and would specify the type, size, and location of measures to be installed to reduce this vulnerability. Preliminary studies conducted by the Sponsors indicated that about 25 percent of the river banks between the tailrace and Delta may require treatment. Measures to be investigated include bank revetments (see glossary), jetties and realignment of the river channel (canalization; see figure 2.7).

Bank revetments, such as the placement of riprap on the bank, would armor the bank and prevent erosion from occurring. The revetments would be installed by placing riprap material along the top of the bank. As erosion occurs, the material would gradually fall into place. This method of placement has been used successfully by Reclamation in the Lower Colorado Basin, by the COE, and others. In areas where this method of placement would not be possible, the riprap would be installed directly on the bank.

Rock jetties are intended to move the flowing water away from the banks. These methods would be used in areas where good stands of riparian vegetation now exist and would enhance the availability of habitat for fisheries and other aquatic species. However, the turbulence resulting from installation of jetties could lead to localized scour of the riverbed. Hence, the applicability of these measures would be limited to those areas of the riverbed which could resist scouring.

Past occurrences of high flows coupled with the instability of the riverbanks has allowed the Uncompahgre River channel to meander in many places. Canalization of meanders would direct river flows into a more defined channel and prevent erosion by moving the flowing water away from the banks. This measure would shorten the actual river length, consequently increasing its hydraulic gradient and accelerating flow velocities leading to

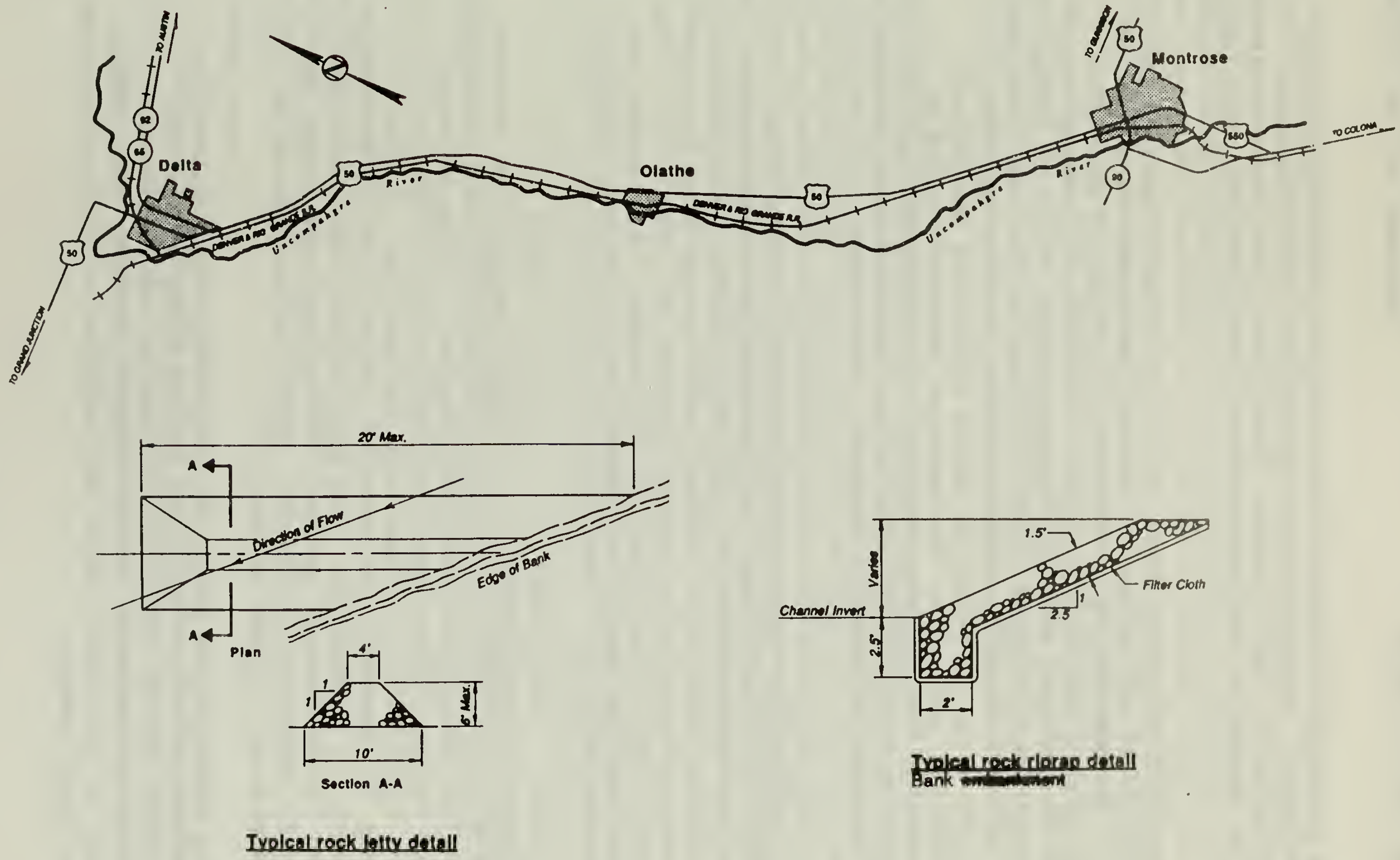


Figure 2.7. Bank stabilization plan and details.

increased potential for bed and bank erosion downstream of the canalized reach. Therefore, the application of this measure would be limited to short reaches (less than 1,000 feet) in areas which could withstand the increased velocities without subsequent erosion.

After commencing facility operations, the Sponsors would monitor riverbank erosion and implement remedial measures where necessary. The monitoring program would consist of periodic aerial and ground inspection of the river channel, communication with local landowners, and field measurements. For the latter element, concrete monuments would be placed at critical locations along the river channel, and the distance from the monument to the riverbank would be measured before commencing operations. After commencing operation, the measured distances would be checked annually to determine changes. Accompanying the field measurements would be photographs of the bank and river at each monument location to visually document conditions.

Access to Facilities.--Access to work areas would be from U.S. Highway 50, county roads, and existing UVWUA maintenance roads. Bridge improvements for equipment hauling would not be needed, although some minor roadways would be upgraded to prevent damages from occurring as a result of heavy equipment loads. The existing maintenance road along the AB Lateral, with a dirt and light gravel surface, would be widened to 12 feet and upgraded to a crushed rock surface.

Safety Features Incorporated into Facility Design.--The Sponsors would incorporate a number of safety features into the facilities for protecting human and wildlife resources. In the enlarged AB Lateral, escape ladders would be constructed at 600-foot intervals. Safety fencing would also be installed at the U.S. Highway 50 crossing, the penstock intake, and the stilling basin west of the powerhouse. Big game escape ramps would be included in the AB Lateral in front of the penstock intake and near the U.S. Highway 50 crossing. These features would be designed according to CDOW criteria.

Air-release check valves would be installed along the penstock for accumulated air to be released during times of filling. Manholes would also be installed for proper ventilation and access during construction and maintenance periods. The number and location of the check valves and manholes would be determined during the final design.

In case of an emergency or unplanned shutdown of power generation, water flow would be maintained through the penstock and released to the river through the turbines. Pressure-sensing devices would be installed along the penstock to detect any rapid pressure drops indicating a ruptured pipeline. If this unlikely event occurred, the gates at the penstock intake would be automatically closed and the South Canal gates would be automatically opened, allowing diversion through the South Canal. If this event occurred during the nonirrigation season, the Tunnel gate would be gradually closed. The turbine valve would remain open to allow water to drain from the penstock downstream of the rupture point. Design of these emergency features and control systems would be reviewed and approved by Reclamation.

Rights-of-way.--Easements for the construction and operation of the penstock, powerhouse, tailrace and transmission lines would be obtained by the Sponsors. Table 2.3 summarizes the anticipated rights-of-way requirements for developing alternative B. Following construction, easement widths would be reduced from 200 feet to 100 feet. Any land rights acquired for the modification of the AB Lateral would be donated to the United States to maintain control over the irrigation system.

Table 2.3.--Rights-of-way requirements for alternative B

Facility	Rights-of-way Width (ft)	Rights-of-way Length (ft)	Total area construction (acres)	Total area operation (acres)
Penstock	[a]200	38,380	172	86
AB Lateral enlargement	200	7,100	32	[b]16
Powerhouse	--	--	4	4
Tailrace	100	2,400	11	6
Transmission line	100	4,500	15	15
Total acres			234	127

[a] Width would be reduced to 75 feet for special environmental areas and to 100 feet for operation and maintenance needs.
[b] Includes 1 acre of Bureau of Land Management (BLM) land.

Alternative C

Alternative C, like alternative B, would divert water from the South Canal and AB Lateral into a penstock that would convey water to a new powerhouse located in northwest Montrose. Discharges from the powerhouse would enter the Uncompahgre River through an excavated tailrace.

Physical features of alternative C would have structural dimensions and configuration identical to those of alternative B. However, alternative C differs from B in that it would enlarge the capacity of the Gunnison Tunnel to 1,300 ft^3/s.

Features of Alternative C.--New construction would include the powerhouse, penstock, transmission line, access roads, and tailrace. In addition to the enlargement of the Gunnison Tunnel, existing facilities including a portion of the AB Lateral and South Canal and access roads would be modified. The dimensions, composition, and configuration of these features would be identical to those described for alternative B, as would access roads, safety features, and rights-of-way needs.

To develop alternative C, the Sponsors would increase the Tunnel's capacity to approximately 1,300 ft^3/s. Specific features include modifying the Tunnel entrance and upper reaches to provide a smoother hydraulic transition between the entrance section, the maintenance hallway and the main portion of the Tunnel. Additional minor work would be done in the unlined section, removing rock outcrops and repairing holes and erosion voids to lower the resistance to flow. Excess material removed from the Tunnel would be used in constructing other development features. All work plans would be approved by Reclamation before construction.

Alternative E

Under alternative E, water from the South Canal and AB Lateral would be diverted into a penstock that would convey water to a new powerhouse located in northwest Montrose. Discharges from the powerhouse would enter the Uncompahgre River through an excavated tailrace.

The physical features of this alternative are similar to those of alternative B; hence, they are not described in detail. However, the proposed plant design capacity of alternative E would be 950 ft^3/s, a value less than that of alternative B. The dimensions of several of the features would be smaller as described below.

Features of Alternative E.--Certain facilities would be constructed for this alternative, while other existing facilities operated by the UVWUA would be modified. New construction would include the powerhouse, penstock, transmission line, access roads, and tailrace. Existing facilities would be modified, including portions of the existing AB Lateral, South Canal, and access roads. No modification to the Gunnison Tunnel would occur as part of development of this alternative. Each of these features is described in greater detail below. Further studies of geotechnical, hydraulic, equipment, and other design parameters may result in slight changes to the information presented.

Canal Modifications.--Alternative E begins at the AB Lateral diversion works on the South Canal. Flows are presently diverted into the lateral by two sluice gates located on the right wall of the South Canal. The planned diversion works would be identical to alternative B; however, the AB Lateral would be modified to a channel width of only 15 feet.

Penstock.--The proposed steel penstock would have a diameter of between 9 and 10 feet and would be installed in the same manner and location as described for alternative B.

Powerhouse.--The powerhouse location and other features would be similar to those described for alternative B. However, for alternative E, the turbines would be designed to use a maximum flow of 950 ft^3/s with an estimated lower limit of 45 to 90 ft^3/s. The transmission line, site access, rights-of-way, and safety features incorporated into the design would be identical to those described for alternative B.

Alternative F

The location, dimensions and configuration of the physical features would be the same as those for alternative B as would the plant operations. Plant flow capacity would be 1,135 ft^3/s. No improvements of the Gunnison Tunnel would be made as part of the development.

The primary difference between alternatives B and F is that additional environmental commitments concerning winter flows in the Gunnison River would be made for alternative F. These commitments, described later, would result in less flow through the turbines and consequently a smaller amount of average annual energy.

Water Supply and Operation of Development Alternatives

Water Supply Allocation

All water to be used in producing electrical energy would be diverted from the Gunnison River. All alternatives would use a priority system for allocating water to the demands of irrigation, instream flow, and hydropower. Irrigation demands would always be given priority over hydropower demands. However, the Uncompahgre River would be used as much as possible to meet irrigation needs in the M&D and Loutzenhizer Canals, permitting use of Gunnison River water for power production. The irrigation needs for the Selig, Ironstone, East and Garnet Canals would be met using water which has passed through the powerplant. The West Canal would continue to be supplied by the South Canal.

The priority system for flow allocation would be as follows.

1. Irrigation demands would be diverted, up to the hydraulic capacity of the Tunnel. Hydropower operations would not interfere with or reduce the amounts of water diverted for irrigation.

2. Minimum flows in the Gunnison River would be met to values stipulated in the environmental commitments for each alternative. Hydropower operations would not divert water that would reduce flows below the specified minimums.

3. Remaining flow in the Gunnison River would be diverted for power generation, up to the hydraulic capacity of the turbines.

When the Uncompahgre River does not have adequate supplies to meet irrigation demands in the M&D Canal, the Loutzenhizer Canal and other senior water rights, the demands would be met by water from the Gunnison River. Hydropower generation would be curtailed; this method is similar to historic operations.

The Gunnison Tunnel and South Canal presently convey water to the Fairview Reservoir for municipal and industrial needs. These diversions would always be met before hydropower needs. In addition, the existing water exchange under the Dallas Creek Project would be met before hydropower needs. This exchange calls for using Ridgway Reservoir for irrigation in exchange for using an equal amount of Gunnison Tunnel water for municipal and industrial purposes.

Control Systems for Facility and Water Supply Operations

Powerhouse operations would occur without an onsite operator. However, plant control design would provide for local manual, local automatic, and remote automatic control. The UVWUA would have the primary responsibility for plant operation by controlling the amount of water diverted into the penstock and through the turbines.

Remote control and operation of the facility would be accomplished with two separate supervisory control and data acquisition (SCADA) systems. One system would be designed to remotely operate the power-generating functions using a master control station at either the UVWUA headquarters or the DMEA Montrose service center. The automatic control system would include automatic startup sequencing, normal and emergency shutdown, and local and remote loading control.

Except for unplanned shutdown, the development would operate continuously, provided water is available. Annual maintenance of all project features would be scheduled to coincide with annual turbine maintenance at Crystal Dam.

Under all development alternatives, a second SCADA system would be used to manage the water supply system. It would be designed to integrate the hydropower alternatives with the existing irrigation function of the UVRP on a daily basis using a computerized water management program (WMP). The WMP would isolate and separate hydropower demands from irrigation demands so that diversions specific to each function could be monitored. The SCADA/WMP system would remotely operate gate controllers at the AB Lateral intake gate, the South Canal control gate, and the existing M&D Canal headgate in response to the available supplies in the Gunnison and Uncompahgre Rivers and irrigation demands. The efficiency and reliability of water management on the UVRP would thus be maximized. The system would also produce written records of flows at key locations including the Gunnison River.

The SCADA/WMP would operate using daily flow data collected from remote terminal units (RTUs) installed at key points in the irrigation system. RTU locations would include the headgates for the M&D, Selig, Loutzenhizer and West Canals and at the AB Lateral. The RTU's would transmit discharge levels to a SCADA system located at the UVWUA headquarters. Instantaneous data would be acquired from existing satellite links to the Uncompahgre gauge at Colona and the Gunnison River gauge downstream of the East Portal of the Gunnison Tunnel. This information would be supplemented with the releases data from Crystal Reservoir supplied by Reclamation and the normal daily settings and readings taken by the UVWUA Watermaster and ditch riders. All data would be combined and processed through the SCADA/WMP system to yield the amount of flow available to the hydropower plant.

When releases from Crystal Dam are less than 1,500 ft^3/s, the SCADA/WMP system would take specific measures to ensure that hydropower diversions comply with the minimum Gunnison River flow commitments of 300 ft^3/s. The SCADA/WMP system would show which diversions are related to hydropower, and thus would be used to adjust hydropower's proportional gate settings. The Gunnison River flow estimates would be checked twice daily against instantaneous measurements at the East Portal U.S. Geological Survey (USGS) gauge and at Crystal Dam to insure accuracy and to prevent minimum flow encroachments. The Sponsors would coordinate these activities with Reclamation to identify anticipated fluctuations in Crystal Dam releases, further minimizing the risk of short-term minimum flow encroachments between gauge checks.

Specific Water Supply Considerations

Although all water used to generate hydroelectric power would be supplied by the Gunnison River, the amounts used for each alternative would vary according to the plant and tunnel capacity and the stipulated instream flow. The estimated flows available for hydropower production were determined using a computerized model of the regional water system. This model utilized water use data provided by the UVWUA and simulated flows in the Gunnison and Uncompahgre Rivers developed by Reclamation. The period of study used for the model was 1952 through 1983, which included several dry and wet periods in addition to average flow periods. Further description of this model is presented in the report entitled, "AB Lateral Unit Water Supply Study" (HDR, 1989).

Alternative A.--The Gunnison River is now operated with a minimum flow of 300 ft^3/s downstream from the Gunnison Tunnel and would be expected to operate this way in the future. However, it should be noted that irrigation demands and existing Aspinall Unit operation may occasionally reduce flows below 300 ft^3/s during extremely dry periods, a potential that exists with or without development.

Alternative B.--The development of this alternative would not place new or additional demands on the Aspinall Unit Reservoirs, and the Tunnel capacity would not be increased. If this alternative is developed, an average of 508,128 acre-feet (702 ft^3/s) would be passed through the turbines (see table 2.4).

Alternative C.--The development of this alternative would not place new or additional demands on the upstream Aspinall Unit reservoirs. However, the Tunnel capacity would be increased to 1,300 ft^3/s. If this alternative is developed, an average of 544,011 acre-feet (751 ft^3/s) annually would be passed through the turbines (see table 2.5).

Alternative E.--The development of this alternative would not place new or additional demands on the upstream Aspinall Unit Reservoirs. If this alternative is developed, an average of 478,204 acre-feet (646 ft^3/s) annually would be passed through the turbines (see table 2.6).

Alternative F.--The development of this alternative would not place new or additional demands on the upstream Aspinall Unit Reservoirs. If this alternative is developed, an average of 502,986 acre-feet (695 ft^3/s) annually would be passed through the turbines (see table 2.7).

Specific Operation Considerations

The operation of each alternative would be as described previously. However, the amounts of power and energy produced by each development alternative would vary because of different flow capacities and annual available flow volume. Power and energy generated by the development would be sold to the Public Service Company of Colorado for use within the state. The power and energy for each alternative are described in the following paragraph.

Table 2.4
Monthly average flows entering AB Lateral Hydropower Facility, in ft^3/s.
Alternative B -- 1,135 ft^3/s turbine capacity, no Tunnel modifications

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual avg.
1952	1,127	1,127	1,127	1,034	754	862	748	545	676	782	1,127	1,127	918
1953	927	870	855	491	622	839	599	444	448	800	1,031	1,127	754
1954	409	140	0	252	505	439	483	247	343	284	0	0	259
1955	344	0	0	418	370	661	408	388	161	122	0	728	302
1956	822	692	599	400	636	780	506	525	190	436	975	1,109	639
1957	1,127	1,127	1,127	825	680	864	859	799	800	986	1,127	1,127	953
1958	1,127	1,127	1,127	1,007	878	851	748	644	325	799	990	1,127	895
1959	688	423	213	223	500	707	599	453	237	367	420	1,127	498
1960	923	854	840	854	677	861	734	545	291	805	983	1,088	788
1961	645	356	135	511	460	714	520	454	468	423	416	1,127	520
1962	1,127	1,127	1,127	916	779	634	683	548	444	899	884	1,081	853
1963	634	372	176	239	431	399	415	457	307	115	0	470	335
1964	786	643	506	467	752	801	559	531	335	713	1,025	1,127	688
1965	1,127	1,127	1,127	1,039	695	756	846	587	824	1,027	1,127	1,127	949
1966	1,027	942	910	531	665	617	515	482	188	226	653	1,127	656
1967	692	530	245	194	333	521	522	428	279	87	0	1,127	414
1968	985	943	948	542	597	795	557	712	630	808	1,127	1,127	814
1969	1,127	1,127	811	912	650	657	635	465	550	1,036	1,127	1,127	850
1970	1,127	1,127	1,127	999	856	818	669	459	891	1,029	1,127	1,127	945
1971	1,127	1,127	1,127	852	618	772	732	533	673	832	1,127	1,127	886
1972	843	746	720	249	480	438	515	441	261	475	1,127	1,127	619
1973	1,127	1,127	1,037	1,024	904	862	839	491	668	733	1,127	1,127	921
1974	908	845	873	736	785	640	703	465	239	176	1,101	1,127	716
1975	1,127	1,127	1,127	861	644	814	843	626	617	507	1,127	1,127	877
1976	799	674	556	280	436	591	582	418	205	231	639	1,102	543
1977	298	0	0	292	425	498	422	306	462	209	0	0	244
1978	1,127	1,127	0	258	614	832	756	559	314	577	1,085	1,127	695
1979	1,127	1,127	1,127	1,023	869	889	835	496	542	681	1,070	1,127	908
1980	1,127	1,127	1,127	988	755	784	692	387	188	725	1,127	1,127	845
1981	1,127	899	739	450	358	457	616	272	241	434	331	381	524
1982	497	1,127	1,127	404	308	602	628	524	778	994	1,127	1,127	768
1983	1,127	1,127	1,083	928	737	827	827	617	495	641	1,079	1,127	883
Average	910	839	739	631	618	706	644	495	440	592	819	996	702
Maximum	1,127	1,127	1,127	1,039	904	889	859	799	891	1,036	1,127	1,127	953
Minimum	298	0	0	194	308	399	408	247	161	87	0	0	244
Std. dev.	262	358	420	307	170	148	137	115	216	303	424	319	218

Source: HDR, 1989.

Table 2.5

Monthly average flows entering AB Lateral Hydropower Facility, in ft^3/s.
Alternative C -- 1,135 ft^3/s turbine capacity, with Tunnel modified to 1,300 ft^3/s capacity

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual avg.
1952	1,135	1,135	1,135	1,135	919	1,027	913	710	841	947	1,135	1,135	1,013
1953	927	870	855	491	722	1,004	599	609	448	965	1,031	1,135	805
1954	409	140	0	252	505	439	483	247	343	284	0	0	259
1955	344	0	0	418	370	661	408	388	161	122	0	728	302
1956	822	692	599	400	675	780	506	690	190	436	975	1,109	657
1957	1,135	1,135	1,135	990	845	1,029	1,024	964	965	1,135	1,135	1,135	1,052
1958	1,135	1,135	1,135	1,135	1,043	1,016	913	809	325	880	990	1,135	971
1959	688	423	213	223	500	707	599	618	237	367	420	1,135	513
1960	923	854	840	854	842	990	793	710	291	970	983	1,088	845
1961	645	356	135	511	460	714	520	619	468	423	416	1,135	535
1962	1,135	1,135	1,135	1,081	944	799	848	713	444	1,064	884	1,081	938
1963	634	372	176	239	431	399	415	622	307	115	0	470	349
1964	786	643	506	467	917	801	559	696	335	713	1,025	1,135	716
1965	1,135	1,135	1,135	1,135	860	921	1,011	752	989	1,135	1,135	1,135	1,039
1966	1,027	942	910	531	830	617	515	647	188	226	653	1,135	685
1967	692	530	245	194	333	521	522	593	279	87	0	1,135	429
1968	985	943	948	542	762	960	722	877	795	973	1,135	1,135	898
1969	1,135	1,135	811	1,037	815	796	758	630	665	1,135	1,135	1,135	931
1970	1,135	1,135	1,135	1,135	1,021	983	834	624	1,056	1,135	1,135	1,135	1,037
1971	1,135	1,135	1,135	1,017	783	937	897	698	838	997	1,135	1,135	986
1972	843	746	720	249	480	438	515	606	261	475	1,135	1,135	634
1973	1,135	1,135	1,037	1,135	1,069	1,027	1,004	656	801	733	1,135	1,135	999
1974	908	845	873	736	950	640	703	630	239	176	1,101	1,135	745
1975	1,135	1,135	1,135	1,026	809	979	1,008	791	782	507	1,135	1,135	963
1976	799	674	556	280	436	591	582	583	205	231	639	1,102	557
1977	298	0	0	292	425	498	422	306	462	209	0	0	244
1978	1,135	1,135	0	258	712	997	921	724	314	577	1,085	1,135	747
1979	1,135	1,135	1,135	1,135	1,034	1,054	1,000	661	542	681	1,070	1,135	975
1980	1,135	1,135	1,135	1,135	920	949	857	552	188	725	1,135	1,135	916
1981	1,135	899	739	450	358	457	616	272	241	434	331	381	525
1982	497	1,135	1,135	404	308	602	793	671	885	1,072	1,135	1,135	812
1983	1,135	1,135	1,083	928	902	992	992	782	660	806	1,079	1,135	968
Average	914	842	742	682	718	791	727	639	492	648	822	1,002	751
Maximum	1,135	1,135	1,135	1,135	1,069	1,054	1,024	964	1,056	1,135	1,135	1,135	1,052
Minimum	298	0	0	194	308	399	408	247	161	87	0	0	244
Std. dev.	265	362	423	363	241	216	207	157	282	358	426	321	251

Source: HDR, 1989.

Table 2.6
Monthly average flows entering AB Lateral Hydropower Facility, in ft^3/s.
Alternative E -- 950 ft^3/s turbine capacity, no Tunnel modifications

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual avg.
1952	950	950	950	950	754	862	748	545	676	782	950	950	838
1953	927	870	855	491	622	839	599	444	448	800	950	950	732
1954	409	140	0	252	505	439	483	247	343	284	0	0	259
1955	344	0	0	418	370	661	408	388	161	122	0	728	302
1956	822	692	599	400	636	780	506	525	190	436	950	950	624
1957	950	950	950	825	680	864	859	799	800	950	950	950	877
1958	950	950	950	950	878	851	748	644	325	799	950	950	828
1959	688	423	213	223	500	707	599	453	237	367	420	950	483
1960	923	854	840	854	677	861	734	545	291	805	950	950	773
1961	645	356	135	511	460	714	520	454	468	423	416	950	505
1962	950	950	950	916	779	634	683	548	444	899	884	950	799
1963	634	372	176	239	431	399	415	457	307	115	0	470	335
1964	786	643	506	467	752	801	559	531	335	713	950	950	667
1965	950	950	950	950	695	756	846	587	824	950	950	950	862
1966	950	942	910	531	665	617	515	482	188	226	653	950	635
1967	692	530	245	194	333	521	522	428	279	87	0	950	399
1968	950	943	948	542	597	795	557	712	630	808	950	950	781
1969	950	950	811	912	650	657	635	465	550	950	950	950	785
1970	950	950	950	950	856	818	669	459	891	950	950	950	861
1971	950	950	950	852	618	772	732	533	673	832	950	950	812
1972	843	746	720	249	480	438	515	441	261	475	950	950	589
1973	950	950	950	950	904	862	839	491	668	733	950	950	849
1974	908	845	873	736	785	640	703	465	239	176	950	950	688
1975	950	950	950	861	644	814	843	626	617	507	950	950	804
1976	799	674	556	280	436	591	582	418	205	231	639	950	530
1977	298	0	0	292	425	498	422	306	462	209	0	0	244
1978	950	950	0	258	614	832	756	559	314	577	950	950	641
1979	950	950	950	950	869	889	835	496	542	681	950	950	833
1980	950	950	950	950	755	784	692	387	188	725	950	950	768
1981	950	899	739	450	358	457	616	272	241	434	331	381	509
1982	497	950	950	404	308	602	628	524	778	950	950	950	706
1983	950	950	950	928	737	827	827	617	495	641	950	950	818
Average	824	756	671	617	618	706	644	495	440	582	728	851	661
Maximum	950	950	950	950	904	889	859	799	891	950	950	950	877
Minimum	298	0	0	194	308	399	408	247	161	87	0	0	244
Std. dev.	196	295	361	289	170	148	137	115	216	290	362	260	192

Source: HDR, 1989.

Table 2.7

Monthly average flows entering AB Lateral Hydropower Facility, in ft^3/s.

Alternative F -- 1,135 ft^3/s turbine capacity, no Tunnel modifications, with de-icing flows

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual avg.
1952	1,127	1,127	1,127	1,034	754	862	748	537	668	782	1,127	1,127	917
1953	859	795	855	491	622	839	599	436	440	800	1,031	1,127	741
1954	341	65	0	252	505	439	483	239	335	284	0	0	247
1955	276	0	0	418	370	661	408	380	153	122	0	728	295
1956	754	617	599	400	636	780	506	517	182	436	975	1,109	626
1957	1,127	1,127	1,127	825	680	864	859	791	792	986	1,127	1,127	952
1958	1,127	1,127	1,127	1,007	878	851	748	636	317	799	990	1,127	894
1959	620	348	213	223	500	707	599	445	229	367	420	1,127	485
1960	855	779	840	854	677	861	734	537	283	805	983	1,088	775
1961	577	281	135	511	460	714	520	446	460	423	416	1,127	507
1962	1,127	1,127	1,127	916	779	634	683	540	436	899	884	1,081	852
1963	566	297	176	239	431	399	415	449	299	115	0	470	322
1964	718	568	506	467	752	801	559	523	327	713	1,025	1,127	675
1965	1,127	1,127	1,127	1,039	695	756	846	579	816	1,027	1,127	1,127	948
1966	959	867	910	531	665	617	515	474	180	226	653	1,127	643
1967	624	455	245	194	333	521	522	420	271	87	0	1,127	401
1968	917	868	948	542	597	795	557	704	622	808	1,127	1,127	801
1969	1,127	1,127	811	912	650	657	635	457	542	1,036	1,127	1,127	849
1970	1,127	1,127	1,127	999	856	818	669	451	883	1,029	1,127	1,127	943
1971	1,127	1,127	1,127	852	618	772	732	525	665	832	1,127	1,127	884
1972	775	671	720	249	480	438	515	433	253	475	1,127	1,127	606
1973	1,127	1,127	1,037	1,024	904	862	839	483	660	733	1,127	1,127	919
1974	840	770	873	736	785	640	703	457	231	176	1,101	1,127	703
1975	1,127	1,127	1,127	861	644	814	843	618	609	507	1,127	1,127	876
1976	731	599	556	280	436	591	582	410	197	231	639	1,102	530
1977	230	0	0	292	425	498	422	298	454	209	0	0	237
1978	1,127	1,127	0	258	614	832	756	551	306	577	1,085	1,127	694
1979	1,127	1,127	1,127	1,023	869	889	835	488	534	681	1,070	1,127	907
1980	1,127	1,127	1,127	988	755	784	692	379	180	725	1,127	1,127	843
1981	1,127	824	739	450	358	457	616	264	233	434	331	381	517
1982	429	1,127	1,127	404	308	602	628	516	770	994	1,127	1,127	761
1983	1,127	1,127	1,083	928	737	827	827	609	487	641	1,079	1,127	882
Average	874	803	739	631	618	706	644	487	432	592	819	996	695
Maximum	1,127	1,127	1,127	1,039	904	889	859	791	883	1,036	1,127	1,127	952
Minimum	230	0	0	194	308	399	408	239	153	87	0	0	237
Std. dev.	290	378	420	307	170	148	137	115	216	303	424	319	222

Source: HDR, 1989.

The installed capacity for alternative B would be 66,240 horsepower (49,415 kilowatt (kW)). Development of this alternative would produce an average of 261,001 megawatt-hours (MWh) of energy per year. The installed capacity for alternative C would be 66,240 horsepower (49,415 kW). Development of this alternative would produce an average of 274,911 MWh of energy per year. Alternative E's installed capacity would be 54,650 horsepower (40,770 kW). Development would produce an average of 247,264 MWh of energy per year. The installed capacity for alternative F would be 66,240 horsepower (49,415 kW), and development would result in the average annual production of 258,619 MWh of energy.

Environmental Commitments and Measures

The Sponsors would include the following environmental measures as part of facility development and operation. An environmental commitment plan will be prepared by Reclamation and will include all commitments in this environmental statement, together with additional measures included in project permits. This plan would be complied with by the Sponsors through project design, construction, and operation. The environmental commitments would also be included in the lease of power privilege, ensuring compliance. Environmental commitments are summarized in attachment A.

Environmental Commitments and Measures Common to All Alternatives

Several environmental measures would be included with the development of all alternatives and are described below for the Gunnison River, the Uncompahgre River, and the lands affected by each alternative.

Gunnison River.--During operation of the power facility, minimum flow requirements would be met in the Gunnison River. None of the alternatives would divert any Gunnison River water that would reduce flows below the Gunnison Tunnel to less than 300 ft^3/s, even if the hydropower water right was senior to any future instream flow right or even if future instream flow rights were less than 300 ft^3/s or not designated at all.

Year-round operation of the Gunnison Tunnel could lead to additional fish loss from the Gunnison River through the Tunnel. The Sponsors propose to construct a fish barrier structure at the AB/South Canal diversion. Fish passing through the Tunnel during the irrigation season could be guided to the South Canal, creating a situation similar to current conditions. The barrier would be an integral part of the AB/South Canal diversion and would consist of a steel rack containing bars sufficiently spaced to limit entrainment of adult trout. Detailed design of the barrier would be coordinated with the CDOW.

Annual maintenance of the Tunnel would be performed by the UVWUA and would be coordinated with maintenance of Crystal Dam to minimize Gunnison River fluctuations.

Uncompahgre River.--Tunnel diversions would be curtailed if such diversions would contribute to a flooding hazard along the Uncompahgre River. The Sponsors would monitor river flows during flood events, controlling tunnel diversions accordingly. To prevent hydropower operations from affecting Reclamation's ability to fill Ridgway Reservoir, the Sponsors have agreed that the UVRP would not place a call on the Uncompahgre River using its senior water rights to the West, M&D, and Loutzenhizer Diversions, if the Gunnison Tunnel was diverting water in excess of UVRP irrigation demands, including UVRP diversions downstream from the proposed tailrace.

The Sponsors would stabilize portions of the Uncompahgre bed and banks before beginning operations to prevent serious erosion damages. The location of this activity is discussed in chapter 3. In addition, the Sponsors would establish a monitoring program to document changes to the river resulting from power operations. This program would be approved by Reclamation before construction and would be based upon low-level aerial photography of the channel obtained during design phases.

Affected Lands.--The Sponsors would pay for any damages to crops or other property associated with obtaining the required construction and operation easements.

In construction areas, topsoil would be stripped and separately stockpiled for later use in revegetation. Approximately 211 acres of land would be revegetated, including disturbed areas along the AB Lateral, the penstock right-of-way, other areas disturbed as a result of penstock construction, disturbed areas along the transmission line, and areas adjacent to the tailrace and powerhouse. Any areas disturbed as a result of stockpiling excess materials would also be revegetated. The landowner would direct the type of revegetation required on cultivated lands. All other areas would be seeded according to recommendations by the Soil Conservation Service. A revegetation plan would be prepared by the Sponsors for Reclamation approval before construction. Lands within the penstock and canal easements would be returned to existing uses (where not required for permanent maintenance roads) after construction is completed.

Excess material from penstock construction would be disposed of only in areas designated in contract specifications. Materials would not be disposed in wetlands or in areas of greasewood shrubland.

Affected Wildlife.--Transmission lines would be of a raptor-proof design to reduce the possibility of raptor electrocution. Design recommendations suggested in the document, Suggested Practices for Raptor Protection of Powerlines - the State of the Art (1981) would be followed.

Two deer escape ramps would be constructed in the concrete-lined portion of the AB Lateral. The ramps would be a modified "Richmond" design (Rautenstrauch and Krausman, 1986) and would have a 4:1 slope, be set diagonally to the canal wall, and have a cable barrier just downstream to direct deer to the escape. Final designs would be approved by the CDOW.

Approximately 12 acres of wetlands would be lost due to construction of any of the alternatives. The Sponsors would develop 12 acres of replacement wetlands on acquired land. The wetland replacement plan is described in chapter 3. The final plan would require Reclamation approval before any project features are constructed, and the wetlands would have to be completed before the facility is operational in the second year.

Pollution Control and Aesthetics.--Construction specifications would include provisions to limit noise and air pollution. The powerhouse, tailrace and associated features would be designed and landscaped to reduce visual impacts. A containment plan would be prepared as part of facility design for oil storage at the powerhouse. State and Federal water quality permits would be obtained by the Sponsors and would be observed during construction and operation. Irrigation and domestic water supplies would not be interrupted during construction and operation.

Endangered Species.--Plans for protecting endangered species have been developed in accordance with the biological opinion prepared by the FWS (1988). Special construction techniques would be included in the specifications and used along the penstock right-of-way where an endangered plant species occurs. In addition, the Sponsors would acquire approximately 60 acres of the plant's habitat in an area designated by the FWS and the BLM. This land would be donated to the BLM before plant operation. If this land were unavailable, the Sponsors would be required to complete an alternative plan as designated by FWS prior to operation. A written plan for protecting these plants during construction would need Reclamation and FWS approval prior to construction. The endangered plant species are discussed in detail in chapter 3.

The Sponsors would perform a standardized aircraft or river survey of the Gunnison River below the Black Canyon of the Gunnison National Monument to the confluence of the North Fork each year for 3 years following project initiation for monitoring bald eagles within the Gunnison River corridor. The Sponsors would also undertake such surveys in 1 year of any subsequent year that may represent an abnormally severe winter (provided a severe winter is not represented in the initial 3-year study period). A single survey would be conducted approximately every two weeks from January through the first of March (five total surveys per year). The surveys would be performed by qualified biologists with raptor survey experience and would assess species, number and age classes of eagles; waterfowl or other potential prey numbers; and extent of ice buildup.

Survey plans would be approved by the BLM and FWS prior to initiation of survey. The Sponsors would provide annual and final progress reports of the surveys to the FWS, BLM, and Reclamation. Any significant impacts or problems noted during the course of the eagle surveys would be brought immediately to the attention of the FWS.

In an effort to better document prey use on the Gunnison River, the Sponsors would do ground/river observations of foraging eagles. No less than 14 workdays of observation by a qualified observer would be conducted from December through March and would record observations of eagle hunting activity and species of prey captured. Attempts would be made to locate day and night perches and roosts to collect and analyze eagle castings.

If impacts to prey species or icing impacts are projected or are realized during the course of the study, appropriate measures would be undertaken through consultation with the FWS to reduce adverse effects. Such measures may include water augmentation during periods of extreme cold to prevent adverse icing conditions.

Specific Environmental Commitments and Measures

In addition to the commitments and measures described previously, each proposed alternative includes specific commitments unique to the features of the alternative. These are described in the following paragraphs.

Alternative B.--No increases to the Gunnison Tunnel capacity would be made as part of the hydropower development features for this alternative.

Alternative C.--Because this alternative proposes to increase the capacity of the Tunnel, the Sponsors would agree to limit diversions from the river during the nonirrigation season to the proposed capacity of the unit, 1,135 ft^3/s. During the irrigation season, flows could be diverted up to 1,300 ft^3/s, subject to availability, priority, and irrigation requirements.

Alternative E.--No increases to the Gunnison Tunnel capacity would be made as part of the hydropower development features for this alternative.

Alternative F.--No increases to the Gunnison Tunnel capacity would be made as part of the hydropower development features for this alternative. During the winter, the Sponsors would bypass a minimum flow in the Gunnison River of 600 ft^3/s when and if ice buildups occur.

The Sponsors would provide 1,000 acre-feet of water diverted from the Gunnison River to be conveyed through the South Canal for fisheries in the Uncompahgre River, should the CDOW undertake a fishery development program at some future time. This flow would be made available during the late summer and would be exclusive of power or irrigation demands.

Alternatives Eliminated from Study

The Sponsors considered a number of other alternatives that have been eliminated from further study. In many instances, the alternatives eliminated were dimensional variations of the selected alternatives. For instance, five different penstock diameters, two types of penstock (steel pipe and prestressed concrete pipe), and two types of penstock lining were considered for each alternative. In addition, five possible penstock routes were evaluated. The penstock type, size and lining options were optimized to maximize economic returns. Penstock routing was optimized to reduce impacts to endangered plants, land use, and landowners.

Within the region, two other possibilities were identified for hydropower production: expanding of existing facilities at Crystal Dam and installing new facilities at Ridgway Dam. Reclamation had considered hydropower development on both structures but discontinued efforts because of poor economic returns. As stated in the introduction, the development of hydropower resources within the UVRP was authorized by Congress in Public Law 75-698. Neither Crystal Dam nor Ridgway Dam is within the boundaries of the UVRP and are not considered to be part of that Project. Consequently, both structures were eliminated from further consideration.

Three additional alternatives seriously studied as part of this report include one variation of alternative C and two alternatives involving sites along the South Canal. These alternatives are described below.

Alternative D

This alternative was considered to maximize hydropower potential. It is similar to alternative C, except that in addition to increasing tunnel capacity to 1,300 ft^3/s, the maximum flow through the turbines would also be 1,300 ft^3/s. If developed, alternative D would produce an average of approximately 277,698 MWh annually by diverting 565,323 acre-feet through the turbines, which is 21,312 acre-feet more than alternative C.

The design features of this alternative would be similar to those of alternative C. However, to accommodate the increased flows, the AB Lateral would be widened to 23 feet, and the tailrace would be widened to 30 feet. Although the powerhouse dimensions would remain the same, the equipment would be somewhat larger and heavier, resulting in an increase of the capital costs of this alternative of nearly $1 million greater than alternative C. Annual operating costs would increase by $150,000.

Developing this alternative would reduce the average annual flows below the Gunnison Tunnel to about 533 ft^3/s (compared to 563 ft^3/s for alternative C). Under the no-action alternative, these flows would be 1,103 ft^3/s.

This alternative was eliminated from further study for several reasons. First, although it would produce more energy than any of the selected alternatives, the increased development costs resulted in slightly lower financial returns. Second, developing the alternative would result in increased environmental impacts without any corresponding financial benefit.

Alternative G (South Canal Sites)

The original hydropower concept proposed in 1981 by the Sponsors involved developing five sites located at existing drop structures or steep grade sections along the South Canal. These developments were analyzed in detail from January 1981 through September 1983. Preliminary designs were prepared. One of the sites was then eliminated because of poor economics. Detailed negotiations occurred with contractors and equipment suppliers. The Sponsors also negotiated power sales and wheeling agreements with Public Service Company and Colorado-Ute.

The configuration and operation of each of the four sites were similar. Water would be diverted from the South Canal through a concrete headrace and trash rack, passed through a 10-foot-diameter steel penstock and horizontal tube-type turbines, and returned to the canal via a stilling basin and a concrete-lined tailrace. In most cases, the powerhouse would be below natural grade, and only a small entrance shelter would be above ground.

Water levels would be controlled by a radial gate in each headrace. Power and energy generated at each site would be connected to the existing transmission grid via new 46-kV transmission lines, which would be constructed within the existing canal right-of-way or within existing county road rights-of-way. A summary of site characteristics is presented in table 2.8, and the approximate location of each site is shown in figure 2.8.

Table 2.8.-- Summary of characteristics, alternative G

Characteristic	Site 1	Site 3	Site 4	Site 5
Turbine flow (ft^3/s)	900	900	900	900
Net head at maximum flow (ft)	51	46	62	28
Rated capacity (kW)	3,514	3,177	4,198	1,908
Average annual energy (MWh)	22,164	19,717	26,260	10,994

Figure 2.8. Location of Alternative G (South Canal sites).

With alternative G, the operation of the irrigation system would be identical to the no-action alternative. However, additional flows would be diverted during the irrigation season up to the Tunnel capacity and during the non-irrigation season up to 900 ft^3/s to increase energy production. The estimated average annual energy production at the four sites would be about 79,136 MWh. If unplanned shutdown of the turbines occurred, the radial gate in the headrace would be closed, allowing the uninterrupted flow of irrigation supplies through the South Canal.

Development of the South Canal sites would have two major differences from the AB Lateral alternatives. First, no changes to the historic flow patterns of the irrigation water would occur. Although more water would be diverted from the Gunnison River (646,196 acre-feet versus the historic 342,162 acre-feet), the water would be discharged into the Uncompahgre River at the South Canal terminus. Second, because flow patterns do not change, development of this alternative would greatly increase the flows in the Uncompahgre River downstream of the South Canal terminus.

Alternative G was eliminated from further consideration for several reasons. Although the development was feasible in 1983, power rates have fallen in the past 5 years and tax credits have been eliminated, while construction costs have risen, a combination of events that have rendered the alternative economically infeasible.

Second, development of the South Canal sites does not take full advantage of the potential hydropower resource. This can be seen by comparing the energy produced by alternative E (which has a similar design flow), 241,815 MWh, to the energy produced at the South Canal sites, 79,135 MWh. It was for this reason that additional studies were initiated in 1984 that resulted in the AB Lateral concept.

Third, the increased flows between the South Canal terminus and Montrose would result in increased erosion and bank degradation in the Uncompahgre River. This action would add further costs of erosion mitigation in addition to the costs of mitigating those impacts between Montrose and Delta.

Alternative H

The inefficiencies of the South Canal sites can be partially offset by alternative H, which captures much of the elevation difference between the South Canal and Uncompahgre River by relocating the diversion works farther downstream from the AB Lateral. For this alternative, a diversion structure would be located about 3 miles downstream of the West Portal of the Gunnison Tunnel at the upper end of South Canal Site 3 (see figure 2.8). Here water would be diverted into a penstock that terminates at a powerhouse located almost due west of the diversion works and just upstream from the Loutzenhizer Canal diversion dam.

The features of this alternative would be similar to those of alternative B. Minor modifications of the South Canal would be needed to increase its capacity between the AB Lateral and the proposed diversion to 1,135 ft^3/s. The diversion structure would consist of two radial gates, one on the South Canal and one in the headrace. The latter feature would be a rectangular channel about 20 feet wide and 50 feet long that would convey flows from the canal to the penstock trash rack and intake.

The penstock would be about 28,500 feet long, have a 10-foot diameter, and would be constructed similar to alternative B. Construction and features of the powerhouse would also be similar to alternative B. The estimated rated capacity of these turbines would be about 40,000 horsepower.

Coupled with this alternative would be the development of South Canal Site 1 (see alternative G) near the West Portal of the Tunnel. Development of both sites would result in production of about 195,923 MWh annually. Because the diverted flows enter the Uncompahgre River upstream of the Loutzenhizer Canal, the demands of that canal can be passed through the powerhouse in addition to those of the Selig Canal and other downstream canals. However, if the Uncompahgre River cannot satisfy all of the demands in the M&D Canal, additional flows would have to be bypassed through the South Canal away from the turbines.

Alternative H would have the advantage of adding water to the Uncompahgre River upstream of Montrose, increasing the potential for recreational development in the area. However, the additional flow would also result in erosion problems within this reach caused by high flows during the winter.

This alternative was eliminated from detailed consideration because the development costs exceeded the estimated benefits. Other factors also entered into this decision. First, the average flow diverted from the Gunnison River would be 956 ft^3/s per year, leaving an average of 613 ft^3/s per year in the river. These figures are identical to those of alternative B, yet the energy production of alternative H (including site 1) is 25 percent less than alternative B. Second, the cost of developing alternative H was estimated to be about $57,235,000, which is less than alternative B.

Increased Minimum Flows in the Gunnison River

Several alternatives were evaluated which considered the effects of increasing the instream flows in the Gunnison River. Alternatives F-3 and F-4 considered an instream flow of 350 and 400 ft^3/s, respectively for the months of June, July, and August. These values and months were selected to determine the economic impacts to the development of providing greater flows for rafting and other interests while still protecting fisheries. Alternative F-5 was studied for similar reasons, although this alternative evaluated an instream flow of 400 ft^3/s during the months of July, August, and September. For each of these alternatives, it was also assumed that deicing flows would be provided to the river during January and February. For alternative F-6, minimum flows were modeled as 450 ft^3/s in December, 600 ft^3/s in January, and 450 ft^3/s in February to accomplish deicing, and 450 ft^3/s in August, 600 ft^3/s in September, and 450 ft^3/s in October to provide additional water for rafting interests.

Under these alternatives and the no-action alternative, flows would still periodically fall below the levels discussed (350, 400, 450, and 600 ft^3/s) due to runoff conditions and operation of upstream water rights.

Each of these alternatives was analyzed in terms of the economic effect to the proposed development as well as the environmental effects to the Gunnison River. In table 2.9, the results of the analysis are compared to alternatives E and F, which are feasible alternatives that reduce diversions through the capacities of the turbines or through ice control releases. Alternatives F-3 through F-6 would increase the average annual volume of water in the Gunnison River, which in turn would subsequently benefit rafting. However, for each of these alternatives the volume of water available for power production would be diminished, resulting in a loss of revenues without a concurrent reduction in overall development costs.

From table 2.9, it is seen that despite increasing the minimum instream flows during specified summer and winter months, the average annual flows in the Gunnison River would still be less than those for alternative E, with the exception of alternative F-6. The benefit/cost ratio for each of the alternatives (F-3 through F-6) is less than 1.0, implying that the costs of development incurred by the Sponsors are greater than the benefits.

Table 2.9.--Summary of minimum flow alternatives

Parameter	Alternative[1] E	F	F-3	F-4	F-5	F-6
Water flow data, in ft^3/s						
Entering Black Canyon	654	619	623	627	629	655
Diverted through Tunnel	915	951	946	942	940	914
Through AB facility	661	695	690	686	684	658
Uncompahgre R. at Cedar Cr.	633	679	674	670	668	642
Economic data						
Power production, MWH	247,264	258,619	251,812	250,098	249,302	240,355
Total capital cost[2], $1,000	$57,068	$62,114	$62,114	$62,114	$62,114	$62,114
Benefit/cost ratio	1.04	1.01	0.98	0.97	0.97	0.93

[1] Alternatives F-3 through F-6 assume similar facility parameters to Alternative F with the following exceptions:

a. Alternative F-3 assumes minimum instream flow of 350 ft3/s during June, July and August.
b. Alternative F-4 assumes minimum instream flow of 400 ft3/s during June, July and August.
c. Alternative F-5 assumes minimum instream flow of 400 ft3/s during July, August and September.
d. Alternative F-6 assumes 450 ft3/s instream flows during February, August, October and December, 600 ft3/s in January and September, 300 ft3/s in remaining months.

[2] Total capital cost includes construction costs and net present worth of annual operation and maintenance costs.

Permits and Regulatory Approvals

Before constructing any alternative, the Sponsors would need to obtain various permits and agreements. A lease of power privilege to use UVRP facilities would be executed with Reclamation. The Sponsors would obtain in the name of the United States all land rights necessary for relocating reaches of the AB Lateral from BLM and private landowners.

Clean Water Act permits would be required from the U.S. Army Corps of Engineers for constructing the tailrace and bank protection on the Uncompahgre River. A Section 401 water quality certification and a Section 402 water discharge permit also would be required from the State of Colorado for construction.

For penstock crossings, various agreements would be obtained from local and State agencies and from the Denver and Rio Grande Railroad. The Sponsors would work directly with the City of Montrose, the Colorado Department of Highways, and Montrose County in designing and constructing crossings and other features.

Water Rights

The hydropower facility under all alternatives would be operated according to Colorado water law. Colorado has a priority system to allocate surface waters for beneficial use. A priority date is assigned based upon the year a decree application is filed with the State. Use of the water is then prioritized, with the earliest priority date receiving the first call on water. The Sponsors have applied for and received two separate water rights specifically for the proposed development. The first, having a 1982 priority date, is for 900 ft^3/s. The second, an additional 235 ft^3/s, carries a 1987 priority date. Together, these rights allow hydropower use for up to the full capacity of the Gunnison Tunnel (1,135 ft^3/s).

Operating the proposed facility under any of the development alternatives would constitute a nonconsumptive use. All flows into the facility would be returned to the river system without being diminished. In addition, the facility would be operated "run-of-the-river," meaning that it would possess no active storage, would have no call on the existing upstream storage reservoirs, and would use flows only as they are released by the reservoir operators under their own operating criteria.

Nonconsumptive, run-of-the-river operation also means that the facility's principal interaction with other water rights holders would be in the reach of the Gunnison River between the Gunnison Tunnel and the City of Delta. Within this reach are several irrigation rights including the North Delta Canal and the Relief, Hartland, and Bona Fide Ditches. Flow demands from these rights can be met from discharges from the North Fork and other tributaries as well as the 300-ft^3/s instream flow below the Tunnel. In addition, three conditional storage (proposed reservoir) rights are held by the City of Delta, CUEA, and the Nature Conservancy, respectively. Although these rights have not been perfected (developed), they are all senior to both hydropower rights. If they are developed, they would be given priority for water use.

The Nature Conservancy, whose right was previously held by the Pittsburg and Midway Coal Mining Company, is negotiating an agreement to convert their storage right into a direct flow, or instream flow right of 300 ft^3/s. If they are successful, the modified right would probably be senior to both hydropower rights. Even if not senior, the hydropower development has agreed to honor a 300 ft^3/s minimum flow in the Gunnison River below the East Portal of the Gunnison Tunnel.

In addition to these decreed rights, additional constraints might be imposed by Federal reserve rights. These rights would be for instream flow and are carried with special Federal land management designations. Courts have ruled that in establishing a special management zone such as the Black Canyon of the Gunnison National Monument, Congress intended to reserve enough water to accomplish the original purpose of the reservation. To date, reserve rights associated with the Black Canyon of the Gunnison National Monument or the Black Canyon Wilderness Area have not been quantified. Should they be quantified in the future, they would be senior to the hydropower rights and would therefore not be affected by hydropower development. Water rights associated with future Congressional designations would be junior to hydropower rights.

The irrigation portion of the Gunnison Tunnel (and most of the UVRP) carries water rights with a 1901 priority date. Irrigation rights are senior to the hydropower rights and would be unaffected by operation of the proposed development under any of the alternatives.

Summary Comparison of Alternatives

Development alternatives B through F are compared in summary form to the no-action alternative in tables 2.10, 2.11, and 2.12. Table 2.10 compares various physical and water-related parameters, table 2.11 compares economic factors, and 2.12 compares various environmental parameters.

Many of the parameters that are compared are dependent upon streamflows in the Gunnison and Uncompahgre Rivers. A summary of these streamflows, including duration curves and monthly average flow curves for flows entering the Black Canyon, is presented in attachment D.

The selection of the Sponsor's preferred alternative was based upon maximizing the benefit/cost ratio. In this analysis, the benefits to the Sponsors, represented by revenues from the sale of power, were compared to the costs of constructing and operating the facility. Net present revenues and costs were determined using three different discount rates (13, 14, and 15 percent) which span the range of financing rates expected by the Sponsors. Construction costs, anticipated to occur during the period 1990 through 1992, were based upon preliminary proposals submitted to the Sponsors by several contractors. Included in the cost estimates are the estimated construction costs of environmental mitigation measures, such as bank stabilization, endangered vegetation species mitigation, and a fish barrier at the AB Lateral/South Canal diversion.

The benefit/cost ratios presented in tables 2.9 and 2.11 incorporate the costs and benefits that the Sponsors of the proposed development would bear. Because the development would not involve Federal expenditures, the analysis does not incorporate other benefits or costs that might ordinarily be included if the development was to be Federally funded. The ratio is used primarily to determine the economic feasibility of an alternative. The range of discount rates used in the analysis in table 2.11 represents the range of private financing rates expected by the Sponsors, based upon a financial life of 15 years.

Implementation of any of the development alternatives would result in additional impacts to the regional economy and environment that are not included in the Sponsor's benefit/cost analysis. Some of these impacts, such as the impacts to an endangered plant, are impossible to fully quantify in economic terms. Table 2.12 summarizes the major impacts that could be reasonably expected to occur if development occurred. Where possible, these impacts have been shown in economic terms.

Alternative C produces the highest benefit/cost ratio and is the Sponsors' preferred alternative.

Table 2.10.--Summary comparison of alternatives

Item	Alternative A	B	C	E	F
WATER FLOW DATA (in ft^3/s)					
Gunnison River:					
Entering Canyon (average annual)	1,103	613	563	654	618
Average December through February flows	1,392	476	471	581	499
Average July through September flows	897	730	637	730	730
Minimum flows	300	300	300	300	300[1]
Below Delta (all periods)	No change	No change	No change	No change	No change
Uncompahgre River:					
Below South Canal (average annual)	540	342	342	342	343
Average December through February flows	89	88	88	88	88
Average July through September flows	910	579	579	579	585
Below Montrose & Delta Canal (average annual)	312	113	113	113	115
Average December through February flows	61	60	60	60	60
Average July through September flows	471	140	140	140	145
Entering Montrose (average annual)	269	65	65	65	67
Average December through February flows	50	48	48	48	48
Average July through September flows	392	58	58	58	63
Below Cedar Creek (average annual)	202	684	735	643	679
Average December through February flows	40	956	960	850	932
Average July through September flows	279	442	536	442	442
Through turbines (average annual)	- NA -	702	751	661	695
Average December through February flows	- NA -	918	922	812	894
Average July through September flows	- NA -	527	621	527	522
PRODUCTION DATA					
Rated capacity (HP)	- NA -	66,240	66,240	54,650	66,240
Average annual energy production (MWh)	- NA -	261,006	274,911	247,264	258,619
Design flow capacity (ft^3/s)	- NA -	1,135	1,135	950	1,135
Net head at maximum capacity (feet)	- NA -	580	580	603	580
PHYSICAL DATA					
Pipeline diameter[2] (inches)	- NA -	120	120	114	120
Tunnel modifications	None	None	Enlarged	None	None

[1] The minimum flow for Alternative F would be increased as necessary during winter months for purging ice buildup in the Gunnison River downstream of the Tunnel.

[2] Penstock diameters are preliminary and subject to change.

Table 2.11.--Alternative cost data, in $1,000, and benefit/cost analysis

Item	Alternative A	B	C	E	F
ALTERNATIVE COST DATA (in 1990 dollars)					
Construction costs[1]	- NA -	$52,959	$53,709	$48,454	$52,959
Development costs[2]	- NA -	$9,155	$9,245	$8,614	$9,155
Total capital costs	- NA -	$62,114	$62,954	$57,068	$62,114
Annual operation and maintenance costs	- NA -	$1,050	$1,050	$950	$1,050
ECONOMIC ANALYSIS (in 1992 dollars)[3]					
Discount rate = 13 percent					
Present value, fixed costs	- NA -	$68,870	$69,797	$63,269	$68,870
Present value, variable costs	- NA -	$8,551	$8,551	$7,737	$8,551
Present value, revenues from sale of power	- NA -	$78,549	$82,733	$74,405	$77,848
Benefit/cost ratio	- NA -	1.015	1.056	1.048	1.006
Discount rate = 14 percent					
Present value, fixed costs	- NA -	$66,037	$66,926	$60,666	$66,037
Present value, variable costs	- NA -	$8,174	$8,174	$7,396	$8,174
Present value, revenues from sale of power	- NA -	$75,106	$79,107	$71,144	$74,436
Benefit/cost ratio	- NA -	1.012	1.053	1.045	1.003
Discount rate = 15 percent					
Present value, fixed costs	- NA -	$63,419	$64,273	$58,261	$63,419
Present value, variable costs	- NA -	$7,827	$7,827	$7,081	$7,827
Present value, revenues from sale of power	- NA -	$71,933	$75,764	$68,138	$71,290
Benefit/cost ratio	- NA -	1.010	1.051	1.043	1.001

[1] Includes design/build costs, land acquisition and environmental mitigation costs.

[2] Includes financing, engineering design, licensing and legal fees, interest during construction, and administrative costs.

[3] Discount rates evaluated represent the range of financing rates expected by the Sponsors.

Table 2.12.--Impacts of alternatives

Item	Alternative A	B	C	E	F
WATER QUALITY AND QUANTITY					
Salt loading reduction (tons)	0	3,044	3,256	2,866	3,014
Annual flow entering Black Canyon (Gunnison R.)(ft^3/s)	1,103	613	563	654	618
Annual flow entering Montrose (Uncompahgre R.)(ft^3/s)	269	65	65	65	67
Annual flow below Cedar Creek (Uncompahgre R.)(ft^3/s)	202	684	735	643	679
ENDANGERED SPECIES					
Clay-loving wild buckwheat affected by const. (acres)	0	<5	<5	<5	<5
Mitigation acreage provided by Sponsors (acres)	0	60	60	60	60
Endangered fisheries affected	None	None	None	None	None
Endangered wildlife affected	None	Bald eagle	Bald eagle	Bald eagle	Bald eagle
WETLANDS					
Acreage affected along AB Lateral (acres)	0	4	4	4	4
Acreage affected along Uncompahgre River (acres)	0	8	8	8	8
Mitigation acreage provided by Sponsors (acres)	0	12	12	12	12
LAND USE					
Permanent easement requirements (acres)	0	127	127	127	127
Temporary easement requirements (acres)	0	249	249	249	249
RECREATION					
Gunnison River Wild & Scenic eligibility retained	Yes	Yes	Yes	Yes	Yes
Rafting, user days	4,673	4,066	3,440	4,066	4,066
Present value, direct expenditures[1] ($1,000)	$4,454	$3,924	$3,480	$3,924	$3,924
Economic impacts ($1,000)	$0	-$530	-$974	-$530	-$530
Fishing, user days	17,680	20,078	21,414	20,063	20,078
Present value, direct expenditures[1] ($1,000)	$6,387	$7,261	$7,748	$7,261	$7,261
Economic impacts ($1,000)	$0	$874	$1,361	$874	$874
CULTURAL RESOURCES					
Cultural resources sites affected	0	0	1	0	0
AIR QUALITY					
Air pollutant emissions offset: SO_2 (tons/yr)	0	800	825	740	800
NO_x (tons/yr)	0	1,300	1,375	1,235	1,300
CO_2 (tons/yr)	0	390,000	412,500	370,000	390,000

[1] Direct expenditures for rafting and fishing shown as net present value. 1988 values inflated at 5 percent per year and discounted to 1992 dollars at 8.875 percent. Annual expenditures (in 1988 dollars) are shown in chapter 3.

CHAPTER 3
AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

Development of the AB Lateral Hydropower Facility alternatives would have both short- and long-term consequences to the surrounding region. The purpose of this chapter is to describe the existing conditions of the region, the consequences of the no-action and development alternatives, and the effect of mitigative measures that would be implemented by the Sponsors.

General Description of the Region

The Uncompahgre Valley, which is about 31 miles in length, lies along the western flank of the Rocky Mountains with elevations ranging from 4,950 feet above sea level near Delta to 6,500 feet above sea level near Montrose. The valley slopes gently from southeast to northwest and is divided by the Uncompahgre River. The Gunnison River flows east of the valley through the Black Canyon of the Gunnison National Monument and the Gunnison Gorge Recreation Area (see figures 3.1 and 3.2).

The climate of the region is typical of lower intermountain valleys of the western United States, with low annual precipitation, low humidity, abundant sunshine, and a wide range of annual and daily temperatures. The average annual precipitation at Montrose is approximately 9 inches, about half of which occurs as winter snow.

The principal natural vegetation within the Uncompahgre Valley is the semidesert grass shrub community which is common in the intermountain west between elevations of 3,000 to 6,000 feet. Sagebrush, saltbush, and greasewood are characteristic plants. Stands of deciduous trees such as cottonwood and willow typically line natural drainages. Seepage from irrigation canals and laterals, along with irrigation return flows, have contributed to the development of wetlands along the irrigation features. Sparse stands of pinyon pine and juniper occur along elevated mesas and foothills around the valley.

About 505,000 acre-feet of water flow into the Uncompahgre Valley annually. Nearly two-thirds of this volume is imported from the Gunnison River via the Gunnison Tunnel (Tunnel) and the remaining volume is derived from the Uncompahgre River and its tributaries. Of the water entering the valley, about 233,000 acre-feet are consumptively used through irrigation or evaporation, and the remainder flows northward out of the valley and into the Gunnison River at Delta.

Common wildlife species in the region include nongame wildlife and the mule deer, cottontail rabbit, mourning dove, ring-necked

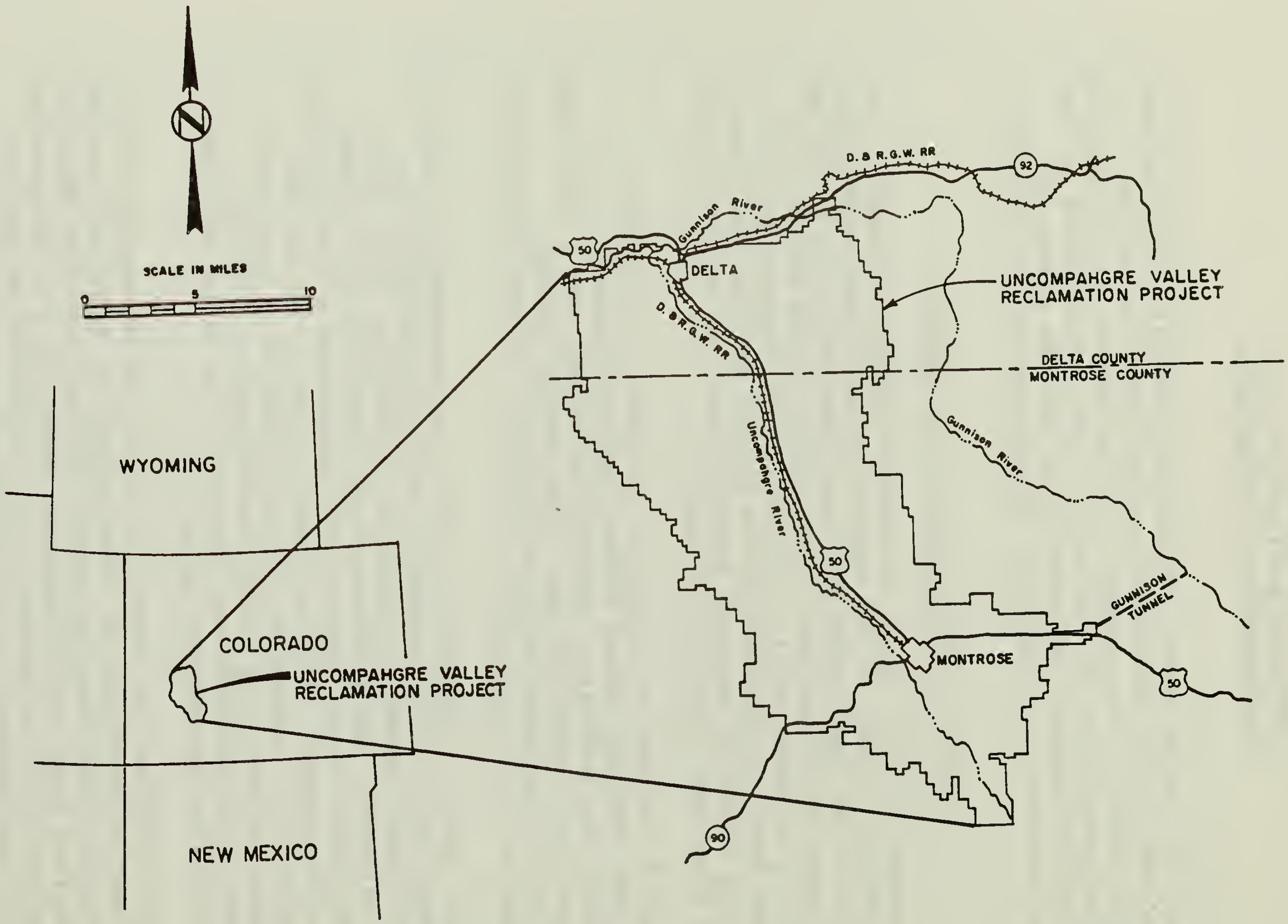


Figure 3.1. General area map, Uncompahgre Reclamation Project.

