UPPER GUNNISON-UNCOMPAHGRE BASIN

PHASE 1 - FEASIBILITY STUDY

FINAL REPORT-APPENDICIES

Prepared

For

THE COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

By

HDR Engineering, Inc.

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PREAMBLE

As graphically depicted on the cover, the water of the Upper Gunnison and Uncompahgre River Basins can be used to meet a variety of different and sometimes competing demands. These include recreational uses, irrigated agriculture, livestock production, and municipal and industrial uses. The basin is also confronted with the prospect of potential transmountain diversions.

This preliminary evaluation of the area's water resources was conducted in response to and in association with a large number of local, state, and Federal water interests. We are pleased to provide this report as the initial step in the identification, analysis, and financing of a balanced water management plan for the basin. We are confident that the data it contains will result in a more focused and informed discussion of the basin's complex water resource issues.

Colorado Water Resources and
Power Development Authority

FINAL REPORT APPENDICES
UPPER GUNNISON-UNCOMPAHGRE BASIN
PHASE I FEASIBILITY STUDY

VOLUME II

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BIBLIOGRAPHY

Aaronson, M.J., 1982a. Testing of Water Quality for Inorganics and Heavy Metals for the National Park Service. Institute of Rural Environmental Health, Colorado Epidemiological Pesticide Studies Center, CSU, Fort Collins, Colorado.

Aaronson, M.J., 1982b. Testing of Water Quality for Total Dissolved Solids, Radiation and Chlorinated Hydrocarbon Pesticides for the National Park Service, Institute of Rural Studies Center, CSU, Fort Collins, Colorado.

Allan, J.D., 1975. The Distributional Ecology and Diversity of Benthic Insects in Cement Creek, Colorado. Ecology 56:1040-1053.

Amax, Inc., 1981. Mount Emmons Environmental Report. Amax, Inc., Denver, Colorado, 3 volumes.

Anderson, R., and R.B. Nehring, 1984. Stream Fisheries Investigations; Job 1, Fish Flow Investigations; Job 3, Special Regulations Evaluations. Colorado Division of Wildlife, Federal Aid Project F-51, Job Prog. Rep. 203 pages.

Apley, M., 1981. Butte's Gas and Oil Iron Hill - Powderhorn Surface Water Quality Study 1978-1980. Western State College, Gunnison, Colorado.

Aquatic Environmental Services, 1983. Phytoplankton of Blue Mesa Reservoir. Unpublished Report, 30 pages.

Aquatic Environmental Services, 1984. Data from Blue Mesa Reservoir Survey, Gunnison, Colorado. Unpublished Data.

Asbury, Greg, 1987. Personal communication. August 20, 1987.

Aurora, City of, Colorado, 1986. The Collegiate Range Project.

Barr, R.S., F. Glover, and D. Klingman, 1974, An Improved Version of the Out-of-Kilter Method and a Comparative Study of Computer Codes, Mathematical Programming, 7(1974), pp. 60-86.

Behnke, Robert J., 1985. Fisheries Impact Analysis for Year-Round Flow Depletion of 1000 cfs from Gunnison River in Black Canyon Area. Department of Fishery and Wildlife Biology, Colorado State University, Fort Collins, Colorado.

Behnke, Robert J., 1986. Potential Impacts of Reduced Winter Flows in Gunnison River on Trout Reproduction and Growth in Relation to Lower Water Temperatures and Ice Formation. Department of Fishery and Wildlife Biology, Colorado State University, Fort Collins, Colorado.

Behnke, Robert J., 1987a. Personal correspondence. June 29, 1987.

Behnke, Robert J., 1987b. Personal correspondence. November 24, 1987.

Bio-Environs, 1985. Limnological Survey of Blue Mesa Reservoir. Unpublished report, 86 pages.

Black & Veatch, 1985. Union Park Pumped Storage Project, Feasibility Study. Prepared for the Natural Energy Resources Company.

Boettcher, Arnold J., 1971. Evaluation of the Water Supply at Six Sites in the Curecanti Recreation Area, Southwestern Colorado. USGS Open-File Report 71005.

Britton, L.J. and D.A. Wentz, 1980. Water Quality Characteristics of Selected Lakes and Reservoirs in Colorado. U.S.G.S. Water-Resources Investigations, Open File Report 80-436. Lakewood, Colorado, 139 pages.

Brooks, Tom, 1983. Hydrology and Subsidence Potential of Proposed Coal-Lease Tracts in Delta County, Colorado. U.S. Geological Survey Water Resources Investigations Report 83-4069.

Brushh Creek Reservoir Association, 1987. Middle Brush Creek Flow and Water Quality Data. Gunnison, Colorado, unpublished.

Burgi, Phil H., 1979. Winter Ice Jams on the Gunnison River. U.S. Bureau of Reclamation, Technical Report REC-ERC-79-4, Denver, Colorado.

Burkhart, W.T., 1977. Taylor River Flow Investigations. Colorado Division of Wildlife; Federal Aid Project F-51-R-4, Job 1. Job Interim Report, 49 pages.

Burkhart, W.T., Randall, and Van Duren, 1981. Final Report for Kokanee Salmon Study, Blue Mesa Peaking Modification Project. Colorado Division of Wildlife, Denver, Colorado.

Butterfield, B., 1988. Personal communication, May 10.

CH2M-Hill, 1977. Water System Feasibility Study for Project 7.

Cameron, Jeffrey, 1987. Personal communication. July 20-31, 1987.

Camp, Dresser & McKee, Inc., 1980. Mount Emmons Water Quality Baseline Studies 1978-1979. Prepared for AMAX, Inc.

Camp, Dresser & McKee, Inc., 1982a. Wastewater Facilities Plan for the East River Valley, Gunnison County, Colorado.

Camp, Dresser & McKee, Inc., 1982b. Flood Insurance Study, City of Gunnison, Colorado, Gunnison County. Federal Emergency Management Agency, Denver, Colorado.

Colborn, Theo, 1985. The Use of the Stonefly, Pteronarcys Californica Newport as a Measure of Biological Availability of Cadmium in a High Altitude River System, Gunnison, Colorado.

Colorado Department of Agriculture, 1986. Colorado Agricultural Statistics: 1984. Denver, Colorado.

Colorao Department of Game, Fish and Parks, 1966. Stream Fishery Studies. Federal Aid Report.

Colorado Department of Game, Fish and Parks, 1968. Wetlands of Colorado.

Colorado Department of Natural Resources and U.S. Forest Service, 1982. Memorandum of Understanding for Recreation Management.

Colorado Division of Parks, and Outdoor Recreation, 1986. Colorado Comprehensive Outdoor Recreation Plan. Denver, Colorado.

Colorado Division of Parks and Outdoor Recreation, 1987. Horizons 1987-1991 Colorado Parks. Denver, Colorado, 21 pages.

Colorado Division of Water Resources, 1985. A Summary of Compacts and Litigation which govern Colorado use of Interstate Streams.

Colorado Division of Wildlife, 1974-1975. Analysis of Fish and Wildlife Resources; Dallas Creek Project Area. Colorado Division of Wildlife, 225 pages.

Colorado Division of Wildlife, 1982. Projected Fisherman Use - Blue Mesa Reservoir June - October 1982. Unpublished data.

Colorado Division of Wildlife, 1983a. Fish and Wildlife Monitoring - Dallas Creek Project, Construction Phase. Colorado Division of Wildlife, Denver, Colorado, 281 pages.

Colorado Division of Wildlife, 1983b. Today's Strategy Tomorrow Wildlife, a Comprehensive Management Plan for Colorado's Wildlife. Colorado Division of Wildlife, Denver, Colorado, 95 pages.

Colorado Division of Wildlife, 1986. Wildlife in the 1980's - 1986 Annual Report to the People of Colorado. CDOW, Denver, Colorado.

Colorado Division of Wildlife, 1987a. Big Game Hunting Information for Southwestern Colorado. Colorado Division of Wildlife.

Colorado Division of Wildlife, 1987b. WILDATA Computer Data Base. Denver, Colorado.

Colorado Division of Wildlife, no date. Colorado Stream Surveys, 1976-1987. Colorado Division of Wildlife, Montrose, Colorado, unpublished.

Colorado Geological Survey, 1975. Geologic Hazards in the Crested Butte -Gunnison Area, Gunnison County, Colorado, Information Series #5.

Colorado Public Utilities Commission, 1987. Colorado Electric Supply Survey, 1985-1995. Denver, Colorado.

Colorado Water Conservation Board and U.S. Department of Agriculture, 1962. Water and Related Land Resources, Gunnison River Basin Colorado.

Colorado Water Resources and Power Development Authority, 1986. St. Vrain Basin Reconnaissance Study. Denver, Colorado.

Colorado Water Resources and Power Development Authority, 1987. Cache la Poudre Basin Study, Final Report. Denver. Colorado

Colorado Wildlife Commission, 1987. Mitigation Policy and Procedures and Guidelines. State of Colorado, Wildlife Commission, Denver, Colorado.

Conoco, Inc., 1984. World Energy Outlook Through 2000.

Consolidated Consulting Services, 1985. Town of Ridgway, Colorado Water and Sewer Study.

Crawford, A.B., and D.F. Peterson, Eds. 1974. Environmental Management in the Colorado River Basin. Utah State University Press, Logan, Utah.

Cudlip, L., R.D. French, D. Hickman, 1987. Blue Mesa Reservoir: An Historical Review of its Limnology, 1965-1985. Bureau of Reclamation Report No. REC-ERC-87-3.

Danni, J., undated ditch inventories of Ohio Creek, Tomichi Creek, Cochetopa Creek, East, Taylor, and Slate Rivers, Gunnison River, Lake Fork and Cebolla Creek, Gunnison Soil Conservation District.

District 10 Regional Planning Commission, 1986. Water Quality Management Plan, District 10, State of Colorado. District 10 Regional Planning Commission, Montrose, Colorado.

District 10 Regional Planning Commission, 1987. Draft East/Slate River Study Summary Report. Montrose, Colorado.

Durbin, E.P., and D.M. Kroenke, 1967. The Out-of-Kilter Algorithm: A Primer, Memorandum RM-5472-PR, December, The Rand Corporation.

Ebasco Services Incorporated, 1986. Union Park Water Supply Project Reconnaissance Evaluation Study. Lakewood, Colorado.

Ebasco Services, Incorporated, 1986-1987. Water Quality Monitoring of Taylor Reservoir. Lakewood, Colorado, unpublished.

Edison Electric Institute, 1986. Electric Perspective. Edison Electric Institute, Washington, D.C.

Engineering Consultants, Inc., 1976. Floodplain Information Report, Gunnison River/Tomichi Creek, Gunnison, Colorado. Colorado Water Conservation Board, Denver, Colorado.

Federal Emergency Management Agency, 1985. Firm Flood Insurance Rate Map, City of Gunnison, Colorado, Gunnison County. National Flood Insurance Program, Denver, Colorado.

Fleming, The David E. Co., 1985. Water Rights Evaluation in the Gunnison River Basin, Collegiate Range Project.

Foster, Stephen Lee, and Rural Communities Institute at Western State College of Colorado, 1984. A 1984-1985 Marketing Plan on Summer Tourism for the Montrose County Chamber of Commerce.

Fulkerson, D.R., 1961. An Out-of-Kilter Method for Minimum Cost Flow Problems, Journal SIAM, c 9, n. 1, March, pp 18-27.

Galloway, Virgil E. Associates and Market Analysis Professionals, Inc., 1986. Market Research Project. Prepared for the Colorado Division of Wildlife; Denver, Colorado.

Gleick, P., 1987. Regional Hydrologic Consequences of Increases in Atmospheric CO2 and Other Trace Gases, Climate Change, 10 (1987), pp 137-161.

Goettl, J.P., J.R. Sinley, and P.H. Davies, 1971. Water Pollution Studies; Study of the Effects of Mineral Mining and Milling Operations on High Mountain Streams. Colorado Division of Game, Fish and Parks, Federal Aid Project F-33-R-6, Job 1, Pages 1-48.

Goettl, J.P. and P.H. Davies, 1977. Water Pollution Studies. Job Progress Report. Federal Aid Project F-33-R-12. Colorado Division of Wildlife.

Greenland, Phillip V., 1983. Optimum Operation Plan Determination for the Taylor Park and Aspinall Unit Reservoir System.

Greer, M.J., 1972. Water Supply Study, Central Colorado Project. Prepared for the Central Colorado Water Conservancy District.

HDR Infrastructure, Inc., 1986. Winter Stock Water Replacement Program, Lower Gunnison Basin Unit, Stage 1.

HDR Infrastructure, Inc., 1987. Uncompahgre Hydropower Project Report o Water Availability.

Hickman, D., 1986. Water Quality Trends for Blue Mesa Reservoir. M.A. Thesis, Western State College, Gunnison, Colorado.

Iorns, W.V. and others, 1964. Water Resources of the Upper Colorado River Basin - Basic Data. U.S. Geological Survey, Professional Paper 442.

Iorns, W.V. and others, 1965. Water Resources of the Upper Colorado River Basin - Technical Report. U.S. Geological Survey, Professional Paper 441.

Johnson, Donn M., and Richard G. Walsh, 1987. Economic Benefits and Costs of the Fish Stocking Program at Blue Mesa Reservoir, Colorado. Department of Agricultural and Resource Economics, Colorado State University, Fort Collins, Colorado, Final Report to Division of Wildlife, Denver, Colorado.

Junge, W.R., 1978. Surficial Geology, North Fork Gunnison River Valley, Delta and Gunnison Counties. Colorado Geological Survey Open-File Report 78-4.

Kehmeier, Ken, 1987. Personal interview, August 21, 1987. Gunnison, Colorado.

Kinnear, B.S, 1966. Fishes of the Black Canyon. M.S. Thesis, Colorado State University, Fort Collins, Colorado, 45 pages.

Kircher, James E., R.S. Dinicola, and R.F. Middleburg, 1984. Trend Analysis of Salt Load and Evaluation of the Frequency of Water-Quality Measurements for the Gunnison, the Colorado, and the Dolores Rivers in Colorado and Utah. U.S. Geological Survey Water Resources Investigations Report 84-4048.

Kircher, J.E., A.F. Choquette, and B.D. Richter. 1985. Estimation of Natural Streamflow Characteristics in Western Colorado. Water Resources Investigations Report 85-4086. USGS, Lakewood, Colorado.

Kirkham, R.M., and W.P. Rogers, 1981. Earthquake Potential in Colorado, A Preliminary Evaluation. Colorado Geological Survey Bulletin 43.

Knight, A.W., and D.W. Argyle, 1962. Limited Limnological Studies of the Gunnison River, Colorado. University of Utah Anthropoligical Papers No. 59, Upper Colorado Series, No. 8, Salt Lake City, Utah.

Kuhn, Thomas H., 1982. The Gunnison City Irrigation System: A Study in Bacteriological Water Quality and Possible Effects Upon the Community. M.A. Thesis, Western State College.

Kunkle, S., R. Nickerson, G.M. Smillie, R. Andrascik, 1983. Metal Concentrations in Fish at Curecanti National Recreation Area, Gunnison, Colorado. Water Resources Field Support Service, National Park Service, WRFSL Project Report No. 83-3-P, 31 pages.

Labadie, J.W., R.C. Lazaro, and S. Phamwon, 1982. Network Model for Integrated River Basin Management: Program CONSIM, presented at the Computer Assisted River Basin-Wide Water Management Seminar and Workshop, November, Colorado State University, Fort Collins.

Labadie, J.W., A.M. Pineda, and D. Bode, 1984. Network Analysis of Raw Water Supplies Under Complex Water Rights and Exchanges: Documentation or Program MODSIM3, Colorado Water Resources Research Institute, Fort Collins.

Livingston, R.K., 1970. Evaluation of the Streamflow Data Program in Colorado. Open File Report, USGS Colorado District, Denver.

Loucks, D.P., J.R. Stedinger, D. A. Haith, 1981. Water Resource Systems Planning and Analysis.

McCain, J.F., and R.D. Jarrett. 1976. Manual for Estimating Flood Characteristics of Natural-flow Streams in Colorado. Technical Manual No. 1, Colorado Water Conservation Board, Denver.

McLaughlin Water Engineers, Ltd., Denver, Colorado, 1987. Functional Design Report, Whitewater Bypass and Fish Passage Facility. Horseshoe Bend Hydroelectric Project, Boise Cascade Corporation, prepared for Brown and Root U.S.A., Inc.

Mancini, Mike, 1987. Personal Interview. Aquatic baseline studies conducted for Ralph E. Clark on Tomichi and Cochetopa Creeks.

Mangum, Fred A., 1983. Aquatic Ecosystem Inventory - Macroinvertebrate Analysis on the BLM Montrose, Colorado District. USDA Forest Service, Intermountain Region Aquatic Ecosystem Analsyis Laboratory, Provo, Utah.

Market Facts, Inc., 1984. National Profile Research - Colorado Vacations. Market Facts, Inc., Chicago, Illinois.

Metcalf and Eddy, 1979. Wastewater Engineering. McGraw-Hill Book Company, New York, New York.

Middleton, William H., 1969. Hybridization and Distribution of Catostomid Fishes in Blue Mesa Reservoir and the Upper Gunnison River Drainage. A M.A. thesis, Western State College of Colorado, Gunnison, Colorado.

Moran, R.E., and D.A. Wentz, 1974. Effects of Metal-Mine Drainage on Water Quality in Selected Areas of Colorado. Colorado Water Resources Circular No. 25.

Morcan Engineering Co., 1974. Engineering Reports on the Municipal Water Supply for the City of Gunnison.

Morrison-Knudsen Engineers, Inc., 1985. Gunnison River Icing Study, Summary Report. Prepared for the Upper Gunnison River Water Conservancy District, Gunnison, Colorado, 59 pages.

National Audobon Society, 1984. The Audobon Energy Plan 1984.

National Park Service, July 1965. The Curecanti Unit of the Colorado River Storage Project, Recreation Potential.

National Park Service, 1971-1986. Monthly Public Use Reports. U.S. Department of the Interior National Park Service, Curecanti National Recreation Area, Colorado.

National Park Service, 1979. Wild and Scenic River Study. U.S. Department of Interior, U.S. Government Printing Office, Washington, D.C.

National Park Service, 1984. Curecanti National Recreation Area, Natural Resources Management Plan and Environmental Assessment. Gunnison, Colorado, 113 pages.

National Park Service, 1986. Curecanti National Recreation Area Water Quality Data Report. NPS, Water Resources Division, Fort Collins, Colorado.

National Park Service, 1982-1987. Curecanti National Recreation Area Water Quality Monitoring Program, Gunnison, Colorado.

Natural Energy Resources Company, 1987. Application for a License - Major Unconstructed Project for the Rocky Point Pumped Storage Project, FERC Project No. 7802.

Natural Energy Resources Company, 1984-1987. Water Quality Monitoring of Lottis Creek, Taylor Reservoir, and Taylor River. Unpublished.

Nehring, R.B., no date. Analysis of Brown Trout Population Dynamics in the Taylor River from 1974 through 1980 in Relation to Winter Flow Conditions. Colorado Division of Wildlife, Montrose, Colorado.

Nehring, R.B., 1979. Evaluation of Instream Flow Methods and Determination of Water Quality Needs for Streams in the State of Colorado. Colorado Division of Wildlife.

Nehring, R.B., 1980. Stream Fishery Investigations. Job 1, Taylor River Flow Investigations. Job 3, Special Regulations Evaluations. Colorado Division of Wildlife, Federal Aid F-51-R-5, Job Prog. Report 161 pages.

Nehring, R.B., and R. Anderson, 1981. Stream Fishery Investigations. Job 1, Taylor River Flow Investigations. Job 3, Special Regulations Evaluation. Colorado Division of Wildlife, Federal Aid F-51-R-6, Job Prog. Rep. 161 pages.

Nehring, R.B., and R. Anderson, 1982. Stream Fishery Investigations. Job 1, Taylor River Flow Investigations. Job 3, Special Regulations Evaluation. Colorado Division of Wildlife, Federal Aid Project F-51-R-7, Job Prog. Rep. 185 pages.

Nehring, R.B., and R. Anderson, 1983. Stream Fishery Investigations. Job 1, Fish Flow Investigations. Job 3, Special Regulations Evaluations. Colorado Division of Wildlife, Federal Aid Project F-51-R, Job Prog. Rep. 188 pages.

Nehring, R.B., and R. Anderson, 1985. Stream Fishery Investigations. Job 1, Fish Flow Investigations. Job 3, Special Regulations Evaluations. Colorado Division of Wildlife, Federal Aid Project F-51, Job Prog. Rep. 171 pages.

Nehring, R.B., 1986. Stream Fishery Investigations. Job 1, Fish Flow Investigations. Job 3, Special Regulations Evaluations. Job 4, Wild Trout Introductions. Colorado Division of Wildlife, Federal Aid Project F-51-R, Job Prog. Rep.

Nehring, R.B., 1987. Personal communication. November 17, 1987.

Nelson, Haley, Patterson & Quirk, Inc., 1972. Master Water Improvements Plan for the City of Gunnison, Colorado.

Nesler, Thomas P., 1986. Mysis-Gamefish Studies. Colorado Division of Wildlife, Federal Aid Project F-83, Job Prog. Rep.

Nolting, D.H., 1968. The Lake Trout in Colorado. Colorado Department of Game, Fish and Parks, 109 pages, unpublished.

Norris, J. Michael and W.S. Maura, 1985. Water Quality Data for Streams in the Upper North Fork of the Gunnison River, Colorado. USGS Open File Report, 85-190.

PRC Engineering, 1980. Fruitland Mesa Project, Colorado, Feasibility Report, Colorado Water Conservation Board, Fruitland Mesa Conservancy District, Englewood, Colorado, October.

PRC Engineering, 1986. Grand Mesa Water Supply Study. Prepared for Colorado Water Conservation Board, Grand Mesa Water Conservancy District and the Colorado River Water Conservation District.

Park, Dave, 1987. Personal communications. July 20-31, 1987.

Paxon, J.E., Jr., No date. A Conflict Analysis: The Developed Recreation User and Multiple Use Management in the Taylor River Canyon. Utah State University.

Peckarsky, B.L., S.I. Dodson, and D.J. Conklin, Jr., 1985. A Key to the Aquatic Insects of Streams in the Vicinity of the Rocky Mountain Biological Lab, Including Chironomid Larvae from Streams and Ponds. Colorado Division of Wildlife, Denver, Colorado.

Perry, James A., II, 1973. Analysis of Aquatic Insect Communities in a High Altitude Ecosystem: Tomichi Creek, Colorado. M.A. Thesis, Western State College of Colorado, Gunnison, Colorado.

Peterson, R., 1988. Personal communication, February 12.

Peterson, R., 1988. Personal communication, March 3.

Pratt, H. P., 1936. Population Studies of the Trout of the Gunnison River. University of Colorado Studies 24:107-116.

Pratt, H. P., 1938. Ecology of the Trout of the Gunnison River, Colorado. PH.D. Diss., University of Colorado, Boulder, 197 pages.

President's Commission on America's Outdoors, 1986. Report and Recommendations to the President of the United States. U.S. Government Printing Office, Washington, D.C.

Public Service Company of Colorado, 1987. Electric Demand and Supply Plan, 1977-2006. Denver, Colorado.

Rector, Claudia D., 1979. Lower Gunnison River Basin Wetland Inventory and Evaluation. USDA, Soil Conservation Service.

Reed, E.B., 1968. Limnological Aspects of the Curecanti Unit. Report to the National Park Service, 74 pages.

Reiser, D.W., M.W. Vitter, and J. Todd, 1982. Reclamation of Colorado Streams Impacted by Acid Mine Drainage. Proc. Colorado-Wyoming, American Fishery Society, 17:120-132.

Richards, R., and H.A. Ferchau, 1978. Butte's Gas and Oil Iron Hill - Powderhorn Study, 1977. Western State College, Gunnison, Colorado.

Richter, Brian D., et. al., 1974. Summary of Basin and Streamflow Characteristics for Selected Basins in Western Colorado and Adjacent States. USGS Open-File Report 84-137.

Rocky Mountain Biological Laboratory, 1986. Bibliography of Scientific Publications. Rocky Mountain Biological Laboratory, Crested Butte, Colorado, 30 pages.

Rosette, Robert K., 1986. Crystal Creek Ranch, A Management Plan for Fish, Wildlife, and Forests. RWC, Inc., Montrose, Colorado, 113 pages.

Rumberg, C.B., B.H. Gery, and K. Butcher, 1978. Gunnison County Stream Water Quality Study. Water Division, Environmental Protection Agency. EPA-903/3-7B-001.

Schafer, J.M., 1979. An Interactive River Basin Water Management Model: Synthesis and Application, Tech. Report 18, Colorado Water Resources Research Institute, Fort Collins.

Schneider, S., 1987. Climate Modeling, Scientific American, May, pp. 72-80.

Siegel, John R., and Sillin, John O., September 1984. Rethinking Utility Strategy Under Conditions of High Growth, Public Utilities Fornightly.

Soil Conservation Service, 1970. Irrigation Water Requirements, Technical Release No. 21, U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C.

Stanford, J.A. and J.V. Ward, 1981. The Effects of Mainstream Dams on Physiochemistry of the Gunnison River. Unpublished, 21 pages.

Stanford, J.A. and J.V. Ward, 1982. The Effects of Regulation on the Limnology of the Gunnison River: A North American Case History. Unpublished, 19 pages.

State Demographer, 1987. Colorado Population Projections. Division of Local Affairs, Demographic Section, Denver, Colorado.

Steven, T.A., P.W. Lipman, W.J. Hail, Jr., F. Barker, and R.G. Luedke, 1974. Geologic Map of the Durango Quadrangle, Southwestern Colorado. USGS, Miscellaneous Inventory, Serial I-764.

Stone & Webster Management Consultants, Inc., 1988. Colorado Joint Planning Study, Economic Potential of Pumped Storage.

Tennant, O.L., 1975. Instream Flow Regimes for Fish, Wildlife, Recreation and Related Environmental Resources. U.S. Fish and Wildlife Service.

Texas Water Development Board, 1972. Economic Optimization and Simulation Techniques for Management of Regional Water Resource Systems: River Basin Simulation Model MINYLD II Program Description, Systems Engineering Division, Austin.

Treyz, G., Friedlander, A. and Stevens, B., 1985. The TFS Regional Modeling Methodology. Regional Studies, Vol. 19.

Tucker, Gordon C., Jr., Ph.D., Nickens and Associates, Montrose, Colorado, November 1984. Archaeological Investigations Along the Uncompahgre Water Users Association and Lateral Irrigation Ditch, Montrose County, Colorado. Prepared for Mesa Engineering, Montrose, Colorado.

U.S. Army Corps of Engineers, Los Angeles District, 1963. Benefits from Flood Control - Dallas Creek Project, Uncompahgre River, Colorado.

U.S. Army Corps of Engineers, Omaha District, 1986. Metropolitan Denver Water Supply Draft Environmental Impact Statement, Executive Summary. Volumes I and II, and technical appendices.

U.S. Army Corps of Engineers, 1981. National Hydroelectric Power Resources Study, Regional Assessment; Western Systems Coordinating Council, Volume XXII.

U.S. Bureau of Land Management, 1986a. Fisher Use in the Gunnison Gorge Recreation Management Area. Uncompahgre Basin Resource Area, Montrose, Colorado.

U.S. Bureau of Land Management, 1986b. Recreational Use in the Gunnison Gorge Recreation Management Area and Other Uncompahgre Basin Recreation Use Areas. Uncompahgre Basin Resource Area, Montrose, Colorado.

U.S. Bureau of Land Management, 1977-1986. Baseline Water Quality Inventory: Gunnison Basin/American Flats Reservoir Area.

U.S. Bureau of Land Management, 1978. Gunnison Basin Unit Resource Analysis; Blue Mesa, Cebolla, Powderhorn, Cochetopa, Sapinero, and Crested Butte Planning Units. Unpublished report, Gunnison, Colorado.

U.S. Bureau of Land Management, 1980a. American Flats Unit Resource Analysis; American Flats and Silverton Planning Units. Unpublished report, Gunnison, Colorado.

U.S. Bureau of Land Management, 1980b. Draft Environmental Impact Statement, Proposed Domestic Livestock Grazing Management Program in the Gunnison Basin Resource Area and Silverton Planning Unit. Montrose District, Colorado.

U.S. Bureau of Land Management, 1981a. American Flats/Silverton Management Framework Plan. Gunnison, Colorado. Unpublished.

U.S. Bureau of Land Management, 1981b. Gunnison Basin Management Framework Plan. Gunnison, Colorado. Unpublished.

U.S. Bureau of Land Management, 1982. Proposed Wilderness Designation of the Wilderness Study Area within the Gunnison Basin and American Flats/Silverton Planning Units of the Montrose District, Colorado: Draft Environmental Impact Statement. Montrose District, Colorado.

U.S. Bureau of Land Management, 1984. Final Suitability Report and Environmental Impact Statement, Proposed Wilderness Designation of the Powderhorn Instant Study Area, Gunnison and Hinsdale Counties, Colorado. Montrose District, Colorado.

U.S. Bureau of Land Management, 1985. Recreation Management Plan for the Gunnison Gorge Recreation Lands. Montrose District, Colorado.

U.S. Bureau of Land Management, 1986. Final Recreation Area Management Plan for the American Flats/Silverton-Lower Lake Fork Special Recreation Management Area. Montrose District, Colorado.

U.S. Bureau of Land Management, 1987a. Final Impact Environmental Statement, Proposed Wilderness Designation of the Wilderness Study Areas within the Gunnison Basin and American Flats/Silverton Planning Units of the Montrose District, Colorado. Montrose District, Colorado.

U.S. Bureau of Land Management, 1987b. Final Environmental Statement, Proposed Domestic Livestock Grazing Program for the Uncompahgre Basin Resource Area. Montrose District, Colorado.

U.S. Bureau of Land Management, 1987c. Recreation Area Activity Plan for the Cochetopa Canyon Special Recreation Management Area (Draft). Montrose District, Colorado.

U.S. Bureau of Land Management, 1987d. Draft Uncompahgre Basin Resource Management Plan and Environmental Impact Statement. Montrose District, Colorado.

U.S. Bureau of Land Management, no date. Gunnison Resource Area Stream Data. Bureau of Land Management, Montrose District Colorado, unpublished.

U.S. Bureau of Reclamation, 1946. Gunnison-Arkansas Project, Colorado.

U.S. Bureau of Reclamation, 1947. Potential Hydroelectric Development, Uncompahgre Project, Colorado.

U.S. Bureau of Reclamation, Region 7, Denver, Colorado, 1948. Gunnison-Arkansas Project, Colorado, Interim Report, Appendix D.

U.S. Bureau of Reclamation, Region 7, Denver, Colorado, 1950. Initial Development, Gunnison-Arkansas Project, Colorado.

U.S. Bureau of Reclamation, Region 4, Salt Lake City, Utah, 1956. Curecanti Unit of the Colorado River Storage Project, Special Report.

U.S. Bureau of Reclamation, 1961. Bostwick Park Project, Colorado, Feasibility Report, Region 4, Salt Lake City, January (includes Appendix B).

U.S. Bureau of Reclamation, Region 4, Salt Lake City, Utah, 1964. Upper Gunnison Project - Colorado, Reconnaissance Report.

U.S. Bureau of Reclamation, 1965. Bostwick Park Project, Colorado Definite Plan Report.

U.S. Bureau of Reclamation, 1967. Designers' Operating Criteria, Blue Mesa Dam and Powerplant, Curecanti Unit, Gunnison Division, Colorado River Storage Project, Office of the Chief Engineer, Denver.

U.S. Bureau of Reclamation, 1970a. Upper Gunnison Project, Colorado, Elko Damsite Feasibility Construction Materials Report.

U.S. Bureau of Reclamation, 1970b. Upper Gunnison Project, Colorado, Cement Creek Damsite, Feasibility Construction Materials Report.

U.S. Bureau of Reclamation, 1970c. Upper Gunnison Project, Colorado, Banana Ranch Damsite, Feasibility Geology Report.

U.S. Bureau of Reclamation, 1970d. Upper Gunnison Project, Colorado, Hinkle Damsite Feasibility Geology Report.

U.S. Bureau of Reclamation, 1970e. Upper Gunnison Project, Colorado, Crookton Canal Feasibility Geology Report.

U.S. Bureau of Reclamation, 1971. Designers' Operating Criteria, Morrow Point Dam and Powerplant, Curecanti Unit, Gunnison Division, Colorado River Storage Project, Office of the Chief Engineer, Denver.

U.S. Bureau of Reclamation, 1973a. Grand Mesa Project, Colorado, Concluding Report.

U.S. Bureau of Reclamation, Region 4, Salt Lake City, 1973b. Concluding Report, Upper Gunnison Project - Colorado.

U.S. Bureau of Reclamation, 1973c. Upper Gunnison Project, Colorado, Concluding Report, Upper Colorado Region, August, Salt Lake City.

U.S. Bureau of Reclamation, 1975. Uncompahgre Project, Curecanti Unit, Colorado River Storage Project and Upper Gunnison River Water Conservancy District, Taylor Park Reservoir Operation and Storage Exchange Agreement.

U.S. Bureau of Reclamation, 1976a. Final Environmental Impact Statement, Dallas Creek Project, Colorado, 253 pages.

U.S. Bureau of Reclamation, 1976b. Definite Plan Report, Dallas Creek Project, Colorado.

U.S. Bureau of Reclamation, 1976c. Dallas Creek Project, Colorado, Definite Plan Report, Upper Colorado Region, Salt Lake City, November (including Appendix B: Water Supply).

U.S. Bureau of Reclamation, 1977a. Fruitland Mesa Project, Colorado, Final Environmental Impact Statement. USBR, Salt Lake City, Utah, 216 pages.

U.S. Bureau of Reclamation, 1977b. Report on the Western Energy Expansion Study.

U.S. Bureau of Reclamation, 1977c. Fruitland Mesa Project, Colorado, Definite Plan Report, Upper Colorado Region, Salt Lake City, November.

U.S. Bureau of Reclamation, 1977-1987. Water Monitoring for the Dallas Creek Project. Grand Junction Projects Office, Grand Junction, Colorado.

U.S. Bureau of Reclamation (Water and Power Resources Service), 1980. Report on Assessment of Small Hydroelectric Development at Existing Facilities.

U.S. Bureau of Reclamation, 1981a. Project Data.

U.S. Bureau of Reclamation, 1981b. Environmental Assessment - Rehabilitation and Betterment Program, Uncompahgre Valley Water Users Association, Uncompahgre Project, Colorado.

U.S. Bureau of Reclamation, Grand Junction Projects Office, 1982a. Project History - Uncompahgre Project, Colorado, Volume 74.

U.S. Bureau of Reclamation, 1982b. Planning Report on the Grand Mesa Project, Colorado.

U.S. Bureau of Reclamation, 1982c. Bostwick Park Project, Montrose and Gunnison Counties, Colorado, Upper Colorado Region.

U.S. Bureau of Reclamation, and Tudor Engineering Company, 1982d. Report on Assessment of Low-Head Hydroelectric Sites in the Western States. Appendix Part II, Colorado.

U.S. Bureau of Reclamation, 1982e. Colorado River Water Quality Improvement Program, Lower Gunnison Basin Unit, Feasibility Report/Draft Environmental Impact Statement, Upper Colorado Region, Salt Lake City.

U.S. Bureau of Reclamation, 1983. Designers' Operating Criteria, Crystal Dam and Powerplant, Curecanti Unit, Gunnison Division, Colorado River Storage Project, Office of the Chief Engineer, Denver.

U.S. Bureau of Reclamation, 1984a. Examination Report for Taylor Park Dam -SEED Program - Uncompahgre Project, Colorado, Upper Colorado Region. Memorandum from T. Brown to Chief, Inspections Branch.

U.S. Bureau of Reclamation, 1984b. Lower Gunnison Basin Unit - Feasibility Report/Final Environmental Statement.

U.S. Bureau of Reclamation, 1984c. Final Environmental Impact Statement/ Feasibility Report. The Lower Gunnison Unit of the Colorado River Water Quality Improvement Program. USBR, Salt Lake City, Utah, 319 pages.

U.S. Bureau of Reclamation, 1987. Examination Report for Taylor Park Dam - SEED Program - Uncompahgre Project, Colorado, Upper Colorado Region. Memorandum from C.W. Smith to Chief, Inspections Branch.

U.S. Bureau of Reclamation, 1988. Draft Environmental Assessment, Uncompahgre Valley Hydropower Project, AB Lateral Facility, Upper Colorado Region, March.

U.S. Corps of Engineers (COE), 1985. Engineering and Design - HYDROPOWER, EM 11110-2-1701. Office of the Chief of Engineers.

U.S. Corps of Engineers, 1988. Metropolitan Denver Water Supply EIS, Volume VIII.

U.S. Department of Housing and Urban Development, 1977. Flood Hazard Boundary Maps, Gunnison County, Colorado, Unincorporated Areas. Federal Insurance Administration.

U.S. Department of the Interior, Regional Solicitor, Intermountain Region, 1984. Memorandum to U.S. Bureau of Reclamation.

U.S. Energy Information Administration, 1984. 1983 Annual Energy Outlook, Washington, D.C.

U.S. Environmental Protection Agency, Region VIII, 1976. Preliminary Report on Blue Mesa Reservoir, Gunnison County, Colorado. National Eutrophication Survey. CERL, Corvallis, EMSL, Las Vegas, 44 pages.

U.S. Environmental Protection Agency, no date. STORET Water Quality Data. NPS data file, Curecanti National Recreation Area, Gunnison, Colorado, unpublished.

U.S. Federal Energy Regulatory Commission, Office of Electric Power Regulation, 1981. Hydropower Sites of the United States, Developed and Undeveloped River Basin (Maps Showing Site Locations, Conventional, Pumped Storage, Retired).

U.S. Fish and Wildlife Service, 1982. 1980 National Survey of Fishing, Hunting and Wildlife Associated Recreation. U.S. Department of the Interior, Washington, D.C.

U.S. Fish and Wildlife Service, 1987. Final Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin, Region 6, Denver, September.

U.S. Forest Service, 1982. Mount Emmons Mining Project; Environmental Impact Statement, Final. Department of Agriculture, U.S. Forest Service. U.S. Government Printing Office, Washington, D.C., 240 pages.

U.S. Forest Service, 1983a. Land and Resource Management Plan, Grand Mesa, Uncompahgre, and Gunnison National Forests, U.S. Forest Service, Delta, Colorado.

U.S. Forest Service, 1983b. Final Environmental Impact Statement; Grand Mesa, Uncompahgre and Gunnison National Forests. USDA Forest Service, Delta, Colorado.

U.S. Geological Survey, and State of Colorado, 1983. Water Resources Data Colorado, Water Year 1982, Volume 2, Colorado River Basin above Dolores River.

U.S. Water and Power Resources Service, 1981. Concluding Report, Peaking Power Generation, Blue Mesa Dam, Colorado.

Upper Colorado River Commission, 1986. Thirty-eighth Annual Report, Salt Lake City.

Van De Velde, Stephen M., and the Rural Communities Institute at Western State College of Colorado, 1985. A 1985 Marketing Plan - Hunting in Montrose County.

WBLA, Inc., 1986. Curecanti Instream Flow Water Rights Study. Prepared for the Nature Conservancy.

WRC Engineering, Inc., 1981. Water Supply System Evaluation and Implementation Plan.

Walsh, R.G., Harpman, D.A., John, K.H. McKean, J.R. and LeCroy, D.L., 1987. Long-Run Forecasts of Participation in Fishing, Hunting, and Nonconsumptive Wildlife Recreation. Colorado State University, Fort Collins, Colorado.

Water Quality Control Commission, 1975. The Upper Gunnison River Drainage. Colorado Department of Health, Denver, Colorado.

Water Quality Control Commission, 1984. Water Quality Standards for Colorado. Colorado Department of Health, Denver, Colorado.

Weber, D.A., 1986. Colorado Stream Data Bank User's Guide, second edition. Colorado Division of Wildlife, Denver, Colorado, DOW-R-M-2-86.

Weber, D.A., 1987. Colorado Lake Data Bank User's Guide. Colorado Division of Wildlife, Denver, Colorado DOW-R-M-87.

Wesche, Thomas A. and Richard, Paul A., 1980. A summary of Instream Flow Methods for Fisheries and Related Research Needs, Eisenhower Consortium Bulletin 9.

Weiler, R., 1985. Blue Mesa Reservoir Historic Data Review Related to Rainbow and Kokanee Fishery 1971-1984. Report to Colorado Division of Wildlife, 8 pages.

Western Engineers, Inc. 1984. Location and Cost Comparisons, Upper Gunnison Project Features.

Western Engineers, 1986. 1985 Development Work for the Upper Gunnison Project.

Western Engineers, Inc., 1987. Upper Gunnison Project, Potential Dam and Reservoir Sites in the Upper Cochetopa Creek Basin.

Wharton Econometric Forecasting Associates, 1987. Long-Term Alternative Scenario and 25-year Extension, Balacynwud, Pennsylvania.

Williams, H. J. 1951. The Operation of Taylor Reservoir and its Effect on Gunnison River Fishing. Colorado Department of Game and Fish, Denver, Colorado, 26 pages.

