Colorado River Return Reconnaissance Study Summary Report

Prepared for:

State of Colorado
Colorado Department of Natural Resources
Colorado Water Conservation Board

Prepared by:

BOYLE ENGINEERING CORPORATION

In Association with:

BBC Research & Consulting
ERO Resources Corporation
Harvey Economics
URS Corporation
Water Consult

November 14, 2003

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Summary Report

Purpose of the CRRRS

This study addresses the general physical, environmental, financial, and institutional aspects of a large-scale water delivery system to satisfy much of Colorado's future water needs. Because this potential water system would pump or "return" water from the Colorado River near the Utah border for upstream uses in the South Platte, Arkansas and Colorado River basins, it is called the Colorado River Return Project or CRRP. This study is the first analysis of this concept and is, therefore, called the Colorado River Return Reconnaissance Study (CRRRS or Study). The CRRRS was authorized under Senate Bill 110 passed by the 64th Colorado General Assembly in the spring of 2003.

The CRRRS is a reconnaissance-level investigation conducted in sufficient detail to:

1. determine whether a need currently exists or may exist in the future for the water made available from the CRRP;
2. establish operational requirements and the preliminary size, type and location of CRRP facilities;
3. identify the most significant environmental and water quality issues;
4. distinguish the major differences between alternative CRRP configurations and the advantages and disadvantages of those configurations;
5. provide a preliminary indication of feasibility for each configuration; and
6. identify the types of potential CRRP sponsors and funding alternatives.

The CRRP would help supply water needs using water that is potentially available to the State in accordance with the Colorado River Compact, a long-standing agreement between the seven states in the Colorado River Basin. The CRRRS identifies and evaluates CRRP configurations for three levels of water diversion and demand: 250,000, 500,000 and 750,000 acre-feet/year (af/yr). To put the CRRP in context with other possibilities for supplying Colorado's future water needs, the study describes alternatives to the CRRP, including water conservation, construction of other water development projects, and transfers of water from current agricultural uses to municipal and industrial uses.

Many engineering, financial and environmental issues affect the feasibility of the CRRP. The CWCB understands these issues are present, but also understands that the entire state faces increasing challenges in the provision of safe, reliable supplies of water for domestic, municipal, industrial, environmental, recreational and other uses. After more than a century of water project construction, the lowest cost sources of supply have generally been developed and the environmental effects of water consumption are evidenced by complex federal, state, and local laws, regulations and policies.

The geographic extent and the magnitude of the water deliveries contemplated under the CRRP generate issues that will likely be of statewide interest. These issues include:

- Colorado River Compact Entitlement – Colorado's total Colorado River Compact entitlement in relation to the amount of water available in the mainstem near the Utah state line is subject to interpretation; the amount of the total compact entitlement that is taken from the Colorado River mainstem will directly affect the developable compact entitlement for the Yampa, White, Dolores, and San Juan basins.
- Endangered Fish Species and the Upper Colorado River Recovery Plan – Although the "15-Mile Reach" receives the most attention in the implementation of the recovery plan, the critical habitat designation extends upstream and downstream of this reach and upstream on the Gunnison River. The existing Recovery Program contemplates an additional 120,000 acre-feet of depletions. All of the studied capacities for the CRRP are greater than this.
- Integration with Existing Water Bodies – the CRRRS is based on conservatively high cost assumptions regarding potential levels of treatment and disposal of treatment waste streams. These topics will require considerable additional study if the CRRP is considered further. Alternative treatment levels are presented in this report to address potential impacts to natural water bodies and to existing water supply systems.
- Impacts to Rural Economies – as cities grow, agricultural water rights are being purchased and transferred to municipal use. This practice can adversely affect entire rural economies and communities.
- State's Role in CRRP Development – a project of this magnitude will generate discussion of the appropriate role of the State of Colorado in developing the state's water resources. The State's current and potential future roles in all aspects of water supply planning, design, permitting, construction and operation will likely be raised. The discussion may include the State's planning responsibilities, funding programs, regulatory authorities, interstate compacts and cooperative programs, and interfaces with federal project operations, funding sources, and regulatory authorities. The possibility of the State owning and operating a water supply system could also come to the forefront as it has in other western states.

The project's costs (per unit of water delivered) are significant, but might not be insurmountable. Two other large challenges must be met if this project is to come to fruition: 1) matching the amount of project water delivered (and cost incurred) to the increases in water demands (and utility revenues available) over time and 2) mitigating the environmental effects of the project.

Acknowledgements

A Technical Committee, consisting of four CWCB Board members: Mr. Greg Hoskin (representing the Colorado River mainstem), Mr. Eric Wilkinson, CWCB Chair (representing the South Platte River basin), Mr. Don Schwindt (representing the San Miguel, Dolores, Animas, and San Juan Rivers) and Ms. Carolyn McIntosh (representing the City and County of Denver) provided guidance regarding the scope of the study and reviewed draft work products. Mr. Hoskin and Mr. Wilkinson provided testimony at legislative hearings leading to the authorization of the CRRRS and also participated in public input meetings. Mr. Hoskin was especially involved with securing legislative approval for the CRRRS.

The CRRRS was prepared under the direction and management of Mike Serlet, P.E., Chief of Water Supply Planning and Finance, of the Colorado Water Conservation Board. Mr. Rod Kuharich, Executive Director and Mr. Dan McAuliffe, Assistant Director provided guidance on CWCB policies and programs. Mr. Rick Brown reviewed

the CRRRS process in relation to the Statewide Water Supply Initiative (SWSI) he is managing. Ms. Catherine Gonzales, Board Coordinator and Public Information Officer organized the public input program.

Many other local, state, and federal agency employees provided input as the CRRRS progressed. Their insights on potential positive and negative attributes of the CRRP are appreciated. General input was received via public meetings and information sent to the CWCB and directly to the consulting team.

Alternative CRRP Configurations

Three potential pipeline corridors, all of which begin on the Colorado River near the Utah State line are used in this study:

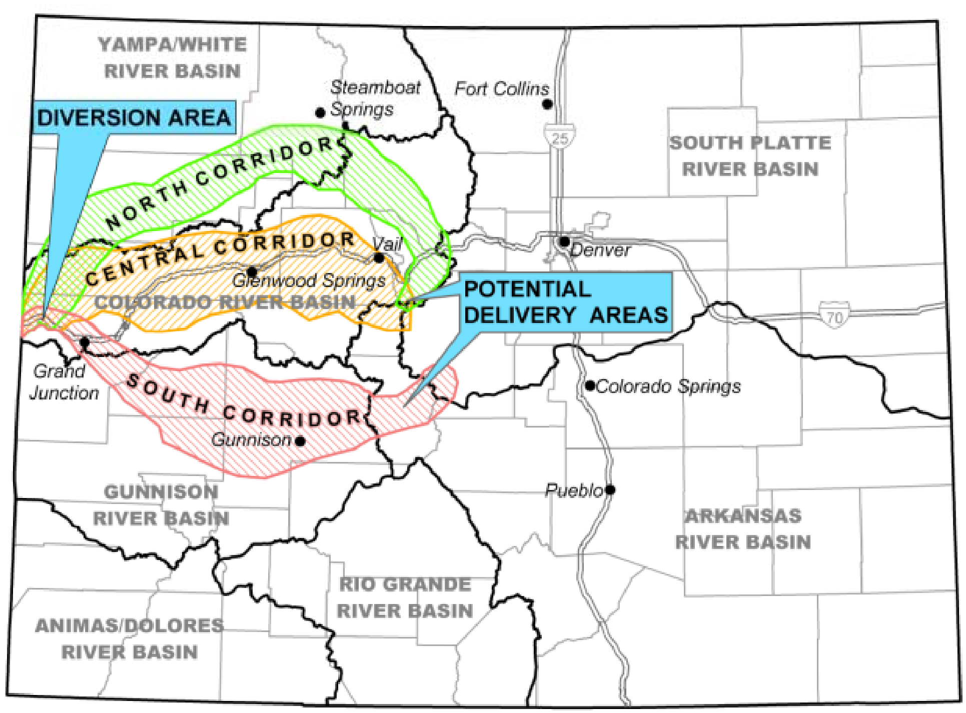
1) The Northern Corridor traverses the White/Yampa river basin before turning south into the upper Colorado River basin and on to the South Platte and Arkansas basins;

2) The Central Corridor extends up the Colorado River mainstem and its upper basin tributaries and on to the South Platte and Arkansas basins; and

3) The Southern Corridor traverses the Gunnison River basin before entering the Arkansas basin and extending on to the South Platte basin.

Locations of these corridors are shown in Figure 1.

Figure 1: Corridor Map



Presented below are major factors affecting the size, location, and type of facilities that would be required for the CRRP.

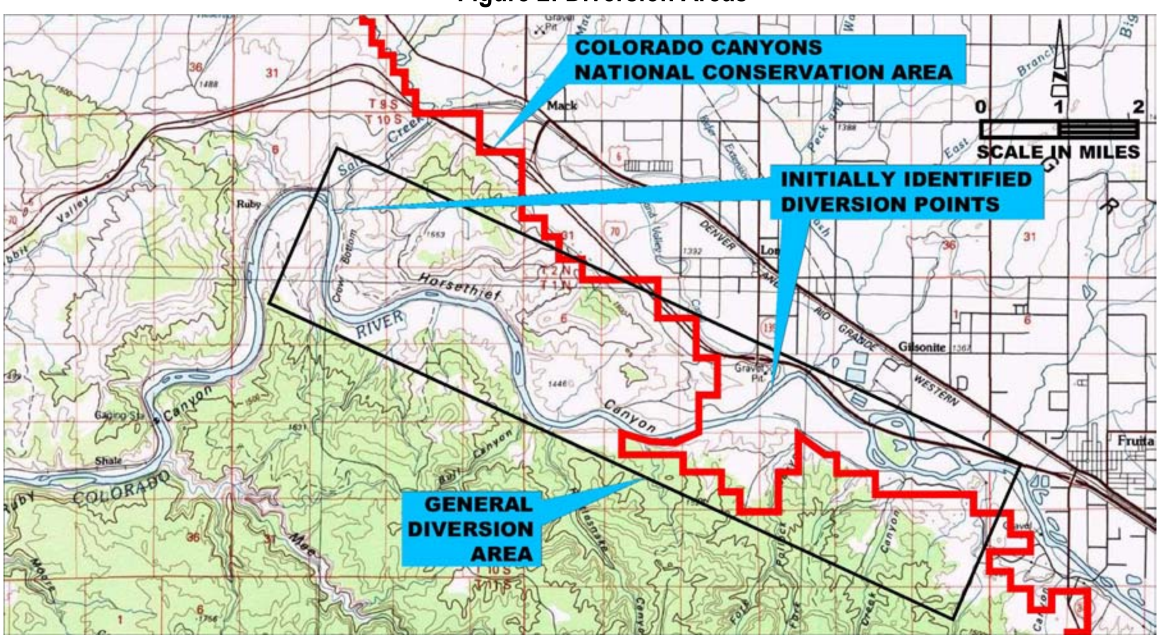
Delivery Capacity

Three annual average CRRP delivery capacities are evaluated in this study: 250,000, 500,000 and 750,000 af/yr. To deliver the full annual delivery capacity, the major facilities were planned to operate at slightly higher capacities to allow the facilities to be off-line for a period for routine maintenance and to account for unplanned outages, such as power failures. These higher design capacities would allow the CRRP to be out of service for a period of two weeks and still provide the full annual project delivery capacity. The following facilities were designed with this additional capacity: 1) Pumping stations; 2) Pipelines; 3) Tunnels and 4) Water Treatment Facilities.

Diversion Locations

It was determined by the state that the only diversion points to be considered at this time should be generally downstream of the last currently used water right on the Colorado River within the State of Colorado (downstream of Grand Junction). Based on this constraint, two potential diversion areas were identified for the CRRRS as shown in Figure 2.

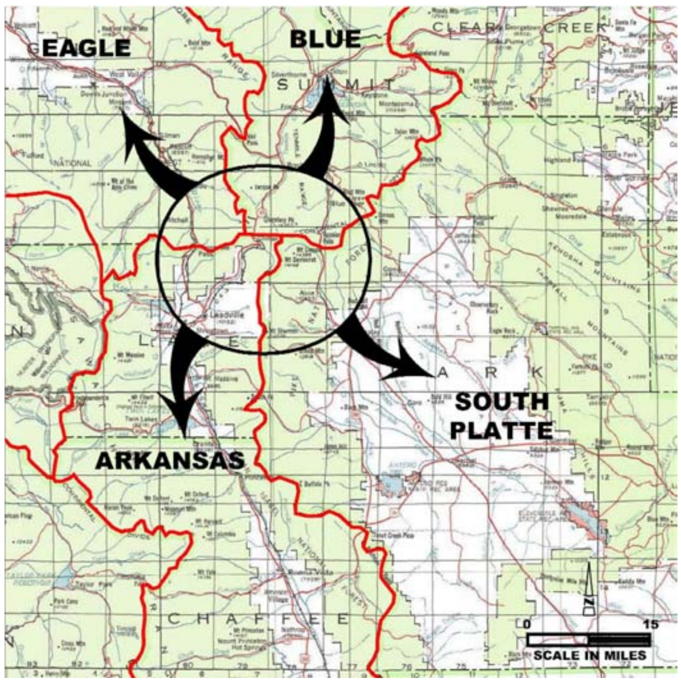
Figure 2: Diversion Areas



Delivery Areas

An advantageous termination point for the CRRP is the upper Eagle basin, where Eagle County, Summit County, Park County, and Lake County nearly meet, because, from this point, the CRRP could deliver water to the South Platte, Arkansas, and Colorado River basins (through deliveries to the Eagle and Blue River basins). Potential delivery locations are shown in Figure 3. Returning water into the Colorado system above Green Mountain Reservoir, Dillon Reservoir, and the rapidly growing population centers in Summit County offers the possibility of meeting both east and west slope needs in a variety of ways. With respect to the Denver metropolitan area, water could potentially be delivered both through the Roberts Tunnel and by way of the upper South Platte, offering redundancy and operational flexibility. The ability to move water into their large east slope reservoirs could be particularly valuable to the Denver area. Water could be delivered to the Arkansas basin via the river channel, with the possibility of Colorado Springs upgrading either their Montgomery pipeline or their Otero pump station and Homestake Pipeline.

Figure 3: Delivery Areas



In addition to the benefit of supplying several different areas, the ability to send the water several different directions from the termination point may resolve issues relating to conveyance capacity.