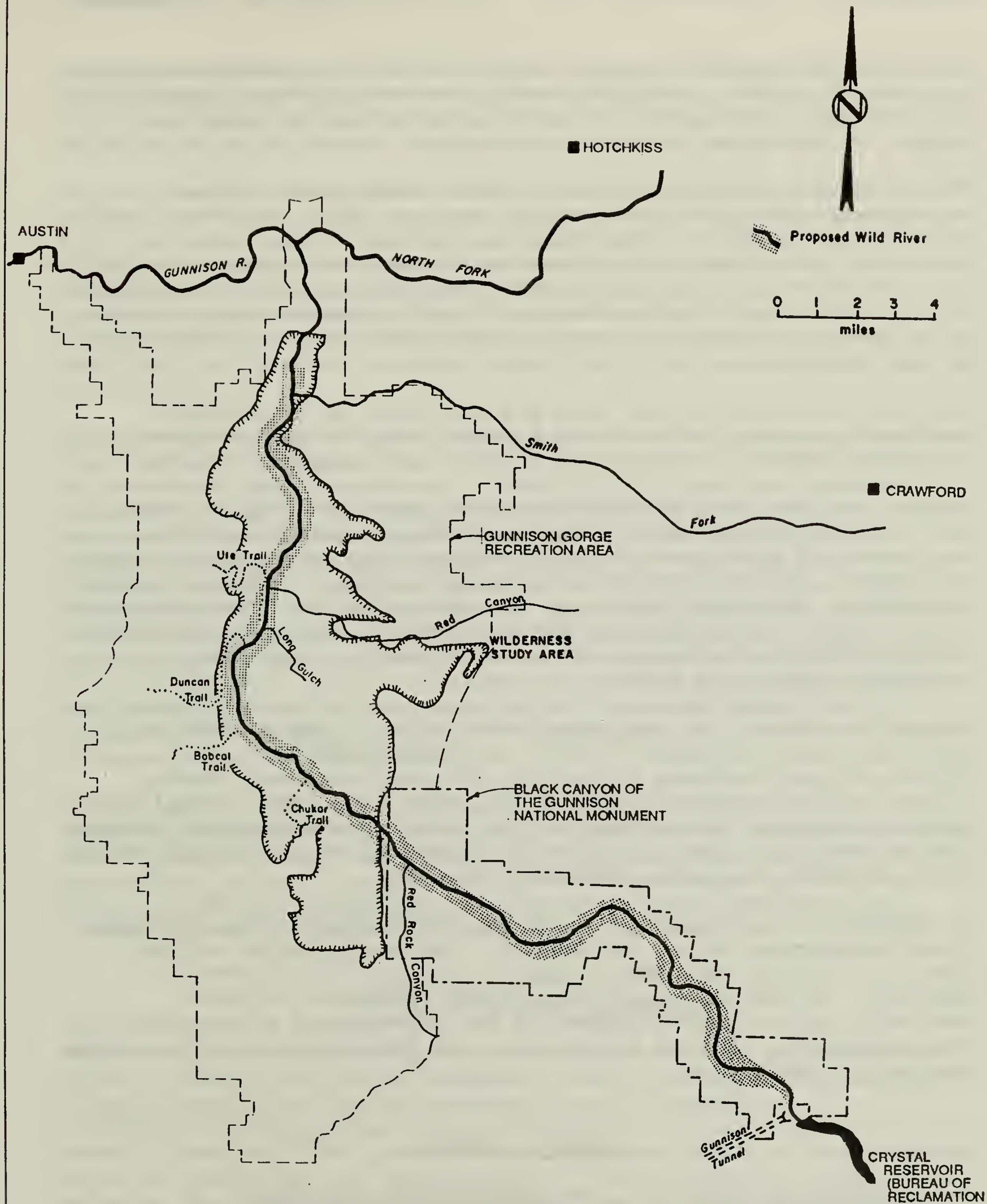


Figure 3.2. Gunnison Gorge area.

pheasant, and Gambel's quail. Waterfowl use the area seasonally and include Canada goose, mallard, green-winged teal, gadwall, and shoveler. Furbearers include beaver, muskrat, gray fox, badger, river otter, and striped skunk.

The Uncompahgre River provides a sport fishery of limited importance due to its dominance by western white, bluehead and flannelmouth suckers. The fishery potential of the river is adversely influenced by high sediment load, low summer flow, and high summer temperatures. However, the Gunnison River supports an excellent trout fishery between Crystal Reservoir and several miles downstream from the river's confluence with the North Fork of the Gunnison.

Cultural resources in the area are reflected by evidence of prehistoric inhabitants of the Archaic Stage through evidence of water development, mining, and agriculture in historic times.

Mining and timbering have occurred in the surrounding mountains, but the Uncompahgre Valley remains primarily agrarian. About two-thirds of Montrose County is national forest or public lands, with about 642,000 acres in private ownership. Of the privately owned land, about 400,000 acres are agricultural. Twenty percent of this area is irrigated by the Uncompahgre Valley Reclamation Project (UVRP). Crops include corn, alfalfa, pinto beans, potatoes, onions and fruit.

Population density in the study area is low. The population of Montrose County is about 25,250, with approximately 10,000 persons residing within the city of Montrose. Delta County, in the northern half of the study area, has a population of about 21,230. Other communities within the study area include Olathe, which is about 11 miles northwest of Montrose, and Delta, which is about 11 miles northwest of Olathe.

In addition to agriculture, tourism and recreation are important local industries during the summer. The Black Canyon of the Gunnison National Monument, which is about 10 miles east of Montrose, is the principal attraction. Montrose is also centrally located with respect to the Uncompahgre Plateau and San Juan Mountains. During the winter, the Telluride ski area brings visitors to Montrose.

General Impacts

As presented in chapter 2, the Bureau of Reclamation (Reclamation) has evaluated four development alternatives in addition to the no-action alternative (alternative A). If no action is taken, conditions in the valley are not expected to change significantly in the foreseeable future. Development of water resources in the Gunnison River drainage, including the Uncompahgre River Basin, would be expected to continue.

Any of the four development alternatives would result in short-term construction-related impacts and long-term operational impacts. Short-term impacts include vegetation clearing, erosion, and construction disturbance, as well as short-term additions to the local economy. Long-term impacts would be related to the decreased flows in the Gunnison River, the increased flows in the Uncompahgre River, and the long-term additions to the local economy resulting from power production at the facility.

The ecology of the Gunnison River has been significantly modified over the last 100 years by the construction of major and minor impoundments and diversions, in addition to land use changes in the river basin. The combination of impoundments and diversions has partially reversed the natural runoff cycles. Highest average flows entering the Black Canyon now occur in the winter, although snowmelt peaks are still observed in the spring (see attachment B). The native fish of the river have been largely replaced by species such as brown and rainbow trout. The existing ecosystem is productive and provides excellent fish and wildlife habitat as well as excellent recreation opportunities. The proposed alternatives would affect this new ecosystem by altering flow regimes, primarily by reducing winter flows, and to a lesser extent summer flows.

The following sections describe the current conditions and the expected impacts to the region if the project is undertaken. The impact analysis has been based upon studies completed as part of this report as well as previous studies conducted by Montrose Partners and the Uncompahgre Valley Water Users Association (UVWUA; hereafter called the Sponsors), Reclamation, or others.

Streamflows and Flooding

Water for the alternatives would be diverted from the Gunnison River, passed through the turbines, and returned to the Gunnison River at Delta via the Uncompahgre River. Under all alternatives, including the no-action alternative, streamflows in these rivers and UVRP canals were determined using a computerized model of the river and canal system. This section describes the existing and post-development streamflows in the Gunnison and Uncompahgre Rivers and assesses the impacts to streamflows.

Derivation of Flow Values

Streamflows in the Gunnison River below the Gunnison Tunnel have been recorded by the U.S. Geological Survey (USGS) since October 1903, and in the Uncompahgre River at Colona since October 1912. These two gauges indicate the quantities of water flowing into the Black Canyon and into the UVRP lands, respectively. Although both gauges have an adequate period of record to estimate the impacts of the proposed development, recent Reclamation impoundments have altered the streamflow regimes in a manner which reduces the value of the recorded data. These impoundments store runoff which occurs in the late spring and early summer for release later in the year. The effect of this action is to change the slope of the flow duration curve by reducing the occurrence of extremely high and low flows and increasing the occurrence of intermediate flows.

The period of study selected for analysis of the proposed development included calendar years 1952 through 1983. This timeframe includes both high and low flow periods and was used by Reclamation for analyses of the Aspinall Unit unrelated to the proposed AB Lateral hydropower development. This same timeframe was used by other governmental entities modeling the Gunnison River flow regimes.

To determine the effects of the proposed alternatives on streamflows, it was necessary to develop estimates of the Gunnison River flows which would have occurred had the Aspinall Unit been in full operation during this timeframe. These estimates were prepared by Reclamation using a computer model which mathematically simulates streamflows in the Gunnison River downstream from Crystal Dam but upstream from the Tunnel. The simulation model was based upon inflows to the Aspinall Unit Reservoirs taken from historical gauge data, where available from the USGS, as well as synthesized data based upon accepted hydrologic practices. Results of the simulation were then compared to the annual volumes recorded by the USGS at the gauge below the Tunnel to ensure that the simulation model yielded reasonable results.

Reclamation's simulation model for the Gunnison River included the current operating rules of the Aspinall Unit. This assumption resulted in eliminating the occurrence of flows less than 300 cubic feet per second (ft^3/s) entering the Black Canyon. Results of the simulation model were then combined with the historical records for Tunnel diversions and canal system diversions to determine the streamflow quantities at various locations within the area affected by the proposed development. A summary of model results is presented in attachment D. A more complete description of this model, together with detailed results of the analyses for the no-action and development alternatives, is presented in the report, AB Lateral Unit Water Supply Study (HDR, 1989).

Streamflow values presented in this report are based upon monthly time increments, which were used to reduce the volume of data required for analysis. Within a given month, the daily flows would fluctuate above and below the average flow for the month depending upon time of year and power releases from the Aspinall Unit. However, in no instance would the daily flows entering the Black Canyon be reduced to values less than 300 ft^3/s for purposes of power production.

Existing Conditions

Gunnison River.--The Gunnison River provides over two-thirds of the water used for irrigation in the UVRP. It originates in Saguache, Hinsdale, and Gunnison Counties to the east of the study area and flows generally north and west, where it joins the Colorado River in Grand Junction. At the Gunnison Tunnel, the river drains an area of about 3,965 square miles. Flows in the river have been recorded by the USGS downstream from the Tunnel since October 1903. The maximum flow recorded at that location was 19,000 ft^3/s, which occurred in June 1921. At several times during the period of record, no flow was observed in the river below the Tunnel; the most recent occurrence of no flow was in September of 1950. Mean monthly flows recorded by the USGS at the gauge below the Tunnel are presented in attachment B.

The effect of the Aspinall Unit Reservoirs on Gunnison River streamflows has been to reduce the occurrence of large peak flows and to reduce the occurrence of occasional low flow periods. These changes can be readily seen in the flow duration curve (see figure 3.3). Because of these flow changes, the actual USGS records were not used for this study. Instead, simulated flows in the river below Crystal Reservoir that incorporate the regulating effects of the Aspinall Unit were developed by Reclamation (see table 3.1).

Tributaries of the river downstream of Crystal Reservoir include the Smith Fork and North Fork of the Gunnison River. The North Fork is the larger of the two. Flows in the North Fork are gauged by the USGS several miles upstream of its confluence with the Gunnison.

Of critical importance to the Gunnison River ecosystem are the flows remaining in the river downstream from the Gunnison Tunnel.

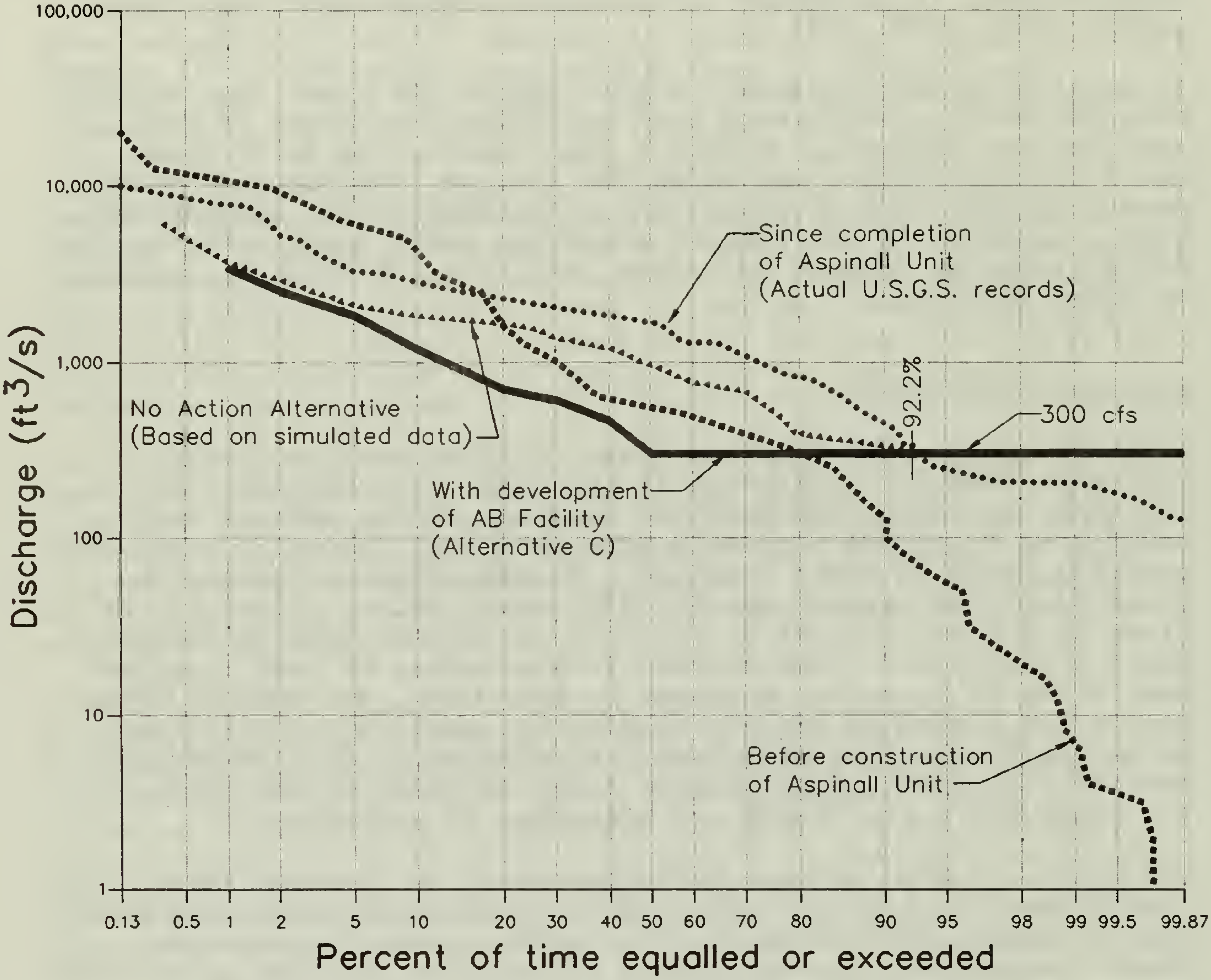


Figure 3.3. Flow duration curve of historic flow data Gunnison River below Gunnison Tunnel for the period 1903 through 1988.

Table 3.1.--Simulated flows in the Gunnison River below Crystal Reservoir (ft^3/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
1952	1,889	2,066	2,210	2,946	3,078	4,561	3,519	1,780	1,700	1,761	1,746	1,466	2,392
1953	1,235	1,178	1,163	1,050	1,535	1,613	1,378	1,754	1,430	1,653	1,339	1,462	1,401
1954	717	448	339	1,023	1,300	1,300	1,300	1,300	1,157	782	333	300	861
1955	652	353	339	1,023	1,300	1,300	1,300	1,300	1,157	782	333	1,036	910
1956	1,130	1,000	907	1,023	1,474	1,407	1,300	1,726	1,157	1,106	1,283	1,417	1,246
1957	2,076	2,236	2,465	2,975	3,195	4,453	6,815	3,052	1,852	1,784	1,771	1,779	2,877
1958	1,862	1,938	2,040	2,460	3,211	4,225	2,047	1,741	1,208	1,516	1,298	1,501	2,086
1959	996	731	521	1,023	1,300	1,300	1,300	1,732	1,157	782	728	1,497	1,092
1960	1,231	1,162	1,148	1,266	1,623	1,564	1,494	1,723	1,244	1,698	1,291	1,396	1,406
1961	953	664	443	1,023	1,300	1,300	1,300	1,736	1,157	782	724	1,618	1,087
1962	1,797	1,880	2,073	2,709	2,651	2,674	3,265	1,730	1,389	1,622	1,192	1,389	2,033
1963	942	680	484	1,023	1,300	1,300	1,300	1,730	1,157	782	333	778	987
1964	1,094	951	814	1,023	1,734	1,393	1,300	1,767	1,163	1,387	1,333	1,458	1,288
1965	1,875	2,053	2,207	2,608	2,787	3,164	4,394	2,378	1,837	1,795	1,765	1,796	2,391
1966	1,335	1,250	1,218	1,024	1,713	1,327	1,300	1,714	1,157	782	961	1,681	1,291
1967	1,000	838	553	1,023	1,300	1,300	1,300	1,725	1,157	782	333	1,595	1,079
1968	1,293	1,251	1,256	1,127	1,676	1,868	1,730	2,035	1,750	1,754	1,745	1,735	1,604
1969	1,758	1,751	1,119	1,560	1,782	1,574	1,558	1,740	1,550	1,611	1,771	1,785	1,629
1970	1,897	1,991	2,205	2,398	2,915	3,298	3,386	1,771	1,808	1,793	1,775	1,790	2,254
1971	1,872	1,921	2,016	2,190	2,010	2,046	2,462	1,735	1,770	1,767	1,677	1,764	1,936
1972	1,151	1,054	1,028	1,023	1,300	1,300	1,300	1,703	1,157	949	1,769	1,543	1,274
1973	1,766	1,755	1,345	1,663	2,059	2,022	2,342	1,768	1,568	1,325	1,755	1,699	1,756
1974	1,216	1,153	1,181	1,135	1,938	1,424	1,359	1,718	1,157	867	1,409	1,725	1,359
1975	1,756	1,751	1,589	1,765	1,964	2,141	3,072	1,828	1,748	1,220	1,508	1,762	1,843
1976	1,107	982	864	1,023	1,300	1,300	1,300	1,726	1,157	782	947	1,410	1,160
1977	606	306	339	1,023	1,300	1,300	1,300	1,300	1,157	782	333	300	840
1978	1,728	1,749	339	1,023	1,533	1,785	1,754	1,735	1,240	1,225	1,393	1,507	1,415
1979	1,753	1,754	1,849	2,138	2,659	2,715	2,861	1,762	1,317	1,339	1,378	1,649	1,933
1980	1,757	1,822	1,909	2,288	2,512	2,570	3,268	1,735	1,157	1,350	1,629	1,684	1,975
1981	1,639	1,207	1,047	1,248	1,282	1,145	1,277	1,277	1,026	1,009	639	689	1,124
1982	805	1,533	1,501	1,202	1,180	1,410	1,604	1,582	1,542	1,513	1,566	1,689	1,426
1983	1,690	1,652	1,391	1,424	1,892	4,554	4,563	2,918	2,033	1,711	1,387	1,789	2,254
Average	1,393	1,346	1,247	1,545	1,878	2,082	2,180	1,788	1,382	1,275	1,233	1,459	1,569
Maximum	2,076	2,236	2,465	2,975	3,211	4,561	6,815	3,052	2,033	1,795	1,775	1,796	2,877
Minimum	606	306	339	1,023	1,180	1,145	1,277	1,277	1,026	782	333	300	840
Std. dev.	433	551	654	669	646	1,074	1,296	375	287	400	508	406	520

Source: Reclamation.

For a few years after the completion of Crystal Reservoir, the Aspinall Unit was operated to provide a minimum instream flow of 200 ft^3/s in the Gunnison River below the Tunnel. However, this value was recently increased to 300 ft^3/s, except during drought periods. This increase was made because of the increased fishery habitat between 200 and 300 ft^3/s. For purposes of this study, the value was always assumed to be 300 ft^3/s for each alternative (no-action and with development). The State of Colorado has not established a minimum flow in the river nor have Federal reserve water rights been quantified. Average monthly flows entering the Black Canyon for the no-action alternative are shown in table 3.2.

Uncompahgre River.--The Uncompahgre River, a major tributary of the Gunnison River, originates in the San Juan Mountains to the south of the study area and flows in a northerly direction to Delta, where it joins the Gunnison River. At Delta, the total drainage area of the river is slightly more than 1,129 square miles. At the USGS gauge near Colona, a small town on the river about five miles upstream from the South Canal confluence, the drainage area is about 443 square miles.

The Uncompahgre River is regulated to some extent by Reclamation at the Ridgway Dam. Simulated monthly flows in the river at Colona, with Ridgway Dam in operation, were developed by Reclamation and are shown in table 3.3.

Returns from irrigation diversions also contribute to the Uncompahgre River. These flows are not monitored or gauged, and it is difficult to estimate their quantity with any accuracy. For purposes of this report, the return flow contribution has been estimated to be 20 ft^3/s between the South Canal outfall and Montrose (Hokit, UVWUA 1988, personal communication).

Principal tributaries to the river within the study area include Horsefly Creek from the west and Dry Cedar and Cedar Creeks from the east. As with return flows, flows from these streams have not been gauged or monitored. Flows in these streams are dependent upon snowmelt and storm runoff during the early spring and carry irrigation return flows during the late summer and early fall. Because these streams flow intermittently, it has been assumed for this report that their contributions would not be available to meet irrigation or power demands.

Presently, streamflows in the Uncompahgre River between the terminus of the South Canal and the City of Delta are affected by irrigation diversions, return flows from irrigation systems, and small tributary drainages. Major irrigation diversions

Table 3.2.--Average monthly flows (ft^3/s) entering the Black Canyon for alternative A (no-action) condition (1952-1983)

Month	Average monthly flows (ft^3/s) Mean monthly	Maximum monthly	Minimum monthly
January	1,382	2,068	598
February	1,337	2,228	300
March	1,180	2,432	300
April	921	2,574	300
May	1,004	2,594	300
June	1,287	3,935	300
July	1,266	6,265	300
August	844	2,248	300
September	579	1,246	300
October	811	1,523	300
November	1,176	1,761	300
December	1,452	1,788	300
Annual average	1,103	2,518	371

Table 3.3.--Simulated flows in the Uncompahgre River below Colona (ft³/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
1952	162	154	127	241	424	846	574	300	245	102	91	81	279
1953	83	73	85	145	267	774	446	205	92	59	87	80	200
1954	73	75	72	96	303	318	330	91	76	75	76	75	139
1955	73	71	80	87	198	571	316	285	49	49	72	78	161
1956	73	71	94	141	389	625	312	143	54	55	74	76	176
1957	78	78	76	89	218	847	1,241	537	290	144	163	151	328
1958	139	144	158	434	947	1,334	537	304	76	59	82	83	358
1959	81	75	76	104	319	654	436	150	59	88	76	75	183
1960	70	71	98	274	381	796	494	241	54	59	76	78	225
1961	80	73	81	119	322	746	459	236	126	143	158	93	220
1962	141	150	162	333	516	462	532	324	76	65	69	67	242
1963	67	71	83	86	330	353	319	197	76	59	76	60	149
1964	68	70	85	114	447	666	519	278	173	68	84	88	223
1965	144	138	156	353	388	542	927	348	278	175	142	145	313
1966	144	132	154	354	403	528	369	185	54	59	66	65	210
1967	67	59	60	89	125	336	369	107	76	59	67	65	124
1968	65	61	75	301	291	564	356	376	240	72	104	80	216
1969	144	145	159	354	385	403	421	206	76	155	164	102	227
1970	141	146	158	327	605	643	532	239	400	210	138	146	308
1971	161	139	154	350	354	566	520	269	220	89	131	75	253
1972	68	76	125	141	283	356	364	146	76	78	97	89	159
1973	160	151	174	368	641	946	745	257	266	140	106	86	337
1974	146	150	195	380	521	452	506	166	84	62	79	75	235
1975	142	78	78	151	335	552	1,395	377	204	59	106	109	301
1976	81	82	89	133	234	476	441	155	72	89	71	81	167
1977	81	76	81	139	182	316	231	81	104	59	74	67	124
1978	72	70	80	129	247	571	555	346	89	65	89	93	201
1979	168	160	216	460	503	600	664	275	248	59	96	130	299
1980	91	85	80	309	397	623	542	194	54	62	79	70	216
1981	67	64	70	136	117	480	527	137	76	59	89	72	158
1982	73	70	86	160	373	545	598	457	334	190	164	138	267
1983	139	140	166	348	565	1,381	1,582	563	262	124	114	109	460
Average	104	100	114	226	375	621	567	255	146	90	99	90	233
Maximum	168	160	216	460	947	1,381	1,582	563	400	210	164	151	460
Minimum	65	59	60	86	117	316	231	81	49	49	66	60	124
Std. dev.	38	37	44	121	166	251	309	119	100	45	31	26	76

Source: Reclamation.

downstream from the South Canal include the Montrose and Delta Canal, the Loutzenhizer Canal and the Selig Canal. (These systems are all part of the UVRP and are described further in chapter 3). Additional UVRP canals located farther downstream include the Ironstone, East and Garnet Canals. Mean monthly flows in the river at five key locations between Colona and the Selig Canal are presented in table 3.4.

Table 3.4.--Average monthly flows (ft^3/s) at various locations along the Uncompahgre River (alternative A)

	Average monthly flows (ft^3/s)				
Month	Below Colona	Below South Canal	Below M & D Canal	Entering City of Montrose	Below Selig Canal
January	104	98	70	58	48
February	100	90	62	50	40
March	114	162	135	123	113
April	226	693	436	392	315
May	375	958	578	491	356
June	621	1,092	627	532	365
July	567	1,152	656	567	419
August	255	871	405	326	212
September	146	700	347	269	184
October	90	421	246	195	149
November	99	139	113	105	95
December	90	80	52	40	30
Average annual	233	540	312	263	195

Periodic floods along the Uncompahgre River have been a problem and have historically disrupted highway and rail traffic and damaged or destroyed irrigation diversion structures and other improvements.

Floods in the Uncompahgre Valley generally result from rapid melting of the mountain snowpack from about the middle of May through early July and from general rainstorms that normally occur from July through October. On the long-term average, rainfall flood events occur less frequently than snowmelt events and do not constitute a serious flood threat. Snowmelt runoff decreases or lessens along the lower Uncompahgre River due to channel storage and the numerous irrigation diversions (Corps of Engineers, 1980).

Snowmelt flooding is characterized by moderate peak flows, large volume, long duration, and marked diurnal fluctuation of flow. Snowmelt runoff may occasionally be augmented by rain. Rainfall flooding is characterized by high peak flows of moderate volume and duration. Flooding is more severe when antecedent rainfall has resulted in saturated ground conditions, or the ground is frozen and infiltration is minimal. Convective-type cloudburst storms, sometimes lasting for several hours, can be expected to occur in the area during the summer. Runoff from these storms is characterized by high peak discharge, short duration and small volume (Corps of Engineers, 1980).

Within the area immediately affected by the development alternatives are several small tributaries to the Uncompahgre River that experience periodic flooding. Several potential penstock routes would cross Cedar Creek and the Montrose Arroyo, a Cedar Creek tributary. Estimated flood discharges in the river, Cedar Creek, and Montrose Arroyo are presented in table 3.5.

Table 3.5.--Peak discharges for area streams (ft^3/s)

		Peak discharges (ft^3/s)			
Stream name	Location	10-yr	50-yr	100-yr	500-yr
Uncompahgre River	(1)	3,100	4,400	5,000	6,600
Cedar Creek	(2)	500	880	1,250	3,200
Montrose Arroyo	(3)	300	800	1,100	2,000

Explanation: (1) At proposed development powerhouse site.
(2) Upstream of confluence with Montrose Arroyo.
(3) Upstream of confluence with Cedar Creek.

Sources: Uncompahgre River: Corps of Engineers, 1980.
Cedar Creek and Montrose Arroyo: Hydro-Triad, 1979.

Impacts of Alternatives

The Sponsors have studied four alternatives for developing the hydropower resources of the UVRP. Alternative A has been defined as the no-action alternative. Alternatives B, C and F would develop a hydropower plant having a design capacity of 1,135 ft^3/s and a minimum flow in the Gunnison River of 300 ft^3/s. Alternative E would develop a hydropower plant having a capacity of 950 ft^3/s. Additionally, alternative C would propose to increase the capacity of the Gunnison Tunnel to 1,300 ft^3/s, and alternative F would provide increased winter flows in the Gunnison River to alleviate ice formation.

Flooding

Alternative A (No Action).--If no action is taken, flood peaks along the Gunnison and Uncompahgre Rivers would not change. However, the operation of Ridgway Reservoir would slightly reduce flood peaks. Historically, the UVWUA has reduced diversions through the Tunnel during Uncompahgre River floods so that less water is passed into the Uncompahgre, an operational rule that would continue if no action is taken.

Development Alternatives (B, C, E, and F).--For each of the development alternatives, flooding conditions on the Gunnison River would not change significantly. As long as concurrent flooding on the Gunnison and Uncompahgre Rivers is not occurring, some additional flows would be diverted through the Tunnel for power production in addition to irrigation. The quantity of additional flows is not large enough to appreciably reduce downstream flood peaks or water surface elevations on the Gunnison.

If concurrent flooding is occurring, the additional flows would not be diverted, and the quantities of water diverted for irrigation and power purposes would be reduced to avoid aggravating flood stages on the Uncompahgre. This reduction would result in the flow continuing through the Gunnison Gorge and into downstream reaches. The amount of flow would not produce appreciable increases in either flood peaks or water surface elevations.

If any of the development alternatives are implemented, each would be operated similarly to the historic operation of the UVRP. River flow at Colona, the South, Montrose and Delta (M&D), and Loutzenhizer Canals would be monitored by the UVWUA. When river flows downstream of the Selig Canal exceed the mean annual flood (1,900 ft^3/s), Gunnison River diversions for power purposes (in excess of irrigation demands) would be reduced until the 1,900 ft^3/s criterion is met. If necessary, diversions for irrigation purposes would also be reduced. The net result would be that operation of the development alternatives would not add to flooding problems on the Uncompahgre River.

In case of a penstock rupture, local flooding would occur but would be quickly controlled by monitoring equipment that would shut down the water supply to the penstock. The entire penstock would contain about 90 acre-feet of water. During the few minutes needed to automatically close the penstock valve at the intake structure, about 10 more acre-feet of water would enter the system. Damage would occur primarily to property adjacent to a penstock rupture; water from a rupture would drain down ditches, washes and drains and ultimately enter Cedar Creek, the Loutzenhizer Canal, or the Loutzenhizer Arroyo.

Gunnison River Streamflows

Alternative A (No Action).--If no action were taken, streamflows in the Gunnison River would remain similar to present conditions. There are potential developments being considered for the Gunnison River, but none of these presently are permitted or under construction. Model results for mean monthly flows entering the Black Canyon during the 32-year study period are presented in table 3.6.

Table 3.6.--Average monthly flows in the Gunnison River entering the Black Canyon for each alternative (ft^3/s).

	Average monthly flows (ft^3/s)				
Month	Alt. A	Alt. B	Alt. C	Alt. E	Alt. F
January	1,382	475	471	561	511
February	1,337	499	495	582	534
March	1,180	500	497	568	500
April	921	628	577	642	628
May	1,004	794	694	794	794
June	1,287	1,001	915	1,001	1,001
July	1,266	1,104	1,021	1,104	1,104
August	844	671	527	671	671
September	579	405	353	405	405
October	811	404	348	414	404
November	1,176	406	403	497	406
December	1,452	455	450	601	455
Average	1,103	613	563	654	619
Annual volume (acre-ft)	798,214	443,612	407,729	472,054	447,786

Development Alternatives.--In terms of Gunnison River streamflows, the primary long-term impact of all development alternatives would be to reduce the amount of water flowing downstream of the Gunnison Tunnel. Average monthly flows below the Tunnel for the various development alternatives are summarized in table 3.6, and model results are presented in tables 3.7 through 3.11. As can be seen from this information, the major changes occur during the nonirrigation season because, under existing conditions, Gunnison Tunnel capacity is being used to divert irrigation water, and little tunnel capacity remains for additional hydropower diversions.

None of the development alternatives would change the operations of the Aspinall Unit; releases from and water elevations of Blue Mesa Reservoir would not be affected. Water would not be released from the Aspinall Unit specifically for the hydropower development. Because the proposed development would not increase the consumptive use of water within the Uncompahgre Valley, this water is ultimately returned to the Gunnison River at Delta via the Uncompahgre River. Hence, the increased diversions would not result in any net depletion of water from the Colorado River system.

Under all development alternatives, the amount of water diverted from the Gunnison River is increased, reducing the quantity of flow entering the Black Canyon. During the winter, the volume diverted increases dramatically, whereas during the summer, the incremental flow diverted for power production is relatively small. Table 3.12 compares the flow diverted at the Tunnel for each development alternative to the no-action alternative; the mean monthly flows shown for alternative A represent the volumes diverted to meet the irrigation demands in the UVRP. The difference between these flows and those shown for the remaining alternatives represent the additional water diverted for hydropower generation.

Uncompahgre River Streamflows

Alternative A (No Action).--Mean monthly flows along the Uncompahgre River would be similar to those presented in table 3.4. River flows would not be altered, and irrigation diversions would not be significantly increased or decreased. Winter diversions for livestock watering would be reduced as Reclamation's Lower Gunnison Basin Unit Winter Water Replacement Program (part of the Colorado River Water Quality Improvement Program) is implemented. This reduction of diversions would also occur under development alternatives.

Table 3.7.--Flows entering the Black Canyon in ft³/s for Alternative A--no-action conditions

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual avg.
1952	1,881	2,058	2,184	2,574	2,225	3,876	2,489	763	788	1,032	1,427	1,458	1,892
1953	1,227	1,170	1,045	480	614	721	372	755	455	1,093	1,204	1,454	882
1954	709	440	300	300	336	342	342	364	514	398	300	300	387
1955	644	345	305	537	380	430	338	356	302	318	300	1,028	442
1956	1,122	992	860	388	540	559	481	891	300	600	1,262	1,409	784
1957	2,068	2,228	2,432	2,494	2,555	3,935	6,265	2,248	1,162	1,309	1,695	1,771	2,518
1958	1,854	1,930	2,032	1,997	2,594	3,631	1,077	847	354	979	1,144	1,493	1,657
1959	988	723	407	300	349	392	346	793	332	510	644	1,489	607
1960	1,223	1,154	1,140	958	698	799	537	782	362	1,165	1,201	1,388	950
1961	945	656	416	571	437	410	349	799	473	682	716	1,610	674
1962	1,789	1,872	2,033	2,058	1,695	1,759	2,329	761	553	1,280	1,070	1,381	1,548
1963	934	672	476	300	339	339	337	791	493	300	300	770	504
1964	1,086	943	760	424	884	527	330	817	375	822	1,150	1,450	798
1965	1,867	2,045	2,199	2,195	1,945	2,495	3,709	1,486	1,246	1,523	1,733	1,788	2,020
1966	1,327	1,242	1,127	300	739	389	355	750	300	436	953	1,673	799
1967	992	830	436	300	371	469	346	791	305	300	325	1,587	588
1968	1,285	1,243	1,113	311	726	1,274	773	1,254	830	1,228	1,737	1,727	1,125
1969	1,750	1,743	1,042	809	817	688	611	777	809	1,343	1,759	1,777	1,157
1970	1,889	1,983	2,187	1,713	2,124	2,475	2,428	820	1,067	1,423	1,705	1,782	1,799
1971	1,864	1,913	1,966	1,364	1,047	1,225	1,545	779	976	1,321	1,669	1,756	1,450
1972	1,143	1,046	804	300	335	358	332	744	333	531	1,761	1,535	767
1973	1,758	1,747	1,331	1,159	1,474	1,517	1,550	779	655	773	1,747	1,691	1,346
1974	1,208	1,145	1,173	592	1,023	478	376	740	300	300	1,401	1,717	871
1975	1,748	1,743	1,564	1,103	1,046	1,602	2,331	853	838	550	1,469	1,754	1,382
1976	1,099	974	771	300	322	320	310	731	300	300	939	1,402	647
1977	598	300	300	300	303	314	309	373	656	379	315	300	371
1978	1,720	1,741	300	300	733	1,103	816	717	385	698	1,306	1,499	938
1979	1,745	1,746	1,834	1,819	1,967	2,191	1,957	744	403	725	1,270	1,641	1,502
1980	1,749	1,814	1,870	1,589	1,628	1,629	2,227	681	300	890	1,621	1,676	1,472
1981	1,631	1,199	700	323	300	300	300	300	336	450	585	681	589
1982	687	1,514	1,403	488	452	727	689	666	898	1,189	1,558	1,681	993
1983	1,682	1,644	1,265	834	1,115	3,915	3,942	2,064	1,131	1,098	1,379	1,781	1,822
Average	1,382	1,337	1,180	921	1,004	1,287	1,266	844	579	811	1,176	1,452	1,103
Maximum	2,068	2,228	2,432	2,574	2,594	3,935	6,265	2,248	1,246	1,523	1,761	1,788	2,518
Minimum	598	300	300	300	300	300	300	300	300	300	300	300	371
Std. dev.	438	551	672	740	718	1,172	1,382	410	300	394	501	405	542

Source: HDR, 1989.

Table 3.8.--Flows entering the Black Canyon in ft³/s for Alternative B--
1,135 ft³/s turbine capacity, no Tunnel modifications

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual avg.
1952	754	931	1,075	1,811	1,943	3,426	2,384	645	565	626	611	331	1,257
1953	300	300	300	300	400	478	300	619	300	518	300	327	371
1954	300	300	331	300	300	300	300	300	300	300	325	300	305
1955	300	345	331	300	300	300	300	300	300	300	325	300	308
1956	300	300	300	300	339	300	300	591	300	300	300	300	328
1957	941	1,101	1,330	1,840	2,060	3,318	5,680	1,917	717	649	636	644	1,742
1958	727	803	905	1,325	2,076	3,090	912	606	300	381	300	366	981
1959	300	300	300	300	300	300	300	597	300	300	300	362	330
1960	300	300	300	300	488	429	359	588	300	563	300	300	378
1961	300	300	300	300	300	300	300	601	300	300	300	483	341
1962	662	745	938	1,574	1,516	1,539	2,130	595	300	487	300	300	925
1963	300	300	300	300	300	300	300	595	300	300	325	300	327
1964	300	300	300	300	599	300	300	632	300	300	300	323	356
1965	740	918	1,072	1,473	1,652	2,029	3,259	1,243	702	660	630	661	1,256
1966	300	300	300	300	578	300	300	579	300	300	300	546	368
1967	300	300	300	300	300	300	300	590	300	300	325	460	340
1968	300	300	300	300	541	733	595	900	615	619	610	600	536
1969	623	616	300	425	647	439	423	605	415	476	636	650	521
1970	762	856	1,070	1,263	1,780	2,163	2,251	636	673	658	640	655	1,119
1971	737	786	881	1,055	875	911	1,327	600	635	632	542	629	801
1972	300	300	300	300	300	300	300	568	300	300	634	408	359
1973	631	620	300	528	924	887	1,207	633	433	300	620	564	638
1974	300	300	300	300	803	300	300	583	300	300	300	590	391
1975	621	616	454	630	829	1,006	1,937	693	613	300	373	627	727
1976	300	300	300	300	300	300	300	591	300	300	300	300	325
1977	300	300	331	300	300	300	300	300	300	300	325	300	305
1978	593	614	331	300	398	650	619	600	300	300	300	372	447
1979	618	619	714	1,003	1,524	1,580	1,726	627	300	300	300	514	821
1980	622	687	774	1,153	1,377	1,435	2,133	600	300	300	494	549	870
1981	504	300	300	300	300	300	300	300	300	300	300	300	317
1982	300	398	366	300	300	300	469	447	407	378	431	554	388
1983	555	517	300	300	757	3,419	3,428	1,783	898	576	300	654	1,128
Average	475	499	500	628	794	1,001	1,104	671	405	404	406	455	613
Maximum	941	1,101	1,330	1,840	2,076	3,426	5,680	1,917	898	660	640	661	1,742
Minimum	300	300	300	300	300	300	300	300	300	300	300	300	305
Std. dev.	202	245	317	513	600	1,035	1,255	354	170	142	142	142	373

Source: HDR, 1989.

Table 3.9.--Flows entering the Black Canyon in ft³/s for Alternative C-- 1,135 ft³/s turbine capacity and 1,300 ft³/s Tunnel capacity

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual avg.
1952	746	923	1,067	1,710	1,778	3,261	2,219	480	400	461	603	323	1,163
1953	300	300	300	300	300	313	300	454	300	353	300	319	320
1954	300	300	331	300	300	300	300	300	300	300	325	300	305
1955	300	345	331	300	300	300	300	300	300	300	325	300	308
1956	300	300	300	300	300	300	300	426	300	300	300	300	311
1957	933	1,093	1,322	1,675	1,895	3,153	5,515	1,752	552	500	628	636	1,644
1958	719	795	897	1,197	1,911	2,925	747	441	300	300	300	358	905
1959	300	300	300	300	300	300	300	432	300	300	300	354	316
1960	300	300	300	300	323	300	300	423	300	398	300	300	321
1961	300	300	300	300	300	300	300	436	300	300	300	475	326
1962	654	737	930	1,409	1,351	1,374	1,965	430	300	322	300	300	840
1963	300	300	300	300	300	300	300	430	300	300	325	300	313
1964	300	300	300	300	434	300	300	467	300	300	300	315	327
1965	732	910	1,064	1,377	1,487	1,864	3,094	1,078	537	552	622	653	1,167
1966	300	300	300	300	413	300	300	414	300	300	300	538	339
1967	300	300	300	300	300	300	300	425	300	300	325	452	326
1968	300	300	300	300	376	568	430	735	450	454	602	592	451
1969	615	608	300	300	482	300	300	440	300	377	628	642	440
1970	754	848	1,062	1,127	1,615	1,998	2,086	471	508	552	632	647	1,026
1971	729	778	873	890	710	746	1,162	435	470	467	534	621	701
1972	300	300	300	300	300	300	300	403	300	300	626	400	344
1973	623	612	300	417	759	722	1,042	468	300	300	612	556	559
1974	300	300	300	300	638	300	300	418	300	300	300	582	363
1975	613	608	446	465	664	841	1,772	528	448	300	365	619	641
1976	300	300	300	300	300	300	300	426	300	300	300	300	311
1977	300	300	331	300	300	300	300	300	300	300	325	300	305
1978	585	606	331	300	300	485	454	435	300	300	300	364	395
1979	610	611	706	891	1,359	1,415	1,561	462	300	300	300	506	753
1980	614	679	766	1,006	1,212	1,270	1,968	435	300	300	486	541	799
1981	496	300	300	300	300	300	300	300	300	300	300	300	317
1982	300	390	358	300	300	300	304	300	300	300	423	546	343
1983	547	509	300	300	592	3,254	3,263	1,618	733	411	300	646	1,043
Average	471	495	497	577	694	915	1,021	527	353	348	403	450	563
Maximum	933	1,093	1,322	1,710	1,911	3,261	5,515	1,752	733	552	632	653	1,644
Minimum	300	300	300	300	300	300	300	300	300	300	300	300	305
Std. dev.	198	241	313	459	549	981	1,203	335	105	81	138	140	345

Source: HDR, 1989.

Table 3.10.--Flows entering the Black Canyon in ft³/s, for Alternative E--
950 ft³/s turbine capacity, no Tunnel modifications

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual avg.
1952	931	1,108	1,252	1,895	1,943	3,426	2,384	645	565	626	788	508	1,338
1953	300	300	300	300	400	478	300	619	300	518	381	504	393
1954	300	300	331	300	300	300	300	300	300	300	325	300	305
1955	300	345	331	300	300	300	300	300	300	300	325	300	308
1956	300	300	300	300	339	300	300	591	300	300	325	459	344
1957	1,118	1,278	1,507	1,840	2,060	3,318	5,680	1,917	717	685	813	821	1,819
1958	904	980	1,082	1,382	2,076	3,090	912	606	300	381	340	543	1,048
1959	300	300	300	300	300	300	300	597	300	300	300	539	346
1960	300	300	300	300	488	429	359	588	300	563	333	438	393
1961	300	300	300	300	300	300	300	601	300	300	300	660	356
1962	839	922	1,115	1,574	1,516	1,539	2,130	595	300	487	300	431	980
1963	300	300	300	300	300	300	300	595	300	300	325	300	327
1964	300	300	300	300	599	300	300	632	300	300	375	500	377
1965	917	1,095	1,249	1,562	1,652	2,029	3,259	1,243	702	737	807	838	1,344
1966	377	300	300	300	578	300	300	579	300	300	300	723	390
1967	300	300	300	300	300	300	300	590	300	300	325	637	355
1968	335	300	300	300	541	733	595	900	615	619	787	777	569
1969	800	793	300	425	647	439	423	605	415	562	813	827	586
1970	939	1,033	1,247	1,312	1,780	2,163	2,251	636	673	737	817	832	1,203
1971	914	963	1,058	1,055	875	911	1,327	600	635	632	719	806	874
1972	300	300	300	300	300	300	300	568	300	300	811	585	389
1973	808	797	387	602	924	887	1,207	633	433	300	797	741	709
1974	300	300	300	300	803	300	300	583	300	300	451	767	419
1975	798	793	631	630	829	1,006	1,937	693	613	300	550	804	800
1976	300	300	300	300	300	300	300	591	300	300	300	452	338
1977	300	300	331	300	300	300	300	300	300	300	325	300	305
1978	770	791	331	300	398	650	619	600	300	300	435	549	502
1979	795	796	891	1,076	1,524	1,580	1,726	627	300	300	420	691	895
1980	799	864	951	1,191	1,377	1,435	2,133	600	300	300	671	726	947
1981	681	300	300	300	300	300	300	300	300	300	300	300	332
1982	300	575	543	300	300	300	469	447	407	422	608	731	450
1983	732	694	433	300	757	3,419	3,428	1,783	898	576	429	831	1,193
Average	561	582	568	642	794	1,001	1,104	671	405	414	497	601	654
Maximum	1,118	1,278	1,507	1,895	2,076	3,426	5,680	1,917	898	737	817	838	1,819
Minimum	300	300	300	300	300	300	300	300	300	300	300	300	305
Std. dev.	285	326	389	532	600	1,035	1,255	354	170	156	209	186	398

Source: HDR, 1989.

Table 3.11.--Flows entering the Black Canyon in ft³/s for Alternative F--1,135 ft³/s turbine capacity, no Tunnell modifications, with de-icing flows

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual avg.
1952	754	931	1,075	1,811	1,943	3,426	2,384	645	565	626	611	331	1,257
1953	368	375	300	300	400	478	300	619	300	518	300	327	383
1954	368	375	331	300	300	300	300	300	300	300	325	300	316
1955	368	345	331	300	300	300	300	300	300	300	325	300	314
1956	368	375	300	300	339	300	300	591	300	300	300	300	340
1957	941	1,101	1,330	1,840	2,060	3,318	5,680	1,917	717	649	636	644	1,742
1958	727	803	905	1,325	2,076	3,090	912	606	300	381	300	366	981
1959	368	375	300	300	300	300	300	597	300	300	300	362	342
1960	368	375	300	300	488	429	359	588	300	563	300	300	390
1961	368	375	300	300	300	300	300	601	300	300	300	483	353
1962	662	745	938	1,574	1,516	1,539	2,130	595	300	487	300	300	925
1963	368	375	300	300	300	300	300	595	300	300	325	300	339
1964	368	375	300	300	599	300	300	632	300	300	300	323	367
1965	740	918	1,072	1,473	1,652	2,029	3,259	1,243	702	660	630	661	1,256
1966	368	375	300	300	578	300	300	579	300	300	300	546	380
1967	368	375	300	300	300	300	300	590	300	300	325	460	352
1968	368	375	300	300	541	733	595	900	615	619	610	600	548
1969	623	616	300	425	647	439	423	605	415	476	636	650	521
1970	762	856	1,070	1,263	1,780	2,163	2,251	636	673	658	640	655	1,119
1971	737	786	881	1,055	875	911	1,327	600	635	632	542	629	801
1972	368	375	300	300	300	300	300	568	300	300	634	408	371
1973	631	620	300	528	924	887	1,207	633	433	300	620	564	638
1974	368	375	300	300	803	300	300	583	300	300	300	590	403
1975	621	616	454	630	829	1,006	1,937	693	613	300	373	627	727
1976	368	375	300	300	300	300	300	591	300	300	300	300	336
1977	368	300	331	300	300	300	300	300	300	300	325	300	310
1978	593	614	331	300	398	650	619	600	300	300	300	372	447
1979	618	619	714	1,003	1,524	1,580	1,726	627	300	300	300	514	821
1980	622	687	774	1,153	1,377	1,435	2,133	600	300	300	494	549	870
1981	504	375	300	300	300	300	300	300	300	300	300	300	323
1982	368	398	366	300	300	300	469	447	407	378	431	554	393
1983	555	517	300	300	757	3,419	3,428	1,783	898	576	300	654	1,128
Average	511	534	500	628	794	1,001	1,104	671	405	404	406	455	619
Maximum	941	1,101	1,330	1,840	2,076	3,426	5,680	1,917	898	660	640	661	1,742
Minimum	368	300	300	300	300	300	300	300	300	300	300	300	310
Std. dev.	170	217	317	513	600	1,035	1,255	354	170	142	142	142	369

Source: HDR, 1989.

Table 3.12.--Comparison of average monthly tunnel diversions for alternatives (ft^3/s)

	Average monthly tunnel diversion for all alternatives (ft^3/s)				
Month	Alt. A	Alt. B	Alt. C	Alt. E	Alt. F
January	11	918	922	832	882
February	8	847	850	764	811
March	66	747	750	679	747
April	624	918	968	903	918
May	875	1,084	1,185	1,084	1,084
June	795	1,081	1,167	1,081	1,081
July	914	1,075	1,158	1,075	1,075
August	944	1,117	1,261	1,117	1,117
September	803	976	1,029	976	976
October	464	871	926	861	871
November	56	827	830	736	827
December	8	1,004	1,010	858	1,004
Average annual	467	956	1,007	915	951
	Annual volumes (acre-feet) diverted for alternatives				
Use	Alt. A	Alt. B	Alt. C	Alt. E	Alt. F
Irrigation	337,824	337,824	337,824	337,824	337,824
Power	0	354,602	390,485	324,679	350,429

Development Alternatives.--On the Uncompahgre River, none of the proposed development alternatives would affect streamflows above the South Canal terminus. However, between that location and the Selig Canal, the amount of water flowing in the river would be reduced. Historically, the irrigation demands for the Selig, Ironstone, East and Garnet Canals flowed into the Uncompahgre River and through Montrose via the South Canal. Because each of the development alternatives would divert water for canal demands through the turbines, this reach of the Uncompahgre River is bypassed. Mean monthly river flows for each development alternative are compared to the no-action alternative at three locations along this reach in tables 3.13 through 3.15.

Between the Selig Canal and Delta, streamflows in the Uncompahgre River would be increased as a result of any of the development alternatives; the amount of increase would vary according to the alternative. Alternative E would result in the least amount of increased flows, and alternative C would result in the greatest increase. Mean monthly flows for each alternative are compared to the no-action alternative in table 3.16.

Table 3.13.--Comparison of average monthly flows in the Uncompahgre River below the South Canal for each alternative (ft³/s)

Month	Average monthly flows (ft³/s)				
	Alt. A	Alt. B	Alt. C	Alt. E	Alt. F
January	98	94	94	94	94
February	90	90	90	90	90
March	162	104	104	104	104
April	693	368	368	368	368
May	958	581	581	581	581
June	1,092	695	695	695	695
July	1,152	698	698	698	698
August	871	581	581	581	589
September	700	455	455	455	463
October	421	249	249	249	249
November	139	91	91	91	91
December	80	80	80	80	80
Average annual	540	342	342	342	343

Table 3.14.--Comparison of average monthly flows in the Uncompahgre River below the M&D Canal for each alternative (ft³/s)

Month	Average monthly flows (ft³/s)				
	Alt. A	Alt. B	Alt. C	Alt. E	Alt. F
January	70	66	66	66	66
February	62	62	62	62	62
March	135	76	76	76	76
April	436	111	111	111	111
May	578	201	201	201	201
June	627	231	231	231	231
July	656	202	202	202	202
August	405	114	114	114	122
September	347	103	103	103	111
October	246	75	75	75	75
November	113	65	65	65	65
December	52	52	52	52	52
Average annual	312	113	113	113	115

Table 3.15.--Comparison of average monthly flows in the Uncompahgre River entering Montrose for each alternative (ft^3/s)

Month	Average monthly flows (ft^3/s)				
	Alt. A	Alt. B	Alt. C	Alt. E	Alt. F
January	58	54	54	54	54
February	50	50	50	50	50
March	123	64	64	64	64
April	392	68	68	68	68
May	491	114	114	114	114
June	532	135	135	135	135
July	567	113	113	113	113
August	326	35	35	35	43
September	269	25	25	25	33
October	195	24	24	24	24
November	105	57	57	57	57
December	40	40	40	40	40
Average annual	263	65	65	65	67

Table 3.16.--Comparison of average monthly flows in the Uncompahgre River below the Selig Canal for each alternative (ft^3/s)

Month	Average monthly flows (ft^3/s)				
	Alt. A	Alt. B	Alt. C	Alt. E	Alt. F
January	48	955	959	868	919
February	40	879	882	796	843
March	113	793	796	725	793
April	315	609	660	595	609
May	356	566	666	566	566
June	365	651	737	651	651
July	419	581	664	581	581
August	212	385	529	385	385
September	184	358	410	358	358
October	149	556	612	546	556
November	95	866	869	775	866
December	30	1,026	1,032	881	1,026
Average annual	195	684	735	643	679

The decreased flows in the Gunnison River, coupled with increased flows in the Uncompahgre resulting from implementing any of the alternatives, would affect several components of the regional ecosystem. These components include water quality, fisheries, vegetation, wildlife, and the recreational use of both streams. Consequences of implementing any of the proposed development alternatives are described in the following sections of this chapter.

Irrigation Systems

The UVRP, one of the oldest irrigation projects in the United States, was one of the first projects built under the authority of the Reclamation Act of 1902. Over 80,000 acres of irrigated land are included within its boundaries (see figure 1.1). Water supplies are diverted from the Gunnison and Uncompahgre Rivers at seven diversion dams and conveyed to irrigated fields through several hundred miles of canals, laterals and drains. Waters diverted but not consumed are returned to the Uncompahgre and Gunnison Rivers. The UVRP is operated and administered by the UVWUA; project features are owned by Reclamation. This section describes the major canals that would be affected by the proposed alternatives.

Existing Conditions

South Canal.--The South Canal, the principal conveyance for transporting flows from the Gunnison River into the Uncompahgre River, begins at the West Portal of the Tunnel and runs southwesterly about 11.4 miles to the Uncompahgre River. The canal has a maximum carrying capacity of about 1,010 ft^3/s at the upper end; however, the capacity is reduced to slightly more than 800 ft^3/s near the river.

Flows in the canal are monitored by the UVWUA at a gauging station located about one mile downstream of the West Portal. Two major diversions are made from the South Canal upstream of the gauging station. Flows are diverted into the existing AB Lateral about one-quarter mile downstream from the Tunnel portal. This lateral is a small, unlined channel that flows in a northerly direction about five miles, where it discharges into the Loutzenhizer Wash. The lateral provides irrigation water to about 4,000 acres along the east edge of the UVRP.

Additional flows are diverted from the AB Lateral into the Cedar Creek wasteway, actually Cedar Creek, a small tributary of the Uncompahgre River. The purpose of this diversion is to convey additional flows into the Uncompahgre River to meet irrigation demands downstream of the Selig Canal as well as the demands from irrigators diverting from Cedar Creek itself. For this study, it was estimated that an average of 5 ft^3/s of the flows diverted into Cedar Creek are needed to meet existing water rights along that stream.

Historically, the average annual demands (see table 3.17) placed by the UVRP canal systems have been met through a combination of sources, including Gunnison River diversions, natural flows of the Uncompahgre River, and return flows from upstream irrigation systems. Because of capacity restrictions in the South Canal, these demands have not always been fulfilled. The Cedar Creek diversion was started to provide capacity for additional flows but has not always been able to provide enough water, even when combined with South Canal flows. When shortages have occurred, diversions into the M&D, Loutzenhizer, and Selig Canals have been proportionately reduced to deliver flows to the Ironstone, East and Garnet systems.

Table 3.17.--Mean monthly diversions into UVRP Canals (ft^3/s)

	Average monthly diversions (ft^3/s)					
Month	Existing AB Lateral	Cedar Creek	West Canal	M&D Canal	Loutz. Canal	Selig Canal
January	0	0	10	28	12	10
February	0	0	10	28	12	10
March	0	0	10	28	12	10
April	23	13	84	266	58	90
May	46	31	129	427	102	166
June	51	28	134	459	115	192
July	52	33	131	459	114	178
August	51	36	128	429	104	147
September	46	27	118	337	93	109
October	29	14	86	179	63	60
November	0	0	10	28	12	10
December	0	0	10	28	12	10
Average	25	15	72	226	59	83
Annual volume (acre-ft)	18,112	11,077	52,172	163,326	42,925	60,081

Flows are carried from the South Canal into the West Canal, described in subsequent sections. Other diversions are made into smaller laterals (designated as the AC, AG, AH and AM) that irrigate about 3,000 acres near the canal. These diversions are recorded, although long-term records are not available. Estimates of flow diverted into these laterals were made using 6 years of ditchrider records provided by the UVWUA.

Added to these flows are estimates of losses due to seepage and evaporation from the South Canal (assumed to be equal to the lateral demands) and estimates of diversions made for the Project 7 Water Treatment facility. For the latter quantity, an average diversion of 5,757 acre-feet per year was assumed for this study. Table 3.18 summarizes the diversions made from the South Canal assumed for this study.

Table 3.18.--South Canal lateral diversions (ft^3/s)

	Diversions (ft^3/s)					
Year	April	May	June	July	August	September
1976	10	21	36	42	48	19
1980	5	33	36	39	39	21
1983	12	31	45	43	42	23
1985	5	34	37	39	38	21
1986	5	32	35	38	36	19
1987	6	33	38	37	33	16
Average	7	31	38	40	40	20

Note: Values do not include flows diverted into AB Lateral or Cedar Creek for irrigation.

West Canal.--The West Canal, built in 1912 as part of the UVRP, is supplied by the South Canal and conveys irrigation flows to about 5,700 acres on the west side of the Uncompahgre River. The canal is about 21 miles long and is generally unlined, although small portions of its length are lined with a trapezoidal concrete section. Flows are recorded by the UVWUA. Maximum mean monthly diversions range from 170 to 180 ft^3/s; mean monthly diversions are shown in table 3.17.

The canal is also used to supply winter stock water to UVWUA members. These supplies are generally provided directly from the

Uncompahgre River, rather than the South Canal, using a temporary diversion dam upstream of the South Canal. The UVWUA does not record quantities diverted for this use. For this study, it was estimated that a monthly average of 10 ft^3/s was representative (Jim Hokit, UVWUA, 1988; personal communication).

Montrose and Delta Canal.--The Montrose and Delta (M&D) Canal was privately built but acquired as part of the UVRP in 1908. The canal is about 40 miles long and diverts flows from the Uncompahgre River to over 25,200 acres along the west side of the valley. The entire length of the canal is unlined, and the canal section is generally 26 feet wide by 5 feet deep.

Maximum flows into the system generally range between 550 and 560 ft^3/s, with the majority of diversions occurring in the irrigation season. Approximately 60 percent of these diversions is flow diverted from the Gunnison River via the South Canal and 40 percent Uncompahgre River water. However, only Uncompahgre River flows are diverted into the system during the winter. Generally, these flows are not recorded but have been estimated by the UVWUA's General Manager to range between 25 and 35 ft^3/s. An average winter flow diversion of 28 ft^3/s was used for this report (see table 3.17).

Loutzenhizer Canal.--The Loutzenhizer Canal diverts water out of the Uncompahgre River at headgates about two miles downstream from the M&D headgates. The canal is nearly 15 miles long and was privately built before the turn of the 20th century. It was acquired by Reclamation for the UVRP in 1908.

The canal serves about 6,200 acres on the east side of the valley near Montrose. It is unlined and has a maximum bottom width of about 16 feet. As with the M&D, the majority of diversions occur during the irrigation season, using waters provided from the Uncompahgre and Gunnison Rivers. Winter diversions normally range from 10 to 15 ft^3/s, with flows provided solely by the Uncompahgre River. For this report, the winter stockwater diversions were estimated to be 12 ft^3/s. Mean monthly diversions for the canal are shown in table 3.17.

Selig Canal.--The Selig Canal irrigates nearly 10,000 acres on the east side of the valley north of Montrose. The canal diverts water from the Uncompahgre at headgates just north of Montrose and runs about 20 miles to the north toward Olathe and Delta. The canal was privately constructed but acquired by Reclamation in 1914. The canal is unlined; although it has a maximum diversion capacity of 320 ft^3/s, its maximum historic diversions have ranged of 190 to 200 ft^3/s. Winter diversions vary between 10 and 15 ft^3/s. For this report, the winter diversions were estimated to be 10 ft^3/s.

Other Canal Systems.--The UVWUA also operates three other canal systems in the valley that divert flow from the Uncompahgre River downstream from the Selig Canal headgates. These systems are the Ironstone Canal, which irrigates over 22,500 acres; the East Canal (7,660 acres); and the Garnet Canal (1,600 acres). The maximum diversion capacities at the headgates of these canal systems are 400, 165, and 75 ft^3/s, respectively (Reclamation, 1984).

In addition to the UVRP canals, several diversions occur upstream of and within the study area. Between the town of Colona and the South Canal, irrigation diversions are made at the Ouray and Reservation Ditches. Between the South Canal and Selig Canal, irrigation diversions are made into the Stark Volkmann, Woodgate-Calloway, Val Verde, and Rice Ditches. Table 3.19 lists the assumed amount of diversions occurring throughout the irrigation season.

Table 3.19.--Assumed diversion patterns of non-UVRP demands between Colona and Selig Canal (ft^3/s)

	Diversion patterns (ft^3/s)					
Location	April	May	June	July	Aug	Sept
Between Colona and South Canal	5	23	28	30	30	15
Between South and Selig Canals	8	33	41	43	43	21

An additional water-righted demand is listed for the CUEA's Bullock Station, although this plant has not operated for several years. However, it was included in table 3.14 (and the alternatives analysis) because the water right has not been abandoned. The assumed diversions in table 3.19 include a small portion of the total right for this plant.

There are several irrigation diversions on the Gunnison River downstream from the North Fork confluence that serve farms and orchards in Delta County. In addition, the North Fork of the Gunnison upstream from the confluence is heavily used for irrigation.

Impacts of Alternatives

Alternative A (No Action).--If no action is taken, operation of the irrigation system would continue as it has in the past. No changes would occur in the average diversions made into the various canals. Winter stockwater diversions from the Uncompahgre River are planned to be replaced by supplies from domestic water lines under the plans for the Lower Gunnison Basin Unit.

Development Alternatives.--Implementing any of the development alternatives would not affect the amount of water supplied for domestic purposes or to any of the irrigation laterals or canals operated by the UVWUA. Irrigation demands would have the highest priority and would not be reduced to increase or maintain power production. Irrigation demands made by non-UVRP systems would not be affected by any of the development alternatives. Water would be diverted to these systems in accordance with Colorado water law.

Flows that have historically been diverted through Cedar Creek would be diverted through the penstock for each of the development alternatives. However, adequate flows would be diverted into this stream to meet all water-righted demands that list this stream as their source of supply.

The diversion headgates of the Ironstone, East and Garnet systems are located downstream of the proposed development. Thus, upstream changes would not affect their water supply. Additional bank erosion in the Uncompahgre River could deposit materials behind the diversion dams and in the canals; thus, the proposed bank stabilization program would be necessary to mitigate this problem.

With any of the development alternatives, flows in the Uncompahgre River entering Montrose would be adequate to meet the water rights of the Bullock Station if operations at this plant are restored. The reduced streamflows would not affect the existing limits and conditions in the discharge permit for the Bullock Station (Colorado Department of Health, 1989). With the development alternatives, water supplies for the M&D and Loutzenhizer Canals would include a larger percentage of Uncompahgre River water. The source of flows would affect water quality considerations. For all development alternatives, diversion demands for these two canals would be met as much as possible from the available supplies in the Uncompahgre River. When the Uncompahgre flows are not sufficient to meet canal demands, Gunnison flows would be conveyed to the systems via the South Canal as they have been historically.

For no-action conditions, about 59 percent of the average annual flow in the Uncompahgre River just below the South Canal terminus comes from the Gunnison River and the remaining 41 percent comes from the Uncompahgre. For all development alternatives, only about 35 percent of the average annual river flow upstream from Montrose would be derived from water imported from the Gunnison. Month-by-month ratios of the Gunnison and Uncompahgre mixtures for no-action and with development alternatives are presented in table 3.20. The implications of these ratios are discussed in the water quality section.

Table 3.20.--Comparison of Gunnison River flow to total river flow (ft^3/s) in the Uncompahgre River at the South Canal terminus[1]

	No action flow (ft^3/s)			With development flow (ft^3/s)		
Month	Gunnison River water entering from canal	Total river	Percent from Gunnison	Gunnison River water entering from canal	Total river	Percent from Gunnison
January	3	98	3	0	94	0
February	0	90	0	0	90	0
March	58	162	36	0	104	0
April	466	693	67	142	368	39
May	601	958	63	223	581	38
June	494	1,092	45	97	695	14
July	609	1,152	53	155	698	22
August	641	871	74	350	581	60
September	564	700	81	320	455	70
October	327	421	78	155	249	62
November	48	139	35		91	0
December	0	80	0	0	80	0
Annual average	319	540	59	121	342	35

[1] This water makes up the irrigation supply for the M&D and Loutzenhizer Canals.

Irrigation diversions downstream from the North Fork confluence should not be adversely affected and would continue to operate in accordance with their water rights. Most developed irrigation rights in the area are senior to the hydropower rights. The water quality for these diversions would decline as discussed later in this chapter. The total dissolved solids (TDS) would increase as less high quality Gunnison River water would be present to dilute flows in the North Fork.

River Mechanics

Existing Conditions

Gunnison River.--Between Crystal Dam and the confluence of the North Fork (see figure 3.2), the Gunnison River is deeply incised into the Precambrian schists and gneisses of the Black Canyon Formation except for two short reaches. From Long Gulch to Red Canyon, the east wall of the canyon is made up of the softer Cretaceous sedimentary rocks. At the Smith Fork confluence, the Precambrian rocks dip downward and the Gunnison River flows in a wider canyon formed in the Cretaceous Morrison Formation (lowest formation), the Dakota Sandstones (intermediate formation) and Mancos Shale (highest formation).

In the less erosive Precambrian sections, the Gunnison River Canyon is very narrow at river level. Even at a flow of 350 ft^3/s, the river floods the canyon from wall to wall in many places. Where the canyon walls do not restrict the river, the bed width is as much as 200 feet. The river bed is primarily cobbles ranging from 2.5 inches to 10 inches in diameter. These cobbles rarely move, and then only short distances during large floods. Because of the upstream reservoirs, very little sediment is transported through the river between Crystal Reservoir and the Smith Fork.

In the very narrow sections, the vertical rock walls make up the banks. In the steep rapids, one bank is rock and the other is boulders. Where alluvial banks form in slack water areas, the banks are usually only two to three feet high.

Below the North Fork, the river flows westerly toward Delta. In the upper half of this reach, the river has incised its way through the Cretaceous sedimentary rocks in a canyon in a series of sharp, nearly right angle bends. The valley and channel sinuosity is 1.4 (sinuousity is the ratio of the actual length of a river reach to the straight-line distance between the beginning and end of the reach). Downstream, the valley walls fall away, leaving the river in a broad valley. In this reach, the river has chosen a somewhat braided pattern, the sinuosity being 1.17. The valley floor slopes steeply toward a narrow belt in which the river runs. Within this one-half mile belt, the river has moved laterally rather freely.

In the canyon reaches below the North Fork, the river width ranges from about 120 to over 400 feet. The widest parts have islands or large middle bars, and the narrowest sections occur at bends. In the broad valley downstream from the canyon, the average width is about 350 feet but varies from 200 to 1,000 feet.

As in the reaches above the North Fork, the river bed is primarily comprised of well-rounded platy cobbles. The banks are primarily alluvial, but in places, the river flows against the Mancos Shale.

The cobbles on the bed of this section of the river rarely move, except for short distances during large floods. The sands and gravels move on the bed and are suspended during spring runoff and during high flow. The sediment moving through the reach is supplied from the North Fork, other small tributaries, and from eroding banks. The local streams draining the Mancos Shale bring in mostly clay with their infrequent runoff. Almost all of this fine sediment is carried through directly to the Colorado River. The sediment load from both the North Fork and the Gunnison River above the North Fork is not large (Stevens, 1988).