Wiltzius, W., 1966-1967. Pre-impoundment Investigations of the Curecanti Unit, Upper Colorado River Storage Project. Determination of the Chemical and Physical Characteristics of the Upper Gunnison Drainage, Job Completion Report. Colorado Division of Wildlife.

Wiltzius, W. J., 1974. Post-impoundment Fishery Investigations, Curecanti Unit, Upper Colorado River Storage Project. Final report for Blue Mesa Reservoir. Colorado Division of Wildlife, 76 pages.

Wiltzius, W.J., 1976. Some Historic Influences of Reservoir and Irrigation on Flows, Temperature and Fish Distribution in The Gunnison River. Colorado Division of Wildlife.

Wiltzius, W. J., 1978. Some Features Historically Affecting the Distribution and Abundance of Fishes in the Colorado River. Final Report for Fishery Investigations of the Lower Gunnison River Drainage. Colorado Division of Wildlife, 215 pages.

Wright McLaughlin Engineers, 1967. Master Planning Report - Water Supply for Montrose, Colorado.

Wrigt-McLaughlin Engineers, 1967. Supplemental Study to Water Supply Master Planning Report for Montrose, Colorado.

APPENDIX B

EXISTING WATER SUPPLY ENTITIES

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EXISTING WATER SUPPLY ENTITIES

B.1 INTRODUCTION

This appendix identifies and describes the various raw water suppliers and users within the study area, summarizes the operating practices of the entities that currently use the Gunnison River or its tributaries as a raw water source and briefly describes the physical raw water supply system that exists within the study area. The Colorado River Water Conservation District (CRWCD), while not a water supplier or user, has an interest in water development within the study area. A brief discussion of that entity and its interest in the study area is therefore also presented.

The information presented here was obtained primarily through interviews with water suppliers and users in the study area and with Water Commissioners from the various water districts located in the study area. The information obtained from the interviews was supplemented by:

1. Visual inspection of the major water diversion and conveyance facilities in the basin
2. Published data related to water rights and existing physical facilities
3. Knowledge of the study area gained from previous studies

B.2 WATER SUPPLIERS AND USERS

B.2.1 General

The following discussion contains an inventory of the existing water supply entities and their raw water delivery systems in the study area. Operating practices of these water suppliers are also discussed. Systems are categorized by their primary purpose as either regulatory, hydroelectric, agricultural, or municipal and industrial (M&I) in nature.

There is only one regulatory system in the study area at present, the Wayne N. Aspinall Unit of the Colorado River Storage Project (Aspinall Unit), formerly known as the Curecanti Unit. Although the Aspinall Unit produces a significant amount of hydroelectric power, it is classified herein as a regulatory system because it was constructed primarily to regulate Gunnison River flow. The Aspinall Unit is owned and operated by the United States Bureau of Reclamation (USBR).

The only commercial hydroelectric system in the study area is the Ouray Hydroelectric Facility. The Rocky Mountain Biological Laboratory operates a microhydro station but it generates power for use by the lab and is not discussed since it is not a commercial plant.

The primary agricultural entities in the study area are the Upper Gunnison River Water Conservancy District, the Uncompahgre Valley Water Users Association (UVWUA), and the Bostwick Park Water Conservancy District. There are also numerous private agricultural ditches in the study area.

The largest purveyor of M&I water in the study area is the Project 7 Water Authority, which treats and delivers water to the cities of Montrose, Olathe, and Delta, as well as to the rural water systems operated by Tri-County Water Conservancy District, Chipeta Water Company, and Menoken Water Company. M&I systems are also operated by the municipalities of Gunnison, Crested Butte, Ouray, and Ridgway. Other significant M&I water suppliers in the study area include Mt. Crested Butte Water and Sanitation District, Skyland Metropolitan District, and Lake City Area Water and Sanitation District.

Most of the water suppliers and physical facilities described herein serve a single-purpose type of water use or where more than one use is served, there is one use that predominates. For purposes of discussion, therefore, water suppliers and physical facilities have been classified by the predominant use they serve. For example, the Ridgway Reservoir at the Dallas Creek Project allocates approximately 25 percent of its stored water for agricultural purposes but is included in the M&I classification since that is the predominant allocation of its water.

B.2.2 Regulatory Facilities

B.2.2.1 Wayne N. Aspinall Storage Unit

The Wayne N. Aspinall Storage Unit (Aspinall Unit) forms a portion of the Colorado River Storage Project (CRSP) and is owned and operated by the USBR. This unit is comprised of three storage reservoirs located on the main stem of the Gunnison River. These reservoirs are: Blue Mesa, Morrow Point and Crystal.

The unit is located in Gunnison and Montrose Counties along the 40-mile section of the Gunnison River between the City of Gunnison and the Black Canyon of the Gunnison National Monument near the City of Montrose. Construction of the Aspinall Unit was authorized by Public Law 84-485 on April 11, 1956.

All of the four CRSP units, including the Apinall Unit, perform two major functions. Their primary function is to regulate streamflow so that water commitments to the Lower Colorado River Basin can be met in dry periods without curtailment of the development of water uses allotted to the Upper Basin. They also produce hydroelectric energy. Power revenues in excess of operating costs and reimbursable construction costs are available to assist in the repayment of CRSP participating projects; for example, the irrigation costs of projects that are beyond the payment ability of the irrigation water users. Transmission of the electric power to load centers is a cooperative effort of existing public and private utilities and the USBR. The combined power system of the storage units and participating projects is operated jointly by the Department of Energy's Western Area Power Administration (WAPA) and USBR's Power Operations Center in Montrose.

Flows of the Gunnison River are largely controlled by Blue Mesa Reservoir, the largest and uppermost of the three Aspinall Unit reservoirs. Water released through the Blue Mesa Powerplant receives short-term re-regulation by Morrow Point Reservoir and by Crystal Reservoir located immediately downstream. Water releases from Morrow Point are primarily for peaking power while releases through the Crystal Power Plant are uniform to satisfy downstream water rights and maintain a flow of 300 cfs through the Black Canyon of the Gunnison National Monument as long as the Blue Mesa Reservoir level is above minimum power pool.

The three Aspinall Unit power plants, with a total installed capacity of 208,000 KW, produce an average of 775 million KWh of electric energy annually. Switchyards at the power plants deliver the power into the WAPA transmission system which is interconnected with the other power-producing plants of the CRSP and participating projects, as well as with other Federal and private power systems. The electric energy is for sale to preference customers and others throughout the storage project market area.

In addition to power generation, the Aspinall Unit regulates the flow of the Gunnison River, thus providing benefits for flood control, minimum streamflow for fisheries, irrigation, and other uses.

Storage in the Aspinall Unit may be used to meet Colorado's commitments to the lower basin, thus permitting diversions by participating projects and others for irrigation, M&I, and other purposes in the Upper Gunnison sub-basin.

Releases from storage are made to the Uncompahgre Project by exchange with Taylor Park Reservoir. Water is also available by exchange for consumptive use upstream in the Upper Gunnison sub-basin above Blue Mesa Reservoir. The Aspinall Unit, however, does not provide releases from storage directly to irrigated lands and M&I users as is the case with other participating projects in the CRSP.

The reservoirs provide extensive recreational benefits, part of which occur within the adjacent Curecanti National Recreation Area. A mitigation program has been implemented to offset project-caused damage to fish and wildlife and also to provide for fish and wildlife enhancement. To date, this program has not been completely fulfilled and authorized but unappropriated Federal funds for the program have not been fully expended.

The following description of the unit's physical facilities is excerpted from the USBR Western Colorado Projects Review, March 1987 for the Aspinall Unit:

> **Blue Mesa Dam, Reservoir, and Power Plant.** Blue Mesa Dam is a compacted earth and rockfill structure, rising 342 ft above the streambed. It has a crest length of 800 ft and contains 3,085,000 cubic yards of material. The reservoir has a capacity of 940,800 af with a surface area of 14.3 square miles. The powerplant consists of two generating units with a combined capacity of 60,000 KW.
>
> **Morrow Point Dam, Reservoir, and Power Plant.** Morrow Point Dam is a double-curvature, thin-arch concrete structure. The crest is 418 ft above the streambed, 724 ft long, and 12 ft wide. The dam is 52 ft wide at the base and contains 365,000 cubic yards of concrete. The reservoir contains 117,000 af of water and has a surface area of 1.3 square miles at full pool. The power plant has two generating units with total capacity of 120,000 KW.

Crystal Dam, Reservoir, and Power Plant. The 225-ft high Crystal Dam is a double-curvature, thin arch structure. It is 29 ft wide at the base and 10 ft wide at the top, with a crest length of 635 ft. It contains 154,000 cubic yards of concrete. The 26,000 af capacity reservoir has a surface area of 0.5 square miles at full pool. The power plant has only one generating unit and is capable of producing 28,000 KW.

The general location of these project facilities is shown in Figures B.1.

B.2.3 Hydroelectric Facilities

B.2.3.1 Ouray Hydroelectric Facility

The Ouray Hydroelectric Power Plant was originally constructed in 1903 by the Ouray Electric Power and Light Company (OEP&L). In 1913 the OEP&L was integrated into the Western Colorado Power Company. The plant was taken out of service in 1972 due to a mechanical failure attributed to a lack of maintenance. In 1975, the Colorado Ute Electric Association (Colorado Ute) purchased the Western Colorado Power Company and its assets, including the Ouray hydro facility.

The facility is located on the Uncompahgre River and the powerhouse is located within the Town of Ouray (See Figure B.1). It is listed by the Federal Energy Regulatory Agency (FERC) as having an installed capacity of 700 KW with a gross head of 437 ft. It is a run-of-river type facility consisting of a diversion dam, penstock and powerhouse. Power is produced utilizing a Pelton type turbine.

Colorado Ute refurbished the plant and restarted commercial operation in 1983. They report (personal communication) that it is presently operating at 500 KW. The power produced by the plant is fed into the Colorado Ute distribution system.

B.2.4 Agricultural Water Suppliers

B.2.4.1 General

Agriculture has historically been the largest user of water within the study area. Extensive systems for the control and delivery of water for agricultural purposes have long been in existence in the study area. Development of irrigation systems in the Gunnison and Uncompahgre River Basins was well underway by the late 1800's. That development consisted of diversion dams, unlined canals and small reservoirs. The USBR became involved in developing Gunnison River water immediately upon its inception in 1902. The projects which were originally developed by the USBR in the area have since been turned over to local water supply entities for operation and maintenance. Project beneficiaries are in the process of repaying the USBR for construction costs. When repayment is complete, these entities may be able to obtain ownership of the projects.

The major agricultural water suppliers located in the study area are as follows: the Uncompahgre Valley Water Users Association, the Bostwick Park Water Conservancy District and the Upper Gunnison River Water Conservancy District. Each of these entities is individually discussed below.

In addition, there are many private ditches located in the study area. These ditches have been grouped by water district and stream for the purposes of presentation in this memorandum and are discussed below as consolidated groups.

B.2.4.2 Uncompahgre Valley Water Users Association (UVWUA)

The UVWUA is a non-profit corporation which was formed in 1903 for the general purpose of supplying irrigation water in the Uncompahgre Valley. The impetus for its formation was to serve as the local entity to participate in the USBR's Uncompahgre Project. It functions in a manner similar to a water conservancy district but was formed prior to the enabling legislation for such districts. The UVWUA obtains its water supply from the USBR-constructed Uncompahgre Project.

Beginning in 1903, the USBR began preparing final designs for a plan conceived several years earlier to supplement irrigation water supplies in the Uncompahgre Valley with Gunnison River water. Construction of the Uncompahgre Project began in 1904 with a tunnel to divert water from the Black Canyon of the Gunnison to the Uncompahgre Valley. The Gunnison Diversion Dam was constructed in 1912. Operation and maintenance of the diversion dam, tunnel and canal system was turned over to the UVWUA in 1932. The final major component of the project, Taylor Park Dam and Reservoir, was completed in 1937. Operation and maintenance of the Taylor facilities was turned over to the UVWUA shortly thereafter. Ownership of the system remains with the USBR. Rehabilitation and Betterment (R&B) loans to UVWUA have periodically been authorized for major maintenance items at the request of the UVWUA, with repayment terms at a low interest rate to be repaid over a period of 50 years. The following description of the project components is excerpted from the USBR Project Data Book (1981).

> The Uncompahgre Project is located on the western slope of the Rocky Mountains in west-central Colorado. Project lands surround the Town of Montrose and extend 34 miles along both sides of the Uncompahgre River to Delta, Colorado. Project features include Taylor Park Dam and Reservoir, the Gunnison Diversion Dam, Gunnison Tunnel, six diversion dams on the Uncompahgre River, 128 miles of main canals, 438 miles of laterals and 216 miles of drains. The system diverts water from the Uncompahgre and Gunnison Rivers to irrigate approximately 86,000 acres of project land.
>
> The project plan provides for storage in Taylor Park Reservoir on the Taylor River, which is a part of the Gunnison River Basin, and diversion of water from the Gunnison River by the Gunnison Diversion

Dam through the Gunnison Tunnel and the South Canal to the Uncompahgre River.

To distribute the waters of the Gunnison and Uncompahgre Rivers, the South and West Canals were constructed. Some of the larger existing private canals that take water directly from the Uncompahgre River were purchased and then enlarged and extended. Laterals were constructed to deliver water from the South Canal to project lands.

Principal project features are shown on Figure B.2 and are described as follows:

Taylor Park Dam and Reservoir. Taylor Park Dam is on the Taylor River, a tributary of the Gunnison River. The dam is a zoned earthfill structure 206 ft high, with a crest length of 675 ft and a volume of 1,115,000 cubic yards. It creates a reservoir with a storage capacity of 106,200 af. The spillway is an overflow type with a crest length of 180 ft and a capacity of 10,000 cubic yards. The outlet works consist of a horseshoe shaped tunnel with a diameter of 10 ft, and a capacity of 1500 cfs.

Gunnison Diversion Dam, Tunnel, and Canal System. The Gunnison Diversion Dam on the Gunnison River, about 12 miles east of Montrose, is a timber-crib weir with concrete wings and a removable crest. The dam has a structural height of 16 ft. It diverts Gunnison River direct flows, as well as releases from the Taylor Park Dam, into the Gunnison Tunnel.

The Gunnison Tunnel was designed as a rectangular section 11 ft wide and 12 ft high, with an arch shaped roof. A number of modifications have been made since the original construction. It is 5.8 miles long and tests performed in the spring of 1987 confirmed a maximum capacity of 1135 cfs.

The South Canal extends from the end of the Gunnison Tunnel for a distance of 11.4 miles to the Uncompahgre River. Part of the canal is concrete lined; the remainder is unlined. The canal has a capacity of 1010 cfs at its upstream end and serves an area of 7020 acres.

The West Canal begins near the terminal structure of the South Canal and extends generally northwest about 21 miles from the Uncompahgre River. This unlined canal has an initial capacity of 172 cfs and serves an area of 5750 acres. The West Canal is diverted directly from the South Canal and a timber and metal flume carries the canal across the Uncompahgre River. There is a small diversion for winter flows directly from the Uncompahgre River.

Montrose and Delta Diversion Dam and Canal. This diversion dam is on the Uncompahgre River about 8 miles south of Montrose. The dam is a concrete structure with radial control gates and a gated sluiceway. The unlined canal extends generally northwest about 40 miles from the diversion point and has a diversion capacity of 563 cfs. The canal serves an irrigated area of 25,250 acres. The original dam and canal were privately constructed and later purchased and rehabilitated by the USBR as part of the Uncompahgre Project. A new structure was built in 1963 and has a diversion capacity of 550 cfs.

Loutzenhizer Diversion Dam and Canal. The diversion dam is on the Uncompahgre River about 2 miles south of Montrose. It originally consisted of a pile and timber weir with a concrete apron but was rebuilt by the UVWUA into a concrete weir and apron with radial gates. The dam has a structural height of 24 ft. The canal extends generally northwest 14.5 miles from the diversion dam and has a diversion capacity of 120 cfs. This canal serves an area of 6200 acres. The original dam and canal were privately constructed and were purchased by the USBR in 1908.

Selig Diversion Dam and Canal. Selig Diversion Dam is on the Uncompahgre River about 5 miles northwest of Montrose. It has a sluiceway with timber gates and an uncontrolled concrete overflow weir and concrete stilling basin. Its structural height is 25 ft. The canal extends generally north about 20 miles from the diversion dam. This unlined canal has a diversion capacity of 320 cfs. This canal serves an area of 9960 acres. The original dam and canal were privately constructed and were purchased by the USBR in 1914.

Ironstone Diversion Dam and Canal. Located on the Uncompahgre River about eight miles northwest of Montrose, the Ironstone Diversion Dam is a concrete structure with a gated sluiceway and a concrete wing. The structural height is 7 ft. The unlined canal runs 14 miles northwest from the diversion dam. The diversion capacity is 400 cfs and this canal serves an area of 22,550 acres. The original dam and canal were privately constructed and were acquired by the USBR in 1915.

East Canal Diversion Dam and Canal. Located on the Uncompahgre River about 10 miles northwest of Montrose, the East Canal Diversion Dam is a concrete and timber weir with an earth embankment wing. The structural height is 16 ft. The unlined canal extends 10.6 miles north from the diversion dam. Its diversion capacity is 165 cfs and it serves an area of 7670 acres. The original dam and canal were privately constructed and were acquired by the USBR in 1911.

Garnet Diversion Dam and Canal. The diversion dam is on the Uncompahgre River about 15 miles northwest of Montrose. The dam is a concrete-faced rockfill weir, and has a structural height of 8 ft. Garnet Canal is unlined and extends 10.7 miles northwest from the diversion dam. Its diversion capacity is 75 cfs and it serves an area of 1590 acres. The original dam and canal were constructed by private interests and purchased by the USBR in 1914.

Lateral and Drainage Systems. There are 438 miles of laterals which distribute water to project lands. A system of subsurface drains totaling 216 miles has been constructed.

Water is diverted through the Gunnison Tunnel under Gunnison River direct flow rights and/or Taylor Park Reservoir storage rights. This water is distributed as needed through the project canal system. Additionally, the UVWUA holds Uncompahgre River direct flow rights. The water rights associated with each of the project features discussed above are shown in Table B.1

TABLE B.1

UVWUA Water Rights

Facility	Source	Quantity	Unit	Priority Date Range
Taylor Park Reservoir	Taylor River	111,260	af	1904
Gunnison Tunnel	Gunnison River/ Taylor Park Res.	1,300	cfs	1901
M&D Canal	Uncompahgre River	627.09	cfs	1882-1888
East Canal	Uncompahgre River	85.08	cfs	1882-1888
Ironstone Canal	Uncompahgre River	202.22	cfs	1882-1888
Garnet Canal	Uncompahgre River	93.33	cfs	1883-1888
Selig Canal	Uncompahgre River	86.64	cfs	1883-1888
Loutsenhizer Canal	Uncompahgre River	102.83	cfs	1883-1888

The UVWUA also has entered into an agreement to purchase up to 11,200 af of supplemental irrigation water from the Dallas Creek Project. That project is discussed in Section B.2.5, Municipal and Industrial Water Users.

B.2.4.3 **Bostwick Park Water Conservancy District (BPWCD)**

The BPWCD was formed in July 1962 for the purpose of serving as the local entity that would enter into a repayment contract with the USBR for the Bostwick Park Project. The BPWCD's charge is to supply irrigation water to the Bostwick Park area located about eight miles east of Montrose (See Figure B.2). The area obtains its water supply from the USBR-constructed Bostwick Park Project.

The Bostwick Park area was settled in the early 1880's, followed by a second influx at the time of irrigation development in 1910. By 1930, the population had reached a peak of 75 to 80 families, but in 1960 it decreased to about 40 families due to the trend toward larger farm units, use of modern labor-saving farm equipment, and drought conditions.

The USBR first reported on the Bostwick Park Project in a reconnaissance report on the Gunnison River Project. The project was authorized as a participating project of the Colorado River Storage Project by Public Law 88-568, September 2, 1964 (78 Stat. 852).

Construction commenced at Silver Jack Dam late in 1966 and was completed in 1971. Silver Jack Reservoir was filled on June 10, 1971, and project water was made available to supplemental service lands from existing ditches on a water rental basis during the 1971, 1972, and 1973 irrigation seasons. A negative declaration of environmental impact was filed July 21, 1972, for drainage rehabilitation and for replacement of the Vernal Mesa conduit. Construction of these facilities was completed during fiscal year 1974.

The following description of the Bostwick Park project is excerpted from the USBR Publication, Project Data (1981a):

The Bostwick Park Project is in west-central Colorado near the City of Montrose. The project develops the flows of Cimarron Creek, a tributary of the Gunnison River, for irrigation and for benefits to sports fishing and recreation. A full and supplemental supply of irrigation water is available for 5180 acres of land. Recreation opportunities and important fishery benefits are provided at Silver Jack Reservoir.

Storage regulation is provided by Silver Jack Dam and Reservoir, constructed on Cimarron Creek. Project water is released from the reservoir to Cimarron Creek. The releases, along with usable natural flows, are diverted from the creek into the Cimarron Canal at a point approximately 2.5 miles below the dam and conveyed 23 miles to the vicinity of the project lands. The Cimarron Canal is a privately owned and operated facility and is not a component of the Bostwick Park Project. Some water is released from the canal and used on lands in the Cimarron area. Most of the water is conveyed to the canal terminus at Cerro Summit and then delivered to the Hairpin and Vernal Mesa Ditches. The Bostwick Lateral diverts water from the Vernal Mesa Ditch and conveys it across Bostwick Park through an 18-inch siphon to lands above the West Vernal Mesa Lateral.

Principal project features are described as follows:

Silver Jack Dam and Reservoir. Silver Jack Dam is located on Cimarron Creek about 20 miles above its junction with the Gunnison River. The rolled-earthfill dam has a structural height of 173 ft. Its crest is 1050 ft long and 30 ft wide. Total volume is 1,278,140 cubic yards of material. The outlet works to Cimarron Creek in the right abutment has a capacity of 280 cfs with the reservoir at the normal water surface elevation of 8926.0 ft and a capacity of 160 cfs at the minimum water surface elevation of 8840.0 ft. The spillway on the right abutment is an uncontrolled ogee section with a capacity of 6220 cfs at maximum water surface elevation. The reservoir has a total capacity of 13,520 af, including 12,820 af of active capacity and 700 af of inactive capacity. When filled to its normal water surface elevation, the reservoir has a surface area of 293 acres.

Bostwick Lateral and Drains. The 3.6-mile Bostwick Lateral was constructed to deliver water to full service lands above the West Vernal Mesa Lateral. Repair, extension, and some new construction of about 7.2 miles of drains were completed by the BPWCD.

The principal project features discussed above are shown in Figure B.2.

Project irrigation facilities were turned over to the Bostwick Park Water Conservancy District for operation and maintenance on January 1, 1976. As in the case of the Uncompahgre project, title to the Bostwick Park project remains with the USBR.

B.2.4.4 **Uncompahgre Valley Private Ditch Systems**

Irrigated lands in the Uncompahgre Valley are served by privately owned ditches as well as by the Uncompahgre Project facilities. Most of these ditches were constructed in the early 1900's and have water rights with appropriation dates of 1916. Many of the major ditches have additional decrees from a mass filing in 1942. These ditches are discussed below, grouped by Water District, and are shown in Figure B.3. The information presented below was obtained from the State Engineers Division office in Montrose and interviews with District Water Commissioners.

Water District 68

Water District 68 is contiguous with Ouray County. It comprises the upper half of the Uncompahgre watershed and contains 23,000 irrigated acres served by 175 ditches. Most of this acreage is in the vicinity of Ridgway, where the Uncompahgre River, Dallas Creek, and Cow Creek converge.

Uncompahgre River Ditches. On the mainstream of the Uncompahgre River above Colona and on its minor tributaries there are more than 90 ditches serving about 8000 acres of land. Among the larger ditches and their approximate capacities are McDonald Ditch (30 cfs), Moody #1 Ditch (30 cfs), Park Ditch (20 cfs) and Pinion Ditch (20 cfs).

Dallas Creek Ditches. Nearly 8000 acres are irrigated in the Dallas Creek watershed. Some of the larger of the 35 Dallas Creek ditches are the Dallas Ditch (40 cfs capacity), Hyde Sneva Ditch (20 cfs), the Doc Wade Ditch (20 cfs), and the Hosner Rowell Ditch (25 cfs).

Cow Creek Ditches. The Alkali Ditch #1, Alkali Ditch #2, and Sneva Ditch are the largest of the 45 Cow Creek ditches. The total irrigated acreage on Cow Creek is 3300.

Water District 41

The lower Uncompahgre River basin is in District 41, which is the most heavily populated of the districts in the study area, although it is among the smallest. In addition to the large canal and lateral systems of the Uncompahgre Project, District 41 contains 79 private ditches serving 14,000 acres of irrigated land. Some of the larger of these ditches are the Ouray Ditch (22 cfs) south of Montrose, the Eagle Ditch (30 cfs) southeast of Olathe, and the Boles and Manney (20 cfs) and the Chipeta Beaudry Ditches (20 cfs) south of Delta.

B.2.4.5 **Upper Gunnison River Water Conservancy District**

The Upper Gunnison River Water Conservancy District (UGRWCD) was formed on July 9, 1959 for the purpose of protecting and conserving the water resources of the Upper Gunnison River Basin. The UGRWCD is administered pursuant to Article 45 of Title 37 of the Colorado Revised Statutes, otherwise known as the Water Conservancy Act of Colorado.

The UGRWCD's activities are administered by a Board of Directors who represent agricultural, municipal, and other groups interested in the beneficial use of water, who are property owners, and who legally reside in the District. The directors are appointed to four year terms by the local district court.

Since its inception, the UGRWCD has represented the interests of the Upper Gunnison Basin in negotiations with the Bureau of Reclamation concerning the size, location, and benefits to be derived from the development and operation of Blue Mesa, Morrow Point, and Crystal Reservoirs. In the 1960's, the UGRWCD served as the local sponsoring agency for the proposed Upper Gunnison Project which was studied at a reconnaissance level by the USBR. The District holds conditional water rights for proposed water storage and conveyance facilities throughout the basin including a number of those addressed in the Upper Gunnison Project studies.

The UGRWCD has also historically served to represent and protect the interests of the Upper Gunnison Basin in connection with proposals by others to develop out-of-basin diversions.

At the present time, the UGRWCD does not operate water facilities from which water assessments or water sales are made. The majority of its revenues are derived from property taxes which are levied against the total assessed valuation of all property within the District. The UGRWCD's Board of Directors is authorized to establish the necessary mill levy within limits set by State laws to meet the District's revenue requirements.

B.2.4.6 **Upper Gunnison Private Ditch Systems**

All irrigated lands above Crystal Reservoir are served by private ditches and reservoirs, with the exception of the Bostwick Park Project lands. Information pertaining to the private ditch system and the acreage served by private ditches was obtained from the State Engineers Office in Denver, the Division Engineers Office in Montrose, Water Commissioners, the USBR and the SCS. Minor discrepancies were contained in the data obtained from the various sources. The data contained in the 1978 ditch inventory carried out by the SCS is considered to be reliable and is within 5% of the USBR's figures. The information presented below is based mainly on the USBR inventory and is considered to be representative of present conditions in the Upper Gunnison Basin. The USBR figures were selected for use in this study because that data is more detailed with respect to land classification. Descriptions of these private facilities are grouped by water district, and further subdivided by stream. Water District 28 includes Tomichi Creek, Quartz Creek, and Cochetopa Creek; District 59 includes Ohio Creek, Slate River, East River and Taylor River; and District 62 includes Big Blue Creek, Cebolla Creek, Cimarron River, and Lake Fork of the Gunnison River.

The water districts and the ditches discussed below are shown on Figure B.4.

Water District 28

The Tomichi Creek basin is situated in the southeastern extremity of the Gunnison watershed. The major tributaries of Tomichi Creek are Cochetopa and Quartz Creeks.

Tomichi Creek. More than 150 ditches serve approximately 16,600 irrigated acres in the Tomichi Creek drainage, including Razor Creek, Needle Creek, Marshall Creek, Hot Springs Creek, and Stubbs Gulch. The largest of these ditches, all on Tomichi Creek, with their respective approximate capacities are: Arch Ditch (130 cfs), Biebel #1 and #2 Ditches (60 cfs), Pioneer Ditch (62 cfs), Owen Redden Ditch (45 cfs), McCanne Ditch #2 (45 cfs), Gullet Tomichi Ditch (45 cfs), and S. Davison and Co. Ditch (80 cfs). All of these ditches have original adjudication dates of 1894, with additional decrees dated 1943. The majority of the irrigated acreage lies in the Tomichi Valley between Gunnison and Sargents.

Quartz Creek. More than 40 ditches in the Quartz Creek drainage serve approximately 2500 irrigated acres north of Tomichi Creek from Parlin to Pitkin. The major ditches in terms of their estimated capacities are: Parlin Quartz Creek Ditch (22 cfs), Tornay Highline Ditch (22 cfs), the Lockwood Mundell Ditch (18 cfs), and Chittenden Ditch (27 cfs). The Lockwood Mundell Ditch has a priority date of 1904 for 10.6 cfs, with an additional decree for 40 cfs in 1943. The others have adjudication dates no earlier than 1943.

Cochetopa Creek. The valleys of Cochetopa Creek have more than 80 ditches serving approximately 5700 irrigated acres located due south of Parlin. The major ditches are in the Upper Cochetopa Valley at the junctures of West Pass Creek, Los Pinos Creek, and Pauline Creek. These ditches and their estimated capacities are: Mesa Ditch (75 cfs), Government Ditch (45 cfs), McDonough Ditch (35 cfs), Smithford #2 Ditch (42 cfs), and Perry Irrigation Ditch (24 cfs). The Government and McDonough Ditches are on Los Pinos Creek, while the others are on the Upper Cochetopa. Water rights for the Perry and Government Ditches date back to 1904, the Mesa Ditch to 1918, the McDonough Ditch to 1943, and the Smithford Ditch to 1961.

Water District 59

Water District 59 is comprised of the area draining into the Gunnison River from the north to as far downstream as Morrow Point Dam. Its major streams are Ohio Creek, the East River, and the Taylor River.

Ohio Creek. Situated north and slightly west of Gunnison, approximately 10,700 acres are irrigated in the Ohio Creek basin. Ohio Creek has approximately 100 operating irrigation ditches, although most are quite small. The primary ditches and their approximate capacities are: May Bohm (70 cfs), Harris Bohm Potato Ditch (40 cfs), Teachout Ditch (50 cfs), Acme Ditch (70 cfs) and Lone Pine Ditch (80 cfs). Original decrees are dated 1906 and supplemental decrees dated 1941 comprise the majority of the water rights on these ditches.

A relatively small basin compared to the acreage irrigated, its steep slopes and relatively tight soils result in a rapid runoff with severe late season water shortages. Stringent water management practices are required and ranchers practice a self-regulated rotational system for applying irrigation water.

East River. The East River Valley located north of the City of Gunnison contains about 6000 acres of irrigated lands served by 36 ditches. The major ditches are: East River #1 Ditch (120 cfs), East River #2 Ditch (75 cfs), Lafayette Ditch (60 cfs), Verzuh Ditch (60 cfs), and Verzuh Young Bifano (50 cfs). The East River ditches have original decrees dated 1906 with additional decrees dated 1941.

Slate River. A tributary to the East River, the Slate River is utilized to irrigate about 1300 acres from 13 ditches. The most significant of these are the Dillsworth Ditch (50 cfs), and the Bocker Ditch (50 cfs). Original decrees for these ditches are dated 1904, with additional decrees dated 1941.

Taylor River. The Taylor River supplies nine ditches serving 360 acres in the Taylor Park area, located about 30 miles northeast of Gunnison. The 1985 diversion records indicate that 76 percent of the 4300 af of water diverted for irrigation was carried by the Redden Elsinore Ditch (50 cfs), and the Spring Creek Irrigating Ditch (50 cfs). Original decree dates are 1916 and 1921, respectively, with an additional decree for the Spring Creek Ditch dated 1941.

Gunnison River. From Almont to Gunnison there are about 50 ditches originating on the Gunnison River which serve a total of 6500 acres. Among the most significant of these ditches are: Gunnison River-Ohio Creek Irrigating Ditch (110 cfs), Gunnison-Ohio Creek Canal (100 cfs), Kelmel Owens #1 Ditch (95 cfs), Gunnison Town Ditch (80 cfs), and Gunnison-Tomichi Valley Ditch (60 cfs). Water rights for these ditches were originally adjudicated in 1906 with additional decrees granted in 1941.

Water District 62

District 62 is located south of the Gunnison River and is bounded by the Cimarron Ridge (Ouray County line) on the west, the Continental Divide on the south, and the Tomichi Creek Basin on the east.

Cebolla Creek. Located on the eastern side of the District, Cebolla Creek provides irrigation water to 4600 acres of land through a system consisting of 78 ditches. Most are quite small compared with those previously discussed, with only three ditches having a capacity in excess of 10 cfs; the Big Ditch (30 cfs), the M,B and A Ditch (20 cfs), and the Rudolph Irrigating Ditch (10 cfs). Capacities and actual flows are estimated, since none of the ditches have flow measuring devices. Original water rights were decreed in 1905, with additional decrees granted in 1941.

Lake Fork of the Gunnison. The Lake Fork of the Gunnison flows north through the center of District 62. Due to unfavorable topography, only 1600 acres of this drainage are irrigated. Of its 83 ditches, the largest is the Lake Fork Ditch with a 10 cfs capacity. All other Lake Fork ditches have capacities less than 10 cfs. There is no flow measurement on any of the Lake Fork ditches. The original water rights decrees are dated 1905, with additional decrees dated 1941.

Big Blue Creek. Big Blue Creek provides water to 11 ditches serving about 1000 acres. The largest ditch by far is the Big Blue Ditch with a 66 cfs decree and a capacity of 50 cfs. A rectangular weir is used for flow measurement. Its original decree is dated 1913, with additional decrees dated 1941 and 1960.

Big Cimarron River. Along the western extremity of District 62 is the Big Cimarron River, which supplies irrigation water to more than 8000 acres from 58 ditches. Most of this acreage is located in the previously described Bostwick Park Project. The key component in delivering project water from Silver Jack Reservoir to the Bostwick Park service area is the Cimarron Canal, decreed for 185 cfs and with a capacity of 145 cfs (personal communication with Water Commissioners). The Cimarron Canal is privately owned and also serves land outside of the Bostwick Park Project. Cimarron Canal decrees are dated 1905 (60 cfs), 1913 (39 cfs) and 1941 (86 cfs).

Other private ditches are McKinley Ditch (38 cfs capcity), Butte and Butte Extension Ditch (20 cfs), and Collier Ditch (10 cfs), all of which are on the Little Cimarron River and the Veo and McMinn Ditches on the Big Cimarron River. These ditches have original decrees dated 1905 and additional decrees dated 1941 except the Butte, which has a relatively junior 1928 decree.

The Big and Little Cimarron Rivers generally experience late summer water shortages.

Gunnison River. Approximately 2000 acres located in District 62 are irrigated by about 50 ditches originating on the Gunnison River or the tributaries of South Beaver Creek, Willow Creek, Soap Creek, Stueben Creek and Pine Creek. Among the largest of these are the Frank Adams #2 Ditch (40 cfs), Cooper #2 Ditch (30 cfs), and Cooper Ditch (20 cfs). These ditches all have their diversions on the Gunnison River between Gunnison and Blue Mesa Reservoirs, with original decrees dated 1905 and additional decrees dated 1941.

B.2.5 Municipal and Industrial Water Users

B.2.5.1 General

Municipal and industrial (M&I) water use is relatively small in the study area in comparison to the total water use. The M&I water and wastewater treatment facilities located in the study area are shown in Figure B.5.

The primary M&I water suppliers within the study area are the Project 7 Water Authority; the municipalities of Gunnison, Crested Butte, Ouray and Ridgway; Mt. Crested Butte Water and Sanitation District; Skyland Metropolitan District; and the Lake City Area Water and Sanitation District. Each of these water suppliers is discussed below.

In addition, there are many small M&I water suppliers in the basin. These entities will be discussed as a group.

B.2.5.2 Project 7 Water Authority

Project 7 Water Authority (Project 7) was created for the purpose of having one treated water supplier to serve the Uncompahgre Valley area.

The seven participating entities are: City of Montrose; City of Delta; Town of Olathe; Tri-County Water Conservancy District (Tri-County); Chipeta Water Company; Menoken Water Company and Uncompahgre Valley Water Users Association (UVWUA). Under the present operating scheme, Project 7 treats and delivers water to all the participating agencies except UVWUA. These agencies then distribute the treated water to their customers. The UVWUA, as described previously in this section, is a purveyor of untreated rather than treated water.

Project 7 went into operation in 1980 after acquiring and enlarging the Montrose Water Filter Plant, and constructing a 25-mile transmission pipeline (18 to 30 inches in diameter) along Highway 50 from Montrose to Delta. The water plant presently has a 26 mgd capacity, and in 1986 operated at an average rate of 5.1 mgd, treating a total of 5690 af of water for the participating entities (See Table B.2).

Project 7 does not own water rights nor does it have taxing authority, but is reimbursed monthly by the participants for the quantity of water treated and delivered to them. At present, raw water is purchased by each entity from Tri-County, who in turn purchases water from the UVWUA under an interim contract until the Dallas Creek water supplies are avilable. In addition, the City of Montrose obtains part of its raw water supply from the Cimarron Ditch and Reservoir Company and delivers it to Project 7 for treatment. The UVWUA water is fed by gravity from the Gunnison Tunnel and South Canal to Fairview Reservoir, which is a 500-af water storage reservoir owned and operated by Project 7. The Cimarron Ditch water is stored in Montrose Reservoir (previously called Cerro Reservoir) and then conveyed by pipeline to Fairview Reservoir. Both the 800 af Montrose Reservoir and the pipeline from Montrose to Fairview Reservoir are owned by the City of Montrose. Other water supply facilities which were previously operated by the participants are no longer in use but are kept operational for backup purposes.

Tri-County is the sole purveyor of water from the USBR's Dallas Creek Project. Of the 39,400 af of water available from that project 28,100 af is allocated for M&I use, 11,200 af is allocated for irrigation and 100 af is allocated for recreation. Tri-County has commitments from Montrose, Delta and Olathe to purchase 14,000 af Dallas Creek water. Present plans are that the Dallas Creek M&I water will be marketed through Project 7, however that is not a requirement of Tri-County's agreement with the USBR and could change. A description of the Dallas Creek Project is presented in a subsequent section of this appendix.

Project 7 does not have responsibility for delivering peak hourly demands. Once past the master meters, the individual entities are responsible for storage of demands in excess of average daily requirements, for distributing water to the end users, and for maintenance of their own distribution systems.

Following is a brief synopsis of the participating entities:

City of Montrose

Service Area:	5 square miles
Number of Taps:	2577 residential (100 outside city limits) 667 commercial
Storage:	3.0 million gallons
1986 Water Use:	2545 af
Water Rights:	100 cfs in Supply Ditch, used for irrigation Commitment to purchase 10,000 af of Dallas Creek Project water; 80 shares Cimarron Ditch and Reservoir Company delivered to Project 7 for M&I use

City of Delta

Service Area:	4 square miles
Number of Taps:	1966 residential (705 outside city limits) 402 commercial
Storage:	5.0 million gallons
1986 Water Use:	1452 af
Water Rights:	Commitment to purchase 3700 af of Dallas Creek Project water

Town of Olathe

Service Area:	1 square mile
Number of Taps:	450 residential 50 commercial
Storage:	None (draws peak hourly demands from Tri-County)
1986 Water Use:	166 af
Water Rights:	Commitment to purchase 300 af of Dallas Creek Project water

Tri-County Water Conservancy District

Service Area:	200 square miles
Number of Taps:	3270 total taps
Length of Pipeline:	335 miles
Storage:	3.15 million gallons
1986 Water Use:	1113 af
Water Rights:	Commitment to purchase 14,100 af of Dallas Creek Project water Conditional storage rights for Ramshorn (25,349 af), Sneva (823

af) and Dallas Divide (17,600 af) Reservoirs

Chipeta Water Company

Service Area:	35 square miles
Number of Taps:	790 total taps
Length of Pipeline:	60 miles
Storage:	1.15 million gallons
1986 Water Use:	217 af
Water Rights:	6 wells, total 1.27 cfs, decreed in 1974 and 1975

Menoken Water Company

Service Area:	40 square miles
Number of Taps:	598 total taps
Length of Pipeline:	62 miles
Storage:	0.1 million gallons
1986 Water Use:	198 af
Water Rights:	Decrees for 1.0 cfs in 1970 and 2.0 cfs in 1975 for springs

B.2.5.3 Dallas Creek Project

The Dallas Creek Project was authorized by the Colorado River Basin Act of September 1968 (Public Law 90-537) as a participating project under the Colorado River Storage Project Act of April 1956 (Public Law 84-485). The repayment contract between the Tri-County Water Conservancy District and the United States was approved by the voters in Ouray, Montrose, and Delta Counties in an election held December 21, 1976, and was validated March 1, 1977.

The Dallas Creek Project is a multipurpose water storage project located in the Upper Uncompahgre River Basin near the Town of Ridgway. The primary purpose of the project is to provide M&I water to the region (28,100 af). The other project purposes are irrigation (11,200 af) and recreation (100 af). The key element of the project is Ridgway Dam which was completed in early 1987. It is expected to take four years to fill the reservoir created by the dam. The project was planned and constructed by the USBR but will be administered, and ultimately owned by the Tri-County Water Conservancy District.