Conveyance Corridors

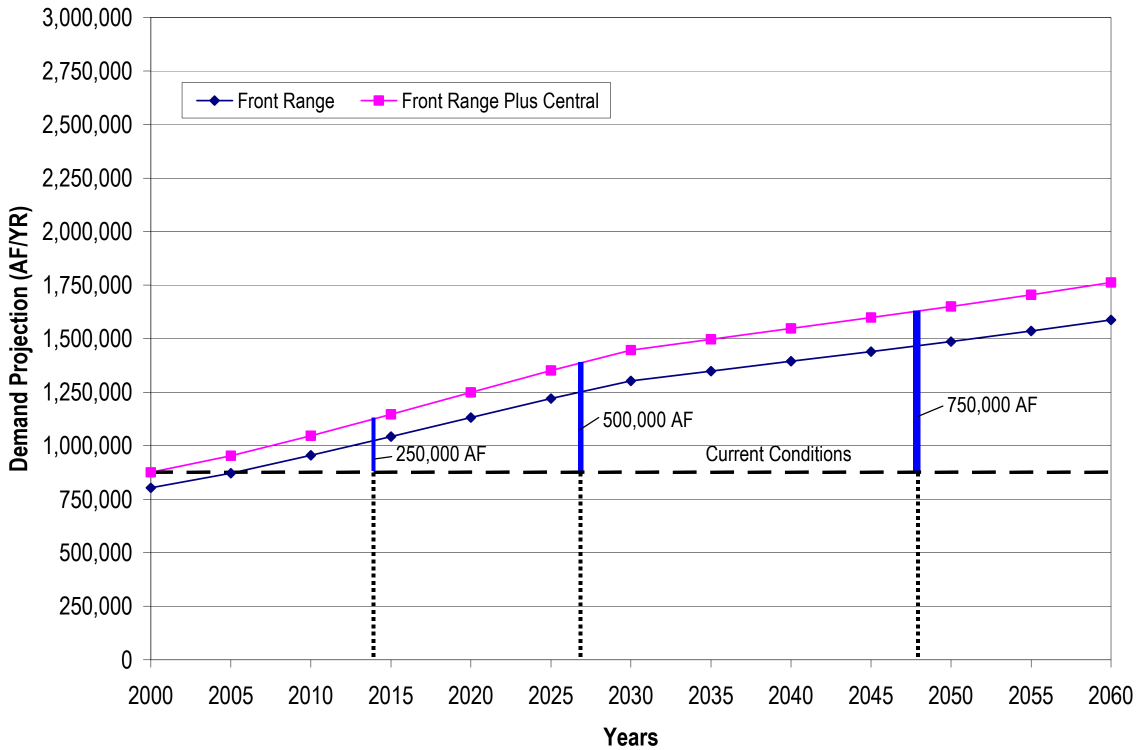
Once the diversion locations and the delivery locations were identified, the next step in the process was to identify routes between the two points. The shortest distance would obviously be a straight line between the two points and without considering other factors would result in the least construction cost. However, topography, obstacles (natural and manmade), environmental and other considerations can greatly increase the pipe length, unit cost of pipe fabrication and installation. These factors can make alternatives that vary from the straight line between the starting and ending point more economically attractive than the straight-line alternative. In addition, sensitive land uses, such as Wilderness Areas and National Parks also affected potential alignments. Consideration of these factors led to the identification of the Northern, Central, and Southern Corridors as shown in Figures 4, 5, and 6 placed at the end of this Summary Report.

Within each corridor, a variety of specific alignments were evaluated. The alignments were identified with enough detail to allow hydraulic calculations to be prepared. It is recognized that all of these alignments would be adjusted in future studies (if any are performed), to improve or optimize the alignment, considering technical, environmental, land ownership, future uses, and other factors.

Future Water Demands and Sources of Supply

Long-term economic growth throughout Colorado, but especially in the South Platte, Arkansas, and Colorado River basins may require significant new sources of supply despite the demand-side management programs that have been, and will continue to be, developed by water supply agencies. The State Demographer's population forecasts were used as the basis to characterize the general magnitude of future water demands for areas potentially served by the project. The largest demands are projected to occur within the Front Range and in the Central Pipeline Corridor. Based upon past experience and judgment, it is believed that the water demand projections resulting from the approach and assumptions employed in this study are higher-end projections. Hence, the final water demand projections have been reduced by 10 percent for a more conservative set of projections appropriate for examining the feasibility of a new project. These 10 percent adjusted projections are those presented in Figure 7.

Figure 7: Water Demand Projections for the Front Range and Central Pipeline Corridors



These water demand projections indicate that an additional 784,000 af of raw water will be required from structural and nonstructural resources in the Front Range between the year 2000 and 2060. Including incremental water demands from the Central Pipeline Corridor Demand Area, a total of 887,000 af of additional water needs will need to be met by 2060.

The water demand projections presented in Figure 7 encompass all estimated domestic, commercial and industrial water needs for the Front Range Demand Area and Central Pipeline Corridor Demand Areas through 2060. These projections do not include estimated water needs for agriculture in or outside these study areas.

Under the water demand projections adopted for the CRRRS, Figure 7 shows that the CRRP supply at the 250,000 af per year delivery level could be needed by new market demand as early as year 2014. The 500,000 af per year delivery level could be theoretically needed by the year 2027, and the 750,000 af scenario could hypothetically be needed by the year 2048. The Front Range Demand Area alone could absorb the high 750,000 af delivery scenario by 2057.

While current or planned structural and non-structural projects may diminish the need for CRRP's water supply, there are several other sources of potential future water demand in the study areas that were not evaluated. One future source of demand is replacement of current supplies that are likely to become unavailable in the future. Present groundwater use in the urbanized Front Range, for example, might be unsustainable as a base load supply without new augmentation or conjunctive use sources. Other sources might also have long-term availability issues or water quality standards might become more strict.

Water Quality Issues and Treatment Options

The following levels of treatment for the project water were considered during the study:

- No Treatment – This "option" is inconsistent with environmental regulations and the study.
- Treatment Level One (Drinking Water Quality) – Treatment to finished drinking water quality of typical Front Range municipal systems (Safe Drinking Water Act, USEPA primary and secondary standards as well as typical front range aesthetics issues such as hardness)
- Treatment Level Two (Receiving Water Quality) – Treatment to match average receiving water quality

Each level of treatment would result in a specific set of water quality parameters that would characterize the project water discharged into the delivery area. Four water treatment technologies were considered, each producing some form of residual byproducts that must be processed and disposed of in some manner.

Construction and Operating Costs

Cost estimates are based on typical reconnaissance level procedures focusing the greatest attention on the largest cost components of the CRRP. Preliminary schematic drawings were prepared for water treatment alternatives, pumping stations, hydroelectric plants and pipelines. All costs are based on 2003 US dollars. Opinions of probable costs were compiled for 31 alignments representing all three corridors. The results for each of the three delivery capacities are shown on Tables 1, 2, and 3 (detailed cost sheets) at the end of this Summary Report.

Total capital costs including construction, easements, engineering, administration and contingencies for the least costly alternatives are as follows:

- For 250,000 af/yr – approximately $3.7 billion or about $14,700 per acre foot
- For 500,000 af/yr – approximately $6.0 billion or about $12,000 per acre foot

- For 750,000 af/yr – approximately $8.7 billion or about $11,600 per acre foot

Total annual operation and maintenance costs including net energy purchases and operation of physical facilities are as follows:

- For 250,000 af/yr – approximately $220 million or about $890 per acre foot
- For 500,000 af/yr – approximately $420 million or about $840 per acre foot
- For 750,000 af/yr – approximately $620 million or about $820 per acre foot

The following general conclusions were reached:

1. Economy of Scale – for all 31 alignments, the estimated capital cost of per acre-foot of water delivered decreases with increasing delivery capacities, that is, at 750,000 af/yr, the CRRP is more cost effective per unit of water delivered than for 500,000 or 250,000 af/yr.
2. Most Cost-Effective Alignments within each Corridor - at this reconnaissance level of study, there are no significant differences in costs between the alignments in each corridor. Therefore, there is flexibility in future selection of specific alignments.
3. Most Cost-Effective Corridors – at this reconnaissance level of study, there are no significant differences in capital costs between the Central and South corridors. There is, however, a significant difference (approximately a 50% capital cost penalty) between the North Corridor and the other two corridors due to the increased length of pipe. Annual operating costs are also higher for the North Corridor. Comparing the least cost alignments in each corridor based on annual costs indicates that the North Corridor is almost 20% more expensive than the Central and almost 40% more expensive than the Southern. Environmental impacts and the differences between each corridor are discussed in the next chapter.

Five of the 31 initial alignments were selected as being representative examples of the range of possibilities in the three corridors and allowed more detailed assessment of likely economic, financial and environmental conditions. These five alignments should not be considered recommended alignments; they should be considered only as alignments that generally represent the broad range of alignments that could be considered in each of the corridors. The project costs for five alternatives are listed in Table 4 below.

Table 4: Cost Summary

Alternative	Total Capital Cost ($ in Millions)	Unit Capital Cost* ($ per af)	Annual O&M Cost ($ in Millions)	Unit O&M Cost* ($ per af/year)
250,000 acre-feet per year Delivery Capacity				
Northern Alignment 1 - N01	$ 6,159	$ 24,637	$ 257	$1,026
Central Alignment 1 - C01	$ 3,667	$ 14,668	$ 221	$ 885
Central Alignment 2 - C05	$ 3,672	$ 14,689	$ 230	$ 920
Southern Alignment 1 - S01	$ 3,862	$ 15,449	$ 201	$ 803
Southern Alignment 2 - S02	$ 3,821	$ 15,286	$ 196	$ 784
500,000 acre-feet per year Delivery Capacity				
Northern Alignment 1 - N01	$ 10,117	$ 20,235	$ 488	$ 967
Central Alignment 1 - C01	$ 6,016	$ 12,032	$ 419	$ 838
Central Alignment 2 - C05	$ 6,137	$ 12,274	$ 445	$ 891
Southern Alignment 1 - S01	$ 6,613	$ 13,226	$ 375	$ 750
Southern Alignment 2 - S02	$ 6,546	$ 13,093	$ 365	$ 730
750,000 acre-feet per year Delivery Capacity				
Northern Alignment 1 - N01	$ 15,093	$ 20,124	$ 721	$ 961
Central Alignment 1 - C01	$ 8,687	$ 11,583	$ 618	$ 824
Central Alignment 2 - C05	$ 8,773	$ 11,697	$ 658	$ 877
Southern Alignment 1 - S01	$ 9,653	$ 12,871	$ 567	$ 756
Southern Alignment 2 - S02	$ 9,669	$ 12,892	$ 537	$ 717
Total Capital Cost – construction, land, engineering, and contingencies (including environmental permitting)				
Unit Capital Cost - total capital cost divided by the project delivery capacity				
O&M Cost - total annual operating and maintenance costs at full capacity				
Unit O&M Cost - total annual operating and maintenance costs at full capacity divided by the project delivery capacity				
Alternative Descriptions *- The alternatives consist of the following segments as shown on Figures 4, 5, 6.*				
Northern Alignment 1 - N01 - NC1-NC2-NC4-NC5-NC7-NC8-NC11-NC13-NC15-NC17, NC18				
Central Alignment 1 - C01 - CC1-CC10-CC13-CC11-CC6-CC3-CC4, CC8				
Central Alignment 2 - C05 - CC1-CC10-CC14-CC12-CC16-CC17-CC18-CC22-CC23-CC20-CC21				
Southern Alignment 1 - S01 - SC1-SC16-SC18-SC25-SC26-SC28-SC22-SC24				
Southern Alignment 2 - S02 - SC1-SC2-SC4-SC5-SC7-SC8-SC10-SC11-SC13-SC14-SC15				

* See the Financial Considerations section of this chapter regarding the affordability of these unit costs.

Economic Considerations

In terms of economic benefits, the chief and unique attribute of the CRRP is that it does not mean a sacrifice of water supplies for others in the state of Colorado. That is, the CRRP will not take water supplies away from existing agriculture, the West Slope, urban users or groundwater users. It is assumed these supplies for the CRRP are excess to Colorado's current water use, so there will be no charges or payment required to obtain these supplies. However, use of this supply for the CRRP precludes future use of this water elsewhere in Colorado. Colorado's total Colorado River Compact entitlement in relation to the amount of water available in the mainstem near the Utah state line is subject to interpretation; the amount of the total compact entitlement that is taken from the Colorado River mainstem will directly affect the developable compact entitlement for the Yampa, White, Dolores, and San Juan basins. It is assumed that the CRRP diversion would be accomplished under state water rights as a new appropriation.

Other economic benefits are noteworthy. The magnitude of construction expenditures on pipe, plant and equipment will generate considerable sales and use taxes of $390 million total over the five years of construction and property tax revenues of $12 million per year for state and local governments. Construction employment will be significant during the construction period, and indications are that workers skilled in the relevant trades will be absorbed first from the local workforce along the pipeline corridor and then throughout the state. Total employment gains of 18,000 persons are possible during the five years of construction and of 1,000 persons during operations. It is possible that a pipe construction plant will be built in Colorado to accommodate this project, representing a longer-term economic stimulus in terms of property taxes, sales and use tax, and employment. A major boost to aggregate mining activity may occur as the pipeline constructors search for bedding along the pipeline route. State personal income tax revenues will increase.

It is anticipated that the operations and maintenance crews and expenditures will be significant throughout the life of the CRRP, which will represent a significant ongoing economic benefit. Additionally, there will be a notable opportunity for the coal and natural gas sectors to boost employment and output in Colorado to provide energy for the operations of the CRRP, which will be another ongoing economic benefit of the project. This increase in energy production will also create additional personal and business income taxes for the State.

This pipeline corridor could also be used for multiple economic purposes. For example, telecommunications, such as fiber optics or other utilities, may wish to take advantage of this right-of-way across Colorado. Secondly, the excess water from the water treatment plant could be considered for use in advanced oil recovery techniques or as liquid medium in a coal slurry pipeline to in-state or out-of-state locations. Therefore, corollary benefits might occur outside the Front Range or the Pipeline Corridors.

With the substantial construction workforce comes an economic stimulus in terms of their purchases of housing, goods and services up to a point, then becoming a cost. If the capacity of public facilities and services along the pipeline corridor are absorbed, the socioeconomic effects will represent costs in terms of expansion of public facility and service capabilities. Housing markets can also be overburdened if appropriate measures are not taken to provide temporary housing and other facilities during the construction of the CRRP.

Social costs of the CRRP will be evident as various stakeholders face the magnitude and the uncertainty that CRRP represents. There is no precedent in Colorado for a water resource development of this size. CRRP also has the opportunity of producing social benefits with a vast reduction in the conflicts, disagreements and competition associated with current water resource development. The extraordinary amount of planning time, studies, and litigation associated with water resource development over a period of many decades might be reduced and funneled into one, large project.

Environmental resource costs are unknown at this time but might be considerable. The pipeline right-of-way could cause a diverse set of environmental resource losses, some of which will be temporary and others of which might be permanent. Construction disturbance will have its own set of impacts on the environment. The water treatment plant and the removal and disposal of the sludge remains an environmental question, as does the disposal of excess excavated material.