Uncompahgre River.--Between the South Canal terminus and the City of Delta, the Uncompahgre River flows through a broad valley cut into the Mancos Shale by a geologically earlier and much larger river. Overall, the sinuosity of the present channel is estimated to be 1.25. As wide as one mile, the valley bottom is made up of alluvium. Near Montrose, there is a deposit of Wisconsin glacial outwash.

Much of this section of the Uncompahgre River is very unstable (Stevens, 1988, and Soil Conservation Service (SCS), 1988). However, a few sections have been protected by the UVWUA, the Colorado Department of Highways, and others. There are meander scrolls, oxbow lakes, abandoned and active side channels, braided sections, meandering reaches and manmade cutoffs. The river varies in width from 60 feet in the stable sections to as much as 450 feet in some parts of the unstable sections.

The channel bed consists of rounded, platy, small-to-medium cobbles; coarse, rounded gravel; and a few boulders. In the stable sections, the banks are approximately 6 feet high and consist of cobbles, gravel and sandy material. In other sections, the river is eroding the high bank but is not carrying enough sediment material to build a new bank on the opposite side. Instead, vegetation has encroached, leaving a poorly defined, very low bank. Near homes, bridges and other structures, one or both banks are protected with large sandstone boulders hauled in and dumped as riprap. Riprap levees have been built under bridges to direct flood waters. At some bends, gravel and riprap levees have been constructed to protect adjacent property.

The river transports all sizes of sediment from clays only microns in diameter to medium cobbles 6 inches in diameter. Almost all the clay and sand particles move through the reach, spending only a short time on the channel bed. The gravels and cobbles move primarily along the bed and are deposited upstream from diversion dams and in the first reaches of the irrigation canals. Ridgway Reservoir is expected to trap a large amount of the sediment derived from the upper basin.

Impacts of Alternatives--Gunnison River

Alternative A (No Action).--If no action were to occur, conditions in the river would continue as they have since completion of the Aspinall Unit. Sediment transport would be minimal, and small amounts of bank erosion would occur below the North Fork. Developments in the North Fork catchment are having, or will have, their effect below the confluence. For example, Reclamation's Paonia Reservoir captures spring snowmelt, reducing some flood peaks. Overall, the Gunnison River between the North Fork and Delta will gradually become narrower and more stable due to the effect of these developments.

Development Alternatives.--Stevens (1988) reported on the effect of the development alternatives to the morphology of the Gunnison River downstream from the Gunnison Tunnel. With development, the morphology of the river would not change. The reduced flows would increase exposure of the river bed between the Tunnel and the North Fork confluence, which would encourage growth of riparian vegetation. However, this vegetation would be scoured away during periodic flood events, which would be largely unaffected by development. After high flow periods, the river would appear the same as without development.

The small quantities of sediment contributed by local tributaries within the Monument would not be affected by development. These sediment loads would occur during high runoff conditions in the tributary. Depending upon flow conditions in the mainstem of the river, these sediments may or may not be moved downstream. If low flow conditions exist, the sediments would be deposited near the confluence of the tributary with the mainstem. However, it would subsequently be moved downstream during flood events on the mainstem.

In the reach between the North Fork and the river's confluence with the Uncompahgre River at Delta, the channel is more susceptible to morphological changes. Erosion in this area would be reduced with development because the volume of flow would be reduced by increased Tunnel diversions.

In the reach between the North Fork and Delta, impacts to the Gunnison River resulting from increased diversions are reduced by the inflows of water from the North Fork. However, the Gunnison River is more susceptible to change downstream from the North Fork than upstream.

The flow diversions to the proposed development would result in more of the bed of the section between the North Fork and Delta being exposed for longer periods. The invasion of riparian vegetation onto exposed bars would rapidly follow, but no significant change would occur in the amount or type of sediment supplied to the reach. The new river morphology would be the result of the balance between the invasion of riparian vegetation during low flows and the scouring and removal of this vegetation during floods. As the large floods are not affected by the proposed development, the net result would be the same as for the river upstream from the North Fork, i.e., more vegetation during low flows and no changes after large floods.

The overall effect of any of the proposed development alternatives would be to increase the stability of the Gunnison River below the North Fork.

<u>Impacts of Alternatives--Uncompahgre River</u>

<u>Alternative A (No Action)</u>.--If no action were to occur, the impact of Ridgway Reservoir would be to produce a more stable, slightly narrower river in the reaches between the dam and the study area. The sediment supply would be less, as the reservoir would trap much of the sediment from the upper catchment and the imported Gunnison River water is relatively free of sediment. Within the study area, bank erosion would continue to persist, requiring periodic activities (during or after flood events) to protect channel banks in critical urban and rural areas. These

activities are expected to consist of the construction of rock jetties and hard points, with occasional installation of riprap over channel banks. Significant amounts of channel bed degradation are not expected to occur within the reach between the South Canal outfall and the City of Delta.

If no action is taken, the Uncompahgre River between the Selig Canal and the City of Delta would continue to erode its banks. However, the rate of erosion would be less than it has been in the past due to the completion of Ridgway Dam.

Development Alternatives.--The stabilizing effect of Ridgway Reservoir would occur and, in addition, all development alternatives would decrease the amount of water in the river between the South Canal terminus and the proposed tailrace. As a result, bank erosion in this reach would decrease or cease altogether in some places. Flows would tend to meander more around the existing bars and islands. The sediment supply would be reduced. The river bed would remain stable as the flows are too small to move the cobbles. The scouring potential would be slightly decreased, so more vegetation would accumulate in the river bottom, trapping the finer sediments and slowly building up new banks.

Between the South Canal and the AB Lateral tailrace, the combined impact of the development alternatives and Ridgway Reservoir over the long term would be to produce a more stable, slightly narrower, more sinuous river. The decrease in width would be approximately 25 percent.

Implementing the proposed alternatives would greatly increase the volume of water in the river between the proposed tailrace and the City of Delta. Because the sediment transport is related to discharge, the mean annual discharge can be used as a qualitative indicator of the amount of increased erosion.

Comparison is made for the average annual river discharge below the tailrace for each alternative in table 3.21.

Initially, the river would become more unstable as a result of the increased flows, with severe lateral erosion on the outside of river bends not now protected. From Table 3.21, it is seen that the amount of erosion would be less for alternative E than for the other alternatives. Over time, the rate of erosion would diminish, but erosion would not completely cease. No significant change would be expected in the river bed. The cobbles in the bed are stable, moved only by large floods.

Table 3.21.--Comparison of average annual flows (ft^3/s) in Uncompahgre River below tailrace for each alternative

Alternative	Mean annual discharge below tailrace (ft^3/s)	Ratio of discharge to no-action discharge[1]
B	685	3.513
C	735	3.769
E	633	3.246
F	679	3.482

[1] Under the no-action alternative, the mean annual discharge below the tailrace would be 195 ft^3/s.

Initially, the river would tend to widen as a result of the bank erosion. Some old bars would be enlarged, and new bars would be created from the sediment eroded from the banks. Riparian vegetation would encroach into abandoned sections of the bed during lower flows but would be flushed downstream during periodic natural flooding events. Over the long run, the river corridor would be enlarged.

Below the proposed tailrace, bank erosion in the Uncompahgre River is expected to increase under all development alternatives. The affected reach is approximately 27.7 miles long. The UVWUA, the Colorado Department of Highways, and private citizens have stabilized about 7.2 miles of this reach; the majority of this work has been near existing bridges and canal diversion dams, although some work has been done in other areas of the river. If the increased erosion would be unchecked, loss of agricultural land and riparian habitat along the present bank location would be expected. Material removed from these areas would be deposited in slow-moving channel reaches downstream from the eroded area, such as near irrigation canal headgates. This material could also be transported into the canals (Ironstone, Garnet, and East) and result in increased operation costs to the UVWUA.

The impacts of increased erosion would be mitigated by the Sponsors' program to stabilize the river where needed before development and to monitor river changes during plant operation. Funding of this program would be derived from initial development capital and from sales of project power. The program would consist of several components. During facility design, the

Sponsors would conduct detailed aerial surveys of the river to establish its present course and to identify critical zones where bank erosion would cause detrimental impacts; for example, bridges, roadways and railroads, irrigation diversion structures, sewage treatment facilities, homes and commercial buildings, and other structures.

If bank protective measures exist near these structures, their ability to withstand the increased flows from the development would be evaluated and, if necessary, additional measures would be designed to prevent additional erosion. If bank protective measures do not exist near these structures, the erosion potential would be determined and, if needed, protective measures would be designed. During this design stage, the Sponsors would prepare and apply for the necessary State and Federal permits.

During construction of the power facilities, bank stabilization measures would be constructed. It is estimated that up to 70,000 linear feet of channel bank could be protected during this phase of the program, which represents approximately 24 percent of the streambanks between Montrose and Delta. Cost of these measures would be included in the initial financing for the development.

Channel protection measures would include channel clearing, channel straightening (in limited areas), rock jetties, riffle ponds to direct flow away from the banks, hard points, revetment works, and bank riprap (see figure 2.8). The Sponsors would coordinate the design efforts of these measures with the Colorado Division of Wildlife (CDOW), the Fish and Wildlife Service (FWS), and local landowners to stabilize the banks as well as to protect the quality of riparian and aquatic habitat along the river. Further coordination would be done with the Corps of Engineers (COE) and Reclamation. The Sponsors would work with these agencies to avoid or minimize impacts to wetlands areas and to aid in creating new wetlands near the river channel. Impacts to riparian vegetation would be mitigated by the Sponsors as part of the wetland mitigation plan.

After commencing plant operations, the Sponsors would continue to monitor the river, implementing additional bank protection as needed. A sinking fund would be established to cover the costs of additional protection. A fixed amount of money derived from project revenues would be deposited annually into such a fund. The fund would then be tapped as needed, with periodic adjustments made to the annual deposit as operational experience is gained. The initial level of funding would be set upon conclusion of pre-project mitigation work, in consultation with Reclamation and the COE.

Water Temperature

Although temperature is usually considered to be a water quality criterion, it is discussed apart from other water quality considerations in this section. The remaining water quality issues such as water chemistry and dissolved oxygen are discussed later.

Existing Conditions

Water temperature plays an important role in biological activity in the Gunnison River. In the summer, water temperature affects the amount of dissolved oxygen present in the river, which in turn affects the fishery. The metabolism, growth, and production of fishes, especially cold water species such as trout, are also affected by high water temperatures. In the winter, if water temperatures become too cold, ice forms. If this ice were to completely cover the river, species using the river during the winter months could be affected. These species include river otters, eagles, and waterfowl. Ice covers, if they occur, would have little direct effect on the fishery of the river. Ice jams, however, can cause scouring of the bed of a river.

Summer Conditions.--Water temperatures in the Gunnison River between Crystal Reservoir and the confluence with the North Fork of the Gunnison River are largely a function of the temperature of releases made from Crystal Reservoir. A substantial amount of historical water temperature data is available for the Gunnison River below Crystal Reservoir and at the North Fork confluence. The USGS maintains a gauging station just downstream from the East Portal of the Gunnison Tunnel that gathers both streamflow and water quality data. Temperature data collected at this station from 1980 through 1986 are summarized in table 3.22. The minimum and maximum measured water temperatures at the East Portal of the Gunnison Tunnel between 1980 and 1986 were 1.5 °C (34.7 °F) on February 4, 1982, and 14.5 °C (58.1 °F) on August 5, 1981, September 16, 1983, and September 14, 1984. Water temperature during the summer is generally highest at the East Portal during August when flows are lowest.

During the summer of 1988, Reclamation, the FWS, and the CDOW collected daily temperature data at various locations along the Gunnison River between the East Portal and the City of Delta. Maximum temperature data are summarized in table 3.23. River flows during this period generally ranged between 330 and 400 ft^3/s.

Table 3.22.--Water temperature statistics for the Gunnison River at USGS Station below East Tunnel Portal (1980 - 1986)

Water temperatures	°C
Average temperature	8.8
Maximum temperature	14.5
Minimum temperature	1.5
Median temperature	10.0
Standard deviation	4.0

Source: USGS (1987).

Table 3.23.-- Maximum water temperatures (°C) observed on the Gunnison River (1988)

Location/Agency	Date	Daily average (maximums,°C)[1]	7-day average (maximums,°C)[1]
Gunnison Tunnel	June 29	10.0	9.8
(FWS)	July 5,6,7	10.0	9.9
Duncan-Ute Trail	July 8	15.3	14.8
(CDOW)	July 14	15.2	15.0
	July 30	15.2	15.0
	August 14	15.3	15.0
Above North Fork	June 22	18.9	-NA[2]-
confluence	June 23	18.4	-NA-
(Reclamation)	June 24	18.3	-NA-
	July 9	18.3	17.4
Above North Fork	June 22	18.5	16.9
confluence	June 23	18.8	17.3
(FWS)	June 24	19.0	17.7
	July 9	18.5	18.1
Austin	June 22	21.5	-NA-
(Reclamation)	July 31	21.7	20.7
	August 3	21.4	20.8
	August 4	21.1	20.9
Below Delta	June 22	21.3	19.3
(FWS)	June 23	21.3	19.7
	June 24	21.5	20.3
	July 2	21.0	20.6

[1] Daily averages and 7-day averages are the maximum values recorded during 1988.

[2] -NA- implies initiation of data sampling occurred less than 7 days before date indicated; hence, 7-day averages are not available.

As can be seen from table 3.23, maximum temperatures near the Ute-Duncan Trail remained below 15.5 °C (59.9 °F) and below 19 °C (66.2 °F) above the North Fork confluence.

Maximum summer water temperature between the North Fork and Delta has periodically exceeded 20 °C (68 °F). Water temperature data collected by the USGS at its Gunnison River station near Delta indicated a maximum water temperature of 22 °C (71.6 °F) on June 29, 1981. Low flows characterized the year 1981, as indicated by a June mean monthly flow of 234 ft^3/s at the East Portal gauging station. North Fork flows were also low during 1981.

Additional water temperature data were collected near Austin and at Delta during the summer of 1988. River flows during the sampling period were generally lower than historic averages.

These data indicated a maximum daily average temperature of 21.7 °C (71.1 °F) near Austin which occurred on July 31. Maximum instan- taneous temperature recorded also occurred on July 31 and was 24.8 °C (76.6 °F). Water temperatures more than 20 °C (68 °F) are not uncommon during low flow years. Nehring (1982) reported water temperatures during 1981 exceeding 20 °C (68 °F) near Delta during much of July and August. Bio/West, Inc. (1981) confirmed Nehring's observations, reporting afternoon river temperatures near Delta of 22 to 23 °C (71.6-73.4 °F) during June through August 1981.

Winter Conditions.--Winter water temperatures on the Gunnison at the East Portal gauging station are similarly a function of the temperature of water released from Crystal Reservoir. Under typical conditions, water leaves the reservoir at temperatures from 2° to 5 °C (35.6° to 41.0 °F) during the winter. Because of the variation in flows and ambient temperature, the location of 0 °C water and the formation of ice have historically migrated longitudinally within the river. Based on model studies performed by Ashton (1987 and 1988), the location of 0 °C water or ice formation fluctuates from below Delta upstream to an area beyond the North Fork confluence during extreme cold spells (see figure 3.4).

Ashton's work is based on an assumed 2 °C water temperature for releases from Crystal Reservoir. Observations in January 1988 showed actual Crystal release temperatures between 1 ° and 3 °C as measured 1 mile downstream from the dam. The approach used by Ashton consisted of dividing the Gunnison into four reaches, calculating the area exposed to the atmosphere in each reach, and balancing the energy contained in the release flow against the heat loss from the water surface. Ashton's work showed that ice

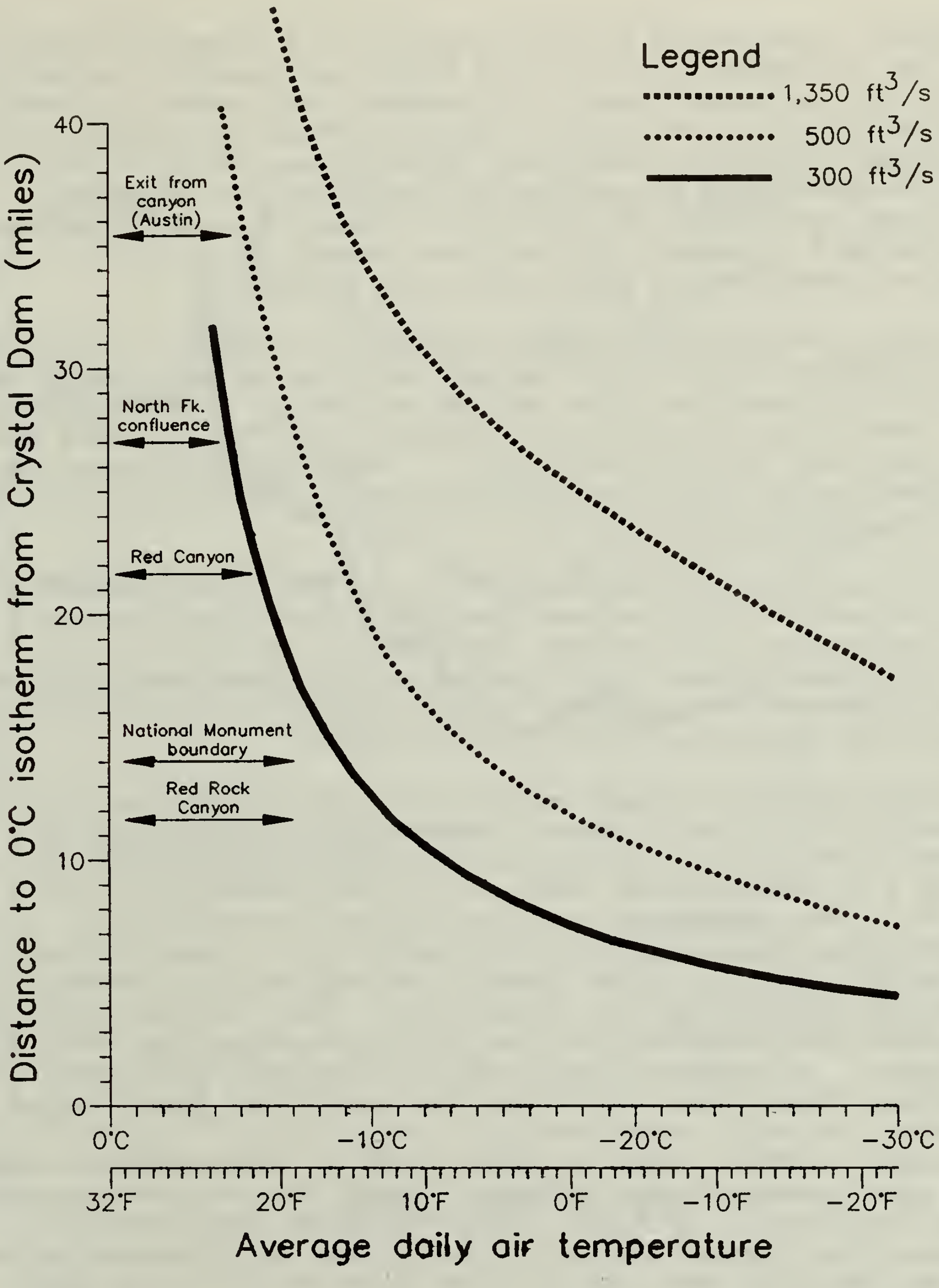


Figure 3.4. Theoretical location of the 0°C isotherm on the Gunnison River (Ashton, 1987).

formation, represented by the location of 0 °C water combined with very low air temperatures, would begin upstream of the North Fork under low flow conditions. For example, at a mean air temperature of -10 °C (14 °F), the 0° isotherm would be located 34 miles downstream of Crystal Reservoir for a flow of 1,350 ft^3/s, 19 miles downstream for a flow of 500 ft^3/s, and 12 miles downstream for a flow of 300 ft^3/s. These distances represent the location of 0 °C water, not the development of an intact ice formation covering the river from bank to bank.

In slightly supercooled waters, minute ice crystals called frazil ice can adhere to the river bottom and form anchor ice or form clusters or floes that rise to the surface as floating frazil ice. Frazil ice forms in open reaches of a fast-flowing river after the water has cooled to 0 °C. Under certain conditions, an ice cover builds from the floating frazil ice and may bridge the river completely (Ashton, 1986).

Ashton's mathematical models (1987 and 1988) were formulated to show the relationship between the approximate location of 0 °C water downstream from Crystal Reservoir in relation to flow. However, these curves do not represent the relative upstream edge of an ice cover. Thus, Ashton also modeled two scenarios to predict the location of the ice cover edge.

The first scenario assumed minimum flow releases from Crystal Reservoir (300 ft^3/s), a water temperature of 1.5 °C (34.7 °F) for releases from the reservoir and the average of morning and evening air temperatures taken at Crystal Reservoir (-7.8 °C or 17.8 °F). The results of this simulation indicate that, at minimum river flows and very cold ambient air temperatures, the theoretical location of an intact ice edge would fluctuate between Red Canyon and the North Fork. Under these conditions and a flow of 500 ft^3/s, the ice edge approached the North Fork confluence. At higher flows, the ice edge was considerably downstream regardless of the weather conditions (see figure 3.5).

The second modeled scenario represented an average-case scenario based upon average water releases. Data for the average-case winter consisted of a 2.5 °C (36.5 °F) water temperature for releases from Crystal Reservoir and actual air temperature data from the Redlands Mesa Agricultural Station (28 °F average) located about 5 miles to the north of the North Fork confluence. Ice cover usually develops downstream from Delta. Figure 3.6 shows the predicted location of the upstream edge of the ice cover during a typical winter at various flows. During a typical winter, the model predicts that the ice cover could approach but would not move upstream of the North Fork confluence even at

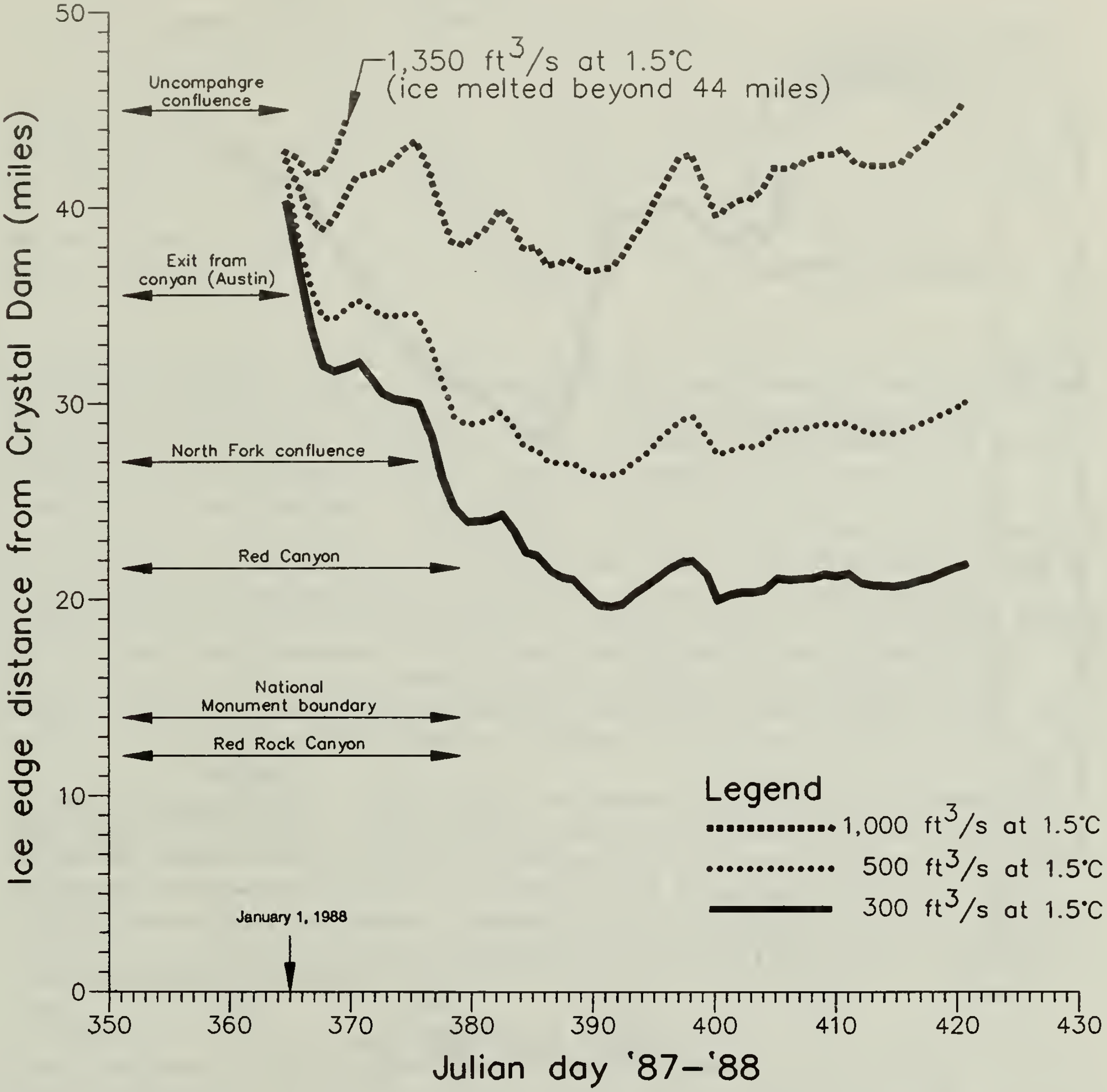


Figure 3.5. Modeled location of ice edge under extreme conditions on the Gunnison River (Ashton, 1987).

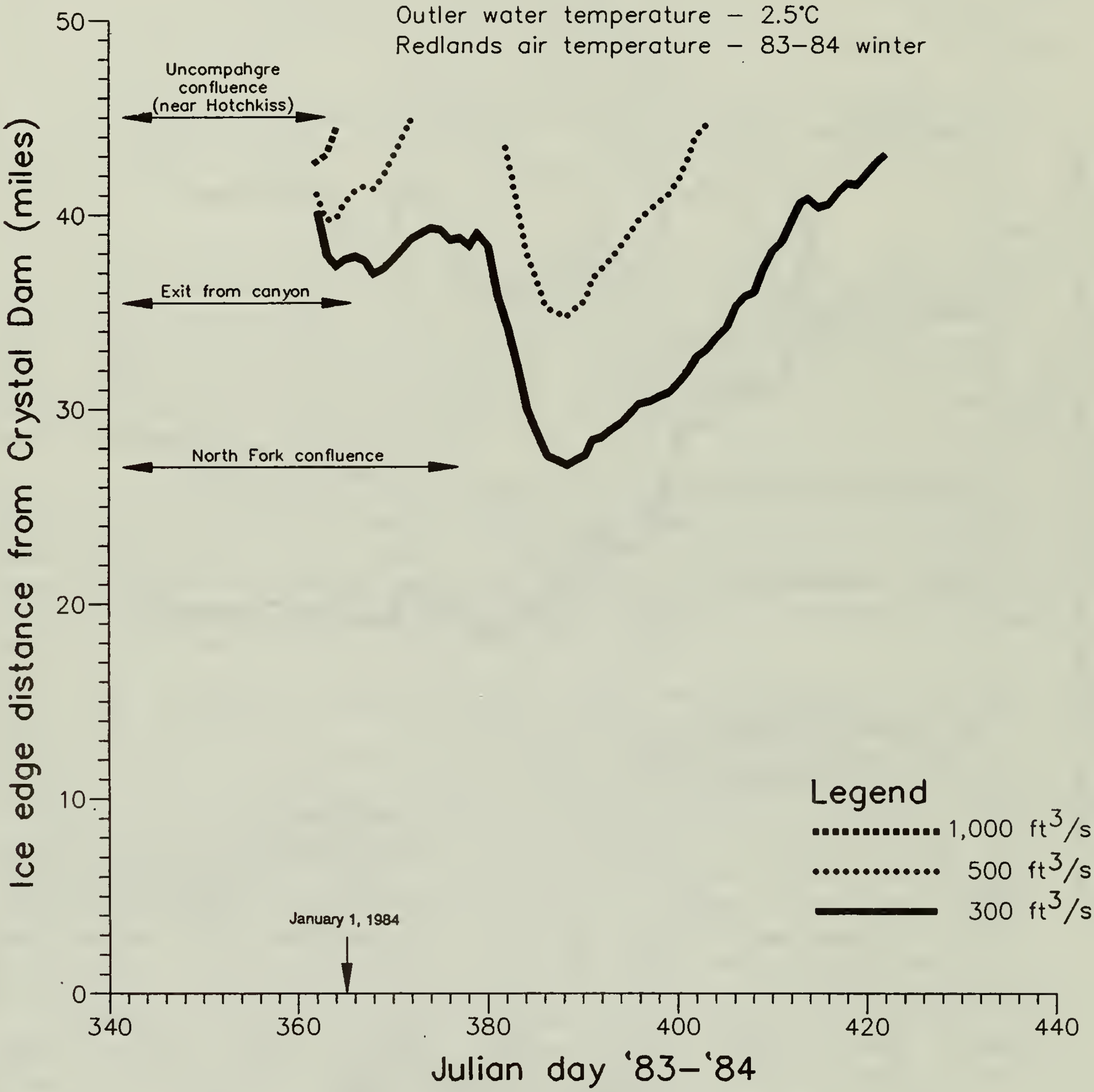


Figure 3.6. Modeled location of ice edge under average conditions on the Gunnison River (Ashton, 1987).

300 ft^3/s. At 500 ft^3/s, the ice edge is predicted to occur at the downstream edge of the Canyon.

From January 20 to 21, 1988, Reclamation performed a field test to determine the location of ice formation in the Gunnison River under reduced flow from Crystal Reservoir. Releases from the reservoir were reduced from 1,300 ft^3/s to 500 ft^3/s. Minimum air temperatures at Crystal Dam ranged from -22.2 °C to -8.9 °C (-8 °F to +16 °F), while highs ranged from -5.6 °C to -2.2 °C (22° to 28 °F). Minimum air temperatures near the North Fork confluence ranged from -17.8 °C to -6.7 °C (0° to 20 °F). Temperature of water released from Crystal Reservoir ranged from 1 °C to 2 °C (34 °F to 35 °F).

During the test, 1 to 2 feet of bank ice formed along the edge of the Gunnison River above the North Fork, and some floating slush ice was observed in the open water. Sheet ice formed around exposed rocks in the channel. Small amounts of frazil ice began forming in the slower water along the banks, but none was observed in midchannel where water velocities were estimated at 2 to 3 feet per second. By midday, nearly all floating slush ice and anchor ice were gone. During the test, the Gunnison River at Austin (10 miles downstream from the North Fork confluence) contained increased bank ice and a large amount of floating slush ice in the open channel. The ice development was greatest at Delta where sheet ice formed around obstructions and on calm water. Under similar temperature conditions and river flows of 1,300 ft^3/s, ice was not observed above the North Fork.

During the winter of 1988-1989, releases from Crystal Reservoir were below 350 ft^3/s. Ice conditions were monitored during the period between Christmas and February 28, a period that included unusually cold conditions. As measured at the Gunnison Tunnel, Crystal Reservoir releases ranged from 2.5 °C (36.5 °F) to 0.4 °C (32.7 °F). During most of January and all of February, releases were below 2.0 °C (35.6 °F).

Surface ice bridged approximately 10 percent (2.5 miles) of the river between Crystal Reservoir and the North Fork. Frazil ice began forming in the river within the Black Canyon of the Gunnison National Monument, and anchor ice occurred as far upstream as the monument. Anchor ice formed in riffles and runs at night and usually disappeared by noon. Shore (bank) ice occurred along the length of the river. Floating ice was common. These observations generally agree with Ashton's models (1987 and 1988) that predicted 0 °C water temperatures to occur in the upper reaches of the Black Canyon of the Gunnison National Monument under certain temperature and flow conditions.

Downstream from the North Fork, similar conditions occurred, although two extensive areas of surface ice bridges occurred -- one just upstream from the Relief Canal Diversion Dam (between Austin and the North Fork confluence) and one upstream from the Hartland Diversion Dam (approximately 2 miles upstream from Delta). Floating frazil ice added to these and created an extensive ice jam above the Hartland Diversion. This jam caused the river to rise and fall approximately 3 to 5 feet and appeared to result in ice scouring of the channel.

Uncompahgre River

Temperature data collected by the USGS at the Colona and Delta gauging stations indicate maximum summer temperatures of 20 °C (68 °F) on August 31, 1983, and 24 °C (75.2 °F) on July 10, 1986, respectively. Winter icing on the Uncompahgre River is common because of the low winter flows. Temperature statistics at the two gauges are presented in table 3.24.

Table 3.24.--Water temperature statistics for Uncompahgre River at USGS Stations near Colona and Delta for the period 1980-1986

Statistic	Colona °C	Delta °C
Average temperature	9.8	12.6
Maximum temperature	20.0	32.0
Minimum temperature	0.0	0.0
Median temperature	10.0	7.5
Standard deviation	5.4	6.9

Source: USGS (1987).

Impacts of Alternatives--Gunnison River

Alternative A (No Action).--If no development is undertaken, no significant change from historic conditions in temperature patterns and seasonal flow variations along the river would be expected. Icing conditions would occur but would be uncommon.

Development Alternatives, Summer Conditions.--Implementation of any of the development alternatives would reduce the flow in the river during the summer. The amount of reduction would vary depending upon the alternative selected, but average river flows would range between 637 ft^3/s for alternative C and 730 ft^3/s for alternatives B, E and F from July through September. If no action were taken, the average flow during this period would be 897 ft^3/s.

Water temperature during the summer is not expected to change significantly immediately below Crystal Reservoir. Downstream, water temperature would increase. As indicated previously, maximum summer water temperatures near Austin during the low flow years of 1981 and 1988 ranged from 20 to 25 °C (68 to 77 °F). In both of these years, the river flows were lower than the average flows expected with development but about equal to those which would be expected under dry conditions. Thus, diverting water from the Gunnison River for hydropower, regardless of the alternative, should not result in water temperatures higher than the conditions observed during these low flow years. However, because the flows with development would be low more frequently (see tables 3.8-3.11), higher temperatures would become more frequent. Mean monthly summer flows between 300 and 500 ft^3/s would occur 28 percent of the time under alternative A; approximately 42 percent under alternatives B, C, and F; and approximately 68 percent under alternative C.

<u>Development Alternatives, Winter Conditions</u>.--Small (1 °C to 2 °C) changes in water temperature would be anticipated as a result of development. During the period of December through February, generally the coldest period of the year, mean monthly flows in the river would average 476, 471, and 499 ft^3/s for alternatives B, C and F, respectively, and 581 ft^3/s for alternative E. For all alternatives, the minimum instantaneous flow of 300 ft^3/s would occur more frequently (see tables 3.7-3.11). Mean monthly winter flows would be below 500 ft^3/s 10 percent of the time for alternative A and 50 to 60 percent of the time for all other alternatives.

In general, the potential for ice formation and accumulation exists within the Gunnison River at flows below 500 ft^3/s during periods of low temperatures. Ice conditions (previously described) seen during the winter of 1988-1989 would be more frequent under alternatives B, C, and D and to a lesser extent under alternatives E and F. Alternative E would yield average monthly flows of 581 ft^3/s during the winter months of December through February.

Average monthly flows from December through February for alternative F are slightly higher (499 ft^3/s) than those for alternatives B and C. The reason for the increase is that alternative F would provide deicing flows of approximately 600 ft^3/s for an adequate period of time to remove ice cover from the river. Therefore, alternative F would result in the periodic recession of the ice edge downstream to locations near those identified for alternative E. The effects of ice formation are discussed later in this chapter.

Impacts of Alternatives--Uncompahgre River

Alternative A (No Action).--If no action is taken, river temperatures in the Uncompahgre River would remain unchanged from historical patterns. During the summer, temperatures would be affected by the amount of water withdrawn for irrigation. Consequently, average temperatures would continue to increase downstream. During the winter, the low flows present in the river would most likely develop an intact ice cover in slow-moving areas toward Delta.

Development Alternatives.--Under all development alternatives, the amount of flow in the Uncompahgre River would be reduced between the South Canal and the tailrace during the irrigation season; flows in the river would be substantially increased year-round downstream from the tailrace.

Reducing flows in the South Canal to Montrose reach would result in higher water temperatures during the summer. Because river flow would still be high (see tables 3.13 and 3.14) between the South Canal and the Loutzenhizer Canal, this change would not be significant except on the reach between the Loutzenhizer Diversion and the proposed tailrace. During the winter, the flow profiles in the river between the South Canal and the tailrace are not significantly changed (50 ft^3/s without development versus 48 ft^3/s with development); hence, water temperatures would not change.

Downstream from the tailrace, water temperatures would be expected to decrease during the summer due to the introduction of relatively cooler Gunnison River water flowing through the powerplant. During the winter months, water temperatures would be expected to increase. Flow tests were conducted by the Sponsors in January 1982. Approximately 300 ft^3/s was diverted through the Tunnel and South Canal over a 12-day period to determine the potential for ice formation in the Uncompahgre River. Visual observations indicated that no intact ice cover developed in the river between the South Canal and Delta (UVWUA, 1984).

Water Quality

Water quality of the Gunnison and Uncompahgre Rivers can be characterized by addressing the physical (e.g., turbidity) and chemical (e.g., hardness) parameters of the respective streams. Water quality data for the Gunnison and Uncompahgre Rivers were obtained from several sources, including the Environmental Protection Agency (EPA), USGS, Bureau of Land Management (BLM), and Reclamation's own data. From these data, a general characterization of the water quality in the affected rivers can be developed. These qualities are important because they determine the type and density of organisms present and the possible consumptive and nonconsumptive uses for the river water. Water quality standards for the rivers are established by the Colorado Department of Health, Water Quality Control Commission (WQCC). This section presents information regarding the water chemistry of the Gunnison and Uncompahgre Rivers within the reaches affected by development alternatives.

Existing Conditions

Gunnison River Between Crystal Reservior and North Fork.--The quality of waters in the Gunnison River downstream from Crystal Reservoir can be determined from studying data taken by the USGS at the gauging station downstream from the East Portal of the Gunnison Tunnel and from occasional data collected by the USGS during 1981, 1984, and 1985 near Delta upstream from the Uncompahgre River confluence. These data were obtained primarily by measurement once each month during the winter, with multiple monthly measurements during the summer.

A good indicator of the dissolved salts content of water is its specific conductance; as the specific conductance increases, the water quality decreases. Generally, approximate total dissolved solids can be estimated by multiplying the specific conductance by 0.66 (USGS, 1985). Specific conductance data for the two stations are summarized in table 3.25. Flow, specific conductance, and temperature versus time for all data collected between 1980 and 1986 for the East Portal and Delta gauging stations are shown in figures 3.7 and 3.8.

Figure 3.7 shows temperature increasing through the summer at the Gunnison Tunnel gauging station, reaching a mean monthly maximum in August. Specific conductance shows little seasonal variation and is positively correlated with the concentration of total ions (positively and negatively charged molecules) in solution; it is an indirect measure of salinity and water quality. The lower the concentration of dissolved substances

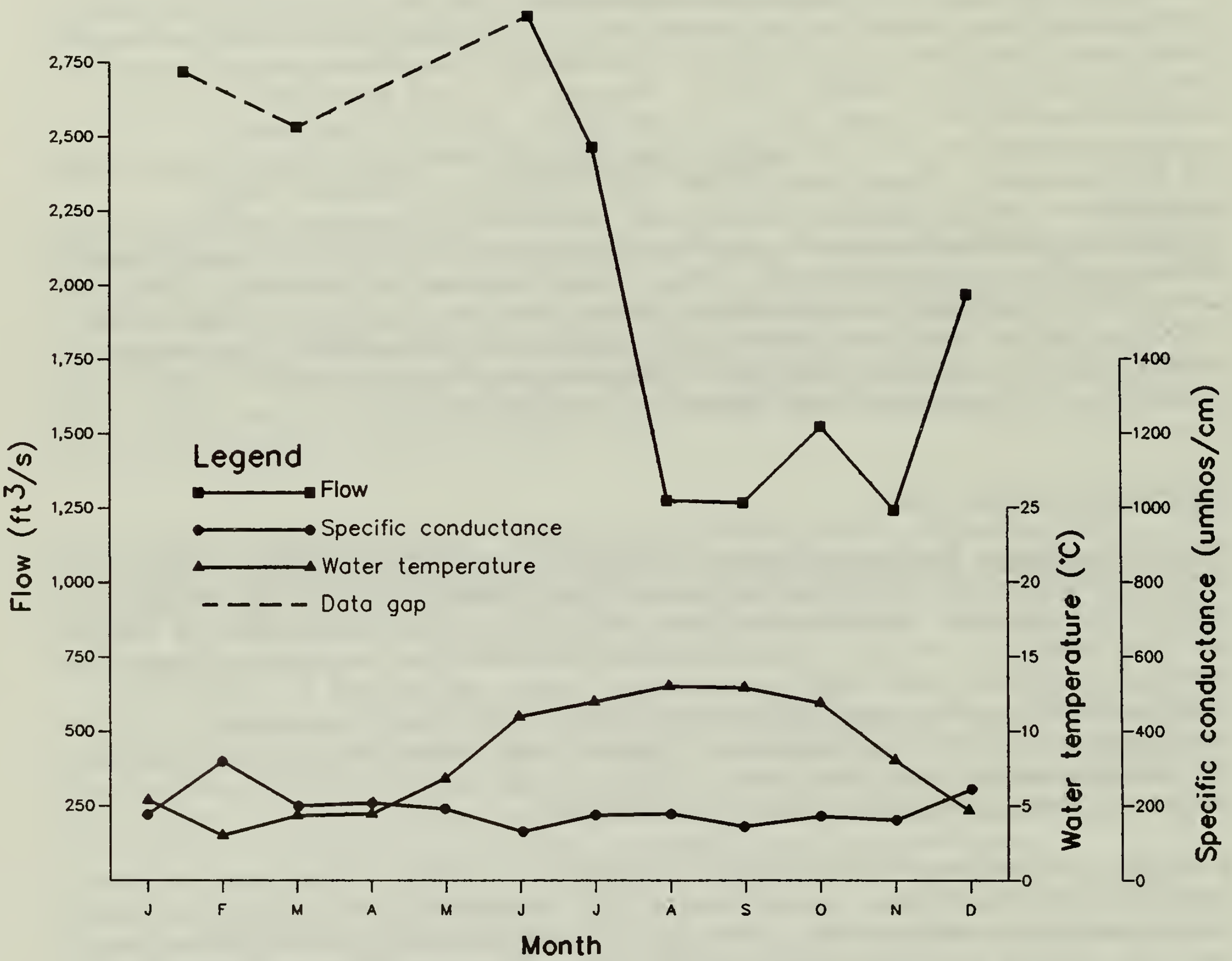


Figure 3.7. Mean monthly specific conductance, water temperature and flow (Gunnison River at the East Portal).

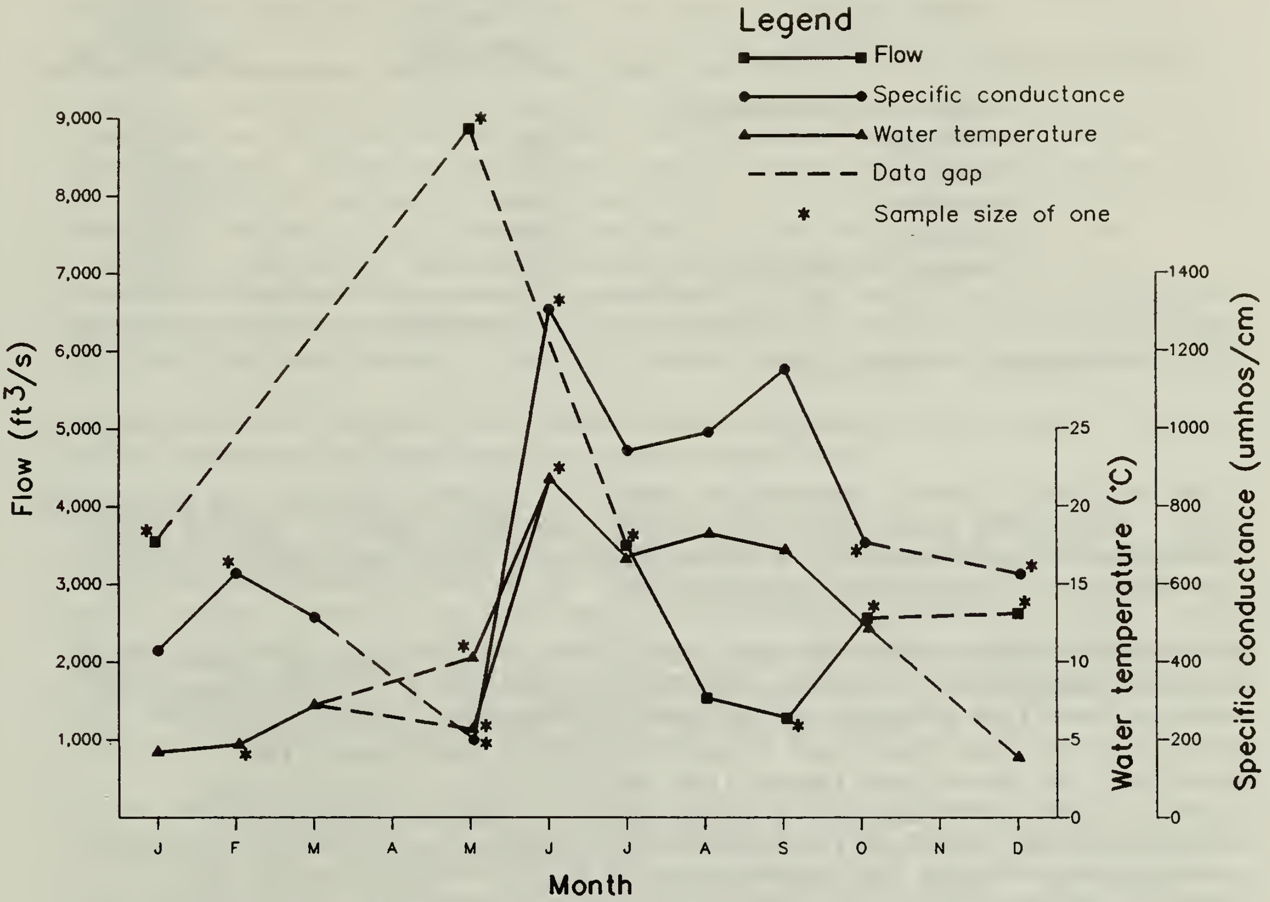


Figure 3.8. Mean monthly specific conductance, water temperature and flow (Gunnison River at Delta).

Table 3.25.--Summary of specific conductance data for the Gunnison River at two USGS gauging stations (for 1980 - 1986)

Statistic	Below Tunnel (umhos/cm)	Near Delta (umhos/cm)
Number of samples	67	20
Average	189	735
Maximum	320	1,500
Minimum	70	235
Median	185	735
Standard deviation	45	381

Source: USGS, 1987.

like calcium (Ca++), magnesium (Mg++), sulfate (SO_4^{--}) and chloride (Cl-) ions, the more pure the water (Wetzel, 1983). Table 3.25 indicates a low specific conductance and excellent water quality at the East Portal gauging station.

Additional water quality information for the Gunnison River from Crystal Reservoir to the North Fork confluence is the result of research on the effects of mainstream dams on the physicochemistry of the Gunnison River (Stanford and Ward, 1983). Stanford and Ward published information about longitudinal physicochemical changes in water quality beginning at the headwaters of the Gunnison River and ending at the confluence of the Gunnison River and the Colorado River. Their data were collected from September 1979 through October 1980. During this period, flows at the East Portal gauging station ranged from a low of approximately 770 ft^3/s to a high of 2,125 ft^3/s (USGS, 1987).

Stanford and Ward (1983) indicate a longitudinal increase in ion concentration (sum of Mg++, Na+, and SO_4^{--}) from the headwaters of the Gunnison to the confluence with the Colorado River (see attachment C), a commonly observed phenomena for rivers in general. They also reported a seasonal change in ion concentration, inversely related to flow. The trend was most obvious at sampling locations least affected by water released from reservoirs. Their data show that the Aspinall Unit Reservoirs tend to reduce seasonal changes in ion concentrations, also the case for other indicators of water quality such as specific conductance. These data suggest that water quality within the upper portion of the Gunnison River immediately below

Crystal Reservoir is a function of the limnology of and releases from the Aspinall Unit Reservoirs.

The ionic composition of the Gunnison River between Crystal Reservoir and the North Fork indicates little influence from irrigation return flows entering from the Smith Fork. The most important factor seems to be the limnology of Crystal Reservoir. Stanford and Ward (1983) found that calcium dominated the ionic composition of the river system upstream of the Black Canyon of the Gunnison National Monument, while sulfate, an ion indicative of irrigation return flows, dominated in the lower reaches of the Gunnison River. The concentration of the nutrient nitrate-nitrogen tended to decline through the Black Canyon of the Gunnison National Monument, presumably the result of autotrophic processes (see attachment C). Conversely, sulfate and dissolved and particulate organic carbon tended to increase (attachment C).

These factors suggest the importance perhaps of the North Fork, which tends to exhibit poorer water quality.

Ground-water inflows seem to contribute little to the water quality characteristics within the Black Canyon of the Gunnison National Monument because of the granitic bedrock (Stanford and Ward, 1983). Based on the data of Stanford and Ward (1983), mean annual sulfate (as sulfur), nitrate (as nitrogen), dissolved organic carbon and particulate organic carbon concentrations at the Gunnison Tunnel were approximately 10.8 mg/l, 0.47 mg/l, 2.5 mg/l and 0.21 mg/l, respectively.

Dissolved oxygen is important because it is required for metabolic processes. Oxygen requirements for sport fish like trout are usually higher than for nongame fish such as suckers. The saturated, dissolved oxygen concentration at the East Portal gauging station can be calculated if certain assumptions are made involving altitude (atmospheric pressure), water temperature, presence or absence of salts, and degree of biological activity. Assuming an altitude of 5,000 feet, a water temperature of 14 °C (57.2 °F), no dissolved solids (essentially no salinity), and no biological activity; a saturated dissolved oxygen concentration of 8.0 mg/l is obtained (EPA, 1985a). This theoretical value is well above the limits specified by WQCC (see table 3.26). Actual 1988 measurements by Reclamation in the Gunnison River above the North Fork on July 11, August 9 and September 16 indicated dissolved oxygen of 12.1, 11.2 and 10.8 mg/l, respectively.

Within Colorado, the WQCC has the authority and responsibility to maintain and improve water quality. The WQCC uses a water quality classification system based on recreation, aquatic life, existing high quality waters, domestic water supply, and

Table 3.26.--Water quality standards and classifications for pertinent reaches of the Gunnison River

Stream segment	Classification	Numeric and physical standards (mg/L)
Gunnison River from Crystal Dam to a point 1 mile below Smith Fork confluence	High Quality, Class 2	Existing conditions
Gunnison River from a point 1 mile downstream of confluence with Smith Fork to immediately above confluence with Uncompahgre River	Recreationai Class 2 Aquatic Life Class 1 Cold Water Supply Agriculture	Dissolved oxygen (D.O.) = 6 7 spawning pH = 6.5-9.0 Fecal Coliform = 2000/100 ml Temperature = 68 °F maximum for aquatic life in Class 1, cold water biota NH3 = 0.02 unionized Residual Cl2 = 0.003 Cyanide (free) = 0.005 S as H2S = 0.002 undiss. Boron = 0.75 Nitrite (NO_2) = 0.05 Nitrate (NO_3) = 10.0 Chloride (Cl) = 250.01 Sulfate (SO_4) = 250.0 Arsenic = 0.05 Cadmium = 0.0004 Chromium (tri) = 0.05 Chromium (hex) = 0.025 Copper = 0.012 Lead = 0.005 Iron (sol) = 0.3 Iron (total) = 0.05 Manganese (sol.) = 0.05 Manganese (tot.) = 1.0 Mercury = 0.00005 Nickel = 0.05 Selenium = 0.01 Silver = 0.0001 Zinc = 0.05

Source: WQCC, 1988.

agriculture. Recreation Class 1 indicates that activities such as swimming are suitable for a particular body of water. Recreation Class 2 signifies stream segments where primary contact recreation does not exist and cannot reasonably be expected to exist in the future. Boating would be considered an acceptable activity under this classification.

Water bodies classified as Aquatic Life Class 1 cold water support cold water animal species. Although water temperature may not limit the distribution of cold water animal species, other factors such as low flow or chemical contamination may, resulting in a designation as Aquatic Life Class 2 cold water. The purpose of this classification system is to provide a reasonable degree of public safety and to provide for the propagation of fish and other aquatic life.

Table 3.26 presents the classification and numeric water quality standards for the pertinent reaches of the Gunnison River. Where applicable, the numeric water quality standards are upper limits for regulatory purposes and do not represent observed concentrations. The Gunnison River between Crystal Reservoir and 1 mile downstream of the Smith Fork is classified as High Quality Class 2--Existing Conditions, a classification that establishes the existing water quality as the numeric standards.

<u>Gunnison River Below the North Fork Confluence</u>.--Water quality within the Gunnison River declines below the confluence with the North Fork, primarily because of irrigation return flows. Stanford and Ward (1983) reported a substantial increase in the sulfate concentration in the Gunnison below the North Fork confluence (see attachment C). Sulfate concentrations greater than 3,000 mg/l may be characteristic of the irrigation and side return flows (Stanford and Ward, 1983). They reported a large increase in annual particulate organic carbon (POC) below the North Fork confluence, while the mean annual concentrations of dissolved organic carbon (DOC) and nitrate increased slightly.

The decline in water quality below the North Fork confluence is reflected by the increased specific conductance at Delta (see table 3.25). Also, specific conductance and water temperature increase seasonally at the Delta gauge in more dramatic fashion than at the East Portal gauge (see figure 3.8). The Gunnison River from 1 mile below the Smith Fork to the Uncompahgre River in Delta is classified by the WQCC as Recreational Class 2, Aquatic Life Class 1 cold.

Uncompahgre River.--Water quality in the Uncompahgre River is low compared to the Gunnison River. Table 3.27 provides specific conductance data collected by the USGS at two gauging stations on the Uncompahgre River for the water years 1980 through 1986. The upstream gauge is at Colona, about 12 miles southeast of Montrose. The downstream gauge is at Delta. At each of the gauging stations, specific conductance and temperature vary seasonally. Water temperature is generally greatest during August at the Colona gauge and July at the Delta gauge. Mean monthly flow, specific conductance and temperature versus time for all data collected between 1980 and 1986 for the Colona and Delta gauging stations are shown in figures 3.9 and 3.10.

Water temperature data collected by the USGS at the Colona and Delta gauging stations indicate maximum summer temperatures of 20 °C (68 °F) on August 31, 1983, and 32 °C (89.6 °F) on July 10, 1986, respectively. Greater suspended solids and chemical oxygen demand probably result in lower dissolved oxygen in the Uncompahgre River than in the Gunnison River.

Table 3.27.--Summary of specific conductance data at two USGS gauging stations on the Uncompahgre River (1980 - 1986)

Statistic	Near Colona (umhos/cm)	Near Delta (umhos/cm)
Number of samples	82	67
Average	605	1,256
Maximum	1,450	2,500
Minimum	170	30
Median	630	1,200
Standard deviation	272	535

Source: USGS, 1987.

A substantial decline in water quality occurs between Colona and Delta. The data presented in table 3.27 show a large increase in specific conductance between these gauging stations. The inverse relationship between streamflow and specific conductance is the same relationship observed on the Gunnison River at Delta (see figures 3.9 and 3.10). Specific conductance is less during May and June, the months with the greatest flows. Poor water quality in this reach of the Uncompahgre River is apparently the result of excessive amounts of dissolved solids from irrigation return

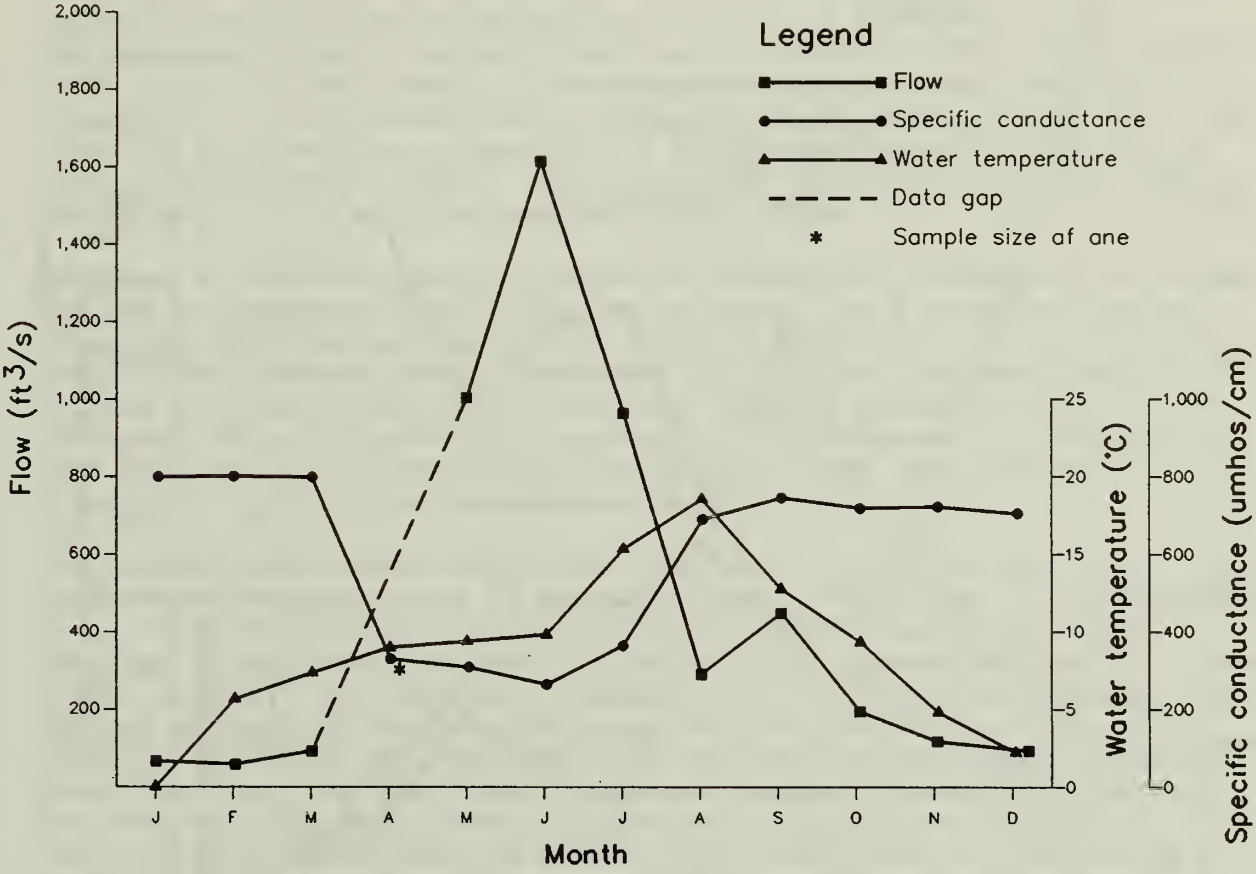


Figure 3.9. Mean monthly specific conductance, water temperature and flow (Uncompahgre River at Colona).

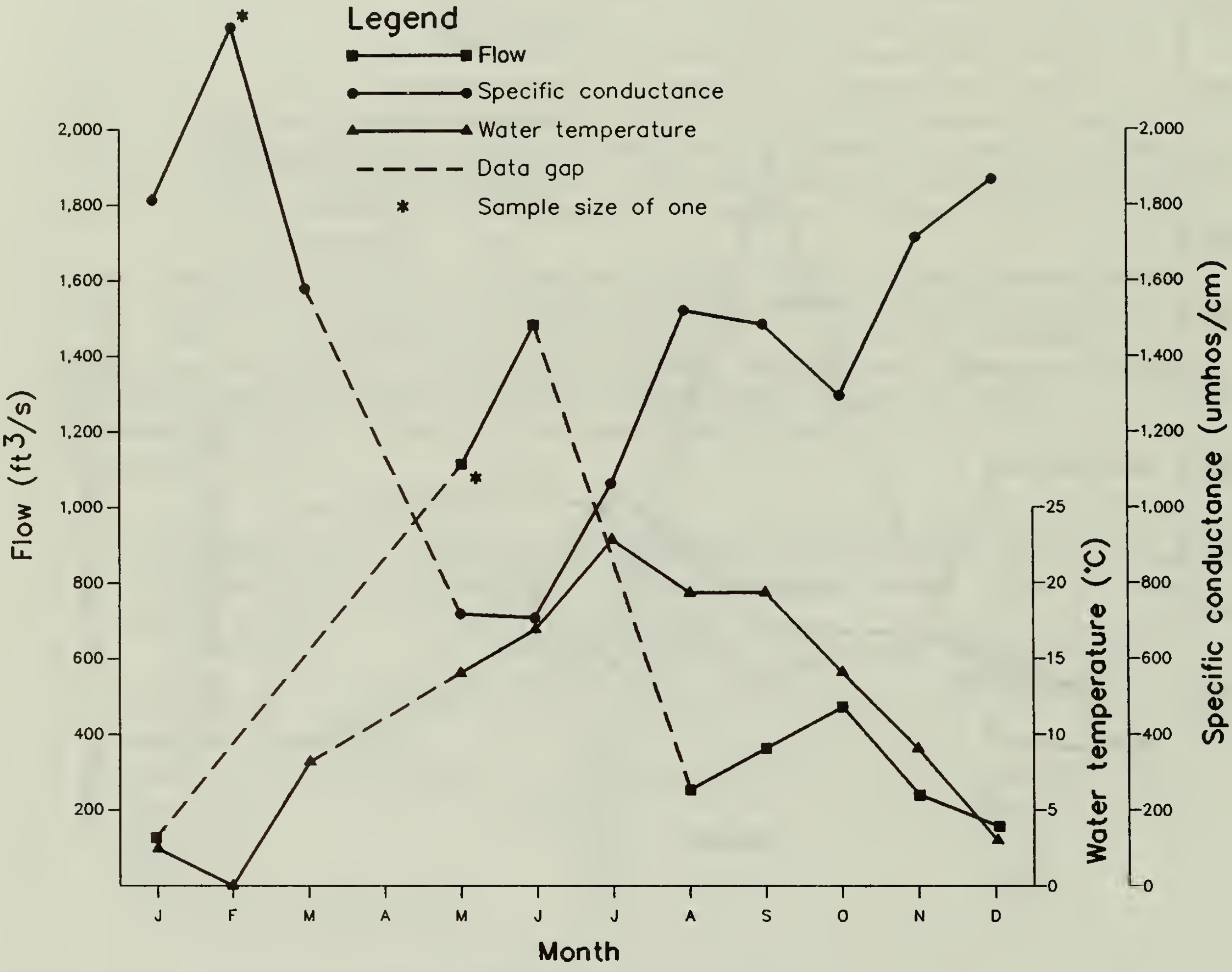


Figure 3.10. Mean monthly specific conductance, water temperature, and flow (Uncompahgre River at Delta).

flows. Limited water quality data for Spring Creek and the Loutzenhizer Arroyo show that these streams carry relatively large amounts of SO_4^{--} and Cl^-.

Seepage from the Uncompahgre River channel into the Mancos Shale seems to be limited, contributing little to salinity in the Uncompahgre River. Salinity estimates made by the Colorado River Water Quality Improvement Program indicate that the present salt loading to the Colorado River from the Uncompahgre Valley is 531,000 tons per year, based on a total outflow of 281,000 acre-feet (Reclamation, 1984). This loading is almost entirely due to tributary inflow and irrigation return flows.

Because of the substantial amount of dissolved substances carried by the Uncompahgre River, the Uncompahgre has a large effect on Gunnison River water quality at their confluence. Stanford and Ward (1983) showed large increases in nitrate, sulfate, particulate organic carbon and dissolved organic carbon in the Gunnison River below Delta, as shown in attachment C. Nitrate and SO_4^{--} carried by the river probably reflect agricultural practices within the Uncompahgre Valley.

The upper Uncompahgre River and some of its tributaries are presumably contaminated by mine drainage, resulting in relatively high concentrations of trace metals in the Uncompahgre River. Studies by Reclamation have indicated that concentrations of zinc, mercury, and cyanide, based on a flow-weighted average, may exceed acceptable levels for aquatic life, while the concentration of selenium and manganese may at times exceed safe drinking water levels. By the time the river reaches Colona, the water volume and alkalinity levels increase, both of which help to dilute and precipitate the heavy metal compounds. Starting in 1988, Ridgway Reservoir began settling out trace metals and sediment, thus reducing concentrations at Colona. Selenium concentrations increase downstream from Colona. Although the WQCC considers the Uncompahgre River from its source to its confluence with Red Mountain Creek upstream of Ouray to be acceptable for domestic supply, the river is not considered acceptable for domestic supply use downstream to Delta (WQCC, 1988).

WQCC classifications for the Uncompahgre River are presented in table 3.28. Below Red Mountain Creek, the river is classified as Recreational Class 2, Agriculture and Aquatic Life Class 1 cold to the Highway 550 bridge south of Montrose. The Aquatic Life designation becomes Class 2 warm water here, indicating no significant cold water sport fishing between this point and the Uncompahgre River's confluence with the Gunnison River at Delta.

Table 3.28.--Water quality standards and classifications for pertinent reaches of the Uncompahgre River

Stream segment	Classification	Numeric and physical standards (mg/L; same as Gunnison River except):
Uncompahgre River from source to a point immediately above confluence with Red Mountain Creek	Recreational - Class 2 Aquatic life - Class 1 Cold Water supply - Agriculture	No Nitrate Standard Copper = 0.065 Chromium (tri) = 0.1 Nickel = 0.05 Selenium = 0.02 Lead = 0.04 Iron (total) = 1.1 Zinc = 0.225
River from point above confluence with Red Mountain Creek to U.S. Highway 550	Recreational - Class 2 Aquatic life - Class 1 Cold Water supply - Agriculture	No standards for NO_3, Cl, SO_4, dissolved iron and manganese; Cadmium = 0.001 Chromium (tri) = 0.1 Copper = 0.065 Iron (total) = 1.1 Lead = 0.04 Nickel = 0.05 Selenium = 0.02 Zinc = 0.225
River from Hwy 550 to confluence with Gunnison River River	Recreational - Class 2 Aquatic life - Class 2 Warm Water supply - Agriculture	D.O. = 5.0 NH3 (unionized) = 0.1 No standards for NO_3, Cl, SO_4 dissolved iron and manganese; Cadmium = 0.005 Chromium (tri) = 0.1 Copper = 0.03 Lead = 0.05 Nickel = 0.2 Selenium = 0.035 Silver = 0.00015 Zinc = 0.1 Iron (total) = 2.3

Source: WQCC, 1988.

Impacts of Development Alternatives

Implementing the development alternatives would not result in the discharge of any new or additional pollutants to the waters of either the Gunnison or Uncompahgre Rivers. Consequently, potential water quality impacts resulting from development would be related solely to diverting additional water for hydropower. Agricultural diversions, the Aspinall Unit Reservoirs and Ridgway Reservoir presently play a major role in influencing water quality within the Uncompahgre and Gunnison Rivers. Potential impacts from the proposed alternatives would be in addition to the present influence from these sources.

Alternative A (No Action)

If no development occurs, water quality in the Gunnison River would not change significantly. Water quality would continue to be affected by the releases from Crystal Reservoir, agricultural runoff from tributary streams, and irrigation diversions. Sediment loads delivered from the Smith Fork and the North Fork of the Gunnison River would continue as at present to affect the Gunnison River's water quality.

Gunnison River Between Crystal Reservoir and North Fork

Development Alternatives.--The principal effect of all of the development alternatives outlined in chapter 2 would be to reduce the amount of water in the Gunnison River between the Gunnison Tunnel and Delta. In terms of water quality, the diminished flows reduce the amount of water available for diluting elements that downgrade water quality.

As discussed previously, water quality immediately below Crystal Reservoir is a function of the quality of water released from Crystal Reservoir. Water quality within Crystal Reservoir varies seasonally as it and upstream reservoirs receive inflow and thermally stratify and destratify. These changes are probably reflected below Crystal Reservoir as well. Between Crystal Reservoir and the Gunnison Tunnel, an area unaffected by the project, no change in water quality is anticipated. The release of water from Crystal Reservoir would continue to dictate water quality. Seasonal variation in specific conductance would remain muted, and water temperature should remain warmest during August.