The Dallas Creek Project consists of the Ridgway Dam and appurtenant structures (See Figure B.2). The dam is an earthfill structure with an embankment volume of 9,191,000 cubic yards and a height of 227 ft above streambed. The dam crest is 2430 ft long and 30 ft wide. The surface area of the reservoir at normal water surface elevation if 6871.3 ft is approximately 1030 acres.

The appurtenant structures consist of a two-level outlet works and a morning glory type spillway. Provisions have also been incorporated into the outlet works to allow for the installation of a 4.2 MW hydroelectric generating plant in the future.

B.2.5.4 City of Gunnison

The City of Gunnison has a present population of about 6000, nearly half of which are students enrolled at Western State College. The service area of the city's water distribution system is essentially the city limits, approximately 3 square miles in size.

To date, the City's domestic water needs have been met by tapping ground water supplies flowing through the pervious surficial deposits resting in an ancient streambed running north and south beneath the city at approximately 9th Street. The water is extracted by a series of nine wells operated in a sequence dictated by system demands. Depth of the wells is typically less than 100 ft. The City has water rights for these wells that total approximately 14 cfs. Conditional groundwater decrees have been acquired for the future construction of four additional wells.

Water quality of the well field is such that, with the exception of Well #4, the water need only be chlorinated before entering the system. Because filtration is required on Well #4, it is used strictly in a backup mode.

The city's water system is used almost exclusively to meet potable water demands. Lawn and garden irrigation requirements are, for most of the city, met by a separate surface irrigation water system containing untreated water supplied by the Gunnison Town Ditch. Domestic water taps are metered, with the college being the largest user of domestic water. The city has no industrial customers who are significantly large water users.

There is a tendency for the aquifer to be depleted through the winter months because of reduced recharge rates. This is due to frozen ground and the cessation of surface irrigation. With domestic water requirements gradually increasing, a deficiency in the ground water supply is projected for the future. Studies conducted over the past several years have been aimed at enabling the city to posture itself for development of surface water supplies at the appropriate time in order to avert a critical shortage. The latest study, completed by WRC Engineering, Inc. (1981) recommends converting to a surface water supply using the existing O'Fallon Ditch diversion on the Gunnison River below Almont to deliver water to a new 5 MGD water treatment plant. The proposal also includes 40,000 ft of 24-inch transmission line. The city has a conditional decree (1957 adjudication) for 10 cfs of O'Fallon Ditch water to be used for non-irrigating purposes. That recommended development has not been implemented to date because near-term water supplies are considered to be adequate. The most pressing immediate need is for 2 million gallons of additional storage to supply peak demands during periods of well system deficiencies.

The city also holds the following water rights:

> Gunnison Town Ditch: This decree was adjudicated in 1906 for 64 cfs. The original decree was for irrigation purposes but municipal use has been added recently.
>
> Gunnison Town Pipeline and Reservoir: This decree includes 15 cfs diversion and 0.75 af of storage. It was originally appropriated in 1888 for irrigation and in 1913 for purposes other than irrigation. The decree was adjudicated in 1941.
>
> Gunnison Reservoirs 1, 2, 3, and 4: Three conditional storage decrees represent a total, aggregate storage value of 84,000 af and have an adjudication date of 1981.

Additionally, the city entered into a contract with the proposed Union Park Project proponent, Natual Energy Resources Company, to purchase 1000 af of water annually when that project is constructed. The contract also provides the option to purchase another 2000 af of water annually and the right to purchase up to 12,000 af of storage in the first phase of the Union Park Reservoir (total storage capacity of 900,000 af).

B.2.5.5 Town of Crested Butte

The Town of Crested Butte is an historic mining town with an economy presently based on recreation and tourism generated by its historic attractions and the nearby ski area at Mt. Crested Butte. Approximately one square mile in size, the town maintains a population of 1000 to 1600, varying seasonally, and reaching its peak during the ski season.

The town's water supply system consists of a diversion dam and intake structure on Coal Creek approximately three miles west of town. The water right for this system is for 6 cfs with an adjudication date of 1941. A package filter plant was installed about 20 years ago and is capable of treating up to 1.0 MGD except during spring runoff periods when raw water turbidity is high. The plant is marginally adequate with typical daily treated flows ranging from 0.5 to 1.0 MGD, and may soon require upgrading. Another of the town's concerns is that significant leakage may be occurring in the distribution system which, if identified and corrected, may alleviate the loading problem on the water treatment plant. The system has storage capacity of 10 million gallons of raw water and 0.5 million gallons of treated water.

B.2.5.6 **Mt. Crested Butte**

Mt. Crested Butte Water and Sanitation District

The incorporated Town of Mt. Crested Butte has its own municipal water supply system which is operated by the Mt. Crested Butte Water and Sanitation District. Its water source is a combination of surface water from the East River and springs located on the north side of Crested Butte Mountain. Water rights include East River direct flows of 1.0 cfs (1961), 3.0 cfs (1965) from springs, Malensek Ditch rights of 6.0 cfs (1924), Vuds Ditch rights of 4.0 cfs (1924), and Malensek #5 Ditch rights of 7.0 cfs (1961). An augmentation plan is now being developed in connection with the ski area developer's proposed "North Mountain" expansion. A 700-af conditional decree was obtained in 1983 for the proposed North Village Reservoir. The District's service area is about 840 acres. Present permanent population is 330 with a seasonal employment force of 1200 and peak day visitor count of 7800 (personal communication with Director of Planning for Mt. Crested Butte).

Within the past two years, a new 1.2 MGD package water treatment plant has been constructed and is on line, giving the District sufficient capacity to accommodate peak demands for the next several years.

Crested Butte Mountain Resort

During the 1987-1988 ski season, the Crested Butte Mountain Resort (CBMR) will have 755 acres of lift-served skiing on Crested Butte Mountain. A snowmaking system is operated by CBMR on Crested Butte Mountain which serves 175 acres. There are no plans at present for any major increase of the snowmaking system.

Crested Butte Mountain Resort is planning a major ski area expansion into Crested Butte North Mountain (Snodgrass Mountain) which lies to the north of the existing ski area development.

A snowmaking system planned for North Mountain will serve approximately 200 acres (Gus Larkin interview, September 14, 1987). In the summer of 1985, CBMR completed construction of a primary pump station on the East River for the purpose of delivering water to its existing snowmaking operation on Crested Butte Mountain and to provide water for the proposed snowmaking system on North Mountain. The pump station is located adjacent to the diversion point for the Crested Butte Water and Sanitation District. Its present capacity for serving Crested Butte Mountain is approximately 5 cfs. This capacity will be approximately doubled when the North Mountain ski area is developed.

Crested Butte Mountain Resort holds an absolute decree of 4.55 cfs and a conditional decree of 1.45 cfs for snowmaking on Crested Butte Mountain. Both decrees were adjudicated in 1981. CBMR's snowmaking operation is covered under a USFS Special Use Permit. According to the terms of an agreement reached between the Colorado Division of Wildlife and CBMR, which is attached to the USFS Special Use Permit, CBMR is required "to utilize its best efforts to maintain not less than 7 CFS of flow in the East River, and to minimize the duration of its diversions which cause said flow to fall below 7 CFS at the point of diversion of the pump station of the Crested Butte Water and Sanitation District." CBMR operates streamflow measuring equipment in the East River to monitor instream flows.

CBMR also holds a conditional water right for snowmaking on Crested Butte North Mountain in the amount of 5.0 cfs which was adjudicated in 1982. CBMR is limited to making its diversions between October 1 and April 30 in its snowmaking decrees.

B.2.5 7 **Skyland**

The Skyland development and resort which is located south of Crested Butte has its own water supply system, operated by the Skyland Metropolitan District. Covering 600 acres, the District currently serves about 50 homes in addition to the resort and clubhouse. Taps are unmetered and water is billed at a flat rate. The system is fed by the Decker Ditch springs with the collection system located in the mountainside along the east side of the development. The water right on these springs is for 1.875 cfs, adjudicated in 1924. Water is collected in a wetwell, then chlorinated and pumped to distribution. The resort includes an 18-hole golf course which has a separate irrigation system with water pumped out of Lake Grant. Natural springs are the source of water for the Lake Grant.

B.2.5.8 **Lake City**

The water supply system for Lake City is operated by the Lake City Area Water and Sanitation District and serves a population of 500. The primary water supply comes from two wells with pumping capacities of 750 gpm and 500 gpm. An infiltration gallery in Henson Creek feeds another 750 gpm pump to provide an emergency backup supply. Filtration is not required and taps are unmetered. Significant distribution system losses are indicated by flow patterns at wastewater lagoons.

Water rights are very junior, and an augmentation plan has been developed. The original Lake City pipeline was decreed for .0983 cfs in 1913. Subsequent filings totalling 7.0 cfs have been made with the earliest filing dated 1969.

B.2.5.9 **Ouray**

Originally a mining town on the upper Uncompahgre River, Ouray has a permanent population of about 800, primarily engaged in providing tourist and recreation related services. High quality spring water from the Canyon Creek drainage south of town is transported by gravity through a 10-inch pipeline and provides an adequate water supply for Ouray's water needs. A 0.5 million gallon storage tank on the transmission line regulates pressure and supplies peak and emergency demands. Chlorine is added downstream of the tank.

B.2.5.10 **Ridgway**

The Town of Ridgway is an agricultural community on the upper Uncompahgre River. Covering 650 acres, it has a present population of just under 400. Ridgway's water rights were decreed in 1916 and allow a diversion of 7.0 cfs out of Beaver Creek, a tributary of Dallas Creek, at a point approximately 7 miles south of town. The water is then conveyed by 4 miles of open ditch to Lake Otonowanda. An 8-inch and 10-inch pipeline constructed in 1980 conveys the water from the lake approximately 2 miles to the water treatment plant, which was also constructed in 1980.

Water quality is excellent at the point of diversion, but is badly degraded along the open ditch segment of the system. Serious operation and maintenance problems restrict usage of the Ridgway Ditch during the winter, at which times Lake Otonowanda is used to maintain a constant supply to the town. Capacity of the lake is roughly estimated at 60 af. In addition to the lake, there is a series of three pre-sedimentation ponds with a total capacity of 55 af at the water treatment plant.

Much of the distribution system was replaced in 1980 with PVC pipe, along with construction of a 300,000 gallon steel tank for treated water storage. The overall condition and capacity of the water system should accommodate the town's water needs for up to a 50% increase in peak demands, according to a study done by Consolidated Consulting Services (1985).

B.2.5.11 **Other M&I Entities**

There are a number of other small M&I water supplies that exist in the basin. Among these are the towns, resorts and developments of Sargents, Pitkin, Parlin, Ohio, Whitepine, Waunita Hot Springs, Almont, Gothic, Tincup, Crested Butte South, Riverbend, Meridian Lake Park, Cimarron and Colona. Whereas Colona is served by the Tri-County system, the others each have their own wells and/or springs for water supply. Many homes, stores, restaurants, etc. have individual private wells or springs. Otherwise, small distribution systems are fed by one or more springs, wells, or a combination thereof.

B.2.5.12 **Curecanti National Recreation Area**

The National Park Service administers the Curecanti National Recreation Area under the authorization of the Colorado River Storage Project Act. The act provides that recreational, fish and wildlife facilities may be operated consistent with the primary purposes of the Aspinall Unit. Included within the recreation area is an administration facility, visitors center, marina, and campground located at Elk Creek, a marina and campground at Lake Fork, and nine other campgrounds or picnicking facilities where water supplies are available.

Water Use

Water supplies of the Elk Creek complex serve the administration building, visitors center, marina and 180 campsites and are currently provided from surface and ground water sources. At Elk Creek, summertime peak water use is approximately 100,000 gpd. Water use on an average summer day is approximately 60,000 gpd and on an average winter day is approximately 16,000 gpd. Elk Creek #1 is an electrically pumped well that provides approximately 16,000 gpd of good quality water. The remainder of the Elk Creek water supply needs are met by surface water supply from Blue Mesa Reservoir. Water drawn from the reservoir occasionally has difficulty meeting standards for turbidity. Future plans are to completely replace the surface water supply system at Elk Creek with an expanded well system that will meet all of the area's M&I needs and eliminate the problem of turbidity.

Water supplies at the Lake Fork Marina serve the marina and 90 campsites and have been provided from a 10,000 gpd spring/gravity fed water source in the past. A new well to serve Lake Fork was completed in late 1987. Average daily summer water use of Lake Fork is approximately 17,000 gpd. Small electrically pumped wells are located at the facilities at Cimarron, Iola, and Stevens Creeks. An electric generator operates the well pump at Ponderosa Campground. The remaining campgrounds and facilities within the recreation area are equipped with hand pumps. Water quality measurements are taken within the recreation area every two weeks. Where necessary, purification is provided with iodinators (personal interview with Jeff Heywood, Curecanti Facilities Manager, September 4, 1987).

B.2.5.13 **Rocky Mountain Biological Laboratory (RMBL)**

RMBL is an independent non-profit corporation dedicated to research and education in the biological sciences. RMBL has owned and operated a high-altitude summer field camp and research facility since 1928 at the historic townsite of Gothic on the East River. The draft master plan for RMBL[1] allows for a maximum of 170 residents, researchers, and students to be residing at the laboratory at any one time. The facilities are currently operated at full capacity. There are no plans to raise these limits for the foreseeable future. RMBL holds a U.S. Forest Service Special Use Permit for 2324 acres surrounding Gothic.

Water Use

RMBL receives its summertime domestic water supply from Gothic Spring on Gothic Mountain and from springs in the Copper Creek drainage. Gothic Spring provides the majority of the summertime supply but is not operated during the winter. The smaller Copper Creek water system operates all year. Both systems are pressurized by gravity and tested frequently, but do not require any water treatment (Ralph Clark personal interview, September 16, 1987).

Incorporated within the Gothic Mountain water delivery system is a micro-hydroelectric facility which provides lighting for several RMBL buildings. RMBL holds absolute decrees in the amount of 0.5 cfs for the Gothic pipeline and the RMBL hydroelectric power plant.

B.3 COLORADO RIVER WATER CONSERVATION DISTRICT

The Colorado River Water Conservation District (CRWCD) is a political subdivision of the State of Colorado, and was formed by the General Assembly in 1937 to conserve and put to beneficial use the waters of the Colorado River in Colorado. The District includes all or part of 15 counties west of the Continental Divide and north of the crest of the San Juan Mountains. The Gunnison River basin represents 8000 of the 29,000 square miles inside the CRWCD boundaries.

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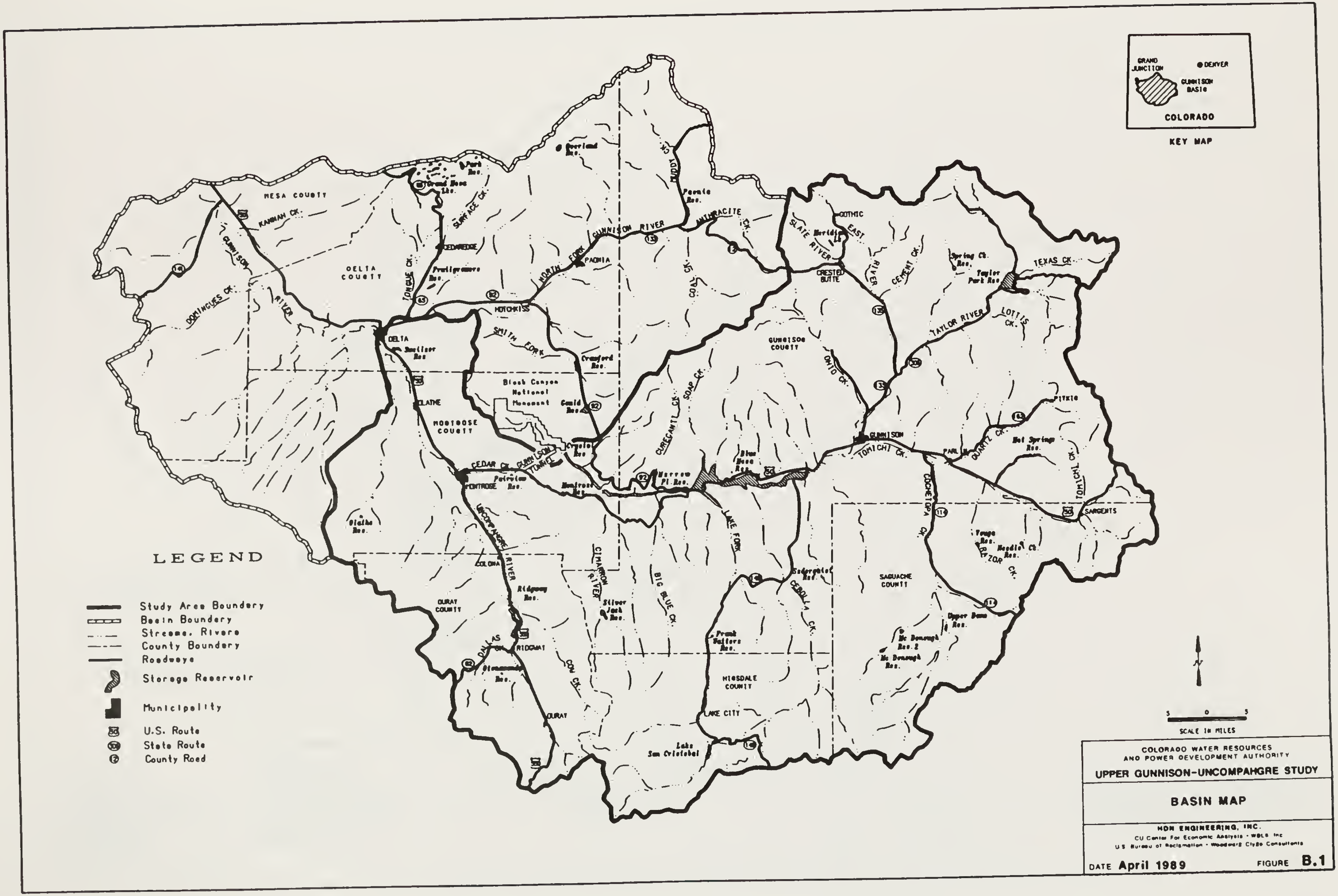
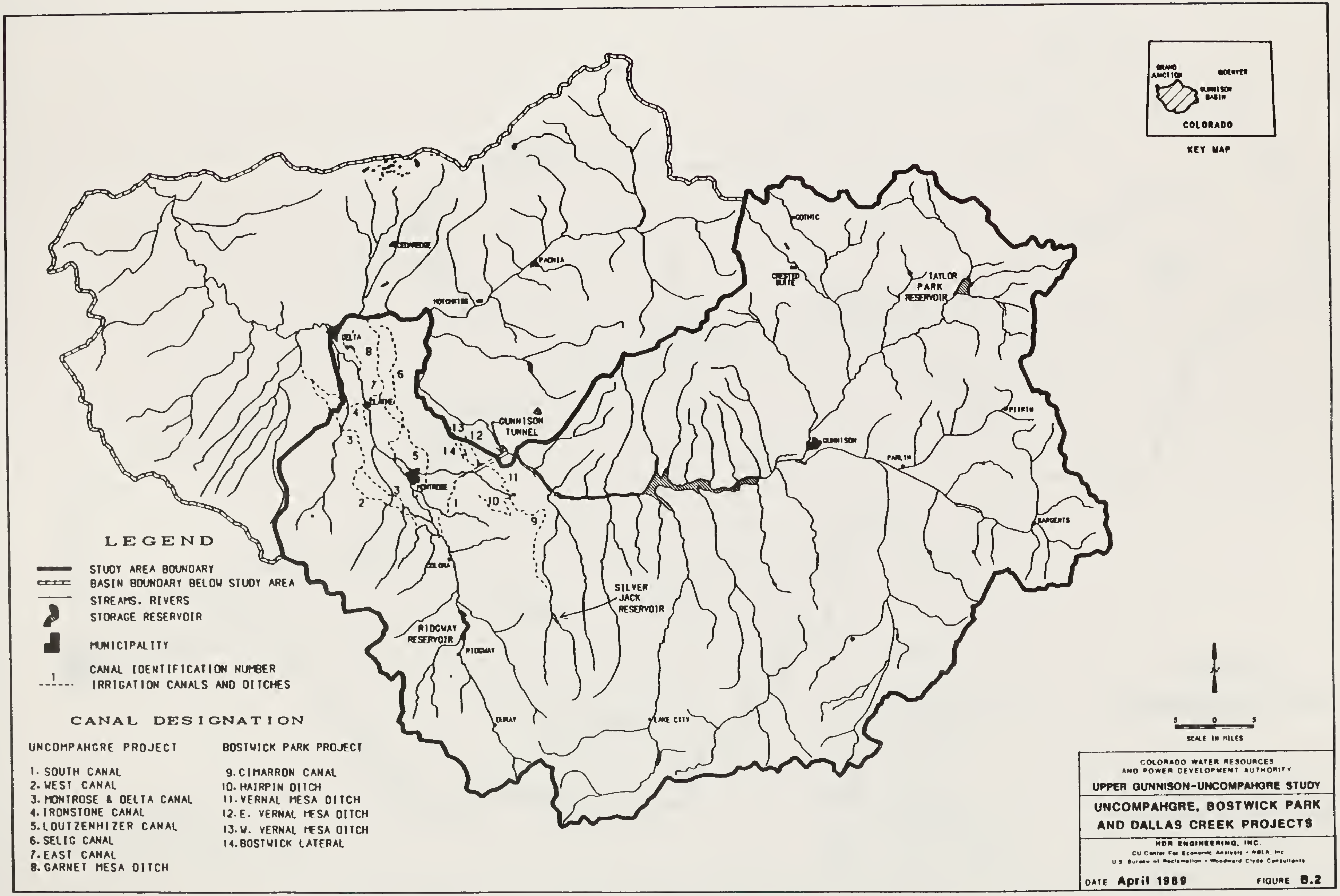
(1) RMBL, 1987. Master Plan - RMBL, Draft in progress. RMBL, Crested Butte, Colorado.

In following its mandate to conserve water for use in the Colorado River basin, CRWCD has obtained water storage and diversion rights, assisted in project planning, and intervened in attempts by out-of-basin interests to appropriate water for export. CRWCD has worked closely with Water Conservancy Districts, providing engineering and legal services in protecting their undeveloped water rights. The District has provided such services to both the UGRWCD and the UVWUA in the past and are co-sponsors of the present study.

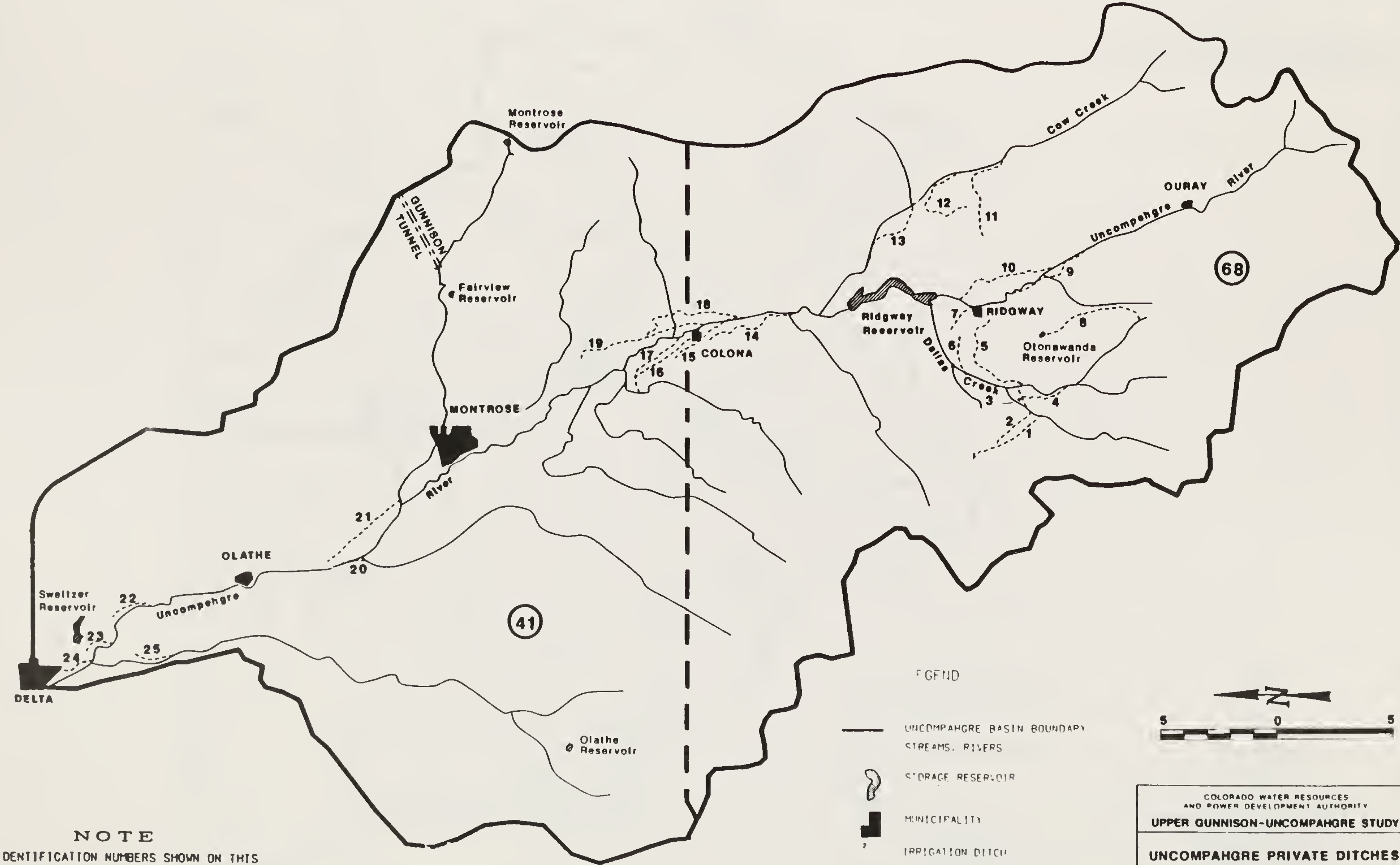
CRWCD adjudicated the original water rights for the Aspinall Storage Units on the Gunnison River, and assigned those rights to the United States. CRWCD also is signatory to the agreements allowing for exchanges of water between Taylor Park Reservoir and Blue Mesa Reservoir.



KEY MAP
GRAND JUNCTION
DENVER
GUNNISON BASIN
COLORADO
LEGEND
Study Area Boundary
Basin Boundary
Streams, Rivers
County Boundary
Roadways
Storage Reservoir
Municipality
U.S. Route
State Route
County Road
MESA COUNTY
DELTA COUNTY
MONTROSE COUNTY
OURAY COUNTY
GUNNISON COUNTY
HINSDALE COUNTY
SAGUACHE COUNTY
GUNNISON RIVER
NORTH FORK
SMITH FORK
UNCOMPAHGRE RIVER
SLATE RIVER
EAST RIVER
TAYLOR RIVER
LAKE FORK
CIMARRON RIVER
TOMICHI CK.
COCHETOPA CK.
CEBOLLA CK.
BIG BLUE CK.
SOAP CK.
CURECANTI CK.
COAL CK.
ANTHRACITE CK.
MUDDY CK.
SURFACE CK.
TONGUE CK.
KANNAH CK.
DOMINGUES CK.
OHIO CK.
CEMENT CK.
TEXAS CK.
LOTTIS CK.
QUARTZ CK.
COW CK.
CEDAR CK.
DALLAS
DELTA
CEDAREDGE
PAONIA
HOTCHKISS
OLATHE
MONTROSE
COLONA
RIDGWAY
OURAY
CRESTED BUTTE
GOTHIC
GUNNISON
PARLIN
PITKIN
SARGENTS
LAKE CITY
Black Canyon National Monument
Lake San Cristobal
COLORADO WATER RESOURCES
AND POWER DEVELOPMENT AUTHORITY
UPPER GUNNISON-UNCOMPAHGRE STUDY
BASIN MAP
HDR ENGINEERING, INC.
SCALE IN MILES
DATE April 1989
FIGURE B.1



LEGEND
STUDY AREA BOUNDARY
BASIN BOUNDARY BELOW STUDY AREA
STREAMS, RIVERS
STORAGE RESERVOIR
MUNICIPALITY
CANAL IDENTIFICATION NUMBER
IRRIGATION CANALS AND DITCHES
CANAL DESIGNATION
UNCOMPAHGRE PROJECT
1. SOUTH CANAL
2. WEST CANAL
3. MONTROSE & DELTA CANAL
4. IRONSTONE CANAL
5. LOUTZENHIZER CANAL
6. SELIG CANAL
7. EAST CANAL
8. GARNET MESA DITCH
BOSTWICK PARK PROJECT
9. CIMARRON CANAL
10. HAIRPIN DITCH
11. VERNAL MESA DITCH
12. E. VERNAL MESA DITCH
13. W. VERNAL MESA DITCH
14. BOSTWICK LATERAL
GRAND JUNCTION
DENVER
GUNNISON BASIN
COLORADO
KEY MAP
CEDAREDGE
PAONIA
HOTCHKISS
DELTA
OLATHE
MONTROSE
GUNNISON TUNNEL
COLONA
RIDGWAY RESERVOIR
RIDGWAY
OURAY
LAKE CITY
SILVER JACK RESERVOIR
GOTHIC
CRESTED BUTTE
TAYLOR PARK RESERVOIR
GUNNISON
PARLIN
PITKIN
SARGENTS
SCALE IN MILES
COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY
UPPER GUNNISON-UNCOMPAHGRE STUDY
UNCOMPAHGRE, BOSTWICK PARK AND DALLAS CREEK PROJECTS
HDR ENGINEERING, INC.
CU Center For Economic Analysis • WBLA, Inc
U.S. Bureau of Reclamation • Woodward Clyde Consultants
DATE April 1989
FIGURE B.2



LEGEND

- UNCOMPAHGRE BASIN BOUNDARY
- STREAMS, RIVERS
- STORAGE RESERVOIR
- MUNICIPALITY
- IRRIGATION DITCH
- WATER DISTRICT BOUNDARY
- (41) WATER DISTRICT NUMBER

N

5 0 5

NOTE

IDENTIFICATION NUMBERS SHOWN ON THIS MAP ARE EXPLAINED ON THE FOLLOWING PAGE.

COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

UNCOMPAHGRE PRIVATE DITCHES

HDR ENGINEERING, INC.
CU Center For Economic Analysis • WBLA Inc
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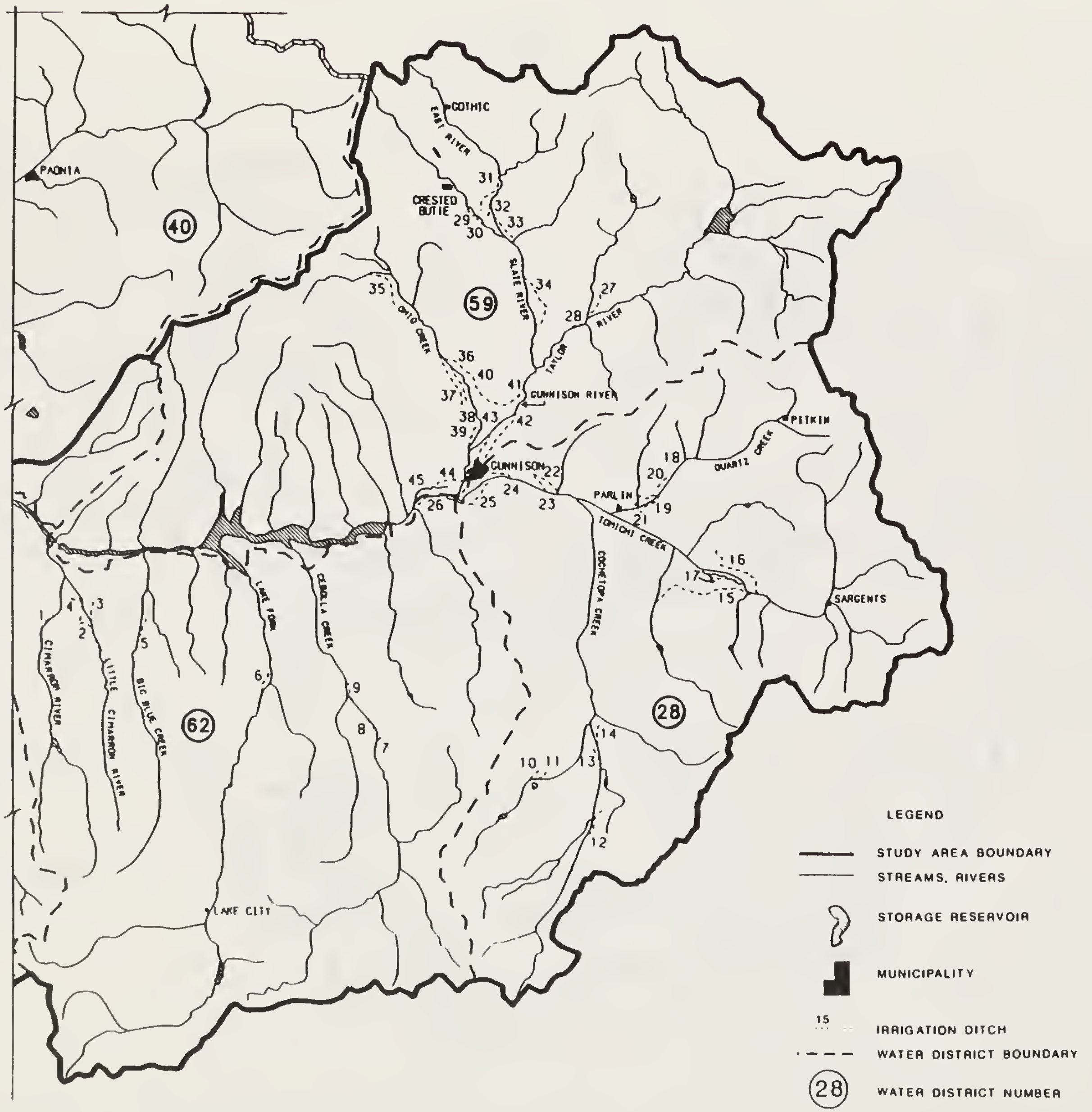
DATE **April 1989** FIGURE **B.3**

NOTE

IDENTIFICATION NUMBERS SHOWN ON THIS MAP ARE EXPLAINED ON THE FOLLOWING PAGE.



COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

UPPER GUNNISON PRIVATE DITCHES

HDR ENGINEERING, INC.
CU Center For Economic Analysis • WBLA Inc
US Bureau of Reclamation • Woodward Clyde Consultants

DATE **April 1989** FIGURE **B.4**

COLORADO WATER RESOURCES
AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

EXISTING M&I FACILITIES

HDR ENGINEERING, INC.
CU Center For Economic Analysis • WBLA Inc
U.S. Bureau of Reclamation • Woodward Clyde Consultants

DATE April 1989 FIGURE B.5

APPENDIX C

DITCHES REPRESENTED AS AGGREGATED DEPLETIONS IN THE HYDROLOGIC/WATER RIGHTS MODEL

APPENDIX C

DITCHES REPRESENTED AS AGGREGATED DEPLETIONS

The smaller irrigation ditches in the Gunnison Basin are represented in the basin model in aggregated form as depletions. Only ditches for which diversion records could be found were included in this aggregation. The depletion amount represented at each aggregation point (model node) was derived from consideration of water rights, historical diversions, irrigated acreage, and consumptive use rates.

The following tables list, by aggregation point, the smaller ditches included in the basin model. After each ditch is the decreed amount considered for that ditch. The total decreed amount for each aggregation point is given at the end of each ditch list.

Because a ditch will often have several decrees falling into various priority classes, it is not usually possible to assign one specific priority class to the ditch. Only the decrees can be assigned to specific priority classes. This breakdown of decrees at each aggregation point is also given following each ditch list. Of course, the sum of decrees for ditches and the sum of decrees for priority classes must be the same.