Financial Considerations

One of the key questions surrounding the CRRP is whether it is financially feasible. The capital and annual operating costs are of such a magnitude that the CRRP must be viewed in relation to its potential to supply much of Colorado's water needs for several decades. Since the CRRP could satisfy the bulk of Colorado's water demand into the foreseeable future, and preliminary water demand projections indicate that future water users in the three river basins will need this supply within the next 20 to 50 years, the more pressing questions become, "Can these water users pay for the CRRP?" and "Are the rate increases reasonable in relation to the system development charges (tap fees) and water rates that consumers will likely have to pay for increasingly expensive water sources?"

Methodology And Assumptions

The financial feasibility of the CRRP is initially characterized by evaluating present value costs and then by identifying the system development charges (SDCs) and water rate increases that would be required to pay for CRRP assuming that customers in the water consuming demand areas pay all the costs through repayment of CRRP revenue bonds.

Interest during construction was capitalized into the bond issues which would begin repayment upon project completion. Annual debt service from capital repayment and interest was added to annual operating costs, whose pumping components increase as deliveries grow to meet demand. The total revenue requirements are met by an equal proportion of tap fees or system development charges (SDC) and water rates. The SDC's and the water rates are computed to equal the total revenue requirements.

In the analysis, revenue requirements projected in nominal or current dollars were discounted back to constant 2003 dollars so that water rate and SDC increases could be compared meaningfully with 2003 charges that exist along the Front Range of Colorado. It was determined that typical annual water rates per single family tap equivalent are about $350, and typical SDC charges per single family tap amount to $5,000.

Present Value Costs

The CRRP capital costs and operating costs must both be considered for a complete picture of the project's financial performance. Two ways of expressing these combined are presented below:

1) capitalizing the operating costs and combining those with up-front project development costs into a single figure; or

2) annualizing the capital costs and combining those with annual operating costs.

In the first case, future operating and maintenance costs are discounted back to present value; in the second case, debt service for the up-front capital costs are added to annual operating costs, and then these annual costs are discounted back to present value and divided by water deliveries to arrive at an annual cost per acre foot, inclusive. The results are set forth in Table 5 below.

Table 5: Total Present Value CRRP Costs

Route and Delivery Capacity	Total Capitalized Costs (millions)	Average Annualized Cost per af
250,000 af/yr		
Northern Alignment 1 – NO1	$ 11,900	$ 3,600
Central Alignment 1 - CO1	$ 8,600	$ 2,600
Central Alignment 2 - CO5	$ 8,800	$ 2,700
Southern Alignment 1 - SO1	$ 8,100	$ 2,500
Southern Alignment 2 - SO2	$ 8,300	$ 2,500
500,000 af/yr		
Northern Alignment 1 - NO1	$ 20,600	$ 3,700
Central Alignment 1 - CO1	$ 14,700	$ 2,800
Central Alignment 2 - CO5	$ 15,000	$ 2,900
Southern Alignment 1 - SO1	$ 13,400	$ 2,500
Southern Alignment 2 - SO2	$ 13,900	$ 2,600
750,000 af/yr		
Northern Alignment 1 - NO1	$ 26,800	$ 5,000
Central Alignment 1 - CO1	$ 19,800	$ 3,700
Central Alignment 2 - CO5	$ 20,200	$ 3,700
Southern Alignment 1 - SO1	$ 18,300	$ 3,300
Southern Alignment 2 - SO2	$ 19,000	$ 3,400

For comparison purposes, water from an existing project is currently being purchased for approximately $22,000/af of firm yield (Colorado-Big Thompson Project Water in the South Platte River Basin). Using the lowest capitalized cost for 500,000 af in Table 5 (Southern Alignment 1), the equivalent unit cost would be $26,800 per af or 22 percent higher than C-BT. Of course, there is not an additional 500,000 af of yield available from the C-BT project and by state law and contractual requirements, C-BT project water can only be used within the boundaries of the NCWCD. C-BT prices have significantly outpaced inflation compared with the price a couple decades ago. Therefore, future affordability of the CRRP may be competitive with other options. Another way of viewing the current price for water (using C-BT to represent the current marginal cost of water) is to consider that the total cost to acquire 500,000 af of yield from other sources but at the current CB-T price would be $11 billion.

A key issue with the CRRP, is its long-term operating costs that extend beyond the 40-year financing period. Therefore, the financial feasibility of CRRP must be determined by water utilities and others needing water as they compare the costs and attributes of CRRP with the costs and attributes of other alternatives available to them, which differ from utility to utility. As of 2003, CRRP is more expensive on an apples to apples basis than most alternatives that are presently purchased by water purveyors. However, in reviewing the CRRP's financial feasibility one should also consider that:

- Colorado's long term future water needs are considerable;
- The real price of water will likely continue to rise;
- The prospects of available alternatives are unknown, but yields might be finite; and
- The planning period for a project of the CRRP magnitude will be long.

Impacts on Water Rates and System Development Charges

The results of the financial analysis indicate that substantial, but perhaps not overwhelming, increases in water charges would be required to pay for the CRRP. Five years after project completion,for the Central Corridor, annual revenues from water rates have to increase by $162 per Single Family Tap Equivalent (SFTE) in 2003 dollars for the 250,000 af delivery scenarios. Tap fee or SDC charges would have to increase $2,316 over the current $5,000 dollar SDC amount. These changes would represent a 46 percent increase for customers in that year. As the customer base grows, the total increases per customer will decline so that forty years after completion, water consumers would experience 23 percent greater water rates and SDC charges as compared with the 2003 rates, expressed in 2003 dollars. The more costly, higher delivery capacity scenarios are more cost efficient on a dollar per acre foot basis, but create a greater financial burden for the customers who must pay for unused capacity in the early years of the project. Hence, the 250,000 af delivery scenario is the most affordable for its customers. Table 6 depicts results for the three different delivery scenarios.

Assuming the Central Corridor is selected for the 250,000 af delivery scenario, present and future customers in the water demand areas would pay water rates and SDCs strictly to pay for the CRRP that increase one percent per year.

It is important to note that the total financial burden on a per customer basis decreases with the growth of new customers and total water use in the demand areas in Colorado. The financial challenge is the debt service burden of the project in the earlier years. This burden is less as the delivery scenarios diminish in size.

Table 6: Summary of Preliminary Financial Impacts of CRRP, Assuming the Central Corridor, by Delivery Scenario

	Years After Project Completion		
Required Increases per SFTE 2003 Constant Dollars	**Five**	**Twenty**	**Forty**
250,000 af/yr			
Water Rates	$162	$121	$82
SDCs	$2,316	$1,726	$1,166
500,000 af/yr			
Water Rates	$297	$221	$150
SDCs	$4,248	$3,166	$2,139
750,000 af/yr			
Water Rates	$397	$296	$200
SDCs	$5,663	$4,220	$2,851
Percent Increases Required in Water Rates and SDCs per SFTE, Compared to 2003*			
250,000 af/yr	46%	34%	23%
500,000 af/yr	85%	63%	43%
750,000 af/yr	113%	84%	57%

* Applies required dollar increases to typical 2003 water rates of $350 per SFTE and $5,000 SDCs per SFTE.

Note: SFTE is single family tap-equivalents. SDCs are system development charges or tap fees. The least expensive central corridor alternative was selected for this financial evaluation. The other alternatives would involve greater financial impacts than presented here.

Environmental Considerations

Environmental benefits of CRRP can be found in the avoidance of numerous and fragmented water resource development projects across the state over the next 50 years. It is unknown whether the cumulative amount of such impacts exceed that of CRRP. Secondly, new waters to the consuming regions will mean more discharge, potentially improving habitat downstream. However, several significant environmental issues could be constraints to development of the CRRP. Some of these issues could be resolved with changes in the location of CRRP features (e.g., adjustments to preliminary pipeline alignments or diversion location). Other significant environmental issues are unavoidable and likely would create substantial hurdles to CRRP development (e.g., changes in flows in designated critical habitat of federally listed fish species, and issues associated with water treatment facilities). At the reconnaissance level of this preliminary environmental evaluation, the following environmental issues appear to be potentially significant environmental constraints for the CRRP:

- Potential conflicts with the current management of some public lands.
- One of the preliminary diversion location occurs within the Colorado Canyons National Conservation Area, which is designated for no surface occupancy.
- Diversions from the Colorado River will affect flows and potentially affect designated critical habitat for federally listed fish species below the diversion.

- Federally listed fish, particularly larval life stages, could be entrained in the diversion constituting “take” under ESA.
- The diversion could form a barrier to the movement of federally listed fish.
- The importation of water diverted from the Colorado River potentially could affect receiving waters on the east side of the Continental Divide.
- Two of the four water treatment alternatives would involve about 22 square miles of evaporative ponds. The ponds will concentrate contaminants in the treated waste stream creating a deleterious for waterfowl and shorebirds.
- The other two water treatment alternatives do not perform as well in meeting the treatment goals as the membrane processes.

Potential significant environmental issues are summarized in Table 7.

Table 7: Potential Significant Environmental Issues

Facility/Issue	Potential Project Constraint	Potential to Resolve Constraint
	Diversion	
Location	Occurs in Colorado Canyons NCA; no surface occupancy.	Obtain variance or move location upstream outside NCA.
Critical Habitat	Would affect flows in designated critical habitat.	Develop ways to mitigate any significant impacts to critical habitat.
Flow Recommendations	All evaluated flow rates would affect recommendations for average peak flows.	Curtail diversions during peak flows.
Entrainment	Would entrain federally listed fish.	Use fish screens to minimize entrainment.
Barrier	Could form a barrier to movements of listed fish species.	Design diversion structures for fish passage.
	Pipeline Alignments	
USFS Lands		
North Alignment (NO1)	Passes through 72 acres of designated roadless area.	Revise alignment to avoid roadless areas or request variance.
Central Alignment 1 (CO1)	Passes through 130 acres of designated roadless area.	Revise alignment to avoid roadless areas or request variance.
Central Alignment 2 (CO5)	Passes through 290 acres of designated roadless area and 103 acres of wilderness area.	Revise alignment to avoid roadless and wilderness areas or request variance.
South Alignment 1 (SO1)	Passes through 658 acres of designated roadless area and 21 acres of wilderness area.	Revise alignment to avoid roadless and wilderness areas or request variance.
South Alignment 2 (SO2)	Passes through 137 acres of designated roadless area.	Revise alignment to avoid roadless areas or request variance.
BLM Lands		
North Alignment (NO1)	Passes through 802 acres of sensitive BLM lands.	Revise alignment to avoid lands designated as no surface occupancy or request variance.
Central Alignment 1 (CO1)	Passes through 57 acres of sensitive BLM lands.	Revise alignment to avoid lands designated as no surface occupancy or request variance.
Central Alignment 2 (CO5)	Passes through 199 acres of sensitive BLM lands.	Revise alignment to avoid lands designated as no surface occupancy or request variance.
South Alignment 1 (SO1)	Passes through 70 acres of sensitive BLM lands.	Revise alignment to avoid lands designated as no surface occupancy or request variance.

Facility/Issue	Potential Project Constraint	Potential to Resolve Constraint
South Alignment 2 (SO2)	Passes through 143 acres of sensitive BLM lands.	Revise alignment to avoid lands designated as no surface occupancy or request variance.
Hazardous Materials Site (no sites were identified for the North Corridor alignments)		
Central Alignment 1 (CO1)	Passes through the Eagle Mine Superfund Site.	Due to location and surrounding topography, this site may be difficult to avoid. Special soil handling and construction techniques would be required.
Central Alignment 2 (CO5)	Passes through the California/Yak Tunnel Superfund Site.	Revise alignment to avoid Leadville area and site or incorporate special soil handling and construction techniques.
South Alignment 1 (SO1)	Passes through two treatment, storage, and disposal facilities.	Revise alignment to avoid treatment, storage, and disposal facilities.
South Alignment 2 (SO2)	Passes through two treatment, storage, and disposal facilities.	Revise alignment to avoid treatment, storage, and disposal facilities.
Outfalls		
Water Quality	Colorado River water quality differs significantly from the receiving bodies of water.	Treat water to standards of receiving bodies of water.
Temperature	Colorado River water is warmer than the cold water aquatic environment of receiving streams.	Determine temperature of water at outfalls; cool water prior to entry into receiving streams if needed.
Channel Maintenance	Increased flows in receiving streams may cause erosion and channel instability.	Determine impacts; mitigate as appropriate.
Increased Flows	Increased flows may alter aquatic habitat.	Mitigate as feasible and appropriate by enhancing aquatic habitat.
Importation of Organisms	Aquatic organisms and/or disease may be imported to the receiving waters.	Determine if treatment of diverted water will avoid importation of aquatic organisms or disease. Additional treatment may be needed.
Treatment		
Evaporative Ponds Required for Membrane Processes (Alternatives 1 and 3)	Concentrated minerals and salts removed from treated water may occur in toxic amounts and enter food chain.	Model to determine accumulated concentrations of potentially toxic elements in evaporative ponds. No feasible means known to keep wildlife from using evaporative ponds.

Facility/Issue	Potential Project Constraint	Potential to Resolve Constraint
Process Effectiveness of Alternatives 2 & 4	If desirable blending ratios with the receiving waters cannot be obtained, it is possible the processes will not meet treatment goals.	Future studies to model variations in diversion location water quality, receiving water quality, predicted treatment process performance and predicted final combined stream water quality after blending.
	Permitting	
Section 404 Permit	May be difficult to demonstrate that the CRRP is the least environmentally damaging practicable alternative to meet future Front Range water needs.	Extensive alternatives analysis.

Conclusions

This reconnaissance study of the CRRP demonstrates that the project may be financially feasible under certain conditions, but many economic, institutional and environmental issues need further assessment. Anticipated population growth in the Arkansas and South Platte river basins combined with municipal and industrial needs in the Colorado River basin will generate sufficient future demand for water from the CRRP, even utilizing conservative demand projections. It is envisioned the project's water supply must be treated sufficiently for discharge into existing water bodies and/or raw water collection systems. The CRRP could have significant impacts on the flows potentially needed for the recovery of endangered fish species in the area designated by the U.S. Fish and Wildlife Service as "critical habitat" extending downstream of the potential diversion near the Utah state line. The impacts to these target flows might be mitigated or avoided with sufficient storage in the CRRP collection system to allow the project to cease diversions when such impacts are anticipated. Advanced treatment processes that could utilize membrane filtration or reverse osmosis technologies would likely be required. These processes are being used extensively in new water treatment plants and expansions to existing plants in Colorado and throughout the country. The potential size of the CRRP treatment facilities, ranging from 230 to 690 million gallons per day (the upper end is approximately equal to the combined capacity of all three Denver Water treatment plants) and relatively degraded water quality of the Colorado River water near the Utah state line requires that the handling of the residual waste stream of the water treatment plant be given special consideration in future studies. The electrical energy to pump water downstream of Grand Junction to the South Platte and Arkansas River basins is significant, but the power requirements should be considered in the context of the additional electrical generation resources that will be needed to supply the future Colorado population and economy. The environmental impacts and financial implications of developing the combinations of alternatives to the CRRP that could supply 250,000 to 750,000 af/yr may have impacts approximating or exceeding, those of the CRRP.