The data presented previously showed an inverse relationship between flow and specific conductance. As river flow increased, specific conductance decreased and water quality improved, suggesting that potential impacts resulting from additional diversion of water would depend on the type of water year. Impacts from project development would be different depending upon whether it is a low-, moderate- or high-flow year.

Because poor quality water (compared to the Gunnison River) does not enter the Gunnison River between Crystal Reservoir and the Smith Fork in sufficient amounts, a deterioration in water quality is not predicted between Crystal Reservoir and the Smith Fork. However, during periods having moderate (600 to 1,000 ft^3/s) or high flows (greater than 1,000 ft^3/s), slight increases in the concentration of ions, particulate and dissolved organic matter and other measures of water quality would occur below the Smith Fork and North Fork. However, even with development, water quality during moderate-to-high flow years would remain excellent in this reach.

During periods having low to moderate flows (300 to 600 ft^3/s), the concentrations of ions, particulate and dissolved organic matter and other water quality measures would increase due to the reduced amount of flow available for dilution. The changes would be within the range experienced since the completion of the Aspinall Unit, and the water quality would remain good within this reach. In 1988, when flows downstream from the Tunnel were usually below 400 ft^3/s, the concentration of ions (as measured by total dissolved solids) in the river upstream of the North Fork confluence remained low (total dissolved solids were below 300 milligrams per liter [mg/l]. Development would not change the species presently inhabiting the river, and water use presently allowed would not be affected. Additional diversions would not be made during low flow periods (300 ft^3/s), so water quality would not be affected. The present WQCC classification of High Quality Class 2 Existing Conditions is unlikely to be affected by project development.

In general, alternative C (which would increase the capacity of the Gunnison Tunnel) would result in the greatest amount of water diverted compared to alternatives B, E and F (see tables 3.8 through 3.11). The additional diversion would occur primarily during November through April, months typified by higher flows. Alternatives B and F should result in similar water quality, based on the quantity of water remaining within the Gunnison River. Alternative E would have a turbine design-flow less than the other alternatives and would therefore divert the least amount of water. In turn, this would provide the greatest amount for diluting the poorer quality Smith Fork flows.

Gunnison River Below North Fork

Development Alternatives.--Water quality impacts increase moving downstream from the North Fork, which exhibits considerably poorer water quality than the Gunnison River. The dissolved solids concentration is much higher than the Gunnison, although the amount of flow contributed by the North Fork is smaller compared to Gunnison flows. Without development, these higher concentrations result in the longitudinal trends in water quality discussed previously. However, with development, the reduced flows would result in less water for dilution over longer durations.

During the summer of 1988, flows in the North Fork, Smith Fork and Gunnison Rivers were substantially below their respective historic averages. Specific conductances measured by Reclamation indicated values of 222 micromhos per centimeter (umhos/cm) in the Gunnison River above the North Fork confluence, 1,297 umhos/cm in the North Fork and 649 umhos/cm in the Gunnison near Austin. These values are representative of historical averages, and flows were equivalent to those expected with development during dry conditions. Hence, although the dilution capability of the Gunnison River would be reduced with development alternatives, the reduction would not result in water quality parameters outside of those historically experienced. Conditions such as occurred in 1988 would be more frequent with the development alternatives, however. The length of time in the spring, or following summer thunderstorms, that the river remained cloudy or turbid due to North Fork inflow would be extended, and total dissolved solids concentrations would increase. In the summer of 1988, total dissolved solids concentrations exceeded 1,000 mg/l in the North Fork and were recorded at around 530 mg/l on the Gunnison River near Austin. The reduced flows should not change the species presently inhabiting the river and would not change the allowable usage including irrigation. Of the alternatives, alternative E would provide the greatest amount of water for dilution of North Fork flows.

Uncompahgre River

Alternative A (No Action).--If no development occurred, water quality in the Uncompahgre River would be changed by the operation of Ridgway Reservoir. Trace metal concentrations within the Uncompahgre River, the result of runoff from mine tailings within the headwaters, should be reduced within the reservoir. Trace metals typically adsorb on the surface of clay and other soil particles. With the decline in water velocity at the upstream end of the reservoir, clay and other soil particles would be deposited, thus settling trace metal contaminants. Consequently, the waters released from the reservoir would be expected to be relatively free from suspended sediments and the associated trace metal contaminants.

The release of water low in suspended sediments from Ridgway Reservoir would result in an initial period of degradation and scour within the river channel for a few miles downstream Ridgway Dam. This action would degrade the quality of water released from Ridgway slightly as the result of increased sediments and turbidity.

Implementing the Lower Gunnison Basin Unit winter water replacement program would also affect water quality in the Uncompahgre River. This salinity control project would decrease the inflow of dissolved salts and would also increase the amount of streamflow in the river during the winter by replacing stockwater supplies diverted from the river with supplies provided through rural water systems.

Development Alternatives.--The principal effect of all of the development alternatives would be to reduce the amount of water in the Uncompahgre River between the South Canal and the tailrace and to increase the amount of water in the river between the tailrace and Delta. In terms of water quality, the diminished flows would result in reducing the amount of water available for dilution of elements which downgrade water quality, but the increased flows downstream from the tailrace would improve water quality, provided measures to limit erosion would be undertaken.

Each of the alternatives would decrease the amount of water entering the Uncompahgre River through the South Canal, primarily between March and November. During the nonirrigation period, flows through the South Canal have been historically curtailed; this pattern would continue with development (except in emergency situations). Therefore, water quality impacts caused by the reduced flows would be evident only during the irrigation season.

Because the proposed method of operation for each of the alternatives is similar, the flows in the Uncompahgre River between the South Canal and the tailrace would be similar. Average monthly flows would be reduced by approximately 180 to 400 ft^3/s with the project alternatives, representing a loss during the irrigation season of approximately 123,460 acre-feet of higher quality Gunnison River water.

Using average specific conductance values at Colona and the Tunnel and ignoring the effects of Ridgway Reservoir, the dissolved solids in the water just below the South Canal would be about 233 mg/l if no development occurred. Using these same assumptions, the dissolved solids concentration with development would nearly double as a result of less flows in the reach between the Loutzenhizer Canal and the proposed tailrace. Although this would represent a significant increase in concentration, it would not result in an increase of total salt loading to the Colorado River system. Further, it would not change the WQCC stream classification because Ridgway Reservoir would be expected to improve the river quality by reducing heavy metals and suspended solids at Colona. Heavy metals may still continue to occur in the river due to metals occurring in the sediments upstream from Montrose. Thus, the net impact resulting from reduced flows from the Gunnison and South Canal would be expected to be less significant.

Selenium and heavy metals are antagonistic, reducing each other's toxicity. The Uncompahgre River gains selenium between Colona and Delta, and heavy metal pollution is declining there due to Ridgway Reservoir. Thus, under all alternatives, including the no-action alternative, it is possible that selenium would become more of a factor in the river. The development alternatives would provide less dilution of selenium between the South Canal and the proposed tailrace and more dilution between the tailrace and Delta; however, the impacts of this occurrence are unknown.

Increased flows in the Uncompahgre River downstream from the tailrace would not add significantly to the deep percolation into the Mancos Shale formation and would have little or no impact on salinity contributions to the river. The decrease in salt loading from lining the enlarged section of the AB Lateral, from the decrease in the amount of water flowing through the South Canal, and from reducing irrigation season diversions into Cedar Creek is estimated to be 3,044 tons per year based on seepage rate estimates (Reclamation, 1984 and 1988).

Water quality within the 25 miles of the Uncompahgre River below the AB Lateral plant tailrace would be improved. Water diverted for hydropower would not be exposed to soils and, therefore, would not acquire the water quality characteristics of irrigation return flows. All development alternatives would increase erosion between the tailrace and Delta. Alternative E would result in the least amount of degradation of the stream channel because of lower flows through the tailrace, reducing the potential for sediment entrainment from bank erosion. Without the bank stabilization program, the sediment load would increase significantly for an undetermined number of years.

Water quality classification and associated discharge permit standards may change if water quality is substantially improved in the Uncompahgre River. After the hydropower project had operated for 3 to 5 years, the Colorado Department of Health would contact the CDOW for a water quality and fish and wildlife analysis. If habitat and an associated cold water trout fishery were developed, the Department of Health could reclassify the river to a higher standard. However, wastewater treatment discharge conditions would not necessarily be changed because increased flows would provide additional dilution (Scherschlight, personal communication, 1987).

Fisheries

Existing Conditions

Gunnison River.--Wide fluctuations in streamflow characterized the Gunnison River before the Aspinall Unit. The extremes of high spring flows an low summer and fall flows were believed to contribute significantly to poor salmonid reproduction and survival before Aspinall construction. Excessive spring flows presumably resulted in increased mortality of swim-up fry, while low summer and flows (less than 200 ft^3/s) lead to unsuitable water temperatures. Attachment B contains historic flow records for the Gunnison River downstream from the East Portal of the Gunnison Tunnel.

Since the Aspinall Unit was completed, relatively stable, cold water flows from Crystal Reservoir have resulted in an excellent trout fishery downstream of the dam. For fishery collections in the Black Canyon of the Gunnison National Monument and downstream areas in the period before and following operation of the Aspinall Unit, refer to Wiltzius (1978). Kinnear and Vincent (1967) document fish populations in the monument before the Aspinall Unit. Stanford and Ward (1981, 1983, and 1984) discuss the limnology and ecology of the Gunnison River. They suggest that the Aspinall Unit Reservoirs have caused a downstream shift (reset) of optimum trout production conditions and other physical and biological processes from the area impounded by Blue Mesa Reservoir to the Gunnison Gorge. In addition, the CDOW has completed extensive research on the river from 1979 to 1988 (Nehring, various dates; Nehring and Anderson, various dates; and Nehring and Miller, 1987).

CDOW has designated the nationally renowned 28-mile Black Canyon reach as wild and Gold Medal water, meaning natural reproduction sustains the fishery and that trophy fish are present. Species abundance above the North Fork may be represented in decreasing order as: rainbow trout > brown trout > flannelmouth, longnose, white and hybrid suckers > mottled sculpin, common carp and longnose dace. Infrequent species include northern pike, yellow perch, green sunfish and bass; presumably immigrants from Crawford and Paonia Reservoirs. The trout comprise about 54 percent of the fish population, sucker spieces 36 percent, sculpin 9 percent, and the remaining species 1 percent (Nehring, 1987a).

Growth, density, biomass and production are typical measures of the quality of a fishery. Table 3.29 presents data collected by CDOW with respect to density and biomass of trout species for various portions of the Gunnison River. These data indicate a general decline in the density and biomass of rainbow and brown trout between the Duncan-Ute Trail and the North Fork-Austin areas. This trend may or may not be indicative of total fish biomass within the Gunnison River but probably reflects interactive effects of fishing harvest and the lack of natural reproduction downstream from the North Fork confluence. Total trout (rainbow and brown) density and biomass during 1986 were 745 fish per hectare (ha) and 203 kilogram (kg) per hectare (ha), respectively, in the Duncan-Ute Trail area, compared to 85 fish per ha respectively, and 26 kg per ha, respectively, in the North Fork-Austin area. Trout density estimates presently range from 2,223 to 2,470 trout per hectare (900 to 1,000 trout/acre) in the less accessible Black Canyon, compared to 741 to 988 trout per hectare (300 to 400 fish/acre) in the area above the North Fork confluence (Reclamation, 1988; Nehring, 1988c).

Additional rainbow and brown trout biomass data collected from 1981 to 1988 by CDOW are presented in table 3.30. These data show brown trout biomass ranging from 25.8 to 170.2 kg per ha and rainbow trout biomass ranging from 50.5 to 243.0 kg per ha during the study period between Duncan-Ute Trail and Smith Fork-North Fork area (Nehring, 1988c). Nehring and Anderson (1983) reported that stable flows from October 1980 through March 1981 led to highly successful incubation and hatching of brown trout eggs. Lower stable flows of 200 to 400 ft^3/s through September 1981 provided excellent spawning and incubation for rainbow trout. Strong year classes in the early 1980's were the result of favorable flow conditions.

Because of the trout's importance as a sport fish, the majority of the fisheries data on the Gunnison River are for trout, and less data are available for nongame fish. Nehring and Anderson (1982) and Nehring (1981) report data on the occurrence of non-sport fish in the Gunnison River; and Wiltzius (1978) presents data on nongame fish within the Black Canyon of the Gunnison National Monument and downstream areas. Sucker density

Table 3.29.--Gunnison River standing crop and biomass estimates (August - September, 1986).

Description of study area and fishing regulations	Study section size: Length (m)	Width (m)	Area (ha)	Species	Population statistics: N	95% C.I.	N/ha	kg/ha	Trout/ha >35 cm
Duncan-Ute Trail--4 trout/day; 1 over 16 inches; catch-and-release 12-16 inches	3,220	31.0	10.0						
				Brown	4,688	±2,013	469	69.8	17
				Rainbow	2,748	±1,549	275	132.8	175
				Total	7,447	±2,319	745	202.6	191
Smith Fork-North Fork--4 trout/day; 1 over 16 inches; catch-and-release 12-16 inches	6,440	31.0	20.0						
				Brown	2,554	±1,152	128	33.3	32
				Rainbow	3,596	±3,640	180	98.8	156
				Total	5,903	±1,994	295	132.2	171
North Fork-Austin--8 trout/day; limited access; heavy siltation	12,900	45.7	59.0						
				Brown	3,243	±1,103	50	13.1	15
				Rainbow	2,524	±1,665	37	12.5	23
				Total	5,880	±2,965	85	25.6	37

Source: Nehring, 1987b.

Table 3.30.--Rainbow and brown trout population statistics for the Gunnison River for 1981-1988[1]

Species	Size (cm)	Density (number/ha) 1981	1982	1983	1984	1985	1986	1987	1988
		Duncan - Ute Trail Area (2 miles - 3.2 km - 10 ha)							
Brown	15 & up	869	603	586	541	330	469	1,236	936
Brown	30 & up	194	141	139	58	58	112	228	141
Brown	35 & up	71	43	39	18	13	31	72	44
Brown	40 & up[2]	119	97	81	59	32	37	211	44
Rainbow	15 & up	339	392	427	217	346	275	1,110	1,054
Rainbow	30 & up	140	181	253	162	333	193	273	245
Rainbow	35 & up	84	97	146	110	261	190	194	245
Rainbow	40 & up[2]	600	423	651	401	892	1,447	1,573	1,153
Biomass, in kg/ha									
Brown		201.2	143.8	134.5	54.6	53.6	69.8	170.2	117.7
Rainbow		110.7	110.3	149.8	84.5	164.5	132.8	236.9	243.0
		Smith Fork - North Fork Area (4 miles - 6.4 km - 20 ha)							
Brown	15 & up	115	186	407	351	249	128	319	255
Brown	30 & up	14	40	128	61	55	76	105	60
Brown	35 & up	8	16	34	22	26	38	53	23
Brown	40 & up[2]	69	120	216	128	126	165	447	152
Rainbow	15 & up	355	228	268	275	205	180	608	452
Rainbow	30 & up	16	66	169	206	193	162	246	229
Rainbow	35 & up	10	16	51	140	140	155	190	80
Rainbow	40 & up[2]	234	192	222	626	770	1,895	2,504	491
Biomass, in kg/ha									
Brown		25.8	48.0	104.5	41.8	45.4	33.3	65.0	41.7
Rainbow		50.5	51.3	81.3	99.4	91.3	98.8	185.7	109.7

[1] Data based on population estimates and the length-frequency distribution of unmarked trout captured.

[2] Total fish for the study section.

Source: Nehring, 1988c.

is greater downstream from the North Fork compared to upstream. Sucker density is presently estimated at 1,000 fish per mile above the North Fork (Nehring, 1987 and Reclamation 1987a).

Rainbow and brown trout growth within the Gunnison River is excellent. Rainbow trout in the Duncan-Ute Trail and Smith Fork and North Fork areas exceed 41 cm (16 inches) during the fourth year of growth. The data in table 3.31 show trout lengths in relation to age, allowing inference of trout age based on length. For example, a rainbow trout during its third year of growth would be anticipated to reach approximately 39.5 cm (15.5 inches) in the same area.

With the development of the Gold Medal fishery above the North Fork, trout populations have improved below the North Fork. Table 3.32 presents the results of a 1981 CDOW survey conducted between the North Fork confluence and the Austin Bridge. These data indicate a greater number of nongame fish than game fish. The abundance of species may be represented as: bluehead sucker > flannel mouth sucker > western white sucker > rainbow trout > longnose dace = brown trout > others. The total trout population downstream from the North Fork was recorded at an all-time high in 1988 with an estimated 14,600 trout, compared to total trout population estimates of 5,900, 5,900, and 11,700 for 1982, 1986, and 1987 (Nehring, 1988c).

Total trout biomass estimates in the reach below the North Fork have been 32.2, 25.6, 51.4 and 57.2 kg/ha for 1982, 1986, 1987, and 1988, respectively. The population data for 1988 were collected following a summer of unusually low flow and high water temperatures. The CDOW believes that recent population increases in this reach are due largely to high numbers of young trout moving out of upstream reaches where high spawning success occurred in 1986 and 1987 (Nehring, 1988c). Farther downstream, suckers and minnow species tend to dominate the river between Delta and its confluence with the Colorado River near Grand Junction.

A number of factors could potentially limit trout populations within the Gunnison River including water quality, predation (including fishing), the prey density, and suitable habitat. The decline in water quality below the North Fork contributes to the decrease in trout density and biomass. Reduced reproduction may result from siltation. Summer water temperatures near Austin commonly exceeds 20 °C. However, Nehring and Anderson (1982) reported healthy, robust rainbow and brown trout during 1981 when water temperature exceeded 20 °C during much of July and August, and trout density and biomass were at an estimated all-time high in the low water year of 1988 (Nehring, 1988c).

Table 3.31.-- Average length (cm) at age for rainbow and brown trout for the lower Gunnison River, 1981 - 1988

Age	1981	1982	1983	1984	1985	1986	1987	1988
North Fork - Austin Brown Trout								
1+	----	----	----	----	----	21.7	26.4	25.8
2+	----	----	----	----	----	30.9	32.9	30.5
3+	----	----	----	----	----	36.4	37.6	40.0
4+	----	----	----	----	----	39.3	40.2	42.7
5+	----	----	----	----	----	40.9	41.8	41.0
6+	----	----	----	----	----	42.7	42.7	49.0
North Fork - Austin Rainbow Trout								
1+	----	----	----	----	----	21.5	36.5	24.8
2+	----	----	----	----	----	32.4	34.4	30.5
3+	----	----	----	----	----	38.7	38.2	37.4
4+	----	----	----	----	----	41.2	39.7	36.4
5+	----	----	----	----	----	43.0	42.4	35.3
Smith Fork-North Fork and Duncan Ute Brown Trout								
1+	25.0	23.6	21.5	15.9	19.2	23.4	19.3	20.3
2+	33.9	32.8	29.6	26.1	26.2	30.0	30.7	27.9
3+	39.1	41.8	37.8	32.5	31.8	35.1	37.6	34.3
4+	45.0	47.5	43.7	38.8	36.5	40.0	39.6	38.5
5+	----	52.0	44.0	46.0	38.0	43.7	40.1	45.8
6+	----	----	----	----	----	51.0	45.7	----
7+	----	----	----	----	----	----	48.0	
Smith Fork-North Fork and Duncan Ute Rainbow Trout								
1+	20.5	20.9	19.5	17.2	22.6	23.1	20.8	19.1
2+	34.5	32.1	28.6	23.6	26.9	33.3	32.5	28.5
3+	41.7	38.6	38.0	31.8	33.7	37.6	39.5	36.1
4+	46.2	44.4	40.3	39.9	38.8	40.8	41.0	41.7
5+	----	48.4	47.0	45.1	44.9	42.6	45.3	43.9
6+	----	----	----	43.0	44.0	45.5	44.5	45.1
7+	----	----	----	----	----	----	47.9	44.5

Source: Nehring, 1988c.

Table 3.32.--Species list and percent composition of fishery in Gunnison River below North Fork confluence

Species	Percent composition
Bluehead sucker	25
Flannelmouth sucker	19
Western white sucker	18
Rainbow trout	16
Longnose dace	6
Brown trout	5
Carp	4
Sucker hybrids	4
Fathead minnow	2
Mottled sculpin	1
Longnose sucker	<1
Roundtail chub	<1

Source: Nehring and Anderson, 1982.

Prey are not believed to presently limit the growth of fish in the Gunnison River. Bio/West, Inc. (1981), sampled macroinvertebrates (primarily aquatic insects) near Delta during 1981, identifying 25 species of macroinvertebrates in riffle habitat and 18 species in run habitat. Sampling also occurred in backwater areas. The riffles were dominated by mayflies, caddisflies and midges (see attachment C). Beetle larvae and stoneflies were also abundant. The species abundance in runs generally mimicked that found in the riffles. Midges and oligochaete worms dominated the backwater areas. Bio/West also reported diatoms as the dominant phytoplankton (floating, minute plants). For information on periphyton density (plants attached to rocks, etc.), see attachment C. Invertebrates were commonly found in the stomachs of suckers, the red shiner and the roundtail chub (Bio/West, 1981) suggesting a healthy lower trophic structure. Stanford and Ward (1983 and 1984) reported very high invertebrate biomass estimates on the Gunnison River near the North Fork confluence. Additional invertebrate information is contained in Wiltzius (1978).

Angling had a significant impact on the structure of the game fish population before specialized fishing regulations on the Gunnison River. These regulations are briefly summarized in table 3.29 and consist of harvest restrictions on the number of fish within certain size categories. Table 3.33 summarizes

Table 3.33.--Annual rainbow and brown trout exploitation or harvest rates for two sections of Gunnison River (in percent)

		Harvest rate (%)	
Year	Species	Duncan/Ute Trail	Smith Fork/North Fork
1982	Rainbow Trout	31.7	54.7
	Brown Trout	21.1	41.3
1986	Rainbow Trout	8.2	20.7
	Brown Trout	7.3	27.6
1988	Rainbow Trout	3.1	37.1
	Brown Trout	3.7	31.9

Source: Nehring, 1983 and 1988c.

rainbow and brown trout exploitation or harvest rates for two sections of the Gunnison River in the early 1980s before special regulations. Nehring (1983) indicated nearly twice the exploitation rate of trout on the North Fork-Smith Fork section of the river compared to the Duncan-Ute Trail area, the difference being greater in 1988 (Nehring, 1988c).

Restrictive regulations have had a positive impact on the fishery (Nehring and Anderson, 1985a). Harvest rates have declined, although catch rates have increased in recent years due to the special regulations. Therefore, angling probably played less of a role in the structure of the fish community in the late 1980s than before size-oriented regulations. Predation by snakes, otters, eagles and other animals could also affect the fishery but are probably not significant factors when compared to the effect of habitat conditions and to a lesser extent fisherman harvest.

Habitat--The presence or absence of suitable habitat for trout reproduction and spawning, a function of flow, is perhaps the most important factor influencing trout populations in the Gunnison River. Table 3.34 provides a description of life cycles for rainbow and brown trout in the river. Spawning by brown trout within the river typically occurs between mid-October and mid-November (Nehring, 1988b). Incubation of the eggs requires approximately 100 to 120 days with hatching occurring in late March. These sac fry spend several weeks within the gravel substrate of the river, before sac absorption, swim-up, and active foraging for food. Conversely, rainbow trout spawning activity typically begins around April 1. The onset of spawning

Table 3.34.--Rainbow and brown trout life histories on Gunnison River

Life history progression				
Spawning -->	Hatching	---------------------->	Swim-up fry -->	Fingerling
		Brown Trout		
(Oct. 15 to Nov. 15)	(March 1 to April 15)	4-6 weeks in gravel	(April 15 to May 15)	(July 1)
		Rainbow Trout		
(April 1 to May 15)	(June 1 to 15)	2-3 weeks in gravel	(June 15 to July 1)	(July 30)

may vary by 2 to 3 weeks, depending upon the water temperature (warmer water results in earlier spawning). Rainbow spawning generally ceases in May, followed by a 30- to 60-day incubation period (average 45 days) and a 1- to 3-week period between the time of hatching and swim-up. Therefore, stable flows sufficient to prevent redd desiccation from mid-October through late February to late March seem best for natural reproduction and recruitment for brown trout. Stable flows from April 1 to July 1 are also required to maximize spawning success for rainbow trout.

Beginning in 1973, CDOW began efforts on the Taylor River to determine the impact of flow regimes on trout population dynamics. During the late 1970s and early 1980s, the FWS initiated a major effort to increase the amount of information related to streamflow and fish population dynamics. Their effort resulted in a habitat evaluation methodology called the Physical Habitat Simulation Model (PHABSIM) and numerous other computer habitat models designed to derive the wetted perimeter for a stream and the weighted usable area (WUA) for various life stages of trout.

The PHABSIM model consists of comparing habitat within a stream or river, expressed as a mathematical function of flow, depth and substrate to the fish's preferred habitat. Preferred habitat is expressed as a mathematical function based on field measurements of flow, depth, substrate and simultaneous collection or observation of fish. The function is termed a preference curve and is theoretically independent of the specific stream. Nehring and Anderson (1985b) and Nehring and Miller (1987) verified the PHABSIM model for the Gunnison River from 1981 through 1986.

Figures 3.11 and 3.12 illustrate the amount of available adult rainbow trout habitat expressed as WUA that presently exists in

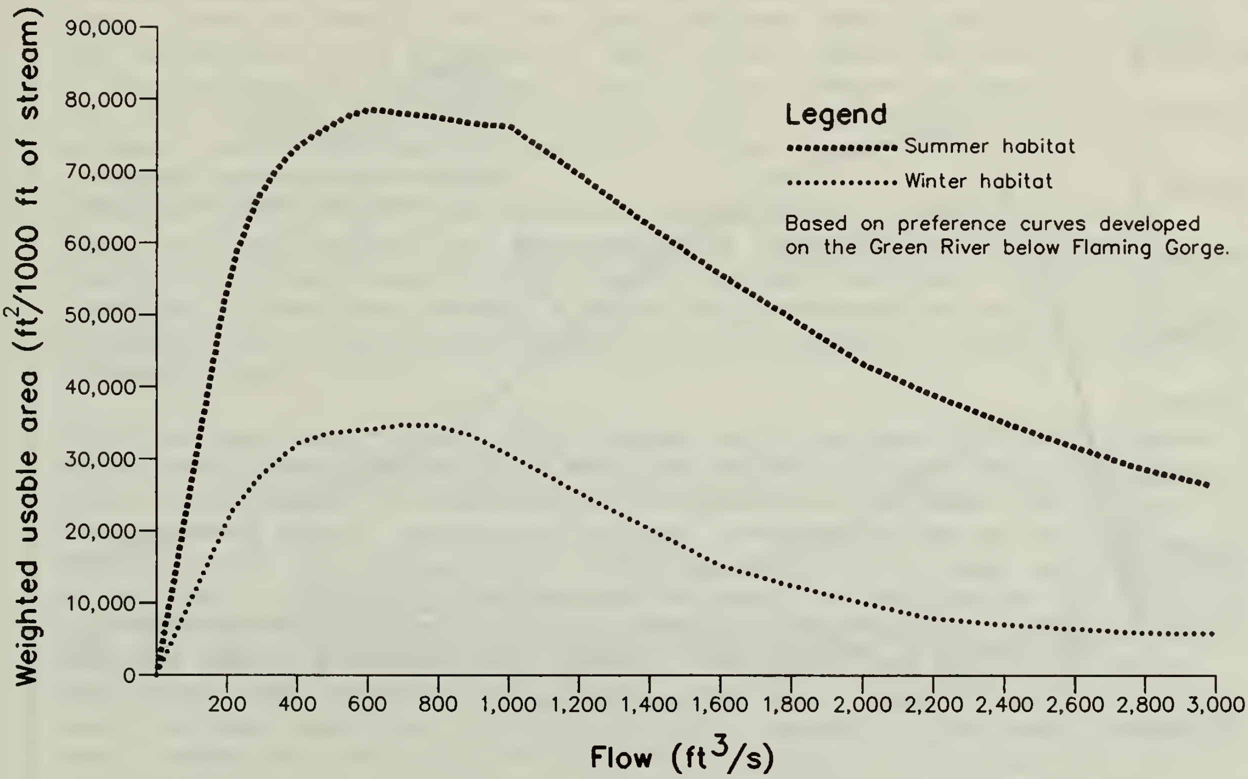


Figure 3.11. Adult rainbow trout habitat (Gunnison River at Duncan Trail).

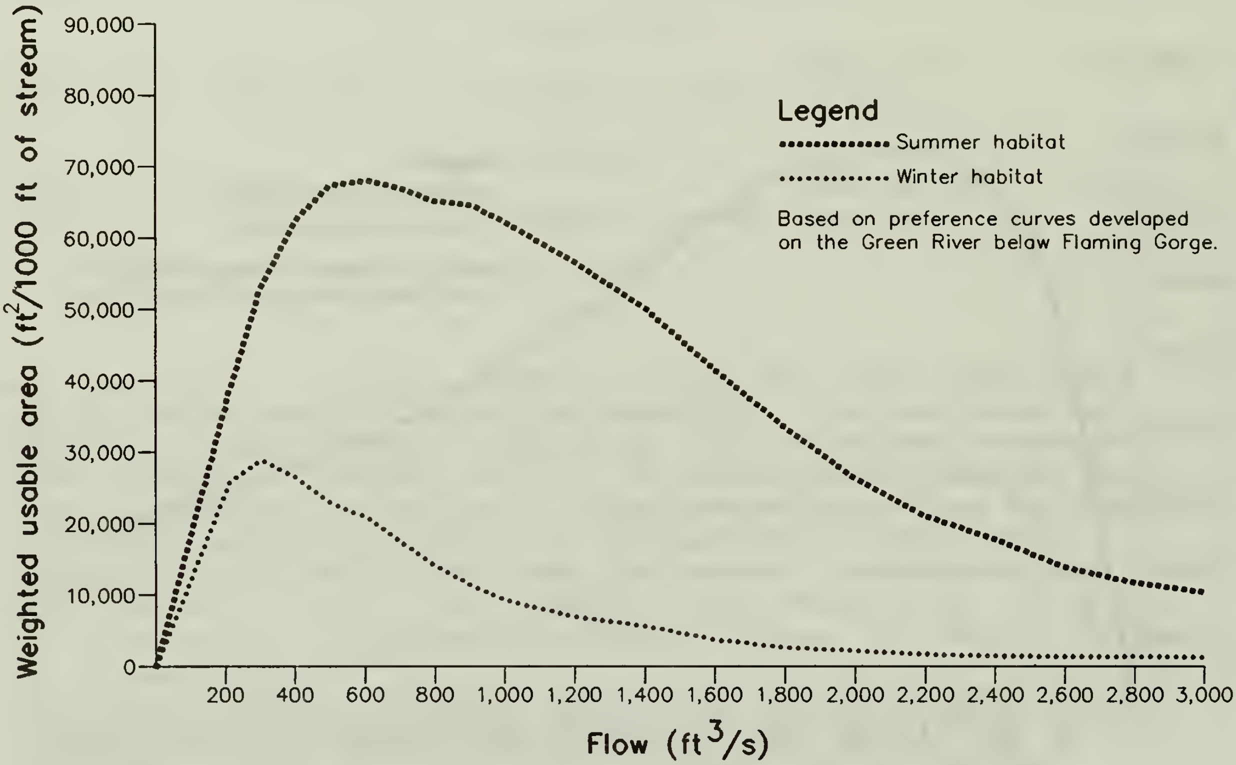


Figure 3.12. Adult rainbow trout habitat (Gunnison River above the North Fork).

the Gunnison River as measured in two river reaches. Adult summer habitat conditions above the North Fork appear best at flows ranging from 400 to 1,000 ft^3/s, while winter habitat conditions are best at flows ranging from 300 to 400 ft^3/s. The WUA-flow relationship is similar for the Duncan Trail area, only a much broader range of flows is optimum. Figure 3.13 indicates that spawning conditions for both rainbow and brown trout above the North Fork are optimum at 500 ft^3/s. Spawning habitat appears to be limited at the Duncan Trail site, with a maximum of 700 square feet per 1,000 feet of river, but follows the same general trend by peaking near 500 ft^3/s.

If brown trout eggs are laid in the spawning gravels at high flows during October and November and these flows are subsequently reduced, many of the redds can be left dry, destroying the eggs. The same potential for egg destruction exists for the rainbow trout during the spawning and incubation period of April through June.

June through early July is the most critical period for rainbow trout and mid-April through May for brown trout. The critical trout life stage in most large southwestern streams and rivers is the swim-up fry or emergence stage. Near-zero water velocity habitat must be present upon swim-up, or the fry may be destroyed by current. PHABSIM predictions related to the amount of swim-up fry habitat correspond well with field observations (Nehring and Miller, 1987; and Nehring, 1988b). Nehring and Miller's study indicated that rainbow and brown trout age 1-year class strength has a strong positive correlation with monthly flow WUA (PHABSIM) and a negative correlation with mean monthly flow from the year of emergence. In other words, trout year class strength is directly related to the amount of fry habitat available at the time of emergence from the gravels and inversely related to mean monthly flow at that time.

Figure 3.14 provides a general representation of a channel cross-section on the Gunnison River within the Gunnison Gorge in relationship to flow. Figure 3.15 indicates that the greatest amount of swim-up fry habitat occurs when flows are below 400 to 500 ft^3/s. At flows of 800 to 1,500 ft^3/s, there is approximately 1 to 2 feet of near-zero velocity water along each bank which produces fair to poor swim-up fry conditions. At approximately 1,500 ft^3/s, the river begins to leave the main channel and inundate the riparian vegetation. This produces a high flow window (1,500 ft^3/s to 2,000 ft^3/s) with improved swim-up fry conditions. However, sudden flow reductions are more likely to occur at these high flows and can isolate the fry from the river.

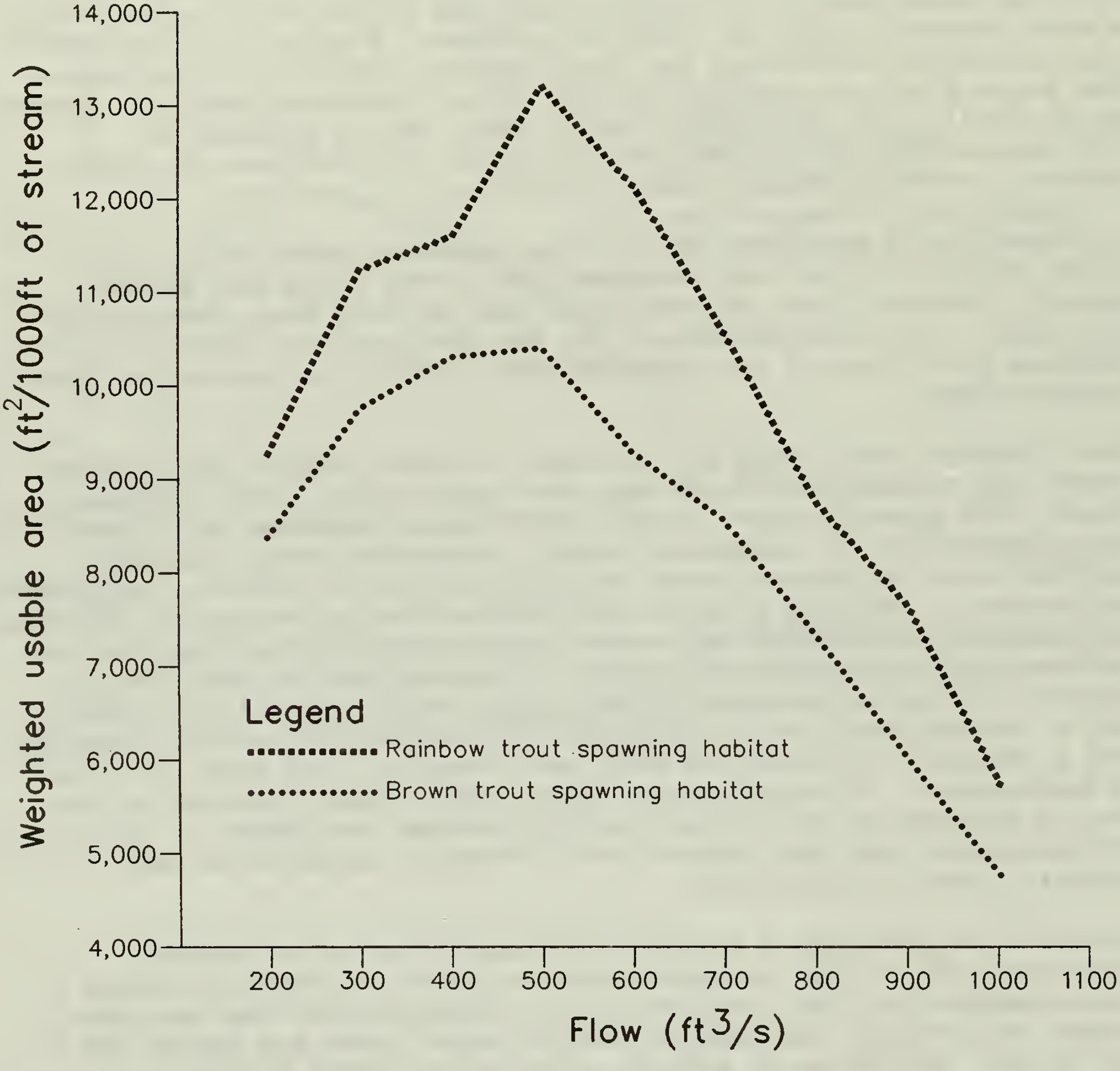


Figure 3.13. Rainbow and brown trout spawning habitat (Gunnison River above North Fork).

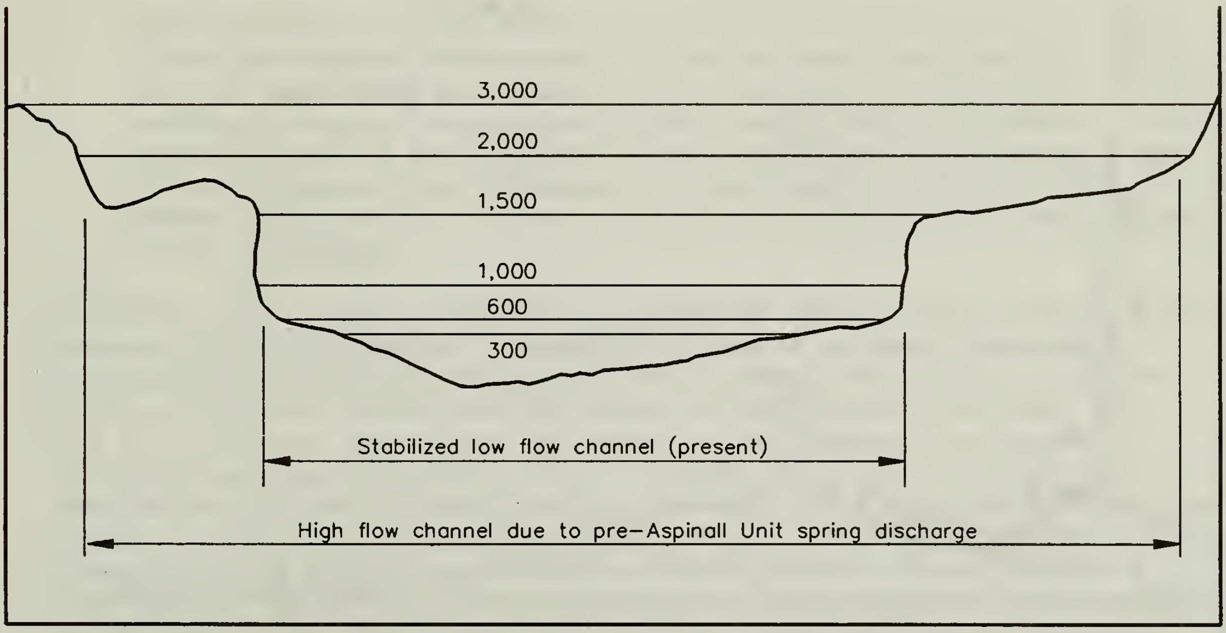


Figure 3.14. Stylized channel cross section (Gunnison River in the Gunnison Gorge, in ft^3/s).

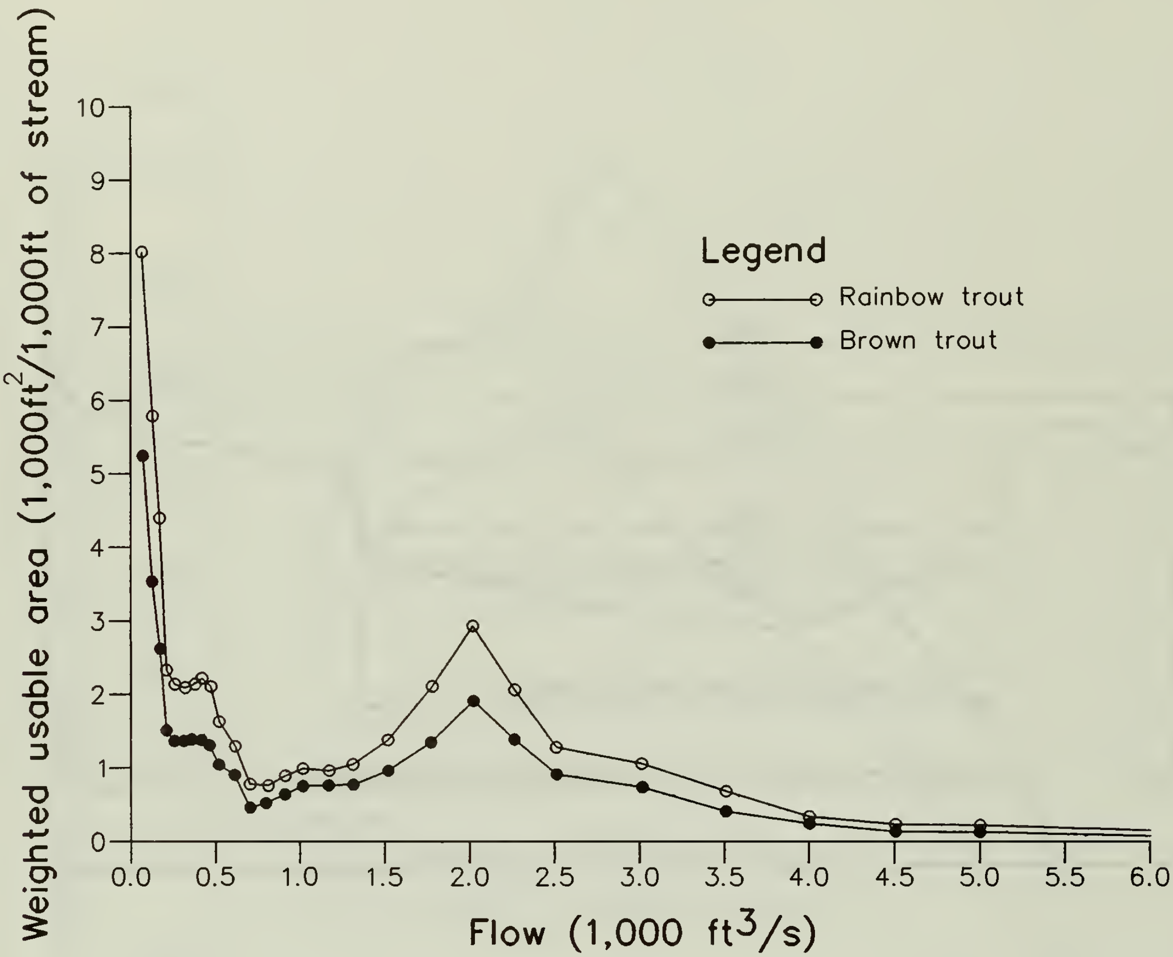


Figure 3.15. 2 to 4 week old fry habitat (swim-up fry) on the Gunnison River (Nehring and Miller, 1987).

In summary, studies have shown that various flow-related factors greatly influence the Gunnison River fishery:

1. A flow of 200 ft^3/s is an adequate minimum, but substantial habitat gains occur between 200 and 300 ft^3/s. Available trout habitat drops dramatically below 200 ft^3/s.

2. Stable flows during the spawning and incubation period are needed to protect the eggs.

3. Medium-to-low stable flows provide the best survival conditions for trout swim-up fry. The 45-day time period (June 1 through July 15) is probably the most critical period in the Gunnison River for rainbow trout reproductive success. The period April 15 through June 15 is critical for brown trout. If significant flow changes are necessary, gradual incremental changes help prevent the total loss of an entire year class of trout.

Stanford (1989) has studied the Gunnison River and estimated that the existing biophysical conditions would be most reasonably protected by both maintaining flows around 600 ft^3/s with as little fluctuation as possible and by minimizing periods of 300 ft^3/s flows (less than 30 days in any 5-year period). Stanford expressed concern that there would be a significant shortening of the discontinuity distance if flows were maintained closer to 300 ft^3/s than 600 ft^3/s (discontinuity distance is the distance from a dam to the point where in the river gradient biophysical conditions resemble those that existed in an upstream area before the river was regulated). Studies on the Gunnison River previously cited indicate that optimum flows for adult trout are around 500 ft^3/s, and the 600 ft^3/s flow stated above would also be excellent. Optimum flows for juvenile and fry, however, are closer to 300 ft^3/s. Also, as can be seen from tables 3.6 through 3.11, minimum flows of 300 ft^3/s are reached under the no-action and development alternatives more often than the recommended 30 days in a 5-year period. At 300 ft^3/s, adult trout habitat conditions are still above 80 percent of the optimum seen at 500 to 600 ft^3/s.

South Canal.--The fishery in the South Canal is seasonal, dependent on the movement of fish through the Gunnison Tunnel. Flows within the South Canal do not occur during the winter because there is no irrigation demand. Because the South Canal is partly located on private land and because it has hazardous sections, it historically has been closed to public fishing.

Uncompahgre River.--The fishery resource of the Uncompahgre River is poor because of high turbidity, heavy siltation, poor substrate condition, poor water quality, poor pool quality, bank instability, high spring flows, and extremely variable summer flows. The fishery habitat in the Uncompahgre River below Colona can be characterized as 24 percent riffle, 75 percent run (72 percent deep-fast, 2 percent deep-slow, 1 percent shallow-slow), and 1 percent pool. The lack of pool and slow deep-run type areas limit the amount of habitat available for adult trout which prefer velocities around 1 foot per second in the summer and 0.5 foot per second or less in the winter. Poor water quality is probably the biggest factor in the low productivity of the Uncompahgre River.

CDOW indicates that siltation is the primary limiting factor in the Uncompahgre River (CDOW, 1976 and 1983). The heavy siltation load may reduce primary production (algae and aquatic plants) and secondary production (macroinvertebrates), potential prey organisms for fish. However, this does not appear to be the case above Montrose, as macroinvertebrate populations appear to be in good condition. Below Montrose, however, macroinvertebrate populations are severely reduced. Siltation may also destroy trout eggs, larvae, and fry by suffocation, limiting trout production.

Seven species of fish are commonly found in the Uncompahgre River below Colona: white, bluehead, and flannelmouth suckers; mottled sculpin; speckled dace; and brown and rainbow trout. Suckers and sculpin dominate the river in numbers and presumably in biomass. Rainbow trout are common in the Uncompahgre River for several miles below the South Canal outfall which discharges cold water of high quality from the Gunnison River. Most of the rainbow trout in this section originate from the Gunnison River through the Gunnison Tunnel and South Canal. In general however, both rainbow and brown trout are uniformly distributed in small numbers between Colona and Montrose. Very few young trout have been collected in this reach, indicating little or no natural reproduction. Below Montrose, both trout species are extremely limited.

Impacts of Development Alternatives

Gunnison River.--As previously discussed, a number of measurements, including species composition, density, biomass, secondary production and WUA, may be used to quantify a fishery's quality. These same measurements may be used to assess impacts on the fishery from the various development alternatives. Prediction of the degree of impact, however (e.g., rainbow trout biomass would increase or decrease by a specific percentage), is difficult.

The loss of fish species from the Gunnison River as a result of development would be unlikely. Negative impact of the development on the species composition and relative abundance (percentage composition) of fish in the Gunnison River downstream of the Uncompahgre River confluence is also unlikely because the amount of water downstream of the confluence would be unaffected by development. However, a shift in the relative abundance of fish species may occur in the Gunnison River above the confluence. Rainbow and brown trout may comprise a greater percentage of the population after completion of the project, the result of increased trout reproduction because of a higher frequency of low and moderate flows. Flows of near 300 ft^3/s between Crystal Reservoir and the North Fork are important during certain periods because of the amount of suitable habitat available for newly hatched swim-up fry. Nehring and Miller (1987) consider fry as the critical bottleneck in trout population dynamics within the Gunnison River. Although trout species may become more important numerically than nongame species such as suckers, a decline in sucker numbers or biomass is not anticipated.

<u>Water Temperature</u>.--As compared to the no-action alternative, one consequence of the development alternatives would be an increase in the frequency of 300 ft^3/s flows in the Gunnison River between Crystal Reservoir and the North Fork confluence. Figure 3.3 shows an increase of approximately 43 percent in the occurrence of mean daily flows of 300 ft^3/s as a result of the alternatives. Water temperature in the Gunnison would also change with the increase in the frequency of 300 ft^3/s flows. During the winter, the frequency of water temperatures near 0 °C (32 °F) upstream of the North Fork and the formation of frazil and sheet ice would increase. Conversely, water temperature during June through August would be likely to increase, especially below the confluence with the North Fork where the influence of Crystal Reservoir on river limnology is less dramatic.

The increased frequency of 0 °C (32 °F) water during the winter between Crystal Reservoir and the North Fork theoretically could affect the fishery in three ways: (1) increased mortality of brown trout eggs deposited during the previous fall; (2) increased time required for development of brown trout; and (3) decreased growth of game and nongame fish resulting from more frequent occurrence of cooler water temperatures.

Increased mortality of brown trout eggs deposited in redds during fall spawning theoretically could result from development of anchor ice or increased scouring by frazil ice. However, according to Behnke (1986), this seems unlikely, based on the observation that brown trout presently inhabit, quite successfully, upper reaches of the Gunnison River where climatic conditions are considerably more severe. Brown trout are similarly present in a large portion of Colorado at considerably higher elevation and the North American continent at northern latitudes where climatic conditions are considerably more harsh than west-central Colorado (Behnke, 1986). According to Behnke, these empirical data should lessen concern that reduced winter flow to 300 ft^3/s in the Black Canyon of the Gunnison would increase the mortality of incubating eggs from ice or the associated effects of lower water temperature. Brown trout are apparently quite adept at selecting redds that maximize the probability of egg survival.

Behnke (1986) briefly summarized the attempts of two other scientists to duplicate brown and brook trout redd selection in Wyoming streams exposed to severe winter conditions. Reiser and Wesche (1977, as cited by Behnke) constructed artificial redds in the Laramie River at sites with ideal hydraulic parameters and placed eggs in these redds. All of the eggs froze in the artificial redds. Survival to hatching only occurred when eggs were planted in natural redds previously constructed by female trout. Physical conditions within the stream bed, such as upwelling of ground water or flow conditions, are apparently critical to egg survival.

A delay in hatching of brown trout eggs in the spring may also result from decreased flow in the Gunnison River. Because of additional diversion of water for the project, the water temperature may decrease by 1 to 2 °F (Behnke, 1986). This would presumably occur further downstream near the North Fork confluence, since water temperature immediately below Crystal is a function of releases from Crystal Reservoir. Behnke (1986) estimated a 7- to 10-day delay in the hatching of brown trout eggs with a decrease in water temperature by 1 to 2 1 °F for a period of 90 to 100 days. This delay seems insignificant when compared to the natural variability in the normal time of hatching for brown trout in the Gunnison River. Nehring (1988b) observed newly hatched brown trout fry during 1987 as early as April 11 and as late as June 12. He concluded that brown trout emergence is spread over a 30- to 40-day period in any single year and perhaps historically over a 60-day period.

Increased water diversion for hydropower, resulting in decreased water temperature during the winter and increased water temperature during the summer, could affect the growth rates of game and nongame fish species. As previously discussed, the changes in water temperature in the Gunnison River should be most apparent a substantial distance downstream from Crystal Reservoir, perhaps near the North Fork confluence. The alternatives would result in a mean monthly reduction in flow of 170 to 310 ft^3/s in the Gunnison River during June through August. The result would be a warming of the Gunnison River. Water temperature presently increases from 7 to 16 °C (45 to 60 °F) during July and August between Crystal Reservoir and the North Fork confluence. These temperatures are in the range considered optimal for trout growth and are also suitable for nongame fish species present. With a reduction in mean monthly flow of approximately 200 ft^3/s during the summer below the Gunnison Tunnel, temperatures near the North Fork confluence may increase by 2 to 4 °F.

The greater occurrence of extended minimum flows of 300 ft^3/s in the Gunnison River after completion of the project would increase the frequency of warmer water temperatures near the North Fork. Nehring (1988c) cited research on trout growth-temperature interrelationships by Eliot (1975a, b) that

> ...strongly supports the hypothesis that water temperatures in the Gunnison Gorge above the North Fork confluence even in a low water year such as 1988 are about as close to optimum conditions as one could probably expect to find in a regulated stream.

Nehring (1982) reported healthy, robust trout near Austin during the summer of 1981, a year when flows approached 230 ft^3/s at the East Portal of the Gunnison Tunnel and water temperatures routinely exceeded 20 °C (68 °F) at Austin (see table 3.24). North Fork inflows were also considerably reduced during 1981 compared to historic flows. The average weekly water temperature during 1988, also a low flow year, did not exceed 18.1 °C (64 °F) above the North Fork confluence but did reach 20 °C (68 °F) at Austin. Maximum instantaneous water temperature near Austin reached 24 °C (75 °F) during 1988. Nehring (1988c) observed that rainbow and brown trout are growing faster in the North Fork to Austin reach of the river than trout upstream of the confluence despite the low flows and elevated water temperatures seen in 1988.

In summary, these data suggest that although increased summer water temperatures would occur, trout growth decrease and trout mortality would probably not occur under the development alternatives. Assuming trout growth rates are not changed substantially by the anticipated change in water temperature, the Gold Medal and wild trout status should be unaffected.

Measurements taken by Reclamation near the North Fork and Austin during 1988 showed dissolved oxygen concentrations in excess of 10 mg/l. These concentrations are suitable for maintaining a trout fishery and should be maintained under development conditions.

Macroinvertebrate populations could be affected by the increased diversion of water through the Gunnison Tunnel by reducing wetted perimeter. Ice is also known to reduce the winter macroinvertebrate populations in Colorado rivers and streams where winters are harsh and ice development extensive (Burkhard, personal communication, 1987). If ice jamming or severe anchor icing occurred to the extent that resulted in significant streambed scouring, macroinvertebrate density and biomass and even fish could be adversely affected. During the 1988-1989 winter, such conditions developed along about 2 miles of the Gunnison River in an area about 2 miles upstream from Delta.

Several investigators have indicated that anchor and frazil ice may increase the number of organisms in the drift by dislodging them from the substrate (Reimers, 1957). However, most studies have concluded that the reduction in total numbers of macroinvertebrates was negligible (Benson, 1955; Brown, Clothier, and Alvord (1953); and Needham and Jones, 1959).

The break up of extensive ice jams with its subsequent grinding and scouring can severely reduce the macroinvertebrate populations in a river. As described previously, this type of ice jam occurred above the Hartland Diversion Dam near Delta downstream from the better trout areas in the river.

Benson (1955) concluded that it was doubtful that anchor ice could smother trout eggs under conditions where the ice was intermittent because the ice generally had a rather porous texture. He did suggest that trout swim-up fry would be vulnerable at the time of emergence if ice were present; however, this timing would not occur on the Gunnison River.

The occasional high winter mortality of trout populations associated with ice conditions is apparently not due to a lack of food or low water temperatures, but rather more likely caused by catastrophic events such as dewatering of stream sections by ice jams (Benson, 1955). This type of extensive ice build up was not observed in the Gunnison Gorge during the low water winter of 1988-1989. Sheet and shelf ice offer cover to trout along otherwise open stretches of river (Maciolek and Needham, 1952).

Impacts to the game and nongame fishery of the Gunnison River resulting from changes in water temperature seem unlikely, especially considering that the minimum postdevelopment flows and maximum water temperatures would not differ substantially from the low flow conditions observed during 1977, 1981 and 1988. During these low flow years, trout populations remained healthy and viable. Higher trophic organisms such as trout are a direct indicator of the health of the ecosystem. If reduced flows and the accompanying changes in water temperature affected macro-invertebrate populations, these impacts should have been reflected by decreased growth or increased mortality in the fish population. This is apparently not the case, as trout production was excellent.

Alternative F would periodically increase flows during January and February to remove ice buildup within the Gunnison River. Flows would be increased to approximately 600 ft^3/s by reducing diversion through the Gunnison Tunnel and be maintained for a sufficient time period to remove ice buildup. This temporary increase in flow should have little impact upon the Gunnison River fishery. Spawning by brown trout is complete, and swim-up fry are not present in the river during this period. Adjustment to the temporary increase in flow should be easily made by adult fish. In fact, the temporary increase in flow may have no positive or negative impact on the fishery. Assuming redd selection by brown trout optimizes egg survival by selecting a location unlikely to freeze under extreme conditions (see previous discussion), the additional flows would provide little additional benefit.

Habitat.--The use of PHABSIM to investigate relationships between fish habitat and flow has been the subject of considerable discussion, primarily oriented toward whether fish habitat expressed as WUA and biomass are correlated. The data presented previously showing the strong positive association between PHABSIM estimates of WUA and actual trout biomass data suggest that the model works quite well in making predictions about the condition of a fishery in relation to flow.

Although PHABSIM may be used to investigate the historical relationship between flow and (indirectly) the viability of a fish population, it may also be used to indicate potential impacts from flow diversion on the fishery. These impacts may be either beneficial or adverse. A potential impact to the fishery from the project may result from decreased flows in the Gunnison River. Figures 3.16 and 3.17 represent a habitat time series for spawning, incubation, fry, and adult rainbow trout life stages for the Gunnison River near the Duncan-Ute Trail.

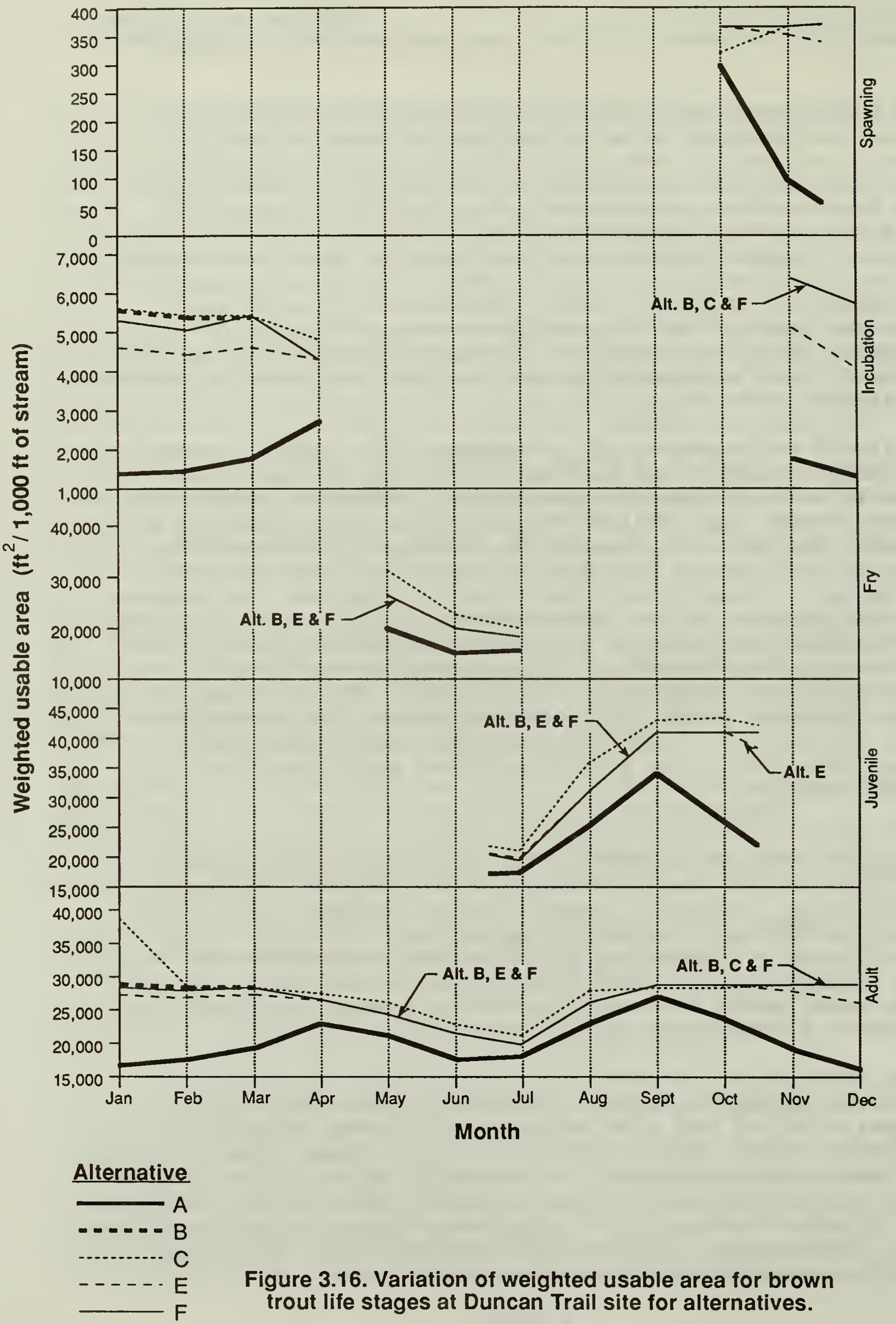


Figure 3.16. Variation of weighted usable area for brown trout life stages at Duncan Trail site for alternatives.

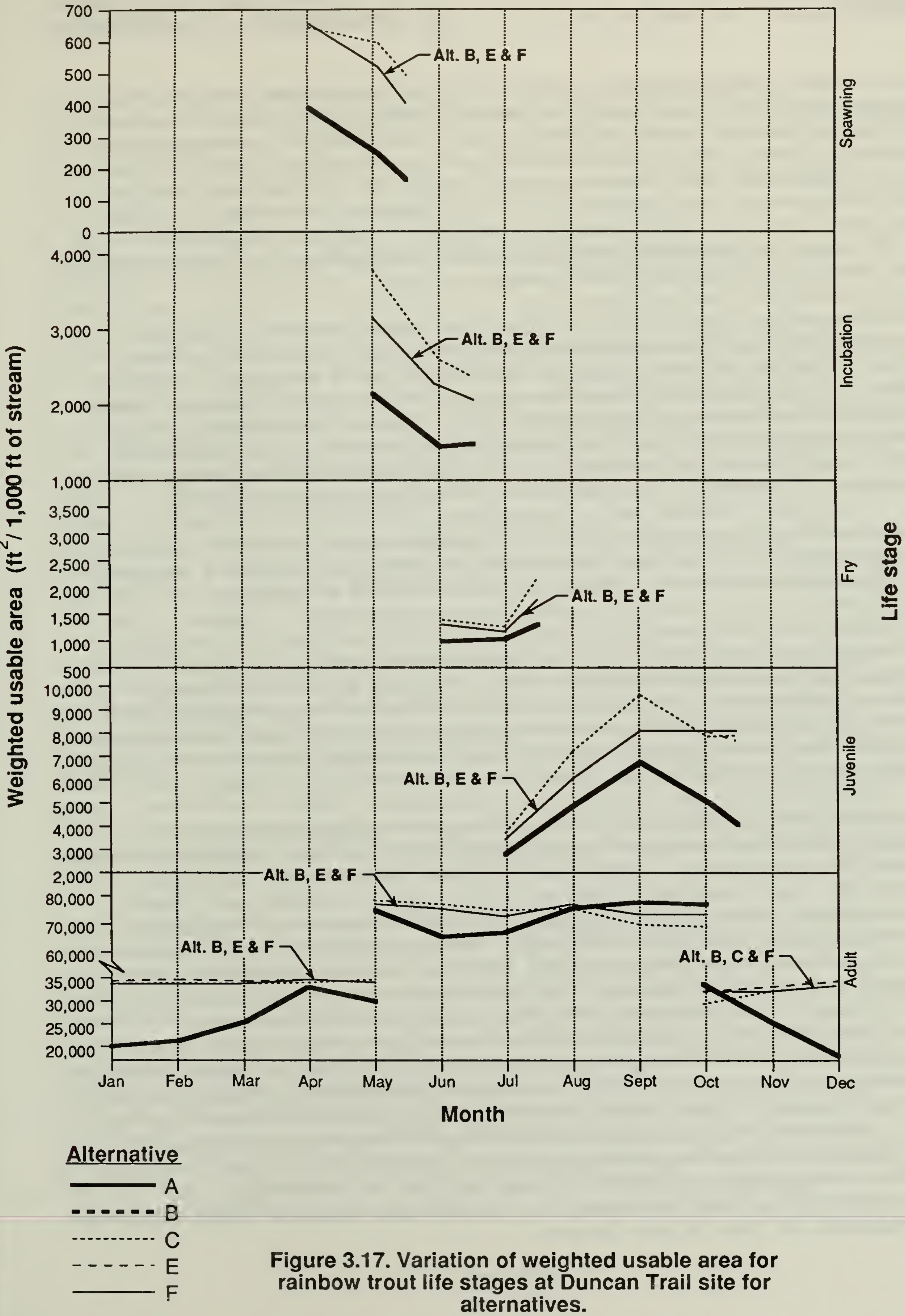


Figure 3.17. Variation of weighted usable area for rainbow trout life stages at Duncan Trail site for alternatives.

Except for alternative A, each of the alternatives results in similar available habitat for the various life history stages. Available habitat under alternative A (no-action) conditions is generally less. This pattern is consistent at the Duncan-Ute Trail and North Fork sites; hence, only the Duncan-Ute Trail PHABSIM results are presented in the figures. The North Fork area does contain more spawning habitat than the Duncan-Ute area. An increase in spawning habitat under development alternatives is also seen in the North Fork area.

The Duncan-Ute Trail section contains large pool-run-riffle complexes and is characteristic of the river in the Gunnison Gorge. The North Fork section demonstrates a broader, flatter channel configuration, characteristic of the river between the Smith Fork and North Fork confluence. About 70 percent of the river downstream of the Gunnison Tunnel exhibits the Gunnison Gorge characteristic of deeply incised canyon walls, while the remaining 30 percent is typical of the North Fork location.

In evaluating the results of the PHABSIM model, consideration must be given to the best flow for the each of the life stages. For the population as a whole, the best flow is where reproduction, survival and growth are optimized. However, the best flow for the specific life stages may differ; for example, the best flow conditions for rainbow trout adults are not necessarily the best conditions for swim-up fry or spawning trout. Therefore, the question of which life stage limits the potential of the fishery becomes important. The PHABSIM results must also be interpreted considering knowledge about the fishery gained through collecting field data and observations.

As stated previously, the swim-up fry or emergence stage is probably the most critical life stage for rainbow and brown trout in the Gunnison River. Nehring (1988b) feels that, in most instances, the limiting life stage for both rainbow and brown trout is the swim-up fry stage. In some cases, the available spawning habitat may be limiting. To assess swim-up fry habitat, Nehring developed a graph of fry habitat versus discharge for the swim-up fry stage (figure 3.15) which shows that low stable flows around 300 ft^3/s from April through July produce the best conditions for the fragile emergence stage. High stable flows around 2,000 ft^3/s also produce excellent emergence conditions as flow moves into the low-lying riparian vegetation (figure 3.14). Between 650 and 1,500 ft^3/s, swim-up fry conditions are fair to poor. However, flows exceeding 500 to 600 ft^3/s are not as favorable for trout spawning habitat (see figure 3.13). Nehring (1988b) recommends an optimum flow of 300 ft^3/s between the beginning of May and mid-July for brown and rainbow trout swim-up fry habitat in the Black Canyon.

Compared to the years since Aspinall Unit construction, the frequency of flows near 300 ft^3/s below the Tunnel would increase with development. Therefore, the swim-up conditions would remain adequate and could improve. The PHABSIM model indicates that alternative A provides the least amount of fry habitat, while alternative C provides the most.

