BIBLIOGRAPHY OF WATER-RELATED STUDIES, SOUTH PLATTE RIVER BASIN--COLORADO, NEBRASKA, AND WYOMING

by Kevin F. Dennehy and Jorge R. Ortiz-Zayas

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CONVERSION FACTORS

Multiply	By	To obtain
mile	1.609	kilometer
square mile	2.590	square kilometer

BIBLIOGRAPHY OF WATER-RELATED STUDIES, SOUTH PLATTE RIVER BASIN--COLORADO, NEBRASKA, AND WYOMING

BY

KEVIN F. DENNEHY AND JORGE R. ORTIZ-ZAYAS

ABSTRACT

This collection of more than 1,270 bibliographic references focuses on the numerous environmental factors that affect water quality in the South Platte River basin. This publication is the first product of the U.S. Geological Survey's National Water-Quality Assessment program in the South Platte River basin. To aid in conducting a water-quality assessment for the basin, sources of water-related studies were compiled from computerized literature searches of biologic, chemical, geologic, and hydrologic data bases. Categories of information include: aquatic biology, atmospheric deposition, climate, geology, land use, runoff, sedimentation, surface- and ground-water hydrology, urban runoff, water chemistry, water quality, and water use and management. References date from 1845 through October 1991. The bibliography includes, in some instances, abstracts of the subject reference. Coauthor and subject indices also are included.

INTRODUCTION

In 1991, the U.S. Geological Survey (USGS) began to implement a full-scale National Water-Quality Assessment (NAWQA) program. The long-term goals of the NAWQA program are to describe the status and trends in the quality of a large, representative part of the Nation's surface- and ground-water resources and to provide a sound, scientific understanding of the primary natural and human factors affecting the quality of these resources. In meeting these goals, the program will produce a wealth of water-quality information that will be useful to policy makers and managers at the Federal, State, and local levels.

A major design feature of the NAWQA program is the integration of water-quality information at different areal scales. The principal building blocks of the program are the study-unit investigations on which the national-level assessments are based. The 60 study-unit investigations that compose the program are hydrologic systems that include parts of the Nation's major river basins and aquifer systems. These study units include areas ranging from about 600 (Oahu) to about 67,000 (Central High Plains) square miles and include about 60 to 70 percent of the Nation's water use and the population served by public water supply. In 1991, the South Platte River basin was among the first 20 NAWQA study units selected for study under the full-scale implementation plan.

To effectively conduct a multidisciplinary water-quality assessment of a large basin, available information from Federal, State, and local sources must be identified. One of the first activities to be performed as part of the South Platte NAWQA investigation was to assemble and organize available water-related information. A computerized literature search was initiated to compile pertinent information that would assist the South Platte study team with the water-quality assessment of the basin. This report establishes a central source of available water-related information for the South Platte River basin.

Purpose and Scope

This bibliography, including coauthor and subject indices, provides a comprehensive collection of available literature on water-related studies conducted in the South Platte River basin, which will aid in the water-quality assessment of the basin by the South Platte study unit. This report contains more than 1,270 references on water-related investigations from 1845 through October 1991. In some instances, abstracts of the subject references also are included. The collection of references includes published reports and books, unpublished master's theses and doctoral dissertations, conference proceedings, and journal articles. Omitted are unpublished manuscripts, publications in press, and book reviews.

Description of Study Area

The South Platte River basin includes parts of three States--Colorado (79 percent), Nebraska (15 percent), and Wyoming (6 percent) and has a drainage area of about 24,300 square miles (fig. 1). The primary river within the basin, the South Platte River, originates in the mountains of central Colorado and flows about 450 miles northeast across the Great Plains to its confluence with the North Platte River at North Platte, Nebraska. The boundaries of the basin are the Colorado River headwaters draining to the west, the upper Arkansas River drainage to the south, the North Platte River drainage to the north, and the Republican River drainage to the east.

The three-State area is inhabited by about 2 million people; 96 percent of whom reside in Colorado. About 68 percent of Colorado's population lives in the South Platte River basin. The majority of the basin population is concentrated along the Front Range urban corridor.