The CRRRS demonstrates that significant new sources of water supply will be required within the State of Colorado and that the CRRP is technically capable of satisfying these needs for water. After more than a century of water project construction, the lowest cost sources of supply have generally been developed. This study shows that while the CRRP may be economically feasible under certain conditions, it would require significant increases in system development charges and water rates over current costs for water. These increases may occur as well, during the development of other similar, more numerous projects that would be required to meet the same demands that could be met by CRRP. Additional study of project concepts and alternatives may identify ways in which project costs may be reduced. There are a number of institutional and environmental issues that require further assessment. There are also two other significant challenges that must be met if this project is to come to fruition: 1) matching the amount of project water delivered (and cost incurred) to match the increases in water demands (and utility revenues available) over time and 2) mitigating the environmental effects of the project.

Recommendations Regarding Future Studies

The results of the CRRRS need to be shared and reviewed with water users, agency personnel, special interests, and the general public. In addition, many of the key issues identified during this initial study of the CRRP need supplementary reconnaissance-level analyses. Public information programs and additional studies could be reasonably accomplished in a year and would allow appropriate discussion and consideration in the on-going Statewide Water Supply Initiative. Presented below are specific recommendations.

Presentation of CRRRS Findings to Affected Parties

A key aspect of the CRRP development is its consideration in the on-going SWSI process. This task would involve presentations to the various SWSI river basin planning groups to help assure that a wide range of CRRP alternatives are understood and considered, but perhaps more importantly, provide responses to questions raised about the CRRP and its strengths and weaknesses. Detailed study results should also be presented to various specialty interests including local, state and federal agencies.

Variations In Layout Of CRRP Structural Components

The conservative assumptions used in this reconnaissance-level study regarding structural components tend to overestimate the cost and complexity of the CRRP facilities. Specialized reconnaissance level studies would be needed to reduce the level of conservatism on the following structural components of the CRRP:

- Alternative diversion points to address concerns with the CRRP's interface with existing land uses
- Alternative diversion structure layouts to minimize impacts on fish migration upstream and downstream and to minimize entrainment of endangered fish species to an appropriate level
- Operation studies to define the general magnitude and location of monthly, seasonal and/or long-term water storage considering effects of potential diversions on downstream flow needs
- Alternative alignments or sections of alignments to incorporate potentially more cost effective open channel conveyance (canals)
- Alternative levels of treatment, required treatment technologies, multiple treatment locations, and handling of treatment by-products
- Multiple delivery points and the possibility of partial utilization of existing facilities
- Further assessment of sources and cost of pumping energy and required electrical transmission facilities

Methods To Enhance Economic And Financial Feasibility

Conceptual level analysis should consider ways to enhance the performance of the CRRP economically and financially. For example, future CRRP analyses should consider inclusion of conventional hydropower generation in the South Platte and/or Arkansas basins. In addition, incorporation of pumped-storage hydropower facilities would likely increase capital costs only marginally since the high pressure pipelines, pump stations, and operating storage are already included in the project but greatly enhance the revenue stream for the project and provide dynamic benefits to the electrical distribution grid. More detailed assessment of avoided costs and impacts of alternatives to the CRRP should also be considered and would compliment and enhance the results and credibility of the SWSI.

Environmental Evaluations

This preliminary environmental evaluation focuses on potential major environmental issues for a reconnaissance level study of the CRRP. If the CRRP is developed further, additional environmental evaluations will be needed. For example, preliminary assessment is made of the impact of CRRP diversions on downstream flow recommendations for endangered fish species. Additional analysis of the flows is on-going by others and formal adoption of flow recommendations is still in progress. Therefore, additional study of the timing of CRRP diversions and the ability of the project to tailor diversions to meet the flow recommendations merits further analysis. For example, storage in the CRRP system will enhance the project's ability to vary the diversion rates without adversely impacting annual yields. A daily analysis of flows will likely be required instead of the reconnaissance-level monthly characterizations presented herein. Environmental assessments of effects along the pipeline alignments and water quality issues downstream of the CRRP diversion and in the receiving water also merit additional study. In addition, this preliminary environmental evaluation is based on current environmental laws and regulations. However, environmental laws and regulations change (e.g., new species are listed, currently listed species could recover, critical habitat is designated, recovery plans are modified, and court decisions are rendered), as do interpretation of environmental law. Development of a project of this magnitude will take many years and subsequent environmental evaluations will need to consider and anticipate changes in environmental laws and regulations.

Future Water Demands In The Three River Basins

The characterization of potential water demands and the degree to which other potential water supply projects would satisfy these demands needs to be more fully addressed. This could be assessed separately and provided for consideration in the SWSI process. A key issue for the CRRP is the amount of future demand that could reliably be provided through other water supply projects and demand management strategies prior to bringing the CRRP on-line. This assessment could provide essential information for the State to consider when assessing how quickly to move forward with development of the CRRP.

Alternatives to the CRRP

A key distinguishing feature of the CRRP is its potential ability to satisfy a large portion of Colorado's future water needs. Therefore, additional analysis is needed of how this large-scale opportunity compares to other options including: 1) development of new sources of water; 2) transfers of existing sources (including agricultural to municipal water use transfers and their inherent effects on rural communities); and 3) demand management. The degree to which other projects and water conservation programs may satisfy future water demand needs to be assessed and is a part of other on-going CWCB studies. As these efforts proceed, additional information on the technical, economic and environmental performance of the alternatives to the CRRP will be needed. The environmental impacts and financial implications of developing the combinations of alternatives to the CRRP that could supply 250,000 to 750,000 af/yr may have impacts approximating, or exceeding, those of the CRRP.

CRRP Implementation Issues

Implementation of the CRRP would require several distinct phases progressing from the reconnaissance level studies presented herein, through feasibility level design, final design and permitting, and finally, construction. In addition to the issues of advancing any large public infrastructure project from one phase to the next, the development of the CRRP must also address the project-specific issues identified in this reconnaissance study. Formal and informal input was received concerning many technical, economic, environmental, and institutional issues affecting the overall feasibility of the CRRP and how the CRRP might be developed. This input was received from varied sources including prospective project users; regulatory and land use agency personnel; contractors, equipment manufacturers, material suppliers; and the general public.

Based on the input received to date, CRRP implementation options must address several major questions in addition to wide-ranging technical design details. These major questions include:

1. Is a project the size of the CRRP really needed and are there better ways to supply Colorado's future water needs?
2. Can the CRRP be tailored to compliment existing and likely future water supply programs?
3. What are the main factors influencing the potential implementation of the CRRP?
4. Can the implementation of the CRRP be staged to match the forecasted increase in water demands over a period of years or decades?
5. Are there ways to enhance the overall layout of the CRRP to improve technical, economic and environmental performance?
6. What are the next steps in CRRP development and how long would it take to bring the project on-line?

The rest of this chapter responds to the questions presented above.

Comparison of The Need for the CRRP With Alternatives to the CRRP

The concepts to the CRRP are not amenable to a direct and definitive comparison with the CRRP because the alternatives are non-specific as to size, location or other characteristics. Further, per acre-foot resource commitments or contributions have not been calculated and are beyond the scope of this reconnaissance level study. If the Project Team were to scale up the water resource alternatives for comparison with the CRRP, this would present other difficulties since non-potable water reuse, water conservation and non-renewable groundwater probably cannot reach the yields of a CRRP. Therefore, Table 8-1 presents a general comparison of the CRRP and alternatives to it.

The CRRP offers unique advantages in terms of total potential yield and the certainty of that yield. The certainty of CRRP yield is likely higher with the smaller delivery scenarios, up to 500,000 af, since the project yield might be more questionable as the volume increases and diversions impact the target flows established in the endangered species recovery plan.

The limited yield potential of CRRP alternatives deserves special consideration. As indicated in the water demand evaluation discussed earlier in this report, future water requirements over the next 50 years might far exceed the potential yields of most, if not all, of the alternatives to the CRRP. For example, water reuse and conservation have finite limits, however desirable they might be as a water resource.

The CRRP's cost per acre-foot is higher than most, though not all, water resource alternatives available. Certain storage and transbasin diversion alternative might be as expensive and may not provide CRRP's economy of scale.

If the CRRP is constructed as a single, large and fixed water resource alternative, it is the most inflexible in terms of its ability to follow the demand curve. For example, groundwater wellfields can be developed incrementally (well by well) to increase yield as water demand increases, avoiding the financial burden that the CRRP represents as delivery capacity greatly exceeds potential water use and sale in the early years following its completion. Those financial burdens may be reduced, however, if that excess capacity could be used to help replenish the depleted Denver aquifer in the early years of the CRRP's operation.

Table 8 depicts the comparative results of each grouping to CRRP according to costs and benefits from an economic, social and environmental perspective.

Structural alternatives tend to have economic costs that could be equal to or greater than CRRP due to the fragmentary nature of new storage and transbasin diversions. The social resource commitments required of the communities involved with CRRP will likely balance the benefits for the communities, will consolidate the debate over water resource development, but will accept the risks associated with CRRP. Environmental costs of CRRP are unknown, but might well be comparable on a per acre-foot basis. Structural alternatives probably offer fewer benefits than the CRRP. Non-structural alternatives create lower costs than CRRP, but fewer benefits, too. Social costs of both CRRP and this group of alternatives are probably minor in relation to the other costs.

Certain generalized observations can be made in comparing the water resource alternatives to the CRRP:

- The resource costs or commitments associated with the agricultural to municipal water transfers might be greater than those of the CRRP if one was to consider that the equivalence of the 500,000 af delivery scenario would hypothetically be a dry up of 250,000 acres of irrigated land in Colorado, assuming 2.0 af of consumptive water use per acre.

- It is quite possible that new storage alternatives, if accumulated to a total of 500,000 af of annual yield, might represent at least equivalent costs and benefits to the CRRP. The fragmentary nature of many new storage projects as compared with one large pipeline is unlikely to be favorable.

- Transbasin diversions are likely to require significant resource commitments. The CRRP is a modified version of the transbasin alternative with an attempt to minimize hydrologic impacts in the Colorado River basin and the headwater counties.

Table 8: A Comparison of CRRP vs. Alternatives

Water Resource Categories	Potential Yield	Certainty of Yield	Direct Cost per af	Flexibility to Follow Demand Curve	Economic Costs and Benefits	Social Costs and Benefits	Environmental Costs and Benefits
CRRP	Can meet projected demands through 2050	Once developed, very high degree of certainty, except at 750,000 af/year delivery	$12-$22k per af depending on corridor and scenario	Inability to follow demand curve with present configuration	Very large up-front capital cost; roadway impacts; no loss to other Colorado water suppliers; major economic stimulus	Creates uncertainty and risk for all stakeholders; will consolidate and maybe reduce future water conflicts	Disposal of treatment residuals and excess fill removal primary concerns; consolidation of environmental conflicts; more supply in consuming regions
CRRP Alternatives*:							
Agricultural to Municipal Water Transfers	Limited senior rights in locations useful to municipalities	High degree of certainty, assuming senior rights	Much less than CRRP, excluding conveyance costs	Relatively flexible in following demand curve	Basin of origin, third-party costs; efficiency gains from transfers	Potential out-migration of population; loss of community institutions	Reduced return flows in basin of origin; as related pollutants reduced; wetland impacts and lower base flows
Non-Potable Water Reuse	Limited to non-native flows, location of demand	Very high degree of certainty	Less than CRRP	Somewhat flexible in following demand curve	Effluent use downstream reduced; efficiency gains	Public acceptability can be limited; providers use own source (less conflict)	Downstream habitat affected; open space better maintained if irrigated with reuse water
Water Conservation	Finite as a base resource	Uncertain yield due to market response	Most conservation programs much less than CRRP	Very flexible in following demand curve	Reduced resources for utilities short term; efficiency benefits	Common public purpose; fairness issues	Negligible environmental effects with exception of less return flows, lower base flows and expansion of use
New Storage	Can meet projected demands only if suitable water rights are obtainable	Once developed, high degree of certainty specific to project	Less than or comparable with, CRRP	Inflexible in following demand curve	Displacement of land use; third party effects; economic, tax stimulus including recreation benefits	Potential displacement of homes and businesses; construction effects	Habitat losses; wildlife, aquatic resource losses; ecosystem changes; impact water quality reduces dilution flows
Transbasin Diversions	Can meet projected demands only if suitable water rights are obtainable	Degree of certainty specific to project	Less than or comparable with, CRRP	Inflexible in following demand curve	Present and future economic losses to basin of origin without adequate measures	Third party impacts	Change in stream flow regime; loss in basin of origin, gain in basin of use
Non-Renewable Groundwater	Limited yield	Somewhat uncertain yields	Much less than CRRP	Highly flexible in following demand curve	Economic costs of depletion, future use; financial burdens follow beneficiaries closely	Potential conflicts over aquifer depletions; precarious water resource policy	Increased stream flows

* Combinations may be required to achieve similar levels of yield.

- In terms of economic and social benefits, the CRRP is likely to offer certain advantages over the other alternatives. Unlike any other resource alternative, the CRRP comes at a zero opportunity cost to State of Colorado water users. West Slope users, for example, will still have access to CRRP water before it flows to the diversion point at the Colorado-Utah border. The economic stimulus of the various project aspects could also be important to economic development efforts along the pipeline corridors and elsewhere in the state. From a social standpoint, the opportunity to consolidate the water resource development conflicts of the state into a single project, as opposed to the numerous likely conflicts over the next 50 years, must be considered an attractive element.

- Environmental costs of the CRRP are unknown, but might well be greater than any of the other water resource alternatives, except transbasin diversions.

In sum, the CRRP offers certain advantages and disadvantages over other water resource alternatives. The CRRP is less well understood than other water resource alternatives, but the comparison of the advantages and disadvantages indicate a mixed picture compared with alternatives.

Tailoring The CRRP To Compliment Other Projects

This assessment of the CRRP provides a conservative result in that this study has assumed no integration of the CRRP with existing or proposed water storage and conveyance facilities even though the CRRP alternatives presented herein include advanced water treatment to facilitate discharge of water into existing streams, reservoirs or pipelines. Integration of the project with existing reservoirs may provide benefits to both projects by potentially reducing CRRP costs for operational or longer term storage and by supplementing existing reservoir supplies so that they can operate at fuller levels and deliver more water in dry periods.

Many of the existing facilities that would be candidates for integrated operations were developed and/or are currently operated by federal agencies. Integration of the CRRP directly with these facilities would certainly constitute a significant federal action requiring NEPA compliance. In addition, these federal projects were initially authorized by Congress for specific purposes and CRRP integration may or may not be in compliance with these purposes. If CRRP integration conflicts with original project authorizations, Congress could act to remedy these issues including appropriate compensation for affected uses. Conversely, CRRP integration may significantly benefit the purposes of existing projects through the provision of additional water supplies to them. In addition to the legislation authorizing the construction of federally supported projects, these projects are typically operated under public laws and/or administrative policies and procedures that were put in place following the construction of the projects. Therefore, there are typically other institutional constraints to project integration that go beyond issues associated with just the authorizing legislation.