TABLE C.1

EAST RIVER BASIN DITCHES

Node No.	Demand Nos.	Ditch Name	Decreed Amount (cfs)
45	DEMN 73-76	DECOMPIEGNE DITCH NO 1	4.00
		DECOMPIEGNE DITCH NO 2	1.50
		DECOMPIEGNE DITCH NO 3	3.00
		DENNIS ALKALI CR DITCH	5.00
		DUTCH CREEK DITCH	4.00
		EAST RIVER NO 1 DITCH	87.83
		FISHER ENLARGEMENT DITC	42.20
		HAPPY HOLLOW HIGHLINE D	5.50
		HOWE + SHERWOOD IRR D	32.00
		IMOBERSTEG WILLOW CR D	15.63
		JAMES WATT DITCH	28.50
		JOHN LORR DITCH	3.00
		KUBIACK DITCH	13.50
		KUNZE DITCH	3.00
		L R SPANN DITCH	8.00
		LONG'S COPLEY PIPELINE	0.26
		LUCERO ENLT+EX OF E R =	0.88
		LUCERO ENLT+EX OF E R =	5.00
		MARSTON DITCH	12.50
		MCDONALD DITCH	2.00
		RED MT HIGHLINE DITCH	4.00
		RICHARD BALL DITCH	25.30
		ROARING JUDY DITCH AKA	26.00
		ROARING JUDY SPRINGS +	139.50
		SAMPSON SPANN DITCH	9.00
		SCHUPP DITCH	15.00
		SHACKLEFORD DITCH	1.63
		SLIDE DITCH	20.50
		SPANN ENLT + EX D	3.00
		UTILITIES INC. WELL NO1	2.00
		WATT NO 2 DITCH	4.00
			527.23

Priority Class	Decreed Amount
1	57.63
2	195.52
3	97.30
4	176.79
Total for Node No. 45	527.23

47	DEMN 97-100	ADAMS CEMENT CREEK DITCH	1.50
		CEMENT CR RANGER STA	5.08
		CEMENT CREEK DITCH	27.50
		JONES HIGH LINE DITCH	8.00
		YARNELL DITCH	6.75
		TIM A HELEN MORGAN DITCH	2.00
		ADAMS RANCH DITCH + POND	1.00
		YARNELL PIPELINE	0.25
			52.08

Priority Class	Decreed Amount
1	11.00
2	25.50
3	14.58
4	1.00
Total for Node No. 47	52.08

51	DEMN 77-84	ANNA ROZICH SPRINGS D	3.50
		ANNA ROZMAN DITCH	20.00
		BAXTER DITCH	8.00
		BERG IRG DITCH NO 1	1.50
		BOCKER DITCH	44.00
		BREEM DITCH	22.80
		CAMPA SPRING DITCH	3.50
		COAL DR DITCH	4.00
		COLUMBINE DITCH	4.00
		COLUMBINE DITCH	1.50
		COPPER CREEK LABORATORY	90.00
		DECKER DITCH	1.88
		DECKER DITCH NO 2	1.50
		DILLSWORTH DITCH	43.03
		E BUCKLEY SW SP D + POND	0.50
		EAST RIVER WATER SCE ADD	5.00
		EUREKA RUN DITCH	1.00
		FOREST QUEEN DITCH	3.00
		GEORGE KAPUSHION DITCH	9.00
		HALOZON DITCH	3.00
		JAKLICH DITCH	2.50
		JAMA SPRING DITCH	0.75
		KAPUSHION DITCH	1.00
		KAPUSHION SEPG RES D	3.00
		KAPUSHION SPRING DAMS	4.50
		LACY DITCH	4.00
		LAKE SPRINGS DITCH	2.50
		MALENSEK DITCH	8.50
		MCCORMICK DITCH	10.00
		MERIDIAN DITCH	12.00
		RESERVOIR W W DITCH	2.00
		ROZICH DITCH	0.44
		ROZICH DITCH	14.00
		ROZICH DITCH	0.44
		ROZMAN DOMESTIC SP DITCH	0.50
		ROZMAN NO 1 DITCH	4.50
		ROZMAN NO 2 DITCH	7.00
		ROZMAN SKI HILL SP DITCH	0.75
		SCHNEIDER DITCH NO 2	20.00
		SLATE RIVER EST MUN WELL	0.62
		SOUTH BUCKLEY SW SP D	0.50
		SPANN NETTICK DITCH	25.00
		SQUAW CREEK DITCH	20.00
		VERZUH PUMP + PIPELINE	1.00
		VUDS DITCH	0.50
		VUDS DITCH NO 2	3.50
		WARREN DITCH	1.88
		WILLOW DITCH	9.00
		WILSON DITCH	4.00
		YELLOWJACKET RUN DITCH	0.47
		CRESTED BUTTE HLDS WTR 1	0.10
		CRESTED BUTTE HLDS WTR 2	0.67
		CRESTED BUTTE LTD PL	3.00
		CRESTED BUTTE PROP HDG 1	4.00
		CRESTED BUTTE TOWN PL	15.00
		CRESTED BUTTE WTR DITCH	6.00
			464.33

Priority Class	Decreed Amount
1	25.87
2	110.44
3	153.33
4	174.69
Total for Node No. 51	464.33

52	DEMN 85-88	BERRY GULTCH DITCH	1.00
		BOTTENFIELD DITCH	17.00
		COLUMBINE DITCH	12.00
		EAST RIVER NO 2 DITCH	44.87
		FERRIS CR RESERVOIR	15.11
		GRANITE DITCH	5.00
		MEADS NO 3 DITCH	7.07
		IMOBERSTEG DITCH	10.00
			112.05

Priority Class	Decreed Amount
1	20.08
2	22.60
3	49.38
4	19.99
Total for Node No. 52	112.05

53	DEMN 89-92	A C JARVIS NO 1 DITCH	10.00
		BEITLER DITCH NO 1	4.00
		BEITLER DITCH NO 2	11.50
		EAST RIVER LABORATORY	46.00
		F E +A C JARVIS DITCH	23.00
		GOTHIC DITCH	2.00
		GOTHIC MOUNTAIN DOM PL	0.20
		GOTHIC PIPELINE	0.50
		KAPUSHION SPRING + POND	0.45
		LAFAYETTE DITCH	40.61
		MALENSEK DITCH NO 5	8.00
		MCCLENATHAN DITCH	8.00
		QUEEN BASIN RUN	20.00
		RUSTLER GULCH LAB	22.50
		VERZUH DITCH	42.50
		VERZUH YOUNG BIFANO D	41.00
			280.26

Priority Class	Decreed Amount
1	8.25
2	57.36
3	112.00
4	102.65
Total for Node No. 53	280.26

54	DEMN 93-96	ADAMS CEMENT CREEK DITCH	1.50
		CEMENT CR RANGER STA	5.08
		CEMENT CREEK DITCH	27.50
		JONES HIGH LINE DITCH	8.00
		YARNELL DITCH	6.75
		TIM A HELEN MORGAN DITCH	2.00
		ADAMS RANCH DITCH + POND	1.00
		YARNELL PIPELINE	0.25
		JORDAN DITCH NO 1	3.00
		REESE DITCH NO1	1.50
		REESE DITCH NO2	2.00
			58.58

Priority Class	Decreed Amount
1	10.93
2	15.75
3	11.26
4	7.58
Total for Node No. 54	58.58

TABLE C.2

TAYLOR RIVER BASIN DITCHES

Node No.	Demand Nos.	Ditch Name	Decreed Amount (cfs)
56	DEMN 101-104	AXTELL	1.50
		BALL DESERT LAND	6.00
		ELMER	1.87
		ELMER DITCH	1.13
		ELMER #2	1.88
		HAYMAKER RES + DITCH	2.00
		REDDEN ELSINORE	14.00
		SPRING CR. IRR.	45.20
			73.58

Priority Class	Decreed Amount
2	50.95
3	22.63
Total for Node No. 56	73.58

Node No.	Demand Nos.	Ditch Name	Decreed Amount (cfs)
57	DEMN 105-108	DOCTOR #1	1.00
		DOCTOR #2	1.00
		HIGHLAND	10.00
		SUMMERVILLE DITCH	9.25
		SUMMERVILLE #2	1.50
			22.75

Priority Class	Decreed Amount
2	12.50
3	6.75
4	3.50
Total for Node No. 57	22.75

TABLE C.3

TOMICHI CREEK BASIN DITCHES

Node No.	Demand Nos.	Ditch Name	Decreed Amount (cfs)
63	DEMN 113-116	HARTMAN ROCKS SP NO 1	0.50
		MOORE DITCH	16.00
		ADAMS NO1 DITCH	14.00
		ADAMS NO2 DITCH	12.00
		AMANDA SPRING PONDS	3.00
		BEVER DITCH	7.50
		BIEBEL DITCHES NOS	45.99
		BILL KNOX PIPELINE	1.60
		CABIN CREEK DITCH	4.00
		CHEENEY NO 2 DITCH	4.20
		CHEENEY NO1 DITCH	6.10
		CLEAR SPRING PIPELI	0.11
		DEERING SPRING DITC	0.40
		DIPPING VAT DITCH	0.50
		ELLIS PUMPING PLANT	0.56
		ELSEN VADER DITCH	15.75
		GOLD BASIN CREEK PL	0.50
		GOODWIN AND WRIGHT	20.00
		GRAHAM DITCH	8.00
		GRIFFING NO1 DITCH	26.00
		GRIFFING NO2 DITCH	12.50
		GULLETT TOMICHI IRG	39.00
		HANNAH J WINTERS NO	12.09
		HARTMAN DITCH NO1	5.00
		HARTMAN DITCHES NO	6.95
		HARTMAN WASTE WTR I	11.50
		HEAD AND CORTAY NOS	18.16
		HEAD NO 2 DITCH	2.70
		HEAD NO1 DITCH	0.30
		IRA PHELPS DITCH	3.30
		JENNINGS ELSEN D EX	6.88
		LANDO DITCH	10.10
		LOBDELL ALDER CREEK	7.00
		LOBDELL DITCH	9.00
		LOBDELL NO2 DITCH	1.50
		LOUIS SARRASIN DITC	3.00
		MARTHAS SPRING DITC	1.70
		MCCABE SPRINGS 3456	2.50
		MCCANNE 2 D LANDO 3	1.00
		MCCANNE 2 LANDO DWB	1.50
		MCCANNE 2 LANDO3 DW	3.68
		MCCANNE 2D L3 DWB E	2.40
		MCCANNE 2D LANDO 3	4.00
		MCCANNE 3 L1 GRIFF	7.43

		MCCANNE 3 LANDO 1 D	6.20
		MCCANNE DITCHES 1+2	8.46
		MCCANNE NO1 DITCH	20.63
		MCCANNE NO2 DITCH	14.18
		MCDOWELL VAN TUYL N	21.00
		OLSON POND + PL	0.35
		OLSON POND PUMP AND	0.15
		PIONEER DITCH	57.30
		PURRIER IRRIGATING	21.50
		RUBY SPRING PIPELIN	0.10
		SOUTH SIDE DITCH	12.00
		VADER RAUSIS DITCH	5.75
			527.52

Priority Class	Decreed Amount
1	83.73
2	357.77
3	73.70
4	12.32
Total for Node No. 63	527.52

73	DEMN 117-120	DUNCAN DITCH	3.50
		OREGAN NO1 DITCH	4.00
		EXT + ENL PARLIN QUARTZD	10.00
			17.50

Priority Class	Decreed Amount
1	0.80
2	3.20
3	3.50
4	10.00
Total for Node No. 73	17.50

83	DEMN 121-124	ANDERSON DITCH	3.50
		JOHN B COATS NO1 DITCH	0.40
		BENNETT MORTON DITCH	0.60
		BENNETT NO2 DITCH	7.00
		BIG SPRING DITCH	1.60
		CAIN BORSUM DITCH	22.00
		COATS BROS DITCH	19.15
		COX IRRIGATING DITCH	0.88
		D A MCCONNELL DITCH	4.00
		GOODRICH DITCH	31.99
		GRATEHOUSE DITCH	6.00
		GULCH NO1 NO2 DITCHES	5.60
		HOT SPRINGS NOS 1+2 D	5.00
		HOT SPRINGS NOS 1+2 D	5.00
		JOHN B COATS NO 2 DITCH	8.00
		JOHN B COATS NO1 DITCH	9.10
		JOHN MYERS NO 2 DITCH	1.30
		KNOWLES BARRETT DITCH	8.00
		KNOWLES DITCH	4.00
		L L BUSH DITCH NO1	1.74
		L L BUSH DITCH NO2	1.65
		L L BUSH DITCH NO3	1.74
		L L BUSH DITCH NO4	1.87
		L L BUSH DITCH NO5	1.45
		LOUIS DITCH	2.10
		MCGOWAN IRRIGATING D	11.00
		MONSON + MCCONNELL D	19.52
		MUNSON CREEK DITCH	1.50
		NEEDLE CREEK DITCH	23.99
		OWEN NO 2 DITCH	2.65
		RODGERS METROZ DITCH	24.00
		SMITH FORD NO2 DITCH	0.99
		STEPHENSON DITCH	32.70
		STITZER DITCH	8.00
		WICKS ROWSER DITCH	1.20
		L L BUSH NOS 1,2,3,4+5	1.20
		MCDONALD BERDEL EX D	1.00
		MUNSON + MCCONNELL D	1.10
		N L PIPELINE	0.59
		N L PIPELINE	0.99
		N L PIPELINE	4.00
		OWEN NO 3 DITCH	1.20
		PILONI SPRING NO6 PL D	0.22
		PILONI SPRINGS NO5 DITCH	4.00
		ROCK SLIDE SPRING DITCH	9.59
		SPRUCE CREEK DITCH	9.59
		STEPHENSON@S GULCH DITCH	1.00
		TARAMARCAZ DITCH NO1	4.00
		TARAMARCAZ NO2 DITCH	2.00
		TOMICHI DOME DITCH	3.60
		TOMICHI DOME SP NO10 D	1.00
		TOMICHI DOME SP NO11 D	1.00
		TOMICHI DOME SP NO11 D	1.00
		TOMICHI DOME SP NO9 POND	1.00
		WATSON WELL NO 1	0.33
		WATSON WELL NO 3	0.26
			327.90

Priority Class	Decreed Amount
1	53.47
2	237.08
3	28.45
4	8.90
Total for Node No. 83	327.90

85	DEMN 125-128	ARCH IRG DITCH ENLT	343.59
		BRIDGE NO4 DITCH	4.80
		CLARK NO1 DITCH	3.00
		CLARK NO2 DITCH	7.00
		CLARK NO3 DITCH	10.00
		COLE DITCH	2.00
		COLE NOS 1,2+3 DITCHES	1.60
		COX AND MCCONNELL DITCH	15.89
		DUNN AND WATTERS DITCH	26.50
		GILBERTSON NO1 DITCH	13.50
		GILBERTSON NO2 DITCH	3.00
		HAWES BERGEN GILBERTSON	15.50
		J T HORN DITCH	2.40
		KANE DITCH	3.50
		LONG BRANCH DITCH	8.00
		LONG BRANCH RGR STA DNO1	1.60
		LONG BRANCH RGR STA DNO2	0.70
		MEANS BROS NO 1 DITCH	0.40
		MEANS BROS NO2 DITCH	7.50
		MEANS BROS NO 4 DITCH	2.00
		MEANS BROS NO5 DITCH	1.40
		MEANS BROS NO 6 DITCH	0.40
		MEANS BROS NO 7 DITCH	1.20
		MUNSON DITCH	1.50
		OWEN NO1 DITCH	16.00
		OWEN REDDEN DITCH	62.51
		S DAVIDSON AND CO DITCH	162.80
		SARGENTS NO 2 D	1.20
		SHIPMAN LATERALS NO 1+2	11.20
		SLOUGH DITCH	5.00
		TEMPLETON DITCH	2.96
		TIE CREEK DITCH	1.70
		VAN BIBBER DITCH	7.00
		WATTERS AND HICKS D ENLT	4.00
		HELLMUTH D NOS 1+2	1.62
		HICKS CREEK DITCH	5.00
		JACKSON DITCH	1.00
		MILK CREEK DITCH	3.00
		PILONI SPRING NO1 DITCH	1.00
		PILONI SPRING NO7 DITCH	0.17
		PILONI SPRING NO8 DITCH	0.17
		WASTE WATER DITCH	1.00
		BLACK SPRING PL + DITCH	3.40
		LARKSPUR DITCH	10.00
			778.11

Priority Class	Decreed Amount
1	119.61
2	449.55
3	124.26
4	84.68
Total for Node No. 85	778.11

TABLE C.4

QUARTZ CREEK BASIN DITCHES

Node No.	Demand Nos.	Ditch Name	Decreed Amount (cfs)
75	DEMN 153-156		
		ALDER DITCH	5.00
		DAVIS AMENDED DITCH	0.80
		OREGAN NO 2 DITCH	4.50
		PARLIN NO 1 DITCH	8.00
		PARLIN NO 2 DITCH	16.50
		PARLIN QUARTZ CR D E+E	40.70
		SUTTON NO 1 AMENDED D	0.40
		SUTTON NO 2 AMENDED D	0.40
		SUTTON NO 3 AMENDED D	0.30
		SUTTON NO 4 AMENDED D	0.70
		SUTTON NO 5 DITCH	0.80
			78.10

Priority Class	Decreed Amount
1	12.70
2	57.20
3	8.20
Total for Node No. 75	78.10

77	DEMN 157-160	BERRY CARTER MINE S	2.10
		BERRY RAYMOND SPRIN	0.60
		BOULDER CR FLUME +	8.00
		CHITTENDEN DITCH	25.30
		CUTJO DITCH	16.14
		FAIVRE DITCH	2.00
		FAIVRE DITCH NO2	2.00
		FIELD AND VADER DIT	9.00
		FLICK DITCH	1.60
		FLICK DITCH NO1	11.60
		FLICK DITCH NO2	1.00
		FLICK DITCH NO3	7.00
		GOLD CREEK	7.00
		GOLD LINKS MINE WTR	2.23
		HUFF AND DICE DITCH	15.60
		LOCKWOOD DITCH	5.00
		LOCKWOOD MUNDELL DI	56.60
		MCINTYRE GULCH DITCH	2.00
		MONO DITCH AND FLUM	2.50
		NESBIT DITCH	2.50
		SORRENSON IRG DITCH	30.00
		SPRING BRANCH DITCH	2.50
		SUTTON QUARTZ CR NO	1.10
		SUTTON QUARTZ CR NO	0.60
		SUTTON QUARTZ CR NO	0.70
		TARKINGTON DITCH	18.00
		TOLL GATE SPRINGS P	1.00
		TORNAY HIGHLINE DIT	20.70
		WATERMAN DITCH	4.00
		WATERMAN MILLER GRI	0.35
		WERNER DITCH	3.00
		WESTSIDE DITCH	9.70
		WILCOX WELL NO 1	0.11
		WILCOX WELL NO 2	0.11
			272.24

Priority Class	Decreed Amount
1	17.20
2	167.14
3	43.60
4	44.30

Total for Node No. 77 272.24

TABLE C.5

RAZOR CREEK BASIN DITCHES

Node No.	Demand Nos.	Ditch Name	Decreed Amount (cfs)
81	DEMN 161-164		
		ANNA NO1 DITCH	8.00
		ANNA NO2 DITCH	4.00
		ANNA NO3 DITCH	4.00
		BALCH DITCH	8.00
		HIRDMAN NOS 1+2+3	10.00
		KENNEDY DITCHES NO 1+2	36.75
		PEARCE DITCH	9.00
		RAZOR CREEK DITCH	3.50
		SNYDER DITCHES NOS 1+2	5.20
		SNYDER DITCHES NOS1+2	26.79
		SNYDER ROUSER DITCH	5.00
		A B COATS DITCH	29.40
		ERNEST VOUGA DITCH	8.90
		ERNEST VOUGA PIPELINE	0.16
		FLAT TOP SP DITCH NO3	2.10
		FLAT TOP SP DITCH NO4	0.10
		FLATTOP SP + DITCH NO6	0.14
		KENNEDY DITCH NO 1	1.95
		KENNEDY DITCH NO 2	1.30
		KENNEDY NO 3 DITCH	0.70
		KENNEDY NO 4 DITCH	0.60
		KENNEDY NO 5 DITCH	1.90
		R A PROSSER DITCH	11.00
		TABLETOP SPRING + PL NO1	0.15
		TABLE TOP SP NO2 + PONDS	0.20
		STEENBERGEN WELL NO 1	0.20
		TABLE TOP WELL	0.11
		TABLE TOP WELL NO 2	0.13

			179.28

Priority Class	Decreed Amount
1	22.75
2	121.94
3	21.56
4	21.17

Total for Node No. 81	179.28

TABLE C.6

COCHETOPA CREEK BASIN DITCHES

Node No.	Demand Nos.	Ditch Name	Decreed Amount (cfs)
65	DEMN 129-132	ALKALI DITCH	3.20
		BARBARAS SPRING + P	0.40
		BEAD CREEK DITCH	0.80
		CAMP SPGS PL NO1+2	0.13
		COLO HWY COCH CAMP	0.13
		COYOTE SPRING PIPEL	0.11
		DAVIS NO1 DITCH	2.10
		DAVIS NO1 EXTENSION	1.20
		DUBER DITCH	8.00
		EAST KRUEGER DITCH	4.00
		EASTSIDE DITCH	6.00
		ELSEN COCHETOPA DIT	6.00
		GUENTHER NO1 DITCH	8.00
		GUENTHER NO2 DITCH	2.00
		HARRIS DITCH	0.40
		HOLLENBECK SPRINGS	1.95
		HOME DITCH DITCH NO	10.60
		JAPECK DITCH NO 2	2.40
		JAPECK DITCH NO 3	2.60
		JAPECK DITCH NO 5	1.50
		LINDSAY GUENTHER DI	3.00
		LOYDS DOM + IRR WTR	0.97
		MCCONNELL IRRIGATIN	2.80
		MCDONNELL IRRIGATIN	15.20
		MITCHELL DITCH	3.00
		MORAN DITCH	7.00
		NORMAN DITCH	12.00
		O'FALLON NO 3 DITCH	13.00
		OFALLON NO4 DITCH	6.50
		PASS CREEK DITCH	1.60
		PISEL CANALS NOS 1+	23.00
		RAUSIS DITCH	40.72
		RAUSIS NO2 DITCH	3.00
		ROCK CREEK DITCH	15.00
		SHARP DITCH	8.00
		SOUTH KRUEGER DITCH	2.00
			218.31

Priority Class	Decreed Amount
1	28.30
2	139.52
3	40.30
4	10.19
Total for Node No. 65	218.31

67	DEMN 133-136	CHARLES W HACK NO 2	3.00
		CHARLES W HACK NO1	0.80
		DOME CREEK DITCH NO	2.00
		DOME DITCH	0.20
		FUNK DITCH DITCH NO	3.00
		FUNK DITCH NO 1	2.62
		FUNK DITCH NO 5	1.64
		FUNK PIPELINE NO2	0.50
		FUNK UPPER DITCHES	1.50
		FUNK UPPER SPRING	0.15
		FUNK WAST WATER DIT	10.40
		GOULD WELL	2.66
		HELLMUTH D NOS 1+2	4.06
		LOCKETT DITCH	0.40
		RICHARDSON NO 2 DIT	0.20
		RICHARDSON NO1 DITC	7.00
		SPRING DITCH	0.40
		WEST PASS CREEK	1.00
			41.53

Priority Class	Decreed Amount
1	6.62
2	11.50
3	16.10
4	7.31
Total for Node No. 67	41.53

69	DEMN 137-140	COLEMAN COCH SP&D N	1.00
		COLEMAN COCH SP&PD	0.11
		COLEMAN COCH SP&PD	0.11
		COLEMAN COCH SP&PD	0.11
		COLEMAN COCH SP&PD	0.11
		COLEMAN COCHETOPA W	0.11
		COLEMAN COCHETOPA W	0.11
		COLEMAN COCHETOPA W	0.11
		COLEMAN COCHETOPA W	0.11
		CURTIS DITCH NO 1	2.00
		CURTIS DITCH NO 2	1.00
		CURTIS WELL	0.11
		DUCKETT DITCH	4.00
		EVERLY NO 1 DITCH	1.80
		EVERLY NO 2 DITCH	2.40
		GWENDOLYN K HACK DI	4.16
		HAZARD DITCH	19.85
		HOME DITCH DITCH NO	25.00
		IRWIN DITCH	1.60
		J M ELLIS NO 1 DITC	4.00
		J M ELLIS NO 2 D	1.00
		J M ELLIS NO 3 DITC	4.00
		MILLER CRARY DITCH	3.30
		N T CRARY NO2 DITCH	1.00
		PERRY IRRIGATING DI	14.40
		SMITH FORD NO1 DITC	1.90
		SMITH FORD NO2 DITC	84.09
		W L PERRY NO 3 DITC	0.70
		WASTE WATER DITCH	1.40
			179.59

Priority Class	Decreed Amount
1	46.10
2	17.10
3	114.35
4	2.04
Total for Node No. 69	179.59

70	DEMN 141-144	BIG ROCK DITCH	35.00
		CAMPBELL SPRING PIP	0.11
		COLEMAN COCH SP&D N	1.50
		COLEMAN COCH SP&PD	0.11
		COLEMAN COCH SP&PD	0.11
		COLEMAN COCH SP&PL	0.11
		COLEMAN COCH SP&PL	0.11
		COLEMAN COCH SP&PL	0.11
		COLEMAN COCH SP&PL	0.11
		COLEMAN COCHETOPA W	0.11
		COLEMAN COCHETOPA W	0.11
		COLEMAN COCHETOPA W	0.11
		COLEMAN RANCHES SP	0.50
		LEAHY DITCH	1.60
		MEAS DITCH AKA MESA	93.00
		MESA SPRING POND +	2.00
		QTR CIRCLE CIRCLE R	2.20
		TARBELL AND ALEXAND	22.94
		TARBELL DITCH	25.00
		W L PERRY NO 6 DITC	6.80
			91.64

Priority Class	Decreed Amount
1	8.40
2	116.94
4	66.30
Total for Node No. 70	191.64

71	DEMN 145-148	COCHETOPA MEADOWS D ENLT	48.00
			48.00

Priority Class	Decreed Amount
2	48.00
Total for Node No. 71	48.00

72	DEMN 149-152	BILLY SANDERSON DIT	3.80
		COLEMAN COCH SP&D N	1.50
		COLEMAN COCH SP&PD	0.11
		COLEMAN COCHETOPA W	0.11
		CRARYS LOS PINOS DI	2.50
		GOVERNMENT DITCH	46.00
		IRWIN DITCH	1.60
		MCDONOUGH DITCH	18.60
		MILLER DITCH	10.00
		NORTHSIDE DITCH	19.20
		POLE ROAD DITCH	1.20
		STEVENS DITCH	0.80
		STRACHAN DITCH	3.40
		TRAIL CREEK DITCH	0.83
		WILLOW CREEK DITCH	1.40
			111.05

Priority Class	Decreed Amount
1	27.28
2	62.72
3	19.20
4	1.85
Total for Node No. 72	111.05

TABLE C.7

OHIO CREEK BASIN DITCHES

Node No.	Demand Nos.	Ditch Name	Decreed Amount (cfs)
35	DEMN 65-68	BIEBEL NO 1 DITCH	4.50
		BIEBEL NO 3 DITCH	10.50
		BUCKEY LEHMAN D	12.50
		CHANNEL DITCH	5.00
		GLEASON IRRIGATING DITCH	49.50
		GOOSEBERRY DITCH	1.13
		GOOSEBERRY MESA IRG D	21.54
		GUS BIEBEL DITCH	7.00
		HARRIS BOHM POTATO DITCH	52.95
		HENRY PURRIER OHIO CR D	30.60
		HENRY PURRIER OHIO CR 2D	1.25
		HILDEBRAND NO 1 DITCH	3.50
		HILDEBRAND NO 2 DITCH	9.00
		HINKLE HAMILTON DITCH	28.00
		HINKLE IRG DITCH	10.00
		HYZER DITCH	4.00
		HYZER VIDAL MILLER	38.50
		LEHMAN HARRIS DITCH	9.00
		LONE PINE DITCH	71.80
		MAY BOHM + ENLD M B H P	70.00
		MOORE HILDEBRAND DITCH	3.00
		OTIS MOORE DITCH	33.00
		PETER PURRIER EAST DITCH	1.00
		PURRIER DITCH	10.00
		SUNNYSIDE IRG DITCH	6.50
		TEACHOUT DITCH	47.75
		TEACHOUT-FAIRCHILD DITCH	17.00
		TINGLEY DITCH	10.90
		VIDAL BROS NO 1 DITCH	5.00
		WILSON DITCH	12.00
		PIONEER DITCH	9.30
		BEAVER DAM DITCH	6.25
		BESSE AND CORTAY WW D	1.38
		BIEBEL NO 1 DITCH	6.00
		CUNNINGHAM W W DITCH	14.00
		EILEBRECHT GOOSEBERRY CR	0.25
		FRANCIS EILEBRECHT EX	3.75
		GILLASPEY WASTE WATER D	2.25
		H W STANLEY DITCH	2.00
		HOUSE SPRING DITCH	0.20
		J H HINKLE DITCH	1.25
		LONE PINE W W DITCH	0.50
		MAGPIE DITCH	1.50
		THORNTON DITCH NO 2	3.50
		WILT WASTE WATER DITCH	2.50
		WILT WASTE WATER DITCH	3.50
		MESA DITCH	41.60
			686.14

Priority Class	Decreed Amount
1	183.80
2	428.73
3	73.30
4	0.31
Total for Node No. 35	686.14

37	DEMN 49-52	BUCKEY DITCH	26.00
		CUNNINGHAM DITCH	73.50
		DAVID HIGH LINE DITCH	1.88
		HORACE G MCMILLIAN DITCH	16.00
		JUDY NORTH HIGH LINE D	20.50
		HENRY PURRIER OHIO CR 2D	11.75
		MCGLASHAN S SIDE MILL CR	21.50
		POLISIC NO 1 DITCH	8.00
		SMELSER DITCH	8.75
		DRY GULCH W W D	3.38
		DUANE MOORE SPRINGS D	2.00
		FAIRCHILD TEACHOUT DITCH	6.00
		FLAT TOP DITCH	3.00
		HAMILTON DITCH	4.50
		LITTLE MILL CR DITCH	5.75
		LITTLE MILL CR D+CUNNIN	5.75
			218.25

Priority Class	Decreed Amount
1	27.70
2	86.50
3	93.05
4	11.00
Total for Node No. 37	218.25

38	DEMN 61-64	ANNIE IRG DITCH	1.00
		BOURNE DITCH	14.00
		CARBON DITCH	11.50
		CASTLETON DITCH	12.00
		EAST WILSON DITCH	6.00
		HOPE RESICH DITCH	33.50
		MCGLASHAN E SIDE IRR D	6.58
		MCGLASHAN W SIDE OHIO CR	3.50
		MCKEE DESERT LAND NO 2D	2.00
		MCKEE NO 1 DITCH	1.25
		MILTON WHITE DITCH	4.00
		PARK DITCH	8.00
		SMITH DITCH	2.00
		SQUIRREL CREEK NO 1 D	10.00
		SQUIRREL CR NO 3 DITCH	8.00
		SQUIRREL CREEK NO6 DITCH	4.50
		WILLOW RUN DITCH	23.00
		WILSON OHIO CREEK DITCH	35.30
		SQUIRREL CREEK NO2 DITCH	1.38
		ALLISON W W SEPG D	3.00
		CAMPBELL DITCH E BRANCH	3.00
		CAMPBELL DITCH WEST BR	3.00
		DOLLARD DESERT LAND D	18.00
		EILEBRECHT-MILLER DITCH	26.00
		FRANK WEINERT DITCH	0.50
		CARBON DITCH	2.50
		MCKEE DITCH	1.00
		MCKEE NO 2 DITCH	1.00
		NU MINE SHAFT SPR + TK	0.10
		OWENS CR DITCH	0.50
		PARTCH PASTURE SPGS 1+2	0.10
		SQUIRREL CR HIGH LINE D	3.13
		STAPLES SPRINGS PIPELINE	0.15
		WEINERT-OWENS CR DITCH	9.00
		MOUNT CARBON DITCH	1.20
		ANDERSON WELL SPR + TANK	0.10
			259.78

Priority Class	Decreed Amount
1	47.75
2	127.95
3	68.38
4	15.70
Total for Node No. 38	259.78

40	DEMN 57-60	ALLISON DITCH	5.00
		BERRY GULTCH #2	1.00
		CARMINE DITCH	7.00
		N WILLOW RUN DITCH	1.25
		OHIO CREEK NO 1 DITCH	5.00
		OHIO CREEK NO 2 DITCH	16.00
		PRICE CR NO 2 DITCH	1.50
		PRICE CR NO 3 DITCH	1.50
		PRICE CR NO 4 DITCH	3.50
		PRICE CREEK DITCH	2.00
		SIMINEO DITCH	27.50
		SOUTH WILLOW RUN D	0.38
		VALENTINES DITCH	8.00
			79.63

Priority Class	Decreed Amount
1	26.00
2	47.63
3	6.00
Total for Node No. 40	79.63

42	DEMN 53-56	ACME DITCH	92.00
		CASTLE CR NO 1 DITCH	6.00
		CASTLE CREEK NO 2 DITCH	2.00
		CASTLE PK FDR DITCH	10.00
		CASTLE PK FDR DITCH NO2	10.00
		ELZE WEBBER DITCH	14.00
		PRESSLER POLISIC DITCH	10.00
		SILKA DITCH	12.80
		UPPER FEEDER SILKA DITCH	5.00
		WILLIAM ELZE DITCH	8.00
			169.80

Priority Class	Decreed Amount
1	28.00
2	86.00
3	55.80
Total for Node No. 42	169.80

TABLE C.8

DITCHES OFF OF GUNNISON MAINSTEM AND SMALL TRIBUTARIES

Node No.	Demand Nos.	Ditch Name	Decreed Amount (cfs)
32	DEMN 41-44	M L S NO 2 DITCH	1.75
		DOS RIOS DITCH	6.00
		GUN ISLAND AC INC DITCH	4.00
		SMITH PIPELINE	0.20
		PARTCH WELL	0.11
		DOS RIOS WELL NO1	0.18
		WOODS WELL	0.22
		DOS RIOS MUNICIPAL WELL2	0.69
		DOS RIOS WELLS	1.87
		ELK RIDGE WELL NO 1	4.00
			19.02

Priority Class	Decreed Amount
1	3.62
2	4.00
3	4.00
4	7.40
Total for Node No. 32	19.02

33	DEMN 45-48	AIR PORT DITCH	3.00
		APRIL DITCH	12.00
		DOOLEY ANTELOPE IRG D	2.61
		FRANK ADAMS NO 1 DITCH	51.50
		GOODWIN KNOX DITCH	11.00
		GRAY-TANNER ANTELOPE CR	14.70
		HARMOR DITCH	3.00
		HYZER-KETCHUM DITCH	16.00
		ISLAND DITCH	16.00
		KELMEL OWENS NO 1 DITCH	80.00
		KELMEL OWENS NO 2 DITCH	59.02
		MOORE DITCH	0.38
		PALISADES DITCH	6.50
		PALISADES DITCH NO 2	1.00
		SEVENTY FIVE DITCH	56.25
		SLOUGH DITCH	4.00
		TWIN BRIDGES ASSN DITCH	1.20
		UTE TRAIL DITCH	8.00
		CABIN SPRING AND PL	0.40
		GUNNISON ISLAND ACRES I	5.00
		GUNNISON ISLD AC IRR D	10.00
		GUNNISON TOWN PIPELINE	15.00
		GUNNISON WATER TANK	0.18
		HIDER DITCH	1.25
		IVX SPRING DITCH	0.95
		PALISADES D ENLT	3.88
		PALISADES D ENLT	3.88
		PICKERING DITCH	17.67
		THOMPSON DITCH	3.00
		WILD WOOD PARK DITCH	15.00
		MELTON IRRIGATING DITCH	2.38
		CUNNINGHAM SPRING + TARN	0.36
		HEADLEE DITCH	4.00
		STEERS GULCH ENL K O 1	3.00
		LAKE LOUISE RESERVOIR	2.00
		LAKE PARTCH	2.00
		GUNNISON WELL NO3	1.11
		GUNNISON WELL NO4	1.11
		GUNNISON WELL NO5	1.11
		DOS RIOS WELL NO2	0.18
		MARKWOOD RESIDENCE WELL	0.55
			440.15

Priority Class	Decreed Amount
1	80.38
2	221.20
3	105.55
4	33.02

Total for Node No. 33 440.15

43	DEMN 69-72	ELMER MARSHALL NO1 DITCH	8.00
		GARDEN DITCH	29.30
		GEO SMITH NO 1 DITCH	2.00
		GEO SMITH NO 2 DITCH	4.38
		GUNNISON+OHIO CR CANAL	172.86
		GUNNISON R OHIO CR IRG D	100.23
		GUNNISON TOMICHI VLY D	59.13
		GUNNISON TOWN DITCH	75.03
		GUNNISON R OHIO CR IRG D	8.00
		JOHN B OUTCULT NO 2 D	39.85
		LIGHTLEY D + LINTON ENLT	28.00
		MARSHALL NO1 DITCH	16.50
		MARSHALL NO2 DITCH	47.00
		PILONI DITCH	31.50
		POWER DITCH	3.75
		SMITH AND WILSON DITCH	7.00
		THORNTON NO 1 DITCH	6.00
		WHIPP DITCH	37.00
		WILSON NO 2 DITCH	4.50
		ELMER MARSHALL #2 DITCH	4.47
		ESTY DRAIN DITCH	3.00
		GUNNISON+TOMICHI VALLEY	2.00
		HOME DITCH	8.00
		JOHN B OUTCALT NO1 D E+E	6.50
		LOST CANYON DITCH	2.00
		O'FALLON DITCH	85.00
		POWER DITCH	18.75
		TOBIN WASTE RETURN SYS	0.50
		WILSON NO 1 DITCH	7.00
		JOHN JOHNSON DITCH	8.00
		DIFFICULT DITCH	4.00
		PONDEROSA DITCH + POND	20.00
		GUNNISON WELL NO 1	1.39
		GUNNISON WELL NO2	1.11
		GUNNISON WELL NO 6	1.11
		CRANOR SKI HILL WELL NO1	0.13
		WILLIAMSON DOMESTIC WEL	0.17
		C+H WELL	0.11
			853.26

Priority Class	Decreed Amount
1	264.85
2	317.32
3	224.07
4	47.02
Total for Node No. 43	853.26

TABLE C.9

SOAP CREEK BASIN DITCHES

Node No.	Demand Nos.	Ditch Name	Decreed Amount (cfs)
23	DEMN 21-24	BIG SOAP PARK DITCH	15.00
		IRVING DITCH	3.75
			18.75

Priority Class	Decreed Amount
2	3.75
3	15.00
Total for Node No. 23	18.75

TABLE C.10

CEBOLLA CREEK BASIN DITCHES

Node No.	Demand Nos.	Ditch Name	Decreed Amount (cfs)
29	DEMN 33-36	A DOERING SPR CR D	7.50
		ANDREWS DITCH	11.08
		BAILEY R + RS WILSON D	8.00
		BAILEY WILSON DITCH	3.00
		BEAR CREEK DITCH	0.90
		BIG DITCH	33.00
		BOWERS DITCH	3.00
		BOWERS SPG + PL NO 1	0.10
		BOWERS SPG + PL NO 2	0.10
		CADWELL DITCH	2.00
		CASCADE DITCH	2.00
		CATHEDRAL BRANCH IRR D	8.00
		CEBOLLA CREEK DITCH	9.57
		CEBOLLA HOT SPGS POOL	2.00
		CLIFF IRR DITCH	10.00
		CLIFF IRR DITCH NO 2	4.50
		COBB-CEBOLLA CR D	10.00
		COLD SPRING DITCH	2.16
		CREED TRAIL IRR DITCH	9.50
		CROWLEY SPG + PL	0.25
		CRYSTAL CR WW DITCH	0.50
		DICK LAMOY SPG NO 1 POND	0.14
		DRY POWDERHORN DITCH	10.00
		E M BOWERS IRG DITCH 93	0.40

E M BOWERS NO 2 D	0.66
EAST DEMPSEY D+PUMPSITE	1.00
EAST DITCH	4.00
EATON GULCH DITCH	2.88
FERRIS DITCH ENLT	3.00
FISH CANYON SPG PL+POND	1.10
FISH CREEK DITCH	1.57
FOSTER D NO 2	1.18
FOSTER IRG D NO 4	1.18
FOSTER NO 1 DITCH	9.00
GOODGION SPG POND	0.50
GOOSE CR SPG DITCH	0.50
GRAY SPRING PIPELINE + D	0.50
HATCHER DITCH	6.00
HOMERUN IRG DITCH	0.66
HOPFER DITCH	2.50
HOT SPRINGS DITCH	2.00
HOT SPRINGS DITCH	3.00
HOWARD SPRING DITCH	1.00
HUFTALEN DITCH	0.27
J W BROWN DITCH	3.50
JOHN W ANDREWS DITCH	0.89
JOHNSON E SIDE DITCH	2.50
JOHNSON W SIDE DITCH	2.50
KELSO GULCH SPG PL	0.10
KEZAR SPG NO 2 POND	0.50
KEZAR SPG NO 3 DITCH	2.00
KEZAR SPG NO 4 DITCH	2.00
KEZAR SPG NO 5 DITCH	1.00
LONE PINE DITCH	9.61
LOWER SPR CREEK D	2.92
LOWER SPRING CR IRR D	2.08
M B + A DITCH	26.00
MAYBELL DITCH NO 1	5.70
MCGREGOR DITCH	7.00
MCNEILL SPRING NO 1 POND	0.10
MCNEILL SPRING NO 2 POND	0.10
MCNEILL SPRING NO 3 POND	0.10
MEADOW VIEW DITCH	1.04
MENDENHALL DITCH	0.80
MESSENGER POND NO 1	0.10
MESSENGER POND NO 2	0.10
MESSENGER POND NO 3	0.10
MESSENGER POND NO 4	0.10
MILK RANCH SPG + PL	0.10
MINERAL CR NO 1 D ENLT	8.00
MINERAL CREEK NO 2 D	11.50
MINERAL CREEK NO 3 D	1.20
MINNIE B NO 2 DITCH	9.30
NICHOLS POWDERHORN DITCH	4.00
O R BOWERS NO 1 D	4.82
OREN BOWERS NO 4 D	3.50
ORIN BOWERS NO 5 D	1.50

ORIN BOWERS NO 6 D	1.00
PASTURE CREEK DITCH	1.00
POISON WEED SPRING POND	0.10
POLE GULCH IRR DITCH	1.20
POWDERHORN DITCH	3.00
POWDERHORN IRG DITCH	4.44
POWDERHORN P + PL HDG #3	2.26
R B WILSON D NO 1 2 3	4.00
RADEKA DITCH	5.00
ROCK CR IRR DITCH	4.00
ROCK CREEK DITCH	2.50
ROCK CREEK DITCH	2.00
RUDOLPH IRR DITCH	15.50
SAMMONS DITCH	3.00
SAMMONS DITCH NO 2	5.00
SAMMONS DITCH NO 3	5.00
SAMMONS IRG D NO 4	3.00
SAMMONS IRG D NO 5	7.50
SAMMONS IRG D NO 6	10.00
SAMMONS POWDERHORN D	6.70
SCHECKER DITCH	8.08
SCHNEPF HIGHLINE DITCH	12.00
SOUTHERN UTE DITCH	0.40
SPENCER SPRING DITCH	2.00
SPRING CREEK DITCH	2.00
SPRING CREEK NO 2 D	0.26
STAVELY DITCH	2.35
STONECIPHER SPG D	0.50
TABOR NO 2 D ENLT	21.41
UPPER CEBOLLA DITCH	22.00
W S THOMPSON DITCH	3.50
WARRANT DITCH	9.00
WARRANT SPRING POND	0.50
WEGENER-KNOLL DITCH	6.00
WEST DITCH	6.00
WILLEY DOM SPG + PL	0.13
WILSON INFILT GALLERY SY	5.00
WILSON SODA SPRING	0.10
WRIGHT DOM SPG + POND 2	0.60
WRIGHT@S CATHEDRAL DITCH	1.00
YOUMANS HOUSE GULCH D	1.00
YOUMANS IRG D NO 1	10.00
YOUMANS IRG D NO 2	8.00
YOUMANS NO 1 DITCH	4.00
YOUMANS NO 3 DITCH	8.00
YOUMANS NO 4 DITCH	4.00
YOUMANS SPG NO 2 PL	0.15
YOUMANS SPG + PL NO 1	0.10
YOUMANS WASTE WATER D	6.00
YOUMANS WATER GULCH D	1.00
	526.24

Priority Class	Decreed Amount
1	83.95
2	266.26
3	76.36
4	99.67
Total for Node No. 29	526.24

TABLE C.11

LAKE FORK BASIN DITCHES

Node No.	Demand Nos.	Ditch Name	Decreed Amount (cfs)
25	DEMN 25-28	ADDINGTON NO 1 D	2.88
		BISHOP SPRING PIPELINE	0.50
		BLUE MESA SPG NO 16 PL	0.27
		BOYD WASTE WATER DITCH	2.00
		CARR DITCH	22.00
		CARR IRR DITCH	12.00
		E P WILSON NO 2 FDR PUMP	1.00
		E P WILSON NO3 PUMP+D	19.00
		HICKS DITCH	0.50
		INDIAN CREEK IRR DITCH	12.00
		INDIAN CREEK NORTH DITCH	2.00
		JOHNSON GULCH DITCH	2.00
		LAKE FORK DITCH	0.79
		LAKE FORK NO 1 DITCH	20.00
		LOWER LAKE DITCH	0.50
		MESSLER DITCH	3.00
		MOORE DITCH	12.03
		MOORE PIPELINE	6.70
		PORCUPINE GULCH DITCH	0.50
		SAP MESA SPG + PL NO 1	0.15
		SAP MESA SPG + PL NO 2	0.15
		SAP MESA SPG + POND NO 3	0.15
		SAP MESA SPG + POND NO 4	0.15
		SMOCK INDIAN CREEK DITCH	2.00
		SPRING BRANCH DITCH	10.30
		SPRING BRANCH DITCH NO 2	2.00
		THOMAS COLD WATER SPG PL	0.50
		WHITE ROCK NO 1 DITCH	1.22
		WILLOW LAKE	0.27
		YEAGER DITCH	2.30
			138.86