Moderate water years where flows between May and July range between 300 and 600 ft^3/s are probably the most important from the standpoint of trout reproduction. With development alternatives, the frequency of these moderate flow conditions during May-through-July would increase from a frequency of 60 percent to 70 percent. Mean monthly flows during these months would decrease by approximately 200 ft^3/s in May, 270 ft^3/s in June, and 150 ft^3/s in July because of increased diversion into the Tunnel. This flow reduction would have a positive impact by reducing many May-through-July flow periods into the 500-to-800 ft^3/s flow range, a range that produces fair swim-up fry conditions. Also, flows in the 500-to-800 ft^3/s range would be pushed into the 300-to-500 ft^3/s range, producing excellent swim-up fry conditions. During high water years such as 1983, the swim-up fry habitat and the ultimate trout recruitment would remain only fair.

Incubation and spawning habitat for rainbow trout are estimated to increase by 60 to 78 percent under development alternatives. The PHABSIM model indicated an even greater improvement in brown trout spawning and incubation habitat. Based on the PHABSIM modeling results, a flow of approximately 500 ft^3/s is best for brown trout spawning habitat on the Gunnison River near the North Fork. Nehring (1988b) recommends a minimum flow of 300 ft^3/s between mid-October and mid-November and between the beginning of April and mid-May for providing spawning habitat for brown trout and rainbow trout, respectively.

Nehring also recommends an optimum flow of 1,200 ft^3/s between mid-October and mid-November and 1,000 ft^3/s between the beginning of April and mid-May for providing spawning habitat for brown trout and rainbow trout, respectively, because some of the higher elevation gravel bars are under water at these river stages. However, as previously discussed, these higher flows are not optimal for other life stages such as swim-up fry and adults. Also, eggs laid in these higher elevation gravel bars are subject to dewatering if flows in the Gunnison River drop. Thus, for ultimate reproductive success, it is probably better for the trout to spawn on the lower elevation gravel bars which are less subject to dewatering. PHABSIM results indicate that little difference exists in incubation and spawning WUA for each of the development alternatives. Again, existing conditions (alternative A) provide the least amount of habitat.

The relatively long incubation period for brown trout (October to March) is a critical period. If brown trout eggs are deposited in the spawning gravels during relatively high flows in October and November and flows are subsequently reduced during the incubation period, many redds can be left dry, destroying the eggs. Nehring (1988b) summarized information about redd dewatering based on the research of a number of scientists who reported that redd dewatering for up to 8 hours or more for several days to weeks did not have a detrimental impact on egg and embryo survival provided: (1) intra-gravel humidity levels were maintained at 100 percent saturation; and (2) maximum and minimum intra-gravel temperature extremes did not reach the lethal limit. Redd dewatering during the winter is likely to result in freezing the developing embryo.

CDOW indicates that most redds in the Gunnison River constructed during flows of 1,000 to 2,000 ft^3/s remain wet at flows above 600 ft^3/s. The project would reduce the number of times flows would drop substantially between fall brown trout spawning and spring hatching. Without development, 1,000- to 2,000-ft^3/s flows in October and November dropped 5 times to below 600 ft^3/s by March over the 32-year study period. If the development were in place, this reduction would not have occurred. In fact, it appears that flows in November, the primary brown trout spawning period, would always be in the 300-to-700 ft^3/s range, near optimum for brown trout spawning. Lower stable winter flows at near optimal spawning and incubation levels as a result of the development should enhance brown trout reproduction in the Gunnison River. However, in 5 years during the 32-year period, simulated flows dropped from 600 ft^3/s to 300 ft^3/s after brown trout spawning, significantly reducing the amount of suitable habitat. Eggs laid at 600 ft^3/s could be dewatered at 300 ft^3/s, reducing successful reproduction. However, the increased fry survival at 300 ft^3/s should help offset the loss of eggs during these years.

Nehring (1988b) recommends minimum and optimum flows of 300 ft^3/s and 500 ft^3/s, respectively, for brown and rainbow trout adults. In general, CDOW believes that adult habitat is not limiting populations on the Gunnison River. Therefore, a moderate change in the available trout habitat resulting from the project is not anticipated to significantly affect the existing trout population. Figures 3.16 through 3.17 show little difference in adult habitat for each of the development alternatives. A gain of habitat is shown in most months, but adult rainbow trout habitat show a reduction during August and September. The greatest habitat decreases occur with alternative C.

The above habitat analyses suggest that physical trout habitat in the Gunnison River below the Tunnel might be enhanced should the facility be developed. The beneficial effect on trout habitat associated with lower flows in the Gunnison River has been previously suggested by others who have studied the possible effects of flow modification on the Gunnison River trout fishery (Kinnear and Vincent, 1967; Nehring and Anderson, 1983; Behnke, 1984). Kinnear and Vincent studied habitat within the Black Canyon of the Gunnison National Monument and discussed the habitat-type changes with differing flows. Density, biomass and production of trout could actually increase as a result of the project. Should trout habitat improve substantially, other factors such as prey availability or overcrowding may become important in regulating trout population in the Gunnison.

A summary of minimum and optimum flow needs for various life stages of brown and rainbow trout is shown in table 3.35. These flows are compared to the average flow conditions that would occur with each of the alternatives.

The year-round water diversion from the Gunnison River through the Gunnison Tunnel could increase the loss of fish from the Gunnison River. Although unquantifiable and probably confined to the 1-mile reach between Crystal Reservoir and the Gunnison Tunnel, these losses might be important regarding the angling success in this easily accessible and heavily fished reach. These losses could be partially offset by gains made by increasing the amount of trout habitat as a result of reduced flows. A fish barrier on the AB Lateral inlet to keep fish in the South Canal would be installed as part of the development. The barrier, with 1.5 to 2-inch bar spacing, would be designed to minimize adult fish entrainment, and the Sponsors would coordinate its design with the CDOW.

<u>South Canal</u>.--Reclamation and the UVWUA restrict access to the South Canal for public safety reasons. However, the canal is nevertheless used by local residents as a fishery. Fish populations are dominated by fish moving through the Gunnison Tunnel. Under all development alternatives, it is anticipated that the fish population in the South Canal would remain comparable to or would increase because of the no-action alternative.

The small resident population of trout in Cedar Creek, a tributary of the Uncompahgre River, should not be affected by reduced diversions of South Canal flows to the creek. Reduced

Table 3.35.--Minimum and optimum flow recommendations, by time period, species and life stage, compared to average monthly flows, in ft^3/s, for alternatives

Species	Life stage	Critical time period	Minimum flow[1]	Optimum flow[1]	Alternative A	B	C	E	F
Brown	Spawning	10/15 - 11/15	300	1,200	994	405	376	455	405
	Incubation	11/01 - 04/01	300	1,200	1,306	467	463	562	481
	Hatching	03/15 - 05/15	300	1,200	1,007	637	586	661	637
	Fry	05/01 - 06/15	300	300	1,098	863	768	863	863
	Juvenile	06/15 - 10/15	300	300	936	723	636	725	723
	Adult	04/01 - 09/30	300	500	984	769	682	771	769
		10/01 - 03/31	300	500	1,228	458	446	539	470
Rainbow	Spawning	04/01 - 05/15	300	1,000	949	683	616	693	683
	Incubation	04/15 - 06/15	300	1,000	1,053	804	720	807	804
	Hatching	06/01 - 07/01	300	1,000	1,287	1,001	915	1,001	1,001
	Fry	06/15 - 07/15	300	300	1,276	1,053	968	1,053	1,053
	Juvenile	07/15 - 10/15	300	300	812	604	516	606	604
	Adult	04/01 - 09/30	300	500	984	769	682	771	769
		10/01 - 03/31	300	500	1,228	458	446	539	470

[1] Source: Nehring, 1988b.

use of the creek as a canal could improve habitat conditions. However, agricultural runoff, highly variable water temperatures, and other factors would continue to preclude a viable fishery.

Uncompahgre River.--Each of the alternatives would decrease the amount of water entering the Uncompahgre River from the South Canal and increase the amount of water entering the Uncompahgre River from the tailrace. Decreased flow to the Uncompahgre River through the South Canal and increased flow through the tailrace is anticipated to be greatest for hydropower development at 1,135 ft^3/s (alternatives B, C and F). Therefore, development at 1,135 ft^3/s represents the greatest potential for fishery impacts on the Uncompahgre River.

The fishery in the Uncompahgre River between the South Canal and Montrose and throughout the river is presently dominated by nongame fish species such as suckers. Although increased water diversion for hydropower would result in reduced flows between the South Canal and the proposed tailrace during the irrigation season, the fish barrier constructed at the AB Lateral diversion would direct adult fish into the canal. Therefore, the number of trout reaching the Uncompahgre through the South Canal should increase slightly due to slightly greater diversions through the Tunnel during irrigation season, assuming that flow conditions alone are important in fish movement.

Trout habitat between the South Canal and the proposed tailrace would be affected by hydropower development at 1,135 ft^3/s. Under the no-action alternative, summer flows on the 2-mile reach of the Uncompahgre River between the South Canal and M&D Canal generally would range from 800 to 1,100 ft^3/s. Flows would be reduced to approximately 700 ft^3/s as a result of a 1,135 ft^3/s powerplant. Summer flows in the 5-mile reach between the M&D Canal and the Loutzenhizer Canal presently range from 200 to 600 ft^3/s and would be reduced to approximately 150 ft^3/s with the project. Summer flows in the 5-mile reach between the Loutzenhizer Canal and the AB Lateral tailrace would decrease from 100 to 400 ft^3/s to 20 to 65 ft^3/s.

Because of the lack of pool habitat between the South Canal and the proposed tailrace, it is possible that greater historical flows (especially between the South Canal and the M&D Canal) created river velocities greater than those considered desirable for the trout habitat. Thus, reduced velocities could increase usable trout habitat between the South Canal terminus and the Loutzenhizer Canal Diversion Dam. However, the 20- to 65-ft^3/s flow regime in the 5 miles of river below the Loutzenhizer Canal would prelude significant sport fishery development. The CDOW has made a preliminary estimate that a minimum flow of 60 to 80 ft^3/s would be needed to sustain a fishery. Habitat at 20- to 65-ft^3/s flows would be adequate for a put and take fishery in the spring and fall. However, summer water temperatures could exceed the range for trout growth and possibly survival.

Because of the variety of nongame fish species, reduced flows would not be expected to result in a decrease in nongame fish density. Should reduced flows result in severe conditions such as extreme summer water temperature, common carp may displace certain sucker species.

Below the proposed tailrace, development would increase river flows by an average of about 375 percent. Compared to present conditions, this may make the river less attractive to some species such as suckers and make the river more habitable to game species such as trout. However, habitat availability for trout may be limited by increased velocity. Substantially increasing the flow below the proposed tailrace where pools and slow deep runs represent less than 5 percent of the surface area could reduce available trout habitat by increasing the velocity beyond that which is optimum for trout.

The interaction of all of these altered environmental factors could be expected to have a positive overall effect on the Uncompahgre River sport fishery below the proposed tailrace, but the extent of the effect cannot be accurately assessed. For example, insufficient data exist to determine whether conditions in the Uncompahgre River would improve to the extent that natural reproduction of rainbow or brown trout would occur. However, it is reasonable to assume that the river would be suitable for establishing a plant-grow-take type of recreational fishery. Due to the project's proximity to Montrose, Olathe, and Delta, the demand would be high if available fishery developed.

Soils and Vegetation

Existing Conditions--Soils

Project Feature Area.--The proposed development would be located in the eastern portion of the UVRP. Physiographically, this area is a plain composed of outwash from the San Juan Mountains to the south of the study area. Its gently undulating or rolling topography has been formed by irregular erosion of the underlying Mancos Shale Formation; this topography is referred to locally as "adobe hills." Elevation in the study area ranges from

6,465 feet above mean sea level at the West Portal of the Gunnison Tunnel to 5,720 feet at Montrose, for a drop of 745 feet or about 100 feet per mile.

The Mancos Formation is a calcareous marine shale and is fractured and jointed near the surface. About 34 percent of the irrigated acreage in the Uncompahgre Valley consists of soils formed on and from the Mancos Formation (Reclamation, 1982). Locally, these soils are termed "adobe soils" and have a medium-fine texture and a depth over the parent material varying from a few feet to more than 20 feet. Some contain excessive amounts of salts that dissolved during weathering and deposited in underlying joints and fractures. Return flows of irrigation water from adobe soils often contain high concentrations of dissolved solids, contributing to the salt-loading problem in the Upper Colorado Basin.

The Sponsors analyzed surficial soil types within a corridor approximately 1/4 mile wide on either side of the penstock alignment from the penstock intake structure to the powerhouse site. The results of this analysis are summarized in table 3.36. The following descriptions of each of the types shown in the table have been extracted from the Soil Conservation Service (SCS; 1967).

Billings.--The soils of this series are deep, well drained, and moderately fine textured to fine textured. They are grassland soils formed on alluvial fans in sediments washed from shale and siltstone exposures and are calcareous throughout.

Depth to shale is generally more than 60 inches, but it is locally between 30 and 60 inches. Fourwing saltbush, sagebrush, and rabbitbrush are characteristic shrubs found on this soil type, often in association with or having been replaced by greasewood and cheatgrass. The soils are moderately productive for alfalfa, corn and small grains if irrigated and managed properly. In some cases, the land is used for orchards.

Chipeta-Persayo.--The soils of the Chipeta-Persayo association are shallow, well-drained, and moderately to fine textured. Like the Billings soil, these soils formed from weathering of calcareous parent material, primarily the Mancos Formation. Unlike the Billings series, these soils formed on upland slopes and ridges.

Table 3.36.--Summary of soils types within the penstock corridor

Soil type	Average slope percent	Area (acres)	Percent of total
Silty clay loams			
Billings (irrigated)	1	526.34	36
Billings	1	269.31	18
Persayo	1	35.84	2
Billings	4	18.43	1
Persayo	4	155.65	11
Silty clays			
Chipeta	1	3.07	0
Billings	4	2.05	0
Chipeta	4	4.10	0
Clay loams			
Vernal	1	23.55	2
Vernal	8	33.79	2
Loams			
Uncompahgre	1	10.24	1
Others			
Chipeta/Persayo complex	8	58.37	4
Rough broken land	50	260.10	18
Badland	50	69.63	5
Totals		1,470.47	100

Source: UVWUA, 1984.

The depth to underlying shale layers is usually less than 18 inches, and Chipeta soils are more fine textured than Persayo soils. Typical natural vegetation on Chipeta soils is saltbush, galleta, and squirreltail. A poor cover of annual weeds, cactus, and saltbush, with few native prairie grasses, develops under natural conditions on Persayo soils. Neither are normally suitable for tillage and are used primarily as range.

Vernal.--The soils of this series are deep, well drained, and moderately fine textured. They are grassland soils that formed on stream terraces in fairly uniform, calcareous material underlain by sand and gravel. Because of the sand and gravel layers, tillage is often difficult, frequent irrigation is needed, and damage to farm machinery often occurs. Therefore, soils of this series are used most frequently as rangeland.

Badlands.--Badlands consist of barren or nearly barren outcrops of gypsum and shale in various stages of weathering. These outcrops are capable of supporting little vegetation. The land is almost impermeable, runoff occurs rapidly following rain, and active erosion occurs.

Rough Broken Land.--Occurs on mesa slopes. Like badlands, this land classification consists mainly of exposures of sedimentary shale and sandstone, gravelly alluvial material, colluvial debris and shallow coarse soils. Unlike badlands, rough broken land may support a fairly dense cover of native grasses, shrubs, and forbs; thus, soils of this type are useful as range but seldom used for agriculture because of steep slopes.

Existing Conditions--Vegetation

Historically, vegetation in this area has been limited to desert shrub types consisting of saltbush at lower elevations and sagebrush at higher elevations (Reclamation, 1984). Pinyon-juniper stands occupied valley fringes, and riparian woodlands occurred along the major waterways. Now a variety of species of vegetation occurs in the study area. Those more typically found on uplands and slopes are intermixed with introduced grasses, forbs and other naturally occurring phreatophytic and mesophytic species associated with riparian zones and wetland habitats. This mixture of species is probably due to a long history of disturbance including construction and maintenance of the canal system and associated facilities, crop production, and livestock grazing.

The species present in the study area are distributed generally within four recognizable vegetation types or associations (see table 3.37)--sagebrush-saltbush shrub and half-shrub communities along the proposed penstock alignment; agricultural lands along the proposed tailrace and penstock alignments; wetlands along the existing AB Lateral; and riparian lands along the Uncompahgre and Gunnison Rivers.

Prior disturbance at the powerhouse site has resulted in that area being populated mainly with a variety of annual and perennial weeds and greasewood. Greasewood is usually found at lower elevations and typically occupies poorly drained soils or disturbed soils. Principal species at the powerhouse site are black greasewood, alkali sacaton, and broom snakeweed. Immediately west of the site are two alfalfa-brome grass hayfields separated by a stand of cottonwoods in which wood and other debris has been dumped.

Table 3.37.--Distribution of vegetation types in penstock corridor

Type	Total acres	Percent of total
Native shrubland	885	56
Agricultural	615	39
Urban/developed	68	4
Riparian	10	1
Total	1,578	100

Source: UVWUA, 1984.

Natural shrub- and half-shrub communities may be either dominated by saltbush, sagebrush, or greasewood. In the project area, this community type occurs along the penstock route and is a mixture of all of these species. The saltbush community of western Colorado includes several species of saltbush usually interspersed between pinyon-juniper areas and irrigated croplands. Dominant species in the study area include shadscale and fourwing saltbush. Prevalent grasses are galleta, bluegrass, and bottlebrush squirreltail. Rabbitbrush and broom snakeweed are also common.

The sagebrush community typically adjoins pinyon-juniper stands at higher elevations than the saltbush community. Big sagebrush, low sagebrush, and fringed sagebrush are the dominant species in the study area with rabbitbrush occurring less frequently.

An annual loss of 50 acres of deciduous and evergreen shrublands by conversion to agricultural use (50 percent) and housing (50 percent) now occurs in the valley each year (Reclamation, 1982). Agricultural land consists of cropland, range, and pasture, and hayland. Crops in the study area include irrigated corn, onions, and beans. Certain crops such as corn provide food sources for local wildlife populations. Pasture and haylands are usually developed on irrigated acreage and produce crops of alfalfa and improved pasture grasses. Small patches of uncultivated shrub vegetation often border pastures.

Gunnison River Corridor.--The major portion of the Gunnison River corridor consists of rock outcrop and extremely shallow soils.

Figure 3.18 shows the general location of soil complexes and land types associated with these units (NPS, 1979a). Mariah and Associates (1987a) characterized vegetation along the Gunnison River as riparian along the river and a complex mosaic of pinyon-juniper and various shrub/grassland types associated with abrupt changes in elevation along the canyon walls.

Historically, riparian vegetation along the Gunnison River above the North Fork was probably limited due to very high spring flows. Water storage and use began upstream in the nineteenth century and has included major storage impoundments such as Taylor Park Reservoir and the Aspinall Unit Reservoirs. The reduction in the high water flushing action has allowed development of several terraces along the river edge. Stanford and Ward (1984) describe vegetation changes occurring since completion of the Aspinall Unit.

Riparian vegetation along the Gunnison River now occurs in one of three zones: as a narrow band of grasses generally less than 8 feet wide adjacent to the river, as shrubs in seeps on gentler slopes of the valley walls, and as more well developed seral plant communities on the few low terraces and occasionally at the locations where side drainages join the Gunnison River. The low terraces have formed primarily during recent times in response to the reduction of spring runoff peaks by upstream dams. Such control prevents or greatly reduces annual flushing of alluvium from the canyon that might otherwise occur, thereby preserving the substrate needed for plant growth and riparian community development. The reduction of periodic high flows also reduces regeneration of cottonwoods.

Distribution of riparian vegetation within the canyon is discontinuous. A very narrow band of canary grass, the dominant invader species in this area, is present in portions of the canyon composed of granitic bedrock. Weber (1983) surveyed plants in the Black Canyon of the Gunnison National Monument and lists riparian species recorded. In contrast, the canyon widens in the Ute Trail crossing area and between the Smith Fork and North Fork where surface formations change from metamorphic to sedimentary rock. Extensive alluviation has occurred in these latter areas, allowing larger riparian zones to develop.

Terrace development in the canyon is most extensive near the Ute Trail crossing. The lowest, primary terrace, which is the youngest and nearest to the river's edge, is composed of alluvium and has probably developed since the river was first regulated. The second terrace at this site is also alluvium but is an older feature which probably developed before regulation of the river.

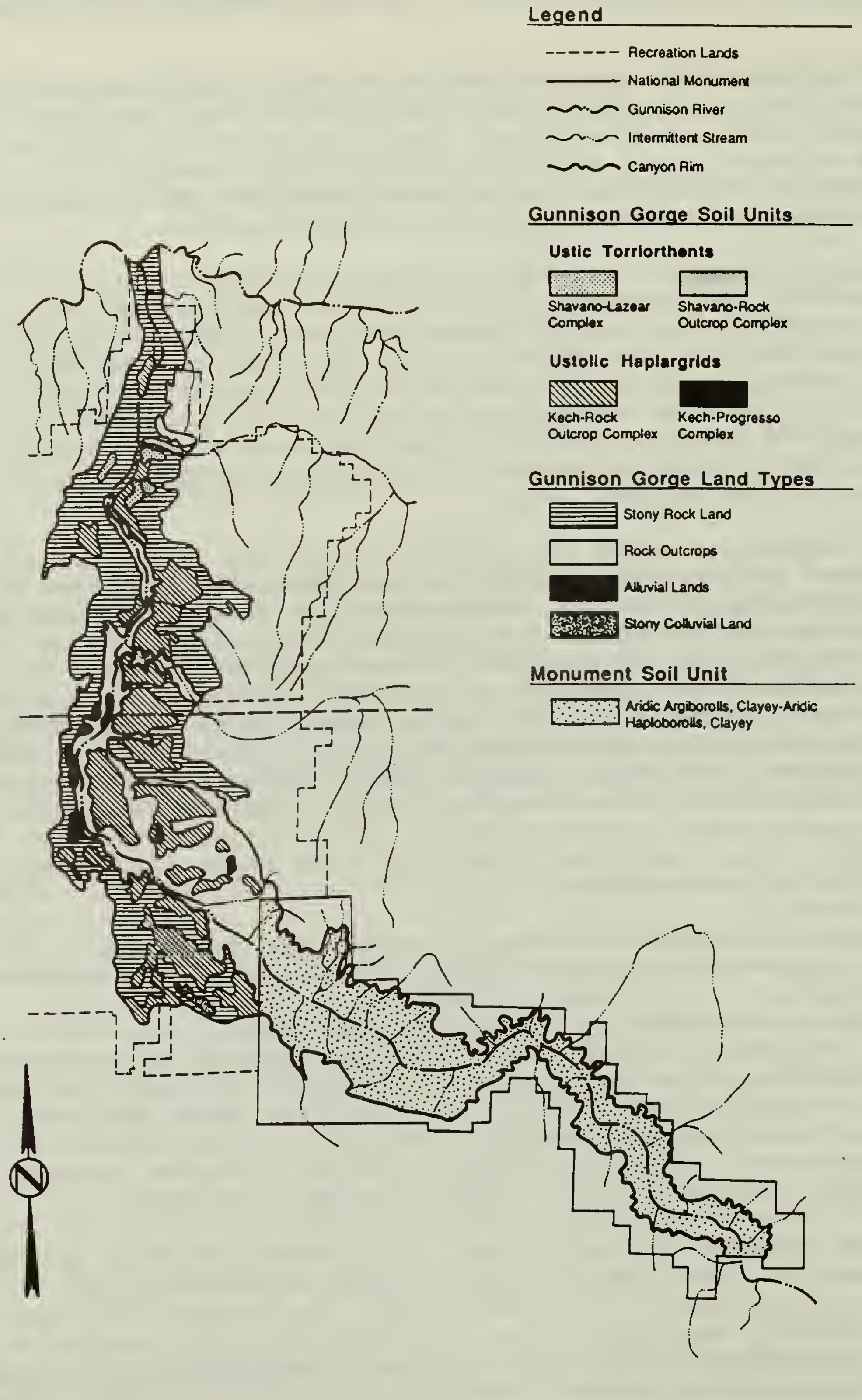


Figure 3.18. Gunnison River corridor soils.

A third and higher terrace of alluvial deposits also occurs here. Pinyon-juniper woodlands and shrub communities occur atop the higher terrace. In addition to pinyon pines and junipers, a sparse band of box-elders occurs some distance from the river in crevices of the granite canyon walls that accumulate precipitation.

The vegetative communities and their seral phases in the Gunnison River Gorge are summarized in table 3.38. Species diversity in these communities is low, with each seral stage dominated generally by one or two species.

Table 3.38.--Riparian vegetation of Gunnison River Gorge

Location/seral stage	Common name
First alluvial terrace	
Invaders	Canary grass
	Smooth horsetail
Secondary phase	Coyote willow
	Canary grass
Tertiary phase	Coyote willow
	Meadow grass
Second alluvial terrace	
Climax	Big sagebrush
	Rubber rabbitbrush
	Indian ricegrass
	Sand dropseed
	Fourwing saltbush
Colluvial terrace	
Climax	Serviceberry
	Big sagebrush
	Pinyon pine
	Juniper
	Bluebunch wheatgrass

Source: Mariah and Associates, 1987a.

In addition to the cited species in table 3.38, phragmites (a reed) and salt cedar, which are less resistant to the flushing action of high flow, replace canary grass and coyote willow, respectively, in protected locations. Salt grass often replaces canary grass at sites upriver from the Smith Fork and greasewood is also more common. Downstream from the North Fork confluence, riparian vegetation becomes more extensive with cottonwood groves scattered along the river's length.

Uncompahgre River Corridor.--Uncompahgre soils are floodplain and low terrace alluvial soils confined in the study area to the Uncompahgre River banks. They are deep, somewhat poorly drained, and moderately coarse to moderately fine in texture. Depth to bedrock is usually 60 inches or more. In their natural state, Uncompahgre soils are vegetated by riparian woodlands consisting mainly of cottonwoods and willows. Under cultivation, they are moderately productive and are used for truck farming, hay, and many other crops.

Cottonwood riparian zones occur along the Uncompahgre River at and downstream from the proposed tailrace. They typically exist as narrow, well-defined, linear stands along river banks as well as along manmade waterways separating upland grass- and shrublands from aquatic habitats. In the study area, such stands are found along the banks of a small, unnamed irrigation ditch immediately west of the powerhouse site and along the Uncompahgre River. They are the most common wetland type in the Uncompahgre Valley (Rector et al., 1979), constituting almost half of the total wetland (Reclamation, 1982).

The riparian zone flanking the river, approximately 100 feet wide on the east bank and approximately 150 feet wide on the west bank, is dominated by cottonwood and Russian olive trees. Plants such as thistle, bindweed, and American licorice are common understory species in these stands. They are typically classed as invaders and are found on disturbed sites. Alfalfa, timothy, and brome from nearby hayfields also occur here.

Endangered Plants

The endangered clay-loving wild buckwheat (*Eriogonum pelinophilum*) is the only listed plant species inhabiting the project impact area. This buckwheat, a low, rounded shrub with white flowers, appears to be restricted to Montrose and Delta Counties. When the plant was listed as endangered in 1984, only one population in a 100-acre parcel of land was known. However, since then more than 50 new locations have been discovered. Mariah and Associates (1986 and 1987b) described their habitat:

> Little was known about the habitat occupied by the species when the taxon was listed as endangered in 1984. Based on observations during the 1986 and 1987 field surveys conducted by Mariah, *E. pelinophilum* is restricted to the more weathered and less contoured Mancos Shale formations just west of the highly dissected adobe hills located east of

both Delta and Montrose. The species usually prefers the more level terrain, but it can also be found within the large drainage systems. When the species is encountered in these areas it is usually found in patches in smaller side ravines in association with black sagebrush (Artemisia nova). Specifically, the habitat of E. pelinophilum can be characterized as follows: gently rolling to level, loose clay soils in various aspects in association with Atriplex cuneata, Artemisia nova, Hilaria jamesii, and Sitanion hystrix.

Habitat of the type that potentially contains E. pelinophilum appears to be scattered in patches throughout a 2- to 3-mile-wide band that extends at least 30 miles north to south between Delta and Montrose. Elevation ranges from 5,180 to 6,240 feet. The species appears to follow a band of the habitat, with the eastern edge bounded by the highly contoured adobe hills and the western edge bounded by the level plain that gently slopes towards the Uncompahgre River. The species does not occur in the area beyond these east-west boundaries.

The many small occurrences of the clay-loving wild buckwheat form six meta-populations. Because all of these sites are within the Uncompahgre Valley, no major topographic barriers exist (with the exception of the Gunnison River which only separates one meta-population, the type locality) between any of them. Approximately one-fourth of the sites are on BLM land and the rest are on private land. Total population and habitat estimates for the species are 45,000 to 50,000 plants and 400 to 450 acres. However, the Uncompahgre Valley has a hopscotch pattern of agriculture, residential development, and the remaining adobes areas. Consequently, the habitat of the clay-loving wild buckwheat has been fragmented and several of the occurrences on private land are less than 4 hectares (10 acres) in size with 300 plants or less. These remnant sites may not be viable for recovery, especially if they are surrounded by residential developments. Although one-fourth of the sites are on BLM land, these larger rangeland sites contain nearly half of the total numbers: About half of the total numbers are contained on the two largest meta-populations, the type locality on privateland 10 miles east of Delta and the BLM South Canal locality 3 miles southeast of Montrose (FWS, 1987).

In a survey of the penstock route, Mariah and Associates (1987b) documented approximately 435 E. pelinophilum plants in small, scattered locations within and adjacent to the penstock route. The populations were healthy, with a good distribution of age classes and vigorous plants. No noticeable problems occurred with insects, fungus, or parasites. It was also observed that a variety of animal species pollinated E. pelinophilum. No indication was seen that the species was adversely affected by grazing.

According to the FWS (1987), two plants that are candidates for official listing as threatened or endangered also occur in western Colorado--adobe penstemon (Penstemon retrorsus) and adobe desert parsley (Lomatium concinnum). These species also occur on the adobes with or near the endangered clay-loving wild buckwheat. The adobe desert parsley and the adobe penstemon inhabit barren, dry soils of the type found along the proposed penstock route. Distribution of the penstemon appears to be similar to E. pelinophilum, although the penstemon has been recorded farther north near Paonia and farther east near Crawford.

Field surveys by Mariah and Associates (1986 and 1987b) failed to locate the desert parsley in the penstock route, but the penstemon was found in approximately the same locations as the clay-loving buckwheat. The plants occupied small swales in clay soils between elevations of approximately 5,900 to 6,150 feet. The penstemon plants were reported to be healthy and vigorous. Approximately 155 of the mat-forming penstemons were recorded in nine areas along the route.

Wetlands

Project Feature Area.--The COE and the Environmental Protection Agency (EPA) jointly define wetlands as those areas having saturated soil conditions (Environmental Laboratory, 1986). Wetland habitats have developed on approximately 10 acres of land at locations along the existing AB Lateral, according to EMANCO (1986b; see figure 3.19). Approximately one acre of wetland also exists at the proposed powerhouse and tailrace site. No wetlands were identified along the proposed penstock route.

The wetlands along the AB Lateral generally exist as narrow, linear bands of phreatophytic or mesophytic species where water has seeped from the downslope or western side of the existing lateral and from smaller laterals and irrigation ditches. However, a relatively large patch of wetland has developed immediately north of U.S. Highway 50 due to canal leakage. Wetlands may also receive nourishment from Cedar Creek, although the amount of water provided by the various sources is not known.

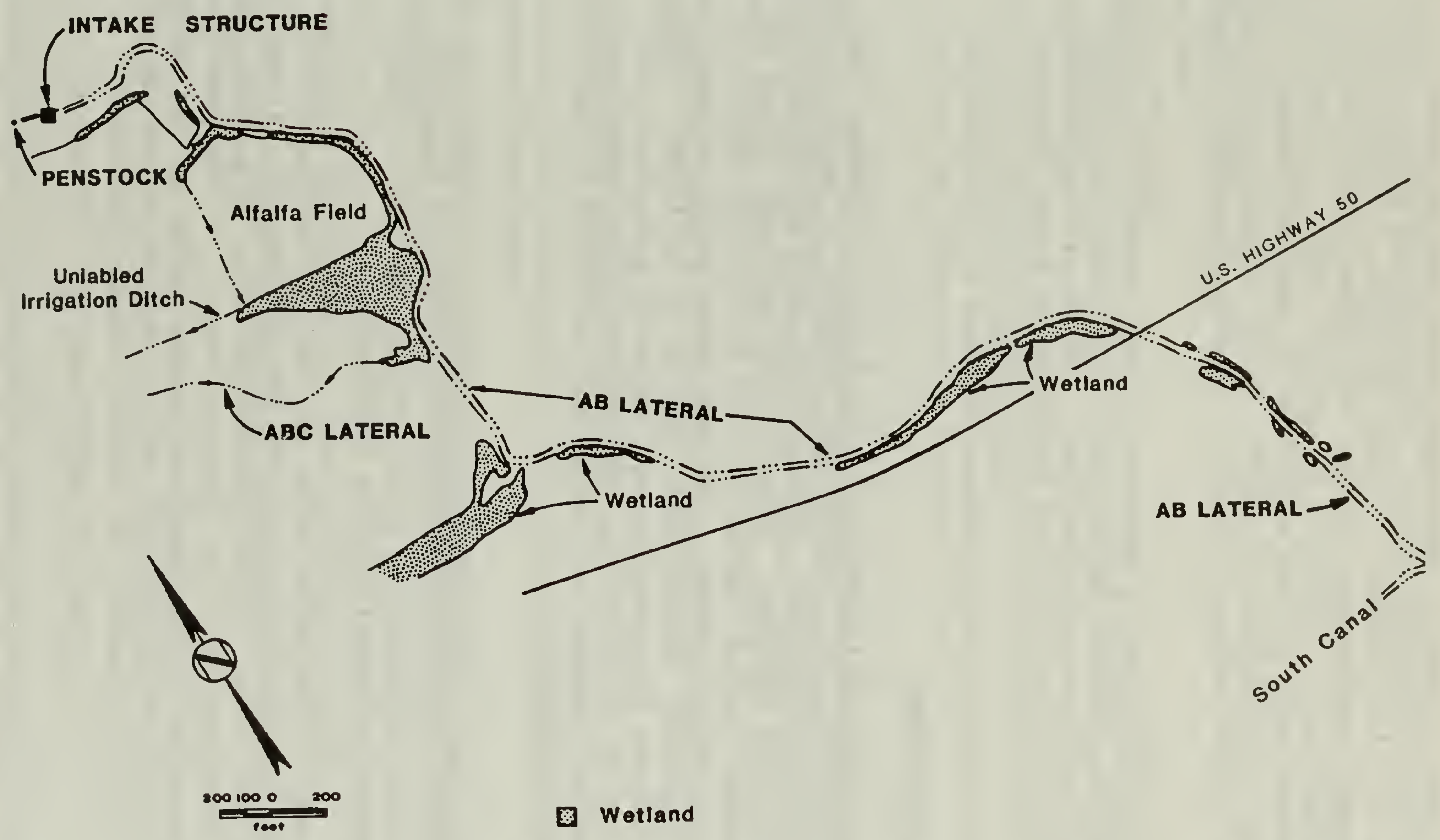


Figure 3.19. Wetlands along AB Lateral.

These wetlands are primarily dominated by willow with Baltic rush and cattail common on wetter sites. A variety of more typical upland species is also common in these wetlands. Rabbitbrush, thistle, milkweed, greasewood, tufted hairgrass, and foxtail barley are subdominants. Willows in several small places on the upslope or eastern side of the existing AB Lateral between the South Canal and U.S. Highway 50 appear to be in poor condition, possibly from limited water, livestock damage, or other factors.

Uncompahgre River Corridor.--Because of the instability of the Uncompahgre River, wetland habitat has developed along areas where the banks are low and undefined. There are approximately 5,000 acres of wetlands along the Uncompahgre River (Rector, et al., 1979).

Impacts of Alternatives

Project Feature Area (Alternative A, No Action).--Under the no-action alternative, no significant changes in vegetation in the study area are predicted. The general area would remain one of desert shrubs and grasses. Most of the wetlands along the existing AB Lateral would remain as they have under historic operation of the canal system. Seepage areas along laterals are periodically repaired, occasionally drying up wetlands. Changes could also occur due to changing agricultural practices and agricultural market conditions. Landowners could expand crop fields or abandon planting, allowing active fields to revert to native grasses and shrubs.

Project Feature Area (Development Alternatives).--Under any of these alternatives, impacts on vegetation would be generally restricted to the construction phase of the project. Table 3.39 summarizes impacts of the facility features.

Construction activities would occur at the confluence of the South Canal and the AB Lateral, along the AB Lateral, along the proposed penstock route, at the powerhouse site, and along the tailrace and transmission line rights-of-way. At the powerhouse site and at the site of the proposed intake works on the South Canal, construction would disturb only a negligible amount of vegetation, consisting mainly of annual invader species.

Table 3.39.--Estimated vegetation disturbance due to facility construction and operation (acres)

Feature	Construction	Operation
Penstock (temporary)	172	Less than 1
AB Lateral enlargement	32	12[1,2]
Tailrace	11	6
Transmission line	15	Less than 1
Powerhouse	4	2
Total	234	Less than 18

[1]/ Includes one acre of BLM land.
[2]/ Includes up to 4 acres of seepage-caused wetlands that would be lost by lining the AB Lateral.

Vegetation and soil disturbance associated with other project features would be more extensive and would occur along the AB Lateral, penstock, tailrace, and transmission line rights-of-way. In these areas, construction activities would consist of:

- removing trees and shrubs as needed to gain access to work sites

- grading the penstock centerline

- marking the centerline of the proposed rights-of-way by land survey techniques

- stringing penstock pipe sections and other construction materials

- excavation using backhoes, scrapers and/or other mechanical equipment as needed for burial of the penstock

- piling excavated materials temporarily on one side of right-of-way

- backfilling of the penstock ditch with at least 36 inches of cover

- excavating for the powerhouse foundation

- fine-grading all disturbed areas and removing excess trash and debris, followed by revegetation as needed

Of the approximately 234 acres affected, all but about 18 acres would be reclaimed after construction. Shrub-dominated wetlands along the existing AB Lateral would be directly affected by enlarging sections of the lateral and by filling in portions of the existing canal that would be abandoned. Alternative E requires 5 feet less expansion of the AB Lateral than the other alternatives, thus diminishing impacts to adjacent vegetation.

Additionally, lining the enlarged lateral sections would reduce seepage, thereby conserving water and reducing salt loading. However, this action would also reduce or eliminate wetlands dependent on the seepage from the lateral. These wetlands are primarily willows. The areas would slowly convert to either shrubland or to cropland by landowners expanding adjacent fields. Wetlands along the northern end of the existing AB Lateral could receive water directly as seepage or leakage from the lateral, as seepage or leakage from sublaterals and other ditches, or from a combination of these sources. It is not possible to accurately portray the source of water serving individual wetlands, so it is difficult to project the ultimate effect of diminishing seepage from the enlarged AB Lateral. However, a maximum of 4 acres of wetlands would be lost.

Portions of the study area are served by existing access roads. Upgrading these roads would remove a negligible amount of additional vegetation, primarily saltbush. Similarly, constructing a new access road along limited sections of the buried penstock and along the transmission line would occur with little loss of vegetation in addition to that removed while constructing these facilities.

<u>Gunnison River Corridor (Alternative A, No Action)</u>.--If no development occurs, the soils and vegetation along the Gunnison River corridor would continue to be affected by Aspinall Unit operation and by human use. Changes would be expected to continue as a result of these activities. On one hand, river regulation will facilitate invasion of riparian species while increased human use along the river will continue to trample vegetation.

<u>Gunnison River Corridor (Development Alternatives)</u>.--The proposed hydropower facility could affect vegetation along the Gunnison River where streamflows would be reduced. All of the proposed alternatives include minimum protected flows of 300 ft^3/s for the Gunnison River. Thus, the impacts on the river would be similar. Alternative C, however, would have the greatest frequency of

300 ft^3/s flows as seen in tables 3.8 through 3.16. Mariah and Associates (1987a) conducted an inventory of vegetation in the Black Canyon of the Gunnison River and arrived at the following results in terms of project impacts: Based on the existing vegetation response to the artificial river flows that exist, the reduced flows would probably allow the riparian vegetation to increase along the river's edge. In most cases, the primary invader would be canary grass. Areas subjected to higher flows with a mixture of alluvium and colluvium, such as at the mouth of side canyons, coyote willow would probably be the primary invader. The various species presently inhabiting the primary terrace would probably not be affected because of the highly capillary nature of the alluvium allowing subirrigation of the terrace. Occasional high water would flood out certain areas.

The vegetation on the second terrace and along the base of the canyon walls would probably not be affected by the reduced flows of the river. In this zone of the colluvium, the vegetation is adapted to more xeric conditions and has long taproots to reach to deeper water levels or does not require as much moisture. No effect is predicted for the boxelder trees, commonly occurring as narrow bands along the lower canyon wall, as these trees also have a long taproot and have the capability to adjust to a lowering of the water table. Many of the individual trees are aided by inhabiting crevices that act as catch basins for water.

In some areas, coyote willow would be replaced by salt cedar, which appears to inhabit less disturbed sites. Thus replacement would be minimized with disturbance by high turbulent water. Canary grass may be replaced by in some areas, which like salt cedar has a competitive advantage at locations less disturbed by turbulent waters.

The proposed development would not affect large floods in the Gunnison River, and the scouring potential of these floods would remain unchanged. Thus, removal of riparian vegetation would continue as under the no-action alternative. When flooding did occur, the primary invaders of these sites would act as on newly deposited alluvium. With development, more of the Gunnison River bed between the Tunnel portal and Delta would be covered with grasses during low and intermediate flows. After each large flood, the river would appear the same as without the project.

<u>Uncompahgre River Corridor (Alternative A, No Action)</u>.--If no development occurs, the Uncompahgre River would become a slightly narrower, more stable river because of the influence of

Ridgway Reservoir. Bank erosion, and stabilization efforts would continue in the reach of the river within the study area.

Uncompahagre River Corridor (Development Alternatives).--All of the proposed alternatives are similar with respect to impacts on vegetation and soils along the Uncompahgre River. In the reach between the South Canal and the proposed powerhouse at Montrose, the Uncompahgre River discharges would be decreased significantly. This reduction in flows would result in a decrease of bank erosion or elimination altogether in some places. The remaining flows would tend to meander more around the existing bars and islands. Riparian vegetation would develop on the newly exposed riverbed. The scouring potential would be slightly decreased so more vegetation would accumulate in the river bottom.

For any of the alternatives, the discharges from the proposed powerhouse would significantly increase the flows in the Uncompahgre River in the reach between the proposed powerhouse and the confluence with the Gunnison River at Delta, but alternative C would show the greatest increase. These new flows of Gunnison River water would erode the banks of the Uncompahgre River. Sediment eroded from the banks would enlarge some old bars and create new ones. Riparian vegetation would erode in some areas, invade in sediment deposition areas and would encroach into abandoned sections of riverbed.

Under all of the development alternatives, the Sponsors would construct channel and bank stabilization works to minimize the erosive impacts of the increased flows, affecting approximately 8 acres of riparian vegetation along the Uncompahgre River. The Sponsors would coordinate with the COE, FWS and CDOW to minimize affecting wetlands areas and to aid in creating any necessary replacement wetlands near the river channel.

All four development alternatives would line the AB Lateral with concrete, substantially reducing seepage, the principal water source for 4 of the 10 acres of wetlands along the lateral. These 4 acres would be expected to revert to native shrub-type habitat. In addition, development would eliminate or diminish up to 8 acres of riparian and wetland habitat as part of the streambank protection plan described in chapter 2.

The net impacts on vegetation and soils would be lessened by the Sponsors' proposed mitigation measures. Current FWS policy for mitigating unavoidable wetland loss is generally to replace in-kind habitat values on an acre-for-acre basis. As mitigation for the anticipated total loss of 12 acres of wetland and riparian habitat, the Sponsors have agreed to create a 12-acre wetland near the proposed powerhouse on land purchased for the project. The replacement area is already within the Uncompahgre floodplain, and if supplied with water and left to grow naturally, would be expected to provide habitat equivalent to that lost along the AB Lateral and Uncompahgre River. Wetlands would be created through one of two methods. A slight (5 to 10 feet) lowering of the 12-acre parcel would be accomplished as part of gravel extraction activities. This would bring the affected acreage close to the existing water table within the frequent flood zone of the Uncompahgre River. Water supplied by either of these two sources would be sufficient to maintain wetland vegetation. Alternatively, a series of small, irregularly shaped, shallow ponds would be excavated in the same area. Again, either ground water or flood waters could recharge the ponds.

All disturbed areas would be reshaped by grading after construction. Landscaping and reseeding would be performed. Additionally, native shrubs and grasses would gradually encroach onto disturbed sites from adjacent, undisturbed areas within the shrubland type, allowing gradual and eventual reestablishment of cover in these areas. Periodic mowing along portions of the transmission line would be performed, preventing large shrubs and trees from becoming reestablished there. Therefore, a conversion of shrubland to semi-shrub grassland would persist for the operational life of the project. This effect would be partially mitigated by filling in approximately 2 acres of the existing AB Lateral which can be expected to eventually develop a native shrub cover. Croplands and pasture would revert to agricultural productivity or grazing use as soon as they are replanted by the landowner.

Endangered Plants

In a survey of the penstock corridor, approximately 435 E. pelinophilum plants were documented in small, scattered locations within and adjacent to the penstock route. Because some of these plants grow on ridges and small ravines that run perpendicular to the penstock route, changing the penstock location would not avoid all the plants. Therefore, a portion (estimated at 100 to 200) of the estimated 435 clay-loving wild buckwheat plants in the corridor would be destroyed in the 200-foot-wide construction right-of-way.

At least four known locations of P. retrorsus (adobe penstemon) are near the penstock route and would be lost during construction. As with E. pelinophilum, this represents a small portion of known populations. Constraints on construction for E. pelinophilum habitat would reduce but not eliminate losses of adobe penstemon.

The following conservation recommendations were developed with the FWS (1988). To reduce losses of clay-loving wild buckwheat and adobe penstemon, special restrictions would be placed on penstock construction in portions of a 2-mile reach where the penstock crosses known populations. Special construction specifications would be developed for these areas. These would include but not limited to the following: Construction rights-of-way would be marked with temporary fencing and reduced to 75 feet in selected areas. Access roads would be selected to avoid plants and clearly marked to prevent off-road travel. Storage and soil waste areas would not be located in these sections unless the areas were confirmed not to contain E. pelinophilum. Topsoil would be stockpiled separately and replaced after the pipeline was placed. The pipeline would be designed to reduce the need for maintenance access in these areas.

In addition, Sponsors would acquire and transfer to the BLM approximately 60 acres of E. pelinophilum and P. retrorsus habitat near Olathe identified by the FWS. If this land were unavailable, the Sponsors would be required to complete an alternative plan as designated by the FWS before operation.

Terrestrial Wildlife

Existing conditions

Wildlife Associated with Riparian Habitat.--Cottonwood riparian zones typically are used by various wildlife species disproportionately more than any other type of semidesert habitat (Thomas et al., 1979). Cottonwood trees along waterways accompanied by an understory of shrubs, forbs, and grasses provide excellent habitat in conjunction with adjacent agricultural lands. In addition to game species, the riparian area is the most important habitat for nongame wildlife, especially birds.

The cottonwood-Russian olive stands along the Uncompahgre River offer potential habitat to medium and large mammals such as mule deer, coyote, bobcat, striped skunk, badger, mink, raccoon, and red fox. Small mammals and birds include desert cottontail, Colorado chipmunk, least chipmunk, rock squirrel, white-footed deer mouse, and ring-necked pheasant. Furbearers include beaver, muskrat, and river otters.

River bottoms are also important to wintering waterfowl and raptors. Of the raptor species found in the area, the two most common are the American kestrel and the red-tailed hawk, both of which breed in the study area. The golden eagle, prairie falcon, goshawk, merlin, great-horned owl, and the ferruginous, Cooper's, marsh, and Swainson's hawk also occur.

Studies have shown a variety of wildlife along the Gunnison Gorge downstream from the Gunnison Tunnel. A resident population of mule deer occur in the canyon and bighorn sheep have been reintroduced (BLM, 1987a). Elk also winter in the Canyon. The canyon is nesting habitat for the peregrine falcon and currently a single nesting pair use the Black Canyon (Madsen, CDOW 1988; personal communication). Bald eagles are winter residents along the river.

Waterfowl use in the canyon is high in the winter when the isolation and open water of the river provide attractive habitat (see table 3.40). During past hunting seasons, the waterfowl concentrated in the lower end of the Gorge (Madsen, CDOW 1988; personal communication). This concentration has been reduced over the last 5 years. Species of waterfowl in the area include the Canada goose, mallard, gadwall, pintail, green- and blue-winged teal, American widgeon, shoveller, lesser scaup, common goldeneye, and common merganser.

Wildlife Associated with Shrubland Habitat.--The desert shrub or halfshrub community typically occurs on relatively flat and unbroken terrain and offers little diversity for wildlife except along drainages, canyon edges and at locations where it adjoins another, more productive habital type such as wetland or agricultural land.

The mule deer is the most common large mammal but typically prefers to use riparian habitat and nearby agricultural land where available. The cottontail rabbit is the most common local game species. Chukars also occur near the AB Lateral. Mourning doves are seasonally abundant, and Gambel's quail and pheasant are also found. While probably not the most common species, the pheasant is probably the most popular game species in the valley. They are an introduced species and are most often found in association with nearby agricultural land or shrub wetlands.

Table 3.40.--Waterfowl counts along the Gunnison River

Date location	Number counted Ducks	Geese
Jan. 6, 1981		
Above North Fork	257	0
Below North Fork	157	0
Jan. 7, 1982		
Above North Fork	3,451	45
Below North Fork	700	55
Jan. 6, 1983		
Above North Fork	5,231	0
Below North Fork	534	22
Jan. 3, 1984		
Above North Fork	2,706	15
Below North Fork	0	0
Jan. 9, 1985		
Above North Fork	20	0
Below North Fork	119	0
Dec. 5, 1985		
Above North Fork	0	0
Below North Fork	82	0
Jan. 21, 1987		
Above North Fork	0	0
Below North Fork	500	210
Dec. 6, 1987		
Above North Fork	36	5
Below North Fork	541	110
Jan. 8, 1988		
Above North Fork	50	8
Below North Fork	6,128	1,858
Dec. 13, 1988		
Above North Fork	121	2
Below North Fork	56	0
Jan. 3, 1989		
Above North Fork	59	0
Below North Fork	321	26

Source: CDOW, 1989.

The only raptor thought to breed in the desert shrub community in this part of Colorado is the Swainson's hawk. Other species, however, such as red-tailed hawk, great-horned owl, turkey vulture, and bald and golden eagles hunt in shrublands.

Small mammals are represented by several species such as the pocket gopher, kangaroo rat, harvest and deer mouse, and others, but their total numbers are typically low due to the under-developed vegetative cover. Furbearers include the striped skunk, badger, and coyote. Additionally, the number of nongame bird species inhabiting this type of area is usually low, although large numbers of a single species may occur.

Few species of amphibians occupy the desert shrub-type habitat because of the scarcity of water. In contrast, a small number of reptiles such as the Great Basin sagebrush lizard and snakes, including the Great Basin gopher snake, occur (EMANCO, 1987). Additional information is tabulated by CDOW (1981 and 1982).

Wildlife Associated with Wetland Habitat.--Few of the wildlife species in the valley, except for those heavily dependent on water, are restricted to a specific habitat type. Thus, most are found from time to time throughout the year in most of the area's common habitat types. Included are the species previously discussed for the desert shrub community and others that may use wetland habitats inter-spersed with other types on a seasonal or even daily basis.

Wetlands are especially important to nongame birds due to the diversity and density of cover found there, particularly during the breeding season. Rector et al. (1979) inventoried a representative sample of wetlands in the Uncompahgre Valley and found 73 species of breeding birds. Shorebirds such as killdeer; common snipe; spotted, solitary, least sandpipers; and greater yellowlegs occur in the valley, usually associated with wetlands. These species are summer residents only and migrate from the area during the nonbreeding season (EMANCO, 1987).

Small mammal trapping in wetlands also produced a greater diversity and density of species, with the deer mouse most common, followed by voles and the western harvest mouse (Reclamation, 1982).

Wetlands are also important to furbearers and herptiles. Muskrats, for example, require considerably less water than beavers and river otters, and therefore may occur in agricultural ditches such as those associated with wetlands in the study area. Similarly, fox, weasel, and skunks are more common in wetland habitats than in other types, especially when wetlands are interspersed with agricultural land. Herptiles largely confined to wetlands in the study area include toads and frogs.

Wildlife Associated with Agricultural Land.--Agricultural lands provide little cover for wildlife but are important habitat areas. Certain crops provide food sources and are important to maintaining local wildlife populations. Agricultural lands are most important where they border other vegetation types. When a grainfield adjoins shrubland habitat, wildlife associated with the shrubland, such as cottontail rabbit, quail, and pheasant use grain as a food source. These areas provide a convenient food source close to nesting and escape cover provided by shrubland. Pastureland provides some grazing for mule deer.

Endangered Wildlife.--Four species of federally listed endangered species inhabit or may have inhabited the study area--the bald eagle, peregrine falcon, whooping crane, and black-footed ferret (FWS, 1988).

The bald eagle (*Haliaeetus leucocephalus*) is a large, long-lived bird of prey restricted in distribution to North America. Sexual maturity is reached at 4 to 6 years of age, but the birds may be considerably older before they breed for the first time. Many birds probably do not reach sexual maturity and few are likely to live until age 30 (FWS, 1983). The bald eagle winters along many of the drainages of the Colorado River, including the Gunnison River (see table 3.41). In addition, bald eagles are commonly seen downstream from the North Fork and along the Uncompahgre River. Food sources in the study area include waterfowl, fish, small mammals, and carrion. The rivers are the primary focus of activities, although the eagles do hunt away from these rivers. During severe cold spells, the relatively warm water in the Gunnison River released from upstream reservoirs reduces ice formation and may attract the eagles. The lack of human activity in the winter in the Gunnison River Gorge may also attract eagles.

The BLM classifies the Gunnison River as one of high use and the Uncompahgre as one of low use in terms of the bald eagle. Assuming that the presence of eagles indicates the presence of required habitat, wintering areas in Colorado that meet the following criteria should be considered essential bald eagle habitat (FWS, 1983): locations used annually by 15 or more eagles for two weeks or longer and locations used by bald eagles during periods of extremely harsh weather, when suitable feeding areas and night roost sites are limited in number (the minimum two-week period of use does not apply to this criterion). The Gunnison Gorge area appears to fit these criteria.

Table 3.41.--Summary of various bald eagle counts, 1980-1989, Gunnison River above North Fork

Time period	Number of eagles
1980	42
1981	35
1982	83
1983	45
1984	48
1985	32
1986	28
1987	43
1988	24
1988	18

Source: CDOW and BLM, unpublished data.

Because no way exists to measure the importance of particular wintering sites to bald eagle survival and reproduction, it is suggested that consideration be given to factors such as the length of time an area is occupied by eagles each year, the amount of use it receives and its potential for supporting more use, the regularity of use over a period of years or during extreme weather when suitable habitat is most limited, and the number and extent of other wintering areas nearby. Preserving such areas is suggested to ensure the survival and recovery of the bald eagles (FWS, 1983).

The peregrine falcon (Falco peregrinus) nests along the Gunnison River downstream from the Gunnison Tunnel and historically in the Cimarron Ridge country south of the study area. Today a single nesting pair uses the Black Canyon (Madsen, CDOW 1988; personal communication). It is possible they use the Uncomaphgre Valley for hunting and during migration.

In the past, whooping cranes (Grus canadensis) occurred in eastern Colorado as occasional migrants. In recent years, however, a new population has been established by using greater sandhill cranes as foster parents for whooping crane chicks. These birds migrate between Idaho and New Mexico, and their migration path includes Montrose and Delta Counties. The whooping crane has been observed in recent years at several locations in the Uncompahgre and Gunnison River drainages, but none of the study area has been identified as essential to the species.

The black-footed ferret (Mustela nigripes) is not known to exist in the Uncompahgre Valley nor are there records of historical sightings in the area. The ferret normally depends on prairie dog towns for food and shelter, but EMANCO (1987) indicated that no prairie dog towns existed in the penstock area.

Several species of vertebrates are candidates for listing as endangered species. These species are under consideration for Federal listing but enjoy no special legal protection. However, the FWS (1988) has suggested that it is "within the spirit of the Endangered Species Act to consider Project impacts to candidate species." Additionally, such species could be proposed for listing or listed before the facility becomes fully operational.

The ferruginous hawk (Buteo regalis) nests in streamside trees such as cottonwoods and junipers or on low cliffs and cutbanks (Snow, 1974). This hawk has been classified by the Colorado Field Ornithologists (1982) as a straggler in the Delta and Montrose areas making nesting of the species in the study area unlikely. Less than four sightings of the species in southwestern Colorado have been recorded.

The Swainson's hawk (Buteo swainsoni) breeds in grassland and shrubland habitat in western Colorado, and therefore nesting in the study area is possible; however, there have been no reports of nesting in the area.

The long-billed curlew (Numenius americanus) is an accidental visitor in western Colorado during migration when it uses wet grasslands, other wet open ground, and areas close to open water lakes and reservoirs for resting and feeding. Irrigated hayfields and wetlands occur along the proposed penstock route, so the area may be used occasionally by members of this species.

The CDOW maintains listings of species within the state in need of protection and (or) special management. These include the whooping crane, white pelican, and greater sandhill crane that migrate through the Uncompahgre Valley. NPS (1979) described use of the Gunnison Basin by cranes and white pelicans as "brief...during their spring migration."

The river otter resides in the Uncompahgre and Gunnison Rivers. It was formerly known to occupy all of the major rivers of North America (Toweill and Tabor, 1982) except in Alaska and the desert southwest. Its original demise in Colorado was attributed to trapping, deterioration of water quality, destruction of riparian habitat and diversion of water to the extent that prey species were diminished (Goodman, 1981).

The river otter was reintroduced to the Gunnison River in 1976 when six animals from eastern Canada were released by CDOW (Jones, 1977). One of the release sites was immediately downstream of the Gunnison Tunnel. Later, 15 more animals were released (Shepherd, 1986). The species has since been observed in the Uncompahgre River and other waterways in the area.

No quantitative data have been collected to date on the fate of otters released in the Gunnison drainage, although sightings have been reported that seem to indicate the otters now occupy the entire Gunnison River and have expanded their distribution to include the Uncompahgre River. According to Beck (1988), CDOW is currently conducting a study to obtain basic information on numbers, relative distribution, habitat requirements, breeding success, and other pertinent information on the otter population occupying the Dolores River. They will monitor population on the Gunnison and Uncompahgre Rivers when better monitoring procedures are established. Currently, otters are known to inhabit the Gunnison and Uncompahgre Rivers, but it is unknown as to their population size, where they are located, breeding success, etc. There was one confirmed sighting of a female with young on the Gunnison in the spring of 1988. There have been six confirmed mortalities in the area since their release, four from beaver traps, one from shooting, and one from unknown causes (Beck, 1988).

The minimum habitat requirements of the otter in the study area have not been addressed, nor has a study of the quantitative change in a local otter population to incremental changes in habitat parameters been performed on any otter population reported in the pertinent literature. EMANCO (1986b and 1987) performed a search of the pertinent literature and found information on the river otter and its biology. Melquist and Hornocker (1983) provided a detailed study of river otter ecology in Idaho; they concluded that the determining factor on habitat use and survivability was the availability of food items, followed by adequate shelter. Shelter generally consists of beaver dens or lodges, dens of other species, dense riparian vegetation, log jams or talus rocks.

Fish compose the bulk of the river otter diet, with crustaceans, amphibians, reptiles, insects, birds, and mammals composing lesser portions (Melquist and Hornocker, 1983; Larsen, 1984; Mack, 1985). Also, fish are apparently preyed upon in direct proportion to their occurrence and density and in inverse proportion to their swimming ability (Ryder, 1955; Erlinge, 1968; Toweill and Tabor, 1982; Melquist and Hornocker, 1983), resulting in predation mainly on large, abundant, slow-moving fish, either those that swim slowly naturally or those that are weakened or injured. For example, Mack (1985) indicated that suckers were selected in Colorado in greater proportion than their availability. Fast-swimming species such as trout are taken in lesser numbers than their availability suggests (Toweill and Tabor, 1982), except where they are especially vulnerable such as on spawning beds or in winter concentration areas. Other slow-moving species include carp, chubs, dace, shiners, and catfish, many of which occur in the Gunnison or Uncompahgre Rivers.

The presence of open water during winter is also essential to allow the otters access to prey. Apparently, one of the criteria used in selecting this river for reintroduction was because portions of the Gunnison River currently remain ice free throughout the year. Otters have been documented leaving drainages that freeze completely, concentrating during winter around areas of open water (Greer, 1955). The relative amount of open water needed is not known, although Mack (cited as personal communication in Dronkert, 1982) gave an estimate of at least one opening in the ice per mile of stream (EMANCO, 1987).

Impacts of Alternatives

Project Feature Area (Alternative A, No Action).--Under the no-action alternative, no significant changes would occur to wildlife in the study area. The habitat would remain as it has in the past. The wetlands along the AB Lateral would remain as they have under historic operation of the canal system although periodic lateral rehabilitation work could reduce water seepage to the wetlands.

Project Feature Area (Development Alternatives): Project operation would have impacts on wildlife. Each alternative is very similar in the impacts on wildlife. Reduced wildlife habitat would result from seepage control from the existing AB Lateral, clearing vegetation, and other activities during construction. Project structures could result in hazards for certain wildlife species.

Facility construction would affect wildlife use on approximately 234 acres during the construction period. However, all but about 18 acres would be reclaimed after construction by revegetating disturbed areas. The most ecologically important loss would be the permanent loss of approximately 4 acres of wetland habitat along the existing AB Lateral. Wetland mitigation should offset wildlife losses.

Hazards.--The concrete-lined AB Lateral canal would pose a hazard to wildlife, particularly mule deer. Large and small animals could fall into the canal while moving through the area. Large animals would be prevented from entering the penstock, but the smooth, steep sides of the concrete-lined lateral might not allow the animals to escape. Two planned deer escape ramps would be included in the enlarged AB Lateral and should reduce the number of trapped animals.

The closeness of the project to U.S. Highway 50 probably inhibits some animals from using the immediate area. Additionally, an occupied residence and UVWUA maintenance facilities could limit the movement of game animals south of the highway. However, the likelihood that wildlife would actually fall into the enlarged lateral on occasion is high.

The overhead transmission line would have the potential for entangling or electrocuting raptors, including the endangered bald eagle. Transmission lines and their rights-of-way also provide access opportunities for persons who may be inclined to harass these species.

Noise and construction activity would temporarily disturb wildlife near work sites. However, the project would not be constructed in an area remote from human civilization. Existing development in the study area ranges from industrial along the western portion to scattered rural homes and farmsteads along the penstock alignment. Traffic is common along U.S. Highway 50 and secondary roads in the area. Thus, to some degree, wildlife has become accustomed to the presence of humans, their vehicles and farm machinery.

Gunnison River Corridor.--Developing any of the alternatives would result in reduced flows in the Gunnison River below the diversion point at the East Portal of the Gunnison Tunnel. Largest reductions in winter months would occur with alternatives B and C. Reduced flows could affect waterfowl, bald eagles, and river otters if ice formation increased significantly. The potential for ice accumulation would be most extensive below the confluence with the North Fork. Ice formation between Crystal Dam and the North Fork would occur more frequently than under present conditions. A series of freeze-thaw cycles rather than continual ice cover would be expected. Reduced water velocities associated with lower flows would probably be more attractive to waterfowl. However, floating ice would be less attractive. As long as open water remained, the river otter and bald eagle should have adequate hunting habitat. As indicated previously, scattered ice bridges totaling approximately 2.5 miles of the river occurred during January and February, 1989. These areas would be lost for use by these species. Potential prey species such as suckers and trout should not be reduced by the facility.

Increased walk-in fishing encouraged by lower summer flows would increase stress on wildlife such as bighorn sheep. This would occur less in winter months when fishing use drops. As discussed previously, there could be some replacement of willows by salt cedar along the Gunnison River. Salt cedar provides lower quality habitat in general in the Southwest (Ohmart, 1987; personal communication).

Uncompahgre River Corridor.--Flow changes in the Uncompahgre River could affect wildlife. The discharges from the proposed tailrace should keep the river free from ice, providing more potential habitat for waterfowl, bald eagles and river otters. Winter flows between the South Canal and tailrace would not change and should not affect wildlife.

It is possible that the increased flow below the tailrace would inhibit big game animals and other species which cross the river. Although the higher flows are within channel capacity and should not entirely block the animal's movements, they would make winter crossings more difficult and energy consuming.

Endangered Wildlife

Flow changes would not be expected to significantly affect fisheries that the bald eagle may use on the Gunnison River. Reduced flows associated with reduced velocities would be more attractive to waterfowl that eagles also may feed on; however, increased icing flows could nullify this. Ice development potential would be increased with lower flows. If significant freezing did occur, particularly during a severe winter, it would occur at a time of greatest stress to wintering eagles. The potential for ice buildup is greatest with alternatives B and C.

Improved winter flows would keep the Uncompahgre River ice-free and could increase wintering waterfowl numbers on the Uncompahgre River downstream from the tailrace. The relatively warm tailrace discharge could attract more waterfowl on the river downstream from Montrose and may indirectly attract bald eagles to this area.

The facility would not affect nesting habitat of the peregrine falcon but would reduce potential hunting areas by reducing wetlands along the AB Lateral Canal. Whooping cranes should not be affected because the loss of habitat for this species in this area, agricultural lands and reservoirs and ponds for feeding and resting, would be temporary.

The project would not adversely affect the black-footed ferret since the species was not found in the study area. There are no areas affected by project construction that are essential to the white pelican, sandhill crane, or any other species of limited distribution that may occasionally visit the Uncompahgre Valley.

Candidate species should not be significantly affected. Potential habitat of the ferruginous hawk would be temporarily disturbed by penstock construction, but long-term impacts on potential habitat would not be significant. Suitable resting and feeding habitat of the long-billed curlew occurs throughout the Uncompahgre Valley, and the relatively small acreage lost due to the AB Lateral Facility would have no impact on the species. The features of the facility should not have any long-term impacts on the Swainson's hawk, although short-term effects include disruption of potential nesting habitat during the construction of the penstock. River otters should not be affected by the Project. The presence of open water, essential to allow otters access to prey, should not be affected significantly by icing associated with the lower flows of the Gunnison River. There should be no effect on the otters on the Uncompahgre River.

Impacts to bald eagles and other raptors would be reduced by implementing proposed mitigation measures. The transmission lines would be constructed according to measures contained in the document <u>Suggested Practices for Raptor Protection on Power-Lines--the State of the Art</u> (1981). This would minimize potential impact on these valuable species from electrocution or entanglement.

Little can be done to exclude persons who are determined to enter an area, especially on foot. However, the possibility that persons who might seek to harass raptors perching on power poles would be reduced because the transmission line route is located in a developed area very near U.S. Highway 50, and traffic along that road may discourage eagles from using the area.

In its Biological Opinion regarding impacts to bald eagles, the FWS (1987) requested the Sponsors to initiate bald eagle surveys during the winter to fully evaluate the long-term impacts of development. The Sponsors would initiate such surveys as described in chapter 2.

Land Use and Recreation

Existing Conditions

General Land Use.--Land use in the project area reflects the major role of government in local land ownership. According to Montrose County (1988), approximately 28 percent of the land in Montrose County is owned by the private sector. In contrast, 68 percent of the land in the county was under Federal government ownership, 3.9 percent was controlled by the State of Colorado, with the remaining 0.1 percent owned by the county and municipalities.

The private land in the county is largely devoted to agriculture. Of the approximate 642,000 acres in private ownership, 400,000 are used for agriculture with about 86,000 acres irrigated. Crops include corn, alfalfa, other hays, small grains, pinto beans, potatoes, onions, sunflowers and fruit. Land use in the AB Lateral and proposed penstock route area is approximately 50 percent dry grazing land, 40 percent irrigated agriculture, and 10 percent urban (Reclamation, 1988). The total amount of agricultural land use has changed little in recent years and little change is projected for the near future (Reclamation, 1988).