The study area is characterized by a diverse population density that ranges from sparsely populated mountainous areas in the headwaters region and rural agricultural areas downstream from Denver to the densely populated Denver metropolitan area in the south-central part of the basin. The principal economy in the mountainous headwaters region is based on tourism and recreation. The economy in the urbanized south-central region is mostly related to manufacturing, service and trade industries, and government services. The economy of the basin downstream from Denver is based on grain and livestock production.

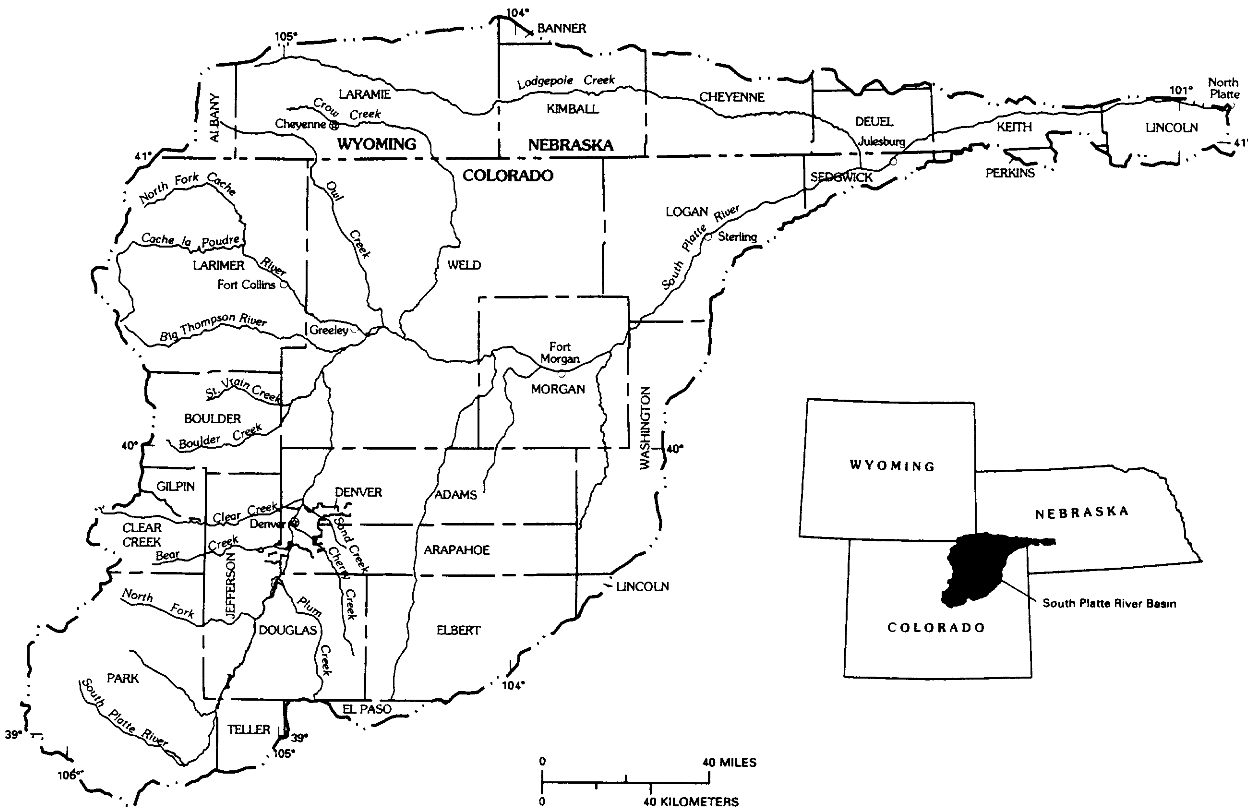

Figure 1. Location of South Platte River basin study unit.