Priority Class	Decreed Amount
1	16.19
2	70.00
3	20.50
4	32.17
Total for Node No. 25	138.86

27	DEMN 29-32	ANTONIO FERRARO D NO 1	3.00
		B AND B DITCH	6.64
		BAKER D 1ST ENLT + PL	8.80
		BAKER EAST SIDE	9.00
		BAKER NO 2 D + 1ST ENLT	7.50
		BRYANT DITCH	1.00
		CAMPBELL CR DITCH	0.92
		CAMPBELL GULCH DITCH	2.08
		CAPITOL CITY WATER LINE	1.00
		CARRIS THOMPSON DITCH	4.00
		CARSON CREEK DITCH	5.30
		CARSON CREEK NO 2 D	2.00
		CASEY DITCH	0.50
		CHILDS PARK DITCH	5.70
		CHRISTIANNA NO I DITCH	2.00
		COPELAND ELK CR D	15.70
		CRAIG DITCH	14.42
		CRYSTAL DITCH	1.50
		D C BAKER NO 1 D	1.31
		DONNELL DITCH	1.50
		DWYER CR DITCH	0.92
		E P WILSON NO1 FDR PUMP	6.50
		EDMONDSON NO 2 DITCH	1.50
		F S WILLIAM D NO 1	0.71
		FERRARO DITCH	1.95
		FERRARO NO 2 DITCH	4.00
		FRENCH D NO 2	5.00
		FRENCH D NO 3	3.00
		FRENCH DITCH	1.00
		FRENCH DITCH NO 2	3.00
		GRANDON PL NO 2	0.11
		GREENFIELD DITCH	0.40
		HEADQUARTERS SPG DITCH	0.44
		HIDDEN TREASURE PL+WTR R	215.00
		HOTCHKISS SPRING PL	0.42
		HUNTER ELK CREEK DITCH	14.00
		INDEPENDENCE IRR DITCH	12.00
		IRVIN BUSCHBAUM PL	0.10
		J N THOMPSON D	2.00
		JOHNSON DITCH	2.00
		JONES CLEARWATER SPG	0.37
		JONES DOMESTIC SPG	0.20
		LAKE CITY AREA WELL PL+R	2.00
		LAKE CITY POWER CO PL	200.00

LAKE CITY TOWN DITCH	5.00
LAKE FORK IRR DITCH	4.48
LASHBOUGH NO 1 DITCH	2.50
LASHBOUGH NO 2 DITCH	3.00
LUCKY CHANCE PL + RES	50.50
MARTIN WADE P	1.30
NO NAME DITCH	0.31
PORTER NO 1 DITCH	4.50
PORTER NO 2 DITCH	3.00
PROVIDENCE CREEK D	2.08
PROVIDENCE NO 2 DITCH	0.52
PROVIDENCE NO I DITCH	1.04
PUEBLO PLACER PIPELINE	0.50
RAMSEY PARK PIPELINE	0.25
RED CLOUD PUMP + PL	0.49
REECE RICHART NO 1 D	10.00
REECE RICHART NO 2 D	4.80
REECE RICHART NO 3 D	2.00
RIGNEY D AKA GONER D	4.27
ROACH DITCH	7.50
RUBY NO 2 PIPELINE	0.25
SAN CRISTOBAL PL NO 1	0.10
SAN CRISTOBAL PL NO 2	0.10
SEELEY DITCH	4.00
SEELEY NO 2 DITCH	3.00
SEELEY NO 3 DITCH	1.00
SILVER LEAF SPRING PL	0.10
SLAUGHTER HOUSE DITCH	1.00
STEEL DITCH	5.50
SUNNYSIDE DITCH	3.50
SWANK DITCH NO 2	3.00
SWANK FISH POND D NO 1	60.00
SWANK FISH POND D NO 2	30.00
SWANK NO 1 PIPELINE	0.15
SWANK NO 2 PL	1.00
THOMAS PROVIDENCE DITCH	0.40
THOMAS ROCK SPRING DITCH	0.20
THOMAS SKUNK CREEK DITCH	2.50
THOMPSON DNO2 AKA HOLRYD	2.08
THOMPSON IRR DITCH	14.00
TROUT CREEK NO 1 DITCH	4.16
VICKERS BROS D NO 1	4.00
VICKERS BROS D NO 2	3.00
VICKERS BROS D NO 3	0.50
VICKERS DITCH NO 1	4.50
VICKERS SPG NO I PL	0.20
WATER DOG LAKE DITCH	2.88
WEST SIDE IRR DITCH	1.04
WHINNERY ELK CR+NARROW G	7.33
WILLIAMS DITCH	1.10
WILSON DITCH	4.16
WRIGHT SPRING PIPELINE	0.25
YOUMANS IRRI D ENL	7.50
	851.03

Priority Class	Decreed Amount
1	24.17
2	358.83
3	286.91
4	181.12
Total for Node No. 27	851.03

TABLE C.12

BLUE RIVER BASIN DITCHES

Node No.	Demand Nos.	Ditch Name	Decreed Amount (cfs)
19	DEMN 17-20	HEAD FERRIER D EXT+ENL	35.50
		MESA CR DITCH	24.00
		VAN TUYL NO 1	3.50
		WISE DITCH	1.37
		DONNY DITCH NO 4	0.16
		ALLEN SPRING DITCH	0.21
		BIG BLUE DITCH	68.47
		BIG BLUE DITCH	1.53
		BRUCE FRANKLIN DITCH	10.85
		E H + Z B MARTIN D NO 1	0.20
		HAZEL DITCH	13.00
		HENRY ANTHOLZ SPG NO7 D	0.30
		MEAKER D + M D AMENDMENT	10.00
		PINE CREEK DITCH	26.61
		SQUIRREL NO 1 DITCH	2.00
		SQUIRREL NO 2 DITCH	4.00
		WORKMAN SPG DITCH	0.17
		PETERSON PINE CR DITCH	4.39
		ARROWHEAD DITCH NO 1	4.00
		ARROWHEAD DITCH NO 2	6.00
		ARROWHEAD DITCH NO 3	8.00
		BALDY SPRING PONDS	0.20
		BROWN SPG POND + PL	0.10
		BUCK PASTURE SPG POND	0.10
		DAVID SPRING POND	0.15
		DESERT SPRING PIPELINE	0.40
		FOUGNIER PIPELINE	3.16
		FREEMAN SPRING PIPELINE	0.15
		HENRY ANTHOLZ NO 11 D	1.00
		HENRY SPG PL + DITCH	0.30
		HOMESTEAD SPRING POND	0.15
		HORIZON RES + DITCH	1.60

JOE WILLIAMS SPG A PL	0.20
JUDE SPRING POND	0.15
KIMBERLY SPG POND + PL	0.10
LANCE SPG + POND NO 2	0.10
LEONA SPRING DITCH	0.25
MIKE SPRING POND	0.10
PINE CREEK SPRING POND	0.10
ROACH LOGAN DITCH	1.00
ARROWHEAD DITCH NO 4	16.00
SNELSON CREEK POND	0.10
SNELSON SPG POND + PL	0.15
SQUIRRELL E FORK PONDS	3.00
ARROWHEAD DITCH NO 5	6.00
TODD SPRINGS PIPELINE	0.14
VICKI SPRING POND	0.10
YOCUM SPRING NO 2 PL	0.10
YOCUM SPRING PL NO 1	0.10
YOCUM SPRING PL NO 3	0.10
BLACK MESA SPG NO 1 PL	0.10
BLACK MESA SPG NO 2 PL	0.10
FOUGNIER GULCH DITCH	2.00
FOUGNIER HOMESTEAD SP PL	0.23
WIGGIN'S SPRING PIPELINE	0.15
JOE WILLIAMS SPG+PL NO 2	0.35
	262.29

Priority Class	Decreed Amount
1	5.39
2	77.48
3	98.73
4	80.69
Total for Node No. 19	262.29

TABLE C.13

CIMARRON RIVER BASIN DITCHES

Node No.	Demand Nos.	Ditch Name	Decreed Amount (cfs)
12	DEMN 5-8	ANTHOLZ DITCH	3.00
		BUBBLING SPRING DITCH	0.50
		BUTTE DITCH	1.00
		BUTTE + BUTTE EX DITCH	19.17
		COLLIER DITCH	13.05
		COLLINS SPRING NO 1 D	0.25
		DAVIDSON SPG DITCH	0.50
		HAWK DITCH + PIPELINE	0.20
		HAWK HOME SPG AREA D +PL	0.50
		HAWK SPRING	0.50
		MAURER DRAW DITCH	3.00
		MAURER TOPLISS D	2.00
		MC KINLEY DITCH ENL	31.00
		MICHAEL E CLOSSER RIGHT	0.20
		MILLER DITCH	1.50
		OCTAVE NICOLAS WW DITCH	1.00
		OLD HARRIS DITCH	3.00
		PETERSON + RILEY DITCH	7.00
		RIVES NO 1 DITCH	0.21
		SODERQUIST DITCH NO 3	2.00
		SODERQUIST SEEP DITCH	3.00
		STUMPY DITCH	2.61
		VANDERBURG D ENL	6.15
		WASHBOARD BASIN PONDS	0.25
		WHITTINGHAM NO 1 D S BR	8.00
			109.59

Priority Class	Decreed Amount
1	19.94
2	47.57
3	29.03
4	13.05
Total for Node No. 12	109.59

13	DEMN 9-12	ANGUS SPRINGS DITCH	1.20
		BAR E SPG PIPELINE	0.11
		BISHOP MESA SPG	1.00
		BLUE LAKE NO 2 DITCH	1.50
		BROWN DITCH	0.32
		BRUTON NO 1 DITCH	5.00
		BRUTON NO 2 DITCH	1.00
		CHARLEY BERRY NO 1 D	0.50
		CHARLEY BERRY NO 2 D	1.00
		CHARLEY BERRY NO 3 D	0.50
		COAL CREEK DITCH	5.54
		COWBOY DITCH	0.25
		FISH CREEK NO 1 FEEDER D	40.00
		FITZPATRICK D NO 1	2.25
		FITZPATRICK D NO 2	2.10
		FREEMAN DITCH	0.25
		FREEMAN DITCH	8.00
		FREEMAN DITCH	0.90
		HAMPTON DITCH	3.10
		HOFMANN SPG + DOM PL	0.20
		LATHROP NO 1 DITCH	1.00
		LATHROP NO 2 DITCH	1.00
		LATHROP NO 3 DITCH	1.00
		LATHROP SPRING PL	0.10
		LEO SPRING + DITCH	0.10
		LITTLE BIG HORN SPG D #	0.50
		LONE TREE DITCH	2.00
		MARIA SPG D NO 1	0.25
		MCMINN DITCH	5.21
		MCMINN-VEO DITCH	0.79
		MUD SPRINGS + PUMP	0.25
		ORME NO 1 DITCH	2.00
		ORME NO 2 DITCH	1.50
		ORME NO 3 DITCH	0.50
		PRICE LATERAL	2.00
		RAINBOW LAKE DITCH	2.00
		RIVES NO 2 DITCH	0.40
		RIVES + LINES DITCH	0.70
		SCHILDTZ LAKES NO 1 2 D	1.00
		SCHILDT-BROWN DITCH	1.57
		SIGAFUS NO 1 DITCH	2.00
		VEO DITCH	15.60
		VEO SPRING + DITCH NO 2	0.50
		VEO SPRING + PL NO 1	0.50
		WHITTINGHAM D NO 2 N BR	8.00
		WHITTINGHAM D NO 3	3.00
		WHITTINGHAM NO 4 DITCH	2.00
		WHITTINGHAM NO 5 DITCH	4.00
		WINKLE NO 1 AND NO 2	2.00
		YORK NO 1 DITCH	1.00
			137.79

Priority Class	Decreed Amount
1	23.73
2	48.35
3	58.85
4	6.86
Total for Node No. 13	137.79

TABLE C.14

CRYSTAL CREEK BASIN DITCHES

Node No.	Demand Nos.	Ditch Name	Decreed Amount (cfs)
11	DEMN 1-4	ANDERSON DITCH NO 1	0.60
		ANDERSON DITCH NO 2	1.40
		DEINES PUMPSITE	2.00
		FROOM DITCH	1.00
		OSCAR RICHARDS D	11.20
		POISON WATER SPG PL	0.10
		PRICE DITCH	1.75
		SIGNAL HILL DITCH	6.03
		UPPER BELLGARDT SPRING	0.10
			24.18

Priority Class	Decreed Amount
2	21.98
4	2.20
Total for Node No. 11	24.18

TABLE C.15

COW CREEK BASIN DITCHES

Node No.	Demand Nos.	Ditch Name	Decreed Amount (cfs)
103	DEMN 165-168	ALKALI DITCH D NO80	32.00
		ALKALI NO 2 DITCH	33.50
		BABB DITCH	4.00
		BROOKE DITCH	3.00
		CHAFFEE DITCH	6.00
		CLIFF POND DITCH	0.75
		DAINE DITCH	2.00
		EASTSIDE DITCH	6.00
		FLUME CREEK DITCH	4.00
		HAYES TEAGUE DITCH	3.00
		ISLAND POND DITCH	8.50
		JOLLY DITCH	4.00
		LEW CREEK DITCH	3.13
		LIESY DITCH	4.00
		MARTIN DITCH	10.00
		NATE CREEK NO 1 DITCH	6.25
		NATE CREEK NO 2 DITCH	4.13
		NATE CREEK NO 3 DITCH	5.00
		NATE CREEK NO 4 DITCH	5.00
		OWL CREEK DITCH	14.25
		PRIVATE DITCH SHAVEN	0.50
		PRIVATE DITCH STEALEY	2.50
		RHOADES DITCH	4.00
		ROSEBUD DITCH	3.63
		SHAREN AND SHAREN NO2 D	3.50
		SHORTLINE D COW CREEK	4.00
		SOL TEAGUE DITCH	8.00
		SPRUCE POND DITCH	0.36
		STEALEY OWL CREEK DITCH	4.75
		TAFT DITCH	0.63
		TAYLOR DITCH	8.00
		WEST SIDE DITCH	4.00
		WHITE DITCH	1.00
		SNEVA DITCH	21.00
			224.36

Priority Class	Decreed Amount
1	137.13
2	73.38
3	9.00
4	4.86
Total for Node No. 103	224.36

TABLE C.16

INDEPENDENT DITCHES
UNCOMPAHGRE MAINSTEM AND TRIBUTARIES

Node No.	Demand Nos.	Ditch Name	Decreed Amount (cfs)
89	DEMN 209-212	BALDY DITCH	30.00
			30.00

Priority Class	Decreed Amount
1	30.00
Total for Node No. 89	30.00

Node No.	Demand Nos.	Ditch Name	Decreed Amount (cfs)
90	DEMN 205-208	BOLES A MANNEY D	15.98
		DARTER + HAUGSTED DITCH	4.20
		DELTA DITCH	35.16
		GARREN LEWIS DITCH	2.50
		SATISFACTION D	20.23
			78.07

Priority Class	Decreed Amount
1	57.27
2	17.39
4	3.41
Total for Node No. 90	78.07

Node No.	Demand Nos.	Ditch Name	Decreed Amount (cfs)
92	DEMN 197-200	EAGLE DITCH	33.85
		GLENDENING D	3.04
		RICE DITCH	7.29
		VALVERDE DITCH	10.00
			54.18

Priority Class	Decreed Amount
1	51.14
4	3.04
Total for Node No. 92	54.18

Node No.	Demand Nos.	Ditch Name	Decreed Amount (cfs)
93	DEMN 189-192	C A PALMER DITCH	3.00
		CHARLES M RYAN DITCH	7.28
		KELLER BROTHERS DITCH	2.00
		S E DILLON DITCH	3.00
		SHAVANO VALLEY DITCH	13.75
			29.03

APPENDIX D

KEY TO HYDROLOGIC/WATER RIGHTS MODEL NETWORK DIAGRAM

APPENDIX D

KEY TO NETWORK DIAGRAM

The lists which follow form a key to Figure 7.1, the Basin Model network. The model network is comprised of 146 nodes and 571 arcs.

Besides the node numbers to which the arc is connected (the "from" and "to" nodes), each arc has three parameters of fundamental importance. These parameters are the lower bound, the upper bound, and the rank. The lower bound sets the minimum flow allowed in the arc and the upper bound sets the maximum flow allowed in the arc. The rank describes the value placed on a unit of flow in the arc; the model allocates water preferentially to arcs having higher ranks in its effort to optimize the water allocation of the entire network.

Four different types of arcs are used in the basin model network, inflow arcs, demand arcs, decree arcs, and links. All four types of arcs have the fundamental parameters described above. The differences between the four types of arcs relate primarily to convenience of CRAM input and output. For example, it is only necessary to provide the "to" node and upper bound of inflow arcs in the model input; the "from" node, lower bound, and rank are initialized internally by the model. Links, on the other hand, require full specification of all fundamental parameters.

Of the 571 arcs, 79 arcs represent inflows or return flows; these arcs are labeled "INFL" on Figure 7.1. Inflow arcs force water into the network because their lower bound is set equal to their upper bound which, in turn, is equal to a particular monthly inflow volume. There are no ranks set for inflow arcs.

Demand arcs, of which there are 262 in the network, withdraw water from the network. These arcs are labeled "DEMN" on Figure 7.1. It is necessary to specify the "from" node, the upper bound, and the rank of each demand arc. Generally speaking, the upper bound reflects the monthly demand volume and the rank reflects (except in a few cases) the water rights priority of the demand.

There are only three decree arcs in the network. These are labeled "DECR." CRAM automatically keeps track of accumulated flows in decree arcs, a feature which is used to track reservoir storage over the course of a year. Decree arcs require full specification of all fundamental arc parameters. The upper bound on a decree arc represents the total accumulated flow which is permitted and the rank represents the priority placed on that flow.

Links are the most versatile type of arc in the network. There are 227 of them, labeled "LINK" on Figure 7.1, in the basin model network. Links can be used in place of all other arc types except decree arcs. All fundamental parameters of links must be provided as model input.

The following lists describe the essential characteristics of the inflows, demands, decrees, and links shown on Figure 7.1.

TABLE D.1

INFLOW ARCS IN BASIN MODEL NETWORK

Arc Number	Description of Nature of Inflow or Contributing Area
INFL 1	inflow from Colo. River at confluence (not used)
INFL 2	Grand Valley irrigation return flows (not used)
INFL 3	gaged gains between Uncompahgre R. and Colorado R.
INFL 4	gaged gains from Tunnel to confluence with Uncompahgre R.
INFL 5	gains between Morrow Point and Crystal except Cimmaron R.
INFL 6	inflows to Silver Jack reservoir
INFL 7	Cimarron basin flows interceptable by the Cimmaron Canal
INFL 8	all remaining Cimarron basin flows, i.e., total Cimarron virgin flow less INFL 7 and INFL 8
INFL 9	all gains between Blue Mesa outlet and Morrow Point dam (inc ludes Blue River, Curecanti Cr., and Pine Cr.)
INFL 10	Lake Fork above Gates site (just downstream of Trout Cr.)
INFL 11	Lake Fork gains between Gates site and Gateview site (below Indian Cr)
INFL 12	redundant arc, not used
INFL 13	Cebolla above Cebolla Site No. 1
INFL 14	Cebolla gains between Site 1 and Site 2
INFL 15	Soap Creek above Soap Cr. site
INFL 16	Steuben, Elk, Coal, Beaver, and Willow Creeks (combined area)
INFL 17	remaining area tributary to Blue Mesa below Gunnison, incl. lower reaches of Lake Fork, Soap, Cebolla and mainstem gains
INFL 18	Gunnison mainstem gains between Ohio Cr. and Tomichi confluence
INFL 19	Mill Creek
INFL 20	Ohio Cr. gains from Castle Cr. to Mill Creek
INFL 21	Castle Creek above Willow Park res.site
INFL 22	Ohio Cr. and tribs above Castle Cr.
INFL 23	Ohio Cr. gains from Mill Cr. to mouth
INFL 24	Gunnison mainstem gains between Almont and Ohio Creek
INFL 25	Slate River above Crested Butte res.site
INFL 26	Slate R. gains below Crested Butte res. plus East River gains below Crested Butte Res. No. 1 site
INFL 27	Middle and East Brush Creeks
INFL 28	West Brush Creek
INFL 29	Brush Creek gains, East River, Ferris Cr. and other tributaries above Crested Butte No. 1 site
INFL 30	inflow to Cement Cr. res site
INFL 31	Cement Cr. gains below res site
INFL 32	East River gains between Cement Cr. and Taylor River
INFL 33	Taylor Reservoir inflow less area above Pieplant site
INFL 34	inflow to Pieplant site
INFL 35	inflow to Union Park reservoir site on Lottis Creek
INFL 36	all contribution of Lottis Creek basin less that included in INFL 35
INFL 37	Taylor River gains between Lottis Cr.and confluence with East R.
INFL 38	inflow to Monarch reservoir site
INFL 39	Tomichi gains between Monarch and Elko sites, incl. Marsnall Cr.

INFL 40	Tomichi gains between Elko site and Razor Cr., incl. Hot Springs Cr.
INFL 41	Razor Cr. above reservoir site
INFL 42	Quartz Cr. inflow to Pitkin res site
INFL 43	Quartz Cr. gains between Pitkin site and Ohio City site, incl. Gold Cr.
INFL 44	Quartz Cr. gains between Ohio City site and Tomichi confluence
INFL 45	Tomichi gains between Razor Cr. and confluence with Cochetopa <u>except</u> Quartz Cr.
INFL 46	inflow to Banana Ranch res site
INFL 47	inflow to Pauline res site
INFL 48	inflow to Flying M res site
INFL 49	all Cochetopa gains below the 3 sites down to the Cochetopa res site, includes West Pass Creek
INFL 50	Tomiochi gains between Cochetopa and Gunnison confluence
INFL 51	redundant arc, not used
INFL 52	inflow to Rams Horn site on Cow Cr.
INFL 53	gaged inflow to Ridgway dam site
INFL 54	Uncompahgre gains below Ridgway to Cow Creek plus Cow Cr. gains below Rams Horn site
INFL 55	Uncompahgre gains between Cow Creek and South Canal
INFL 56	inflow from Horsefly Creek drainage
INFL 57	inflow from Happy Canyon drainage
INFL 58	inflow from Spring Creek drainage
INFL 59	inflow from Dry Creek drainage
INFL 60	groundwater return flow[1] from Uncompahgre Project land
INFL 61	groundwater return flow from Uncompahgre Project land
INFL 62	groundwater return flow from Uncompahgre Project land
INFL 63	groundwater return flow from Bostwick Park Project land
INFL 64	surface water return flow from Uncompahgre Project land
INFL 65	surface water return flow from Uncompahgre Project land
INFL 66	surface water return flow from Uncompahgre Project land
INFL 67	surface water return flow from Uncompahgre Project land
INFL 68	surface water return flow from Uncompahgre Project land
INFL 69	surface water return flow from Uncompahgre Project land
INFL 70	surface water return flow from Uncompahgre Project land
INFL 71	surface water return flow from Uncompahgre Project land
INFL 72	surface water return flow from Uncompahgre Project land
INFL 73	surface water return flow from Bostwick Park Project land
INFL 74	surface water return flow from Uncompahgre Project land
INFL 75	return flow from Project 7 water users
INFL 76	return flow from Project 7 water users
INFL 77	return flow from Project 7 water users
INFL 78	surface water return flow from Uncompahgre Project land
INFL 79	imports from Gunnison River via Gunnison Tunnel

1 All return flows are computed internally in the basin model

TABLE D.2

DEMAND ARCS IN BASIN MODEL NETWORK

Arc Number	Description of Demands Represented by Arcs
DEMN 1-4	Class I-IV aggregated depletions[1] on Crystal Creek
DEMN 5-8	Class I-IV aggregated depletions on lower Cimarron River
DEMN 9-12	Class I-IV aggregated depletions on upper Cimarron River
DEMN 13-16	Class I-IV aggregated depletions on tributaries to Cimarron Canal
DEMN 17-20	Class I-IV aggregated depletions on Blue River
DEMN 21-24	Class I-IV aggregated depletions on Soap Creek
DEMN 25-28	Class I-IV aggregated depletions on lower Lake Fork
DEMN 29-32	Class I-IV aggregated depletions on upper Lake Fork
DEMN 33-36	Class I-IV aggregated depletions on Cebolla Creek
DEMN 37-40	Class I-IV aggregated depletions on smaller tributary basins below Gunnison
DEMN 41-44	redundant arcs, not used
DEMN 45-48	Class I-IV aggregated depletions on Gunnison mainstem below Ohio Creek
DEMN 49-52	Class I-IV aggregated depletions on Mill Creek
DEMN 53-56	Class I-IV aggregated depletions on Castle Creek
DEMN 57-60	Class I-IV aggregated depletions on Ohio Creek below Castle Creek but above the Castle/Price reservoir site
DEMN 61-64	Class I-IV aggregated depletions on Ohio Creek below the Castle/Price site but above Mill Creek
DEMN 65-68	Class I-IV aggregated depletions on Ohio Creek below Mill Creek
DEMN 69-72	Class I-IV aggregated depletions on Gunnison mainstem above Ohio Creek
DEMN 73-76	Class I-IV aggregated depletions on East River below Cement Creek
DEMN 77-80	Class I-IV aggregated depletions on Slate River
DEMN 81-84	redundant arcs, not used
DEMN 85-88	Class I-IV aggregated depletions on East River below the Crested Butte No. 1 reservoir site
DEMN 89-92	Class I-IV aggregated depletions on East River above the Crested Butte No. 1 reservoir site
DEMN 93-96	Class I-IV aggregated depletions on Brush Creek
DEMN 97-100	Class I-IV aggregated depletions on Cement Creek
DEMN 101-104	Class I-IV aggregated depletions on Taylor River below Spring Creek
DEMN 105-108	Class I-IV aggregated depletions on Taylor River above Spring Creek
DEMN 109-112	Class I-IV aggregated depletions above Taylor Park reservoir
DEMN 113-116	Class I-IV aggregated depletions on Tomichi Creek below Cochetopa Creek
DEMN 117-120	Class I-IV aggregated depletions on Tomichi Creek between Quartz and Cochetopa Creeks
DEMN 121-124	Class I-IV aggregated depletions on Tomichi Creek between Elko reservoir site and Razor Creek
DEMN 125-128	Class I-IV aggregated depletions on Tomichi Creek above the

	Elko reservoir site
DEMN 129-132	Class I-IV aggregated depletions in lower Cochetopa Canyon
DEMN 133-136	Class I-IV aggregated depletions in upper Cochetopa Canyon
DEMN 137-140	Class I-IV aggregated depletions on Cochetopa Creek above West Pass Creek and below Pauline Creek
DEMN 141-144	Class I-IV aggregated depletions in vicinity of the Banana Ranch reservoir site
DEMN 145-148	Class I-IV aggregated depletions in vicinity of the Pauline reservoir site
DEMN 149-152	Class I-IV aggregated depletions in vicinity of the Flying M reservoir site
DEMN 153-156	Class I-IV aggregated depletions on lower Quartz Creek
DEMN 157-160	Class I-IV aggregated depletions on upper Quartz Creek
DEMN 161-164	Class I-IV aggregated depletions on Razor Creek
DEMN 165-168	Class I-IV aggregated depletions on Cow Creek
DEMN 169-172	Class I-IV aggregated depletions by independent ditches between the M&D and Loutsenhiser Canals
DEMN 173-176	Class I-IV aggregated depletions on Horsefly Creek
DEMN 177-180	Class I-IV aggregated depletions by independent ditches between the Loutsenhiser Canal and Happy Canyon Creek
DEMN 181-184	Class I-IV aggregated depletions on Happy Canyon Creek
DEMN 185-188	Class I-IV aggregated depletions by independent ditches between Happy Canyon Creek and the Selig Canal
DEMN 189-192	Class I-IV aggregated depletions on upper Spring Creek
DEMN 193-196	Class I-IV aggregated depletions on lower Spring Creek
DEMN 197-200	Class I-IV aggregated depletions by independent ditches between the Ironstone and East Canals
DEMN 201-204	Class I-IV aggregated depletions by independent ditches between the East and Garnet Canals
DEMN 205-208	Class I-IV aggregated depletions by independent ditches below the Garnet Canal
DEMN 209-212	Class I-IV aggregated depletions on upper Dry Creek
DEMN 213-216	Class I-IV aggregated depletions on lower Dry Creek
DEMN 217-219	Bostwick Park consumptive use, surface return flow, and groundwater return flow demands
DEMN 220-221	Project 7 consumptive use and return flow demands
DEMN 222-224	AB Lateral consumptive use, surface return flow, and groundwater return flow demands
DEMN 225-227	South Canal consumptive use, surface return flow, and groundwater return flow demands
DEMN 228-230	West Canal consumptive use, surface return flow, and groundwater return flow demands
DEMN 231-233	M&D Canal consumptive use, surface return flow, and groundwater return flow demands
DEMN 234-236	Loutsenhiser Canal consumptive use, surface return flow, and groundwater return flow demands
DEMN 237-239	Selig Canal consumptive use, surface return flow, and groundwater return flow demands
DEMN 240-242	Ironstone Canal consumptive use, surface return flow, and groundwater return flow demands
DEMN 243-245	East Canal consumptive use, surface return flow, and groundwater return flow demands
DEMN 246-248	Garnet Canal consumptive use, surface return flow, and groundwater return flow demands

DEMN 249	Gunnison Tunnel diversion
DEMN 250	Snowshoe reservoir conditional decree
DEMN 251	Lamm reservoir conditional decree
DEMN 252	Paonia conditional decree
DEMN 253	Fruitland Mesa conditional decree
DEMN 254	Grand Junction Pipeline conditional decree
DEMN 255	Gunnison Reservoir No. 2 conditional decree
DEMN 256	Crested Butte Mtn Resort conditional decrees
DEMN 257	Crested Butte mining, new conditional decree
DEMN 258	Town of Crested Butte
DEMN 259	City of Gunnison direct flow conditional decree
DEMN 260	Lake City mining, new conditional decree
DEMN 261	Tri-County M&I contract sales
DEMN 262	Brush Creek Reservoir conditional decree

1 Specific ditches comprising aggregated demands are listed in Appendix C.

TABLE D.3

DECREE ARCS IN BASIN MODEL NETWORK

Arc Number	Description
DECR 1	Blue Mesa storage
DECR 2	Ridgway storage
DECR 3	Taylor Park storage

TABLE D.4

LINK ARCS IN BASIN MODEL NETWORK

Arc Number	Description
LINK 1	Colorado River from Gunnison River to Redlands, not used
LINK 2	Colorado River from Redlands to Ruby, not used
LINK 3	Colorado River below Ruby, not used
LINK 4	Gunnison River below Redlands Power Canal
LINK 5	Gunnison River from Delta to Redlands Power Canal
LINK 6	Gunnison River from Black Canyon to Delta
LINK 7	Gunnison River in the Black Canyon below Gunnison Tunnel
LINK 8	Gunnison River immediately below Crystal Dam
LINK 9	Crystal Dam spillway
LINK 10	Crystal Dam river outlet
LINK 11	Gunnison River, total inflow to Crystal reservoir
LINK 12	Crystal Creek below Fruitland Mesa Canal
LINK 13	Gunnison River immediately below Morrow Point Dam
LINK 14	Morrow Point spillway
LINK 15	Morrow Point river outlet
LINK 16	Gunnison River, total inflow to Morrow Point reservoir
LINK 17	Gunnison River immediately below Blue Mesa
LINK 18	Blue Mesa spillway
LINK 19	Blue Mesa river outlet
LINK 20	Blue Mesa bypass
LINK 21	Gunnison River, total inflow to Blue Mesa reservoir
LINK 22	Cimarron River at Cimarron
LINK 23	Cimarron River above Little Cimarron River
LINK 24	Cimarron River below Cimarron Canal
LINK 25	Cimarron Canal upper section
LINK 26	Cimarron Canal, lower section
LINK 27	Blue River inflow to Morrow Point reservoir
LINK 28	Lake Fork below Gateview (inflow to Blue Mesa)
LINK 29	Lake Fork from Trout Creek to Gateview
LINK 30	Lake Fork from Gates reservoir site to Trout Creek
LINK 31	Lake Fork from Lake City to Gates reservoir site
LINK 32	Cebolla Creek below Powderhorn (inflow to Blue Mesa)
LINK 33	Cebolla Creek from Spring Creek to Powderhorn
LINK 34	Small tributaries below Gunnison
LINK 35	Gunnison River below Gunnison
LINK 36	Gunnison River from Ohio Creek to Tomichi Creek, lower section
LINK 37	Gunnison River from Ohio Creek to Tomichi Creek, upper section
LINK 38	Ohio Creek near mouth
LINK 39	Ohio Creek below Mill Creek
LINK 40	Mill Creek below ditches
LINK 41	Ohio Creek from Carbon Creek to Mill Creek
LINK 42	Ohio Creek from Price Creek to Carbon Creek
LINK 43	Ohio Creek from Baldwin to Price Creek
LINK 44	Ohio Creek from Castle Creek to Baldwin
LINK 45	Castle Creek below ditches
LINK 46	Gunnison River between Almont and Ohio Creek, lower section
LINK 47	Gunnison River between Almont and Ohio Creek, upper section

LINK 48	East River between Cement Creek and Almont, lower section
LINK 49	East River between Cement Creek and Almont, upper section
LINK 50	East River from Slate River to Cement Creek
LINK 51	Slate River above East River
LINK 52	East River from Farris Creek to Slate River
LINK 53	East River from Brush Creek to Farris Creek
LINK 54	Brush Creek below West Brush Creek
LINK 55	Brush Creek above West Brush Creek
LINK 56	Cement Creek near mouth
LINK 57	Middle Cement Creek
LINK 58	Upper Cement Creek
LINK 59	Taylor River below Spring Creek
LINK 60	Taylor River between Lottis Creek and Spring Creek
LINK 61	Taylor River below Taylor Park reservoir
LINK 62	Taylor River, total inflow to Taylor Park reservoir
LINK 63	Taylor River between Pieplant reservoir site and Willow Creek
LINK 64	Taylor Park reservoir bypass
LINK 65	Pump to Union Park
LINK 66	Turbine from Union Park
LINK 67	Lottis Creek below West Lottis Creek
LINK 68	Lottis Creek above West Lottis Creek
LINK 69	Tomichi Creek near Gunnison
LINK 70	Tomichi Creek below Cochetopa Creek
LINK 71	Tomichi Creek above Cochetopa Creek
LINK 72	Tomichi Creek below Quartz Creek
LINK 73	Tomichi Creek between Razor and Quartz Creeks
LINK 74	Tomichi Creek above Razor Creek
LINK 75	Tomichi Creek below Elko reservoir site
LINK 76	Tomichi Creek below Marshall Creek
LINK 77	Tomichi Creek above Marshall Creek
LINK 78	Cochetopa Creek near mouth
LINK 79	Lower Cochetopa Canyon
LINK 80	Upper Cochetopa Canyon
LINK 81	Cochetopa Creek above West Pass Creek
LINK 82	Los Pinos Creek
LINK 83	Cochetopa Creek above Los Pinos Creek
LINK 84	Pauline Creek
LINK 85	Cochetopa Creek above Pauline Creek
LINK 86	Quartz Creek below Parlin reservoir site
LINK 87	Quartz Creek above Parlin reservoir site
LINK 88	Quartz Creek below Ohio City reservoir site
LINK 89	Quartz Creek above Ohio City reservoir site
LINK 90	Quartz Creek above Gold Creek
LINK 91	Cow Creek below Rams Horn reservoir site
LINK 92	Cow Creek near mouth
LINK 93	Ridgway bypass
LINK 94	Uncompahgre River below Ridgway Dam
LINK 95	Uncompahgre River below Cow Creek
LINK 96	Uncompahgre River near Colona
LINK 97	Total Gunnison Tunnel diversion
LINK 98	South Canal below AB Lateral
LINK 99	South Canal below Fairview reservoir
LINK 100	South Canal below turnouts
LINK 101	South Canal deliveries to Uncompahgre River

LINK 102	AB Lateral diversion
LINK 103	Project 7 diversion from South Canal
LINK 104	Cerro reservoir release to Project 7
LINK 105	Diversion to South Canal turnouts
LINK 106	West Canal diversion
LINK 107	M&D Canal diversion
LINK 108	Uncompahgre River below M&D Canal
LINK 109	Horsefly Creek net inflow to Uncompahgre River
LINK 110	Loutsenhiser Canal diversion
LINK 111	Uncompahgre River below Loutsenhiser Canal
LINK 112	Happy Canyon Creek net inflow to Uncompahgre River
LINK 113	Selig Canal diversion
LINK 114	Uncompahgre River below Selig Canal
LINK 115	Spring Creek above Project retrun flows
LINK 116	Spring Creek below Project return flows
LINK 117	Ironstone Canal diversion
LINK 118	Uncompahgre River below Ironstone Canal
LINK 119	East Canal diversion
LINK 120	Uncompahgre River below East Canal
LINK 121	Garnet Canal diversion
LINK 122	Uncompahgre River below Garnet Canal
LINK 123	Dry Creek above Project return flows
LINK 124	Dry Creek below Project return flows
LINK 125	Uncompahgre River near Delta
LINK 126	Soap Creek inflow to Blue Mesa
LINK 127	Lower Razor Creek
LINK 128	Upper Razor Creek
LINK 129	Blue Mesa release
LINK 130	Blue Mesa target storage
LINK 131	Blue Mesa excess storage
LINK 132	Ridgway target storage
LINK 133	Ridgway excess storage
LINK 134	Ridgway release
LINK 135	Ridgway Dam river outlet
LINK 136	Ridgway spillway
LINK 137	Taylor Park target storage
LINK 138	Taylor Park excess storage
LINK 139	Taylor Park release
LINK 140	Taylor Park river outlet
LINK 141	Taylor Park spillway
LINK 142	Garnet Canal excess surface return flow
LINK 143	East Canal excess surface return flow
LINK 144	AB Lateral excess surface return flow
LINK 145	Loutsenhiser Canal excess surface return flow
LINK 146	South Canal turnouts excess surface return flow
LINK 147	Selig Canal excess surface return flow
LINK 148	West Canal excess surface return flow
LINK 149	M&D Canal excess surface return flow
LINK 150	Ironstone Canal excess surface return flow
LINK 151	Project 7 yield from Cimarron Canal
LINK 152	Blue Mesa forecast
LINK 153	Cimarron River below Silver Jack reservoir
LINK 154	Silver Jack target storage
LINK 155	Silver Jack excess storage

LINK 156	Minimum flow requirement for endangered species, not used
LINK 157	Redlands Power Canal
LINK 158	Gunnison Tunnel irrigation decree
LINK 159	Gunnison Tunnel conditional power decree
LINK 160	Crystal Dam power outlet
LINK 161	Morrow Point Dam power outlet
LINK 162	Blue Mesa power outlet
LINK 163	Cimarron Canal #1 direct flow decree
LINK 164	Cimarron Canal #2 direct flow decree
LINK 165	Cimarron Canal #3 direct flow decree
LINK 166	Ridgway power outlet, not used
LINK 167	Excess inflow to Cimarron Canal
LINK 168	Project 7 direct deliveries from Cimarron Canal
LINK 169	Montrose Pipeline to Project 7
LINK 170	Cerro reservoir diversion to storage
LINK 171	Fairview reservoir release
LINK 172	Silver Jack spillway
LINK 173	Taylor Park forecast
LINK 174	Ridgway forecast
LINK 175	Artificial inflow system, used only for model debugging
LINK 176	Artificial inflow system, used only for model debugging
LINK 177	Artificial inflow system, used only for model debugging
LINK 178	Taylor Park forecast system
LINK 179	Taylor Park forecast system
LINK 180	Gunnison Tunnel supplementary power application
LINK 181	AB Lateral hydropower facility
LINK 182	Lower Brush Creek instream flow decree
LINK 183	Castle Creek instream flow decree
LINK 184	Cebolla Creek instream flow decree
LINK 185	Cement Creek instream flow decree
LINK 186	Cement Creek instream flow decree
LINK 187	Upper Cimarron River instream flow decree
LINK 188	Upper Cimarron River instream flow decree
LINK 189	Lower Cimarron River instream flow decree
LINK 190	Pauline Creek instream flow decree
LINK 191	Cochetopa Creek instream flow decree
LINK 192	Cochetopa Creek instream flow decree
LINK 193	Cochetopa Creek instream flow decree
LINK 194	Cochetopa Creek instream flow decree
LINK 195	Slate River instream flow decree
LINK 196	Lower East River instream flow decree
LINK 197	Lake Fork instream flow decree
LINK 198	Lake Fork instream flow decree
LINK 199	Lake Fork instream flow decree
LINK 200	Lake Fork instream flow decree
LINK 201	Upper Ohio Creek instream flow decree
LINK 202	Upper Ohio Creek instream flow decree
LINK 203	Upper Ohio Creek instream flow decree
LINK 204	Upper Ohio Creek instream flow decree
LINK 205	Lower Ohio Creek instream flow decree
LINK 206	Lower Creek instream flow decree
LINK 207	Upper Quartz Creek instream flow decree
LINK 208	Lower Quartz Creek instream flow decree
LINK 209	Lower Quartz Creek instream flow decree

LINK 210	Lower Quartz Creek instream flow decree
LINK 211	Lower Quartz Creek instream flow decree
LINK 212	Soap Creek instream flow decree
LINK 213	Upper Taylor River instream flow decree
LINK 214	Upper Taylor Canyon instream flow decree
LINK 215	Middle Taylor Canyon instream flow decree
LINK 216	Lower Taylor Canyon instream flow decree
LINK 217	Lottis Creek instream flow decree
LINK 218	Upper Tomichi Creek instream flow decree
LINK 219	Lower Tomichi Creek instream flow decree
LINK 220	Lower Tomichi Creek instream flow decree
LINK 221	Lower Tomichi Creek instream flow decree
LINK 222	Lower Tomichi Creek instream flow decree
LINK 223	East River above Brush Creek
LINK 224	Upper Brush Creek instream flow decree
LINK 225	Uncompahgre River above Cow Creek
LINK 226	North Fork Gunnison River net inflow to mainstem
LINK 227	Cimmaron Canal tributary decrees
LINK 228	North Fork conditional return flows
LINK 229	Snowshoe Reservoir carryover storage
LINK 230	Snowshoe Reservoir diversion to storage
LINK 231	Taylor Park Exchange account contents
LINK 232	Black Canyon instream flow decree

APPENDIX E

VIRGIN INFLOW DEVELOPMENT AND RESERVOIR INFLOW FORECASTS

VIRGIN FLOW DEVELOPMENT

UPPER GUNNISON-UNCOMPAHGRE BASIN
MODEL INFLOW DEVELOPMENT

Purpose and Scope

The following report discusses methodologies used in developing inflows provided by the Bureau of Reclamation (USBR) for WBLA's Upper Gunnison-Uncompahgre Basin Model Study.