From institutional or legislative perspectives, it may be easier to integrate CRRP operations and water supplies with non-federal projects, the most notable, of course, being the Blue River and Moffat systems owned by Denver Water and the Homestake system owned by Aurora and Colorado Springs. CRRP supplies could be introduced directly into these existing systems but another possibility would be to use the CRRP supplies as exchange or replacement water. This type of arrangement would have a wide variety of technical, economic, and environmental issues and, to date, none of the three cities have indicated any opinions or any interest in considering CRRP options pending its review of this report.

The CRRP could also be used to supplement existing and proposed water supplies in the Colorado, Gunnison, and/or White/Yampa river systems depending on the corridor(s) eventually selected. Physical deliveries could be made along the pipeline alignment to existing facilities or to existing stream reaches suffering from diminished flows. Secondary pipelines from the main pipeline could also be constructed and additional storage could be constructed to serve the multiple benefits of CRRP operational storage and local water supply.

Main Factors Affecting CRRP Implementation

There are several factors that may have significant effects on developing the CRRP. These factors include endangered species, handling of water treatment by-products, conveyance of water in the three river basins to end-users and waterbodies, availability of pumping energy, and minimizing the duration of construction activities.

Potential effects on downstream Endangered Species

Compliance with ESA requirements and established flow recommendations is discussed extensively in Chapter 7. Potential approaches to mitigate impacts require significant further study.

Handling Of Water Treatment By-Products

As shown in Chapter 6, the level of treatment needed for the CRRP water supplies in order to potentially discharge it into natural and/or man-made water bodies over such a broad geographic area brings significant cost and environmental concerns. All project development strategies for the CRRP should address these issues early in subsequent studies if the development strategy is to be credible. Detailed studies will be needed and they should be initiated early-on so that baseline data can be generated to support assessments of long term effects. Information should be obtained from other areas around the country where degraded water supplies are being used or are being considered for future domestic and other uses.

Conveyance Of Water To End-Users And Waterbodies In The Colorado, South Platte And Arkansas River Basins

This reconnaissance study appropriately stops short of identifying which water uses would be supplied in each of three basins. Various development scenarios will need to be defined in future studies, even if they are still performed at a reconnaissance level of detail. These scenarios could bracket the broad range of possibilities by evaluating various percentages of the CRRP delivery being allocated to different uses within the three major river basins. Subordinate scenarios could consider the range in water supplies that might be delivered to general areas, or sub-basins, so that preliminary assessments could be made of the cost, technical feasibility and environmental/institutional issues of this water conveyance.

Availability Of Pumping Energy

CRRP development strategies will need to address the availability and the cost of acquiring pumping energy for the project. As discussed in Chapter 6, the ability of existing generating resources are sensitive to the size of the CRRP. It should also be noted that development of the CRRP would only occur with continued population growth in Colorado and that new electrical generation resources will be needed to supply the resulting increases in residential, commercial and industrial electrical power needs with or without the CRRP as a primary source of water. Key questions, therefore, are how much additional generating capacity will be needed in addition to the capacity needed for other purposes and how much additional generating capacity would be needed for the CRRP compared to other sources of future water supply? CRRP development strategies need to further assess the current and likely future energy availability, ways to minimize CRRP's energy consumption, alternative sources of pumping energy including emerging technologies and renewable energy sources that might be tailored to CRRP's specific concentrated loads, and ways to minimize the economic impacts of supplying the pumping energy including the incorporation of pumped-storage electrical generation facilities within the CRRP delivery system.

Construction Duration

The overall cost of CRRP construction will be significantly influenced by the amount of capital that must be in place at the start of the multi-year construction period. Appropriate allowances for interest payments during construction and other costs associated with securing project financing are included herein. Project development strategies should consider methods to decrease the amount of time required for construction including alternative project delivery methods including "design-build" approaches for at least certain components of the system. Advance purchase of electro-mechanical equipment with long delivery timeframes could also be considered. Other measures to help assure that the project does not incur unexpected delays during permitting and other delays during construction should also be considered.

Staged Implementation of the CRRP

As discussed earlier in this chapter, a key disadvantage of the CRRP in relation to other potential water supply alternatives is CRRP's relative inability to be gradually implemented to match future growth in water demands. Without methods to stage the implementation of the CRRP, a large water supply would become available before or after it is most needed. There are, however, potential ways to stage CRRP implementation, each with their own advantages and disadvantages. For example, one approach to staged implementation could involve sequential expansion of initially constructed facilities including diversion capacity, treatment capacity, and additional pumps even though the costs of pipe and tunnel construction would be incurred upfront. Another approach would be to initially construct only portions of the overall delivery system. As an illustrative example only, one concept would be to construct a pipeline carrying treated water from near the Utah state line as currently envisioned to the upstream end of the "15-Mile Reach" or beyond, perhaps as far upstream as the Shoshone powerplant or Green Mountain Reservoir. The operation of first stage systems might likely be as complicated and controversial as the ultimate CRRP system and would require detailed study with considerable input from affected interests. There are also many other variations that could include multiple, but smaller individual pipelines and other diversion points that could be considered.

Regardless of the staged implementation approach, each phase of project implementation would need to stand on its own merits from environmental permitting perspective and there would be a risk that subsequent phases might not be implemented for a variety of reasons.

Potential Enhancements to the CRRP Layouts

There are many ways that the physical layouts of the CRRP facilities might be enhanced. Since this is a reconnaissance-level study, conservative assumptions were used that tend to overestimate the size and impacts of the facilities. Alternative project development strategies could consider methods to decrease the facility sizes and impacts including the following:

- Alternative diversion points
- Alternative types of diversion structures
- Alternative levels of treatment
- Alternative treatment technologies

- Open channel conveyance canals for portions of the alignments
- Multiple treatment locations
- Multiple delivery points

Next Steps

The CRRRS was conducted at a reconnaissance level and distinguishes the major differences in alternative project configurations. As the very first step in compiling information on the CRRP, the most important purpose of this study is to provide information for a wide variety of interests including water supply entities, regulatory and land use agencies, and the general public to consider. The general process of developing a public infrastructure project is shown in Table 9.

As shown below, the minimum time expected to implement the CRRP would be about 15 years if all the implemented phases were performed sequentially (without any overlap) and no special measures were taken to expedite the phases. Alternatively, if all the phases could be accomplished without significant delays; certain design activities were overlapped (fast-tracked), eliminated or combined; purchase of long-lead-time electro-mechanical equipment (for example, pumps and turbines) were expedited, and innovative project delivery methods (for example, design-build approaches versus traditional design-bid-build) were used, the absolute minimum time for CRRP implementation would be on the order of 10 to 12 years. At the other extreme, the table above shows that a time frame of 27 years would be required to implement the project if all phases are performed sequentially and none of the methods discussed above are used to advance the schedule.

Table 9: Typical Project Implementation Phases

	Implementation Phases	Purposes	Time Required (years)[1]
Chrononological Sequence[2] Time	Reconnaissance Studies	Provide initial information for interested parties to consider	1
	Supplementary Reconnaissance Studies	Provide additional information to clarify previous studies, answer specific questions, and address the interaction of the project with other on-going or proposed projects.	1
	Feasibility Studies	Initiation of detailed geological, geotechnical, environmental and other field studies to support selection of alternatives for pre-design studies.	1– 3
	Pre-Design Studies	Define the location and likely footprints of all major structures; identify likely sources of construction materials; and provide detailed information on technical, economic, environmental, and social/legal/institutional issues to support the selection of one or more preferred alternatives.	1 – 3
	Regulatory Compliance	Identify, prepare, and obtain requisite local, state, and federal permits for the construction of the project.	3 – 6
	Final Design – Plans, Specifications, and Bidding Documents	Provide information needed by contractors on which to base legally-binding bids for construction.	2 – 4
	Construction Bidding	Obtain the least-cost reliable bid for construction of all and/or components of the project assuming multiple bid packages.	1
	Construction	Self explanatory	4 – 6
	Project Start-up	Test and implement project components as they are completed (assuming multiple bid packages). Also test the entire project in a sequential manner to minimize safety concerns and assure a fully functional project prior to contractor demobilization.	1 – 2

[1] Typical minimum time frames for a project of the magnitude of the CRRP. Time frames represent the amount of time needed to execute the work once it has been approved and does not include allowances for delays in decision making processes between phases. The time required to come to agreement on performing subsequent phases of work can often exceed the time required to do the work.

[2] Implementation phases can often overlap to shorten the overall time required for project implementation. For example, Regulatory Compliance often overlaps with Pre-Design, and Final Design activities and Construction bidding might begin for some components of the project (bid packages) before the final designs are fully completed on other project components.

Table 1 - Total Project Costs - 250,000 acre-feet per year Delivery Capacity ($ in Millions)

	Capital Costs																						Annual Operations			
	Infrastructure											Contingencies		Land								Summary				
Alternative	Pipe	Appurts.	Const. Cond.	Tunnels	Pump Stat.	Hydro	Diver. Struc.	Water Treatment	Storage	Power Trans	Total Capital	General 30%	E&A 20%	WTP Land Cost	# of PS	PS Land Cost	# of Hydro	Hydro Land Cost	Pipe Length (miles)	Pipe Ease. Cost	Total L & E Costs	Total Project Cost	Pump & Hydro	WTP	Pipeline	Total O&M
N01	$ 2,090	$ 104	$ 313	$ 147	$ 355	$ 87	$ 0.9	$ 605	$ 75	$ 250	$ 4,027	$ 1,208	$ 805	$ 92	14	$ 0.4	7	$ 0.09	260	$ 26	$ 118	$ 6,159	$ 175	$ 68	$ 13	$ 257
N02	$ 1,997	$ 100	$ 300	$ 147	$ 365	$ 88	$ 0.9	$ 605	$ 75	$ 250	$ 3,929	$ 1,179	$ 786	$ 92	15	$ 0.4	7	$ 0.09	253	$ 25	$ 118	$ 6,011	$ 178	$ 68	$ 13	$ 259
N03	$ 2,054	$ 103	$ 308	$ 147	$ 357	$ 87	$ 0.9	$ 605	$ 75	$ 250	$ 3,986	$ 1,196	$ 797	$ 92	14	$ 0.4	7	$ 0.09	257	$ 26	$ 118	$ 6,098	$ 175	$ 68	$ 13	$ 257
N04	$ 2,015	$ 101	$ 302	$ 147	$ 341	$ 75	$ 0.9	$ 605	$ 75	$ 250	$ 3,912	$ 1,174	$ 782	$ 92	14	$ 0.4	6	$ 0.08	253	$ 25	$ 118	$ 5,986	$ 194	$ 68	$ 13	$ 275
N05	$ 2,051	$ 103	$ 308	$ 147	$ 371	$ 104	$ 0.9	$ 605	$ 75	$ 250	$ 4,015	$ 1,204	$ 803	$ 92	15	$ 0.4	9	$ 0.12	260	$ 26	$ 118	$ 6,140	$ 178	$ 68	$ 13	$ 259
N06	$ 2,108	$ 105	$ 316	$ 147	$ 363	$ 103	$ 0.9	$ 605	$ 75	$ 250	$ 4,073	$ 1,222	$ 815	$ 92	14	$ 0.4	9	$ 0.12	264	$ 26	$ 119	$ 6,229	$ 175	$ 68	$ 13	$ 256
N07	$ 2,146	$ 107	$ 322	$ 147	$ 361	$ 102	$ 0.9	$ 605	$ 75	$ 250	$ 4,116	$ 1,235	$ 823	$ 92	14	$ 0.4	9	$ 0.12	268	$ 27	$ 119	$ 6,293	$ 175	$ 68	$ 13	$ 256
N08	$ 2,070	$ 104	$ 311	$ 147	$ 347	$ 90	$ 0.9	$ 605	$ 75	$ 250	$ 3,999	$ 1,200	$ 800	$ 92	14	$ 0.4	8	$ 0.10	260	$ 26	$ 118	$ 6,118	$ 173	$ 68	$ 13	$ 254
C01	$ 734	$ 37	$ 110	$ 392	$ 244	$ 33	$ 0.9	$ 605	$ 75	$ 140	$ 2,371	$ 711	$ 474	$ 92	11	$ 0.3	3	$ 0.04	184	$ 18	$ 111	$ 3,667	$ 140	$ 68	$ 13	$ 221
C02	$ 738	$ 37	$ 111	$ 403	$ 235	$ 29	$ 0.9	$ 605	$ 75	$ 140	$ 2,374	$ 712	$ 475	$ 92	11	$ 0.3	3	$ 0.04	184	$ 18	$ 111	$ 3,671	$ 139	$ 68	$ 13	$ 220
C03	$ 816	$ 41	$ 122	$ 377	$ 256	$ 36	$ 0.9	$ 605	$ 75	$ 140	$ 2,469	$ 741	$ 494	$ 92	11	$ 0.3	3	$ 0.04	193	$ 19	$ 112	$ 3,815	$ 143	$ 68	$ 13	$ 224
C04	$ 725	$ 36	$ 109	$ 223	$ 297	$ 63	$ 0.9	$ 605	$ 75	$ 200	$ 2,336	$ 701	$ 467	$ 92	15	$ 0.4	5	$ 0.07	168	$ 17	$ 109	$ 3,613	$ 150	$ 68	$ 13	$ 231
C05	$ 730	$ 37	$ 110	$ 260	$ 295	$ 63	$ 0.9	$ 605	$ 75	$ 200	$ 2,375	$ 713	$ 475	$ 92	15	$ 0.4	5	$ 0.07	168	$ 17	$ 109	$ 3,672	$ 149	$ 68	$ 13	$ 230
S01	$ 961	$ 48	$ 144	$ 150	$ 258	$ 78	$ 0.9	$ 605	$ 75	$ 180	$ 2,500	$ 750	$ 500	$ 92	12	$ 0.3	6	$ 0.08	195	$ 19	$ 112	$ 3,862	$ 120	$ 68	$ 13	$ 201
S02	$ 1,078	$ 54	$ 162	$ 74	$ 226	$ 46	$ 0.9	$ 605	$ 75	$ 150	$ 2,472	$ 741	$ 494	$ 92	11	$ 0.3	4	$ 0.05	217	$ 22	$ 114	$ 3,821	$ 115	$ 68	$ 13	$ 196
S03	$ 973	$ 49	$ 146	$ 155	$ 275	$ 78	$ 0.9	$ 605	$ 75	$ 180	$ 2,537	$ 761	$ 507	$ 92	12	$ 0.3	6	$ 0.08	198	$ 20	$ 112	$ 3,918	$ 118	$ 68	$ 13	$ 200
S04	$ 1,001	$ 50	$ 150	$ 127	$ 276	$ 73	$ 0.9	$ 605	$ 75	$ 180	$ 2,537	$ 761	$ 507	$ 92	13	$ 0.3	5	$ 0.07	202	$ 20	$ 113	$ 3,918	$ 121	$ 68	$ 13	$ 202
S05	$ 990	$ 49	$ 148	$ 121	$ 277	$ 72	$ 0.9	$ 605	$ 75	$ 180	$ 2,519	$ 756	$ 504	$ 92	13	$ 0.3	5	$ 0.07	199	$ 20	$ 112	$ 3,891	$ 121	$ 68	$ 13	$ 203
S06	$ 1,027	$ 51	$ 154	$ 100	$ 246	$ 63	$ 0.9	$ 605	$ 75	$ 180	$ 2,502	$ 751	$ 500	$ 92	11	$ 0.3	5	$ 0.07	202	$ 20	$ 112	$ 3,866	$ 112	$ 68	$ 13	$ 194
S07	$ 1,057	$ 53	$ 158	$ 71	$ 247	$ 58	$ 0.9	$ 605	$ 75	$ 180	$ 2,505	$ 751	$ 501	$ 92	12	$ 0.3	4	$ 0.05	206	$ 21	$ 113	$ 3,870	$ 114	$ 68	$ 13	$ 195
S08	$ 1,001	$ 50	$ 150	$ 119	$ 217	$ 48	$ 0.9	$ 605	$ 75	$ 150	$ 2,415	$ 725	$ 483	$ 92	11	$ 0.3	4	$ 0.05	215	$ 21	$ 114	$ 3,737	$ 107	$ 68	$ 13	$ 188
S09	$ 979	$ 49	$ 147	$ 141	$ 220	$ 53	$ 0.9	$ 605	$ 75	$ 150	$ 2,421	$ 726	$ 484	$ 92	11	$ 0.3	5	$ 0.07	216	$ 22	$ 114	$ 3,745	$ 108	$ 68	$ 13	$ 189
S10	$ 997	$ 50	$ 150	$ 126	$ 272	$ 89	$ 0.9	$ 605	$ 75	$ 150	$ 2,514	$ 754	$ 503	$ 92	12	$ 0.3	8	$ 0.10	214	$ 21	$ 114	$ 3,885	$ 119	$ 68	$ 13	$ 200
S11	$ 1,016	$ 51	$ 152	$ 97	$ 267	$ 86	$ 0.9	$ 605	$ 75	$ 150	$ 2,500	$ 750	$ 500	$ 92	12	$ 0.3	8	$ 0.10	218	$ 22	$ 114	$ 3,864	$ 119	$ 68	$ 13	$ 200
S12	$ 1,059	$ 53	$ 159	$ 96	$ 228	$ 52	$ 0.9	$ 605	$ 75	$ 150	$ 2,479	$ 744	$ 496	$ 92	11	$ 0.3	5	$ 0.07	218	$ 22	$ 114	$ 3,832	$ 114	$ 68	$ 13	$ 195
S13	$ 1,078	$ 54	$ 162	$ 81	$ 280	$ 88	$ 0.9	$ 605	$ 75	$ 150	$ 2,573	$ 772	$ 515	$ 92	12	$ 0.3	8	$ 0.10	216	$ 22	$ 114	$ 3,974	$ 125	$ 68	$ 13	$ 206
S14	$ 1,097	$ 55	$ 165	$ 52	$ 275	$ 86	$ 0.9	$ 605	$ 75	$ 150	$ 2,560	$ 768	$ 512	$ 92	12	$ 0.3	8	$ 0.10	220	$ 22	$ 114	$ 3,954	$ 125	$ 68	$ 13	$ 207
S15	$ 1,030	$ 52	$ 155	$ 120	$ 206	$ 42	$ 0.9	$ 605	$ 75	$ 150	$ 2,435	$ 731	$ 487	$ 92	10	$ 0.3	4	$ 0.05	213	$ 21	$ 114	$ 3,767	$ 105	$ 68	$ 13	$ 187
S16	$ 1,013	$ 51	$ 152	$ 142	$ 210	$ 48	$ 0.9	$ 605	$ 75	$ 150	$ 2,447	$ 734	$ 489	$ 92	10	$ 0.3	5	$ 0.07	214	$ 21	$ 114	$ 3,785	$ 107	$ 68	$ 13	$ 188
S17	$ 1,032	$ 52	$ 155	$ 126	$ 264	$ 84	$ 0.9	$ 605	$ 75	$ 150	$ 2,544	$ 763	$ 509	$ 92	11	$ 0.3	8	$ 0.10	212	$ 21	$ 114	$ 3,929	$ 119	$ 68	$ 13	$ 200
S18	$ 1,053	$ 53	$ 158	$ 98	$ 258	$ 81	$ 0.9	$ 605	$ 75	$ 150	$ 2,531	$ 759	$ 506	$ 92	11	$ 0.3	8	$ 0.10	217	$ 22	$ 114	$ 3,911	$ 119	$ 68	$ 13	$ 200