The majority of Federal lands are BLM, national forests, or UVRP lands. Lands controlled by the Federal government along the Gunnison River include the Curecanti National Recreation Area, Black Canyon of the Gunnison National Monument, both of which are managed by the NPS, and BLM's Gunnison Gorge Recreation Area.

Regarding urbanized areas, the population of Montrose County is about 25,250, with approximately 10,000 persons residing within the City of Montrose. Other population centers are Olathe (population: 1,262), about 10 miles northwest of Montrose, and Delta (population: 3,931), approximately 11 miles northwest of Olathe in Delta County. Population density is low within the two counties.

Montrose County's system of community facilities, such as highways, railroads, commercial bus and air service, schools, parks, and utilities, was developed to meet population demands in the early 1980s. Although the county population has increased, it has done so slowly, maintaining excess capacity in community infrastructure making it adequate to serve present and near-future populations without further growth.

Very little industrial development occurs in the region. Limited mining and timbering have occurred in the mountains surrounding the valley in past years. No mineral extraction activities are occurring in the immediate project area, except for sand and gravel (Reclamation, 1988). Development of geothermal or other natural resources of commercial importance is unlikely (Reclamation, 1988).

<u>Gunnison River Recreation</u>.--Montrose and Delta Counties contain a wealth of recreational opportunities. Two of these opportunities include Gunnison River rafting and fishing, both of which make substantial contributions to the economies of both counties. Because of their economic importance, rafting and fishing use are described separately later in chapter 3.

The Gunnison River and its canyon (see figure 3.2) are one of the most interesting tourist and sportsperson attractions in western Colorado. They owe their reputation to the spectacular vistas and hiking trails of the Black Canyon of the Gunnison National Monument, the Gold Medal fishing waters, and the relatively pristine aesthetic values of the Gunnison Gorge Recreation Area. The BLM's recreation management plan for the Gunnison Gorge emphasizes management to protect and preserve natural values.

About 250,000 to 300,000 visitor-days of use occur in the Black Canyon of the Gunnison National Monument each year. Most of these users visit the area because of its dramatic scenery. A major theme of the Monument is interpretation of the canyon itself and the Gunnison River that carved it. Most visitors view the canyon from trails and overlooks on the canyon rim where an interpretative visitor's center and camping and picnic facilities are located. Trails within the Monument lead into the gorge and are used by backpackers, day hikers, anglers, and rock climbers. Over the last four years, inner canyon hikers have averaged 1,009 visitors per year, with the highest use in 1988 when 1,183 hikers registered. Records are not kept of inner canyon users who enter from upstream or downstream from the Monument's boundary; but NPS officials report this use is increasing and was especially evident in 1988 when low river flows permitted people to travel greater distances throughout the canyon (Thoreson, personal communication, 1989).

The NPS is currently conducting studies to evaluate the feasibility of enlarging the Black Canyon of the Gunnison National Monument. This study is scheduled for completion by September 30, 1989.

The segment of the river within the Monument is generally not usable for boating except by highly experienced kayackers, although it provides an opportunity for high quality trout fishing.

The aesthetic value of the Gunnison River itself varies according to the river flows. The most visual elements such as rapids, pools, cobbles and riparian vegetation are present between 300 to 700 ft^3/s. On the other hand, high spring flows give the visitor an indication of the powerful forces that carved the canyon.

Special Land Uses.--Portions of the Gunnison River and adjacent lands are eligible for designation under the Wild and Scenic Rivers Act and the Wilderness Act (see Chapter 2). A 11,800-acre area of the Black Canyon of the Gunnison National Monument was designated a wilderness area in 1976. These areas are described in NPS (1979a and 1979b) and BLM (1987).

Other Recreation (Uncompahgre River).--The Uncompahgre River below the proposed powerhouse tailrace has only limited recreational or aesthetic value resulting from periodic dewatering, excessive sedimentation and turbidity, excessive channelization, and lack of access. Fishing on the Uncompahgre River below Montrose is poor.

The Uncompahgre River between the South Canal terminus and the M&D Canal does have some limited recreational use because of the introduction of relatively high quality water and trout from the Gunnison River through the Gunnison Tunnel and the South Canal. However, due to limited public access in the area, angler use is limited to a few residents with knowledge of the local area. Several small recreation lakes have been developed beside the river between the South Canal outfall and Montrose. These are filled by springs or from irrigation ditches. In addition, local interest has grown along this reach of the river to enhance the use of the riparian areas that line much of the Uncompahgre River.

Other Recreation (South Canal).--The fishery in the South Canal is a seasonal fishery, dependent on fish movement through the Tunnel. Flows within the South Canal are curtailed during the winter for maintenance and repair of the Tunnel and canal system.

Other Recreation (Hunting).--Hunting in the Montrose area is an important recreation resource. The project area lies mainly within CDOW Large Game Management Unit 64 (LGMU64) though the project itself would occupy a small geographic part of the unit. LGMU64 showed a recreational day use for deer hunting of 4,360 days with 909 hunters participating. In 1987, elk hunting accounted for 2,093 recreational days usage with 400 hunters involved (CDOW, 1987). Very little big game hunting occurs near the project feature area.

Small game hunting may play a more important role in recreation usage in the immediate project area than big game hunting. During the 1984-85 small game hunting season, over 60,000 recreational days were spent in the pursuit of game in CDOW Small Game Management Unit 64 (SGMU64) which encompasses the proposed project area. The immediate project area includes a very small part of the unit, and the hunting usage is proportionally reduced for the project area. Upland game birds, such as the pheasant (over 25,000 days of recreational use) are hunted extensively in the region. Small mammals like the cottontail rabbit (over 10,000 days of recreational use) which are commonly found in the project area, are also heavily hunted in SGMU64. No data are available on the amount of hunting usage in the project area; however, the immediate area of proposed development is used for pheasant, rabbit and chukar hunting.

According to EMANCO (1986b), the UVRP access roads and irrigation ditches are probably used as a local recreational resource, though no data are available on such usage. The canal and lateral system are not open for public use because of safety hazards and because much of the system is on private land. However, it is common to view autos, trucks, and off-road vehicles such as trail motorcycles on backroads in the project area, especially during upland bird hunting seasons. This includes roads maintained by UVWUA to provide access for maintenance of irrigation facilities. No data are available on visitor-days or use at any of these locations, since accounts of recreational visitors are anecdotal.

Other Developments.--One major recreational development in the project area is Sweitzer Lake, a 137-acre recreational lake owned and managed by the Colorado Division of Parks and Outdoor Recreation (CDPOR). This lake is located about 2 miles southeast of Delta. Boating, swimming, and picnicking at the lake account for most of its 70,000-90,000 visitor days of annual use (CDPOR, 1981).

Another recent development in the area is the bike path between Montrose and Chipeta Lakes. This bike path, which begins at River Bottom Park in Montrose, has been developed by private interests with government support using an abandoned railroad right-of-way. Future plans include expanding the path from Chipeta Lakes south to Ouray. Also, a riverfront park is planned at Delta near the confluence of the Uncompahgre and Gunnison Rivers.

Private investors have also developed "Pleasure Park" on the Gunnison River a short distance downstream from the North Fork confluence. This facility offers a wide variety of recreational opportunities, including rafting, picnicking and camping. Jet boats are used to transport floaters upstream from the park to the Smith Fork confluence. The facility also includes a pavilion which will be used for "dances, reunions, conventions, parties and all manner of events..." (Delta County Independent, 1988).

Minor recreational developments are limited to public facilities at schools and city parks and include playgrounds, tennis courts, ball fields, swimming pools, and picnic areas. Other recreational opportunities are dispersed throughout the region and include horseback riding, bicycling, and hiking.

Impacts of Alternatives

General Land Use.--The development alternatives would temporarily affect 234 acres of land of which approximately 172 acres would be used for the penstock, 32 acres for the canal modifications, 15 acres for the powerhouse and tailrace, and 15 acres for the transmission line. After construction, about 18 acres would be required for operation.

Penstock construction would temporarily disturb unused ground, grazing lands, irrigated farmlands, and roadways within the City of Montrose. Although 172 acres would be required for construction, less than one acre would be required for operation. Land use above the buried penstock would revert to preconstruction use. However, development of new structures such as residences and buildings within the limits of the 100-foot right-of-way would be restricted to allow maintenance of the penstock.

Permanent land use changes would occur at the powerhouse, tailrace and in a 12-acre tract near the powerhouse, and in 6 acres along the AB Lateral. The land at the powerhouse is now unused; it would be converted to industrial use for the building, switchyard, stilling basin and vehicle parking. The tailrace lands are presently used for livestock grazing; approximately 6 acres of this would be converted to industrial use for conveyance of water from the powerhouse to the Uncompahgre River. Additionally, 12 acres of grazing land between the powerhouse and the river would be converted to wetlands as part of the wetlands mitigation plan. At the AB Lateral, 6 acres of grazing land would be converted to a gravel maintenance road.

No construction or development activities would occur at the East Portal of the Gunnison Tunnel or along the Gunnison River. Hence, development would not cause any land disturbances or land use changes along the Gunnison River.

Irrigation water and hydropower water needs would be managed by UVWUA. No long-term negative impacts to the current agricultural practices are anticipated due to the development. In the construction phase, the project could cause interruptions or reduced irrigation water flows for short time periods (less than one hour) along the existing AB Lateral and South Canal.

Gunnison River Recreation.--There would be no facilities constructed along the Gunnison River and no alteration of existing facilities there. Operation of the proposed alternatives would, however, alter the existing streamflow regime in the Gunnison River downstream from the Gunnison Tunnel. The altered flows would affect recreation use, resulting in increased hike-in fishing and decreased rafting use as described later in this chapter. (Tables 3.6 through 3.11 should be referred to for estimated flow changes under all alternatives.)

The flow changes would affect recreation use in the inner canyon of the Black Canyon of the Gunnison National Monument. According to the NPS (1988),

> The low flow level (seen more frequently under development alternatives) will make it much easier to travel both up and downstream by foot. Access will no longer be from the canyon rim and

down but laterally along the river from the easily reached East Portal and lower gorge areas. Easier access means more people, more human impact on the resource, and less of a wilderness experience.

The aesthetics of the Gunnison Gorge would be affected by reduced flows with the greatest changes apparent under alternative C. These changes would be most apparent in the winter when the greatest flow reductions occurred. The frequency of flows in the 300 to 700 ft^3/s range would increase from 50 percent (no-action alternative) to 70 to 80 percent with development alternatives. At this flow range, many visual elements are apparent--riffles, cobbles, and pools. From another viewpoint, the erosive power of the river would appear to be less under the development alternatives. This reduction would be most apparent in the early spring, late fall and winter.

Average summer flows in the Monument would be reduced from 897 ft^3/s to 637 ft^3/s (Alternative C) or 730 ft^3/s (Alternatives B, E and F). Average winter flows would be reduced from 1,392 ft^3/s to a range of 471 to 581 ft^3/s, depending on the alternative. Minimum streamflows would not change with the facility in operation although the frequency of river flows of 300 ft^3/s would increase. According to the NPS (1988), during periods of reduced flows, "...the flows would no longer impress the wilderness users and give them a feeling for the tremendous water power the Gunnison had, which gave it the ability to carve the canyon to its present depth. The roar of the river will be gone."

Stevens (1988) concluded that the changes in flow regimes would not affect the river mechanics of the Gunnison River through the canyon, thus the natural short- and long-term geologic conditions of the canyon would not change. The fishery resources in the Monument should not be adversely affected and may even be improved. Even under extreme case conditions winter and summer water temperatures should not be adversely affected due to the Monument's proximity to Crystal Reservoir. However, recreation use in the Monument could be affected. Although stream fishing makes up a small portion of the use in the Monument (less than 1 percent [NPS, 1979]), this use would be affected by the facility. The lower summer flows would increase the accessibility of the river within the Monument. Under low flow conditions, the NPS would need to increase their management of the river corridor, which would increase management costs. This management could include permit systems for entering the Monument from upstream and downstream points in addition to existing permit systems for other trails. The existing road closure to the East

Portal area in the winter would continue under all alternatives and would continue to reduce use during this period.

Special Land Uses.--Under the no-action alternative, the Gunnison River is eligible for designation as a wild river and sections of the Gunnison Gorge Recreation Area are eligible as wilderness.

The AB Lateral alternatives would not make the eligible segment of the Gunnison River ineligible for potential designation in the National Wild and Scenic Rivers System according to the NPS (1988). As indicated in Chapter 2, both recreation use and volume of water in the reach of river would be affected. The Wild and Scenic River Study (NPS, 1979a and 1979b) mentioned that flows were expected to stabilize near 200 ft^3/s with the completion of Crystal Dam and continued to state that, "Reclamation expects to maintain a flow of at least 400 ft^3/s below the Tunnel whenever Blue Mesa Reservoir is full. This is expected to occur during the March-through-September period in 85 percent of the years." As discussed later in the chapter, hike-in fishing would be expected to increase and rafting decrease under development alternatives.

Reclamation requested that BLM evaluate the suitability of the Gunnison Gorge Wilderness Study Area for wilderness if the AB Lateral Facility were constructed and operated. The BLM (1988a) stated that,

> Although operation of the facility may affect wilderness quality, the Bureau of Land Management would not change its recommendations to the Secretary of Interior that the Gunnison Gorge is preliminarily suitable for wilderness designation. However, only Congress can designate an area as wilderness. We cannot say how Congress would react towards a designation of the Gunnison Gorge as a wilderness, if the AB Lateral Facility is completed.

In the wilderness study area, increased hike-in fishing use and streamside travel would result in increased soil compaction, vegetation damage and removal, disturbance to wildlife, and an increase in the number of campsites. Due to increasing publicity about the Gunnison River this increase would occur under the no-action alternative but the increase would be greater under development alternatives. At lower flows, walk-in anglers can disperse more easily along the river; however, increased use can lead to a loss of solitude. The actual increase in use can be estimated; for example, angler use was approximately 35 percent higher in the low water year of 1988 as compared to the high water year of 1983.

The increased number of anglers would be offset to some extent because anglers can disperse along the river much more readily because of improved wading conditions. In addition, jet boat activity between the Smith Fork and North Fork segments of the Gunnison River is reduced at lower flows, thus decreasing this source of noise.

The ultimate carrying capacity of the river is not known. Even in a year like 1988 with record number of anglers, fishing pressure was less than 20 percent of that observed on prime trout fisheries along the South Platte and Fryingpan Rivers in Colorado. This may indicate a capacity for the fishery to sustain more use; but is no indication of the capacity of other values in the canyon. The BLM (1988a) estimated that carrying capacities for recreation use in the Gunnison Gorge and presented plans to monitor use. In the future, hike-in use may have to be regulated to a greater degree to protect resources.

Other Recreation (Uncompahgre River).--Under all development alternatives, increased flows below the tailrace could improve the recreational value of the Uncompahgre River as the result of relatively stable year-round releases of high quality clear Gunnison River water. These releases, coupled with the effect of Ridgway Dam upstream, could improve the water quality of the channel and stabilize or expand the wetlands of this area (Clark, personal communication, 1988). A cold water trout fishery could develop in the river in response to the improved habitat conditions. However, habitat may still limit development of a significant fishery. The realization of the full recreational potential of this development would require increased public access (Reclamation, 1988).

The stabilized wetland area would enhance its wildlife potential that would, in turn, help increase its recreational and aesthetic value. Wintering waterfowl and their associated pursuit by hunters and birdwatchers could also increase downstream on the Uncompahgre River in response to the winter release of relatively warm water (32 to 35°F) that should maintain an open, ice-free channel downstream to Delta (Reclamation, 1988).

The potential recreational and aesthetic value of sections of the Uncompahgre River between the Loutzenhizer Diversion Dam and the AB Lateral tailrace would be reduced with development due to the reduced flows in this reach. Although the number of trout entering the Uncompahgre River from the South Canal essentially would be unchanged, special management could be required to preserve the trout population and fisherman use in this reach of the river. Impacts would be reduced but not eliminated under alternative F, which provides extra water to the reach.

Chipeta Lakes and River Bottom Park along this reach of the river are managed for public recreation. Their ponds are filled by springs or existing ditches which divert from the Uncompahgre River under senior water rights. Thus, their water supply would not be affected by development of any of the alternatives.

Other Recreation (South Canal).--During the irrigation season, the project would direct approximately 40 percent of the Gunnison Tunnel flow of 1,135 ft^3/s into the AB Lateral, reducing the flow in the South Canal. The Sponsors would install a fish barrier on the AB Lateral at the South Canal diversion which would limit adult trout from entering the lateral, guiding them instead through the South Canal. Thus, during the irrigation season the number of trout entering the South Canal should remain unchanged.

Other Recreation (Hunting).--The project would have an insignificant impact on hunting by changing 18 acres of land that are used by animals as habitat. However, on the rest of the project site, the impacts would be temporary in nature, due to revegetation plans.

The Montrose CDOW office has stated that the project could positively affect hunting on the reach of the Uncompahgre River below the tailrace (Clark, CDOW, personal communication, 1988). The increased flows below the tail-race as a result of developing the project could enhance the area's wetlands and improve eagle and wildlife habitat. The increased flows would make the river more floatable (within certain reaches) and could increase accessibility for duck hunters. Overall, the proposed development would have no significant impact on hunting in the Gunnison River Basin.

Other Developments.--None of the development alternatives is predicted to significantly affect current or future use of Sweitzer Lake, although the quality of the water supply to the lake would improve. However, development would affect the Montrose-Chipeta Lake bike path and River Bottom Park. The impacts would be largely aesthetic due to the reduced flows in the Uncompahgre River between the South Canal and Montrose. The river is visible from the bike path at the bridge where it crosses the river; otherwise, the visibility of the river is obscured by riparian vegetation. No impacts to existing structures, i.e., bridges or bike-path paving, would occur. The western boundary of River Bottom Park is formed by the Uncompahgre River. Reduced summer flows in the channel would affect the aesthetics of the river in this reach.

At the Pleasure Park on the Gunnison River, reduced flows during low and moderate flow periods would reduce rafting. Jet boat activity between the Pleasure Park and Smith Fork would be reduced. For example, in 1988, with flows between 300 and 400 ft^3/s, jet boat activity was curtailed. Concurrently, the reduced flows would also stimulate interest in walk-in fishing activities, which may offset the reduced rafting usage. Other values, such as camping, picnicking, etc., would not be affected.

Social and Economic Conditions

Existing Conditions

The area immediately affected by the proposed development would include Montrose and Delta Counties in southwestern Colorado. Montrose County had a 1980 population of 24,352 and an estimated population in 1986 of 25,248 (from 1980 Census population data and local sources). The largest community in the county and the nearest community to the project is Montrose with a 1980 population of 8,722 and an estimated population in 1986 of 10,010. Employment data in table 3.42 indicate that total employment has declined in Montrose County since 1982 with the unemployment rate at times as great as 13.2 percent. The leading economic sectors in the county are, in order of importance, trade, services, agriculture, and government.

Delta County had a 1980 population of 21,225, and Delta, the largest community in the county, had a 1980 population of 3,931. Employment data in table 3.43 indicate that total employment has declined in Delta County since 1982 with the unemployment rate at times as great as 14.8 percent. The leading economic sectors in the county are, in order of importance, trade, services, agriculture, and government.

Table 3.42.--Employment in Montrose County

Year	Labor force	Employment	Unemployment	Unemployment rate (percent)
1980	11,532	10,641	891	7.7
1981	11,372	10,467	905	8.0
1982	11,572	10,104	1,423	12.3
1983	11,552	10,233	1,319	11.4
1984	11,488	10,151	1,337	11.6
1985	10,972	9,627	1,345	12.3
1986	10,895	9,458	1,437	13.2
1987[1]	10,859	9,503	1,356	12.5

[1]/ Average monthly labor force for January thru August 1987.

Source: Colorado Division of Employment.

Table 3.43.--Employment in Delta County

Year	Labor force	Employment	Unemployment	Unemployment rate (percent)
1980	8,204	7,597	607	7.4
1981	8,497	7,902	595	7.0
1982	9,025	7,924	1,101	12.2
1983	10,010	8,939	1,071	10.7
1984	9,578	8,572	1,006	10.5
1985	8,767	7,881	886	10.1
1986	8,411	7,166	1,245	14.8
1987	8,209	7,207	1,002	12.2

Source: Colorado Division of Employment.

The counties' system of community facilities, such as highways, railroads, commercial bus and air service, schools, parks, and utilities, were developed to meet population demands in the early 1980s. Excess capacity in community infrastructure remains, making it adequate to serve present and near-future populations.

No mineral extraction activities occur in the immediate project area except for two sand and gravel operations, both of which are owned by the same company. One operation is located upstream (south) from Montrose, and the other is located downstream from the proposed tailrace near the existing Montrose Sewage Treatment Plant. Geothermal or other natural resources of commercial importance which could be developed in the future are unlikely.

Montrose and Delta Counties are both close to the Gunnison Gorge, which offers a variety of recreational opportunities, including trout fishing and rafting. These opportunities are nationally known; consequently, they are responsible for economic contributions to the area. The economic contributions and the anticipated impacts of the development alternatives are discussed below.

Gunnison River Fishing.--The steep terrain of the Gunnison Gorge generally restricts hike-in angler use of the Gunnison River between Crystal Reservoir and the North Fork confluence. The river is accessible by car at the Gunnison Tunnel and at the North Fork confluence. Access to the entire reach between these points is by steep and, in some cases, unmaintained foot trails. On the river bottom, lateral movement along the river is also restricted, especially during higher flow periods.

Table 3.44 presents estimates of hours of fishing activity and trout catch in four selected years since the completion of Crystal Reservoir. Angler-use statistics compiled by the CDOW indicate an inverse relationship between flow levels and fishing activity. Flows above 1,000 ft^3/s result in significant decreases in fishing activity. This relationship is reflected in the 1983 data (see table 3.44), when fishermen use on the Gunnison was significantly reduced by flows in excess of 1,000 ft^3/s from May through September. Fishing activity was reported to be heavy in the late summer of 1987 when flows fell to around 600 ft^3/s and was heavy in 1988 when flows remained in the range of 300 to 400 ft^3/s (Nehring, 1988c).

According to the CDOW:

> The Gunnison River in the Black Canyon is most fishable in the 200-600 ft^3/s range. It is still fishable at 600-1,000 ft^3/s but cannot be crossed safely even in chest waders at these levels. In flows over 1,000 ft^3/s, the fishability of the river is very limited except from a raft, boat or canoe.

Because of the Gunnison River's rapidly growing regional and national popularity, the CDOW feels that, in an unusually dry year (200 to 300 ft^3/s from April to September), 100,000 angler hours can be expected between the Gunnison Tunnel and the North Fork confluence (Nehring, 1983). This level has not been reached to date, but as public interest increases, this level of use may be reached.

Table 3.44.--Comparison of angler use and catch (number of fish) for the Gunnison Gorge from Crystal Reservoir to confluence with North Fork

	1977[1]	1982[2]	1983[3]	1988[4]
Angler Hours	22,079	51,128	39,160	52,219
Total Catch	11,345	57,363	33,723	84,286
Total Harvest		17,713	13,151	13,395
Rainbow Catch	11,634	31,849	24,140	56,663
Rainbow Harvest		10,125	11,067	9,848
Brown Catch	2,529	24,934	9,562	27,623
Brown Harvest		7,275	2,085	3,547
Total Catch per Angler-hour	0.65	1.12	0.86	1.61
Rainbow Catch per Angler-hour	0.53	0.62	0.62	1.08
Brown Catch per Angler-hour	0.12	0.49	0.24	0.53

1/ April 16 to October 11
2/ May 1 to September 30
3/ May 1 to September 30
4/ May 1 to September 30
Sources: Nehring, 1983 and 1988b.

Gunnison River Rafting.--The BLM indicates that both commercial and private rafting in the gorge have increased dramatically since the early 1980s, due to increased publicity, improved fishing, and above-normal river flows. In 1982, the BLM issued 2 commercial rafting permits; in 1987 they issued 15 permits. The increased use occurred during a period of unusually high summer flows (J. Sering, personal communication, 1986). (Background information is from Tucker-Leak, 1987 and 1988, and BLM, 1987).

In 1982, the BLM estimated rafting use at 208 user days. By 1986 and 1987, use reached 2,700 and 3,500 user days, respectively. At first, most of the rafting use was by commercial outfitters. However, as a result of changes in BLM policies regarding permit allocations, private use is now nearly even with commercial use--about 55 percent commercial and 45 percent private use.

Low water conditions in late 1987 restricted commercial outfitters with larger rafts. Because it was necessary to do maintenance repairs to an upstream powerplant, flows in the gorge were reduced from approximately 1,600 ft^3/s in early July to about 800 ft^3/s by late July. Beginning approximately August 18, flows were further reduced to approximately 600 ft^3/s with this flow level continuing into mid- to late September. According to BLM staff, the lower water conditions and the accompanying publicity led to an increase in private boat trips by people who thought the fishing would be much improved in the gorge. There was an increase in boating accidents during this period due to the low flows or due to the inexperience of the boaters, with 90 percent of the accidents occurring with private floaters. However, several commercial outfitters began using smaller boats and increased their use of the river leaving the total commercial use at or near its previous level.

A comparison of both day and overnight trips for commercial and private boaters is provided in table 3.45 for 1986 through 1988. In 1987, a major change occurred with whitewater rafting at higher flow periods early in the year to fishing-oriented rafting at lower flows later in the season. In 1988, average flows in the Gunnison Gorge decreased to 353, 355, and 395 ft^3/s in June, July and August, respectively. As table 3.45 shows, these low flows resulted in reduced day and overnight trips for both private and commercial floaters. The number of private boaters during the 1988 season decreased by 58 percent from 1987 levels and commercial boaters decreased by 27 percent from their 1987 levels. These decreases indicate that when flows drop below 600 ft^3/s, floating the Gunnison Gorge becomes more technically demanding, and both private and commercial rafters reduce the number of rafting trips.

The boating data summarized in table 3.45 are conservative because they are based on voluntary registrations. Because commercial outfitters are licensed and must register when they take a party on the river, the records of commercial raft trips are fairly accurate. Although private rafters are requested to register before entering the river, many do not. The BLM estimates that the number of private boaters is about 25 percent greater than the numbers in their records. The numbers in table 3.45 are from BLM data and have not been adjusted to reflect this underestimate.

Table 3.45.--Summary of private and commercial boating use on the Gunnison River (1986 - 1988)

	June			July			August			September			Totals		
	'86	'87	'88	'86	'87	'88	'86	'87	'88	'86	'87	'88	'86	'87	'88
Day trips															
Private	na	20	5	18	37	12	33	21	5	8	4	6	59	82	32
Commercial	7	30	10	16	19	14	18	25	15	4	3	3	45	77	49
Overnight trips															
Private	na	5	10	5	22	15	19	33	5	5	14	8	29	74	43
Commercial	6	18	11	15	41	23	37	33	26	14	19	16	72	111	79
Day boaters															
Private	na	95	18	108	182	48	165	77	23	38	22	34	311	376	140
Commercial	58	208	83	109	147	105	188	186	111	40	16	23	395	557	355
Overnight boaters															
Private	na	21	32	60	113	50	86	156	19	19	52	50	165	342	165
Commercial	65	100	83	122	325	183	279	239	208	93	116	124	559	780	620
Total boaters															
Private	na	116	50	168	295	98	251	233	42	57	74	84	476	718	305
Commercial	123	308	166	231	472	288	467	425	319	133	132	147	954	1,337	975
Total boaters	na	424	216	399	767	386	718	658	361	190	206	231	1,430	2,055	1,280

Source: Tucker-Leak, 1987 and 1988b.

Economic Contributions of Rafting and Fishing.--The regional economic effects of both Gunnison River rafting and fishing were estimated from the number of boater and angler days in recent years and the daily expenditures for each group. The economic study area (ESA) was assumed to be Delta, Montrose, Mesa, Ouray and Gunnison Counties because these are where the majority of expenditures occur. Estimates of boater and angler days are presented in table 3.46. Boater days are presented for private and commercial trips since the expenditures associated with each type are different. The 1987 rafting season was used as the basis for estimating the existing economic contributions of the Gunnison Gorge because the low flow levels of 1988 make it an unrepresentative year. The estimate of angler days was derived from CDOW reports (Nehring, 1988c) and personal communications (Nehring, 1988d).

Table 3.46.--Estimate of boater days and angler days for Gunnison Gorge (1987)

User category	Total days
Boater days[1]	
Private boater days[2]	1,435
Average group size (people)	4.6
Average length of stay (days)	1.6
Commercial boater days	1,886
Average group size (people)[3]	5.9
Average length of stay (days)	1.7
Angler days[4]	11,286

1/ Boater days were calculated from information supplied by BLM (Tucker-Leak, 1987, 1988a, 1988b).
2/ Private boater days were increased by 25 percent to correct for non-registrations.
3/ Group size does not include outfitter or guide personnel.
4/ Angler days were calculated based on information from CDOW (Nehring, 1988). One angler day is assumed to equal 4 angler hours (Nehring, 1988d).

Daily expenditure estimates for rafting were taken from a recent survey of rafters (Public Information Corporation, 1986), and estimates of angler expenditures were derived from a FWS survey done in 1980. These figures were adjusted to 1988 values using GNP-Implicit Price Deflator methods (U.S. Department of Commerce,

1988) and are summarized in table 3.47. Total economic and employment contributions to the area resulting from fishing and rafting activities in the Gunnison Gorge during 1987 are presented in table 3.48. Multiplying activity days times daily expenditures for each kind of recreation use, rafting and fishing, resulted in an estimate of total expenditures in 1987 of approximately $538,900.

Table 3.47.--Local expenditure estimates for rafting and fishing, per person/per day[1]

Category of use	Expenditures
Private rafting[2]	
Hotel/Motels	$ 19
Transportation and camping fees	2
Restaurants	12
Other; Food, Drink, Misc.	4
Total	$ 37
Commercial rafting	
Rafting company average fee[3]	$ 69
All other (same as private)	37
Total	$106
Fishing - per person/per day[4]	$ 25

[1]/ Values escalated to 1988 dollars using GNP-Implicit Price Deflator method.
[2]/ From a survey by the Public Information Corporation (1986).
[3]/ Average rafting commercial fee derived from data supplied by BLM District Office in Montrose, CO.
[4]/ Source: FWS (1980).

To estimate the full economic effect in the region, sales, earnings and employment multipliers were applied to total expenditures for each category to arrive at estimates of total regional effects to the economy resulting from rafting and fishing activities. The multipliers used were derived from the RIMS-II Multiplier Model (U.S. Department of Commerce, 1988). As table 3.48 shows, rafting and fishing activities in 1987 resulted in total sales of $877,000, created 41 jobs and added $279,100 to personal earnings in the region.

Table 3.48.--Economic contribution to the ESA made in 1987 from recreation and fishing activities in the Gunnison Gorge (in 1988 dollars)[1]

Category	Total seasonal expenditures	Total regional sales[2]	Total employment generated[2]	Total labor income generated[2]
Boaters				
Private	$ 53,600	$ 87,000	4	$ 27,800
Commercial	200,300	326,000	15	103,800
Subtotal	$253,900	$413,000	19	$131,500
Anglers	$285,000	$464,000	22	$147,600
Totals	$538,900	$877,000	41 (Jobs)	$279,100

1/ ESA = Economic Study Area equals Delta, Montrose, Mesa, Ouray and Gunnison Counties.
2/ Source: U.S. Department of Commerce, 1986.

Impacts of Alternatives

General (Alternative A, No Action).--If no hydropower development occurs, the general economy of the region would not be changed. Fishing and rafting would continue and probably increase as important economic factors. Use would vary from year to year dependent on river flow conditions. No major changes in the local economy are foreseen.

General (Development Alternatives).--If any of the development alternatives would be implemented, the general economy of the region would be affected by both short-term and long-term development-related effects. These effects include the construction of the facility (short-term) and its operation (long-term), and would be related to the capital expenditures made by the Sponsors.

The estimated construction cost of the facility would range between $48 and $53 million, depending upon the selected alternative. Of these costs, approximately $25 million would be spent in the local economy for labor and materials. The balance of the cost would be spent outside of the local economy for purchasing specialized equipment and materials. The Sponsors have estimated that construction would result in a one-time expenditure of $300,000 to the City of Montrose for sales and use tax and a one-time expenditure of $500,000 to the State of Colorado for sales tax.

The construction of the facility would occur over a 2-year period. Three construction crews would be employed for canal and lateral modifications, penstock installation, and powerhouse construction. According to the Sponsors, the average field crews would be 48 to 50 people in each year, with peak manpower requirements between 70 and 100 people. The local labor force would contribute about 60 percent of these requirements. The maximum crew size is anticipated to be 25 to 30 persons for canal modifications, 25 to 35 for penstock installation, 25 to 30 for powerhouse construction, and 3 to 5 for installing the transmission line. Canal work would take from 2 to 4 months and would be completed during the nonirrigation season. Penstock construction may require a full year for completion, with the actual amount of time depending on weather conditions. A 16-month construction period is anticipated for the powerhouse.

The Colorado State Employment Service reports that there would be no problem in acquiring this number of skilled construction employees from the present number of unemployed (Reclamation, 1988). Additionally, the Employment Service indicated that construction workers in the Montrose, Ouray, Delta, and Mesa County areas all tend to compete for local jobs creating a large pool of construction labor. If additional construction workers are needed from outside the area, adequate lodging and subsistence accommodations are available. The presence of these employees would also provide a limited and unquantifiable local benefit due to purchases of food and lodging in the area during construction.

Purchases of local goods and services during the plant's operation would also be relatively modest but would benefit the local economy to some degree. No new businesses are anticipated to provide the necessary goods and services; thus, little commercial or industrial growth would be stimulated by the project. However, the additional power supply generated by the project may be attractive to new industrial or commercial enterprises.

Operation of the proposed facility would create a steady source of revenue to the UVWUA and to Montrose County. Annual property taxes paid to the County have been estimated by the Sponsors to range between $400,000 and $800,000. The final tax assessment would depend upon the alternative selected and its ultimate valuation. The net economic impacts to Montrose County residents resulting from this windfall cannot be assessed now because it is not known if the county would increase spending levels or reduce property taxes to residents. The Montrose County property tax receipts are presently about $10 million annually.

The Sponsors have estimated the revenue to the UVWUA to range between $150,000 and $300,000 for the first year of operation and increasing thereafter to over $1 million per year by 2008. The actual values would depend on the alternative selected, power wheeling arrangements, property taxes, final bids on construction and financing terms. These revenues would be used for three purposes, including retirement of UVWUA indebtedness, rehabilitation and betterment of the irrigation system, and reducing assessments to water users.

For this report, it has been assumed that no reduction in water user assessments would occur during the first 15 years of operation and the revenue to the UVWUA ($150,000) would be equally divided between debt retirement and rehabilitation and betterment work. Water user assessments would probably not increase, as they would under the no-action alternative. The monies used for the latter category would create additional economic impacts to the region in the form of increased regional sales, increased labor requirements and increased labor income. These impacts, along with the short-term economic impacts stemming from construction dollars entering the economy, are summarized in table 3.49.

Table 3.49.--Economic contributions to economic study area resulting from construction and operation of proposed hydropower facility

Category	Total seasonal expenditures	Total regional sales	Total labor income generated
Short term			
Construction (per year)	$12,500,000	$22,025,000	$7,287,500
State sales taxes	+$500,000	Not estimated	
Local sales tax	+$300,000	Not estimated	
Long term (estimated for 1st year of operation only)			
UVWUA revenues			
R&B	$75,000	$127,600	$50,600
Debt retirement	$75,000	Not estimated	
Annual property tax	+$400,000	Not estimated	

Long-term local employment would not increase significantly due to operation of the power facility since operation would be automatic. Routine maintenance and repair would be performed by present employees of the UVWUA supplemented by specialized contract labor as required.

The facility would have slight impacts to both sand and gravel operations. The operation located south (upstream) from the proposed tailrace would benefit from the reduced flows in the river during summer months. The reduction would result in exposing more materials, allowing more economic extraction.

However, the gravel operation downstream from the tailrace would be affected by the increased flows, particularly during the winter. The degree of impact is impossible to assess at this time because gravel mining operations here have been indefinitely suspended due to a recent change in ownership (1988). Previous owners constructed a temporary roadway along the riverbank to provide access between the gravel pits and rock-crushing facilities. With the increased flows resulting from hydropower development, construction of this temporary access road would be more difficult. Should mining operations resume, the Sponsors would assist the new owner in finding a suitable location for the access road after beginning hydropower operations.

<u>Impacts to the Rafting and Fishing Economy (Alternative A, No Action)</u>.--If no action was taken, the rafting and fishing economy in the Gunnison Gorge would continue to be influenced by natural flow variation, operation of the Aspinall Unit, irrigation diversions through the Gunnison Tunnel, and use regulations of the BLM and CDOW. Rafting use would be affected by the new management plan recently implemented by BLM. Under this plan, BLM would restrict the Gunnison Gorge to 2 commercial launches per day, along with a goal of 4 private launches daily (BLM, 1988b).

June through September constitute the primary rafting season in the Gunnison Gorge. From experience gained in 1987 and 1988, it appears that although small rafts and kayaks can negotiate the river at flows below 600 ft^3/s, 600 ft^3/s appears to be the minimum flow needed for larger commercial boats (Tucker-Leak, BLM 1988a; personal communication). For recreation and fishing-oriented rafting, optimum flows are probably between 600 and 1,000 ft^3/s. Optimum flows for whitewater boating are estimated between 1,200 and 2,500 ft^3/s (BLM, 1989). The evidence from these two years and from information gained from interviews with commercial rafters suggests that under extended low-flow conditions, whitewater rafters would be replaced over time by fishing-oriented boaters in smaller boats.

Using the flow data presented in table 3.6 for June through September and the 32-year study period, the economic returns to the ESA resulting from rafting and fishing were estimated based upon the expenditure estimates presented in table 3.47. During months in which the average flow was greater than 600 ft^3/s, it was assumed that the full benefit of rafting would be achieved; i.e., the maximum number of launches under current BLM restrictions would occur.

However, during months in which the flows averaged less than 600 ft^3/s, it was assumed that the number of launches would be reduced until flows reached 300 ft^3/s. The impact of the reduced flows on commercial rafting was estimated by assuming that: (1) maximum allowable river traffic would occur at flows of 600 ft^3/s or greater, (2) traffic would be reduced by 25 percent at flows of 450 to 600 ft^3/s, and (3) traffic would be reduced by 50 percent at flows of 450 to 300 ft^3/s. For private boaters, it was assumed that, (1) maximum river traffic would occur at 600 ft^3/s or over, (2) traffic would be reduced by 33 percent at flows between 450 and 600 ft^3/s, and (3) traffic would be reduced by 67 percent at flows between 450 and 300 ft^3/s.

The percentage reductions in rafting use assumed for this report are estimates. However, in light of recent BLM data (Tucker-Leak, 1988), the reductions may be conservative. Gunnison River flows were generally below 400 ft^3/s throughout most of the summer of 1988. During this period, commercial rafting use decreased by 27 percent from 1987 use and private use decreased by 57 percent.

According to comments received during the scoping process, there is not agreement among rafters as to what the actual minimum flow should be to achieve maximum economic returns. Consequently, the no-action flows entering the Black Canyon were analyzed for several minimums between 600 and 1200 ft^3/s to determine a range of possible economic contributions. Results of this analysis are shown in table 3.50.

From table 3.50, it is seen that the number of boater days and the value of direct expenditures decline as the assumed minimum flow value increases. This tendency should be expected, as the number of months in which the average flows are equal to or greater than 600 ft^3/s is greater than the number of months in which higher values occur. As a result of this analysis, the

600 ft^3/s was assumed to represent the worst case in terms of analyzing the economic impacts of hydropower development on the rafting industry. Direct expenditures at this flow level are higher than at any other flow level, implying that the economic impacts of development at this flow level (600 ft^3/s) would be greater.

Table 3.50.--Economic contributions attributable to rafting and fishing for no-action alternative

Minimum flow value for maximum use	Private boater days	Commercial boater days	Direct expenditures
600 ft^3/s	2,688	1,985	$311,000
800 ft^3/s	2,414	1,846	$286,000
900 ft^3/s	2,320	1,798	$278,000
1,000 ft^3/s	2,311	1,793	$276,000
1,200 ft^3/s	2,265	1,769	$273,000

According to Nehring (1983), the Gunnison River below the Gunnison Tunnel is most fishable when river flows range between 200 and 600 ft^3/s. Although it is still fishable at flows up to 1,000 ft^3/s, the river cannot be safely crossed even in chest waders. At flows of over 1,000 ft^3/s, "the fishability of the river is very limited except from a raft, boat or canoe." Resulting from the Gunnison River's rapidly growing regional and national popularity, the CDOW feels that in an unusually dry year (200 to 300 ft^3/s from April to September) 100,000 angler-hours could be expected between the Gunnison Tunnel and the North Fork confluence (Nehring, 1983).

This suggests that for flows averaging between 300 and 600 ft^3/s over the six-month period of April through September, a maximum usage of 25,000 angler-days could be expected. For this report, this usage was separated into a pattern of 2,000 angler-days in April, 3,000 in May, 6,000 in June, 5,000 in July and August, and 4,000 angler-days in September. Further, the monthly usage was adjusted to account for the difficulty of bank and wade-in fishing at higher flows. To calculate the anticipated angler usage under the no action and development alternatives, it was assumed that the angler use decreased in the following pattern: (1) for mean monthly flows less that 600 ft^3/s, the maximum monthly angler-days would occur; (2) for mean monthly flows between 600 and 800 ft^3/s, the maximum angler-days would be reduced by 25 percent; (3) for mean monthly flows between 800 and 1,000 ft^3/s, the maximum angler-days would be reduced by 50 percent; and (4) for mean monthly flows in excess of 1,000 ft^3/s, the maximum angler-days would be reduced by 75 percent. It should be noted that increased regulation of recreation may be necessary in the future to protect the resources along the Gunnison River, and this would affect angler numbers.

Using this usage pattern combined with the flows entering the Black Canyon for the no action alternative (see table 3.6), an average of 17,680 angler days would be annually available. Applying the expenditure estimates of $25 per angler day results in an average annual direct expenditure of $446,000 resulting from angler use of the Gunnison River.

Impacts to the Rafting and Fishing Economy (Development Alternatives).--Under any of the alternatives being considered, the rafting industry could expect an increase in the number of months where flows would fall below 600 ft^3/s. With each of the four alternatives proposed for the AB Lateral Facility, there would be changes in both rafting and hike-in angler use of the Gunnison River.

Generally, decreases in river flows would result in decreased rafting opportunities but increased hike-in angler use. The effects of decreased flows on the rafting industry can be observed in the reductions in rafting associated with reduced flows during August and September of 1987 and during 1988. During late August and September of 1987, flows in the Gunnison Gorge were kept relatively constant at around 600 ft^3/s. During 1988, flows were reduced to below 400 ft^3/s in May, June, July and August. Representatives of the rafting industry indicated that the lower flows during 1988 restricted use by rafts larger than 14 feet. Rafts 12 to 14 feet in length could negotiate the river at these flows but were subject to increased wear and tear.

Using these assumptions and the flow data for each of the alternatives presented in tables 3.8 through 3.11, the direct expenditures, total regional sales, employment and labor income resulting from rafting on the Gunnison River were computed using RIMS Multipliers (U.S. Department of Commerce, 1988). Results of this analysis are shown in table 3.51.

Table 3.51.--Comparison of annual economic contributions to economic study area from rafting activities in the Gunnison Gorge for all alternatives [1]

Alternative	User Category	User days	Direct expenditures	Total regional sales	Total employment generated	Total labor income generated
A	Private	2,688	$100,000	$163,000	8	$51,800
	Commercial	1,985	$211,000	$344,000	16	$109,300
	Total	4,673	$311,000	$507,000	24	$161,100
B, E & F	Private	2,286	$85,000	$138,000	6	$44,000
	Commercial	1,780	$189,000	$308,000	14	$97,900
	Total	4,066	$274,000	$446,000	21	$141,900
C	Private	1,872	$70,000	$114,000	5	$36,300
	Commercial	1,568	$167,000	$272,000	13	$86,500
	Total	3,440	$237,000	$386,000	18	$122,800
		Impacts of development alternatives				
B, E & F	Private	-402	-$15,000	-$25,000	-1	-$7,800
	Commercial	-205	-$22,000	-$36,000	-2	-$11,400
	Total	-607	-$37,000	-$61,000	-3	-$19,200
C	Private	-816	-$30,000	-$49,000	-2	-$15,500
	Commercial	-417	-$44,000	-$72,000	-3	-$22,800
	Total	-1,233	-$74,000	-$121,000	-6	-$38,300

1/ Economic study area includes Delta, Montrose, Mesa, Ouray and Gunnison Counties.

Although rafting activity can be expected to decline with reduced flows in the Gorge, hike-in fishing activity should increase. This is because, as discussed earlier, flows in the 300-to-600 ft^3/s range produce excellent fishability on the Gunnison River; flows of 600 to 800 ft^3/s, good fishability; flows of 800 to 1,000 ft^3/s, fair fishability; and flows over 1,000 ft^3/s, poor fishability. As was illustrated previously, all alternatives for the project, except alternative A, would decrease flows during the primary angler-use period of April through September. Thus, for all of the alternatives proposed for the AB Lateral except for alternative A, the no-action alternative, an increase in hike-in fishing activity in the Gunnison Gorge would occur.

Table 3.52.--Comparison of annual economic contributions to economic study area from fishing activities in the Gunnison Gorge for all alternatives [1]

Alternative	Category	User days	Direct expenditures	Total regional sales	Total employment generated	Total labor income generated
A	Fishing	17,680	$446,000	$726,000	34	$231,000
B	Fishing	20,078	$507,000	$826,000	39	$262,600
C	Fishing	21,414	$541,000	$881,000	41	$280,200
E	Fishing	20,063	$507,000	$826,000	39	$262,600
F	Fishing	20,078	$507,000	$826,000	39	$262,600
		Impacts of development alternatives				
B	Fishing	2,398	$61,000	$100,000	5	$31,600
C	Fishing	3,734	$95,000	$155,000	7	$49,200
E	Fishing	2,383	$61,000	$100,000	5	$31,600
F	Fishing	2,398	$61,000	$100,000	5	$31,600

1/ Economic study area includes Delta, Montrose, Mesa, Ouray and Gunnison Counties.

The impact of the development alternatives on hike-in fishing activity was calculated following the assumptions outlined for alternative A. Values are presented in table 3.52, and include the effects on regional sales, employment and labor income.

The overall economic impacts of the AB Lateral with respect to both rafting and fishing are shown in tables 3.51 and 3.52. Development of any of the proposed alternatives would reduce the total expenditures attributable to private and commercial rafting on the Gunnison River. Because alternatives B, E and F propose to divert the same amount of flow during the rafting season (June through September), their respective impacts are identical, and would reduce direct expenditures by about 12 percent. However, alternative C would result in larger diversions due to the increase in Tunnel capacity, and consequently greater impacts to rafting would occur, reducing direct expenditures by about 24 percent.

On the other hand, implementation of alternatives B, E or F would increase fishing expenditures by about 14 percent, and alternative C would increase expenditures by about 21 percent.

Summary

The alternatives represent social and economic tradeoffs. Development alternatives provide substantial tax revenues to Montrose County; substantial revenues to the UVWUA, which has members in both Montrose and Delta Counties; and construction employment. The greatest revenues would occur under alternative C; however, greatest declines in the rafting economy would also occur under this alternative. Actual angler and hike-in usuage of the Black Canyon of the Gunnison National Monument and the Gunnison Gorge is predicted to increase under development alternatives, with the greatest increase under alternative C. This increased recreation use may be accompanied by increased resource and management problems.

Cultural Resources

Existing Conditions

Cultural resources surveys conducted in the Uncompahgre Valley have documented the occurrence of prehistoric sites ranging in age from the Archaic through the precontact period. Historic properties, some of which have been listed on the National Register of Historic Places, also occur in the Uncompahgre Valley (Chandler, 1984 and 1986).

As one of the oldest irrigation projects in the nation, the Uncompahgre Project is of historical significance. The Gunnison Tunnel, for example, is listed on the National Register. Similarly, the M&D Canal and the South Canal have been officially determined as eligible for listing.

Agricultural practices and construction and maintenance associated with the Uncompahgre Project have obliterated many traces of prehistoric cultural activity in the area (Chandler, 1984 and 1986). Five Class III cultural resource surveys have been conducted in the AB Lateral Facility area by Collins et al. (1981), Chandler (1984 and 1986), Tucker (1984), and McDonald (1987).

The Laboratory of Public Archaeology at Colorado State University, Fort Collins, conducted a survey in 1980 along the South Canal (Site Number 5MN1851) and the AB Lateral in connection with the Lower Gunnison Basin Unit (Collins et al., 1981). Two historic sites (5MN1618 and 5MN1617) were located near the AB Lateral Facility. One is a ditch rider's house and one a railroad bridge. Neither site is considered to be eligible to the National Register of Historic Places, and both are outside of the facility area. Chandler (1984) surveyed the area around the AB Lateral headgate on the South Canal in connection with another hydroelectric project. One historic site (5MN2347), an adobe structure, was recorded near 5MN1618; it is not considered to be eligible to the National Register and is outside the area of the AB Lateral Facility.

Tucker's survey of the AB Lateral penstock route (1984) located one site and one isolated find. The isolated find (5MN2716) consisted of a single lithic flake of prehistoric origin and is not eligible for the National Register. Site 5MN2715 consists of four wooden structures, a stock pond, and a trash concentration enclosed within a wooden post and barbed-wire fence. Tucker (1984) concluded that this property is part of the original homestead of Cyrus Stilson dating from 1891. Because the site is considered to be architecturally and historically significant, it may be eligible for listing on the National Register.

The existing AB Lateral is part of the South Canal system (5MN1851) which has been officially determined to be eligible for nomination to the National Register. Therefore, Chandler (1986) also photographed five irrigation structures in the area that would be affected by the facility: (1) the AB Lateral headgate on the South Canal; (2) the ABA Lateral headgate and bridge across the AB Lateral; (3) the ABC Lateral headgate on the AB Lateral; (4) the AB 0.99 Lateral headgate on the AB Lateral; and (5) a log bridge abutment on the west bank of the AB Lateral. Chandler (1986) also reported that engineering plans for these structures are on file at the UVWUA office in Montrose. McDonald (1987) surveyed the transmission line for the AB Lateral Facility and found one previously recorded site in the survey area, the Selig Canal (5MN1854) which is not eligible to the National Register.

The only other National Register site known to exist in the area is the Gunnison Tunnel, which it is a National Engineering Landmark as well (NPS, 1976).

Impacts of Alternatives

Facility development would involve new construction and modifications of the AB Lateral and installation of a new diversion structure on the South Canal. These modifications would substitute for rehabilitation and betterment activities that would occur under the no-action alternative. In any case, these elements have been fully recorded. Therefore, modification to a replacement of these structures would not be considered to be a significant adverse effect (CSHPO, 1986). Other cultural resources would be avoided under the no-action alternative although they would continue to be subject to natural degradation, decay, and vandalism.

Three of the four alternatives would not modify the Gunnison Tunnel as part of the development. Under alternatives B, E and F, the Tunnel would not be affected. However, modifications to the Tunnel are proposed as part of alternative C. The proposed work would be accomplished within the Tunnel; no construction activities would be evident to the general viewing public. The work would be limited to those activities necessary to increase the hydraulic carrying capacity of the Tunnel, as described in chapter 2. Construction activities would be coordinated with the Colorado State Historic Preservation Officer (CSHPO) and Reclamation.

Except for the Stilson Homestead, no previously unrecorded cultural features of significance were discovered in the area. The Sponsors would install temporary fencing or otherwise assure that the homestead would not be affected during construction. Therefore, it is unlikely that any known site would be affected by construction. Should previously unknown cultural materials be revealed by construction activity, construction at the site would cease and Reclamation and the CSHPO would be notified to evaluate the nature and possible significance of the material before reinitiating work. The CSHPO determined that no adverse impact would occur on any significant cultural resources, provided that the present scope of the development remains essentially unchanged (CSHPO, 1986a and 1986b).

Air Quality and Noise

Existing Conditions

Air Quality.--The proposed development site, located in Montrose County, has little industry and a low population density resulting in little degradation of ambient air quality. The primary source of air pollution in the area is from the combustion of fossil fuels for transportation, agriculture and heating. A secondary contributor to air pollution in the valley is fugitive emission of dust from agricultural tillage of the semiarid soils.

Ambient air quality standards, which have been established by the EPA, establish the maximum ground level concentrations of designated pollutants in the ambient air that the agency determines to be adequate to protect the public health and welfare. At present, National Ambient Air Quality Standards (NAAQS) have been adopted by the EPA for six pollutants, otherwise known as "criteria pollutants": particulates, sulfur dioxide (SO_2), ozone, oxides of nitrogen (NO_x), carbon monoxide (CO), and lead (40 CFR Part 50, 1987). An area that is determined to be in compliance with NAAQS standards for a given pollutant is designated as an attainment area for that pollutant. The EPA determines attainment status for criteria pollutants by comparing modeled or monitored data of the area to the applicable ambient air quality standards.

The area of the proposed development is classified as attainment for all the "criteria pollutants," based on review of Code of Federal Regulations 40 (40 CFR) parts 81 to 99, revised July 1, 1987. That is, the air quality in the Montrose County area meets or exceeds the NAAQS.

Noise.--Noise in the proposed project area is generally low and not disturbing. Normal sources of noise include vehicles, periodic agricultural equipment such as tractors and harvesters, wind, animal life, and occasional airplane overflights (USBR, 1988).

Except close to heavily traveled roadways such as U.S. Highway 50 and within Montrose, day-night weighted sound levels within the project area probably range from 20 to 25 decibels on the A-scale (dB(A)) at midnight to 45 to 50 dB(A) during typical afternoons with moderate wind. A value of 55 dB(A) is comparable to the noise approximately 50 feet from a road carrying light auto traffic.

Impacts of Alternatives

Air Quality.--The proposed right-of-way for the facility alternatives would be about 234 acres; however, construction would occur only on a maximum of about 5 acres on a given day. Activities during the construction phase of the AB development would result in fugitive dust emissions and emissions from internal combustion engines. Dust would be generated due to excavation, earthmoving, traffic on unpaved surfaces, and wind erosion. An average particulate emission factor for heavy construction which accounts for all of these activities is 1.2 tons per acre per month of construction activity (EPA, 1985b). The emission factor assumes application of no mitigative measures. The unmitigated fugitive dust emission rate from the construction activities can be calculated based on the following assumptions: (1) Construction occurs on a maximum of 5 acres per day, (2) construction takes place 6 days a week (26 days a month), (3) fugitive dust emission rate of 1.2 tons (2,400 lbs) per acre per month (EPA, 1985b), and (4) twelve-hour work day.

To determine the daily emission of fugitive dust per acre per day, the emission rate of 2,400 lbs per acre per month is divided by 26 working days (2,400 lbs/acre/month - 26 days = 92.3 lbs/acre/day).

Multiplying 5 acres by the daily emission rate per acre (92.3 lbs/acre) yields the maximum daily fugitive dust emission rate from the project construction activities. This could result in a low-level release of approximately 461 lbs per day of fugitive dust. Over the course of a 12-hour work day this is an unmitigated emission rate of approximately 38.5 lbs/hr. However, the concentrations are short-lived, settling rapidly when construction ceases for the day. In addition, the high concentrations of dust would primarily occur within the project site boundaries. Mitigation measures applied to control and reduce the amount of fugitive dust should greatly reduce particulate emission and help eliminate potential occurrences of high particulate concentrations during construction.

Motor vehicles such as pickup trucks typically emit hydrocarbons, such as carbon monoxide and nitrogen oxide, while diesel-powered construction equipment emit source pollution consisting of particulate matter, sulfur and nitrogen oxides, hydrocarbons, and carbon monoxide (EPA, 1985b).

For example, at normal emission rates for these types of equipment, a pickup truck on the project construction site in use for 12 hours a day could produce 1 lb of hydrocarbons, 9.5 lbs of carbon monoxide and 1 lb of nitrogen oxide. Operation of a road grader at the powerhouse site for a 12-hour working day could generate 0.7 lb of particulate matter, 1 lb of sulfur oxides, 9 lbs of nitrogen oxides, 0.5 lb of hydrocarbons, and 1.8 lbs of carbon monoxide (EPA, 1985b).

Hydroelectric facility operation would have little, if any, direct impact on the air quality of the region. Implementing this project could have a net positive effect on the region's air quality due to its potential pollution emission offsets. Operation of the project would mean that an equivalent amount of generation would not be produced elsewhere. The estimated emission offsets for the project are shown for the various development alternatives in table 3.53.

Table 3.53.--Emissions offsets, in tons of pollutant, achieved with development

Alternative	Pollutant	Annual offset	Offset over 40-year Project life
B and F	SO_2	800	32,000
	NO_x	1,300	52,000
	CO_2	390,000	15,600,000
C	SO_2	825	33,000
	NO_x	1,375	55,000
	CO_2	412,500	16,500,000
E	SO_2	740	30,000
	NO_x	1,235	49,000
	CO_2	370,000	14,800,000

The values presented in table 3.53 are based on emission factors developed by the EPA in their "Compilation of Air Pollutant Emission Factors" (4th Edition, 1985, EPA Publication AP-42). Assumptions include low sulfur Wyoming coal (0.3 percent), a low to mid range NO_x release (18 lbs/ton), and conservative carbon combustion ratios.

Noise.--The primary noise effects during construction of the proposed project would result from additional traffic caused by commuting construction workers, material-delivery trucks and operation of construction equipment at the project site during a normal workday.

The type and numbers of construction equipment used on the project would vary during each construction phase. Each phase from penstock construction to plant site preparation, foundation construction, building erection, equipment installation, and finishing requires a different number of workers and different types of equipment. The construction would be characterized by the near-continuous operation of large equipment, compactors, water trucks, cranes, truck-mounted augurs, dozers, pile drivers and graders throughout the workday. The location of equipment and the amount of usage (from idling to operation at full power) are highly variable. However, these activities are all temporary in nature.

The State of Colorado presently exempts construction noise from any enforceable standards during the daytime hours (7 A.M. through 7 P.M.). During nighttime hours, the exemption is lifted and the standard reverts to the type of neighborhood in which the construction activity is occurring (see table 3.54).

Table 3.54.--Maximum permissible noise levels, dB, allowed by Colorado State Law

Type	Daytime (7 a.m. - 7 p.m.)	Nighttime (7 p.m. - 7 a.m.)
Residential	55	50
Commercial	60	55
Light industrial	70	65
Industrial	80	75

Noise created during penstock construction could affect residential (at various locations along the route), commercial and light industrial areas (near the downstream end of the penstock). Noise created by construction at the powerhouse could affect residential, commercial and light industrial areas that are located nearby.

The noise level at the powerhouse during operation would be created by four primary sources: the turbines, generators, transformers and minor vehicular traffic in and out of the site. Turbine and generator noise would originate inside the plant structure and would be muffled by the walls and roof of the building. Within the operational areas of the plant, the noise levels and vibrations would conform to the safe levels as established by Occupational Safety and Health Administration regulations.

Outside of the plant structure, only the transformers would be a constant noise source, producing an estimated 60 dB(A). Within a distance of 500 feet of the transformer this level should be reduced to approximately 40 dB, which would comply with Colorado's nighttime residential noise level of 50 dB or less. Because the nearest residences are several blocks away from the plant site, plant operation would not be a significant impact to local residents.

Vehicular traffic to and from the plant would be infrequent because plant operation would be automated. Plant traffic would consist of UVWUA employees involved in routine maintenance and emergency repairs.

The penstock would not be a source of noise or vibration, as it is buried. The small amount of noise and vibration generated by the flowing water would be dampened by the earth.

Impacts of noise and air pollution would be reduced by special measures during the construction and operation of the facility. Operation of construction equipment, especially earthmoving equipment, produces both air emissions and fugitive dust. Although these impacts are short-term and localized, several measures would be employed to mitigate their effects.

Measures to minimize mobile source emissions and impacts would be required in the construction contract as follows: (1) construction vehicles would be well maintained under an inspection and maintenance program to minimize air pollutant emissions; (2) engine idling would be discouraged when vehicles are not directly in use during construction; and (3) entrance and egress routes would be limited and delivery times for materials will be scheduled to reduce queue lengths for vehicles serving the site.

Fugitive dust generated by construction activity could be significant in the short-term, uncontrolled worst-case condition. Sources of on-site fugitive dust include: conveyance, transfer, earthmoving, and dumping operations, vehicular traffic, open storage areas, and other releases. Several commonly used mitigative measures are proposed to reduce construction-generated fugitive dust emissions. Conveyance operations would be enclosed wherever possible. All transfer points and material handling operations would be cleaned periodically. Dumping and transfer of loose, fine-aggregate materials would be restricted. Vehicles transporting these materials would be covered and loading/unloading would be controlled.

Vehicular traffic on unpaved areas would be avoided where possible and vehicle speeds would be controlled. Surface dust loadings on paved access routes would be minimized by periodic sweeping. Open storage areas containing fine, unbound materials would be either covered or sprayed with surfactants and/or water to reduce wind effects. Watering of unpaved surfaces would be done during construction in order to control dust. Dust emissions can be virtually cut in half with complete water coverage applied twice a day (EPA, 1985b). Employing wind breaks and covering dusty material storage areas also helps reduce fugitive dust by sheltering exposed materials from the wind.

Disturbed surfaces would be promptly revegetated at the end of construction to minimize dust emissions due to wind erosion.

Cumulative Impacts

Cumulative impacts are those which result from the incremental impacts of an action added to other past, present and reasonably foreseeable future actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Cumulative impacts on flow regimes, water quality, and recreation are particularly important in relation to the AB Lateral Facility. Upstream water projects have significantly altered the flow regime in the Gunnison River (see attachment B) and Ridgway Reservoir is now beginning to significantly affect flow regimes and water quality in the Uncompahgre River.

To more accurately describe impacts of the AB Lateral alternatives, future river and reservoir operations have been projected under the no-action alternative. The changes due to the proposed alternatives have been compared to this base so that the total impacts on the river system can be seen.

Cumulatively, the impacts of reduced flows in the Gunnison River and the resultant increased opportunity for hike-in human use would result in the reduction of some of the values that make the area attractive. This combined with ongoing private and public efforts to acquire additional access to the river could, in all probability, result in more restrictive management practices being instituted by the National Park Service and Bureau of Land Management to preserve natural values.

The cumulative impacts of past water development on the riparian vegetation and associated wildlife of the Gunnison and Uncompahgre Rivers are also significant. Overall, the high spring flows that characterize rivers in Colorado have been diminished. Late season flows are supplemented for irrigation or hydropower operations. In general, riparian vegetation has increased in response to lower spring flows; however, certain species that benefit from periodic flooding such as cottonwoods are adversely affected.

A number of other projects upstream from the Aspinall Unit are being considered, which include transmountain diversions to the eastern slope of Colorado. The feasibility of these proposals is directly affected by Colorado law. If any of the development alternatives proposed in this report would be implemented, the available water supply for those projects could be reduced if their water rights are junior to those of the AB Lateral Facility.

CHAPTER 4
CONSULTATION AND COORDINATION

This chapter summarizes public involvement on the Uncompahgre Valley Hydropower Project and will serve as the public involvement summary report.

Initial Activities

Since 1979, proposals have been made for the development of hydropower in the Uncompahgre Valley by many groups including the Uncompahgre Valley Water Users Association (UVWUA) and Montrose Partners (referred to as the "Sponsors"). These proposals have been considered by numerous groups and agencies. Early studies were conducted under procedures of the Federal Energy Regulatory Commission (FERC) and involved assorted alternatives for producing power from water diverted from the Gunnison River through the Gunnison Tunnel. Reviews under the FERC procedures generated a significant amount of correspondence in efforts to complete consultation and coordination efforts.

Various parties either prepared preliminary comments on the hydropower proposals or requested information and data relating to the affected environment of the project area. Agencies and organizations who participated at this stage included the following:

Federal agencies

- Environmental Protection Agency
- U.S. Army - Corps of Engineers
- U.S. Department of Agriculture - Forest Service
- U.S. Department of Interior -
  - Bureau of Land Management
  - Bureau of Reclamation
  - Fish and Wildlife Service
  - National Park Service
  - Office of Environmental Project Review

State agencies

- Department of Health
- Division of Parks and Outdoor Recreation
- Division of Wildlife
- Public Utilities Commission
- State Engineer
- State Historic Preservation Officer
- Water Conservation Board
- Water Quality Control Division

Local agencies

City of Montrose
Montrose County
Tri-County Water Conservancy District

The primary environmental concerns raised in this early consultation included:

- loss of small mammal habitat and increased erosion due to construction,

- location of powerlines to minimize habitat disturbance,

- possible hazards to raptors through electrocution on contacting powerlines or through increased hunting pressure in the powerline right-of-way,

- the potential for game animals to be trapped in the canals or laterals,

- hazards to waterfowl that might strike the powerline,

- effects of increased river icing or lowering of ambient temperatures on overwintering waterfowl and other migratory and resident fauna below Gunnison Tunnel,

- adverse effects of peak flow fluctuations on riparian zones and banks along the Gunnison and Uncompahgre Rivers,

- increased flows in the Uncompahgre River impeding game movement,

- a minimum flow in the Gunnison River below the tunnel at 300 ft^3/s or greater to protect the Gold Medal trout fishery as well as endangered or threatened species found in the Colorado River,

- effects of fish populations if instream work on the powerplant system occurred during fish spawning seasons,

- coordination of project maintenance with operation of Wayne N. Aspinall Unit to avoid fluctuations harmful to trout,

- design of project features to prevent hazards to fish during powerplant shutdowns, and

- effects on endangered species requiring Section 7 consultation under the Endangered Species Act.

In response to these initial concerns, the Sponsors and other applicants under the FERC procedures conducted several specific environmental studies and reviewed existing data.

As indicated in chapter 1, the Bureau of Reclamation (Reclamation) published a Notice of Intent to contract for hydropower development on the Uncompahgre Project in the Federal Register (50 CFR 50238) on November 9, 1985. The Department of Interior through Reclamation became the lead Federal agency; thus the hydropower proposal was no longer under FERC's authority.

Early in 1986, the Bureau of Land Management (BLM), Fish and Wildlife Service (FWS), and Colorado Division of Wildlife (CDOW) were contacted to discuss any additional environmental concerns and necessary environmental studies. In June 1986, news releases on the AB Lateral facility were issued to local newspapers and other news media. In response to this information, comments were received from the Nature Conservancy and the Western Colorado Congress. Concerns raised and studies suggested by these agencies and organizations included the following:

- need for a survey of endangered plants along the penstock route,

- need for quantification of fish losses through the Gunnison Tunnel,

- determination of the effect of ice on Gunnison River waterfowl and eagles,

- consideration of the effect of flows on Uncompahgre Valley gravel operations,

- consideration of the effect of flows on livestock operations on the Uncompahgre River,

- consideration of the northern pike in the analysis of Gunnison River impacts,

- use of existing rafting data to assess impacts on rafting,

- study of the potential of a tailrace fishery on the Uncompahgre River downstream from the powerplant, and

- determination of the effect of a project on water quality in the Uncompahgre River.

These issues were addressed in several ways. Field surveys of the endangered plant species were initiated and an analysis of icing potential in the Gunnison River was conducted. Contacts were made with landowners along the Uncompahgre River to determine the potential problems with livestock and gravel operations. The CDOW was contacted on fish loss through the Gunnison Tunnel, waterfowl, northern pike management and the tailrace fishery. The FWS was contacted concerning data needs regarding bald eagles on the Gunnison River, and consultation under section 7 of the Endangered Species Act was initiated between Reclamation and FWS. These issues are discussed in detail in chapter 3.

In 1987, Reclamation began preparation of an environmental assessment for the AB Lateral Facility. Two environmental scoping meetings were held regarding the facility in October 1987, one in Denver and one in Montrose. A Notice of Environmental Scoping Meetings was published in the Federal Register before the meetings and news releases were published in local newspapers. In addition, letters were sent to various interested agencies and organizations advising them of the meetings, including local, state, and Federal agencies and organizations such as Trout Unlimited and Western River Guides. Concerns and issues raised in the scoping meetings are listed below.