Flows were developed for inflows INFL 3 through INFL 59 of the basin model network, as described in WBLA's November 9, 1987 memorandum regarding Inflow Points for Basin Model, Upper Gunnison-Uncompahgre Basin Study. (A copy of the memorandum is provided in Appendix A.)

Flows were developed for three areas:

1) Gunnison River mainstem: Gunnison Tunnel to Colorado River (INFL3 and INFL4)

2) Upper Gunnison River: Gunnison River above Crystal Dam (INFL5 through INFL51)

3) Uncompahgre River: (INFL52 - INFL59)

Inflows for the Gunnison River mainstem below the Gunnison Tunnel (INFL3 and INFL4) represent historic flows. Inflows for the Upper Gunnison area above Crystal Dam (INFL5 through INFL51) represent virgin flow estimates. Uncompahgre Basin inflows (INFL52 - INFL59) reflect a combination of historic and virgin flow estimates. Flows for INFL52 and INFL56 through INFL59 are virgin flow estimates. INFL53 through INFL55 represent historic flows.

Main Stem Gunnison River Inflows below Gunnison Tunnel: INFL3 and INFL4

Excluding the Uncompahgre River, gains for the mainstem of the Gunnison River below the Gunnison Tunnel were developed using 4 USGS gaging stations: the Gunnison River near Grand Junction (09152500), the Gunnison River below Gunnison Tunnel (09128000), the Uncompahgre River at Delta (09149500), and the Gunnison River at Delta (09144250). The first 3 stations represent the boundaries of the reach, and the last station divides the reach into upper and lower reaches. These 2 reaches represent the Gunnison River above and below the mouth of the Uncompahgre River.

Sufficient streamflow records exist to compute the gains for the entire reach for the period of study by subtracting the flows of the Gunnison River below the tunnel and the Uncompahgre River at Delta from the flow of the Gunnison River near Grand Junction. The gains for the years before 1964 were adjusted to reflect depletions and change in storage which would have occurred if the Paonia and Smith Fork Projects were operating.

The Gunnison River at Delta has 10 years (1977-86) of streamflow records that are concurrent with the other 3 stations. With the data from this station, the gains for 1977-86 for the upper and lower reaches were computed. Subtracting the flows of the Gunnison and Uncompahgre Rivers at Delta from the Gunnison River near Grand Junction showed that one-third of the time a loss occurred in the lower reach, with most of the losses occurring from 1982-1986. A review of the computed gains in this reach indicated that the losses are not likely and are probably a result of the accuracy of one or more of the gaging stations. A comparison of the magnitude of the losses to the flow of the

Uncompahgre River indicates that the majority of the difference must occur in the Gunnison River stations, however, it is unknown which station it is.

The 1977-86 data indicated that 14 percent of the total gains occurred in the lower reach and 86 percent in the upper reach. Gains for the upper and lower reaches of the Gunnison River were assigned a proportional amount of the total long-term gains based on these percentages. The gains for the lower and upper reaches are given in files INFL3 and INFL4, respectively (copies of these files are given in Appendix F).

Upper Gunnison Mainstem and Subbasins above Crystal Dam: [INFL5 - INFL51]

Core station virgin flow file development

Virgin flow estimates were derived for inflows INFL5 to INFL51 above Crystal Dam in the Upper Gunnison Basin for the Gunnison River mainstem and subbasins.

Virgin flows were developed for selected gaging stations to serve as "core" stations from which inflows within subbasins were derived. Virgin flow estimates of core stations were derived by adjusting historical gaged flows for irrigation consumptive use depletions, reservoir storage and evaporation, and transbasin diversions. Flow estimates for each core station were developed for water years 1952-1983. Core stations for which virgin flows were derived are listed in Table 1. Locations of virgin flow core stations are given in Figure 1.

Virgin flow estimates for the Gunnison River at Crystal Dam were used as a base for development of upstream core station flows. Original virgin flow estimates for the Gunnison River at Crystal Dam station were obtained from the

USBR Upper Colorado Region Colorado River Simulation System (CRSS) hydrology data base. Virgin flows for this station included adjustments made for irrigation consumptive use, reservoir change in storage (Taylor Park, Blue Mesa, Morrow Point, and Silver Jack), reservoir evaporation (Blue Mesa, and Morrow Point), reservoir bank storage (Blue Mesa), and transbasin diversions (Tarbell, Tabor, and Larkspur Ditches).

Original CRSS virgin flows for the Gunnison River at Crystal Dam were modified to reflect changes made in irrigation consumptive use depletion values. Changes were made to reflect a constant irrigated acreage for the study period. The monthly distribution of irrigation depletions was also modified to more closely represent depletion timing under virgin flow conditions. A detailed discussion of irrigation consumptive use depletions is given in Appendix B. Discussion of virgin flow development methodologies for the Gunnison River at Crystal Dam and the other core stations is given in Appendix C.

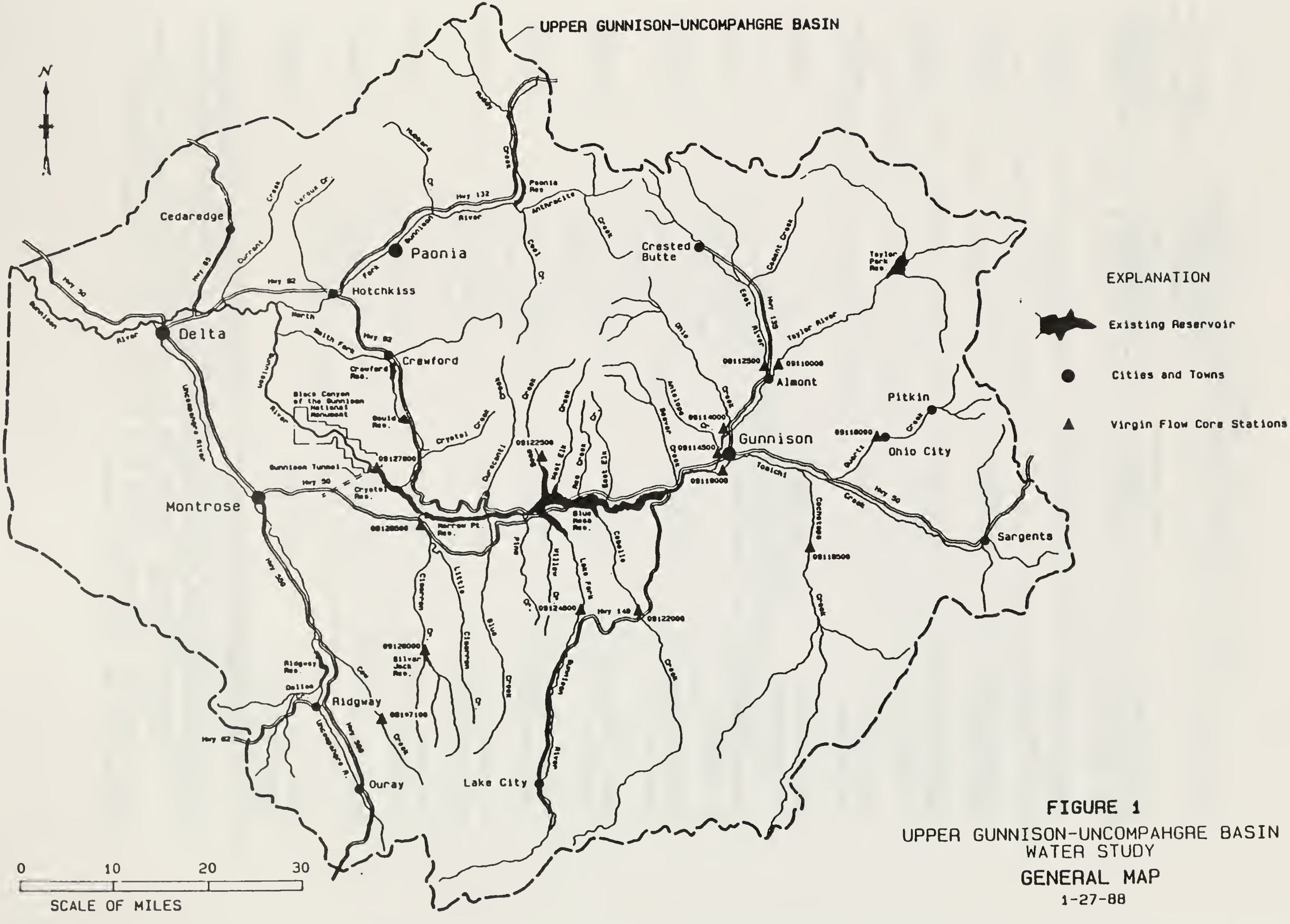


FIGURE 1
UPPER GUNNISON-UNCOMPAHGRE BASIN
WATER STUDY
GENERAL MAP
1-27-88

Table 1
Upper Gunnison River core stations

Station name	USGS station number[2/]	Adjustments included[1/] in virgin flow development	USBR virgin flow files [water years 1952-1983]
Gunnison River at Crystal Dam	09127800	I, S, E, T, B	VG27800
Cimarron River at Cimarron	09126500	I, S, T, C	VG26500
Cimarron River near Cimarron	09126000	S, C	VG26000
Lake Fork at Gateview	09124500	I	VG24500
Soap Creek at Sapinero	09123000	I, C	VG23000
Cebolla Creek at Powderhorn	09122000	I, T, C	VG22000
Tomichi Creek at Gunnison	09119000	I, T	VG19000
Cochetopa Creek near Parlin	09118500	I, T, C	VG18500
Quartz Creek near Ohio	09118000	I, C	VG18000
Gunnison River near Gunnison	09114500	I, S	VI14500
Ohio Creek near Gunnison	09114000	I, C	VG14000
East River at Almont	09112500	I	VG12500
Taylor River at Almont	09110000	S	VC10000
Taylor River below Taylor Park Reservoir	09109000	S	VC09000

1/ Adjustment abbreviations: I - Irrigation consumptive use depletions, S - Reservoir storage, E - Reservoir evaporation, T - Transbasin diversions, C - Extension of records by correlation, B - Bank storage

2/ Gunnison River at Crystal Dam is a Colorado River Simulation System (CRSS) hydrology data base virgin flow station. Station number 09127800 is a CRSS designation within USGS format.

Adjusted core station virgin flow development

Three difference files were developed to inspect flows for intervening areas between core station points.

The first difference file was developed for the virgin flow core stations located above the Gunnison River at Crystal Dam (09127800) and below the Gunnison River near Gunnison (09114500), Tomichi Creek at Gunnison (09119000), Cebolla Creek of Powderhorn (09122000), Soap Creek at Sapinero (09123000), Lake Fork at Gateview (09124500), and Cimarron River at Cimarron (09126500) (see Figure 1). Virgin flow core station files used in deriving this difference file are listed in Table 2.

Table 2
Difference file derivation1/
(Gunnison River above Crystal Dam)

Station	Filename
Gunnison River at Crystal Dam	VG27800 [base]
Gunnison River near Gunnison	- VI14500
Tomichi Creek at Gunnison	- VG19000
Cebolla Creek of Powderhorn	- VG22000
Soap Creek at Sapinero	- VG23000
Lake Fork at Gateview	- VG24500
Cimarron River at Cimarron	- VG26500

1/ - = minus

The difference file representing flows for this intervening area is shown in Table 3. There are 56 negative values in table 3. Twenty-two of these values diverge by more than 10 percent (assumed maximum difference attributable to gaging accuracy) from the Gunnison River at Crystal Dam. The occurrence of negative values above an assumed allowable gaging error may be attributed to assumptions made in accounting for reservoir effects in virgin flow development at the Gunnison River at Crystal Dam base station.

Bank storage effects are computed as a constant percentage of Blue Mesa Reservoir monthly change in content (10 percent). Actual bank storage and release, both pattern and quantity, may be different.

Reservoir evaporation is accounted for using fixed monthly evaporation rates multiplied by reservoir area. No consideration was made for fluctuation in monthly evaporation rates on a year-to-year basis.

In addition, reservoir effects (i.e., bank storage and evaporation) are not taken into account for all reservoirs.

The second difference file was developed for the virgin flow core stations above the Gunnison River near Gunnison (09114500): Ohio Creek near Gunnison (09114000), East River at Almont (09112500), and Taylor River at Almont (09110000) virgin flow core stations (see Figure 1). Core station files used to derive this difference file are shown in Table 4.

Table 3
VG27d00-[VI14500+VG19000+VG22000+VG23000+VG24500+VG26500]
Oct- Sept
1000 AF

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1952	5.8	1.4	0.8	4.8	5.0	4.4	36.6	80.6	83.6	4.7	-0.0	-1.9	225.8
1953	5.2	4.1	3.5	2.2	1.4	5.8	13.0	28.2	52.3	7.0	2.2	1.8	126.7
1954	4.0	6.0	5.8	3.3	3.8	6.3	6.8	3.0	-5.8	-2.3	-2.0	1.6	30.5
1955	3.5	3.4	3.5	2.0	0.3	0.2	14.1	23.7	17.7	-3.2	0.9	-2.4	63.7
1956	1.4	4.1	7.5	4.4	2.1	5.8	16.2	34.2	28.8	2.7	-2.5	-3.2	103.5
1957	2.3	-0.5	-0.5	0.2	3.2	5.8	19.9	66.2	95.4	44.9	6.7	1.8	245.4
1958	2.3	5.2	9.3	4.5	4.8	3.5	28.8	127.0	64.8	4.2	1.5	3.8	259.7
1959	1.3	2.1	1.9	1.4	2.9	1.4	10.7	24.0	33.1	2.7	4.1	0.2	95.8
1960	8.2	6.8	2.2	4.2	8.0	21.0	52.6	31.8	33.7	-0.2	-3.3	-0.1	164.9
1961	3.1	4.4	3.7	2.5	3.0	7.3	10.8	26.4	10.0	-2.8	-0.6	2.8	70.6
1962	8.7	8.0	3.9	4.2	5.9	3.5	46.0	67.2	40.7	16.4	2.2	6.2	214.8
1963	5.4	8.1	6.4	1.9	3.3	17.0	14.3	18.1	6.6	0.4	1.7	3.6	87.2
1964	3.5	5.7	1.0	1.1	2.1	2.9	15.3	66.3	37.2	7.1	3.5	4.1	153.8
1965	6.4	2.1	1.7	4.6	3.5	5.4	25.9	59.4	59.0	36.4	9.4	9.1	222.9
1966	10.1	7.1	1.6	6.0	8.0	15.5	28.4	46.5	12.9	3.7	-1.6	0.0	138.2
1967	9.0	6.1	7.1	7.7	5.3	12.5	7.3	28.0	18.1	-2.0	-0.7	5.6	104.0
1968	1.6	3.2	-3.3	6.7	6.8	12.8	11.3	55.4	60.7	3.7	4.7	-4.2	159.4
1969	6.6	3.7	3.7	9.0	4.1	0.9	44.9	70.8	33.2	19.8	4.1	0.3	201.1
1970	16.2	2.0	1.2	4.9	1.9	9.6	27.6	141.2	57.2	14.1	8.0	18.7	302.6
1971	14.5	9.4	9.7	3.2	11.1	34.0	48.3	47.8	59.5	8.7	-5.7	-0.4	240.1
1972	3.7	9.6	5.8	8.7	8.8	19.6	7.6	24.4	30.1	-5.2	-8.2	-0.8	104.1
1973	9.1	-2.2	2.2	-1.3	4.0	7.3	15.7	86.5	74.6	11.7	-4.5	-3.7	199.4
1974	4.5	2.8	4.9	-3.7	4.8	13.9	30.5	88.4	40.6	4.3	-4.5	-6.9	179.6
1975	3.7	3.9	5.7	6.4	4.1	6.3	13.4	85.2	79.0	52.9	0.6	-3.4	257.8
1976	2.2	0.2	-1.6	11.3	11.7	6.6	20.7	46.5	24.3	-1.1	-11.7	6.2	115.3
1977	0.5	0.6	-3.2	-2.3	1.3	-10.3	17.7	2.7	-3.7	-2.5	-3.4	-2.0	-4.5
1978	5.9	2.5	3.4	7.0	3.2	22.1	26.4	81.0	83.8	20.7	-15.4	-12.7	227.9
1979	-5.8	-3.3	-10.0	3.3	-13.7	3.8	35.6	63.0	84.0	24.2	4.0	-5.3	179.8
1980	-0.1	-3.4	1.0	3.8	6.6	5.7	25.1	93.0	110.5	29.8	2.4	-3.3	271.1
1981	-2.6	0.8	6.2	0.8	4.7	4.5	10.5	8.3	15.7	11.4	8.2	8.3	76.8
1982	8.9	2.5	-1.7	6.6	0.3	6.9	22.5	83.2	82.9	33.1	19.7	19.5	284.4
1983	5.3	7.1	-1.7	3.1	3.4	10.4	19.0	106.5	114.2	31.5	8.7	2.9	310.4

N	32	32	32	32	32	32	32	32	32	32	32	32	32
MEAN	4.3	3.5	2.6	3.6	3.9	8.5	22.9	56.7	48.0	11.8	0.9	1.4	168.8
STD	4.4	3.4	4.1	3.3	4.2	8.1	12.7	34.9	32.6	15.2	6.6	6.5	83.0
MIN	-5.8	-3.4	-10.0	-3.7	-13.7	-10.3	6.8	2.7	-5.8	-5.2	-15.4	-12.7	-4.5
MAX	16.2	9.6	9.7	11.3	11.7	34.0	52.6	141.2	114.2	52.9	19.7	19.5	310.4

Table 4
Difference file derivation
(Gunnison River above Gunnison River near Gunnison)[1/]

Station	Filename
Gunnison River near Gunnison	VI14500 [Base]
Ohio Creek near Gunnison	- VG14000
East River at Almont	- VG12500
Taylor River at Almont	- VC10000

1/ - = minus

The difference file resulting from subtraction of these files is presented in Table 5, it shows an average annual difference of -20,800 acre-feet. Fifty-seven percent (219) of the monthly values in Table 5 are negative. More than 25 percent (97) of these values diverge by more than 10 percent of the Gunnison River near Gunnison flows.

Virgin flow estimates for the Gunnison River near Gunnison (VI14500) were derived by adding estimated irrigation consumptive use depletions to gaged historic flows at this site. Flows were further adjusted for Taylor Reservoir changes in storage. Flows for the East River at Almont (VG12500) were developed by adjusting historic gaged flows at the site for irrigation consumptive use depletions. Virgin flow estimates for the Taylor River at Almont (VC10000) were derived by adjusting historic gaged flows at this site for changes in storage in Taylor Park Reservoir. (Irrigation depletion above this site was considered negligible.)

Flow estimates of Ohio Creek near Gunnison (VG14000) were derived by correlation with East River at Almont flows. (Historic flows for Ohio Creek near Gunnison are available for water years 1945-1950.) More detailed discussion of virgin flow derivation at these stations is given in Appendix C.

Table 5
VI14500-[VC10000+VG12500+VG14000]
Oct-Sept
1000 AF

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1952	-0.3	-1.1	-0.9	-0.6	-0.5	-0.4	11.7	6.7	-19.6	-6.5	0.1	-6.6	-18.0
1953	-1.1	2.5	1.2	0.3	0.5	0.1	-1.6	-9.0	-4.8	-3.4	-1.1	-6.5	-22.4
1954	-1.3	0.9	-0.2	0.0	0.1	1.0	-6.0	-18.1	-11.6	-5.5	-3.2	-3.8	-47.7
1955	-2.5	-0.2	-0.3	-0.7	-0.8	-0.0	1.5	-10.0	-15.8	-7.0	-0.3	-8.3	-44.2
1956	-2.4	-0.8	-1.0	-0.9	-0.8	0.7	5.5	-11.6	-9.6	-4.5	0.5	-5.9	-30.7
1957	0.1	1.2	1.9	1.4	0.9	1.1	6.7	9.7	6.8	1.9	1.0	-3.2	29.5
1958	-1.6	0.2	1.8	2.5	1.0	-0.4	5.5	-0.1	-6.8	-7.0	-2.0	-5.9	-12.8
1959	-2.7	0.9	2.9	3.3	2.6	1.5	1.5	-5.3	-10.9	-6.5	-2.8	-4.5	-20.0
1960	1.2	-0.0	0.4	0.3	0.2	1.8	7.3	-10.1	-12.6	-4.1	-2.0	-3.2	-20.8
1961	-1.0	0.2	-0.1	-0.1	-0.2	0.6	0.1	-14.3	-9.8	-4.3	-3.2	0.5	-31.6
1962	-4.8	-1.5	-1.5	0.2	-0.5	-0.5	18.1	-1.7	-10.7	-0.4	1.1	-5.3	-7.5
1963	-0.4	0.4	0.6	0.7	1.4	1.9	-1.4	-18.6	1.1	1.2	3.8	-1.8	-11.3
1964	-0.1	-1.6	-0.2	0.0	-0.2	0.3	2.1	-9.6	-8.4	-0.7	4.0	-3.4	-17.8
1965	-2.8	0.4	1.3	0.8	0.0	1.0	6.8	2.7	3.4	3.9	3.7	-0.7	20.5
1966	-4.0	0.1	3.2	2.6	2.3	2.1	0.5	-14.1	-3.9	-5.7	-4.2	-9.2	-30.3
1967	-2.0	-1.0	-2.6	-1.8	-0.9	2.7	-3.2	-17.0	-9.6	-6.1	-1.7	-5.1	-48.3
1968	-3.5	-1.2	2.4	1.6	1.0	0.4	1.7	-4.2	-5.2	-6.1	1.8	-7.1	-18.4
1969	-2.8	2.2	1.6	1.2	1.1	1.3	5.2	-1.8	-3.2	-0.7	0.7	-5.6	-0.8
1970	2.0	1.3	0.5	0.3	-0.1	0.5	1.4	9.1	-6.6	0.6	-3.2	-1.0	3.8
1971	-1.5	1.9	1.6	1.6	-1.3	2.2	-5.2	-11.0	-10.8	-7.5	-1.0	-0.8	-31.8
1972	-4.1	0.1	1.8	1.4	0.4	2.1	0.3	-17.8	-15.0	-4.2	-4.1	-6.8	-45.9
1973	-3.1	0.1	0.4	-0.7	-0.5	1.1	1.9	-6.0	-9.3	3.5	-0.6	-4.2	-17.4
1974	-5.2	-0.3	-0.2	1.7	0.6	1.2	0.6	-15.7	-20.2	-6.2	-1.1	-4.0	-48.8
1975	-1.5	1.3	1.7	0.9	-1.7	0.1	3.6	-13.9	-5.3	-11.9	-0.2	-4.1	-31.0
1976	-5.1	-0.7	-0.2	-3.7	-3.3	-0.1	0.5	-16.6	-13.4	-0.5	1.2	3.8	-38.3
1977	-1.6	0.2	5.4	4.2	1.3	-0.1	-5.2	-12.1	-8.4	-3.7	-1.7	-2.8	-26.5
1978	-1.5	1.8	3.1	0.9	-0.3	1.1	2.9	-10.6	-7.7	-3.2	1.9	-3.7	-15.3
1979	0.9	-0.2	-1.7	0.6	2.0	-6.5	0.9	17.6	-7.3	-11.6	-5.4	-4.7	-15.4
1980	-5.9	-1.7	-1.5	-1.9	-1.7	-1.0	10.1	2.9	-19.0	-18.1	-1.6	2.0	-37.3
1981	0.4	-0.3	-0.3	-0.7	-0.1	0.4	-4.0	-10.4	-7.0	-2.3	-2.1	-0.3	-26.7
1982	-1.2	-0.9	2.0	0.9	-0.2	-0.9	5.1	-2.6	-5.0	-6.1	2.9	0.8	-5.2
1983	0.9	-0.9	-0.3	2.2	0.3	-0.8	-0.1	0.5	6.3	-2.8	-0.0	-1.9	3.4

N	32	32	32	32	32	32	32	32	32	32	32	32	32
MEAN	-1.8	0.1	0.7	0.6	0.1	0.5	2.3	-6.7	-8.1	-4.2	-0.6	-3.5	-20.8
STD	2.0	1.1	1.5	1.6	1.2	1.6	5.1	9.2	6.5	4.5	2.4	3.0	18.9
MIN	-5.9	-1.7	-2.6	-3.7	-3.3	-6.5	-6.0	-18.8	-20.2	-18.1	-5.4	-9.2	-48.8
MAX	2.0	2.5	3.4	4.2	2.6	2.7	18.1	17.6	6.8	3.9	4.0	3.8	29.5

Inspection of historic flows for the water years 1945-1950 (for which concurrent data is available at these four stations) shows an average loss of -25,000 acre-feet between these stations. Average annual flows and differences for water years 1945-1950 at these stations are given in Table 6.

Table 6
Differences in flow
Historic period of concurrent data 1/

Station	1945	1946	1947	1948	1949	1950
	Water Year					
Annual Flows (1,000 Acre-Feet)						
09114500	429.1	397.2	544.1	673.2	539.0	469.5
-09114000	66.8	48.4	79.0	93.4	81.2	60.0
-09112500	216.8	194.0	270.9	279.8	244.4	219.7
-09110000	155.8	191.3	216.5	317.2	242.7	224.5
Difference:	-10.3	-36.5	-22.3	-17.2	-29.3	-34.7
Average Difference: -25.05						

1/Gunnison River near Gunnison (09114500)minus Ohio Creek near Gunnison (09114000)minus East River at Almont (09112500) minus Taylor River at Almont (09110000).

Discussion with USGS personnel indicated no known gaging problems at these sites. Average annual flow for the Gunnison River near the Gunnison station (09114500) for water years 1945-1950 is 508,700 acre-feet. A five percent gaging error would represent 25,400 acre-feet. Why this error would consistently occur on the low side, however, is not known.

The third difference file was developed for the stations above Tomichi Creek at Gunnison (09119000) and below the Tomichi Creek at Parlin (09117000), Quartz Creek near Ohio (09118000), and Cochetopa Creek near Parlin (09118500) (see Figure 1). Core station files used in developing this difference file are listed in Table 7.

Table 7
Difference file derivation
(Tomichi Creek above Tomichi Creek near Gunnison)[1/]

Station	Filename
Tomichi Creek at Gunnison	VG19000
Tomichi Creek at Parlin	- TOM2
Quartz Creek near Ohio	- VG18000
Cochetopa Creek near Parlin	- VG18500

1/ - = minus

The difference file resulting from this file subtraction is shown in Table 8. Nearly 26 percent (99) of the values in Table 8 are negative. Forty-two of these negative values diverge by more than 10 percent of the base station flow (Tomichi Creek of Gunnison). The occurrence of negatives in this difference file may be explained by contributing core station file development. Both flow files VG18000 and VG18500 were developed by correlation.

After inspecting these difference files, particularly for the stations above the Gunnison River near Gunnison, a second set of adjusted core station virgin flow files was developed. Adjustments were made by direct proportioning of negative values by the ratio of each contributing inflow to the total inflow. Thereby, negative values in difference files were set to zero.

Adjusted Core Station Virgin Flow Files:

Gunnison River above Crystal Dam

Adjustments were first made to virgin flow files at those core stations which comprise the Gunnison River at Crystal Dam, equating negative values as shown in Table 3 to zeros.

Table 8
VG19000-[VG18000+VG18500+TOM2]
Oct-Sept
1000 AF

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1952	-0.2	0.5	0.1	0.0	0.2	0.1	6.4	2.6	0.2	1.1	2.4	0.8	14.2
1953	0.2	0.7	-0.0	0.1	0.2	1.3	1.5	0.3	1.1	2.0	3.2	0.7	11.3
1954	0.7	0.9	0.5	0.2	0.2	0.6	-1.7	-6.0	-3.1	-0.7	1.1	0.2	-7.1
1955	-0.4	0.3	-0.0	-0.2	-0.2	0.3	0.4	-4.2	-5.8	-1.3	1.0	0.6	-9.5
1956	-0.7	0.5	0.4	0.2	0.0	0.3	2.4	-3.6	-4.7	0.3	0.4	-0.9	-5.4
1957	-0.1	0.9	0.2	-0.1	-0.1	0.5	3.1	4.5	7.8	2.2	5.8	2.6	27.3
1958	1.5	1.2	0.3	-0.1	-0.1	0.5	5.0	5.2	5.2	1.8	1.6	0.5	22.6
1959	0.5	1.2	0.6	0.3	0.1	0.9	0.8	-1.8	-4.4	-0.0	2.0	0.3	0.6
1960	1.2	0.6	0.2	0.1	0.1	1.5	1.8	-2.0	-1.2	1.4	1.5	0.0	5.4
1961	0.7	1.0	0.8	0.1	0.1	0.9	0.8	-2.8	-1.0	0.8	1.1	0.8	3.3
1962	0.7	1.3	0.5	0.1	-0.1	0.6	2.4	-4.0	-2.4	1.2	1.5	-0.1	1.7
1963	0.5	0.4	0.3	0.4	0.5	2.1	0.2	-3.5	1.1	1.2	1.1	0.0	4.3
1964	-0.6	0.2	-0.2	0.0	0.1	0.2	2.2	-2.0	0.3	2.0	2.4	0.3	4.9
1965	-0.6	1.1	0.8	0.5	0.3	0.5	3.1	-1.1	-3.0	3.6	4.0	1.9	11.1
1966	0.7	0.5	0.3	0.2	-0.1	0.6	-0.1	-4.1	0.2	1.8	1.7	0.1	1.8
1967	-0.3	0.9	0.4	-0.0	0.0	0.7	-1.3	-4.8	-2.3	0.8	0.8	-0.7	-5.8
1968	-0.6	0.5	0.4	0.1	0.0	0.5	0.7	-1.8	-0.6	1.8	3.3	0.6	4.9
1969	-0.0	0.4	0.1	0.1	0.1	1.5	0.8	-4.8	-0.3	1.7	1.7	0.6	1.9
1970	2.5	1.4	0.4	0.1	0.4	0.9	3.6	0.5	0.8	2.7	4.7	3.3	21.3
1971	1.4	1.3	0.9	0.7	0.3	0.9	-1.0	-0.5	-2.6	0.4	2.5	1.6	6.4
1972	1.8	0.2	0.1	0.0	0.4	2.1	-0.4	-3.3	-2.0	1.4	1.2	-0.4	1.1
1973	0.4	1.1	-0.0	-0.1	-0.2	0.5	1.2	1.8	4.9	2.7	2.8	1.3	16.4
1974	0.4	0.9	0.1	-0.1	-0.2	1.9	0.9	-4.0	-1.1	1.5	2.1	-0.2	2.1
1975	0.3	0.9	0.3	-0.1	-0.3	0.3	2.4	1.8	4.6	2.7	3.5	0.8	17.2
1976	0.3	1.1	0.9	0.5	0.7	1.1	1.7	-3.7	-1.6	0.3	2.2	0.6	4.3
1977	1.1	1.0	0.8	0.1	0.4	0.5	-0.9	-3.2	-0.6	0.6	0.4	0.0	0.2
1978	0.0	0.6	0.5	-0.1	0.0	1.5	1.5	-0.9	-2.3	-0.2	1.1	0.7	2.4
1979	0.7	0.9	-0.2	-1.0	-0.7	1.2	2.4	-1.4	-1.5	-0.8	1.4	0.3	1.3
1980	0.3	0.9	0.2	-0.1	-0.4	-0.3	2.3	-0.8	-3.7	-0.2	1.4	1.0	0.6
1981	0.8	0.6	-0.3	-0.1	-0.1	0.1	-1.9	-2.5	-1.1	1.6	1.4	-0.1	-1.6
1982	0.1	0.6	0.3	-0.3	0.0	1.1	0.4	-1.8	-0.7	-1.3	2.7	3.7	4.8
1983	2.1	1.4	0.8	-0.1	-0.1	1.1	1.4	1.4	11.5	4.9	4.7	1.6	30.7

N	32	32	32	32	32	32	32	32	32	32	32	32	32
MEAN	0.5	0.8	0.3	0.0	0.0	0.8	1.3	-1.5	-0.3	1.2	2.1	0.7	6.1
STD	0.8	0.4	0.3	0.3	0.3	0.6	1.8	2.7	3.6	1.4	1.3	1.0	9.7
MIN	-0.7	0.2	-0.3	-1.0	-0.7	-0.3	-1.9	-6.0	-5.8	-1.3	0.4	-0.9	-9.5
MAX	2.5	1.8	0.9	0.7	0.7	2.1	6.4	5.2	11.5	4.9	5.8	3.7	30.7

Adjusted and unadjusted virgin flow core file designations for this reach are given in Table 9.

Table 9
Adjusted and unadjusted virgin flow core files:
(Gunnison River above Crystal Dam)

Station	Unadjusted Virgin flow (Core file)	Adjusted Virgin Flow (Core File)
Gunnison River at Crystal Dam	VG27800*	NA
Gunnison River near Gunnison	VI14500	VJ14500
Tomichi Creek at Gunnison	VG19000	VJ19000
Cebolla Creek at Powderhorn	VG22000	VJ22000
Soap Creek at Sapinero	VG23000	VJ23000
Lake Fork at Gateview	VG24500	VJ24500
Cimarron River at Cimarron	VG26500	VJ26500

* Base station - no adjustment.

Moving upstream, adjustments were then made to virgin flow core stations contributing to the Gunnison River near Gunnison and Tomichi Creek at Gunnison.

Adjusted Core Station Virgin Flow Files:
Gunnison River above Gunnison River near Gunnison

Negative values resulting from subtraction of initial virgin flow estimates for the Ohio Creek near Gunnison (VG14000), East River at Almont (VG12500), and Taylor River at Almont (VC10000) from the adjusted flows for the Gunnison River near Gunnison (VJ14500) were proportioned to these stations to derive adjusted virgin flow core station files VJ14000, VJ12500, and VJ10000. (The difference file is presented in Table 10.) Adjustments were also made to initial virgin flow estimates for the Taylor River below Taylor

Table 10
VJ14500-[VC10000+VG12500+VG14000]
Oct-Sept
1000 AF

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1952	-0.3	-1.1	-0.9	-0.6	-0.5	-0.4	11.7	6.7	-19.6	-6.5	0.1	-7.3	-18.7
1953	-1.1	2.5	1.2	0.8	0.5	0.1	-1.6	-9.0	-4.8	-3.4	-1.1	-6.5	-22.4
1954	-1.3	0.9	-0.2	0.0	0.1	1.0	-6.0	-18.1	-14.6	-6.4	-4.0	-3.8	-52.4
1955	-2.3	-0.2	-0.3	-0.7	-0.8	-0.0	1.5	-10.0	-15.8	-8.8	-0.3	-9.0	-46.7
1956	-2.4	-0.8	-1.0	-0.8	-0.8	0.7	5.5	-11.6	-9.6	-4.5	-0.8	-7.3	-33.4
1957	0.1	0.9	1.5	1.4	0.9	1.1	6.7	9.7	6.8	1.9	1.0	-3.2	28.8
1958	-1.6	0.2	1.3	2.5	1.0	-0.4	5.5	-0.1	-6.8	-7.0	-2.0	-5.9	-12.8
1959	-2.7	0.9	2.9	3.3	2.6	1.5	1.5	-5.3	-10.9	-6.5	-2.8	-4.5	-20.0
1960	1.2	-0.0	0.4	0.3	0.2	1.8	7.3	-10.1	-12.6	-4.3	-3.6	-3.3	-22.7
1961	-1.0	0.2	-0.1	-0.1	-0.2	0.6	0.1	-14.3	-9.8	-5.5	-3.4	0.5	-33.0
1962	-4.9	-1.5	-1.5	0.2	-0.5	-0.5	18.1	-1.7	-10.7	-0.4	1.1	-5.3	-7.5
1963	-0.4	0.4	0.6	0.7	1.4	1.9	-1.4	-16.8	1.1	1.2	3.8	-1.8	-11.3
1964	-0.1	-1.6	-0.2	0.0	-0.2	0.3	2.1	-9.6	-8.4	-0.7	4.0	-3.4	-17.8
1965	-2.8	0.4	1.3	0.8	0.0	1.0	6.8	2.7	3.4	3.9	3.7	-0.7	20.5
1966	-4.0	0.1	3.2	2.6	2.3	2.1	0.5	-14.1	-3.9	-5.7	-4.8	-9.2	-30.9
1967	-2.0	-1.0	-2.6	-1.8	-0.9	2.7	-3.2	-17.0	-9.6	-7.3	-2.0	-5.1	-49.8
1968	-3.5	-1.2	0.5	1.6	1.0	0.4	1.7	-4.2	-5.2	-6.1	1.8	-9.0	-22.2
1969	-2.8	2.2	1.6	1.2	1.1	1.3	5.2	-1.8	-3.2	-0.7	0.7	-5.6	-0.8
1970	2.0	1.3	0.5	0.3	-0.1	0.5	1.4	8.1	-6.6	0.6	-3.2	-1.0	3.8
1971	-1.5	1.9	1.6	1.6	-1.3	2.2	-5.2	-11.0	-10.8	-7.5	-3.9	-1.0	-34.9
1972	-4.1	0.1	1.8	1.4	0.4	2.1	0.3	-17.8	-15.0	-6.9	-8.1	-7.1	-52.9
1973	-3.1	-1.0	0.4	-1.4	-0.5	1.1	1.9	-6.0	-9.3	3.5	-2.9	-5.9	-23.2
1974	-5.2	-0.3	-0.2	-0.3	0.6	1.2	0.6	-15.7	-20.2	-6.2	-3.4	-7.2	-56.3
1975	-1.5	1.3	1.7	0.9	-1.7	0.1	3.6	-13.9	-5.3	-11.9	-0.2	-5.7	-32.6
1976	-5.1	-0.7	-0.9	-3.7	-3.3	-0.1	0.5	-16.8	-13.4	-1.1	-5.7	3.8	-46.5
1977	-1.5	0.2	1.9	2.8	1.3	-4.9	-5.2	-12.1	-10.0	-4.3	-3.2	-3.6	-39.2
1978	-1.5	1.3	3.1	0.9	-0.3	1.1	2.9	-10.6	-7.7	-3.2	-6.3	-9.3	-29.1
1979	-1.9	-1.9	-7.6	0.6	-7.0	-6.5	0.9	17.6	-7.3	-11.6	-5.4	-7.4	-37.5
1980	-6.0	-3.5	-1.5	-1.8	-1.7	-1.0	10.1	2.9	-19.0	-18.1	-1.6	0.1	-41.1
1981	-1.1	-0.3	-0.3	-0.7	-0.1	0.4	-4.0	-10.4	-7.0	-2.3	-2.1	-0.3	-28.2
1982	-1.2	-0.9	1.2	0.9	-0.2	-0.9	5.1	-2.6	-5.0	-6.1	2.9	0.8	-6.0
1983	0.9	-0.9	-1.2	2.2	0.3	-0.8	-0.1	0.5	6.3	-2.8	-0.0	-1.9	2.5

N	32	32	32	32	32	32	32	32	32	32	32	32	32
MEAN	-2.0	-0.0	0.3	0.5	-0.2	0.3	2.3	-6.7	-3.3	-4.5	-1.6	-4.3	-24.2
STD	1.9	1.3	2.0	1.5	1.7	1.9	5.1	9.2	6.6	4.6	3.0	3.4	20.7
MIN	-6.0	-3.5	-7.6	-3.7	-7.0	-6.5	-6.0	-18.8	-20.2	-18.1	-8.1	-9.3	-56.3
MAX	2.0	2.5	3.2	3.3	2.6	2.7	19.1	17.6	6.8	3.9	4.0	3.8	28.8

Park Reservoir core station values [file VC09000] after adjustments were made to core station flows for the Taylor River at Almont.