Table Heading Legend and Descriptions

Alternative - alternative name

Capital Costs

- **Pipe** - the baseline installed construction cost for the pipeline
- **Appurts.** - allowance for pipe appurtenances such as valves and misc. items (5% of the baseline pipe cost)
- **Const. Cond.** - allowance for difficult construction conditions such as rock, limited access, etc. (15% of baseline)
- **Tunnels** - total construction cost for all of the tunnels included in the alternative
- **Pump Stat.** - total construction cost for all of the pump stations included in the alternative
- **Hydro** - total construction cost for all of the hydropower facilities included in the alternative
- **Diver. Struc.** - construction cost of the diversion structure
- **Water Treatment** - Construction cost of the water treatment plant
- **Storage** - construction cost of the operational storage include in the alternative
- **Power Trans** - Construction cost of installing power transmission
- **Total Capital** - total cost of construction for the infrastructure items listed above

General 30% - allowance of the 30% of the Total Capital cost for unaccounted for items and contingency

E&A 20% - allowance of 20% for engineering, legal, administration and permitting

Land

- **WTP Land Cost** - cost of land required for the treatment plant
- **# of PS** - number of pump stations included in the alternative
- **PS Land Cost** - cost of the land required for all of the pump stations
- **# of Hydro** - number of hydro power facilities included in the alternative
- **Hydro Land Cost** - cost of the land required for all of the hydropower facilities
- **Pipe Length (miles)** - total length of pipe
- **Pipe Ease. Cost** - cost of the pipeline easement
- **Total L & E Cost** - total cost of the land purchases and easement acquisition

Total Project Cost - Includes the total Capital Cost, Contingency, E & A, and Land and Easement Acquisition

Annual Operations

- **Pump & Hydro** - total operations cost for pump stations and hydropower facilities (including hydropower revenue)
- **WTP** - operations cost for the water treatment plant
- **Pipeline** - maintenance cost of the pipeline and tunnels (0.5% of the total pipeline and tunnel construction cost)
- **Total O&M** - total annual operations cost for the above items

Table 2 - Total Project Costs - 500,000 acre-feet per year Delivery Capacity ($ in Millions)

	Capital Costs																						Annual Operations			
	Infrastructure											Contingencies		Land								Summary				
Alternative	Pipe	Appurts.	Const. Cond.	Tunnels	Pump Stat.	Hydro	Diver. Struc.	Water Treatment	Storage	Power Trans	Total Capital	General 30%	E&A 20%	WTP Land Cost	# of PS	PS Land Cost	# of Hydro	Hydro Land Cost	Pipe Length (miles)	Pipe Ease. Cost	Total L & E Costs	Total Project Cost	Pump & Hydro	WTP	Pipeline	Total O&M
N01	$ 3,392	$ 170	$ 509	$ 168	$ 707	$ 152	$ 2	$ 1,103	$ 150	$ 250	$ 6,602	$ 1,981	$ 1,320	$ 185	14	$ 1	7	$ 0.09	260	$ 28	$ 214	$ 10,117	$ 345	$ 130	$ 13	$ 488
N02	$ 3,228	$ 161	$ 484	$ 168	$ 728	$ 155	$ 2	$ 1,103	$ 150	$ 250	$ 6,429	$ 1,929	$ 1,286	$ 185	15	$ 1	7	$ 0.09	253	$ 28	$ 213	$ 9,857	$ 351	$ 130	$ 13	$ 494
N03	$ 3,339	$ 167	$ 501	$ 168	$ 711	$ 153	$ 2	$ 1,103	$ 150	$ 250	$ 6,544	$ 1,963	$ 1,309	$ 185	14	$ 1	7	$ 0.09	257	$ 28	$ 214	$ 10,030	$ 346	$ 130	$ 13	$ 489
N04	$ 3,257	$ 163	$ 489	$ 168	$ 678	$ 132	$ 2	$ 1,103	$ 150	$ 250	$ 6,393	$ 1,918	$ 1,279	$ 185	14	$ 1	6	$ 0.08	253	$ 28	$ 213	$ 9,802	$ 381	$ 130	$ 13	$ 525
N05	$ 3,308	$ 165	$ 496	$ 168	$ 739	$ 183	$ 2	$ 1,103	$ 150	$ 250	$ 6,565	$ 1,969	$ 1,313	$ 185	15	$ 1	9	$ 0.12	260	$ 28	$ 214	$ 10,061	$ 349	$ 130	$ 13	$ 493
N06	$ 3,416	$ 171	$ 512	$ 168	$ 721	$ 181	$ 2	$ 1,103	$ 150	$ 250	$ 6,674	$ 2,002	$ 1,335	$ 185	14	$ 1	9	$ 0.12	264	$ 29	$ 215	$ 10,225	$ 345	$ 130	$ 13	$ 489
N07	$ 3,470	$ 174	$ 521	$ 168	$ 717	$ 180	$ 2	$ 1,103	$ 150	$ 250	$ 6,735	$ 2,020	$ 1,347	$ 185	14	$ 1	9	$ 0.12	268	$ 29	$ 215	$ 10,317	$ 345	$ 130	$ 13	$ 488
N08	$ 3,341	$ 167	$ 501	$ 168	$ 691	$ 160	$ 2	$ 1,103	$ 150	$ 250	$ 6,533	$ 1,960	$ 1,307	$ 185	14	$ 1	8	$ 0.10	260	$ 28	$ 214	$ 10,014	$ 338	$ 130	$ 13	$ 481
C01	$ 1,242	$ 62	$ 186	$ 445	$ 484	$ 59	$ 2	$ 1,103	$ 150	$ 140	$ 3,873	$ 1,162	$ 775	$ 185	11	$ 1	3	$ 0.04	184	$ 20	$ 206	$ 6,016	$ 276	$ 130	$ 13	$ 419
C02	$ 1,225	$ 61	$ 184	$ 465	$ 466	$ 53	$ 2	$ 1,103	$ 150	$ 140	$ 3,849	$ 1,155	$ 770	$ 185	11	$ 1	3	$ 0.04	184	$ 20	$ 206	$ 5,979	$ 272	$ 130	$ 13	$ 415
C03	$ 1,378	$ 69	$ 207	$ 454	$ 537	$ 63	$ 2	$ 1,103	$ 150	$ 140	$ 4,102	$ 1,231	$ 820	$ 185	11	$ 1	3	$ 0.04	193	$ 21	$ 207	$ 6,360	$ 301	$ 130	$ 13	$ 445
C04	$ 1,245	$ 62	$ 187	$ 256	$ 592	$ 111	$ 2	$ 1,103	$ 150	$ 200	$ 3,909	$ 1,173	$ 782	$ 185	15	$ 1	5	$ 0.07	168	$ 18	$ 204	$ 6,067	$ 296	$ 130	$ 13	$ 439
C05	$ 1,244	$ 62	$ 187	$ 297	$ 600	$ 110	$ 2	$ 1,103	$ 150	$ 200	$ 3,955	$ 1,187	$ 791	$ 185	15	$ 1	5	$ 0.07	168	$ 18	$ 204	$ 6,137	$ 302	$ 130	$ 13	$ 445
S01	$ 1,654	$ 83	$ 248	$ 171	$ 544	$ 135	$ 2	$ 1,103	$ 150	$ 180	$ 4,271	$ 1,281	$ 854	$ 185	12	$ 1	6	$ 0.08	195	$ 21	$ 207	$ 6,613	$ 232	$ 130	$ 13	$ 375
S02	$ 1,840	$ 92	$ 276	$ 89	$ 442	$ 81	$ 2	$ 1,103	$ 150	$ 150	$ 4,225	$ 1,267	$ 845	$ 185	11	$ 1	4	$ 0.05	217	$ 24	$ 209	$ 6,546	$ 222	$ 130	$ 13	$ 365
S03	$ 1,675	$ 84	$ 251	$ 178	$ 541	$ 135	$ 2	$ 1,103	$ 150	$ 180	$ 4,300	$ 1,290	$ 860	$ 185	12	$ 1	6	$ 0.08	198	$ 22	$ 207	$ 6,656	$ 229	$ 130	$ 13	$ 372
S04	$ 1,718	$ 86	$ 258	$ 150	$ 542	$ 125	$ 2	$ 1,103	$ 150	$ 180	$ 4,313	$ 1,294	$ 863	$ 185	13	$ 1	5	$ 0.07	202	$ 22	$ 208	$ 6,678	$ 233	$ 130	$ 13	$ 377
S05	$ 1,698	$ 85	$ 255	$ 143	$ 545	$ 125	$ 2	$ 1,103	$ 150	$ 180	$ 4,285	$ 1,285	$ 857	$ 185	13	$ 1	5	$ 0.07	199	$ 22	$ 207	$ 6,634	$ 236	$ 130	$ 13	$ 379
S06	$ 1,777	$ 89	$ 267	$ 114	$ 483	$ 110	$ 2	$ 1,103	$ 150	$ 180	$ 4,274	$ 1,282	$ 855	$ 185	11	$ 1	5	$ 0.07	202	$ 22	$ 208	$ 6,619	$ 217	$ 130	$ 13	$ 361
S07	$ 1,822	$ 91	$ 273	$ 85	$ 484	$ 100	$ 2	$ 1,103	$ 150	$ 180	$ 4,290	$ 1,287	$ 858	$ 185	12	$ 1	4	$ 0.05	206	$ 22	$ 208	$ 6,642	$ 222	$ 130	$ 13	$ 365
S08	$ 1,698	$ 85	$ 255	$ 143	$ 424	$ 83	$ 2	$ 1,103	$ 150	$ 150	$ 4,092	$ 1,228	$ 818	$ 185	11	$ 1	4	$ 0.05	215	$ 23	$ 209	$ 6,347	$ 206	$ 130	$ 13	$ 349
S09	$ 1,658	$ 83	$ 249	$ 170	$ 433	$ 94	$ 2	$ 1,103	$ 150	$ 150	$ 4,090	$ 1,227	$ 818	$ 185	11	$ 1	5	$ 0.07	216	$ 24	$ 209	$ 6,345	$ 208	$ 130	$ 13	$ 351
S10	$ 1,699	$ 85	$ 255	$ 146	$ 536	$ 157	$ 2	$ 1,103	$ 150	$ 150	$ 4,283	$ 1,285	$ 857	$ 185	12	$ 1	8	$ 0.10	214	$ 23	$ 209	$ 6,633	$ 248	$ 130	$ 13	$ 391
S11	$ 1,722	$ 86	$ 258	$ 117	$ 525	$ 152	$ 2	$ 1,103	$ 150	$ 150	$ 4,265	$ 1,279	$ 853	$ 185	12	$ 1	8	$ 0.10	218	$ 24	$ 209	$ 6,607	$ 230	$ 130	$ 13	$ 374
S12	$ 1,814	$ 91	$ 272	$ 116	$ 449	$ 91	$ 2	$ 1,103	$ 150	$ 150	$ 4,237	$ 1,271	$ 847	$ 185	11	$ 1	5	$ 0.07	218	$ 24	$ 209	$ 6,565	$ 220	$ 130	$ 13	$ 364
S13	$ 1,846	$ 92	$ 277	$ 92	$ 554	$ 158	$ 2	$ 1,103	$ 150	$ 150	$ 4,423	$ 1,327	$ 885	$ 185	12	$ 1	8	$ 0.10	216	$ 24	$ 209	$ 6,843	$ 240	$ 130	$ 13	$ 384
S14	$ 1,868	$ 93	$ 280	$ 63	$ 543	$ 153	$ 2	$ 1,103	$ 150	$ 150	$ 4,404	$ 1,321	$ 881	$ 185	12	$ 1	8	$ 0.10	220	$ 24	$ 210	$ 6,816	$ 241	$ 130	$ 13	$ 385
S15	$ 1,770	$ 89	$ 266	$ 144	$ 403	$ 74	$ 2	$ 1,103	$ 150	$ 150	$ 4,150	$ 1,245	$ 830	$ 185	10	$ 1	4	$ 0.05	213	$ 23	$ 209	$ 6,433	$ 203	$ 130	$ 13	$ 347
S16	$ 1,735	$ 87	$ 260	$ 170	$ 414	$ 85	$ 2	$ 1,103	$ 150	$ 150	$ 4,156	$ 1,247	$ 831	$ 185	10	$ 1	5	$ 0.07	214	$ 23	$ 209	$ 6,443	$ 208	$ 130	$ 13	$ 351
S17	$ 1,766	$ 88	$ 265	$ 146	$ 519	$ 151	$ 2	$ 1,103	$ 150	$ 150	$ 4,341	$ 1,302	$ 868	$ 185	11	$ 1	8	$ 0.10	212	$ 23	$ 209	$ 6,720	$ 228	$ 130	$ 13	$ 371
S18	$ 1,791	$ 90	$ 269	$ 118	$ 508	$ 146	$ 2	$ 1,103	$ 150	$ 150	$ 4,325	$ 1,297	$ 865	$ 185	11	$ 1	8	$ 0.10	217	$ 24	$ 209	$ 6,697	$ 230	$ 130	$ 13	$ 374