Sources of Related Information

Interested individuals may wish to consult other bibliographies to supplement the references listed in this report. There have been a number of investigations conducted on the geologic and hydrologic aspects of the South Platte River basin by Federal, State, and private organizations. Most of the published information has been compiled into bibliographies and indices that are readily accessible to the public. A bibliography of geologic and hydrologic studies of the Front Range urban corridor lists references published prior to July 1, 1972 (Chronic and Chronic, 1974). Another published bibliography of interest is a comprehensive collection of references published between 1875 and January 1, 1975, that covers literature pertaining to the geology of Colorado (American Geological Institute, 1976). Other compilations are available on hydrogeologic studies in Colorado (Pearl, 1971) and on geological investigations in north-central Colorado (Johnson, 1927).

Approach

A computerized bibliographic search was conducted on selected data bases using DIALOG Information Retrieval Service. The data bases searched and pertinent descriptive information are listed in table 1. The online search was performed using a combination of broad and specific phrases and keywords (fig. 2).

In addition to the computerized search, the following agencies were contacted for information concerning water-related publications that might not have been listed in the 11 data bases searched:

- Colorado Division of Wildlife, Denver, Colorado
- Colorado Water Resources Research Institute, Fort Collins, Colorado
- National Park Service, Technical Information Service, Lakewood, Colorado
- U.S. Bureau of Reclamation, Great Plains Region Library, Billings, Montana
- U.S. Environmental Protection Agency, National Enforcement Information Center Library, Denver, Colorado
- U.S. Fish and Wildlife Service, Land Acquisition Planning Office, Lakewood, Colorado
- U.S. Fish and Wildlife Service, Office of Information and Transfer, Fort Collins, Colorado
- U.S. Forest Service, Rocky Mountain Regional Office, Lakewood, Colorado
- U.S. Geological Survey, Colorado Water Resources Library, Denver, Colorado
- U.S. Soil Conservation Service, Colorado State Office, Lakewood, Colorado

Table 1. List of data bases searched

Name of data base	Time coverage	Description
Aquatic Sciences and Fisheries Abstracts	1978 to 1991	Comprehensive data base on the science, technology, and management of marine and freshwater environments.
Biosis Previews	1969 to 1991	Comprehensive worldwide coverage of research in the biological and biomedical sciences.
Conference Paper Index	1973 to 1991	Centralized source of information on reports of research and development from papers presented at conferences and meetings.
Dissertation Abstracts Online	1861 to 1991	Indexing data base of all American dissertations accepted at accredited institutions.
Enviroline	1971 to 1991	Indexing and abstracting data base covering all aspects of the environment.
Environmental Bibliography	1973 to 1991	Bibliographic data base of periodicals covering the fields of ecology, atmospheric studies, energy, land resources, water resources, nutrition, and health.
GEOREF	1785 to 1991	Earth-science data base produced by American Geological Institute, Alexandria, Va.
NTIS	1964 to 1991	National Technical Information Service data base of government-sponsored research reports.
Pollution Abstracts	1970 to 1991	Indexing source of environmental-related literature on pollution, its sources, and its control.
Water Resources Abstracts	1968 to 1991	Online version of Water Resources Abstracts.
Zoological Record Online	1978 to 1991	Online version that provides worldwide coverage of zoological literature.

SELECTED KEYWORDS

REGIONS

Central Colorado
North-central Colorado
Northeastern Colorado
Southeastern Wyoming
Western Nebraska

COUNTIES

Adams	Elbert	Logan
Albany	El Paso	Morgan
Arapahoe	Gilpin	Park
Boulder	Jefferson	Perkins
Cheyenne	Keith	Sedgwick
Clear Creek	Kimball	Teller
Denver	Laramie	Washington
Deuel	Larimer	Weld
Douglas	Lincoln	

HYDROLOGIC UNITS

Badger Creek	Crow Creek	Owl Creek
Bear Creek	Dear Trail	Pawnee Creek
Beaver Creek	Denver Basin	Platte River
Big Thompson River	Highline Canal	Sand Creek
Bijou Creek	High Plains Aquifer	Sidney Draw
Boulder Creek	Kiowa Creek	South Platte River
Cache la Poudre River	Lodgepole Creek	St. Vrain River
Cherry Creek	Lone Tree Creek	Two Mile Creek
Clear Creek	Ogallala Aquifer	