Adjusted and unadjusted virgin flow core file designations for this reach are given in Table 11.

Table 11
Adjusted and unadjusted virgin flow core files:
(Gunnison River above Gunnison River near Gunnison)

Station name	Unadjusted flow file	Adjusted flow file
Gunnison River near Gunnison	VI14500	VJ14500*
Taylor River Almont	VC10000	VJ10000
Taylor River below Taylor Park Reservoir	VC09000	VJ09000
East River at Almont	VG12500	VJ12500

* Base station

Adjusted Core Station Virgin Flow Files: Tomichi Creek above Tomichi Creek at Gunnison

Negative values derived by subtraction of initial virgin flow estimates for Tomichi Creek at Parlin (TOM2), Quartz Creek near Ohio (VG18000), and Cochetopa Creek near Parlin (VG18500) from adjusted flows for Tomichi Creek at Gunnison (VJ19000) were proportioned to these stations to derive adjusted flow files TOM2C, VJ18000, and VJ18500. (The difference file is presented in Table 12.)

Adjusted and unadjusted virgin flow core file designations for this area are given in Table 13.

Table 12
VJ19000-[VG18000+vq18500+TOM2]
Oct-Sept
1000 AF

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1952	-0.2	0.5	0.1	-0.0	0.2	0.1	6.4	2.6	0.2	1.1	2.4	0.5	13.9
1953	0.2	0.7	-0.0	0.1	0.2	1.3	1.5	0.3	1.1	2.0	3.2	0.7	11.3
1954	0.7	0.9	0.5	0.2	0.2	0.6	-1.7	-6.0	-3.6	-0.9	0.8	0.2	-8.1
1955	-0.4	0.3	-0.0	-0.2	-0.2	0.3	0.4	-4.2	-5.8	-1.5	1.0	0.2	-10.1
1956	-0.7	0.5	0.4	0.2	-0.0	0.3	2.4	-3.6	-4.7	0.3	0.0	-1.3	-6.2
1957	-0.1	0.8	0.1	-0.1	-0.1	0.5	3.1	4.5	7.8	2.2	5.8	2.6	27.1
1958	1.5	1.2	0.3	-0.1	-0.1	0.5	5.0	5.2	5.2	1.8	1.6	0.5	22.6
1959	0.6	1.2	0.6	0.3	0.1	0.9	0.8	-1.8	-4.4	-0.0	2.0	0.3	0.6
1960	1.2	0.8	0.2	0.1	0.1	1.5	1.8	-2.0	-1.2	1.4	0.9	0.0	4.8
1961	0.7	1.0	0.8	0.1	0.1	0.9	0.8	-2.8	-1.0	0.4	1.0	0.8	2.8
1962	0.7	1.3	0.5	0.1	-0.1	0.6	2.4	-4.0	-2.4	1.2	1.5	-0.1	1.7
1963	0.5	0.4	0.3	0.4	0.5	2.1	0.2	-3.5	1.1	1.2	1.1	0.0	4.3
1964	-0.5	0.2	-0.2	0.0	0.1	0.2	2.2	-2.0	0.3	2.0	2.4	0.3	4.9
1965	-0.6	1.1	0.8	0.5	0.3	0.5	3.1	-1.1	-3.0	3.6	4.0	1.9	11.1
1966	0.7	0.5	0.3	0.2	-0.1	0.6	-0.1	-4.1	0.2	1.8	1.4	0.1	1.5
1967	-0.3	0.9	0.4	-0.0	-0.0	0.7	-1.3	-4.8	-2.3	0.6	0.7	-0.7	-6.1
1968	-0.5	0.5	-0.1	0.1	0.0	0.5	0.7	-1.8	-0.6	1.8	3.3	-0.2	3.6
1969	0.0	0.4	0.1	0.1	0.1	1.5	0.8	-4.6	-0.3	1.7	1.7	0.6	1.9
1970	2.5	1.4	0.4	0.1	0.4	0.9	3.6	0.5	0.8	2.7	4.7	3.3	21.3
1971	1.4	1.6	0.9	0.7	0.3	0.9	-1.0	-0.5	-2.6	0.4	1.5	1.5	5.3
1972	1.8	0.2	0.1	0.0	0.4	2.1	-0.4	-3.3	-2.0	0.6	-0.2	-0.5	-1.2
1973	0.4	0.7	0.0	-0.3	-0.2	0.5	1.2	1.8	4.9	2.7	2.1	0.6	14.4
1974	0.4	0.6	0.1	-0.7	-0.2	1.9	0.9	-4.0	-1.1	1.5	1.4	-1.0	0.0
1975	0.3	0.9	0.3	-0.1	-0.3	0.3	2.4	1.6	4.6	2.7	3.5	0.2	16.6
1976	0.3	1.1	0.6	0.5	0.7	1.1	1.7	-3.7	-1.6	0.2	0.5	0.8	2.2
1977	1.1	1.0	0.2	-0.2	0.4	-1.5	-0.9	-3.2	-1.0	0.2	-0.1	-0.2	-4.2
1978	0.0	0.5	0.5	-0.1	-0.0	1.5	1.5	-0.9	-2.3	-0.2	-0.6	-0.7	-0.7
1979	0.0	0.3	-1.5	-1.0	-1.9	1.2	2.4	-1.4	-1.5	-0.8	1.4	-0.3	-3.1
1980	0.3	0.3	0.2	-0.1	-0.4	-0.3	2.3	-0.8	-3.7	-0.2	1.4	0.6	-0.4
1981	0.4	0.6	-0.3	-0.1	-0.1	0.1	-1.9	-2.5	-1.1	1.6	1.4	-0.1	-2.0
1982	0.1	0.6	0.0	-0.3	0.0	1.1	0.4	-1.8	-0.7	-1.3	2.7	3.7	4.5
1983	2.1	1.4	0.5	-0.1	-0.1	1.1	1.4	1.4	11.5	4.9	4.7	1.6	30.4

N	32	32	32	32	32	32	32	32	32	32	32	32	32
MEAN	0.5	0.8	0.2	0.0	0.0	0.8	1.3	-1.6	-0.3	1.1	1.9	0.5	5.1
STD	0.8	0.4	0.4	0.3	0.4	0.7	1.8	2.7	3.7	1.4	1.5	1.1	10.0
MIN	-0.7	0.2	-1.5	-1.0	-1.9	-1.5	-1.9	-6.0	-5.8	-1.5	-0.6	-1.3	-10.1
MAX	2.5	1.8	0.9	0.7	0.7	2.1	6.4	5.2	11.5	4.9	5.8	3.7	30.4

Table 13
Adjusted and unadjusted virgin flow core files
(Tomichi Creek above Tomichi Creek at Gunnison)

Station Name	Unadjusted Flow File	Adjusted Flow File
Tomichi Creek at Gunnison	VG19000	VJ19000*
Tomichi Creek at Parlin	TOM 2	TOM2C
Quartz Creek near Ohio	VG18000	VJ18000
Cochetopa Creek near Parlin	VG18500	VJ18500

* Base station.

Copies of adjusted virgin flow core station files are given in Appendix D.

Inflow Development for INFL5 - INFL51

Two sets of virgin flow estimates for model inflow points in the Upper Gunnison Basin (INFL5 - INFL51) were derived using unadjusted and adjusted core station virgin flow estimates. The general methodology for inflow development used elevation/yield and area proportioning techniques. Core station long-term yields [from 1952-1983] were used to derive elevation/yield curves. Estimates of 1952-1983 yields for subbasin inflows were taken from these curves. Annual and monthly flow estimates of subbasin inflows were developed by distributing the long-term yield as taken from the elevation/yield curve in the same proportions as annual and monthly flows of the core station.

Where data was available, monthly distribution factors were applied to core station values to obtain distributions which better represented subbasin areas.

Methodologies used for individual inflow derivation are summarized in Appendix E. Copies of individual inflow files (both adjusted and unadjusted) are given in Appendix F.

Individual inflows within a subbasin sum together to yield the flow of the core station for the basin. Inflow file summations are presented in Table 14 for unadjusted inflows and Table 15 for adjusted inflows. (File suffix ".VIR1" indicates unadjusted inflow files; suffix ".VIR2" indicates adjusted values.)

Table 13
Summary of inflow file summations
(unadjusted flows)

1) INFL33.VIR1 + INFL34.VIR1 = VC09000

2) VC09000 + INFL35.VIR1 + INFL36.VIR1 + INFL37.VIR1 = VC10000

3) INFL25.VIR1 + INFL26.VIR1 + INFL27.VIR1 +INFL28.VIR1 + INFL29.VIR1 + INFL30.VIR1 + INFL31.VIR1 + INFL32.VIR1 = VG12500

4) INFL19.VIR1 + INFL20.VIR1 + INFL21.VIR1 + INFL 22.VIR1 + INFL23.VIR1 = VG14000

5) VC10000 + VG12500 + VG14000 + INFL18.VIR1 + INFL24.VIR1 = VI14500

6) INFL46.VIR1 + INFL47.VIR1 + INFL48.VIR1 + INFL49.VIR1 = VG18500

7) INFL42.VIR1 + INFL43.VIR1 = VG18000

8) VG18000 + VG18500 + INFL38.VIR1 + INFL39.VIR1 + INFL40.VIR1 + INFL41.VIR1 + INFL44.VIR1 + INFL45.VIR1 + INFL50.VIR1 = VG19000

9) INFL15.VIR1 = VG23000

10) INFL6.VIR1 + INFL7.VIR1 + INFL8.VIR1 = VG26500

11) INFL5.VIR1 + INFL9.VIR1 + INFL10.VIR1 + INFL11.VIR1 + INFL13.VIR1 + INFL14.VIR1 + INFL16.VIR1 + INFL17.VIR1 + VI14500 + VG19000 + VG23000 + VG26500 = VG27800

Table 15
Summary of inflow file summations
(Adjusted Flows)

1) INFL33.VIR2 + INFL34.VIR2 = VJ09000

2) VJ09000 + INFL35.VIR2 + INFL36.VIR2 + INFL37.VIR2 = VJ10000

3) INFL25.VIR2 + INFL26.VIR2 + INFL27.VIR2 + INFL28.VIR2 + INFL29.VIR2 + INFL30.VIR2 + INFL31.VIR2 +INFL32.VIR2 = VJ12500

4) INFL19.VIR2 + INFL20.VIR2 + INFL21.VIR2 + INFL22.VIR2 + INFL23.VIR2 = VJ14000

5) VJ10000 + VJ12500 + VJ14000 + INFL18.VIR2 + INFL24.VIR2 = VJ14500

6) INFL46.VIR2 + INFL47.VIR2 + INFL48.VIR2 + INFL49.VIR2 + VJ18500

7) INFL42.VIR2 + INFL43.VIR2 = VJ18000

8) VJ18000 + VJ18500 + INFL38.VIR2 + INFL39.VIR2 + INFL40.VIR2 + INFL41.VIR2 + INFL44.VIR2 + INFL45.VIR2 + INFL50.VIR2 = VG19000

9) INFL15.VIR2 = VJ23000

10) INFL6.VIR2 + INFL7.FIR2 + INFL8.VIR2 = VJ26500

11) INFL5.VIR2 + INFL9.VIR2 + INFL10.VIR2 + INFL11.VIR2 + INFL13.VIR2 + INFL14.VIR2 + INFL16.VIR2 + INFL17.VIR2 + VJ14500 + VJ19000 + VJ23000 + VJ26500 = VJ27800

Uncompahgre River Inflows: INFL52-INFL59

Flows for eight inflow points were developed for the Uncompahgre Basin:

INFL 52 - Inflow to Ramshorn Site on Cow Creek.

INFL 53 - Gaged inflow to Ridgway Dam Site.

INFL 54 - Uncompahgre gains below Ridgway to Cow Creek plus Cow Creek gains below Ramshorn Site.

INFL 55 - Uncompahgre gains between Cow Creek and South Canal.

INFL 56 - Inflow from Horsefly Creek Drainage.

INFL 57 - Inflow from Happy Canyon Drainage.

INFL 58 - Inflow from Spring Creek Drainage.

INFL 59 - Inflow from Dry Creek Drainage.

Virgin flow estimates for INFL 52 were developed from flows for station 09147100, Cow Creek near Ridgway. Details of flow development are given in Appendix C.

INFL 53 through 55 were developed using INFL 52 and historic flows for the Uncompahgre River near Ridgway, Dallas Creek near Ridgway, Cow Creek at the mouth, and Uncompahgre River at Colona; all these were used in USBR operation studies completed for the Dallas Creek Project. Flows for these stations are given in Tables 16 through 19.

INFL 53 was developed by summing flow values for Uncompahgre River near Ridgway and Dallas Creek near Ridgway.

INFL 54 was developed by subtracting Uncompahgre River near Ridgway plus Dallas Creek near Ridgway plus the inflow to Ramshorn site from the Uncompahgre River near Ridgway plus Dallas Creek near Ridgway plus Cow Creek at the mouth. This difference is equivalent to Cow Creek at the mouth minus inflows to the Ramshorn site.

The flows for the Uncompahgre River at Colona were assumed to represent UncompahgrE River flows above the South Canal. INFL 55 was developed by subtracting Uncompahgre River near Ridgway plus Dallas Creek near Ridgway plus Cow Creek at the mouth from flows for the Uncompahgre River at Colona.

INFL 56 through 59 were developed from and elevation/yield curve based on flow values for Pleasant Valley Creek near Noel (Station 091 46600) and Spring Creek near Beaver Hill (Station 091 49400). Flow development for these inflows is further discussed in appendix E. Listing of these flow files are given in Appendix F.

Table 16
Uncompahgre R nr Ridgway
Oct-Sept
1000 AF

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1952	2.6	2.8	3.0	2.7	2.3	2.7	8.4	26.9	56.8	24.7	10.7	6.4	150.0
1953	4.2	2.8	3.0	3.1	2.6	3.3	4.6	14.9	39.5	13.2	7.6	3.1	101.9
1954	3.5	3.9	3.1	2.6	2.6	2.5	4.0	11.3	10.2	10.3	4.4	6.4	64.7
1955	5.6	2.9	2.7	2.5	2.2	3.2	4.6	15.0	25.5	8.7	7.9	3.0	83.8
1956	2.5	2.6	3.1	2.7	2.4	4.0	6.0	19.8	24.1	8.5	4.9	2.7	83.5
1957	3.0	2.7	2.7	3.0	3.0	2.9	5.1	21.8	64.0	57.8	15.2	9.1	190.3
1958	5.2	4.5	3.9	2.6	3.2	3.8	10.5	60.0	60.1	16.0	8.0	6.1	183.9
1959	4.2	4.1	3.3	2.8	2.6	3.3	4.9	14.4	34.9	9.4	8.3	3.2	95.4
1960	6.4	3.7	2.9	2.4	2.2	4.4	10.3	18.8	40.5	16.3	6.0	3.7	117.5
1961	3.9	3.5	3.0	2.6	2.4	3.9	6.2	23.0	32.2	10.1	8.6	8.0	107.6
1962	6.1	4.4	3.0	2.6	3.3	2.9	10.4	19.6	35.5	23.3	8.5	5.1	124.7
1963	5.8	3.9	3.2	2.5	3.4	4.1	6.4	19.4	16.9	10.2	6.4	5.5	87.7
1964	4.0	4.1	3.1	2.5	2.2	2.5	6.1	24.6	30.6	16.9	12.4	5.6	114.6
1965	4.0	3.0	2.8	2.6	2.4	3.1	8.8	19.7	39.2	38.9	14.4	10.1	149.0
1966	6.6	5.1	3.9	3.0	2.4	4.3	7.2	24.8	23.1	11.9	6.3	3.9	104.5
1967	4.2	3.4	3.0	2.5	2.5	3.8	4.3	17.2	22.0	15.1	9.6	4.6	92.2
1968	4.5	3.6	2.9	2.6	2.6	3.5	4.4	16.4	48.1	17.8	15.8	4.9	127.1
1969	4.5	3.4	2.6	2.9	2.2	3.2	5.3	23.9	25.0	21.3	8.4	7.0	113.9
1970	9.0	5.5	3.9	3.0	3.0	3.1	4.8	27.6	35.2	19.3	12.1	14.9	142.4
1971	7.8	5.6	4.1	3.2	2.8	3.9	9.0	13.2	35.9	20.2	8.5	7.6	121.7
1972	5.2	4.0	3.2	2.9	2.9	4.4	5.4	14.2	24.0	8.8	4.5	5.3	84.8
1973	6.3	4.5	3.1	2.6	2.3	3.2	4.0	20.9	46.4	33.0	11.8	6.1	144.2
1974	4.8	3.5	3.2	3.0	2.4	5.0	5.9	23.8	26.6	14.1	5.9	3.4	101.6
1975	3.7	3.2	2.6	2.3	1.9	2.9	4.0	15.8	44.6	45.9	13.0	5.8	145.7
1976	4.1	3.4	2.9	2.3	2.5	2.7	4.6	16.0	26.7	13.0	6.7	3.9	88.8
1977	2.6	3.2	2.2	2.0	1.9	2.5	5.0	7.5	10.0	5.4	4.5	4.5	51.5
1978	3.7	3.4	2.8	2.4	2.1	3.9	7.2	17.0	53.4	28.6	8.4	4.6	137.5
1979	3.5	3.0	2.5	2.5	2.1	3.4	6.5	23.5	49.1	31.5	11.2	4.1	142.9
1980	4.1	4.0	3.2	2.7	2.5	2.5	5.1	13.1	36.4	16.1	6.9	3.5	100.5
1981	3.5	3.2	2.9	2.4	2.0	2.5	4.6	9.7	22.9	16.5	6.1	4.8	80.5
1982	4.6	4.2	3.1	2.7	2.5	3.3	5.7	17.2	38.6	29.0	18.5	12.8	142.2
1983	7.2	4.3	3.4	2.3	2.4	3.8	5.2	17.8	54.2	52.2	16.8	6.7	176.8

N	32	32	32	32	32	32	32	32	32	32	32	32	32
MEAN	4.8	3.7	3.1	2.7	2.5	3.4	6.2	19.6	35.4	20.8	9.3	5.8	117.3
STD	1.6	0.8	0.4	0.3	0.4	0.7	2.0	8.9	13.9	13.0	3.8	2.8	33.6
MIN	2.5	2.7	2.2	2.0	1.9	2.5	4.0	7.5	10.0	5.4	4.4	2.7	51.5
MAX	5.0	5.6	4.1	3.2	3.4	5.0	10.5	60.0	64.0	57.8	18.5	14.9	190.3

Table 17
Dallas C nr Ridgway
Oct-Sept
1000 AF

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1952	0.6	0.9	1.0	0.8	0.6	0.9	4.2	2.8	6.0	6.3	5.4	2.2	31.7
1953	1.0	0.9	1.0	1.0	0.8	1.1	2.3	0.2	3.3	2.4	2.7	0.6	17.3
1954	0.6	1.4	1.0	0.8	0.8	0.7	2.2	0.1	0.6	1.6	1.8	1.8	13.4
1955	1.8	0.9	0.8	0.9	0.6	1.0	2.6	0.3	1.9	1.8	2.5	0.5	15.6
1956	0.2	1.1	1.0	1.0	0.8	1.3	2.4	0.5	2.1	1.7	0.4	0.2	12.7
1957	0.1	0.9	0.9	0.9	1.0	1.0	3.1	4.0	4.5	12.2	8.2	2.9	39.7
1958	1.1	1.8	1.6	1.1	1.3	1.7	6.4	6.2	6.9	1.9	2.5	1.5	34.0
1959	1.1	1.0	0.9	0.7	0.9	1.0	2.1	0.9	1.1	1.0	3.0	0.6	14.3
1960	1.3	1.1	0.8	0.7	0.8	1.5	4.3	0.5	2.8	1.5	1.9	0.5	17.7
1961	1.0	1.2	0.9	0.9	0.8	1.5	3.5	1.2	2.6	1.6	3.6	2.8	21.6
1962	1.7	1.3	0.9	0.9	1.1	1.1	3.7	1.0	1.6	3.7	2.2	1.1	20.3
1963	1.6	1.3	1.0	1.3	1.2	2.3	0.9	0.1	0.4	1.7	2.6	1.4	15.8
1964	0.6	1.4	1.0	0.8	0.8	0.9	3.8	3.9	2.0	2.4	4.6	1.9	24.1
1965	1.2	1.2	1.5	1.3	1.2	1.2	5.5	4.8	3.8	11.2	5.2	3.1	41.2
1966	2.2	2.1	1.7	1.3	1.1	2.3	2.5	0.4	2.0	3.0	1.6	0.6	20.8
1967	1.1	1.3	1.2	1.0	1.0	1.3	0.5	0.1	0.9	1.1	2.4	1.5	13.4
1968	0.4	1.3	1.0	0.8	0.7	1.0	1.1	1.1	3.0	1.7	5.4	1.0	18.5
1969	0.8	1.3	1.1	1.2	0.7	1.4	2.8	0.3	1.5	4.4	1.9	2.4	19.8
1970	2.4	1.6	1.4	1.0	0.9	1.2	2.6	4.8	4.6	5.5	3.8	5.0	34.8
1971	2.8	1.9	1.6	1.4	1.2	2.3	2.5	0.6	2.2	2.8	2.6	2.9	24.8
1972	1.8	1.4	0.9	0.8	0.9	1.6	2.4	0.2	1.5	1.0	0.9	1.2	14.6
1973	2.0	1.8	1.2	1.0	0.7	1.3	2.0	3.6	6.6	9.0	5.2	1.4	35.8
1974	1.5	1.1	1.0	0.9	0.8	2.3	3.8	1.8	1.3	1.5	1.1	0.2	17.3
1975	1.0	1.0	0.8	0.7	0.6	1.0	1.2	0.6	4.9	11.9	4.8	1.4	29.9
1976	1.0	1.4	1.4	0.8	0.9	1.1	2.0	0.2	2.0	1.7	1.4	0.7	14.6
1977	1.2	0.9	0.8	0.7	0.6	0.9	1.1	0.4	0.3	0.6	1.0	0.6	9.1
1978	0.6	1.0	0.7	0.7	0.5	1.3	4.0	1.0	5.3	4.3	1.6	0.4	21.4
1979	0.9	1.2	1.1	1.1	0.7	2.1	3.5	6.0	6.2	7.2	4.0	0.8	34.8
1980	0.8	1.3	0.9	0.6	0.8	0.9	2.5	5.2	3.0	3.0	2.1	1.2	22.3
1981	0.5	0.9	0.9	0.8	0.9	1.1	1.2	0.0	0.8	2.8	1.6	2.1	13.6
1982	1.3	1.4	1.1	1.1	0.9	1.2	3.5	3.6	2.3	4.9	7.8	5.4	34.5
1983	2.6	1.6	1.1	1.0	1.0	1.3	2.8	7.2	7.2	14.1	8.7	2.7	51.3

N	32	32	32	32	32	32	32	32	32	32	32	32	32
MEAN	1.2	1.3	1.1	0.9	0.9	1.3	2.8	2.0	3.0	4.1	3.3	1.6	23.5
STD	0.7	0.3	0.3	0.2	0.2	0.5	1.3	2.2	2.0	3.7	2.1	1.3	10.3
MIN	0.1	0.9	0.7	0.6	0.5	0.7	0.5	0.0	0.3	0.6	0.4	0.2	9.1
MAX	2.3	2.1	1.7	1.4	1.3	2.3	6.4	7.2	7.2	14.1	8.7	5.4	51.3

Table 18
Cow C at Mouth
Oct-Sept
1000 AF

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1952	0.2	0.5	0.6	0.5	0.3	0.5	2.6	12.0	20.2	8.6	1.2	0.1	47.3
1953	0.7	0.5	0.6	0.7	0.5	0.7	1.1	5.1	14.7	2.7	0.5	0.0	27.8
1954	0.4	1.0	0.6	0.4	0.5	0.4	0.8	2.7	0.9	1.0	0.1	0.1	8.9
1955	1.1	0.5	0.5	0.4	0.3	0.7	1.1	5.1	7.7	0.1	0.5	0.0	18.0
1956	0.5	0.5	0.7	0.6	0.4	1.3	2.0	11.7	11.1	0.2	0.0	0.0	29.0
1957	0.0	0.5	0.5	0.5	0.6	0.7	1.5	5.7	26.3	18.6	4.2	0.9	60.0
1958	0.7	1.2	0.9	0.4	0.6	0.9	2.0	17.2	23.2	4.0	1.0	0.2	52.3
1959	0.0	0.5	0.7	0.5	0.5	0.6	1.0	6.0	12.5	0.9	0.4	0.1	24.1
1960	1.1	0.7	0.5	0.5	0.4	1.2	3.9	7.5	18.5	2.8	0.2	0.2	37.5
1961	0.4	0.6	0.7	0.6	0.4	0.7	1.6	8.4	10.0	0.7	0.6	2.4	27.1
1962	1.3	1.7	1.0	0.6	0.7	0.8	4.1	8.7	12.0	4.7	0.3	0.8	37.2
1963	0.9	0.6	0.4	0.4	0.5	1.2	1.8	6.5	1.3	1.2	0.5	0.3	15.6
1964	0.5	0.5	0.3	0.4	0.5	0.8	1.6	10.3	12.5	2.5	1.1	0.2	31.5
1965	0.3	0.8	0.7	0.6	0.4	0.7	2.6	6.9	18.1	10.7	1.9	1.3	45.0
1966	1.7	1.0	0.9	0.7	0.5	1.3	2.4	12.5	5.6	0.1	0.1	0.0	26.8
1967	0.6	0.4	0.4	0.4	0.2	0.5	1.1	6.4	6.2	0.2	0.3	0.0	16.7
1968	0.6	0.5	0.4	0.3	0.3	0.6	1.3	7.7	20.7	3.4	1.4	0.0	37.4
1969	0.9	0.6	0.6	0.6	0.4	0.7	3.1	9.7	7.3	1.7	0.0	0.2	25.8
1970	1.8	1.4	0.7	0.6	0.7	0.9	1.4	16.4	14.0	2.4	0.3	2.6	43.1
1971	0.8	1.0	1.0	0.7	0.5	0.7	2.3	4.8	11.1	1.4	0.6	2.3	27.2
1972	1.5	0.6	0.4	0.5	0.4	1.3	1.5	4.8	1.8	1.0	0.4	0.3	14.5
1973	0.3	1.1	0.6	0.5	0.5	0.8	1.2	12.4	17.9	4.1	0.3	1.1	41.3
1974	0.5	0.6	0.6	0.7	0.5	1.1	1.4	6.1	6.9	2.9	0.4	0.0	25.7
1975	0.5	0.5	0.5	0.4	0.4	0.7	1.2	4.1	18.3	14.8	3.6	0.6	45.7
1976	0.5	0.7	0.6	0.5	0.5	0.5	0.9	6.7	9.6	1.2	0.3	0.1	22.2
1977	0.7	0.6	0.4	0.3	0.3	0.5	1.0	1.8	0.9	0.5	0.1	0.1	7.2
1978	0.7	0.6	0.5	0.4	0.3	0.6	2.2	7.5	18.0	5.8	0.3	0.7	37.6
1979	0.5	0.6	0.4	0.5	0.5	0.7	1.9	14.0	19.0	3.9	0.3	0.7	43.5
1980	0.7	0.7	0.1	0.5	0.5	0.5	0.9	6.7	9.6	1.2	0.3	0.1	21.9
1981	0.0	0.6	0.4	0.5	0.4	1.3	1.5	4.8	1.8	1.0	0.4	0.3	13.0
1982	0.8	0.9	0.4	0.4	0.3	0.6	1.7	5.2	4.4	7.2	5.2	1.3	28.6
1983	1.2	1.3	0.4	0.4	0.5	1.2	1.5	8.7	21.9	16.8	5.2	0.0	59.1

N	32	32	32	32	32	32	32	32	32	32	32	32	32
MEAN	0.7	0.8	0.6	0.5	0.4	0.8	1.8	8.0	12.1	4.0	1.0	0.5	31.2
STD	0.5	0.3	0.2	0.1	0.1	0.3	0.8	3.7	7.2	4.9	1.4	0.7	13.8
MIN	0.0	0.4	0.1	0.3	0.2	0.4	0.8	1.8	0.9	0.1	0.0	0.0	7.2
MAX	1.8	1.7	1.0	0.7	0.7	1.3	4.1	17.2	26.3	18.6	5.2	2.6	60.0

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Table 19
Uncompahgre R at Colona
Oct-Sept
1000 AF

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1952	3.4	4.7	5.1	4.4	3.6	4.5	18.4	38.1	75.7	34.8	19.0	7.8	219.5
1953	5.0	4.6	5.1	5.3	4.2	5.6	8.9	19.8	55.1	17.5	10.8	2.1	144.0
1954	3.5	6.9	5.3	4.2	4.3	3.9	7.4	14.4	12.7	12.9	4.2	7.9	87.6
1955	8.3	4.7	4.4	4.1	3.5	5.4	8.8	20.1	36.1	10.2	11.3	2.1	119.0
1956	2.0	4.6	5.2	4.5	3.9	7.4	12.1	27.6	34.0	10.0	5.0	1.7	118.0
1957	2.3	4.4	4.6	5.0	5.1	4.9	9.9	30.6	84.0	76.8	33.5	14.3	275.9
1958	7.4	8.5	7.0	4.3	5.5	6.9	25.0	79.6	79.8	21.6	11.7	7.3	264.6
1959	5.2	6.4	5.6	4.8	4.4	5.3	9.6	19.3	46.7	10.9	10.9	2.7	131.8
1960	9.4	5.7	4.5	3.7	3.7	8.2	23.6	26.8	56.1	20.1	6.9	2.9	171.6
1961	4.0	5.6	5.0	4.7	4.0	6.7	13.2	34.2	44.8	13.2	12.8	13.5	161.7
1962	11.7	8.6	5.6	4.2	5.6	5.4	16.4	34.3	47.0	33.5	10.0	5.0	187.5
1963	7.7	5.7	4.6	4.2	5.3	7.6	6.8	20.1	14.6	11.2	9.2	6.3	105.5
1964	4.1	6.4	4.1	3.8	3.6	4.9	13.1	39.3	45.3	22.7	17.7	7.6	172.6
1965	5.7	5.6	5.5	4.8	4.1	5.3	17.8	30.2	54.3	57.5	21.9	14.6	227.3
1966	13.5	8.3	6.9	5.4	4.0	8.5	14.0	32.6	28.2	14.1	6.9	3.2	145.6
1967	4.8	5.0	4.5	3.9	3.5	5.1	4.3	16.4	25.5	14.6	11.2	4.7	103.5
1968	4.4	5.3	4.2	3.7	3.4	5.4	6.4	21.4	67.1	22.3	25.2	4.8	173.6
1969	4.7	5.4	5.0	5.0	3.8	5.8	15.8	25.9	32.8	26.2	8.5	8.8	151.7
1970	16.2	5.2	5.1	4.7	4.9	5.5	9.6	51.6	52.4	33.1	15.0	24.4	238.7
1971	13.2	8.4	7.0	6.8	5.0	7.7	15.9	17.6	54.8	27.7	11.4	11.8	187.2
1972	6.4	7.0	4.7	4.2	4.9	7.9	2.7	17.5	31.2	8.4	4.3	5.5	112.6
1973	9.4	8.5	6.1	5.3	4.0	6.3	11.1	46.7	89.1	46.2	16.3	8.0	257.0
1974	7.1	5.5	5.4	4.9	4.4	10.8	14.8	33.6	34.2	17.9	6.3	4.0	154.9
1975	4.6	5.3	4.3	3.9	3.6	5.0	7.9	29.6	64.6	89.6	17.8	5.9	242.3
1976	5.0	7.0	6.8	4.4	4.7	5.6	8.6	18.2	29.5	14.5	8.0	4.3	116.6
1977	5.3	4.7	4.3	4.0	3.5	4.7	7.6	10.0	9.9	4.9	3.7	4.9	68.0
1978	3.6	5.2	3.9	3.8	3.2	6.4	13.8	25.8	67.3	34.3	8.8	4.4	180.5
1979	4.7	5.9	5.6	5.4	3.9	9.6	20.8	43.1	64.3	41.2	16.5	4.2	225.2
1980	4.2	6.4	8.1	5.2	4.8	4.6	8.7	24.4	48.0	20.2	8.0	3.2	145.8
1981	4.4	5.2	4.4	3.6	3.2	4.2	9.8	9.0	30.0	20.1	6.9	5.8	104.6
1982	5.0	7.3	4.9	4.6	4.0	6.1	12.5	30.6	49.3	47.6	36.2	20.6	228.7
1983	12.0	8.3	5.3	4.6	4.3	7.3	10.9	41.5	103.1	98.2	35.4	9.7	340.6

N	32	32	32	32	32	32	32	32	32	32	32	32	32
MEAN	6.6	6.3	5.3	4.5	4.2	6.2	12.3	29.3	49.2	29.2	13.5	7.3	173.9
STD	3.5	1.4	1.0	0.7	0.7	1.6	4.9	14.0	22.6	23.1	8.8	5.3	63.4
MIN	2.0	4.4	3.9	3.6	3.2	3.5	4.3	8.0	9.9	4.9	3.7	1.7	68.0
MAX	16.2	9.2	8.1	6.8	5.6	10.8	25.0	79.6	103.1	98.2	36.2	24.4	340.6

Conclusions and Recommendations

Flows as they were developed are considered to adequately represent appraisal level estimates of model inflows.

Two sets of virgin flow estimates for Upper Gunnison inflows (INFL5 through INFL51) were developed. Adjusted inflows were developed for which negative values in difference files were eliminated and set to zero. This adjustment was made by reducing contributing core station flow values for those months in which negatives occurred. Adjusted inflows represent a more conservative water supply situation than unadjusted values. Flows for contributing areas located upstream are reduced, while lower intervening area flows are increased.

Unadjusted inflows may more represent virgin flow conditions on a long-term annual average basis. However, using unadjusted flows results in negative values occurring in difference files. It is therefore recommended that adjusted inflow file values be used: they represent a more conservative water supply scenario, and eliminate negative inflows from occurring in difference files.

Should the opportunity arise for reiteration of inflow development, several changes which would result in the reduction in frequency and magnitude of negative difference file values should be considered:

Irrigation Depletions:

> Present virgin flow derivation has used estimates of irrigation consumptive use to approximate stream depletions attributable to irrigation. As such, these depletions do not adequately address the storage within the soil of early irrigation season diversions and subsequent later season return flows. If possible, future flow development should consider the accounting of irrigation depletions in terms of actual diversions and return flows.

Reservoir Effects:

In addition to irrigation depletions, another aspect to be checked would be reservoir effects considered in deriving virgin flow estimates for the base station (Gunnison River at Crystal Dam).

Bank storage effects are computed as a constant percentage (10 percent) of Blue Mesa monthly change in storage. In high storage and release months, this can result in a significant adjustment. Actual bank storage and release patterns and quantities may be different.

Reservoir evaporation is accounted for by using constant monthly evaporation rates multiplied by reservoir area. No consideration is made for fluctuation in monthly evaporation rates on a year-to-year basis.

Miscellaneous:

In addition to the above considerations, several other adjustments to the virgin flow estimates for the Gunnison River at Crystal Dam virgin flow estimates, though minor, should be taken into account. These include:

1. An approximate 8,000 acre-foot increase to 1955 irrigation depletions (see Appendix B).
2. Consideration of Crystal Reservoir storage effects from 1977 through 1983.
3. Verification that Cimarron Canal diversions from the Cimarron River have been considered.

Incorporating these changes would involve a considerable amount of work.

The resulting degree of improvement in flow estimates is not presently known.

RESERVOIR INFLOW FORECASTS

APPENDIX E

RESERVOIR INFLOW FORECASTS

Three of the four major reservoirs in the Upper Gunnison and Uncompahgre basins rely on inflow forecasts in their operations. These are Blue Mesa, Taylor Park, and Ridgway reservoirs. This Appendix describes the development of the inflow forecasts used in the basin model for operation of these three reservoirs.

BLUE MESA FORECASTS

Systematic inflow forecasts for Blue Mesa have been made only since 1971, and the procedures used to make these forecasts have been modified several times since then. The historical inflow forecasts were examined by USBR personnel in the Salt Lake City Regional Office and normalized to produce a uniform set of historical April-July runoff forecasts. These normalized forecasts are displayed in Table E.1.

TABLE E.1

HISTORICAL APRIL-JULY FORECASTED INFLOW
BLUE MESA RESERVOIR
(values in 1000 acre-feet)

	Forecast Date				
Year	Jan 1	Feb 1	Mar 1	Apr 1	May 1
1971	705.0	650.0	715.0	610.0	550.0
1972	750.0	740.0	640.0	535.0	490.0
1973	850.0	800.0	770.0	755.0	775.0
1974	605.0	700.0	620.0	540.0	550.0
1975	595.0	670.0	735.0	830.0	865.0
1976	530.0	450.0	535.0	530.0	545.0
1977	320.0	180.0	100.0	150.0	205.0
1978	720.0	755.0	810.0	855.0	795.0
1979	715.0	860.0	930.0	970.0	1000.0
1980	630.0	815.0	900.0	1050.0	1100.0
1981	525.0	420.0	306.0	350.0	280.0
1982	770.0	785.0	800.0	870.0	864.0
1983	645.0	580.0	520.0	645.0	690.0
1984	1300.0	1170.0	1100.0	1130.0	1275.0
1985	970.0	915.0	855.0	900.0	925.0
1986	950.0	810.0	930.0	880.0	1000.0

In order to run the basin model for the entire 1952-83 study period it was necessary to develop inflow forecasts for the years prior to operation of Blue Mesa. To do this, snow course measurements taken in and near the Upper Gunnison basin were examined to determine whether they showed strong relationship to the historical inflow forecasts and whether they contained data going back to 1952. Of the ten snow courses reviewed, four were selected as having potential for use in predicting Blue Mesa inflow forecasts. The four selected were the Porphyry Creek, Park Cone, North Lost Trail, and Lake City snow courses.

The beginning-of-the-month snow water equivalents for combinations of these snow courses were regressed against the corresponding historical inflow forecasts using commercial multiple-regression software. The coefficients of determination of various predictive models were compared and a set of best fit models selected for use in developing forecasts for the years prior to 1971. The resulting forecasting models are listed in Table E.2.

TABLE E.2

PREDICTOR MODELS
FOR
BLUE MESA APRIL-JULY FORECASTED INFLOW

Forecast Date	Forecasting Model	R^2
Jan 1	Inflow (KAF) = 56.57*X3 + 314.6	.70
Feb 1	Inflow (KAF) = 41.89*X1 + 34.62*X2 - 3.71*X3 + 68.9	.81
Mar 1	Inflow (KAF) = 27.36*X1 + 5.39*X2 + 27.37*X3 - 96.0	.87
Apr 1	Inflow (KAF) = 13.35*X1 + 23.08*X2 + 25.74*X3 - 192.8	.87
May 1	Inflow (KAF) = 19.51*X1 + 47.83*X2 - 20.06*X4 + 237.7	.96*

where: X1 = snow water equivalent on North Lost Trail snowcourse
X2 = snow water equivalent on Park Cone snowcourse
X3 = snow water equivalent on Porphyry Creek snowcourse
X4 = snow water equivalent on Lake City snowcourse

* April-July forecast adjusted for actual April inflow

These predictor equations were then used to compute April-July inflow forecasts for the years 1952-1970. The resulting forecasts for 1952-83 were then adjusted to reflect total inflows from the forecast month through July, i.e. the January 1 forecast then reflected January through July inflow. This was accomplished by adding average inflows for the months of January, February, and March, as appropriate. The June and July forecasts were similarly adjusted by subtracting observed May and June inflows. July forecasts were further adjusted so as to have a minimum value of 30 KAF. The resulting forecast values are given in Table E.3.