Table Heading Legend and Descriptions

Alternative - alternative name

Capital Costs

- **Pipe** - the baseline installed construction cost for the pipeline
- **Appurts.** - allowance for pipe appurtenances such as valves and misc. items (5% of the baseline pipe cost)
- **Const. Cond.** - allowance for difficult construction conditions such as rock, limited access, etc. (15% of baseline)
- **Tunnels** - total construction cost for all of the tunnels included in the alternative
- **Pump Stat.** - total construction cost for all of the pump stations included in the alternative
- **Hydro** - total construction cost for all of the hydropower facilities included in the alternative
- **Diver. Struc.** - construction cost of the diversion structure
- **Water Treatment** - Construction cost of the water treatment plant
- **Storage** - construction cost of the operational storage include in the alternative
- **Power Trans** - Construction cost of installing power transmission
- **Total Capital** - total cost of construction for the infrastructure items listed above

General 30% - allowance of the 30% of the Total Capital cost for unaccounted for items and contingency

E&A 20% - allowance of 20% for engineering, legal, administration and permitting

Land

- **WTP Land Cost** - cost of land required for the treatment plant
- **# of PS** - number of pump stations included in the alternative
- **PS Land Cost** - cost of the land required for all of the pump stations
- **# of Hydro** - number of hydro power facilities included in the alternative
- **Hydro Land Cost** - cost of the land required for all of the hydropower facilities
- **Pipe Length (miles)** - total length of pipe
- **Pipe Ease. Cost** - cost of the pipeline easement
- **Total L & E Cost** - total cost of the land purchases and easement acquisition

Total Project Cost - Includes the total Capital Cost, Contingency, E & A, and Land and Easement Acquisition

Annual Operations

- **Pump & Hydro** - total operations cost for pump stations and hydropower facilities (including hydropower revenue)
- **WTP** - operations cost for the water treatment plant
- **Pipeline** - maintenance cost of the pipeline and tunnels (0.5% of the total pipeline and tunnel construction cost)
- **Total O&M** - total annual operations cost for the above items

Table 3 - Total Project Costs - 750,000 acre-feet per year Delivery Capacity ($ in Millions)

	Capital Costs																						Annual Operations			
	Infrastructure											Contingencies		Land								Summary				
Alternative	Pipe	Appurts.	Const. Cond.	Tunnels	Pump Stat.	Hydro	Diver. Struc.	Water Treatment	Storage	Power Trans	Total Capital	General 30%	E&A 20%	WTP Land Cost	# of PS	PS Land Cost	# of Hydro	Hydro Land Cost	Pipe Length (miles)	Pipe Ease. Cost	Total L & E Costs	Total Project Cost	Pump & Hydro	WTP	Pipeline	Total O&M
N01	$ 5,237	$ 262	$ 786	$ 205	$ 1,060	$ 211	$ 3	$ 1,618	$ 225	$ 250	$ 9,856	$ 2,957	$ 1,971	$ 277	14	$ 1	7	$ 0.09	260	$ 31	$ 309	$ 15,093	$ 515	$ 193	$ 13	$ 721
N02	$ 4,978	$ 249	$ 747	$ 205	$ 1,092	$ 215	$ 3	$ 1,618	$ 225	$ 250	$ 9,581	$ 2,874	$ 1,916	$ 277	15	$ 1	7	$ 0.09	253	$ 30	$ 309	$ 14,680	$ 523	$ 193	$ 13	$ 730
N03	$ 5,146	$ 257	$ 772	$ 205	$ 1,066	$ 212	$ 3	$ 1,618	$ 225	$ 250	$ 9,754	$ 2,926	$ 1,951	$ 277	14	$ 1	7	$ 0.09	257	$ 30	$ 309	$ 14,941	$ 516	$ 193	$ 13	$ 722
N04	$ 5,029	$ 251	$ 754	$ 205	$ 1,018	$ 183	$ 3	$ 1,618	$ 225	$ 250	$ 9,537	$ 2,861	$ 1,907	$ 277	14	$ 1	6	$ 0.08	253	$ 30	$ 309	$ 14,613	$ 570	$ 193	$ 13	$ 777
N05	$ 5,108	$ 255	$ 766	$ 205	$ 1,109	$ 254	$ 3	$ 1,618	$ 225	$ 250	$ 9,793	$ 2,938	$ 1,959	$ 277	15	$ 1	9	$ 0.12	260	$ 31	$ 310	$ 14,999	$ 521	$ 193	$ 13	$ 727
N06	$ 5,271	$ 264	$ 791	$ 205	$ 1,082	$ 251	$ 3	$ 1,618	$ 225	$ 250	$ 9,959	$ 2,988	$ 1,992	$ 277	14	$ 1	9	$ 0.12	264	$ 31	$ 310	$ 15,248	$ 513	$ 193	$ 13	$ 719
N07	$ 5,365	$ 268	$ 805	$ 205	$ 1,076	$ 250	$ 3	$ 1,618	$ 225	$ 250	$ 10,064	$ 3,019	$ 2,013	$ 277	14	$ 1	9	$ 0.12	268	$ 32	$ 310	$ 15,407	$ 512	$ 193	$ 13	$ 718
N08	$ 5,163	$ 258	$ 774	$ 205	$ 1,036	$ 223	$ 3	$ 1,618	$ 225	$ 250	$ 9,755	$ 2,927	$ 1,951	$ 277	14	$ 1	8	$ 0.10	260	$ 31	$ 309	$ 14,942	$ 505	$ 193	$ 13	$ 711
C01	$ 1,890	$ 94	$ 283	$ 531	$ 726	$ 82	$ 3	$ 1,618	$ 225	$ 140	$ 5,592	$ 1,677	$ 1,118	$ 277	11	$ 1	3	$ 0.04	184	$ 22	$ 300	$ 8,687	$ 412	$ 193	$ 13	$ 618
C02	$ 1,919	$ 96	$ 288	$ 554	$ 699	$ 74	$ 3	$ 1,618	$ 225	$ 140	$ 5,615	$ 1,685	$ 1,123	$ 277	11	$ 1	3	$ 0.04	184	$ 22	$ 300	$ 8,723	$ 407	$ 193	$ 13	$ 613
C03	$ 2,111	$ 106	$ 317	$ 544	$ 761	$ 87	$ 3	$ 1,618	$ 225	$ 140	$ 5,910	$ 1,773	$ 1,182	$ 277	11	$ 1	3	$ 0.04	193	$ 23	$ 301	$ 9,167	$ 421	$ 193	$ 13	$ 627
C04	$ 1,893	$ 95	$ 284	$ 320	$ 889	$ 154	$ 3	$ 1,618	$ 225	$ 200	$ 5,680	$ 1,704	$ 1,136	$ 277	15	$ 1	5	$ 0.07	168	$ 20	$ 298	$ 8,818	$ 443	$ 193	$ 13	$ 649
C05	$ 1,879	$ 94	$ 282	$ 297	$ 900	$ 153	$ 3	$ 1,618	$ 225	$ 200	$ 5,650	$ 1,695	$ 1,130	$ 277	15	$ 1	5	$ 0.07	168	$ 20	$ 299	$ 8,773	$ 452	$ 193	$ 13	$ 658
S01	$ 2,498	$ 125	$ 375	$ 209	$ 816	$ 186	$ 3	$ 1,618	$ 225	$ 180	$ 6,234	$ 1,870	$ 1,247	$ 277	12	$ 1	6	$ 0.08	195	$ 23	$ 301	$ 9,653	$ 360	$ 193	$ 13	$ 567
S02	$ 2,801	$ 140	$ 420	$ 111	$ 664	$ 112	$ 3	$ 1,618	$ 225	$ 150	$ 6,243	$ 1,873	$ 1,249	$ 277	11	$ 1	4	$ 0.05	217	$ 26	$ 304	$ 9,669	$ 331	$ 193	$ 13	$ 537
S03	$ 2,527	$ 126	$ 379	$ 218	$ 812	$ 186	$ 3	$ 1,618	$ 225	$ 180	$ 6,275	$ 1,883	$ 1,255	$ 277	12	$ 1	6	$ 0.08	198	$ 23	$ 302	$ 9,714	$ 342	$ 193	$ 13	$ 548
S04	$ 2,601	$ 130	$ 390	$ 184	$ 813	$ 173	$ 3	$ 1,618	$ 225	$ 180	$ 6,317	$ 1,895	$ 1,263	$ 277	13	$ 1	5	$ 0.07	202	$ 24	$ 302	$ 9,778	$ 349	$ 193	$ 13	$ 555
S05	$ 2,572	$ 129	$ 386	$ 176	$ 817	$ 172	$ 3	$ 1,618	$ 225	$ 180	$ 6,277	$ 1,883	$ 1,255	$ 277	13	$ 1	5	$ 0.07	199	$ 24	$ 302	$ 9,718	$ 353	$ 193	$ 13	$ 559
S06	$ 2,687	$ 134	$ 403	$ 141	$ 724	$ 151	$ 3	$ 1,618	$ 225	$ 180	$ 6,266	$ 1,880	$ 1,253	$ 277	11	$ 1	5	$ 0.07	202	$ 24	$ 302	$ 9,702	$ 323	$ 193	$ 13	$ 529
S07	$ 2,764	$ 138	$ 415	$ 107	$ 725	$ 137	$ 3	$ 1,618	$ 225	$ 180	$ 6,312	$ 1,893	$ 1,262	$ 277	12	$ 1	4	$ 0.05	206	$ 24	$ 303	$ 9,770	$ 331	$ 193	$ 13	$ 538
S08	$ 2,593	$ 130	$ 389	$ 160	$ 636	$ 114	$ 3	$ 1,618	$ 225	$ 150	$ 6,018	$ 1,805	$ 1,204	$ 277	11	$ 1	4	$ 0.05	215	$ 26	$ 304	$ 9,331	$ 308	$ 193	$ 13	$ 514
S09	$ 2,515	$ 126	$ 377	$ 194	$ 649	$ 130	$ 3	$ 1,618	$ 225	$ 150	$ 5,987	$ 1,796	$ 1,197	$ 277	11	$ 1	5	$ 0.07	216	$ 26	$ 304	$ 9,285	$ 310	$ 193	$ 13	$ 517
S10	$ 2,565	$ 128	$ 385	$ 181	$ 805	$ 217	$ 3	$ 1,618	$ 225	$ 150	$ 6,276	$ 1,883	$ 1,255	$ 277	12	$ 1	8	$ 0.10	214	$ 25	$ 304	$ 9,718	$ 370	$ 193	$ 13	$ 576
S11	$ 2,602	$ 130	$ 390	$ 147	$ 788	$ 211	$ 3	$ 1,618	$ 225	$ 150	$ 6,264	$ 1,879	$ 1,253	$ 277	12	$ 1	8	$ 0.10	218	$ 26	$ 304	$ 9,700	$ 344	$ 193	$ 13	$ 550
S12	$ 2,752	$ 138	$ 413	$ 145	$ 673	$ 127	$ 3	$ 1,618	$ 225	$ 150	$ 6,243	$ 1,873	$ 1,249	$ 277	11	$ 1	5	$ 0.07	218	$ 26	$ 304	$ 9,668	$ 329	$ 193	$ 13	$ 536
S13	$ 2,779	$ 139	$ 417	$ 113	$ 830	$ 218	$ 3	$ 1,618	$ 225	$ 150	$ 6,493	$ 1,948	$ 1,299	$ 277	12	$ 1	8	$ 0.10	216	$ 26	$ 304	$ 10,044	$ 359	$ 193	$ 13	$ 565
S14	$ 2,817	$ 141	$ 422	$ 79	$ 814	$ 212	$ 3	$ 1,618	$ 225	$ 150	$ 6,481	$ 1,944	$ 1,296	$ 277	12	$ 1	8	$ 0.10	220	$ 26	$ 305	$ 10,025	$ 360	$ 193	$ 13	$ 567
S15	$ 2,697	$ 135	$ 405	$ 179	$ 604	$ 103	$ 3	$ 1,618	$ 225	$ 150	$ 6,118	$ 1,835	$ 1,224	$ 277	10	$ 1	4	$ 0.05	213	$ 25	$ 303	$ 9,481	$ 304	$ 193	$ 13	$ 510
S16	$ 2,632	$ 132	$ 395	$ 216	$ 621	$ 118	$ 3	$ 1,618	$ 225	$ 150	$ 6,110	$ 1,833	$ 1,222	$ 277	10	$ 1	5	$ 0.07	214	$ 25	$ 304	$ 9,468	$ 311	$ 193	$ 13	$ 517
S17	$ 2,659	$ 133	$ 399	$ 185	$ 779	$ 209	$ 3	$ 1,618	$ 225	$ 150	$ 6,359	$ 1,908	$ 1,272	$ 277	11	$ 1	8	$ 0.10	212	$ 25	$ 303	$ 9,842	$ 340	$ 193	$ 13	$ 546
S18	$ 2,703	$ 135	$ 405	$ 151	$ 762	$ 203	$ 3	$ 1,618	$ 225	$ 150	$ 6,355	$ 1,906	$ 1,271	$ 277	11	$ 1	8	$ 0.10	217	$ 26	$ 304	$ 9,836	$ 341	$ 193	$ 13	$ 547