SPECIFIC TERMS

Aquatic Biology	Land Use	Water Chemistry
Climate	Limnology	Water Management
Fish Populations	Riparian Habitats	Water Pollution
Ground Water	Stream Sediment	Water Quality
Hydrology	Urban Runoff	Water Use

Figure 2. Keywords used in electronic retrieval of water-related studies from DIALOG data bases.

Arrangement of References

References are arranged alphabetically by principal author (individual or corporate) and numbered consecutively. Some reference numbers intentionally have been skipped as a result of editing, and a few references that were incorrectly listed have since been corrected and appended at the end of the alphabetical listing. The bibliography presented here is the product of a computer search of reference data bases that were subsequently downloaded and compiled into the subject report. In some instances, abstracts were also downloaded when available and included in the bibliography. Terminology and use of abbreviations are inconsistent in the abstracts. No attempt was made to edit these abstracts or define abbreviations. Extensive efforts have been made to ensure that the majority of the citations in the bibliography are correct. However, because of the manner in which they were compiled, some citations may contain errors or may be incomplete. Coauthor and subject indices located at the back of the report refer to reference numbers previously mentioned.

Terms used in the subject index were selected from the "Water Resources Thesaurus" (U.S. Office of Water Research and Technology, 1980). Some additional terms selected were chosen by the authors to try to make it easier to find a given reference.

Acknowledgments

The authors wish to thank April Kobayashi, Colorado District Librarian, for her efforts in conducting the DIALOG Information Services, Inc. retrieval of 11 data bases that were scanned and downloaded to produce this bibliography. Additionally, we would like to recognize John W. Martin, U.S. Fish and Wildlife Service (USFWS), Land Acquisition Planning Office, and Richard Sojda, USFWS, Office of Information and Transfer, for their assistance in providing additional biology-related references that were missed by our computerized search.

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Chronic, Felicie and Chronic, John, 1974, Bibliography and index of geology and hydrology, Front Range urban corridor, Colorado: U.S. Geological Survey Bulletin 1306, 102 p.

Johnson, J.H., 1927, Bibliography of the geology of north-central Colorado: Colorado School of Mines Quarterly, v. 20, no. 4, 38 p.

Pearl, R.H., 1971, Bibliography of hydrogeologic reports in Colorado: Colorado Geological Survey Bulletin 33, 39 p.

U.S. Office of Water Research and Technology, 1980, Water resources thesaurus (3d. ed.); Washington, D.C., U.S. Department of the Interior, Office of Water Research and Technology Report, OWRT IT-80/1, variously paged.

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1. Abbott, D. M., 1975, The precambrian geology of the East Inlet area, southwest Rocky Mountain National Park, Colorado: Golden, Colo., Colorado School of Mines, MS thesis, 96 p.

2. Adams, A.M., 1984, Infestation of *Fundulus kansae* (Garman) (*Pisces: Cyprinodontidae*) by the copepod *Lernaea cyprinacea* Linnaeus, 1758, in the South Platte River, Nebraska: Am. Midl. Nat., v. 112, no. 1, p. 131-137.

Fundulus kansae (Garman) is a host for *Lernaea cyprinacea* Linnaeus, 1758, a copepod, reported for the first time from the South Platte River at Ogallala, Nebraska, in the summer of 1980. The parasitic copepod was not obtained from collections of *F. kansae* taken during the 5 years prior to 1980, nor during the 2 summers thereafter (1981-1982). The introduction of the copepod in 1980 followed flooding of the river and surrounding areas. The parasite was eliminated from the study area by the following summer and was probably affected by a low winter population and a spring flood of lesser magnitude than that of 1980. The parasite population was clumped (overdispersed) and both the negative binomial and log-series distributions provided good fits to the observed data, with the log-series giving a closer fit for the entire copepod population as well as for the subpopulations of adult and larval copepods.