TABLE E.3

BLUE MESA INFLOW FORECASTS USED IN BASIN MODEL

CURRENT MONTH THROUGH JULY
(values in 1000 acre-feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul
1952	805.20	1049.50	1189.60	1339.90	1012.35	628.09	161.79
1953	805.20	641.50	601.70	598.10	592.68	451.07	156.13
1954	805.20	674.40	437.50	423.90	130.81	31.54	30.00
1955	805.20	510.30	645.50	524.40	285.30	167.05	33.87
1956	746.50	843.40	900.70	719.50	623.66	417.66	218.08
1957	825.70	1265.70	1059.20	1134.70	1294.46	1073.13	466.83
1958	904.90	616.10	711.70	756.20	509.39	136.81	30.00
1959	650.40	440.60	678.90	557.10	540.23	436.58	286.12
1960	808.80	490.60	646.00	734.50	404.19	275.72	60.78
1961	910.60	418.90	479.90	538.40	673.63	545.16	425.58
1962	803.10	1042.10	1155.60	1048.70	677.51	351.06	30.00
1963	633.40	526.80	581.40	532.70	165.08	40.70	30.00
1964	684.30	470.90	586.10	617.30	680.18	517.11	358.81
1965	978.50	1091.80	954.20	1137.60	992.29	724.54	324.32
1966	735.20	667.00	654.20	363.60	381.54	227.23	79.01
1967	746.50	722.60	641.80	536.90	402.70	269.41	79.91
1968	650.40	677.30	717.10	620.10	666.59	502.93	221.91
1969	684.30	1034.50	890.80	800.20	415.83	182.40	30.00
1970	1063.30	870.70	757.80	819.80	770.38	376.29	89.45
1971	786.20	706.90	749.90	610.00	313.43	150.45	30.00
1972	831.20	796.90	674.90	535.00	370.99	246.26	40.97
1973	931.20	856.90	804.90	755.00	691.44	490.24	197.43
1974	686.20	756.90	654.90	540.00	425.63	205.55	38.27
1975	676.20	726.90	769.90	830.00	755.05	576.92	262.27
1976	611.20	506.90	569.90	530.00	405.81	263.73	100.04
1977	401.20	236.90	134.90	150.00	126.19	86.20	36.27
1978	801.20	811.90	844.90	855.00	632.57	455.94	103.98
1979	796.20	916.90	964.90	970.00	811.59	555.23	213.50
1980	711.20	871.90	934.90	1050.00	900.76	628.80	233.28
1981	606.20	476.90	340.90	350.00	213.24	159.25	49.58
1982	851.20	841.90	834.90	870.00	723.20	539.24	253.60
1983	726.20	636.90	554.90	645.00	573.83	409.48	30.00

TAYLOR PARK INFLOWS

Taylor Park inflow forecasts are keyed to the Blue Mesa forecasts. The Taylor Park inflow forecast is computed by multiplying average Taylor Park inflow for a given period by the ratio of the Blue Mesa forecast for that period to the average Blue Mesa forecast for that period. For example, if the Blue Mesa forecast on March 1 is 110% of the average March 1 Blue Mesa forecast, the Taylor Park forecast is 110% of the average Taylor Park inflow for March through July. Table E.4 lists the average Taylor Park inflows, obtained from the USBR regional office in Salt Lake City, which were used to derive these forecasts.

TABLE E.4

AVERAGE TAYLOR PARK INFLOWS

Month	Average Inflow, AF
Jan	4,000
Feb	4,000
Mar	4,000
Apr	9,000
May	30,000
Jun	47,000
Jul	21,000

In the basin model, Taylor Park is operated on a forecast basis only in the months of March through May. In all other months operations are keyed to maintenance of instream flows in the Taylor River.

RIDGWAY RESERVOIR

Ridgway reservoir has not yet been placed into operation and no inflow forecasts have been derived by the USBR. Inflow forecasts for the basin model were derived from combined gaged inflows of the Uncompahgre River near Ridgway and Dallas Creek near Ridgway and observations of snow water equivalent on the Ironton and Red Mountain snow courses. The actual inflows for the months of March through July were used as the independent variable in these regressions.

TABLE E.5

PREDICTOR MODELS
FOR
RIDGWAY MARCH-JULY FORECASTED INFLOW

Forecast Date	Forecasting Model	R^2
Mar 1	Inflow (KAF) = 6.07*X1 + 0.225*X2 + 22.53	.39
Apr 1	Inflow (KAF) = 5.24*X1 + 0.20*X2 + 17.73	.58
May 1	Inflow (KAF) = 0.98*X1 + 3.31*X2 - 20.6	.65

where: X1 = snow water equivalent on Ironton snowcourse
X2 = snow water equivalent on Red Mountain snowcourse

Forecasts for June 1 and July 1 were derived by subtracting the actual May and June runoff values from the May 1 forecasts. January 1 and February 1 forecasts were taken simply as the average April through July inflow. The resulting forecast values are given in Table E.6.

TABLE E.6

RIDGWAY INFLOW FORECASTS USED IN BASIN MODEL

CURRENT MONTH THROUGH JULY
(values in 1000 acre-feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul
1952	94	94	139	145	137	108	45
1953	94	94	88	70	62	47	4
1954	94	94	56	52	26	14	3
1955	94	94	70	70	63	48	20
1956	94	94	121	95	79	59	33
1957	94	94	111	126	91	65	0
1958	94	94	127	132	123	57	0
1959	94	94	83	101	84	69	33
1960	94	94	99	100	88	69	26
1961	94	94	80	92	75	51	16
1962	94	94	107	100	83	63	26
1963	94	94	87	76	52	32	15
1964	94	94	88	106	65	37	4
1965	94	94	104	119	98	73	30
1966	94	94	85	50	55	30	5
1967	94	94	93	57	54	36	14
1968	94	94	119	108	97	80	28
1969	94	94	116	110	75	50	24
1970	94	94	107	111	87	55	14
1971	94	94	108	85	74	60	22
1972	94	94	73	50	62	47	22
1973	94	94	102	113	114	89	36
1974	94	94	127	106	99	74	46
1975	94	94	139	150	136	119	70
1976	94	94	107	99	86	70	41
1977	94	94	67	66	62	54	44
1978	94	94	128	132	96	78	20
1979	94	94	118	106	103	74	18
1980	94	94	102	114	94	75	36
1981	94	94	54	66	35	26	2
1982	94	94	120	123	99	78	37
1983	94	94	92	126	99	74	13

APPENDIX F

PLANNING CRITERIA AND COST ESTIMATING METHODS

APPENDIX F

PLANNING CRITERIA AND COST ESTIMATING METHODS

F.1 INTRODUCTION

Structural measures were considered in this study as a potential means of satisfying future water demands. After structural components were identified, preliminary engineering layouts were prepared using USGS 7-1/2 minute quadrangle sheets. The layouts were used as the basis for preparing reconnaissance-level cost estimates for each alternative component. The remainder of this appendix presents the planning criteria utilized in preparing the layouts and also discusses the methodology used to prepare the cost estimates.

F.2 PLANNING CRITERIA

The following general criteria were established and utilized uniformly in developing conceptual layouts for each component.

- o Dead storage capacity to accommodate sediment and to establish the minimum operating level of reservoirs considered in the planning process was established to be 10 percent of the total reservoir capacity. Storage facilities associated with transmountain diversion projects proposed by other developers were sized according to data presented by the individual developers where available.

- o Outlet works capacity was established to be 400 percent of the maximum release requirement determined from preliminary operation studies.

- o Spillway capacity was based on the Probable Maximum Flood (PMF) determined for each reservoir site considered.

- A minimum of 10 ft of freeboard above the spillway crest elevation was used for embankment dams.

- To assure safe unattended operation ungated spillways were used for all storage facilities considered.

- Facilities for river diversion during construction were sized to accommodate the flood of record at each storage site considered (synthetically derived for the period 1952-83).

- Land acquisition for dams and reservoirs was assumed to be 150 percent of the reservoir surface area at maximum pool elevation.

- Reservoir area clearing quantities were obtained by calculating the area of wooded lands within the reservoir based on the preliminary layouts.

- Aqueduct design capacities were determined by assuming that the annual yield of the project would be transported in a one-year period with a 10 percent allowance for downtime to accommodate maintenance operations.

- Aqueducts and pumping plants were sized to meet the target flow rate with the collection reservoir at minimum pool elevation and terminal reservoir at maximum pool elevation.

- The Manning Equation, solved for closed conduit pressure flow conditions with a 0.015 "n" value, was used to compute aqueduct head loss. This value is an average for the entire conduit and accounts for different types of materials and minor losses.

- Minimum economical unfinished tunnel diameters were established to be 12 ft based on construction considerations.

- Aqueducts associated with transmountain diversion projects proposed by other developers were sized as proposed by the individual developers.

- Upstream control was assumed for all aqueducts.

- Reinforced concrete (RC) pipe was assumed for all pipelines reaches with dynamic head requirements that were within commercially available pressure classes.

- Fabricated steel pipe was assumed for all aqueduct reaches (siphons) with dynamic head requirements that exceeded commercially available RC pipe classes.

- Maximum allowable velocities in hydroplant water conductors were established at 20 fps.

F.3 COST ESTIMATING METHODS

Cost estimates were prepared using a combination of three methodologies; Bureau of Reclamation reconnaissance level cost estimating programs, application of unit costs to estimated quantities, and lump sum construction costs of similar features from other projects. Quantity estimates and sizing parameters were obtained from preliminary engineering layouts prepared for each component considered. Miscellaneous items were estimated at 10 percent of the construction cost to account for minor items which were not specifically estimated. This was applied on a selective basis where considered appropriate. All costs are expressed at January 1989 price levels.

The total capital cost includes the total estimated direct construction cost; contingencies; engineering and administrative expenses; and interest during construction. Contingencies were set at 25 percent of the construction costs before adding engineering and administrative expenses. The 25 percent contingency accounts for costs associated with; unforeseen geotechnical conditions, environmental mitigation, construction delays, and other factors that cannot be quantified during initial phases of project planning. As the project progresses to final design and more detailed information is obtained, the amount set aside for contingencies is usually reduced. Engineering and contract administrative costs (including administrative costs associated with obtaining environmental permits and licesnes) were estimated to be 15 percent of the direct construction cost. Interest during construction was computed based on an 8 percent interest rate with a linear drawdown of funds over the construction period.

Total investment cost includes total capital cost, debt service reserve fund, and financing expenses. The debt service reserve fund was assumed to equal one year of debt service. Financing expenses were estimated to be approximately 3 percent of the total capital cost for projects less than or equal to $40 million and 1.5 percent of total capital cost for projects greater than $40 million.

Annual debt service costs are based on 30 year financing at an 8 percent interest rate. Annual operation and maintenance (O&M) costs were estimated in two categories. The first category represents labor, equipment, and supply costs required to operate and maintain the facilities. The second category represents energy costs and power revenues associated with the annual operation of the facilities.

Category one O&M costs associated with in-basin storage facilities were estimated using an empirical formula relating reservoir storage capacity to annual labor, equipment, and supply costs. Category one O&M costs associated with transmountain diversion projects were estimated as 0.75 percent of direct construction costs.

Annual power and energy costs were estimated at $126.72 per KW year and $0.02522 per KWH respectively. These costs represent combined peak and off-peak energy and were obtained from Public Service Company of Colorado through informal, personal contact. Power and energy revenues were obtained from Bureau of Reclamation data and are presented in Table F.1

TABLE F.1
Power and Energy Benefits
(50/50 Private and Public Financing)

Type of Plant	Power ($/KW year)	Energy ($/KWH)
Base Load	289	0.0163
Intermediate Load	95	0.0484
Peak Load	51	0.0660

F.4 BUREAU OF RECLAMATION COST ESTIMATING PROGRAMS

F.4.1 Embankment Dams

A reconnaissance level cost estimating program entitled "FLOWDAM" was used to estimate the cost of earthfill embankment dams. This program is based on historic cost data associated with Bureau of Reclamation projects. The program computes construction quantities and then calculates appropriate unit costs with consideration for the magnitude of required quantities and other site specific input parameters. Input data required by the program and the standardized values assumed are presented on Table F.2.

TABLE F.2
"Flowdam" Input Parameters

Parameter	Assumed Value
Topography of Dam Axis	Site Specific
Dam Crest Elevation	Site Specific
Upstream Slope of Dam	2.5 : 1
Downstream Slope of Dam	3 : 1
Upstream Slope of Zone 1 (Impervious)	1 : 1
Downstream Slope of Zone 2 (Shell)	1 : 1
Top Width of Dam	30 ft
Top Width of Zone 1	15 ft
Depth of Zone 2 Over Zone 1	2 ft
Depth of Slope Protection (Rip Rap)	2 ft
Bottom Width of Cutoff Trench	35 ft
Depth of Cutoff Trench	50 ft
Depth of Surface Stripping	1 ft
Shrinkage Factor for Zone 1	15 percent
Shrinkage Factor for Zone 2	15 percent
Zone 1 Haul Distance	5 mile
Zone 2 Haul Distance	5 mile
Rip Rap Haul Distance	5 mile
Construction Diversion Capacity	25-year Flood
Spillway Capacity	PMF
Outlet Works Capacity	400 percent Release Requirement
Outlet Works Head	Site Specific

Program output consists of Zone 1, Zone 2, and rip rap volumes and associated unit costs; foundation excavation volume and unit cost; and lump sum costs for spillway, outlet works, and diversion during construction. Average end area calculations were manually performed to determine the volume of drain material and applied to a drain material unit cost of $15 per cubic yard. Chimney drains were assumed to line the downstream interface between Zone 1 and 2 embankment materials with a 4 ft thickness. Blanket drains were assumed to extend from the downstream Zone 1 embankment toe to the downstream Zone 2 toe with a 4 ft thickness. Relocation of existing facilities were determined from the preliminary reservoir layouts.

F.4.2 Pumping Plants

A reconnaissance level cost estimating program entitled "PUMPLT" was used to estimate the cost of pumping plants. This program is based on historic cost data associated with Bureau of Reclamation projects. Input data required by the program and the standardized values assumed are presented on Table F.3.

TABLE F.3
"Pumplt" Input Parameters

Parameter	Assumed Value
Supply Voltage	69 KV
Total Plant Capacity	cfs (site specific)
Number of Pumping Units	2 in parallel
Total Dynamic Head	ft (site specific)

Program output consists of lump sum estimates for structures,waterways, pumps, motors, accessory electrical equipment, miscellaneous equipment, and switchyards. Pumping plant intake structures are not included in the lump sum waterways cost and were estimated from construction costs associated with similar features modified to reflect site specific design parameters.

F.4.3 Power Plants

A reconnaissance level cost estimating program entitled "PWRPLT" was used to estimate the cost of conventional power plants. This program is based on historic cost data associated with Bureau of Reclamation projects. Input data consists of type of plant; average head; and plant capacity expressed in megawatts.

For conventional power plants associated with in-basin storage facilities it was assumed that average head would equal 90 percent of the available head between maximum operating water surface elevation and the streambed elevation at the dam axis. Plant capacity was calculated using the assumed head, discharge equal to 90 percent of the average annual flow, and 85 percent overall unit efficiency. Power and energy benefits were calculated assuming intermediate load plant operation. For conventional power plants associated with transmountain diversion water conductors, plant capacity was calculated using the estimated head, aqueduct design discharge, and 85 percent overall efficiency. Power and energy benefits were calculated assuming base load plant operation.

Pumped-storage projects were estimated primarily by using the unit price data explained later.

F.4.4 Pipelines

A reconnaissance level cost estimating program entitled "PIPE" was used to obtain installed costs for reinforced concrete pipe in a wide range of pressure classes and diameters. Input data required by the program and the standardized values assumed are presented in Table F.4.

TABLE F.4

"Pipe" Input Parameters

Parameter	Assumed Value
Pipe Diameter	Inches (site specific)
Pressure Class	psi or ft (site specific)
Depth of Excavation	ft (site specific)
Average Wage Rate (including fringes)	$20 per hour
Area Factor	Mountainous Terrain
Average Pipe Transport Distance	100 mile

Program output consists of a table of specified diameters and pressure classes with associated unit installed costs. The unit costs were then applied to the pipe quantities obtained from the preliminary layouts and hydraulic grade line analysis.

F.5 UNIT PRICES

The unit prices presented in Table F.5 are based on data from similar construction features. The data was obtained from recent bid tabulations, estimates contained in recent preconstruction studies of similar projects and inquiries to state and Federal agencies. Published USBR inflation indices were used to project the data to January 1989 price levels. Specific indicies published in the April 1988 edition of Construction Cost Trends published by the USBR were used when available; otherwise the composite index was applied. Finally the data was reviewed and revised to reflect site specific conditions and applied to estimated construction quantities.

TABLE F.5
Unit Price Data

Item	Unit	Unit Price
Water Conductor Tunnels (12 Ft Diameter):		
Less Than or Equal to 50,000 Feet Long	L.F.	$ 1,200
Greater Than 50,000 Feet Long	L.F.	$ 1,400
Fabricated Welded Steel Pipe for Siphons	LB.	$ 1.75
Select Granular Filter/Drain Material	C.Y.	$ 15.00
69 KV H-Frame Transmission Line	Mile	$ 120,000
345 KV Transmission Line	Mile	$1,000,000
Two Lane Paved Surface State Highway	Mile	$1,000,000
Two Lane Gravel Surfaced Road	Mile	$ 350,000
Land Acquisition	Acre	$ 1,000
Reservoir Clearing	Acre	$ 2,000
Relocation of Roaring Judy Fish Hatchery	L.S.	$2,000,000
Relocation of Town of Sargents	L.S.	$1,000,000

F.6 APPLICATION OF CONSTRUCTION COSTS FROM SIMILAR FEATURES

Project features and cost items for which unit cost data and cost estimating programs were not available were estimated using the construction costs of similar features from other projects. These costs were indexed to the January 1989 price level and modified to reflect site specific conditions. Table F.6 presents a summary of these features/cost items and cost modification parameters.

TABLE F.6
Cost Data From Similar Features and Cost Items

Item	Basis
Mobilization:	
Construction projects less than or equal to $25,000,000	Four percent of Total Construction Cost
Construction projects greater than $25,000,000	Two percent of Total Construction Cost
Foundation treatment	Five percent of embankment dam cost
Dam instrumentation	Two percent of embankment dam cost up to a maximum of $250,000
Tunnel intake structures	The construction costs of similar facilities, modified for site specific conditions using design discharge and structure height as cost modification parameters.
Pumping plant intake structures	The construction costs of similar facilities, modified for site specific conditions using design discharge and elevation differential between minimum and maximum water surfaces.

Table F.6 (continued)

Stream Stabilization and Erosion Protection	The construction costs of similar features, modified for site specific conditions using incremental flow equal to design discharge.
Pumped-storage power tunnels, access tunnels, shafts and underground caverns	The construction costs of similar facilities, modified for site-specific conditions and indexed for inflation.
Pumped-storage mechanical and electrical equipment	The construction cost of similar facilities and/or manufacturers' estimates modified for site specific conditions and indexed for inflation.

APPENDIX G

COMPONENT AND PLAN EVALUATION SHEETS

Structural Component Screening Sheets

Lower Los Pinos Site
Los Pinos Creek

TABLE G.1

Comparative Screening Criteria for Structural Components
In-Basin Components

Technical Evaluation:

Factor	Ranking: No	Ranking: Yes
Meets 100 percent of Target Objective 1 N/A (no identified M+I water demand)		
Meets 100 percent of Target Objective 4 - supplemental water needs met on 1,490 acres (25% of basin)		X

Factor	Ranking: No Water Available for Recreation	Ranking: Some Water Available for Recreation
Meets Target Objective 3 Average annual flow enhancement release is 800 AF/yr. Minimum flow at Paulin - 50% of targ[et]		X

Factor	Ranking: Low	Ranking: Moderate	Ranking: High
Geologic & Cost Risk Assessment	X	no geologic hazards indicated	
Hydrologic Reliability Functional Reliability		X Average inflow (52-83) is 7,400 AF	

Environmental Evaluation:

Factor	Ranking: Potentially Detrimental to Present Condition	Ranking: Neutral	Ranking: Potentially Beneficial to Present Condition
Wildlife (Above big game winter range)		X	
Fishery (Flow control/enhancement beneficial - good quality stream inundated)		X	
Botany (wetland/meadows inundated)		X	
Cultural Resources		X	
Recreation/Aesthetics (good location and size for flatwater recreation)			X
Water Quality (good quality inflow, would control minor sediment problems)		X	

Lower Los Pinos

Institutional/Social Evaluation:

Factor	Severe Problems Expected	Some Difficulty Expected	No Significant Problems Expected
Public Acceptance		X	
Land Use Conflicts		X (inundation of 299 acres meadows/wetlands)	
Land Acquisition		X	
Water Rights (Conditional water right for 15,457 AF)			X

Economic Evaluation:

Total Cost: $11,859,000

Annual Capital Cost of Firm Yield: $169/AF

Cold Spring Park Quad
12,000 AF storage
Cochetopa subbasin
Map I.D. - #77

Pauline Site
Pauline Creek

TABLE G.2

Comparative Screening Criteria for Structural Components
In-Basin Components

Technical Evaluation:

Factor	Ranking: No	Ranking: Yes
Meets 100 percent of Target Objective 1 N/A (No identified M&I water demand)		
Meets 100 percent of Target Objective 4 — supplemental needs met on 1,700 acres (30% of total basin)		X

Factor	Ranking: No Water Available for Recreation	Ranking: Some Water Available for Recreation
Meets Target Objective 3 (Average annual flow enhancement release = 800 AF/yr. Minimum flow at Paulin – 13% of target		X

Factor	Ranking: Low	Moderate	High
Geologic & Cost Risk Assessment	X (no indicated geologic hazards)		
Hydrologic Reliability Functional Reliability		X (Average annual inflow (52-83) = 6,500 AF)	

Environmental Evaluation:

Factor	Ranking: Potentially Detrimental to Present Condition	Neutral	Potentially Beneficial to Present Condition
Wildlife (above big game winter range)		X	
Fishery (Flow control/enhancement benefits downstream; good lake fishery; inundate good brown trout stream)		X	
Botany (inundate 203 acres meadow type)		X	
Cultural Resources		X	
Recreation/Aesthetics (scenic, flatwater limited now, good location			X
Water Quality (good inflow, reservoir would generally improve water quality)		X	

Pauline

Institutional/Social Evaluation:

Factor	Severe Problems Expected	Some Difficulty Expected	No Significant Problems Expected
	Ranking		
Public Acceptance		X (reservoir in scenic area)	
Land Use Conflicts		X (inundate 203 acres)	
Land Acquisition		X (Forest Service land)	
Water Rights	X (Conditional water right not available)		

Economic Evaluation:

Total Cost: $19,657,000

Annual Capital Cost of Firm Yield: $245/AF

Elk Park Quad
10,000 AF storage
Cochetopa Subbasin
Map I.D. #126

Castleton Site
Castle Creek

TABLE G.3

Comparative Screening Criteria for Structural Components
In-Basin Components

Technical Evaluation:

Factor	Ranking: No	Ranking: Yes
Meets 100 percent of Target Objective 1 N/A (No identified M+I demand)		
Meets 100 percent of Target Objective 4 (Provides supplemental water to 3,700 acres or 34%)		x

Factor	Ranking: No Water Available for Recreation	Ranking: Some Water Available for Recreation
Meets Target Objective 3	Average annual flow enhancement release = 2,400 AF/yr. Minimum Flow at Gunnison = 56% of target	X

Factor	Ranking: Low	Ranking: Moderate	Ranking: High
Geologic & Cost Risk Assessment	X (No identified geologic hazards)		
Hydrologic Reliability Functional Reliability		X (Average annual inflow (52-83) is 21,500 AF)	

Environmental Evaluation:

Factor	Ranking: Potentially Detrimental to Present Condition	Ranking: Neutral	Ranking: Potentially Beneficial to Present Condition
Wildlife (Above deer/elk winter range)		X	
Fishery Flow enhancement beneficial downstream; inundate stream/beaver pond fishery)		X	
Botany (meadow area - beaver ponds inundated)	X		
Cultural Resources		X	
Recreation/Aesthetics (improve public access inundate scenic area)		X	
Water Quality (Flow enhancement)		X	

Castleton

Institutional/Social Evaluation:

Factor	Severe Problems Expected	Some Difficulty Expected	No Significant Problems Expected
Public Acceptance		X	Inundation of scenic area will be controversial
Land Use Conflicts		X	
Land Acquisition		X	
Water Rights (Conditional water right for 9,000 AF at this site)			X

Economic Evaluation:

Total Cost: $20,343,000

Annual Capital Cost of Firm Yield: $105/AF

Mt. Axtell Quad
20,000 AF storage
Ohio Subbasin
MAP ID = #120

Elko Site
Tomichi Creek

TABLE G.4

Comparative Screening Criteria for Structural Components
In-Basin Components

Technical Evaluation:

Factor	Ranking: No	Ranking: Yes
Meets 100 percent of Target Objective 1 N/A (No identified M+I water demand)		
Meets 100 percent of Target Objective 4 (Provides supplemental water to 6,000 Acres or 42% basin)		X

Factor	Ranking: No Water Available for Recreation	Ranking: Some Water Available for Recreation
Meets Target Objective 3 Average annual flow enhancement release = 4,200 AF/yr. Minimum flow at Gunnison met 34% of target		X

Factor	Ranking: Low	Moderate	High
Geologic & Cost Risk Assessment	X (No indicated geologic hazard)		
Hydrologic Reliability Functional Reliability (Average annual inflow (52-83) is 41,700 AF)			X

Environmental Evaluation:

Factor	Ranking: Potentially Detrimental to Present Condition	Neutral	Potentially Beneficial to Present Condition
Wildlife	X Reservoir and highway relocation in big game range. Waterfowl habitat created.		
Fishery Flow control beneficial downstream. Turbidity control Stream fishery inundated			X
Botany		X Inundation 534 acres irrigated land/wet	
Cultural Resources		X	
Recreation/Aesthetics Good location and access. Area already developed so aesthetic impact less			X
Water Quality Turbidity control, cooler summer temperatures downstream			X

Institutional/Social Evaluation:

Factor	Severe Problems Expected	Some Difficulty Expected	No Significant Problems Expected
Public Acceptance		X	
Land Use Conflicts		X	Inundation of 534 acres of irrigated land; 4. miles highway relocation
Land Acquisition		X	
Water Rights	Conditional water right for 29,200 AF at Monarch site		X

Economic Evaluation:

Total Cost: $18,877,000

Annual Capital Cost of Firm Yield: $65/AF

Sargents Quad
30,000 AF storage
Tomichi subbasin
Map I.D. # 85

Sargents #1 Site
Tomichi Creek

TABLE G.5

Comparative Screening Criteria for Structural Components
In-Basin Components

Technical Evaluation:

Factor	Ranking: No	Ranking: Yes
Meets 100 percent of Target Objective 1 N/A (No identified M+I demand)		
Meets 100 percent of Target Objective 4 (supplemental water needs to 5,500 acres - 39% basin)		X

Factor	Ranking: No Water Available for Recreation	Ranking: Some Water Available for Recreation
Meets Target Objective 3 Average annual flow enhancement release = 4,100 AF/yr. Minimum flow at Gunnison met 62% of target		X

Factor	Ranking: Low	Ranking: Moderate	Ranking: High
Geologic & Cost Risk Assessment	X no indicated geologic hazard		
Hydrologic Reliability Functional Reliability		X Average annual inflow (52-83) - 38,400 AF	

Environmental Evaluation:

Factor	Ranking: Potentially Detrimental to Present Condition	Ranking: Neutral	Ranking: Potentially Beneficial to Present Condition
Wildlife	X	Reservoir and highway relocation in big game range. Waterfowl habitat created.	
Fishery Flow control beneficial to stream fishery, reduction of turbidity, flatwater fishery created		X	
Botany	X inundation 661 acres meadow/wetlands		
Cultural Resources		X	
Recreation/Aesthetics Good, accessible location. Area developed so less aesthetic impact			X
Water Quality Reservoir would control turbidity, lower summer temperatures			X

Sargents #1

Institutional/Social Evaluation:

Factor	Severe Problems Expected	Some Difficulty Expected	No Significant Problems Expected
	Ranking		
Public Acceptance		X	
Land Use Conflicts		X	Inundation of 661 acres irrigated land, relocation 5 mi. highway 50 and village of Sargents
Land Acquisition		X	
Water Rights	Conditional water right for 29,200 AF at Monarch Site		X

Economic Evaluation:

Total Cost: $20,900,000

Annual Capital Cost of Firm Yield: $76/AF

Sargents Quad

30,000 AF storage

Tomichi subbasin

Map I.D. #72

Sargents #2 Site
Tomichi Creek

TABLE G.6

Comparative Screening Criteria for Structural Components
In-Basin Components

Technical Evaluation:

Factor	Ranking: No	Ranking: Yes
Meets 100 percent of Target Objective 1 N/A (No identified M+I demand)		
Meets 100 percent of Target Objective 4 (Supplemental water needs to 5,500 acres - 39% basin)		X

Factor	Ranking: No Water Available for Recreation	Ranking: Some Water Available for Recreation
Meets Target Objective 3 Average annual flow enhancement release = 4,100 AF. Minimum flow at Gunnison met 62%.		X

Factor	Ranking: Low	Ranking: Moderate	Ranking: High
Geologic & Cost Risk Assessment	X (No indicated geologic hazard)		
Hydrologic Reliability Functional Reliability — Average annual inflow (52-83) = 38,400 AF		X	

Environmental Evaluation:

Factor	Ranking: Potentially Detrimental to Present Condition	Ranking: Neutral	Ranking: Potentially Beneficial to Present Condition
Wildlife	X Reservoir and highway relocation in big game range. Waterfowl habitat created		
Fishery Flow control beneficial to stream fishery, reduction of turbidity, flatwater fishery created		X	
Botany	X Inundation 674 acres meadows/wetlands		
Cultural Resources		X	
Recreation/Aesthetics Good, accessible location. Area developed so less aesthetic impact			X
Water Quality Reservoir would control turbidity, lower summer temperatures			X

Institutional/Social Evaluation:

Factor	Severe Problems Expected	Some Difficulty Expected	No Significant Problems Expected
Public Acceptance		X	
Land Use Conflicts		X	Inundation 674 acres irrigate land. Relocation 5 mi. Highway 50 and village of Sargents
Land Acquisition		X	
Water Rights	Conditional water right for 29,200 AF at Monarch site		X

Economic Evaluation:

Total Cost: $18,239,000

Annual Capital Cost of Firm Yield: $67/AF

Sargents Quad

30,000 AF Storage

Tomichi subbasin

Map I.D. #76

Sargents #3 Site
Tomichi Creek

TABLE G.7

Comparative Screening Criteria for Structural Components
In-Basin Components

Technical Evaluation:

Factor		Ranking: No	Ranking: Yes
Meets 100 percent of Target Objective 1	N/A (No identified M+I water demand)		
Meets 100 percent of Target Objective 4	Provides supplemental service to 4,500 acres or 31% basin		X

Factor		Ranking: No Water Available for Recreation	Ranking: Some Water Available for Recreation
Meets Target Objective 3	Average annual flow enhancement release = 2,400 AF/yr. Minimum flow at Gunnison met 11%		X

Factor	Ranking: Low	Ranking: Moderate	Ranking: High
Geologic & Cost Risk Assessment	X (No indicated geologic hazard)		
Hydrologic Reliability Functional Reliability		X (Average annual inflow (52-83) is 21,200 AF).	

Environmental Evaluation:

Factor	Ranking: Potentially Detrimental to Present Condition	Ranking: Neutral	Ranking: Potentially Beneficial to Present Condition
Wildlife	X Reservoir and highway relocation in big game range. Waterfowl habitat created		
Fishery	Flow control beneficial to stream fishery, reduction of turbidity, flatwater fishery created		X
Botany	X Inundation 474 acres irrigated meadows		
Cultural Resources		X	
Recreation/Aesthetics	Good access and location. Area developed so less aesthetic impact.		X
Water Quality	Reservoir would control turbidity, lower summer temperatures		X

Institutional/Social Evaluation:

Factor	Severe Problems Expected	Some Difficulty Expected	No Significant Problems Expected
Public Acceptance		X	
Land Use Conflicts		X	Inundation of 474 Acres irrigated land; relocation of 6.6 mi. Highway 50
Land Acquisition		X	
Water Rights Conditional water right for 29,200 AF at Monarch site			X

Economic Evaluation:

Total Cost: $23,124,600

Annual Capital Cost of Firm Yield: $108/AF

Sargents Quad

25,000 AF Storage

Tomichi subbasin

Map I.D. #82

Sargents #4 site
Tomichi Creek

TABLF G.8

Comparative Screening Criteria for Structural Components
In-Basin Components

Technical Evaluation:

Factor	Ranking: No	Ranking: Yes
Meets 100 percent of Target Objective 1 N/A (No identified M+I demand)		
Meets 100 percent of Target Objective 4 (Supplemental water supply to 5,000 acres or 36% basw		X

Factor	Ranking: No Water Available for Recreation	Ranking: Some Water Available for Recreation
Meets Target Objective 3	Average annual flow enhancement release = 3,300 AF/yr. Minimum flow at Gunnison met 23%	X

Factor	Ranking: Low	Ranking: Moderate	Ranking: High
Geologic & Cost Risk Assessment	X	No indicated geologic hazard	
Hydrologic Reliability Functional Reliability	Average annual inflow (52-83) is 31,100 AF		X

Environmental Evaluation:

Factor	Ranking: Potentially Detrimental to Present Condition	Ranking: Neutral	Ranking: Potentially Beneficial to Present Condition
Wildlife	X	Reservoir and highway relocation in big game range. Waterfowl habitat created	
Fishery Flow control beneficial to stream fishery, reduction of turbidity, flatwater fishery created			X
Botany	X	Inundation 571 acres irrigated meadows/wet land	
Cultural Resources			
Recreation/Aesthetics Good access. Area already developed so less aesthetic impact			X
Water Quality Reservoir would control turbidity, lower summer temperatures			X

Saugents #4

Institutional/Social Evaluation:

Factor	Severe Problems Expected	Some Difficulty Expected	No Significant Problems Expected
Public Acceptance		X	
Land Use Conflicts		X	Inundation of 571 acres irrig. land, 5 miles U.S. Highway 50 and village of Saugents
Land Acquisition		X	
Water Rights Conditional water rights for 29,200 AF at Monarch Site			X

Economic Evaluation:

Total Cost: $17,000,000

Annual Capital Cost of Firm Yield: $70/AF

Saugents Quad
25,000 AF Storage
Tomichi subbasin
Map I.D. #78

Alternative Plan Screening Sheets

TABLE G.9

Screening Criteria for Alternative Plans

Alternative No. 1

Technical Evaluation:

Factor	Ranking: Low	Moderate	High
Meet Target Objective 1		*Not Applicable*	
Meet Target Objective 2			X
Meet Target Objective 3		1) X	
Meet Target Objective 4	X		
Meet Target Objective 6			X
Relocations *(Lack of)*			X
Reliability		X	

Overall Rank *LOW*

Any plan recieving a low ranking in meeting target objectives must be ranked low overall

Environmental Evaluation:

Factor	Ranking: Potentially Detrimental to Present Condition	Neutral	Potentially Beneficial to Present Condition
Wildlife		X	
Fishery			X
Botany		X	
Cultural Resources		X	
Recreation			X
Water Quality		X	

Overall Rank *High*

Institutional/Social Evaluation:

Factor	Ranking: Severe Problems Expected	Some Difficulty Expected	No Significant Problems Expected
Public Acceptance			X
Land Use Conflicts			X
Land Acquisition		X	
Water Rights			X

Overall Rank *High*

Economic Evaluation

Total Cost: *\$7.8 x 10^6 Invest. Cost*; *\$0.9 x 10^6 Annual Cost*

Annual Capital Cost of ~~Firm Yield~~ *Storage*:
In-Basin ~~Yield:~~ *storage*: *N/A*
Out-of-Basin Yield:

Annual Capital Cost of Hydro: *N/A*
Conventional:
Pumped Storage:

1. Plan does not consume water and is ranked high in that regard. Plan does nothing to assure a continued supply for recreation therefore is low in that regard.

TABLE G.10

Screening Criteria for Alternative Plans

Alternative No. 2

Technical Evaluation:

Factor	Low	Moderate	High
Meet Target Objective 1		N/A	
Meet Target Objective 2	X		
Meet Target Objective 3		1) X	
Meet Target Objective 4			2) X
Meet Target Objective 6		3) X	
Relocations (Lack of)		X	
Reliability		X	

If "Meets Target Objective" ranked low, Overall Rank is Low.

Overall Rank *Low*

Environmental Evaluation:

Factor	Potentially Detrimental to Present Condition	Neutral	Potentially Beneficial to Present Condition
Wildlife	X		
Fishery			X
Botany		X	
Cultural Resources		X	
Recreation			X
Water Quality			X

Overall Rank *Moderate*

1) Plan stores water during spring and provides streamflow enhancement on two streams the remainder of year.

2.) Satisfies 70% of the identified shortage.

3.) Provides sediment reduction on three streams.

Institutional/Social Evaluation:

Factor	Severe Problems Expected	Some Difficulty Expected	No Significant Problems Expected
Public Acceptance	4) X		
Land Use Conflicts		X	
Land Acquisition			X
Water Rights			X
Overall Rank			

Economic Evaluation

Total Cost: $83.2 x 10^6 Invest Cost; $7.6 x 10^6 Annual Cost

Annual Capital Cost of ~~Firm Yield~~ Storage:
In-Basin ~~Yield~~ storage: $137/af annual
Out-of-Basin Yield: N/A

Annual Capital Cost of Hydro:
Conventional:
Pumped Storage: N/A

4) Three dams are included in this plan, two of which are beneficial to streamflow downstream and would provide good flatwater recreation. The third would not enhance streamflow and would have frequent, severe reservoir level fluctuations.

TABLE G.11

Screening Criteria for Alternative Plans

Alternative No. 3

Technical Evaluation:

Factor	Ranking: Low	Ranking: Moderate	Ranking: High
Meet Target Objective 1		N/A	
Meet Target Objective 2			X
Meet Target Objective 3		1) X	
Meet Target Objective 4			2) X
Meet Target Objective 6		X	
Relocations (lack of)		X	
Reliability		X	

If any Target Objective recieves low rank, Overall Rank is low.

Overall Rank *Moderate*

Environmental Evaluation:

Factor	Ranking: Potentially Detrimental to Present Condition	Ranking: Neutral	Ranking: Potentially Beneficial to Present Condition
Wildlife	X		
Fishery			3) X
Botany		X	
Cultural Resources		X	
Recreation			X
Water Quality		X	

Overall Rank *Moderate*

1. Insures streamflow enhancement on two streams.

2. Satisfies 80% of identified shortage

3 High rank primarily due to recreation components

Institutional/Social Evaluation:

Factor	Ranking: Severe Problems Expected	Ranking: Some Difficulty Expected	Ranking: No Significant Problems Expected
Public Acceptance	4) X		
Land Use Conflicts		X	
Land Acquisition			X
Water Rights			X

Overall Rank *Moderate*

Economic Evluation

Total Cost: *\$91.4 x 10^6 Invest Cost*; *\$8.4 x 10^6 Annual*

Annual Capital Cost of ~~Firm Yield~~ *Storage*:
In-Basin ~~Yield~~ *Storage*: *\$153/af Annual*
Out-of-Basin Yield: *NA*

Annual Capital Cost of Hydro:
Conventional:
Pumped Storage: *N/A*

4) Plan contains same element that are in Alt 2 therefore same potential problems exist.

TABLE G.12

Screening Criteria for Alternative Plans

Alternative 4

Technical Evaluation:

Factor	Ranking: Low	Ranking: Moderate	Ranking: High
Meet Target Objective 1		N/A	
Meet Target Objective 2			1/ X
Meet Target Objective 3		2/ X	
Meet Target Objective 4			3/ X
Meet Target Objective 6		4/ X	
Relocations		X	
Reliability		X	

If any Target objective recieves low rank, Overall Rank is low

Overall Rank *Moderate*

Environmental Evaluation:

Factor	Ranking: Potentially Detrimental to Present Condition	Ranking: Neutral	Ranking: Potentially Beneficial to Present Condition
Wildlife	X		
Fishery			1/ X
Botany		X	
Cultural Resources		X	
Recreation			X
Water Quality		X	

Overall Rank *Moderate*

1/ Primarily due to recreation components.

2/ Provides streamflow enhancement on 2 streams

3/ Satisfies 80% of identified shortage

4/ Provides sediment reduction on 3 streams

Institutional/Social Evaluation:

Factor	Ranking: Severe Problems Expected	Ranking: Some Difficulty Expected	Ranking: No Significant Problems Expected
Public Acceptance	5/ X		
Land Use Conflicts		X	
Land Acquisition			X
Water Rights			X

Overall Rank *Moderate*

Economic Evaluation

Total Cost: $86.4 x10^6 Invest Cost; $7.9 x10^6 Annual

Annual Capital Cost of ~~Firm Yield~~ Storage:
In-Basin ~~Yield:~~ Storage: $144/af annual
Out-of-Basin Yield: N/A

Annual Capital Cost of Hydro:
Conventional:
Pumped Storage: ~~N/A~~

5/ Three dams, one of which has severe reservoir fluctuations and does not provide streamflow enhancement.

TABLE G.14

Screening Criteria for Alternative Plans

Alternative 6

Technical Evaluation:

Factor	Low	Moderate	High
	Ranking		
Meet Target Objective 1		N/A	
Meet Target Objective 2			X
Meet Target Objective 3		X	
Meet Target Objective 4		1/ X	
Meet Target Objective 6		X	
Relocations		X	
Reliability		X	

Overall Rank *Moderate*

Environmental Evaluation:

Factor	Potentially Detrimental to Present Condition	Neutral	Potentially Beneficial to Present Condition
	Ranking		
Wildlife	X		
Fishery			X
Botany		X	
Cultural Resources		X	
Recreation			X
Water Quality			X

Overall Rank *Moderate*

Institutional/Social Evaluation:

Factor	Severe Problems Expected	Some Difficulty Expected	No Significant Problems Expected
	Ranking		
Public Acceptance		2/ X	
Land Use Conflicts			X
Land Acquisition			X
Water Rights			X

Overall Rank *High*

Economic Evluation

Total Cost: *$35.8x10^6 Invest. Cost*; *$3.3x10^6 Annual*

Annual Capital Cost of ~~Firm Yield~~ *storage*:
In-Basin ~~Yield~~: *storage*: *$132/af annual*
Out-of-Basin Yield: *NA*

Annual Capital Cost of Hydro:
Conventional:
Pumped Storage: *N/A*

1. Satisfies 40% of identified shortage.

2. Only one reservoir involved and it provides recreation benefits so resistance should not be too great.