Concerns and Issues

Minimum flows for Gunnison River

Date of hydropower water rights and whether later instream flow rights would be honored

The relationship of project to Lower Gunnison Basin Unit winter water replacement program

Potential of fish losses through Gunnison Tunnel

Effect of project on Blue Mesa Reservoir

Effect of project on the Upper Gunnison-Uncompahgre Basin Study

Effects on utilities in City of Montrose

Potential for improved water quality and flow to cause classification of the Uncompahgre River to be upgraded, in turn causing stricter discharge limitations to be placed on Montrose sewer plant

Type of permit Reclamation would issue on project

Impact of higher winter flows in Uncompahgre River on wetlands and land use including positive and negative effects on waterfowl, livestock, vegetation, and other parameters

Designation of Reclamation as the lead agency and question as to why Reclamation would not prepare environmental statement

Potential of topsoil along penstock to be returned to irrigated lands

Assessment of new transmission line

Placing pipeline within easements of existing drainage ditches to avoid productive fields

Authority needed to perform surveying on private land

Alternative routes for penstock

Use of water that goes into Uncompahgre River in spring (earlier than at present) and availability to farmers

Use of earlier spring water for recreation, i.e., fishery purposes

Earlier spring water creating more of a floodplain situation with positive and negative effects

Effects of higher flows in Uncompahgre River on salt leaching from banks

Potential for increased flooding on Uncompahgre River

Consideration of Ridgway Dam for reducing flooding caused by powerplant

Need for Section 404 Permit

Need for program of bank protection on the Uncompahgre

Capacity of AB Lateral

Consideration of community benefits and local control

At the meetings, Reclamation explained that either a finding of no significant impact or a draft and final environmental impact statement would be prepared to comply with the National Environmental Policy Act.

The issues raised at the scoping meetings were used to finalize the Sponsors' proposal and to finalize the environmental assessment. Additional contacts were made with the CDOW, BLM, Corps of Engineers, FWS, Region 10 League for Economic Assistance and Planning (Region 10), The Nature Conservancy, the Colorado Department of Health, and others to clarify and answer issues. The FWS (1988b) has prepared a draft Planning Aid Memorandum on the project in accordance with the Fish and Wildlife Coordination Act and a Biological Opinion in accordance with the Endangered Species Act. The draft recommendations of the FWS include in-kind replacement of wetland losses, inclusion of winter flows such as in alternative F to reduce icing, inclusion of deer escapes in the enlarged AB Lateral, development of a South Canal management plan, and establishment of a summer minimum flow of 60 to 80 ft^3/s in the Uncompahgre River through Montrose (see attachment E for the draft recommendations and Reclamation's proposed action on these recommendations).

Environmental Assessment

The environmental assessment (EA) was mailed to approximately 200 individuals, organizations and agencies in March and April 1988. In addition, copies were available in local libraries, at the UVWUA office in Montrose and the BLM office in Montrose. A press release was issued on the availability of the assessment and the matter received substantial coverage by local and state news media.

A review period of 30 days was set for the assessment; however, it was extended to 60 days after several individuals and organizations requested additional time. The extension was the subject of additional news releases, and individual notification was made to those who requested an extension.

During the review period, meetings with local government agencies were held to answer questions on the project. In addition, meetings were held with the Colorado Division of Parks and Outdoor Recreation, Trout Unlimited, the Sierra Club, Region 10, FWS and CDOW. The Sponsors also met with several local agencies and individuals to answer questions concerning the project.

Approximately 300 comment letters were received on the EA; comments fell into three general categories: additional studies or an environmental impact statement (EIS) needed on the project, opposed to the project based on various reasons, and supporting the project based on various reasons.

Specific comments are available for inspection at Reclamation's Grand Junction Projects Office. The primary environmental issues addressed are summarized below and were considered the most significant issues for additional consideration in the EIS.

Effect of the proposal on various land uses and land use designations along the Gunnison River (i.e., Wild and Scenic River status, wilderness study area status)

Effect of reduced flows in Gunnison River on water temperature

Effect of proposals on Gunnison River fishery, particularly downstream from the North Fork

Effect on rafting on the Gunnison River

Effect on reserved water rights associated with the Black Canyon of the Gunnison National Monument and the existing wilderness area

Effect on channel morphology, erosion, sedimentation and other river mechanics factors on the Gunnison and Uncompahgre Rivers.

Effect on existing and potential recreation use of the Uncompahgre River

Effect on recreation/tourism from a visitor use and economic standpoint

More discussion on the purpose and need for the project is needed

Additional alternatives should be addressed

In response to the comments received and based on the environmental assessment itself, Reclamation determined that an environmental impact statement should be prepared. This decision was published in local and state newspapers as well as being the subject of a notice in the Federal Register. Additional studies and coordination were initiated to answer comments on the assessment. These efforts are summarized as follows.

CONCERN	RESPONSE
The effect of the project on various land uses and land use designations along the Gunnison River (such as Wild and Scenic River status and wilderness).	Additional consultation work was done with the National Park Service and the BLM on these issues. Written comments were obtained from both agencies.
The effect of project on water temperatures in Gunnison River in summer and winter.	Low flows in the summer of 1988-1989 provided an excellent opportunity to monitor water temperatures. Temperature stations were installed between Crystal Reservoir and Delta and were used to monitor summer and winter temperatures. In addition, further studies were completed by a consultant with expertise in icing. Alternative F includes plans to bypass additional flows down the Gunnison River to reduce icing if it becomes a problem.
Effect of project on Gunnison River fishery downstream from the North Fork confluence.	Once again, the 1988-1989 water temperature data will help assess these conditions. Also, Reclamation obtained input from the CDOW on angler use, fish harvest, distribution, and fish population collected at the end of 1988 from the Gunnison River upstream and downstream from the North Fork confluence.
Effect of the project on river rafting.	Information from BLM on the effects of low flows on rafting in the 1988 season provides additional data to evaluate this impact. Comments made on the EA are being used to better define the types of rafting, minimum and optimum flow needs, and other flow-related factors.

CONCERN	RESPONSE
Effect of the project on river morphology and related subjects.	An independent consultant prepared an analysis of this subject, and the results are included in this EIS.
Effect of the project on recreation use and potential use along the Uncompahgre River.	Additional flow analyses were completed to better determine flow changes in this area to more accurately define pre- and post-project conditions. An alternative plan includes provisions to supplement flows in this reach.
Effect of the project on recreation and tourism from an economic standpoint.	An independent consultant prepared information on recreation and tourism impacts in Montrose and Delta Counties.
Need for project should be explained more thoroughly.	This section of the EIS has been expanded with additional information not included in the EA.
Additional alternatives should be addressed.	The EIS includes more detail on alternatives considered and why they are considered viable or nonviable.

In September 1988, a status letter on the preparation of the environmental impact statement was mailed to news media and to interested organizations and agencies. The Notice of Intent to prepare the environmental impact statement was published in the Federal Register on December 27, 1988.

Environmental Impact Statement

The availability of this draft environmental impact statement has been published in the Federal Register and in local and state newspapers. Public hearings will be held in Denver, Montrose, and Delta, Colorado. The initial distribution list for the statement is shown below. Additional copies of the statement are available upon request from Reclamation offices in Grand Junction, Colorado, and Salt Lake City, Utah.

A final environmental statement will be prepared by Reclamation addressing comments received on the draft. Following publication of the final environmental impact statement, a record of decision will be prepared stating Reclamation's decision on the project.

Distribution List

Copies distributed by the Deputy Commissioner's Office, Denver, Colorado.

- Advisory Council on Historic Preservation
- Congressional Delegation
  - Senator William Armstrong, U.S. Senate
  - Congressman Ben Nighthorse Campbell, U.S. House of Representatives
  - Senator Timothy Wirth, U.S. Senate
- Department of Agriculture
- Department of Army
- Department of Energy
  - Federal Energy Regulatory Commission
  - Western Area Power Administration
- Department of Health and Human Services
- Department of Interior
  - Bureau of Indian Affairs
  - Bureau of Land Management
  - Bureau of Mines
  - Fish and Wildlife Service
  - Geological Survey
  - National Park Service
- Department of Transportation
- Environmental Protection Agency

Copies distributed by Upper Colorado Regional Office, Salt Lake City, Utah.

Federal

- Advisory Council on Historic Preservation
- Congressional Delegation
  - Senator William Armstrong, Grand Junction, Colorado
  - Congressman Ben Nighthorse Campbell, Grand Junction, Colorado
  - Senator Timothy Wirth, Grand Junction, Colorado
- Department of Agriculture
  - Forest Service, Delta, Grand Junction, and Montrose, Colorado
  - Soil Conservation Service, Delta, Denver, Grand Junction, and Montrose, Colorado
- Department of the Army
  - Corps of Engineers, Sacramento, California; Grand Junction, Colorado

Department of Energy
- Federal Energy Regulatory Commission, San Francisco, California
- Western Area Power Administration, Golden and Montrose, Colorado; Salt Lake City, Utah

General Services Administration, Denver, Colorado
Department of Health and Human Services, Denver, Colorado
Department of Interior
- Bureau of Indian Affairs, Golden, Colorado
- Bureau of Land Management, Denver, Grand Junction, and Montrose, Colorado
- Bureau of Mines, Denver, Colorado
- Fish and Wildlife Service, Grand Junction, Colorado, and Salt Lake City, Utah
- Geological Survey, Grand Junction, Colorado
- National Park Service, Denver, Gunnison, and Montrose, Colorado
- Office of the Regional Solicitor, Salt Lake City, Utah

Department of Transportation, Lakewood, Colorado
Environmental Protection Agency, Denver, Colorado

State

Governor, State of Colorado, Denver, Colorado
Lieutenant Governor, State of Colorado, Denver, Colorado
Attorney General, State of Colorado, Denver, Colorado
Colorado Department of Natural Resources, Denver, Colorado
Colorado Department of Highways, Grand Junction, Colorado
Colorado District Engineer, Montrose, Colorado
Colorado Division of Parks and Outdoor Recreation, Denver, Grand Junction, and Montrose, Colorado
Colorado Division of Water Resources, Denver, Colorado
Colorado Division of Wildlife, Denver, Montrose, and Gunnison, Colorado
Colorado Geological Survey, Denver, Colorado
Colorado Office of Planning and Budget, Denver, Colorado
Colorado State Clearinghouse, Denver, Colorado
Colorado State Historic Preservation Officer, Denver, Colorado
Colorado Water Conservation Board, Denver, Colorado
Colorado Water Resources and Power Development Authority, Denver, Colorado

State Legislators, Local

Representative Ken Chlouber, Leadville, Colorado
Representative Lewis Entz, Hooper, Colorado
Representative Tim Foster, Grand Junction, Colorado

Representative Margaret Masson, Crawford, Colorado
Representative Dan Prinster, Grand Junction, Colorado
Senator Tilman Bishop, Grand Junction, Colorado
Senator Robert DeNier, Durango, Colorado
Senator Robert L. Pastore, Monte Vista, Colorado

Libraries

Adams County Public Library, Aurora, Colorado
Arapahoe County Public Library, Boulder, Colorado
Delta Public Library, Delta, Colorado
Douglas County Public Library, Castle Rock, Colorado
Eagle County Public Library, Eagle, Colorado
El Paso County Public Library, Colorado Springs, Colorado
Fort Collins Public Library, Fort Collins, Colorado
Gunnison County Public Library, Gunnison, Colorado
Jefferson County Public Library, Lakewood, Colorado
Mesa County Public Library, Grand Junction, Colorado
Montrose Regional Library, Montrose, Colorado
Ouray Public Library, Ouray, Colorado

News Media

Crested Butte Chronicle, Crested Butte, Colorado
The Daily Sentinel, Grand Junction, Colorado
Delta County Independent, Delta, Colorado
Denver Post, Denver, Colorado
Gunnison Country Times, Gunnison, Colorado
Montrose Daily Press, Montrose, Colorado
North Fork Times, Paonia, Colorado
Ouray County Plaindealer, Ouray, Colorado
Rocky Mountain News, Denver, Colorado

Local Agencies and Private Organizations

Adrift Adventures, Fort Collins, Colorado
American Rivers, Washington, DC
American Wilderness Alliance, Englewood, Colorado
Arkansas Valley Audubon Society, Pueblo, Colorado
Audubon Society, Grand Junction, Colorado
Bill Dvorak's Kayak and Rafting Expeditions, Nathrop, Colorado
Bona Fide Ditch Company, Delta, Colorado
Cinnamon Ridge Homeowner's Association, Montrose, Colorado
City of Delta, Delta, Colorado
City of Montrose, Montrose, Colorado
Colorado Environmental Coalition, Denver, Colorado

Colorado Mountain Club, Montrose, Colorado
Colorado River Water Conservation District, Glenwood Springs, Colorado
Colorado River Outfitters Association, Westminister, Colorado
Colorado-Ute Electric Association, Montrose, Colorado
Colorado White Water Association, Boulder and Littleton, Colorado
Colorado Wildlife Federation, Denver, Colorado
Delta County Commissioners, Delta, Colorado
Delta County Tourism Council, Delta, Colorado
Gunnison County Planner, Gunnison, Colorado
Gunnison River Expeditions, Hotchkiss, Colorado
Humpback Chub River Tours, Dolores, Colorado
Mesa County Water Association, Fruita, Colorado
Montrose Concrete Products Company, Montrose, Colorado
Montrose County Airport Authority, Montrose, Colorado
Montrose County Farm Bureau, Montrose, Colorado
Montrose County Chamber of Commerce, Montrose, Colorado
Montrose County Commissioners, Montrose, Colorado
Montrose Industrial Development, Montrose, Colorado
Montrose Visitors and Convention Bureau, Montrose, Colorado
National Parks and Conservation Association, Salt Lake City, Utah
Paonia Chamber of Commerce, Paonia, Colorado
Planned Economic Progress, Inc., Cedaredge, Colorado
Project 7 Water Authority, Montrose, Colorado
Region 10, Montrose, Colorado
San Miguel County Commissioners, Telluride, Colorado
Schnieder's Ready Mix, Inc., Montrose, Colorado
Sierra Club Legal Defense Fund, Denver, Colorado
Sierra Club, Boulder, Denver and Grand Junction, Colorado
The Nature Conservancy, Boulder, Colorado
The Telluride Institute, Telluride, Colorado
Town of Olathe, Olathe, Colorado
Town of Ouray, Ouray, Colorado
Town of Ridgway, Ridgway, Colorado
Tri-County Water Conservancy District, Montrose, Colorado
Trout Unlimited, Denver, Gunnison, Grand Junction, and Montrose, Colorado
Uncompahgre Recreational Corridor Coalition, Montrose, Colorado
Uncompahgre Valley Association, Montrose, Colorado
Uncompahgre Valley Water Users Association, Montrose, Colorado
Water Market Update, Santa Fe, New Mexico
Western Colorado Congress, Montrose, Colorado
West Slope Energy Research Center, Hotchkiss, Colorado
Wilderness Aware, Buena Vista, Colorado
Wilderness Society, Denver, Colorado

Interested Individuals

Roland T. Adams, Delta, Colorado
H. Hayes Alexander, Montrose, Colorado
John Alexander, Delta, Colorado
William Alexander, Montrose, Colorado
David Anderson, Montrose, Colorado
Robert D. Anders, Delta, Colorado
Bob Andrews, Paonia, Colorado
Frank Antal, Delta, Colorado
Doyle and Mrs. Ashby, Delta, Colorado
Shane Atchley, Delta, Colorado
Dennis Bailey, Montrose, Colorado
John Baldus, Montrose, Colorado
Lynn C. Becker, Montrose, Colorado
John Benjamin, Hotchkiss, Colorado
Dick and Muriel Berry, Cedaredge, Colorado
James G. Bock, Boulder, Colorado
David A. Bowman, Olathe, Colorado
Larry Boyd, Delta, Colorado
Kenneth Brew, Delta, Colorado
Merle Brew, Olathe, Colorado
Robert Brew, Delta, Colorado
Henry A. Brooks, Hotchkiss, Colorado
Guy Brooner, Montrose, Colorado
Lynn M. Brown, Montrose, Colorado
Bill Brunner, Paonia, Colorado
Bradley M. Burch, Olathe, Colorado
James Burch, Superior, Colorado
Buzz Burrell, Paonia, Colorado
Keith Catlin, Montrose, Colorado
Roger G. Cesario, Crested Butte, Colorado
James R. Clark, Delta, Colorado
Ralph Clark III, Gunnison, Colorado
Debra Clary, Paonia, Colorado
Rich Cline, Hotchkiss, Colorado
E. Ray Coffee, Montrose, Colorado
Dallas Collins, Montrose, Colorado
V.L. Cook, Delta, Colorado
Lee Cooper, Montrose, Colorado
Wilbur Cooper, Olathe, Colorado
Robert Cory, Montrose, Colorado
John P. Cossick, Montrose, Colorado
Greg Cranson, Paonia, Colorado
Mrs. Dudley Davis, Delta, Colorado
Darla S. DeRuiter, Boulder, Colorado
Thurlow De Vries, Olathe, Colorado
Elbert Dougan, Delta, Colorado
Curielle Duffy, Crawford, Colorado
Dale H. Eckerdt, Montrose, Colorado

Norman Edgell, Montrose, Colorado
Philip V. Egidi, Hotchkiss, Colorado
Michael and Mrs. English, Montrose, Colorado
Gerald Ethridge, Montrose, Colorado
Joel Evans, Montrose, Colorado
Sally Evans, Boulder, Colorado
Paul Fedler, Delta, Colorado
Michael G. Figgs, Boulder, Colorado
Fred Flower, Montrose, Colorado
Valerie Fogleman, Corpus Christi, Texas
William M. Folger, Denver, Colorado
Gary Frigetto, Montrose, Colorado
Gary Gabrel, Boulder, Colorado
David Galinat, Olathe, Colorado
Frank Garcia, Montrose, Colorado
Bo Gates, Paonia, Colorado
Caleb Gates, Denver, Colorado
Scott Gerber, Crested Butte, Colorado
Kay Gerke, Montrose, Colorado
Gregory Gibson, Montrose, Colorado
Everett Gilbert, Montrose, Colorado
Don R. Gladwell, Montrose, Colorado
Bill Graham, Grand Junction, Colorado
Gene Gray, Olathe, Colorado
Kenneth Gray, Delta, Colorado
Joe Greiner, Buena Vista, Colorado
James Grett, Olathe, Colorado
Dick Guadagno, Paonia, Colorado
Diane Hackl, Telluride, Colorado
Elenor Haley, Montrose, Colorado
Drew Hardman, Montrose, Colorado
Robert J. Harris, Montrose, Colorado
Jeff Hatton, Grand Junction, Colorado
Merry Havens, Boulder, Colorado
Phil Hayden, Telluride, Colorado
Bernie Heideman, Hotchkiss, Colorado
Leonard Hendzel, Hotchkiss, Colorado
Walter Hill, Montrose, Colorado
Steve Hinchman, Hotchkiss, Colorado
George Hines, Delta, Colorado
Kenneth Hines, Delta, Colorado
Randy Hines, Delta, Colorado
Harold L. Hish, Montrose, Colorado
Gerald Holden, Delta, Colorado
Charles A. Holder, Eckert, Colorado
John Holton, Delta, Colorado
Carolyn M. Homewood, Montrose, Colorado
Carl Hughes, Montrose, Colorado
Ruth Hutchins, Fruita, Colorado
John W. Isgreen, Montrose, Colorado

Kurt Isgreen, Montrose, Colorado
Enoch Jackson, Olathe, Colorado
Keith Jensen, Delta, Colorado
Chris Johnson, Paonia, Colorado
Nina Johnson, Boulder, Colorado
David C. Johnston, Paonia, Colorado
Earl P. Jones, Boulder, Colorado
Scott Jorgensen, Delta, Colorado
Robert J. Jutten, Montrose, Colorado
John Kaser, Montrose, Colorado
Bob Kennemer, Jr., LaVeta, Colorado
Lisa J. Kerman, Ouray, Colorado
Karl Kiser, Las Cruces, New Mexico
Gary Kolsis, Paonia, Colorado
Stuart Krebs, Montrose, Colorado
Edward Kubin, Montrose, Colorado
George Kubin , Montrose, Colorado
Thomas Kyle, Montrose, Colorado
Donald E. LaBarr, Montrose, Colorado
Carol Lee, Montrose, Colorado
Gale Longwell, Olathe, Colorado
Jim Longwell, Montrose, Colorado
Erlinda Lopez, Montrose, Colorado
Debbie Maddox, Montrose, Colorado
F. Craig Magee, Houston, Texas
A. Marchbanks, Delta, Colorado
Kenneth Marchbanks, Delta, Colorado
Kenny Marks, Gunnison, Colorado
Chip Marlow, Montrose, Colorado
Harry Marolf, Montrose, Colorado
Ed Marston, Paonia, Colorado
Mike Martin, Grand Junction, Colorado
Jane McGary, Hotchkiss, Colorado
Greg and Jill McKennis, Glenwood Springs, Colorado
Glenn McKinney, Olathe, Colorado
Robert McPhee, Denver, Colorado
Frank Meaker, Montrose, Colorado
Randall Meaker, Montrose, Colorado
Fred Miller, Montrose, Colorado
Glen Miller, Grand Junction, Colorado
Artie Milligan, Montrose, Colorado
Brian Mitchell, Paonia, Colorado
Dennis Mitchell, Montrose, Colorado
Harold Mitchell, Jr., Montrose, Colorado
Guy Mock, Montrose, Colorado
Carl L. Moore, Montrose, Colorado
Claire Moore, Paonia, Colorado
Mary Moran, Aspen, Colorado
Thomas Morris, Montrose, Colorado
Beth Moxley, Montrose, Colorado

Norman J. Mullen, Boulder, Colorado
David and Rita Johnston/Murphy, Paonia, Colorado
Paul Murrill, Paonia, Colorado
Mari Hoffmann-Nelson, Kelso, Washington
Robin Nicholoff, Hotchkiss, Colorado
Linda Mudd O'Brien, Grand Junction, Colorado
R.G. and Mrs. Ohlheiser, Crawford, Colorado
Mark Paigen, Paonia, Colorado
Carla Hathaway Palmer, Steamboat Springs, Colorado
Kenneth and Ida Parks, Delta, Colorado
Kevin Parks, Paonia, Colorado
Stephen M. Parzybok, Paonia, Colorado
Keith Pfeiffer, Montrose, Colorado
Howard and Mrs. Pridy, Olathe, Colorado
Richard Proctor, Delta, Colorado
Nancy Psencik, Ouray, Colorado
Mark Quire, Nederland, Colorado
Kim Ragotzkie, Fort Collins, Colorado
D.L. Reddick, Montrose, Colorado
Anthony Richards, M.D., Delta, Colorado
Con and Mrs. Roberts, Montrose, Colorado
Kim Roberts, Hotchkiss, Colorado
Miland Roberts, Montrose, Colorado
Becky Rumsey, Paonia, Colorado
Ed Saunders, Montrose, Colorado
Thomas Savage, Montrose, Colorado
John Savarese, Staten Island, New York
Lee Sayre, Paonia, Colorado
Bob Schell, Montrose, Colorado
Lloyd M. Schiel, Montrose, Colorado
Edward Schmalz, Delta, Colorado
Steve Schmalz, Delta, Colorado
Robert S. Schmidt, Montrose, Colorado
Kay Schrieber, Gunnison, Colorado
Francis J. Schumann, Denver, Colorado
David Seaver, Cedaredge, Colorado
Jon Sering, Montrose, Colorado
Mrs. A.E. Seymour, Olathe, Colorado
Earl W. Seymour, Olathe, Colorado
Steve Shea, Delta, Colorado
Julie Sikorski, Montrose, Colorado
Mark Silversher, Telluride, Colorado
Darrel Sinner, Delta, Colorado
Joe Skinner, Grand Junction, Colorado
Donald Smith, Montrose, Colorado
Rich Smith, Crested Butte, Colorado
Eric Sowell, Montrose, Colorado
John Spezia, Steamboat Springs, Colorado
Alfred Spinhirne, Montrose, Colorado
Chris Squires, Denver, Colorado

Jack A. Stanford, Polson, Montana
LeRoy Stanford, Cedaredge, Colorado
Sam Stewart, Montrose, Colorado
Paul Story, Montrose, Colorado
Nancy Strong, Colorado Springs, Colorado
Clint Stroud, Delta, Colorado
Leigh Sullivan, Telluride, Colorado
Lawrence Suppes, Olathe, Colorado
Wayne Talmadge, Paonia, Colorado
Howard Taylor, Montrose, Colorado
Marvin Taylor, Montrose, Colorado
Andy Tczap, Denver, Colorado
Bill Tembrock, Hotchkiss, Colorado
Mrs. Addie Threlkeld, Coaldale, Colorado
Dick Todd, Montrose, Colorado
Phil Trumbo, Montrose, Colorado
Robert W. Urquhart, Montrose, Colorado
John Wade, Pueblo, Colorado
William Wallace, Montrose, Colorado
Catherine C. Warren, Montrose, Colorado
John Welfelt, Delta, Colorado
Jody L. Werner, Buena Vista, Colorado
Fred Wetlaufer, Montrose, Colorado
Kent Wheeler, Salt Lake City, Utah
Charles White, Denver, Colorado
Gary and Syril Whitlock, Montrose, Colorado
Louis Wick, Delta, Colorado
Joe and Ruby Williams, Montrose, Colorado
Mike Wilson, Gunnison, Colorado
Fred Witaschek, Englewood, Colorado
Andy Wolcott, Paonia, Colorado
Steve Wolcott, Paonia, Colorado
Steven Wondzell, Las Cruces, New Mexico
John Wood, Englewood, Colorado
Mary Wood, Montrose, Colorado
Ralph Woods, Montrose, Colorado
Frank Young, Olathe, Colorado
Fred Yost, Washington, DC

CHAPTER 5
LIST OF PREPARERS

This environmental impact statement has been prepared by Reclamation using an interdisciplinary team effort. Reclamation's Grand Junction Projects Office, Upper Colorado Regional Office, and Denver Office were involved in its preparation. Certain studies were prepared by private consultants as were preliminary sections of the report. In addition, private citizens as well as representatives from local, state, and Federal agencies have provided data or prepared reports that were used in the statement's preparation. These individuals and organizations are cited in the text and in the references cited portion of this report.

The following list includes those primarily responsible for the document.

<u>Reclamation Personnel</u>

Name: Peggy Barnett
Position: Archeologist
Education: M.A., Archeology
Experience: 9 years
Input to report: Cultural resources coordination

Name: Linda Branch
Position: Writer-editor
Education: B.A. Journalism
Experience: 14 years
Input to report: Editing and publishing

Name: Fred Crabtree
Position: Supervisory Civil Engineer
Education: B.S., Civil Engineering
Experience: 27 years
Input to report: Design, operation and maintenance concerns

Name: Patrick Koelsch
Position: Fishery Biologist
Education: M.S. Environmental Science
Experience: 12 years
Input to report: Fisheries

Name: Steve McCall
Position: Environmental Specialist
Education: M.S. Wildlife Biology
Experience: 17 years
Input to report: Environmental coordination

Name: Coll Stanton
Position: Hydraulic Engineer
Education: B.S. Agricultural Engineering
Experience: 14 years
Input to report: Hydrology, water rights

Name: Lynnette Wirth
Position: Public Involvement Specialist
Education: B.S. Education
Experience: 11 years
Input to report: Public involvement matters

Private Consultants

Name: Kelly A. Bettendorf
Position: Environmental Assistant
Education: B.S. Biology
Experience: 1 year
Input to report: Terrestrial wildlife, soils and vegetation

Name: Barry Butterfield
Position: Civil Engineer
Education: M.S. Water Resources
Experience: 12 years
Input to report: Hydrology and technical analysis

Name: Mark R. Deutschman
Position: Environmental Specialist
Education: B.A. Zoology
Experience: 4 years
Input to report: Water temperature and quality, fisheries

Name: Richard Kentro
Position: Environmental Planner
Education: M.S. Environmental Planning
Experience: 14 years
Input to report: Quality assurance

Name: George Minerich
Position: Environmental Specialist
Education: B.S. Environmental Studies
Experience: 1 year
Input to report: Air quality and noise, land use

Name: Michael A. Stevens
Position: River morphologist
Education: PhD, Civil Engineer
Experience: 21 years
Input to report: River mechanics and channel morphology

Name: James Thompson
Position: Economist
Education: PhD Sociology
Experience: 24 years
Input to report: Fishing and rafting economics

Name: Jeffrey Turner
Position: Environmental Specialist
Education: M.S. Geography
Experience: 10 years
Input to report: Environmental analysis

The following Upper Colorado Regional Office and Denver Office Personnel provided technical review of the report:

Reed Harris-fisheries, endangered species
Gordon Lind-NEPA compliance
Marvin Hein-hydropower, lease of power privilege
Art Cudworth-hydrology
Bob Strand-sedimentation
Larry Schluntz-economics
Thayne Coulter-social aspects, public involvement

CHAPTER 6
REFERENCES

Ashton, G.D. 1986. River and lake ice engineering. Water Resources Publications. Chelsea, Michigan.

____________ 1987. Effect of diversions of flows of Gunnison River on ice extents downstream. Report prepared for EMANCO, Inc. Houston, Texas.

____________ 1988. Analyses of potential icing problems in the Gunnison River. Report prepared for EMANCO, Inc. Houston, Texas.

Beck, T. 1988. Colorado Division of Wildlife. Personal communication to Bureau of Reclamation, Grand Junction, Colorado.

Behnke, R.J. 1984. Fisheries impact analysis for year-round flow depletion of 1000 cfs from Gunnison River in Black Canyon area. MS prepared for West Slope Hydro Partners and submitted to Federal Energy Regulatory Commission as Supplement to License Application Submitted February 3, 1984, Uncompahgre Valley Hydroelectric Project No. 2, FERC Project No. 8023. Colorado. 23 pp.

__________. 1986. Potential impacts of reduced winter flows in Gunnison River on trout reproduction and growth in relation to lower water temperatures and ice formation. Department of Fishery and Wildlife Biology, Colorado State University.

Benson, N.G. 1955. Observations on anchor ice in a Michigan trout stream. Ecology 36(3):529-530.

Bio/West, Inc. 1981. Aquatic Biology Studies for Proposed Colorado-Ute Electric Association Powerplant near Grand Junction, Colorado. December. 66 pp. Logan, Utah.

Brown, G.J.D., W.D. Clothier, and W. Alvord. 1953. Observation on ice conditions and bottom organisms in the West Gallatin River, Montana. Montana Academy of Science Proceedings. 13:21-27.

Burkhard, W.T. 1987. Colorado Division of Wildlife. Personal communication to Bureau of Reclamation, Grand Junction, Colorado.

Chandler, S. 1984. Survey of Cultural resources for the Uncompahgre Valley Hydroelectric Project Nos. 1-6, Montrose, Colorado. Report prepared by Nickens & Associates, Montrose, Colorado, for INDECO, Minneapolis, Minnesota.

__________. 1986. Archaeological investigations for the Uncompahgre Valley Hydropower Project, Montrose County, Colorado. Report prepared by Nickens & Associates, Montrose, Colorado, for EMANCO, Inc., Houston, Texas.

Clark, R. 1988. Colorado Division of Wildlife. Personal communication with HDR, Inc. Minneapolis, Minnesota.

Collins, Susan et al. 1981. Survey of Cultural Resources in the Lower Gunnison Basin Unit, Colorado River Water Quality Improvement Program. Colorado State University, Laboratory of Public Archeology.

Colorado Department of Health. 1989. Letter from Public Health Engineer, Denver, to Bureau of Reclamation, Grand Junction, Colorado dated February 7, 1989.

Colorado Division of Local Government. 1984. Community profile - City of Montrose. Demography Section, Denver, Colorado.

Colorado Division of Parks and Outdoor Recreation. 1981. State Comprehensive Outdoor Recreation Plan. Denver, Colorado.

Colorado Division of Wildlife. nd. Gunnison River - a gold medal river. Brochure available from Division of Wildlife, Regional Office, Montrose, Colorado.

__________. 1976. Fish and Wildlife Analysis for the Dallas Creek Water Project. Contract No. 14-06-400-6067. Denver, Colorado.

__________. 1981. Colorado reptile and amphibian distribution latilong study, 2nd edition. Nongame Section, Colorado Division of Wildlife, Denver, Colorado.

__________. 1982. Colorado mammal distribution, latilong study. Nongame Section, Colorado Division of Wildlife, Denver, Colorado.

__________. 1983. Fish and wildlife monitoring, Dallas Creek Project, construction phase. Contract No. 0-07-40-L1532. Denver, Colorado.

__________. 1986. Wildlife in the 1980's, 1986 Annual Report to the People of Colorado. Denver, Colorado.

__________. 1987. Harvest Statistics - Large Game 1987. Denver, Colorado.

__________. 1989. Waterfowl counts. Unpublished data, Montrose, Colorado.

Colorado Field Ornithologists. 1982. Colorado bird distribution, latilong study. Zoological Collections, Denver Museum of Natural Science. Denver, Colorado.

Colorado Public Utilities Commission. 1988. Decision C88-792, issued June 29, 1988. Denver, Colorado.

Colorado State Engineer, 1987. Personal communication with Jim Hokit, UVWUA. Montrose, Colorado.

Colorado State Historic Preservation Officer. 1986a. Letter to EMANCO, Inc., Houston, Texas, dated June 25, 1986.

__________. 1986b. Letter to EMANCO, Inc., Houston, Texas, dated September 19, 1986.

__________. 1987. Letter to EMANCO, Inc., Houston, Texas, dated September 23, 1987.

Colorado State Planning Division. 1973. Colorado Yearbook, 1973. Denver, Colorado.

Delta County Independent, 1988. 1988 Tourist Guide. Delta County Independent/North Fork Times. Delta, Colorado.

Dronkert, A.E. 1982. The North American river otter-its biology, ecology, and conservation. Unpublished BA Thesis, University of California, Santa Cruz, California.

Elliot, J.M. 1975a. The growth rate of brown trout (Salmo trutta L.) fed on maximum rations. Journal of Animal Ecology. 44:805-822.

__________. 1975b. The growth rate of brown trout (Salmo trutta L.) fed on reduced rations. Journal of Animal Ecology. 44:823-842.

EMANCO, Inc. 1986a. Environmental report on proposed hydropower development - Shavano Falls Hydropower Facility - Uncompahgre Valley Hydropower Project - Montrose County, Colorado. Report prepared for Mitex, Inc., Boston, MA, for submission to U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region, Grand Junction, Colorado.

__________. 1986b. Environmental Report on Proposed Hydropower Development, AB Lateral Hydropower Facility, Uncompahgre Valley Hydropower Project, Montrose, Colorado. Prepared for Mitex, Inc. Boston, Massachusetts.

__________. 1986c. Supplement to environmental report on proposed hydropower development - Shavano Falls Hydropower Facility - Uncompahgre Valley Hydropower Project - Montrose County, Colorado. Report prepared for Mitex, Inc., Boston, Massachusetts, for submission to U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region, Grand Junction, Colorado.

__________. 1987. Supplement to Environmental Report on Proposed Hydropower Development, AB Lateral Hydropower Facility, Uncompahgre Valley Hydropower Project, Montrose, Colorado. Prepared for Mitex, Inc., Boston, Massachusetts.

Environmental Laboratory. 1986. Corps of Engineers Wetlands Delineation Manual, Technical Report Y-86, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Michigan.

Environmental Protection Agency (EPA). 1976. Noise Emission Standards for Construction Equipment, EPA Document No. 55019-76-004. Washington.

__________. 1976. Quality Criteria for Water. Office of Water and Hazardous Materials. Washington DC.

__________. 1984. AP-42, Compilation of Air Pollutant Emissions.

__________. 1985a. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Groundwater, Part 1. EPA 600, June 1985, 002a. 609 pp.

__________. 1985b. Compilation of air pollutant emission factors. AP-42, Fourth Edition.

Erlinge, S. 1968. Food studies on captive otters (Lutra lutra L.). Oikos 19(2):259-270.

Federal Emergency Management Agency. 1984. Firm flood insurance rate map, Montrose County, Colorado (unincorporated areas).

Goodman, P. 1981. Otter (Lutra canadensis) recovery plan, draft. Colorado Division of Wildlife. Denver, Colorado.

Greer, K.R. 1955. Yearly food habits of the river otter in the Thompson Lakes region, northwestern Montana, as indicated by scat analysis. Am. Midland Naturalist 54:299-313.

HDR Engineering, Inc. 1989. AB Lateral Unit Water Supply Study. Report submitted to Bureau of Reclamation, Grand Junction, December.

Hokit, J. 1988. Manager, Uncompahgre Valley Water Users Association. Personal communication to HDR Engineering, Inc., Omaha, Nebraska.

Hydro-Triad, Ltd. 1979. Floodplain Information and Urban Drainage Report, Cedar Creek, Montrose Arroyo, Dry Cedar Creek. Lakewood, Colorado.

Jones, M.P. (ed). 1977. Colorado transplanting river otters: ES Program Expands. Endangered Species Technical Bulletin 2(1):5.

Kinnear, B.S. and R.E. Vincent. 1967. Fishes and fish habits of the Gunnison National Monument. Colorado Cooperative Fish Unit Report submitted to the National Park Service, Denver, Colorado. 45 pp.

Larsen, D.N. 1984. Feeding habits of river otters (Lutra canadensis) in coastal southeastern Alaska. J. Wildl. Mgmt. 48(4):1446-1452.

Maciolek, J.A. and P.R. Needham. 1952. Ecological effects of winter conditions on trout and trout foods in Convict Creek, California, 1951. Trans. American Fish Society 81:202-217.

Mack, C.N. 1985. River otter restoration in Grand County, Colorado. M.S. Thesis, Colorado State University, Fort Collins, Colorado.

Madsen, D. 1988. Colorado Division of Wildlife. Personal communication with HDR Engineering, Inc., Minneapolis, Minnesota.

Mariah and Associates. 1986. Threatened and endangered plant survey and reconnaissance for riparian and wetland habitats on portions of the AB Lateral and Shavano Falls Facilities of the Uncompahgre Valley Hydropower Project, Montrose County, Colorado. Report prepared for EMANCO, Inc., Houston, Texas.

__________. 1987a. Riparian vegetation reconnaissance of the Black Canyon of the Gunnison, spring 1987. Report prepared for EMANCO, Inc., Houston, Texas.

__________. 1987b. Field Observations, Locations of Populations, and Biology of Eriogonum pelinophilum from Western Colorado. Report prepared for EMANCO, Inc., Houston, Texas.

McDonald, Stan. 1987. 1987 Archaeological Investigations for the Uncompahgre Valley Hydropower Project, Montrose County, Colorado. Prepared by Nickens and Associates, Montrose, Colorado for EMANCO, Inc., Houston, Texas.

Melquist, W.E. and M.G. Hornocker. 1983. Ecology of river otters in west central Idaho. Wildlife Monographs. 83.

Needham, P.R. and A.C. Jones. 1959. Flow, temperature, solar radiation, and ice in relation to activities of fishes in Sagehen Creek, California. Ecology. 4(3):465-473.

Nehring, R.B. 1981. Report on Electrofishing Survey of the Lower Gunnison River from the North Fork confluence to the Austin Bridge, 1981. Colorado Division of Wildlife, Montrose, Colorado.

__________. 1982. Stream Fisheries Investigations. Colorado Division of Wildlife, Federal Aid in Fish and Wildlife Restoration, F-51-R, Job Progress Report, Ft. Collins.

__________. 1983. Gunnison River Sport Fish Population and Fisherman Use and Catch Study from the East Portal Access Area Below Crystal Dam to the North Fork Confluence. Colorado Division of Wildlife. Fort Collins, Colorado.

__________. 1984. Colorado Division of Wildlife. Personal communication to Bureau of Reclamation, Grand Junction, Colorado.

__________. 1987a. Colorado Division of Wildlife. Personal communication to Bureau of Reclamation, Grand Junction, Colorado.

__________. 1987b. Fish Flow Investigations. Colorado Division of Wildlife, Federal Aid in Fish and Wildlife Restoration, F-51-R, Job 1, Progress Report, Ft. Collins, Colorado.

__________. 1988a. Wild Trout Introductions. Colorado Division of Wildlife, Federal Aid in Fish and Wildlife Restoration, F-51-R, Job No. 2, Progress Report, Ft. Collins, Colorado.

__________. 1988b. Fish Flow Investigations. Colorado Division of Wildlife, Federal Aid in Fish and Wildlife Restoration, F-51-R, Job No. 1, Progress Report, Ft. Collins, Colorado.

__________. 1988c. Fisherman Use and Catch Evaluation of the Gunnison River and Sport Fish Population Analysis for 1988 from the East Portal Access Area below Crystal Dam to the North Fork Confluence. Colorado Division of Wildlife for Bureau of Reclamation under Contract No. 8-FC-40-06580.

__________. 1988d. Colorado Division of Wildlife. Personal communication to Western Research Corporation, Laramie, Wyoming.

Nehring, R.B. and R. Anderson. 1981. Stream Fisheries Investigations. Colorado Division of Wildlife, Federal Aid in Fish and Wildlife Restoration, Project, F-51-R-6. Ft. Collins, Colorado.

__________. 1982. Special Regulations Evaluations. Colorado Division of Wildlife, Federal Aid in Fish and Wildlife Restoration Job Progress Report, F-51-R, Job No. 3, Progress Report, Ft. Collins, Colorado.

__________. 1983. Fish Flow Investigations. Colorado Division of Wildlife, Federal Aid in Fish and Wildlife Restoration, F-51-R, Progress Report, Ft. Collins, Colorado.

__________. 1985a. Special Regulations Evaluations. Colorado Division of Wildlife, Federal Aid in Fish and Wildlife Restoration, Project F-51-R, Progress Report, Ft. Collins, Colorado.

__________. 1985b. Fish Flow Investigations. Colorado Division of Wildlife, Federal Aid in Fish and Wildlife Restoration, F-51. Job Progress Report, Ft. Collins, Colorado.

Nehring, R.B. and D.D. Miller. 1987. The influence of spring discharge levels on rainbow trout and brown trout recruitment and survival, Black Canyon of the Gunnison River, Colorado, as determined by IFIM/PHABSIM models. Proceedings of the Western Association of Fish and Wildlife Agencies and the Western Division of the American Fisheries Society. 67:388-397.

Oblinger-Smith Corporation. 1972. Water and sewer facility plan for Montrose County, Colorado. Prepared for the Colorado Division of Planning, Denver, Colorado.

Olendorff, R.R., A.D. Miller, and R.N. Lehman. 1981. Suggested practices for raptor protection on power lines -- the state of the art in 1981. Raptor Research Found., Raptor Res. Rpt. No. 4, Department of Vet. Biology, University of Minnesota. St. Paul, Minnesota.

Omhart, Robert. 1987. Arizona State University. Personal communication to Bureau of Reclamation, Salt Lake City, Utah.

PedCo - Environmental, Inc. 1978. Survey of fugitive dust in coal mines. Prepared for EPA, Region VIII, Denver, Colorado. 144 pp.

Public Information Corporation. 1986. Whitewater Rafting in Colorado. Published by Public Information Corp., Denver, Colorado.

Public Service Company of Colorado (PSCo). 1987. Electric demand and supply plan. Public Service Company of Colorado, Denver. February.

_________. 1988. Electric demand and supply plan. Public Service Company of Colorado, Denver, Colorado. December.

Rasmussen, D.I. 1941. Biotic communities of Kaibob Plateau. Ecol. Monogr. 11:229-275.

Rautenstrauch, K. and P. Krausman. 1986. Preventing Desert Mule Deer Drownings in the Mohawk Canal, Arizona. University of Arizona for the Bureau of Reclamation, Boulder City, Nevada.

Rector, C.D., Mustard, E. and J. Windell. 1979. Lower Gunnison River Basin wetland inventory and evaluation. Soil Conservation Service, Denver, Colorado.

Reimers, N. 1957. Some aspects of the relation between stream foods and trout survival. California Fish and Game. 43:43-69.

Roedner, B.J., D.A. Hamilton, and K.E. Evans. 1978. Rare plants of the Ozard Plateau - a field identification guide. North Central Forest Exp. Sta., U.S. Forest Service, St. Paul, Minnesota. 238 pp.

Ryder, R.A. 1955. Fish predation by the otter in Michigan. J. Wildl. Mgmt. 19:497-498.

Scherschlight, John. 1987. Colorado Department of Health. Personal communication to Bureau of Reclamation, Grand Junction, Colorado.

Sering, J. 1986. Bureau of Land Management. Personal communication to Bureau of Reclamation, Grand Junction, Colorado.

Shepherd, J. 1986. Personal communication to Mariah Associates, Laramie, Wyoming.

Snow, Carol. 1974. Habitat Management Series for Unique or Endangered Species-Ferruginous Hawk. Report No. 13, Bureau of Land Management, Denver, Colorado.

Soil Conservation Service. 1967. Soil survey-Delta-Montrose Area, Colorado. U.S. Department of Agriculture, Soil Conservation Service in cooperation with Colorado Agricultural Experiment Station.

__________. 1988. Streambank erosion study, Uncompahgre River. Soil Conservation Service, Denver, Colorado.

Stamp, N.E. 1978. Breeding birds of riparian woodland in southcentral Arizona. Condor 80:64-71.

Stanford, Jack A. 1989. Flow Alteration and Ecosystems Stability in the Gunnison River, Colorado: A Perspective. University of Montana, Flathead Lake Biological Station (unpublished paper). 8 pp.

Stanford, J.A. and J.V. Ward. 1981. Preliminary interpretation of distribution of Hydropsychidae in a regulated river. Pages 323-328 in Proceedings of the Third International Symposium on Trichoptera. G.P. Moretti, ed. Series Entomologica, Volume 20. Dr. W. Junck, Publisher, The Hague, Netherlands.

__________. 1983. The effects of mainstream dams on physiochemistry of the Gunnison River, Colorado. Pages 43-56 in Proceedings of the 1981 Symposium on the Aquatic Resources Management of the Colorado River Ecosystem. V.D. Adams and V.A. Lamarra, eds. Ann Arbor Science Publishers. Ann Arbor, Michigan.

__________. 1984. The effects of regulation on the limnology of the Gunnison River: A North American case history. Pages 467-480 in Lillehammer, A. and S. Saltveit (eds.), Regulated Rivers. Univ. As. Oslo, Norway.

Stevens, M.A. 1988. Changes in River Morphology caused by AB Lateral Powerplant. Report submitted to HDR Engineering, Inc., and Bureau of Reclamation, Grand Junction.

Thomas, W.T., C. Maser, and J.E. Rodiek. 1979. Wildlife habitats in managed rangelands--the Great Basin of southeast Oregon--riparian zones. Pacific NW Forest and Range Expt. Stat., Gen. Tech. Rpt. PNW-80, La Grande, Oregon.

Thoreson, R. 1989. National Park Service. Personal communication to Bureau of Reclamation, Grand Junction, Colorado.

Toweill, D.E. and J.E. Tabor. 1982. River otter (Lutra canadensis). Pp. 688-703 In Chapman, J.A. and G.A. Feldhamer (eds.). Wild mammals of North America, John Hopkins Univ. Press, Baltimore and London.

Tucker, G.C., Jr. 1984. Archaeological investigations along the Uncompahgre Valley Water User's Association AB Lateral irrigation ditch, Montrose County, Colorado. Report prepared for Mesa Engineering, Montrose, by Nickens & Associates, Montrose.

Tucker-Leak, K.S. 1987. Recreation use in the Gunnison Gorge Recreation Management Area and other Uncompahgre Basin recreation use areas. Bureau of Land Management, Montrose, Colorado.

__________. 1988a. Bureau of Land Management. Personal communication with Western Research Co., Laramie, Wyoming.

__________. 1988b. Recreation use in the Gunnison Gorge Recreation Management Area and other Uncompahgre Basin recreation use areas. Bureau of Land Management, Montrose, Colorado.

Uncompahgre Valley Water Users Association/Montrose Partners. 1984. Competing applications for license for major project-existing AB Lateral Hydro Project. Filed before the Federal Energy Regulatory Commission, Washington DC, December 22.

U.S. Army Corps of Engineers. 1980. Flood hazard information, Montrose and Olathe, Montrose County, Colorado. Sacramento District, Sacramento, California. February.

U.S. Department of Commerce, 1988. Regional Multipliers: A user handbook for the regional multipliers: a user handbook for the regional input-output modeling system.

U.S. Department of Interior, Bureau of Land Management. 1987. Uncompahgre Basin Wilderness Technical Supplement. Montrose, Colorado.

__________. 1988a. Memorandum from State Director to Regional Director, Bureau of Reclamation, September 16.

__________. 1988b. Addition to the Recreation Area Management Plan for the Gunnison Gorge Recreation Lands. Montrose, Colorado.

U.S. Department of Interior, Bureau of Reclamation (Reclamation). 1975. Final environmental statement, Fryingpan-Arkansas Project, Colorado, Vol. 1. Department of the Interior, Water and Power Resources Service, Washington DC. 582+ pp + Appendices.

__________. 1981. Concluding report, peaking power generation, Blue Mesa Dam, Colorado. (Water and Power Resources Service). Upper Colorado Region, Salt Lake City, Utah.

__________. 1982. Colorado River water quality improvement program - Lower Gunnison Basin Unit - feasibility report. Appendix E, environmental evaluations, reports of cooperating agencies. Upper Colorado Region, Salt Lake City, Utah.

__________. 1984. Final environmental impact statement -- Lower Gunnison Basin of the Colorado River water quality improvement program. Document Number INT FES 84-5 prepared by Upper Colorado Region, U.S. Bureau of Reclamation, Salt Lake City, Utah.

__________. 1986. Environmental Assessment, Shavano Falls Hydropower Facility, Uncompahgre Valley Hydropower Project. Salt Lake City, Utah.

__________. 1987a. Biological Assessment - AB Lateral Hydropower Facility Uncompahgre Valley Hydropower Project. Grand Junction, Colorado.

__________. 1987b. Finding of No Significant Impact-Shavano Falls Hydropower Facility. Salt Lake City, Utah.

__________. 1988. Environmental Assessment. Uncompahgre Valley Hydropower Project, AB Lateral Facility. Salt Lake City, Utah.

__________. 1989. Letter from Acting Area Manager to Projects Manager, Grand Junction, Colorado. January 26.

U.S. Department of Interior, Fish and Wildlife Service. 1978. Impact of transmission lines on birds in flight - proceedings of a workshop. Biological Services Program, Fish and Wildlife Service, U.S. Department of the Interior, FWS/OBS-78/48. Washington DC. 151 pp.

__________. 1980. Habitat evaluation procedures (HEP) - ESM102. Washington DC.

__________. 1982. Colorado River Fishery Project Field Investigations, Part 1, 2, and 3. Salt Lake City, Utah.

__________. 1983. Northern states bald eagle recovery plan. U.S. Fish and Wildlife Service.

__________. 1987. Technical/Agency draft recovery plan for Eriogonum pelinophilum (clay-loving wild-buckwheat). U.S. Fish and Wildlife Service, Grand Junction, Colorado.

__________. 1988a. Biological Opinion: AB Lateral Hydropower Facility - Uncompahgre Valley Hydropower Project. Denver, Colorado.

__________. 1988b. AB Lateral Hydropower Facility, Uncompahgre Valley Hydropower Project-draft planning aid memorandum. Golden, Colorado.

U.S. Department of Interior, U.S. Geological Survey. 1985. Study and interpretation of the chemical characteristics of natural water. USGS Water Supply Paper No. 2254.

__________. 1987. (various years). Water Resources Data. Water Data Reports CO-79-2, CO-80-2, CO-81-2, CO-82-2, CO-83-2, CO-84-2, CO-85-2, CO-86-2, and CO-87-2. Prepared in cooperation with the State of Colorado and other agencies.

U.S. Department of Interior, National Park Service. 1976, 1979-1985. Listing of sites on the National Register of Historic Places.

__________. 1979a. Final Environmental Impact Statement Gunnison Wild and Scenic River Study. Prepared in cooperation with Colorado Department of Natural Resources. Rocky Mountain Regional Office, Denver, Colorado.

__________. 1979b. Wild and Scenic River Study, Gunnison River. Rocky Mountain Regional Office, Denver, Colorado.

__________. 1988. Letter from Regional Director, Rocky Mountain Region to Regional Director, Upper Colorado Region, September 30.

Warner, P. 1988. Montrose County Planner. Personal communication with HDR Engineering, Inc., Minneapolis, Minnesota.

Water Quality Control Commission. 1988. Classifications and Numeric Standards for Gunnison and Lower Dolores River Basins. Colorado Department of Health, Water Quality Control Commission, Denver.

WBLA, Inc. 1986. Curecanti minimum stream flow water rights study - draft. Manuscript prepared for The Nature Conservancy, Colorado Field Office, Boulder, August. 39 pp + Appendices.

Weber, William A. 1983. Checklist of vascular plants, Black Canyon of the Gunnison National Monument. University of Colorado Museum. Boulder, Colorado.

Western Systems Coordinating Council (WSCC). 1988. Ten-year Coordinated Plan Summary 1988-1997. May, 1988.

Wetzel, R.G. 1983. Limnology. Saunders College Publishing.

Wiltzius, W.J. 1978. Some historical factors affecting the distribution and abundance of fishes in the Gunnnison River. Final Report to U.S. Bureau of Reclamation, Colorado Division of Wildlife, Denver, Colorado.

Woodbury, A.M. and H.N. Russel, Jr., 1945. Birds of Navajo country. University of Utah Bull. 35, Biol. Ser. 9(1):1-160.

GLOSSARY OF TERMS

acre-feet	A measure of water volume, 1 foot of water covering an acre in area.
age class	A grouping of organisms in which all of the individuals originated in the same regeneration period.
alluvium	A deposit of sand and gravel formed by flowing water.
back-calculated length	Mathematical relationship between fish age determined by scale measurements and fish length.
benthos	Organisms living in or on the bottom of a lake or stream.
biomass	The amount of living matter in the form of one or more kinds of organisms present in a particular habitat.
Celsius (centigrade)	$°C-(°F-32)5/9$
colluvium	A deposit of soil and gravel deposited at the foot of slopes by gravity.
cubic foot per second	A measure of a moving volume of water (ft^3/s)
cultural resource	Any building, site, district, structure, or object significant in history, architecture, archeology, culture, or science.
degradation	The geologic process wherein streambeds and flood plains are lowered in elevation by the removal of material. The opposite of aggradation.
discontinuity distance	The distance from a dam to a point in a river gradient where biophysical conditions resemble those that existed in an upstream area before regulation.

ecosystem	A complex system composed of a community of fauna and flora taking into account the chemical and physical environment with which the system is interrelated.
endangered species	A species which is in danger of extinction throughout all or a significant portion of its range.
Fahrenheit	°F-(9/5°C)+32
forbs	An herb other than grass.
fry	Fish between the egg and fingerling stage.
gneiss	A metamorphic rock of granite or feldspar.
head	The difference in elevation between two bodies of water.
hectare	An area of land or water equal to 2.471 acres.
invader plants	Species, often annuals, which are not part of the climax vegetation, and invade land when there is little or no competition from other plant species.
Julian day calendar	The system used especially by astronomers of numbering days consecutively from an arbitrarily selected point instead of by cycles of days.
lease of power privilege	A contract between the Interior Department and the project Sponsors allowing use of Federal facilities for power production.
limnology	The scientific study of physical and chemical conditions in fresh waters.
macro-invertebrates	Animals lacking a backbone and internal skeleton, such as insects, worms and crayfish.

mesophyte	A plant growing under medium condition of moisture.
meta-population	A group of occurrences without any major physiographic barriers between them that would block gene flow.
micron	A unit of measure equal to one thousandth of a millimeter (0.000039 inch)
National Register	The National Register of Historic Places is the federally maintained register of significant districts, sites, buildings, structures, architecture, archeology, and culture.
Oligochaeta	Oligochaete-any of various worms of the class.
periphyton	Organisms that live attached to underwater surfaces.
phreatophyte	A deep-rooted plant that grows in riparian zones and obtains water from the water table or the soil just above it.
phytoplankton	Passively floating plant life, primarily algae.
reach	A portion of a stream or river.
recruitment	The increase in population caused by natural reproduction or immigration.
redd	The spawning ground or nest of various fishes.
revetment (bank)	A facing for supporting an embankment.
riparian (vegetation)	Living on the banks of a river or stream.
riprap	Stones placed on the face of a dam or on streambanks or other land surfaces to protect them from erosion.
salmonid	Of or related to the Salmonidae, the family of fishes including trout.

schist	A metamorphic rock having nc granites or feldspar.
sediment	Any usually finely divided organic and/or mineral matter deposited by water in nonturbulent areas.
sere	A series of ecological (vegetative) communities.
sinuosity	The ratio of the total length of the river reach to the straight line distance between the beginning and end of the reach.
South Canal terminus	The point where the South Canal enters the Uncompahgre River.
specific conductance	A measure of the electrical conductivity of water that reflects the concentration of dissolved solids in the water. Generally, the total dissolved solids can be estimated by multiplying the specific conductance by 0.66.
surfacant	A water soluble compound which is applied to ground surfaces to reduce dust emissions.
taxon (pl. taxa)	A group of genetically similar organisms.
thermal stratification	A temperature gradient within a body of water caused by warmer water occupying the upper level of the water and colder, denser water occupying the lower level.
threatened species	A species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.
trophic	Related to nutrition, particularly the types of food an organism requires.
trophic level	Place of an organism in the food chain.

trophy fish	In terms of trout, a fish that exceeds 14 inches.
weighted usable area	An expression of the quantity of fish habitat, in feet squared per 1000 feet of river channel.
wetland	An area characterized by periodic inundation or saturation, hydric soils, and vegetation adapted for life in saturated soil conditions.
year class	Animals born in a given year.

LIST OF ABBREVIATIONS AND ACRONYMS

BLM	United States Bureau of Land Management
Btu	British thermal unit
CDOH	Colorado Department of Health
CDOW	Colorado Division of Wildlife
CDPOR	Colorado Division of Parks and Outdoor Recreation
cfs	cubic feet per second
cm	centimeter
COE	Corps of Engineers
CPUC	Colorado Public Utilities Commission
CRSP	Colorado River Storage Project
CUEA	Colorado Ute Electric Association
C.I.	confidence interval
dB	decibel
DEIS	Draft environmental impact statement
DMEA	Delta-Montrose Electric Association
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESA	Economic Study Area
FERC	Federal Energy Regulatory Commission
ft^3/s	cubic feet per second
FWPCA	Federal Water Pollution Control Act
FWS	U.S. Fish and Wildlife Service
ha	hectare
kg	kilogram
kg/ha	kilograms per hectare
km	kilometer
kV	kilovolt
kW	kilowatt
kWh	kilowatthour
m	meter
mg	milligram
mg/L	milligrams per liter
MW	megawatt
MWh	megawatt-hours
M&D	Montrose and Delta Canal
N	sample size
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act of 1969
NOx	Oxides of Nitrogen
NPS	National Park Service
N/ha	number per hectare
°C	degrees Celsius (centigrade)
°F	degrees Fahrenheit
O&M	Operation and maintenance

OSHA	Occupational Health and Safety Administration
PCCP	Pre-stressed concrete cylinder pipe
PHABSIM	Physical Habitat Simulation Model
PSCo	Public Service Company of Colorado
PURPA	Public Utilities Regulatory Policies Act of 1978
Reclamation	US Bureau of Reclamation
RTU	Remote terminal unit
R&B	Rehabilitation and betterment
SCADA	Supervisory Control and Data Acquisition
SCS	Soil Conservation Service
SHPO	State Historic Preservation Officer
SOx	Oxides of Sulfur
Sponsors	Uncompahgre Valley Water Users Association and Montrose partners
spp.	species (two or more)
sp.	species (one)
TDS	Total dissolved solids
Tunnel	Gunnison Tunnel
USBR	U.S. Bureau of Reclamation
USDI	U.S. Department of the Interior
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UVRP	Uncompahgre Valley Reclamation Project
UVWUA	Uncompahgre Valley Water Users Association
WAPA	Western Area Power Administration
WMP	Water Management Program
WSCC	Western Systems Coordinating Council
WUA	Weighted usable area

ATTACHMENT A

ENVIRONMENTAL COMMITMENTS

ATTACHMENT A
ENVIRONMENTAL COMMITMENTS

The following is a list of environmental commitments for the AB Lateral Hydropower Facility. Unless specified, each commitment applies to all development alternatives (alternatives B, C, E, and F). These commitments will be included in any lease of power privilege negotiated between the Sponsors and Reclamation.

Streamflows and Water Rights

- Hydropower diversions would not be made that would reduce streamflows downstream from the Gunnison Tunnel below 300 ft^3/s, even if the hydropower water right was senior to any future instream flow right or even if future instream flow rights were less than 300 ft^3/s or not designated at all.

- Hydropower diversions would be reduced as described in chapters 2 and 3 if flooding along the Uncompahgre River was aggravated.

- Hydropower operations would not interfere with or reduce the amount of water diverted for irrigation under the UVRP; nor would hydropower diversions interfere with the domestic water supplies furnished through the Gunnison Tunnel or with the existing exchange agreement under the Dallas Creek and Uncompahgre Projects that provides for municipal water to be furnished through the Tunnel.

- The West Canal would continue to receive its irrigation supplies directly from the South Canal.

- Under alternative F, the Sponsors would bypass a minimum flow in the Gunnison River of 600 ft^3/s (if available from Crystal Reservoir releases) when and if adverse icing conditions occur. Also under alternative F, the Sponsors would provide 1,000 acre-feet of water diverted from the Gunnison River to be conveyed through the South Canal for fisheries in the Uncompahgre River.

- No increase in Gunnison Tunnel capacity for hydropower production would be made, except in alternative C where the capacity would be increased to 1,300 ft^3/s.

- Powerplant capacity would be limited to 950 ft^3/s under alternative E and 1,135 ft^3/s under other alternatives.

- The UVRP would not place a call on the Uncompahgre River using its senior water rights of the West, Montrose and Delta, and Loutzenhizer Diversions if the Gunnison Tunnel was diverting water in excess of UVRP irrigation demands, including UVRP diversions downstream from the proposed tailrace.

Bank Stabilization

- The Sponsors would complete initial bank stabilization efforts (as described in chapters 2 and 3) before operation of the hydropower facility.
- Channel conditions in the Uncompahgre River would be monitored and further corrective actions taken during the operation of the facility.
- Bank stabilization work would be done under the conditions of a Section 404 Permit to be obtained by the Sponsors.

Vegetation and Land Use

- All areas disturbed during construction would be restored and reseeded. Irrigated lands would be restored as directed by the landowner. Topsoil would be stockpiled and replaced on the surface of disturbed areas.
- A wetland replacement area of approximately 12 acres would be developed near the tailrace to replace wetlands lost on an acre-for-acre basis. The replacement plan would require approval by Reclamation and the FWS before construction of any project facility and would be completed before the second year of operation of the hydropower facility.
- Construction specifictions would designate areas for disposal of materials. Material would not be disposed of in wetlands or areas of greasewood.
- A revegetation plan would be approved by Reclamation before construction (defined here as an award of a construction contract).

Fish and Wildlife

- Transmission lines and poles would be of a raptor-proof design.
- Two deer escapes would be included in the enlarged AB Lateral as described in chapter 2.

- A fish barrier would be constructed at the AB Lateral-South Canal diversion.

Endangered Species

- A plan for protection of the endangered clay-loving wild buckwheat would require approval from Reclamation and FWS before construction. This plan would describe in detail how impacts to these plants would be minimized as described in chapter 2.

- Approximately 60 acres of habitat of the clay-loving wild buckwheat would be acquired before operation of the facility and transferred to the BLM. If the land were not available, the Sponsors would be required to complete an alternative plan (as designated by the FWS) before operation.

- The Sponsors would monitor bald eagle use as described in chapter 2.

Construction Period

- The Sponsors would pay for any damages to crops or other property associated with obtaining the required construction and operation easements.

- Construction specifications would include provisions to limit noise and air pollution and to minimize traffic disruptions.

- Irrigation supplies would continue to be supplied during the construction period.

- The Sponsors would obtain all necessary construction and operation permits before construction.

- Cultural resources clearance surveys would be conducted on any new areas of construction not previously surveyed and cleared.

- Construction specifications would provide measures to protect cultural resources discovered during construction.

- The Stilson Homestead, a cultural resources site, would not be disturbed during construction or operation.