Table Heading Legend and Descriptions

Alternative - alternative name

Capital Costs

- **Pipe** - the baseline installed construction cost for the pipeline
- **Appurts.** - allowance for pipe appurtenances such as valves and misc. items (5% of the baseline pipe cost)
- **Const. Cond.** - allowance for difficult construction conditions such as rock, limited access, etc. (15% of baseline)
- **Tunnels** - total construction cost for all of the tunnels inlcuded in the alternative
- **Pump Stat.** - total construction cost for all of the pump stations included in the alternative
- **Hydro** - total construction cost for all of the hydropower facilities included in the alternative
- **Diver. Struc.** - construction cost of the diversion structure
- **Water Treatment** - Construction cost of the water treatment plant
- **Storage** - construction cost of the operational storage include in the alternative
- **Power Trans** - Construction cost of installing power transmission
- **Total Capital** - total cost of construction for the infrastructure items listed above

General 30% - allowance of the 30% of the Total Capital cost for unaccounted for items and contingency

E&A 20% - allowance of 20% for engineering, legal, administration and permitting

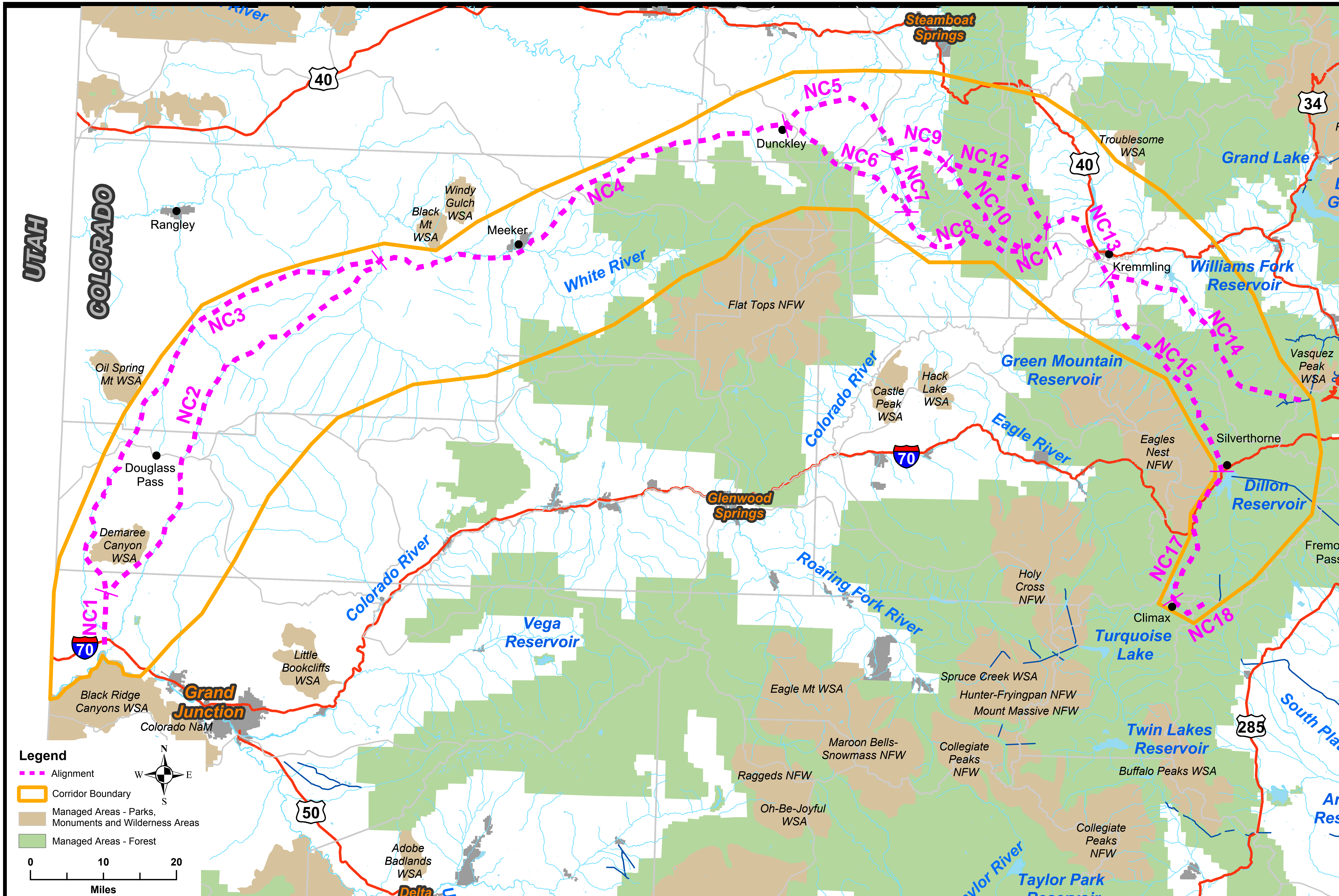
Land

- **WTP Land Cost** - cost of land required for the treatment plant
- **# of PS** - number of pump stations included in the alternative
- **PS Land Cost** - cost of the land required for all of the pump stations
- **# of Hydro** - number of hydro power facilities included in the alternative
- **Hydro Land Cost** - cost of the land required for all of the hydropower facilities
- **Pipe Length (miles)** - total length of pipe
- **Pipe Ease. Cost** - cost of the pipeline easement
- **Total L & E Cost** - total cost of the land purchases and easement acquisition

Total Project Cost - Includes the total Capital Cost, Contingency, E & A, and Land and Easement Acquisition

Annual Operations

- **Pump & Hydro** - total operations cost for pump stations and hydropower facilities (including hydropower revenue)
- **WTP** - operations cost for the water treatment plant
- **Pipeline** - maintenance cost of the pipeline and tunnels (0.5% of the total pipeline and tunnel construction cost)
- **Total O&M** - total annual operations cost for the above items



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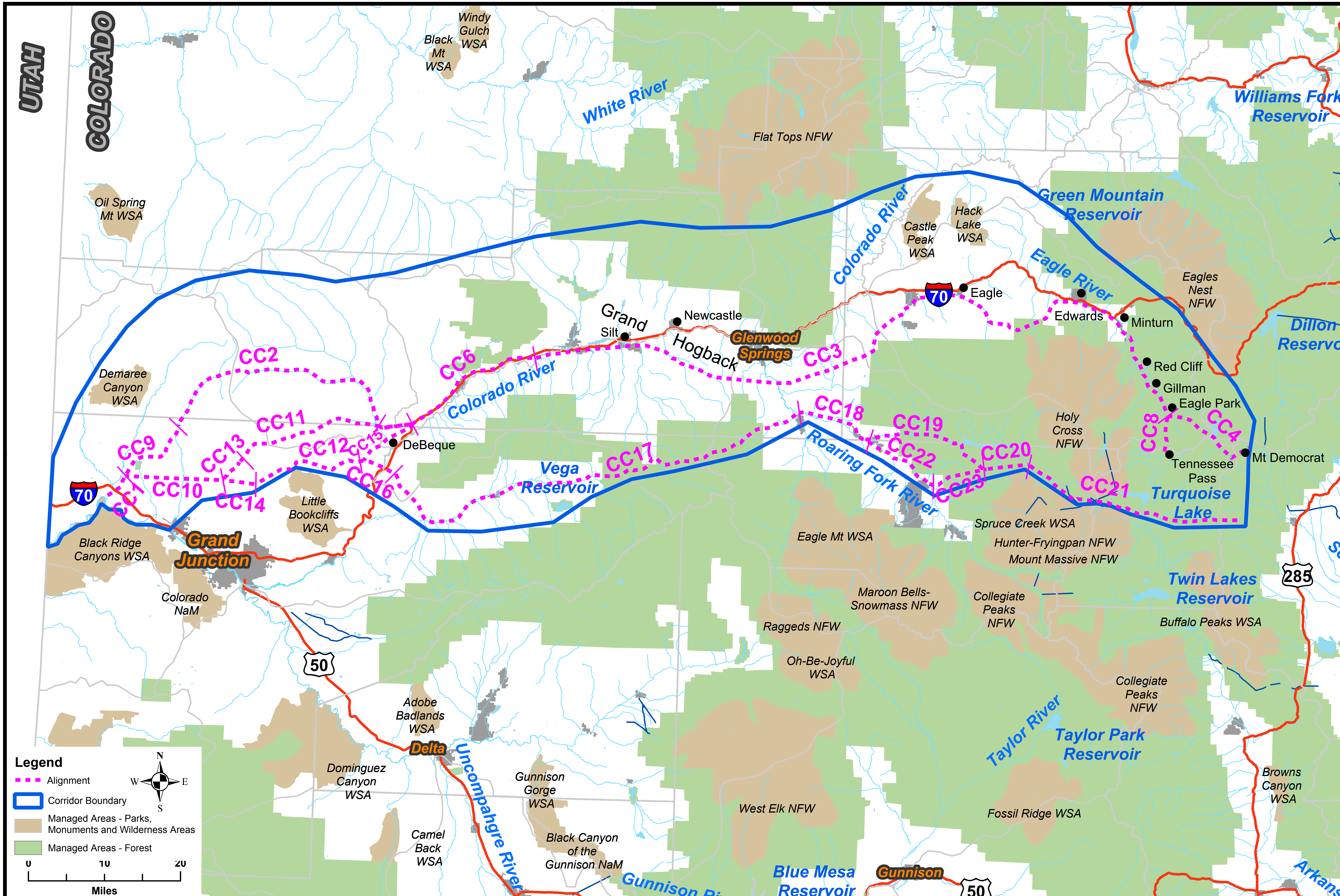
COLORADO RIVER RETURN RECONNAISSANCE STUDY

NORTH CORRIDOR ALIGNMENTS

FIGURE
4



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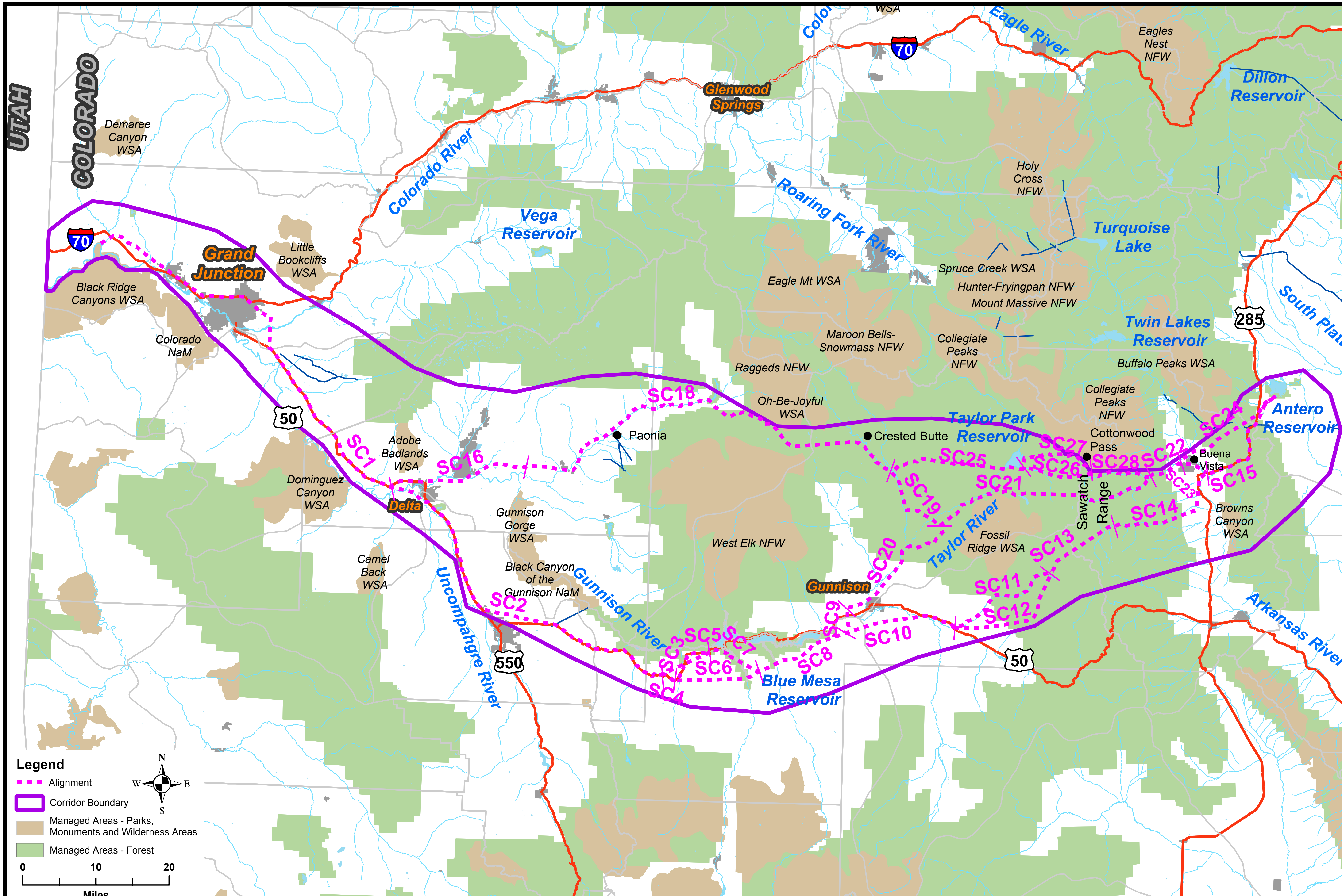
COLORADO RIVER RETURN RECONNAISSANCE STUDY

CENTRAL CORRIDOR ALIGNMENTS

FIGURE 5



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COLORADO RIVER RETURN RECONNAISSANCE STUDY

SOUTH CORRIDOR ALIGNMENTS

FIGURE 6