ATTACHMENT B

HISTORICAL FLOWS IN THE

GUNNISON RIVER

Table B.1

Monthly mean discharges, in ft^3/s, for the Gunnison River below the East Portal of the Gunnison Tunnel, USGS Station No. 09128000, for the period 1903 - 1988.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann. volume, acre-feet
							BEFORE GUNNISON TUNNEL						
1903										641	519	413	
1904	390	416	535	1,503	3,851	3,292	1,103	1,232	896	1,020	500	340	912,355
1905	330	340	700	1,217	5,246	8,383	2,039	1,130	560	519	491	475	1,294,530
1906	465	460	750	2,270	6,620	8,830	3,510	1,470	1,060	905	620	475	1,658,826
1907	470	460	990	2,500	4,400	10,500	6,620	2,400	1,310	986	640	450	1,918,366
1908	450	450	700	1,940	2,690	4,880	2,170	1,630	698	634	510	475	1,040,646
1909	460	450	750	1,950	7,160	10,800	5,470	1,880	2,600	1,270	610	470	2,048,251
							BEFORE TAYLOR PARK RESERVOIR						
1910	460	460	1,730	3,703	6,292	5,336	1,337	882	464	467	550	480	1,339,950
1911	470	460	700	2,309	6,251	8,696	4,456	1,436	836	2,114	886	610	1,768,933
1912	540	500	800	2,793	7,156	8,883	4,423	1,292	674	981	562	480	1,759,720
1913	450	420	590	2,269	4,685	4,250	1,225	538	756	785	709	525	1,039,375
1914	475	450	900	2,187	7,521	8,268	3,762	1,450	759	1,014	909	520	1,708,149
1915	490	480	890	1,672	2,529	5,084	1,735	322	241	409	510	440	892,393
1916	400	390	730	2,173	5,726	8,232	2,692	2,039	706	1,038	700	550	1,534,562
1917	420	490	550	1,548	3,563	10,770	4,410	1,015	279	419	580	450	1,477,025
1918	420	540	650	1,259	5,088	8,961	2,169	1,105	1,100	746	666	470	1,397,927
1919	340	400	680	1,614	4,882	3,286	1,285	490	189	340	640	500	886,804
1920	450	500	850	943	8,436	10,343	3,146	763	207	680	760	540	1,670,886
1921	530	500	660	815	5,063	11,235	3,309	1,263	592	253	650	500	1,530,601
1922	500	520	660	1,205	6,087	6,411	1,146	339	25	28	487	430	1,077,600
1923	390	430	570	958	5,477	7,714	3,132	1,442	764	758	732	500	1,383,310
1924	500	520	610	2,067	5,487	6,381	825	34	32	342	553	470	1,074,760
1925	450	490	780	2,354	3,870	3,340	1,204	513	744	472	670	450	926,021
1926	360	460	600	1,563	4,156	5,813	1,291	314	81	387	526	490	967,751
1927	440	500	640	1,524	6,450	6,146	2,276	982	1,525	1,113	910	700	1,403,863
1928	620	580	950	1,344	8,613	7,132	2,138	513	60	201	599	420	1,403,098
1929	380	420	860	1,539	6,528	8,294	2,566	2,097	2,447	1,353	979	580	1,695,499
1930	400	450	550	3,282	2,979	5,010	934	1,182	80	333	432	500	971,778
1931	430	440	480	324	657	1,220	138	46	34	203	527	480	299,353
1932	400	390	520	1,427	5,113	5,594	2,101	501	48	42	415	400	1,025,111
1933	380	370	650	386	3,047	6,012	707	166	51	16	269	469	754,483
1934	410	450	435	469	1,573	208	63	47	31	17	116	420	256,334
1935	380	370	520	329	1,885	7,204	1,606	298	204	385	501	350	844,253
1936	390	400	550	3,089	6,942	3,622	632	745	202	189	440	360	1,062,819
1937	360	410	470	1,674	5,766	2,583	524	70	8	136	500	440	783,820
							AFTER TAYLOR PARK RESERVOIR BUT BEFORE ASPINALL UNIT						
1938	390	340	600	2,801	5,428	8,641	2,577	1,208	1,017	765	660	441	1,501,029
1939	420	300	926	1,942	4,209	3,107	1,153	1,180	829	599	471	360	938,434
1940	310	250	482	1,225	3,023	2,297	1,012	979	666	456	497	330	697,987
1941	320	360	482	1,037	5,654	5,568	2,509	975	1,005	1,161	862	605	1,243,886
1942	480	440	570	3,033	5,246	7,660	2,364	1,308	899	526	487	412	1,413,771
1943	370	424	581	3,317	4,175	5,334	2,032	1,715	1,233	799	674	434	1,273,186
1944	368	429	517	1,168	5,909	7,571	3,004	1,309	1,027	526	494	353	1,371,328

Table B.1 (cont'd)
Monthly mean discharges, in ft^3/s, for the Gunnison River below the East Portal of the Gunnison Tunnel, USGS Station No. 09128000, for the period 1903 - 1988.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann. volume, acre-feet
AFTER TAYLOR PARK RESERVOIR BUT BEFORE ASPINALL UNIT													
1945	399	389	457	970	4,367	4,534	2,478	1,757	979	616	572	411	1,086,103
1946	388	435	651	1,885	2,510	4,512	1,339	1,142	919	601	503	365	919,589
1947	340	352	491	1,355	5,093	6,171	3,418	1,488	1,168	1,036	776	603	1,349,742
1948	536	544	590	2,681	8,074	6,949	2,318	1,303	1,093	596	568	466	1,555,706
1949	359	386	506	2,197	4,688	7,983	3,751	1,371	969	696	644	419	1,448,108
1950	377	414	430	2,144	2,960	4,288	1,489	1,157	883	467	439	411	932,694
1951	394	394	587	1,224	3,055	4,553	1,818	1,300	1,024	592	449	408	954,657
1952	450	439	468	2,593	7,248	9,386	2,965	1,693	1,260	986	603	516	1,728,908
1953	484	432	593	1,054	2,556	5,790	1,855	1,374	1,065	677	596	460	1,021,914
1954	373	404	477	998	1,654	1,074	1,176	1,040	720	579	432	377	563,282
1955	325	279	325	1,152	2,265	2,982	1,298	1,280	929	519	434	461	740,598
1956	376	329	467	1,661	3,937	3,822	1,086	1,026	909	565	427	322	902,342
1957	317	377	470	1,460	4,683	12,164	8,990	3,024	1,277	926	955	878	2,150,408
1958	543	535	595	2,082	8,670	6,755	1,448	1,196	922	569	546	474	1,472,678
1959	411	422	436	1,152	2,139	3,612	1,124	1,201	897	849	631	381	800,027
1960	395	443	880	2,714	2,802	4,717	1,506	1,135	1,012	617	522	397	1,033,480
1961	331	341	515	873	2,882	2,880	1,177	1,149	894	911	765	506	800,348
1962	465	522	493	3,668	6,121	6,203	3,158	1,366	1,108	576	529	393	1,486,786
1963	323	435	860	1,348	2,550	1,800	1,176	1,184	718	607	480	321	714,468
1964	294	308	362	1,095	4,161	3,931	1,654	1,346	980	649	508	449	952,877
AFTER ASPINALL UNIT													
1965	454	404	487	2,521	5,276	7,859	5,896	2,361	1,666	937	172	141	1,705,714
1966	143	155	336	1,351	1,689	1,790	1,295	1,215	1,157	588	214	267	617,302
1967	323	319	430	1,129	1,138	1,125	1,198	1,083	1,160	866	1,149	2,040	724,443
1968	1,246	1,150	671	1,081	1,482	1,353	1,130	1,001	1,265	880	1,500	1,837	880,318
1969	1,835	821	1,865	2,208	1,952	1,467	1,393	1,736	1,506	1,270	1,466	1,319	1,140,234
1970	1,474	1,325	1,871	1,901	2,948	4,756	2,875	1,814	1,911	1,875	1,950	2,128	1,620,843
1971	2,544	3,153	3,322	3,356	1,529	1,660	1,908	2,127	1,800	1,308	1,379	1,674	1,548,904
1972	1,609	1,533	1,134	1,198	1,222	1,233	1,121	1,181	1,092	699	1,278	1,881	914,799
1973	1,833	799	682	951	1,816	2,141	1,640	2,336	1,593	1,289	749	2,048	1,083,681
1974	2,732	2,892	2,224	980	1,409	1,265	1,173	1,149	1,126	905	1,396	1,397	1,119,957
1975	1,522	1,398	1,190	2,305	4,008	2,175	1,254	1,195	1,236	1,340	1,566	1,863	1,271,675
1976	1,712	1,119	898	294	269	333	524	266	465	379	1,186	1,485	537,907
1977	1,411	778	413	237	239	233	194	236	237	228	307	310	289,914
1978	443	523	408	232	418	1,211	963	463	670	685	838	1,493	504,272
1979	1,720	2,202	2,541	2,328	1,694	1,575	1,331	953	1,050	769	783	1,764	1,125,953
1980	1,701	1,776	1,931	1,619	2,124	1,852	1,049	812	770	512	1,782	1,784	1,066,554
1981	1,725	1,241	691	231	226	234	240	259	391	512	490	646	413,349
1982	667	1,558	1,448	452	420	759	763	754	1,048	1,279	1,627	1,746	752,908
1983	1,743	1,704	1,291	850	1,148	4,175	4,197	2,000	5,156	1,261	1,397	1,822	1,611,320
1984	2,314	2,609	3,068	2,380	4,465	8,020	4,510	1,750	1,476	1,586	1,850	1,607	2,148,361
1985	2,614	2,843	2,798	3,162	3,022	3,837	1,751	1,190	1,135	1,614	1,772	1,921	1,664,120
1986	2,278	2,245	1,893	1,456	2,385	1,263	3,016	1,287	1,562	1,487	1,818	2,165	1,379,843
1987	2,228	2,332	2,407	1,112	1,242	996	1,339	943	633	978	1,502	1,563	1,039,906
1988	1,545	1,612	1,601	795	397	353	355	395	574				

Table B.2
Summary statistics of monthly mean discharges, in ft^3/s, for the Gunnison River below the East Portal of the Gunnison Tunnel, USGS Station No. 091280.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann. volume, acre-feet
						Before Gunnison Tunnel Period: 1903 - 1909							
Average	428	429	738	1,897	4,995	7,781	3,485	1,624	1,187	854	556	443	1,478,829
Maximum	470	460	990	2,500	7,160	10,800	6,620	2,400	2,600	1,270	640	475	2,048,251
Minimum	330	340	535	1,217	2,690	3,292	1,103	1,130	560	519	491	340	912,355
Std.dev.	56	47	147	474	1,695	3,051	2,157	467	741	267	64	51	468,337
						Before Taylor Park Reservoir Period: 1910 - 1937							
Average	437	457	699	1,672	5,065	6,287	1,973	782	469	544	599	483	1,176,292
Maximum	620	580	1,730	3,703	8,613	11,235	4,456	2,097	2,447	2,114	979	700	1,768,933
Minimum	340	370	435	324	657	208	63	34	8	16	116	350	256,334
Std.dev.	63	53	246	882	2,004	2,763	1,293	585	551	478	191	72	408,223
						After Taylor Park Reservoir but before Aspinall Unit Period: 1938 - 1964							
Average	390	397	549	1,808	4,298	5,344	2,218	1,341	978	684	575	443	1,150,161
Maximum	543	544	926	3,668	8,670	12,164	8,990	3,024	1,277	1,161	955	878	2,150,408
Minimum	294	250	325	873	1,654	1,074	1,012	975	666	456	427	321	563,282
Std.dev.	67	73	143	813	1,833	2,517	1,572	393	153	183	136	113	371,106
						After Aspinall Unit Period: 1965 - 1988							
Average	1,576	1,520	1,483	1,422	1,772	2,153	1,713	1,188	1,278	1,011	1,225	1,517	1,094,012
Maximum	2,732	3,153	3,322	3,356	5,276	8,020	5,896	2,361	5,156	1,875	1,950	2,165	2,148,361
Minimum	143	155	336	231	226	233	194	236	237	228	172	141	289,914
Std.dev.	728	854	910	917	1,355	2,128	1,418	643	942	434	545	599	477,146
						Period of record Period: 1903 - 1988							
Average	743	736	875	1,661	3,887	4,925	2,084	1,133	910	740	757	747	1,166,973
Maximum	2,732	3,153	3,322	3,703	8,670	12,164	8,990	3,024	5,156	2,114	1,950	2,165	2,150,408
Minimum	143	155	325	231	226	208	63	34	8	16	116	141	256,334
Std.dev.	651	669	637	852	2,211	3,108	1,523	598	701	416	422	569	423,718

ATTACHMENT C

WATER QUALITY AND BIOLOGICAL DATA

Table C-1.--Results of macroinvertebrate sampling in riffle habitats on the Gunnison River, Colorado, 1981. Numbers are averages/ft^2 (Bio/West, Inc., 1981)

	April				May				June				July				August				September			
	Upper		Lower		Upper		Lower		Upper		Lower		Above		Below		Above		Below		Above		Below	
	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.
Ephemeroptera																								
Baetidae																								
Baetis sp.	3.9	2.8	18.3	7.0	394.8	224.9	501.7	467.3	83.3	37.9	91.0	30.0	5.5	5.0	12.0	8.0	9.7	11.7	11.9	2.9	20.0	13.9	29.0	13.6
Ephemerellidae																								
Ephemerella inermis	97.6	55.8	37.5	28.8	170.0	›.6	300.0	113.4	19.9	14.4	21.0	18.0												
Heptageniidae																								
Heptagenia sp.							12.0	10.3					0.3	0.5	1.0	1.4					4.5	7.7	3.7	5.7
Rithrogena sp.			0.3	0.5																				
Leptophlebiidae																								
Choroterpes sp.																	1.4	1.0						
Traverella albertana													2.8	3.6	3.0	2.6	0.7	0.8	0.8	1.6			3.0	3.8
Tricorythidae																								
Tricorythodes sp.	4.0	8.0	0.8	1.0	4.0				6.0	7.7	2.0	2.3	19.0	19.0	6.3	6.7	22.3	10.4	8.3	3.2	51.8	38.0	28.8	8.3
Trichoptera																								
Hydropsychidae																								
Cheumatopsyche sp.	65.0	94.3	22.5	38.6	20.0	24.0	20.0	40.0	7.2	5.3	18.0	23.0	17.3	13.0	13.3	16.0	9.5	5.9	6.7	7.6	22.8	16.2	11.0	22.0
Hydropsyche spp.	447.7	509.3	320.0	379.0	489.0	389.9	1280.0	665.9	184.0	86.9	299.0	149.8	255.0	102.5	414.3	218.6	86.2	87.2	106.3	60.0	205.2	141.9	296.7	252.8
Hydroptilidae																								
Hydroptila sp.																	0.9	0.7	4.8	5.5	1.3	2.7		
Trichoptera pupae					8.0	11.3			5.6	2.0	16.0	18.8	2.3	2.5	0.8	1.5	0.5	1.0					3.3	4.0
Hemiptera																								
Veliidae																								
Rhagovelia sp.																					0.3	0.5		
Coeleoptera																								
Elmidae																								
Microcylloepus sp.[1]	4.3	7.9	18.0	18.8	4.0	8.0	10.0	15.1	8.2	10.7	23.0	15.1	12.3	8.4	21.0	10.4	3.7	4.1	16.3	16.4	0.7	1.4	18.7	19.6
Microcylloepus sp.	3.2		6.5	7.9	9.0	10.5	48.0	36.4	4.6	3.5	107.0	58.2	33.0	33.6	73.3	53.2	26.4	22.7	149.1	70.9	50.8	26.5	229.0	122.5
Optioservus sp.															2.0	2.3								
Plecoptera																								
Perlodidae																								
Isoperla spp.	32.6	32.7	16.0	8.2	36.0	32.3	57.0	10.5	0.8	1.6														
Odonata			0.3	0.5			0.3	0.5																
Diptera																								
Ceratopogonidae					7.0	8.3	2.0	4.0																
Chironomidae	78.0	36.8	72.5	16.1	1883.0	690.9	2834.0	613.3	452.8	257.8	724.0	82.4	45.8	22.4	17.5	15.3	132.1	17.8	227.9	144.5	296.0	73.0	470.3	147.2
Empididae	7.3	3.8	5.0	4.7																1.0	2.0			
Simuliidae																								
Simulium sp.			1.3	1.9	18.0	33.4	2.0	4.0	3.6	7.2													0.7	1.4
Unknown					1.0	2.0																		
Chironomidae pupae																					35.5	19.6	33.0	10.5
Athericidae																								
Atherix sp.																					0.3	0.5		
Decapoda																								
Astacidae																								
Orconectes sp.							0.8	0.5							0.3	0.5	0.8	1.0			0.3	0.5	0.3	0.5
Hydracarina			0.3	0.5																	18.5	11.7	18.0	16.2
Oligochaeta	1.2	2.4	6.3	12.5											1.8	3.5	13.0	26.0			17.0	8.9	212.0	147.3
Nematoda	0.5	1.0																						
Total Numbers	782.9	732.5	539.0	513.9	3158.0	1238.3	5196.0	1254.4	777.0	291.0	1310.3	224.2	394.0	168.3	569.0	297.4	284.1	109.8	588.0	254.2	726.3	291.6	1307.4	336.5
Diversity D̄	1.8		2.04		1.70		1.76		1.75		1.9		18.2		1.47		2.31		2.02		2.45		2.52	

[1]Adults

Table C-1.--Results of macroinvertebrate sampling in riffle habitats on the Gunnison River, Colorado, 1981. Numbers are averages/ft^2 (Bio/West, Inc., 1981)--(Continued)

RUN	April				May				June			
	Upper		Lower		Upper		Lower		Upper		Lower	
	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.
Ephemeroptera												
Baetidae												
Baetis sp.					6.7	3.1	32.3	13.5	7.0	5.4	26.0	12.7
Ephemerellidae												
Ephemerella inermis			8.8	9.0	29.3	11.0	29.0	17.9	6.0	3.2	5.0	5.6
Heptageniidae												
Heptagenia sp.			1.8	2.9			2.0	1.4	1.8	1.7		
Leptophlebiidae												
Choroterpes sp.												
Traverella sp.												
Tricorythidae												
Tricorythodes sp.			1.3	1.9	8.0	5.6	4.0	1.6	9.5	3.0	4.5	4.0
Trichoptera												
Hydropsychidae												
Cheumatopsyche sp.			6.8	13.5	1.7	2.9	20.3	14.0			5.0	10.0
Hydropsyche sp.			47.3	60.0	11.7	8.3	342.8	68.7	13.8	7.4	137.8	95.3
Hydroptilidae												
Hydroptila sp.												
Trichoptera pupae									0.8	0.5	10.5	9.7
Coeleoptera												
Elmidae												
Microcylloepus sp.[1]			0.3	0.5			14.0	14.8			14.0	12.2
Microcylloepus sp			2.0	2.2	1.0	1.7	34.3	27.5	1.0	1.2	24.0	8.7
Optioservus sp.												
Plecoptera												
Perlodidae												
Isoperla spp.			6.8	6.7	0.3	0.6	38.8	10.9				
Diptera												
Ceratopogonidae			0.3	0.5			2.0	4.0				
Chironomidae	13.8	14.2	57.0	50.6	181.3	80.9	386.0	100.6	66.8	52.2	93.5	41.6
Empididae			1.8	2.4								
Tipulidae												
Simuliidae												
Simulium sp.					0.7	1.2						
Chironomidae pupae												
Decapoda												
Astacidae												
Orconectes sp.							0.8	1.0				
Hydracarina												
Oligochaeta	5.3	5.1	39.0	36.8	3.0	5.2			1.3	2.5		
Nematoda												
Total Numbers	19.0	10.6	169.8	113.5	235.0	101.3	928.5	102.1	108.3	53.6	334.3	151.1
Diversity D̄	0.9		2.40		1.39		2.08		1.91		3.10	

RUN	July				August				September			
	Upper		Lower		Upper		Lower		Upper		Lower	
	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.
Ephemeroptera												
Baetidae												
Baetis sp.	3.5	5.7	4.3	1.9	10.8	5.1	14.0	8.1	12.3	4.8	17.3	12.0
Ephemerellidae												
Ephemerella inermis												
Heptageniidae												
Heptagenia sp.	0.5	0.6	1.0	1.4	2.0	2.3	0.3	0.5	1.0	0.8	3.0	3.8
Leptophlebiidae												
Choroterpes sp.					1.5	0.6						
Traverella sp.			0.5	1.0			3.5	1.3			0.7	1.4
Tricorythidae												
Tricorythodes sp.	20.3	10.8	4.3		41.3	13.8	3.8	2.6	81.0	46.3	15.5	8.1
Trichoptera												
Hydropsychidae												
Cheumatopsyche sp.	3.8	0.5	7.0	2.5	2.3	1.5	8.8	4.5			16.0	8.6
Hydropsyche sp.	13.8	9.3	127.0	73.2	14.5	6.8	68.0	16.8	4.5	3.1	116.2	65.3
Hydroptilidae												
Hydroptila sp.					1.3	1.3						
Trichoptera pupae											0.7	1.4
Coeleoptera												
Elmidae												
Microcylloepus sp.[1]	0.5	0.6	6.8	2.8			2.8	1.9			11.0	10.6
Microcylloepus sp	1.5	1.7	47.8	18.3	6.3	2.6	47.0	29.4	2.5	2.7	109.2	46.7
Optioservus sp.									0.5	1.0		
Plecoptera												
Perlodidae												
Isoperla spp.												
Diptera												
Ceratopogonidae												
Chironomidae	6.5	2.5	5.3	2.6	76.5	23.8	72.8	10.6	135.8	80.0	394.7	158.6
Empididae												
Tipulidae												
Simuliidae												
Simulium sp.												
Chironomidae pupae									10.0	8.8	18.7	12.6
Decapoda												
Astacidae												
Orconectes sp.			1.3	1.5	0.5	0.6			0.3	0.5	1.3	1.5
Hydracarina											18.0	13.3
Oligochaeta									67.5	32.4	140.8	44.0
Nematoda									0.5	1.0		
Total Numbers	50.3	20.7	204.3	84.0	155.3	43.5	222.8	42.9	317.5	170.5	893.3	287.3
Diversity D̄	2.27		1.70		2.10		2.24		1.92		2.42	

[1]Adults

Table C-1.--Results of macroinvertebrate sampling in riffle habitats on the Gunnison River, Colorado, 1981. Numbers are averages/ft^2 (Bio/West, Inc., 1981)--(Continued)

	April				May				June				July				August				September			
	Upper		Lower		Upper		Lower		Upper		Lower		Upper		Lower		Upper		Lower		Upper		Lower	
	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.
Ephemeroptera																								
Baetidae																								
Baetis sp.	1.3	2.3							8.7	11.5	1.3	2.3												
Ephemerellidae																								
Ephemerella inermis					2.7	2.3																		
Tricorythidae																								
Tricorythodes sp.																								
Tricoptera																								
Hydropsychidae																								
Cheumatopsyche sp.									5.3	9.2							2.0	2.8						
Hydropsyche sp.	1.3	2.3			4.0	6.9									1.3	2.3								
Coeleoptera																								
Elmidae																								
Microcylloepus sp.															1.3	2.3								
Hemiptera																								
Corixidae																								
Hespacorixa sp.							1.3	2.3	12.0	20.8					42.7	37.2								
Diptera																								
Ceratopogonidae							1.3	2.3			4.0	0					2.0	2.8			4.0	6.9	6.0	6.0
Chironomidae	6.7	4.6	40.0	26.2	164.0	194.0	74.7	24.4	668.0	1001.7	597.3	34.0	56.0	72.8	124.0	176.8	6.0	2.8	57.3	72.0	52.0	25.0	172.0	76.0
Chironomidae pupae																					6.7	2.8	1.3	2.3
Unknown larvae																			1.3	2.3				
Decapoda																								
Astacidae																								
Orconectes sp.									5.3	9.2			1.2	2.3										
Oligochaeta	10.7	12.2	28.0	24.9	5.3	9.2	8.0	13.9	10.7	18.5	62.7	28.9	38.7	60.2	128.0	137.6	6.0	2.8	192.0	160.6	234.7	182.1	665.3	176.0
Gastropoda																								
Physidae																								
Physa sp.							1.3	2.3																
Total	20.0	12.0	72.0	16.0	176.0	197.7	86.7	26.7	708.0	980.4	665.3	58.9	96.0	131.9	297.3	346.0	16.0	5.7	247.3	229.2	297.3	212.1	848.0	207.5

Table C-2.--Relative abundance of net plankton from two areas in the mainstream Gunnison River, 4/81-9/81. "Upper" location was upstream of Delta, Colorado. "Lower" location was near Grand Junction, Colorado

	4/81		5/81		6/81		7/81		8/81		9/81	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Cyanophyta												
Gleocapsa							I	I				
Oscillatoria	I		I							I	I	I
Chlorophyta												
Pediastrum									I		I	
Scenedesmus				I		I	I	I	I			
Chrysophyta												
Anomoeoneis								I				I
Cocconeis	I	C	C	I			I		I	I		I
Cymatopleura	I		I				I	I				
Cymbella				I		I	I	I	I	I	I	I
Diatoma	I	C	I	I		I				I		I
Gyrosigma										I		
Melosira							I	I			I	I
Navicula	C	C	A	C		C	C	C	C	C	C	C
Nitzschia	C	C	C	I		C	C	C	I	I	C	I
Pinnularia			I									
Rhoicosphenia		I		I		I	I	I				
Surirella				I				I				
Synedra		I					I	I		I	I	

B - greater than 9,000
A - 3,000-9,000
C - 500-3,000
I - less than 500 cells/liter

Source: Bio/West, Inc., 1981.

Table C-2.--Relative abundance of net plankton from two areas in the mainstream Gunnison River, 4/81-9/81. "Upper" location was upstream of Delta, Colorado. "Lower" location was near Grand Junction, Colorado--(Continued)

	4/81		5/81		6/81		7/81		8/81		9/81	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Cyanophyta												
Gleocopsa												
Oscillatoria		I		I		C	I	I	I	I	I	
Chlorophyta												
Ankistrodesmus						C						
Chlorococcum							A	C				
Closterium							I					
Pediastrum										I		
Scenedesmus							I	I				
Spirogyra												B
Chyrysophyta												
Amphora									I			
Anomoeoneis												
Cocconeis		I	I	I		I	I	I	I	I	I	
Cyclotella						I						
Cymatopleura				I		I						
Cymbella	I	I	I	I		I			I	I	I	
Diatoma				I		I						
Gomphonema										I		
Gyrosigma										I		I
Melosira		I		I								
Navicula	C	C	C	C		A	C	C	A	B	C	C
Nitzschia	C	C	I	I		A	A	A	A	B	C	C
Pinnularia		I										
Rhoicosphenia	I	I	I	I		I	I	I				
Surirella	I	I		I								
Synedra	I			I			I	I		I		I

B - greater than 9,000; A - 3,000-9,000; C - 500-3,000; I - less than 500 cells/liter
Source: Bio/West, Inc., 1981.

Table C-2.--Relative abundance of net plankton from two areas in the mainstream Gunnison River, 4/81-9/81. "Upper" location was upstream of Delta, Colorado. "Lower" location was near Grand Junction, Colorado--(Continued)

	4/81		5/81		6/81		7/81		8/81		9/81	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Euglenophyta												
Euglena	I		I	I		I	I	I	B	I		

B - greater than 9,000 c/l
A - 3,000-9,000 c/l
C - 500-3,000 c/l
I - less than 500 c/l

Souce: Bio/West, Inc., 1981.

Table C-3.--Periphyton density (mg/m^2 of chlorophyll) at two stations on the Gunnison River in 1981

Date	Upper station[1]	Lower station[2]
April	164	143
May	577	427
June	183	213
July	116	124
August	157	135
September	118	39

[1] Station located upsteam of Delta.
[2] Station located near Grand Junction.
Source: Bio/West, 1981.

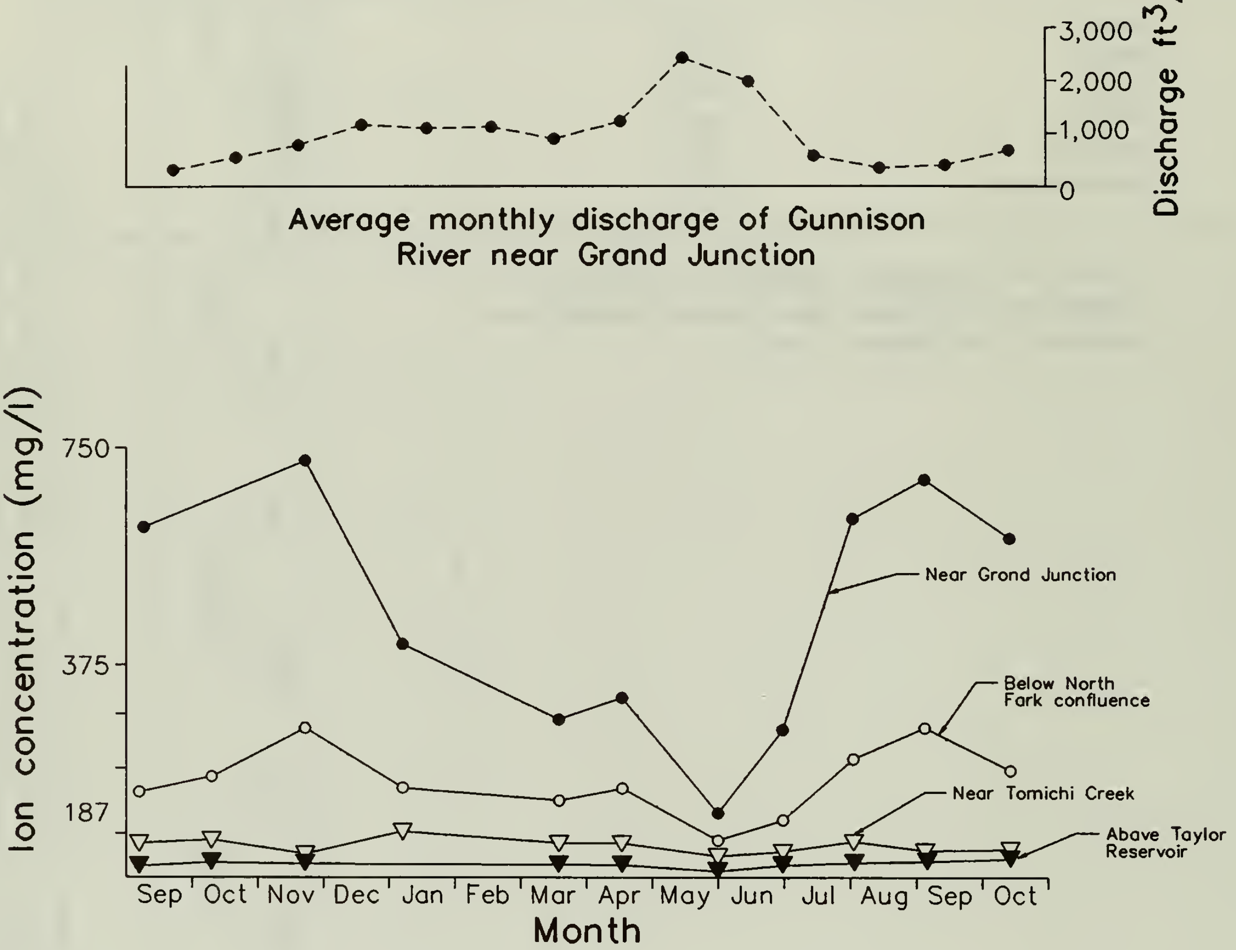
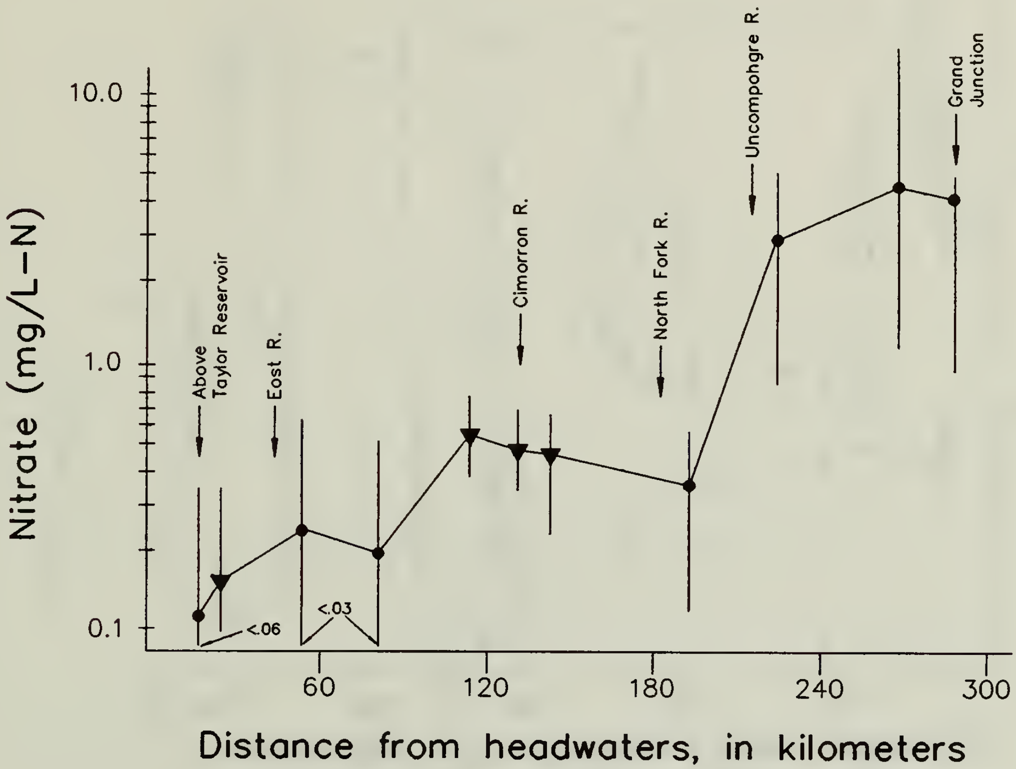


Figure C-1. Concentration of major ions (sum of calcium, magnesium, sodium and sulfate) in the Gunnison River. Data are mean monthly values collected from 1979-80. (modified figure from Stanford and Ward, 1983).



Legend

Inverted triangles indicate tailwater sites below mainstream dams.

Bars indicate range of values for 11 sampling periods during 1979–80.

Figure C-2. Mean annual nitrate concentrations on Gunnison River (Stanford and Ward, 1983).

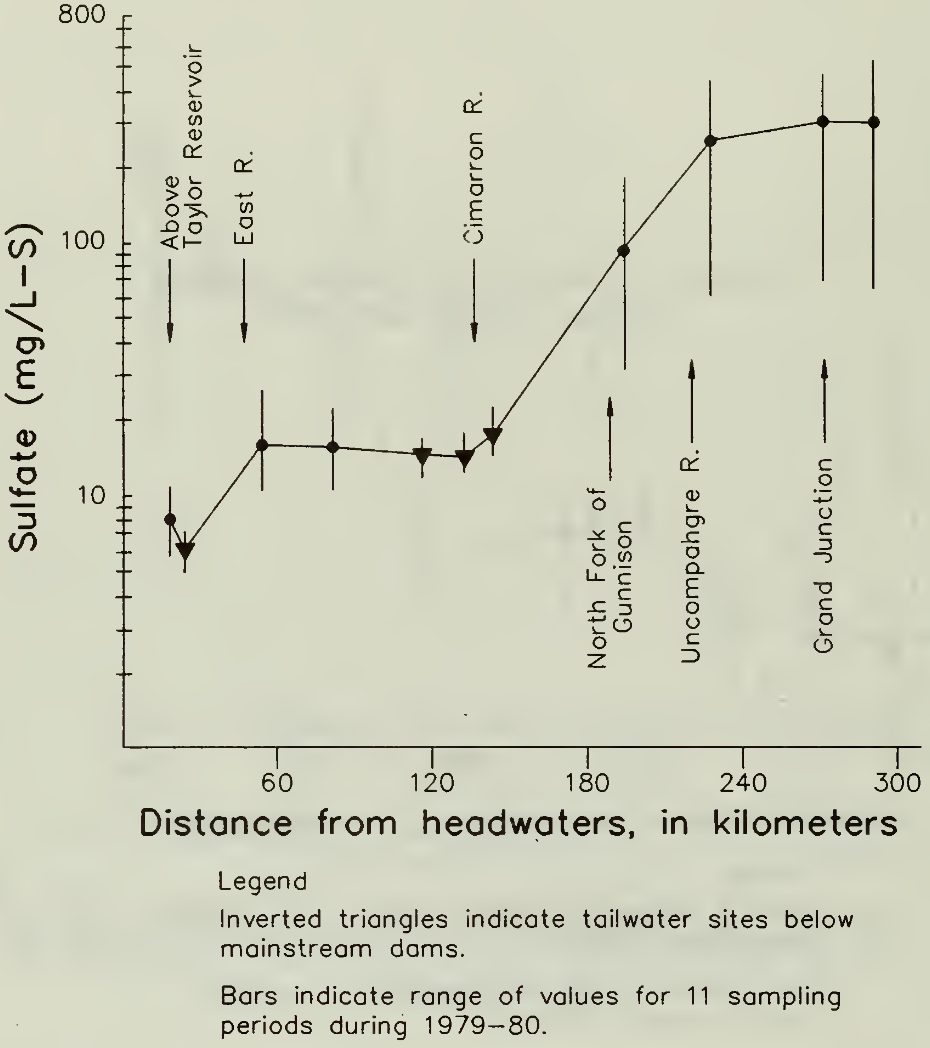
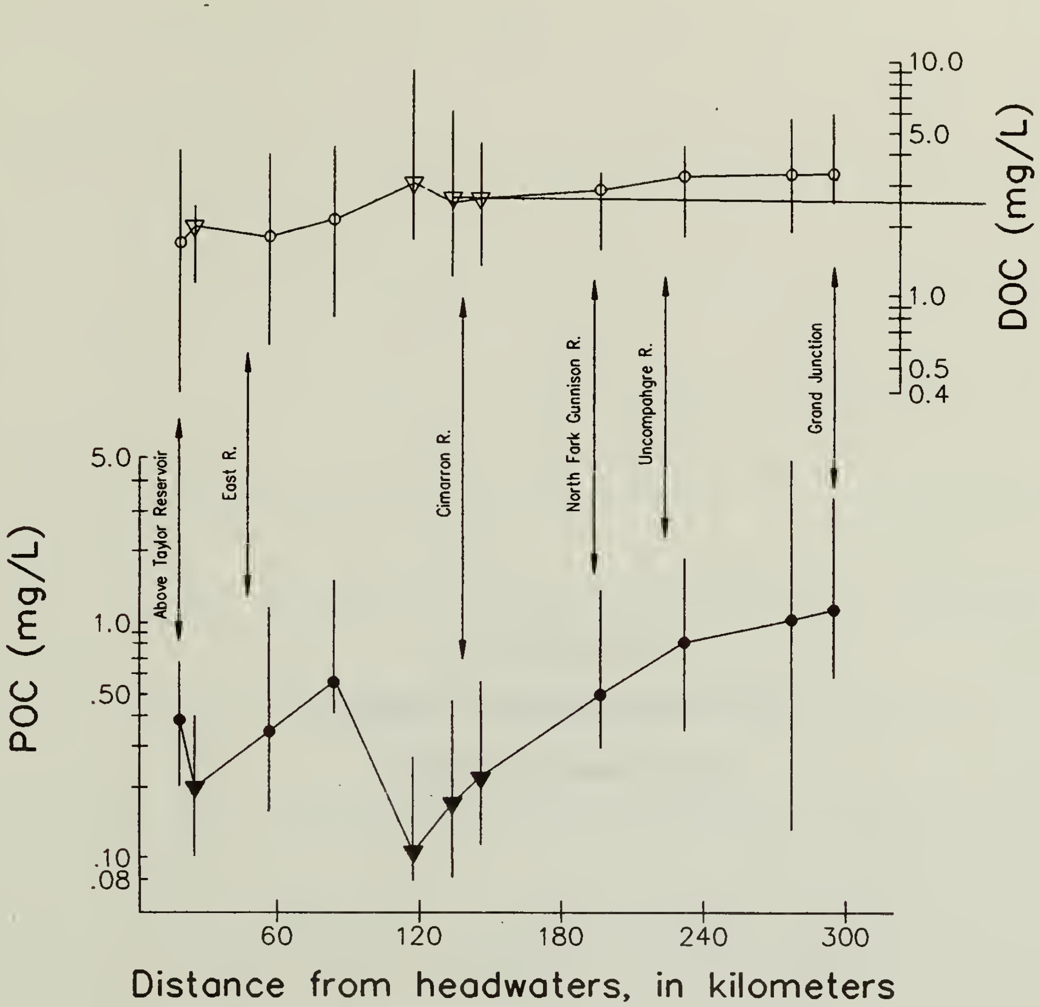


Figure C-3. Mean annual sulfate concentrations on the Gunnison River (Stanford and Ward, 1983).



Legend

Inverted triangles indicate tailwater sites below mainstream dams.

Bars indicate range of values for 11 sampling periods during 1979–80.

Figure C-4. Mean dissolved organic carbon (DOC) and particulate organic carbon (POC) on the Gunnison River (Stanford and Ward, 1983).

ATTACHMENT D

WATER QUANTITY DATA FOR

STUDY ALTERNATIVES

Table D.1
Average annual water balances for existing conditions and development alternatives (acre-feet).

Location:	Model node (1)	Existing Conditions	B	C	D	E	ALTERNATIVE F	F-3	F-4	F-5	F-6	G	H
Gunnison River:													
Below Crystal Dam	GUN	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038
Diverted through Tunnel	DIV	337,824	692,426	728,309	749,621	662,503	688,253	685,033	681,734	680,618	661,576	646,161	692,426
Entering Black Canyon	REM	798,214	443,612	407,729	386,417	473,536	447,786	451,006	454,305	455,420	474,462	489,877	443,612
South Canal:													
Entering Canal	DIV	337,824	692,426	728,309	749,621	662,503	688,253	685,033	681,734	680,618	661,576	646,161	692,426
AB Lateral demands	ABD	18,112	18,112	18,112	18,112	18,112	18,112	18,112	18,112	18,112	18,112	18,112	18,112
Cedar Creek wasteway demands	CED	11,077	1,210	1,210	1,210	1,210	1,210	1,210	1,210	1,210	1,210	11,077	1,210
AB Lateral Unit	ABP	- NA -	508,128	544,011	565,323	478,204	502,986	499,766	496,467	495,351	476,309	- NA -	528,393 (2)
At Rating Cable	SCG	308,634	164,977	164,977	164,977	164,977	165,945	165,945	165,945	165,945	165,945	616,972	673,104
West Canal demands	WCD	49,177	49,177	49,177	49,177	49,177	49,177	49,177	49,177	49,177	49,177	49,177	49,177
Other laterals demands	SCD	28,210	28,210	28,210	28,210	28,210	28,210	28,210	28,210	28,210	28,210	28,210	28,210
Exiting Canal	SCU	231,247	87,589	87,589	87,589	87,589	88,557	88,557	88,557	88,557	88,557	539,585	67,324
Uncompahgre River:													
River at Colona	UNC	168,685	168,685	168,685	168,685	168,685	168,685	168,685	168,685	168,685	168,685	168,685	168,685
Private demands above South Canal	UP1	10,955	10,955	10,955	10,955	10,955	10,955	10,955	10,955	10,955	10,955	10,955	10,955
River above South Canal	UNA	157,730	157,730	157,730	157,730	157,730	157,730	157,730	157,730	157,730	157,730	157,730	157,730
South Canal flows	SCU	231,247	87,589	87,589	87,589	87,589	88,557	88,557	88,557	88,557	88,557	539,585	67,324
River below South Canal	UN1	391,157	247,499	247,499	247,499	247,499	248,467	248,467	248,467	248,467	248,467	699,494	227,234
Montrose & Delta Canal demands	MCD	163,326	163,326	163,326	163,326	163,326	163,326	163,326	163,326	163,326	163,326	163,326	163,326
River below M & D Canal	UN2	225,718	82,060	82,060	82,060	82,060	83,028	83,028	83,028	83,028	83,028	534,055	61,795
Inflow from Horsefly Creek	HFY	7,189	7,189	7,189	7,189	7,189	7,189	7,189	7,189	7,189	7,189	7,189	7,189
Loutzenhizer Canal demands	LCD	42,925	42,925	42,925	42,925	42,925	42,925	42,925	42,925	42,925	42,925	42,925	42,925
Private demands below South Canal	UP2	11,482	11,482	11,482	11,482	11,482	11,482	11,482	11,482	11,482	11,482	11,482	11,482
River gains from return flows	UGN	12,248	12,248	12,248	12,248	12,248	12,248	12,248	12,248	12,248	12,248	12,248	12,248
River entering Montrose	UN3	190,681	47,024	47,024	47,024	47,024	47,991	47,991	47,991	47,991	47,991	499,019	555,151
AB Lateral Unit inflows	ABP	- NA -	508,128	544,011	565,323	478,204	502,986	499,766	496,467	495,351	476,309	- NA -	528,393 (3)
Selig Canal demands	SCD	60,081	60,081	60,081	60,081	60,081	60,081	60,081	60,081	60,081	60,081	60,081	60,081
Cedar Creek inflow	CER	10,351	484	484	484	484	484	484	484	484	484	10,351	484
River below Cedar Creek	URM	140,952	495,554	531,437	552,750	465,631	491,381	488,161	484,862	483,746	464,704	449,290	495,554
System balances													
Gunnison River: Inflows		1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038
Outflows		337,824	692,426	728,309	749,621	662,503	688,253	685,033	681,734	680,618	661,576	646,161	692,426
Balance		798,214	443,612	407,729	386,417	473,535	447,786	451,006	454,305	455,420	474,462	489,877	443,612
South Canal: Inflows		337,824	692,426	728,309	749,621	662,503	688,253	685,033	681,734	680,618	661,576	646,161	692,426
Outflows		106,576	604,837	640,720	662,032	574,913	599,695	596,475	593,176	592,060	573,018	106,576	625,102
Balance		231,248	87,590	87,590	87,590	87,590	88,558	88,558	88,558	88,558	88,558	539,585	67,325
Uncompahgre River: Inflows		429,720	784,323	820,206	841,518	754,399	780,149	776,929	773,630	772,514	753,472	738,057	784,323
Outflows		288,768	288,768	288,769	288,769	288,769	288,768	288,768	288,768	288,768	288,768	288,768	288,769
Balance		140,952	495,554	531,437	552,749	465,630	491,380	488,161	484,862	483,746	464,704	449,289	495,554

Notes: (1) See Figure D.1 for location of nodes.
(2) Hydropower flows for Alternative H diverted from South Canal below rating cable.
(3) Hydropower flows for Alternative H enter Uncompahgre River upstream from Loutzenhizer Canal.

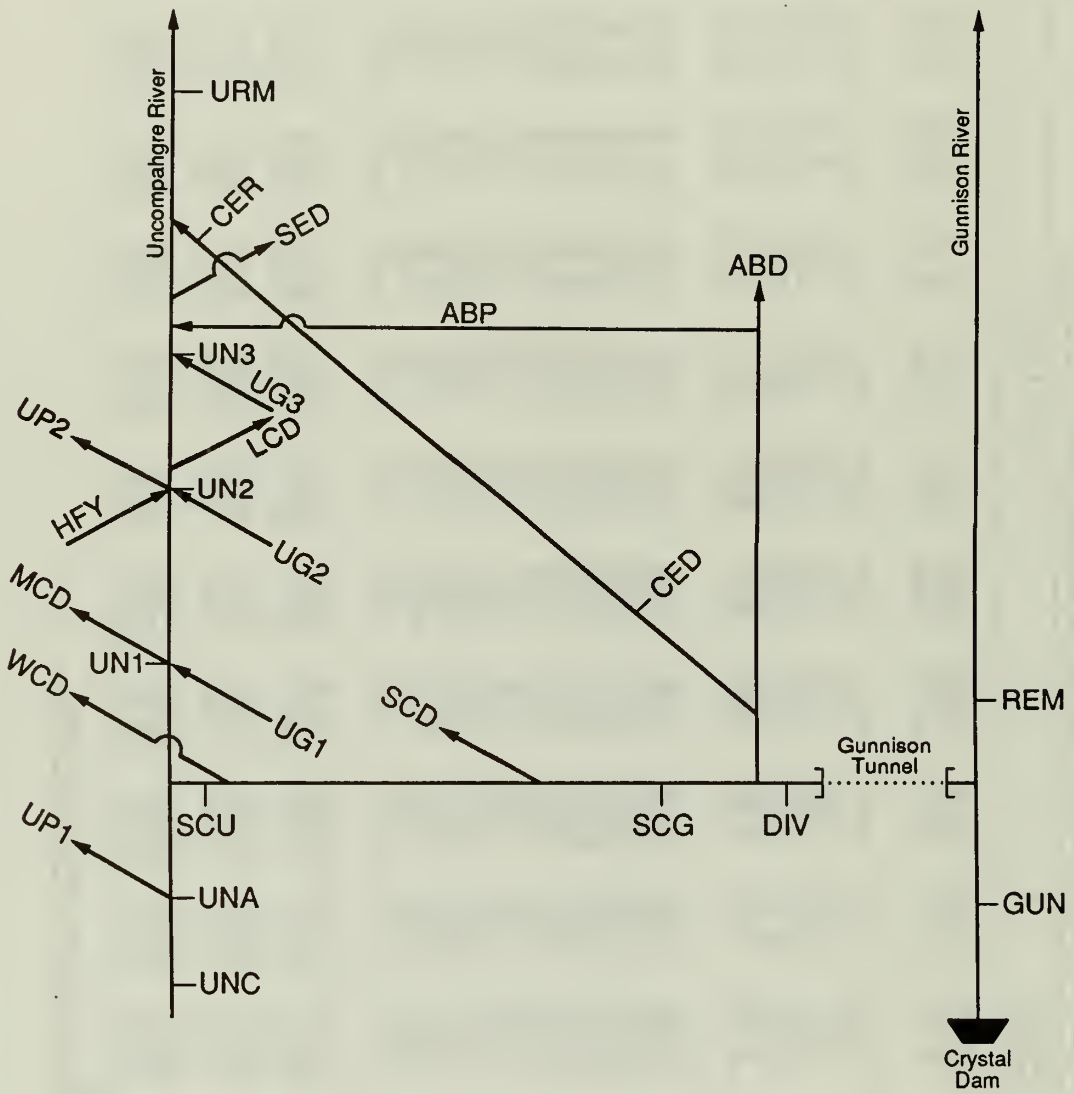


Figure D.1. Flow schematic for system water balances.

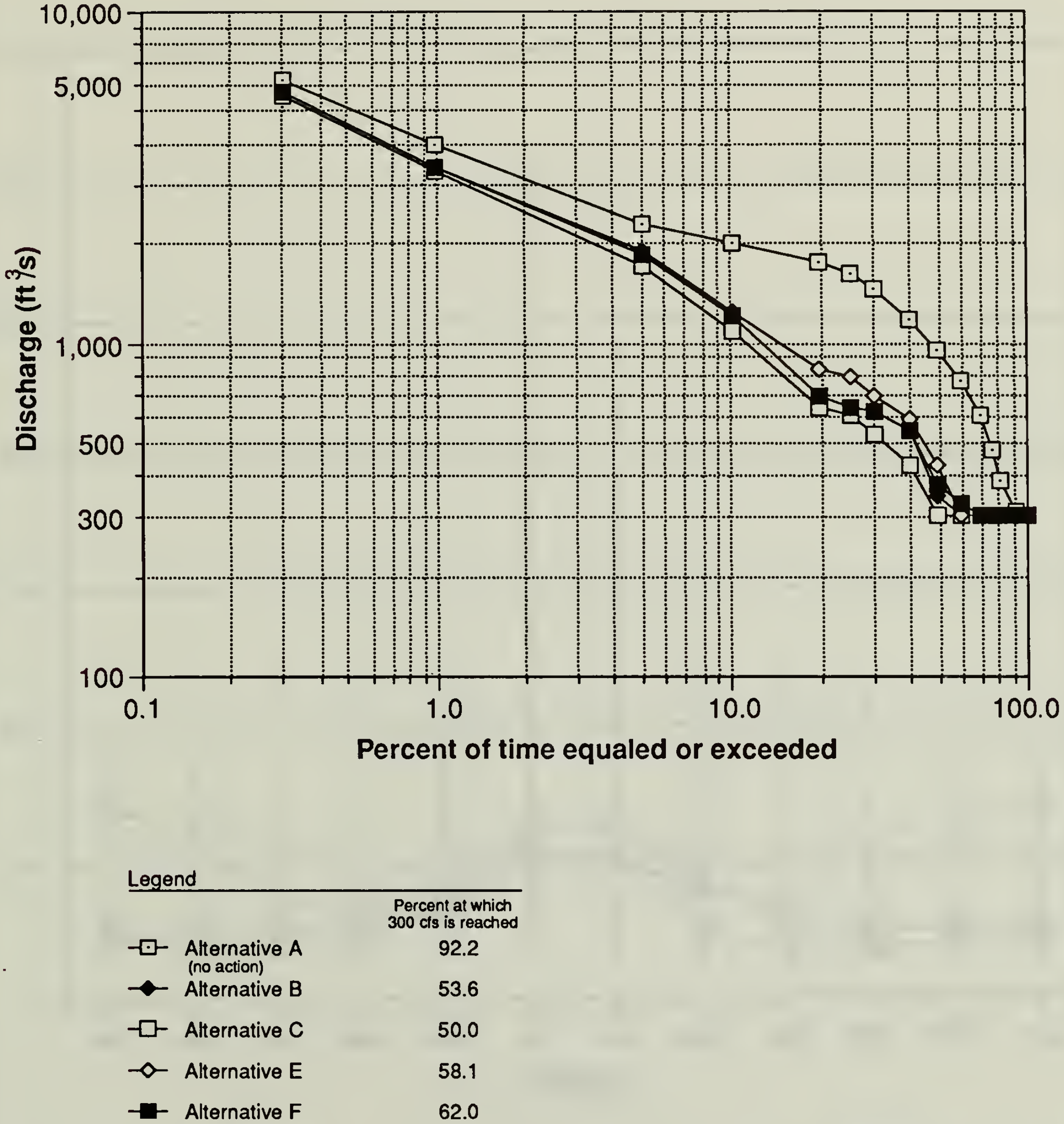
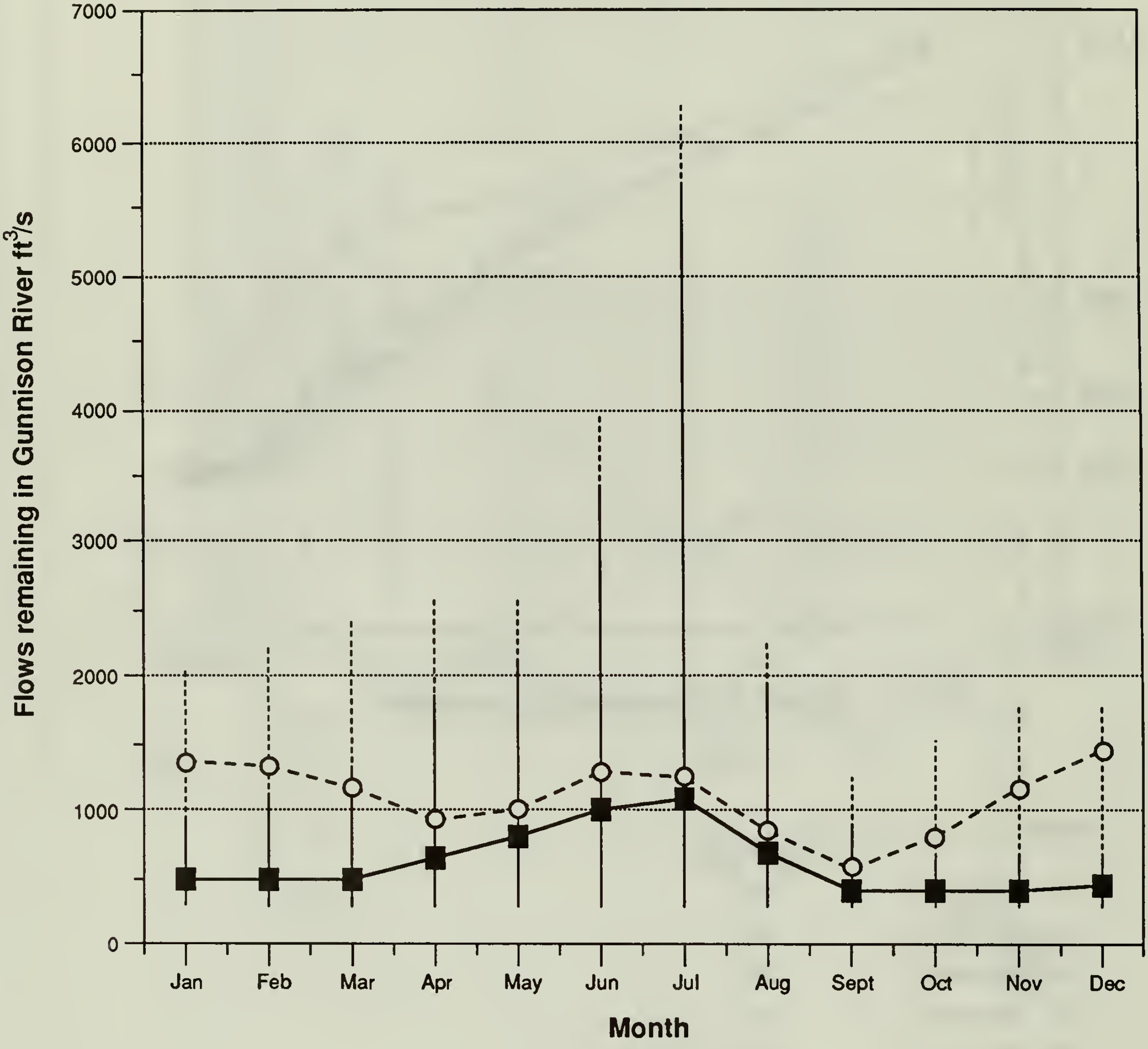


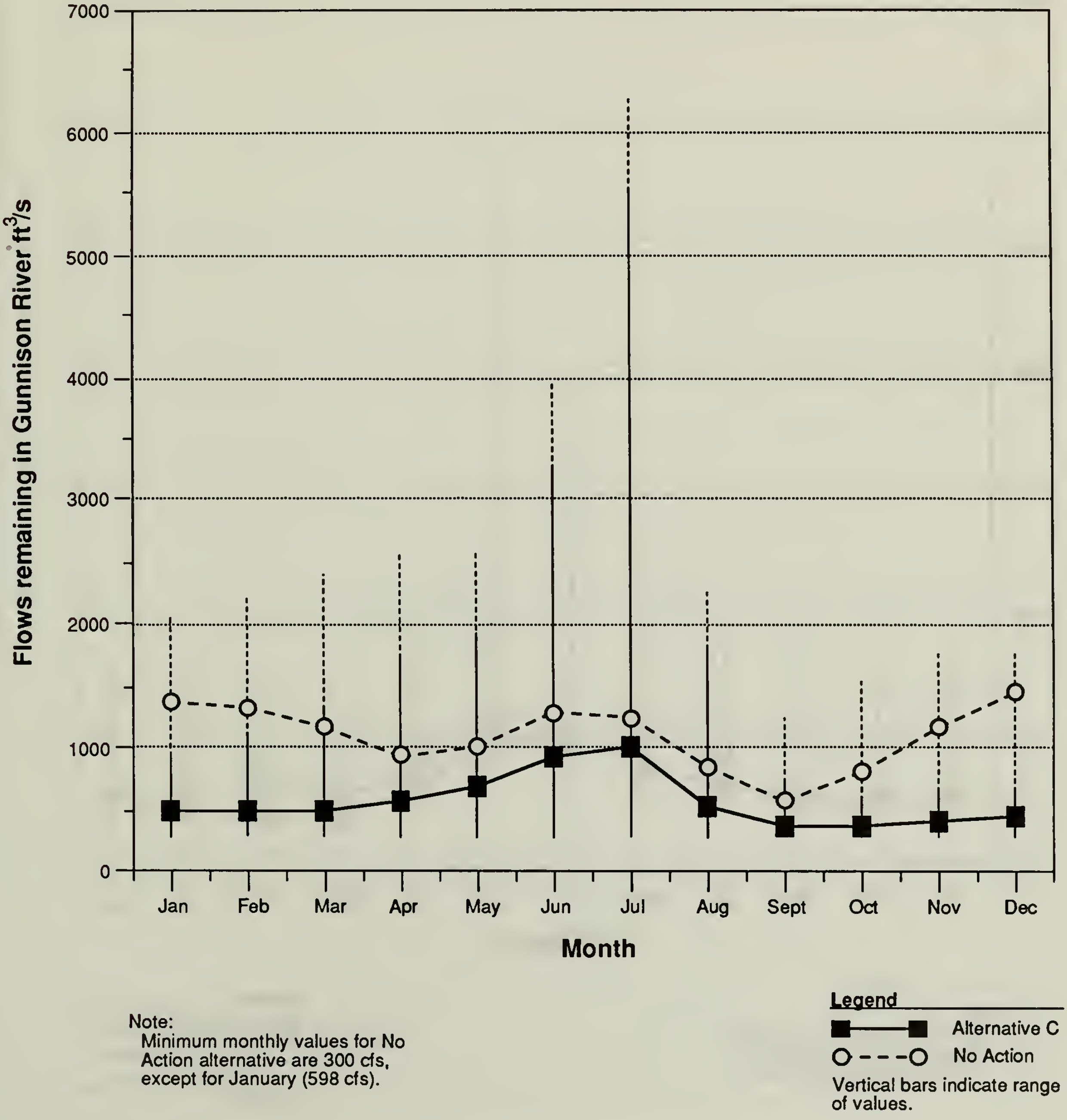
Figure D.2. Duration curve of flows entering Black Canyon for no-action and development alternatives.



Note:
Minimum monthly values for No Action alternative are 300 cfs, except for January (598 cfs).

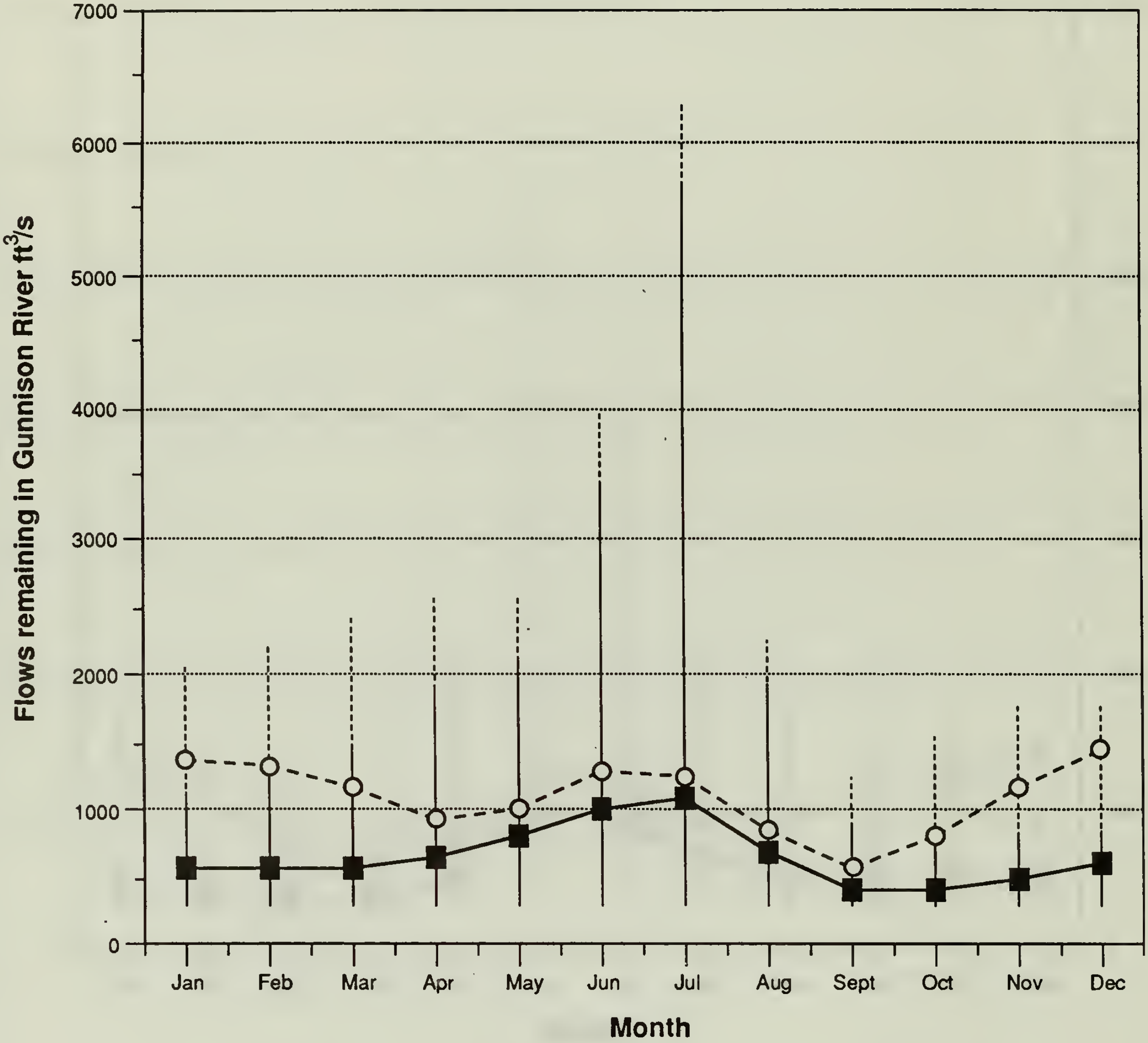
Legend
Alternative B
No Action
Vertical bars indicate range of values.

Figure D.3. Mean monthly flows and flow ranges for Alternative B compared to no-action alternative.



Note:
Minimum monthly values for No Action alternative are 300 cfs, except for January (598 cfs).

Figure D.4. Mean monthly flows and flow ranges for Alternative C compared to no-action alternative.



Note:
Minimum monthly values for No Action alternative are 300 cfs, except for January (598 cfs).

Legend

Alternative E

No Action

Vertical bars indicate range of values.

Figure D.5. Mean monthly flows and flow ranges for Alternative E compared to no-action alternative.

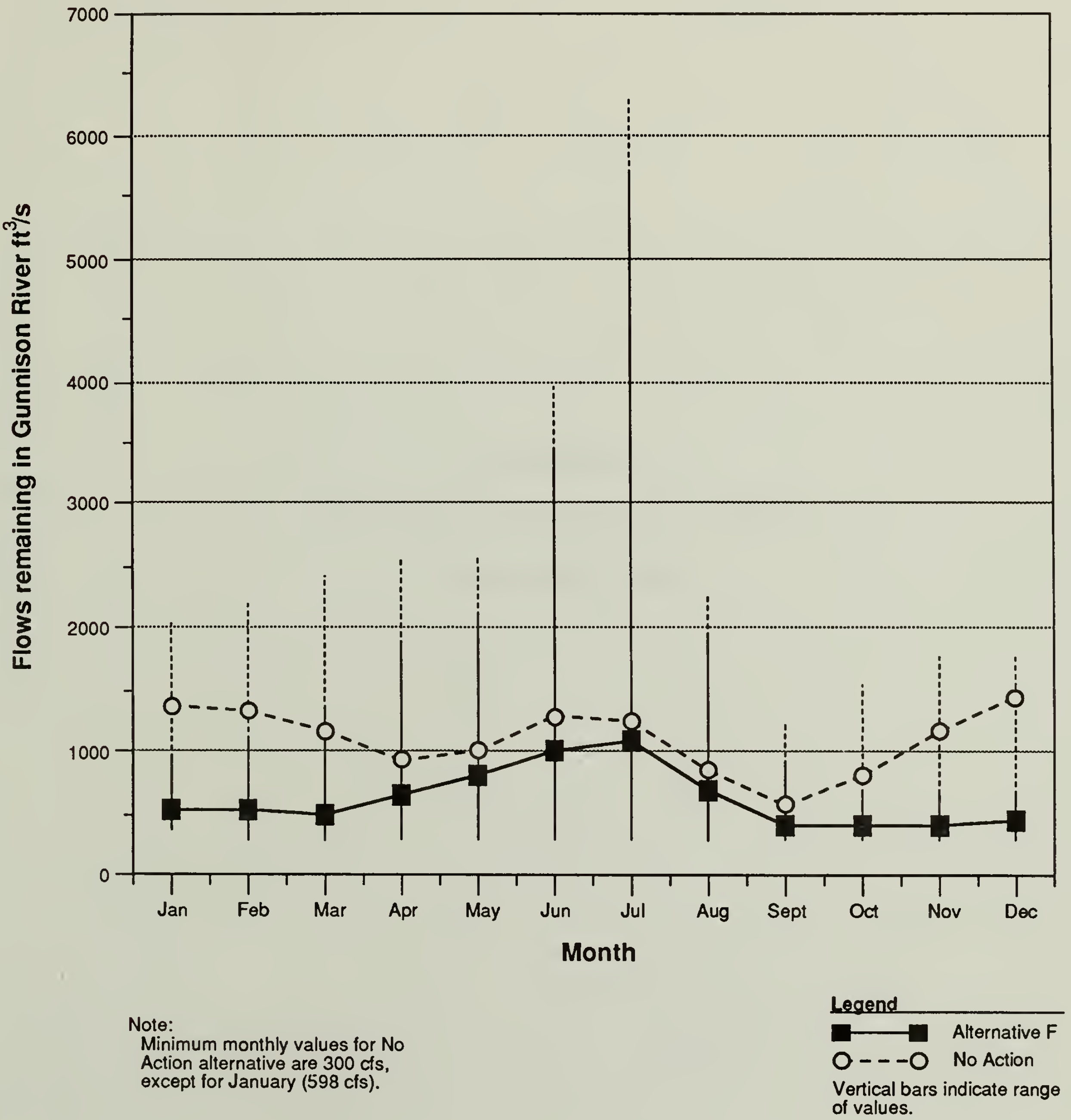


Figure D.6. Mean monthly flows and flow ranges for Alternative F compared to no action alternative.

ATTACHMENT E

DRAFT FISH AND WILDLIFE SERVICE

RECOMMENDATIONS

ATTACHMENT E
DRAFT FISH AND WILDLIFE SERVICE RECOMMENDATIONS

The following are draft Fish and Wildlife Service recommendations on the project which will be finalized for the final environmental impact statement.

1. Reduce potential impacts to prey species of wintering bald eagles by selecting alternative F as the recommended plan.

2. Provide "in-kind" replacement of habitat types, with a minimum of 1:1-acre replacement in the wetlands mitigation plan.

3. Evaluate potential wetland losses from Cedar Creek and areas downstream of the tailrace; the wetland losses should be quantified and appropriate mitigation proposed.

4. Mitigate impacts to riparian habitats.

5. Reduce potential impacts to waterfowl and other migratory birds by selecting alternative F as the recommended plan.

6. Develop a cooperative canal management program for the South Canal.

7. Establish a minimum flow of 60 to 80 ft^3/s from July 1 through September 30 from the Loutzenhizer Canal to the tailrace.

8. Continue fisheries studies in the Gunnison Gorge to determine any project impacts. Include provisions in the proposed project for any measures determined necessary to protect trout populations.

9. Conduct temperature modeling on the Gunnison River below the confluence of the North Fork.

10. Reduce impacts to river otters by selecting alternative F as the recommended plan.

11. Incorporate wildlife escape structures into the design of the concrete-lined AB Lateral.

Recommendations 2, 3, 4, and 11 are included in all of the alternatives. Recommendation 9 has been completed by monitoring water temperatures during 1988 and 1989 when flows were between 300 and 400 ft^3/s for long periods and by modeling.

Recommendations 1, 5, and 10 would only be accomplished in alternatives F or some combinations of F and other alternatives. The Sponsor's preferred alternative is alternative C.

Recommendation 6 has not been included in alternative plans because Reclamation does not consider the South Canal fishery a responsibility of the AB Lateral project. Also, because of safety and land ownership considerations, the encouragement of greater recreational use of the South Canal is not presently desirable. The flow recommendation in alternative 7 is only partially met. Alternative F is the most responsive alternative to this recommendation.

The Colorado Division of wildlife is expected to continue their long-term fishery monitoring of the Gunnison River, which should accomplish recommendation 8. Minimum flow provisions and measures to reduce flow fluctuations are included in all alternatives.