3. Adams, A.M., 1985, Parasites on the gills of the plains killifish, *Fundulus kansae*, in the South Platte River, Nebraska: Transactions Am. Microsc. Soc., v. 104, no. 3, p. 278-284.

4. Adams, A.M., 1986, The parasite community on the gills of *Fundulus kansae* (Garman) from the South Platte River, Nebraska: Acta Parasitol. Pol., v. 31, no. 6, p. 47-54.

5. Adams, J.W. and Sharp, W.N., 1970, Thalenite in the white cloud pegmatite, South Platte District, Jefferson County, Colorado (abstr.), *in* Geological Association of Canada-Mineralogical Association of Canada, Joint Annual Meetings, Abstracts of Papers: Winnipeg, Manitoba, Canada.

6. Adams, J.W., and Sharp, W.N., 1972, Thalenite and allanite derived from yttrofluorite in the White Cloud Pegmatite, South Platte area, Colorado: U.S. Geological Survey Professional Paper 800-C, C63-C69 p.

Third reported occurrence of thalenite in North America, rare earth X-ray fluorescence analyses of thalenite, allanite, yttrian fluorite, and yttrofluorite

7. Ahern, J., and Baird, C., 1983, Acid precipitation in southeastern Wyoming: Laramie, Wyo., Wyoming Water Research Center, W84- 00639; OWRT-A-032-WYO(1), 105 p.

Snowfall, snowpack, and rainfall samples were collected in Laramie, Wyoming and in the Snowy Range west of Laramie from March to June 1981 to determine the occurrence and sources of acid precipitation in southeast Wyoming. Electrodes measured different pH values in the samples; however, fast-response electrodes yielded higher and apparently more accurate pH measurements. The pH values in the Laramie precipitation and snowpack were typically greater than 5.0, but all the Snowy Range snowpack pH values were less than 5.0. The lower pH values in the Snowy Range snowpack were caused by higher concentrations of the acid-forming nitrate and lower concentrations of the neutralizing calcium. Two organic species, formate and acetate, were detected in the Laramie samples, but had no significant influence on the acidity of the samples.

8. Ahlbrandt, T.S., 1982, Chronology and sedimentology of some North American cold climate dune fields, *in* J. O. Nriagu and R. Troost, comps., Eleventh international congress on sedimentology, Hamilton, Ontario, Canada, Aug. 22-27, 1982: v. 11, p. 67.

9. Ahlbrandt, T.S., and Harris, R.E., 1975, Clastic dikes in the Fountain and Casper formations (Permo-Pennsylvanian), southeastern Wyoming: Contributions to Geology, v. 14, no. 1, p. 51-54.

10. Ahrens, T.P., 1950, Groundwater investigation, Granby Pump Canal, Colorado Big Thompson Project, Colorado: U.S. Bur. Reclamation.

11. Aiken, J.D., 1984, Evaluation of legal and institutional arrangements associated with ground water allocation in the Missouri River basin states: Lincoln, Nebr., Nebr. Water Resour. Center, Project Completion Report Grant No. 14-34-0001-8412, 88 p.

12. Aiken, J.D., 1980, The National Water Policy Review and Western Water Rights Law Reform: An Overview: Nebraska Law Review, v. 59, no. 2, p. 327-344.

Although economic development has traditionally been accepted as a primary objective in the formulation of State and federal water policies, the achievement of most economic development objectives has resulted in increased public concern regarding the protection and preservation of natural resources. Inconsistent federal water policies have resulted from the enactment of federal environmental legislation which conflicts with existing reclamation, flood control, and hydroelectric power production programs. Water development programs are also being subjected to closer budgetary examinations than in the past. The proposed major objectives of a review and development of a national water resources management policy initiated by President Carter in 1977 included modification of State water laws to meet the environmental protection and water use efficiency objectives. Strong protests by the western States resulted in the elimination of this reform in State water rights laws as an explicit objective. However, several existing innovative water policies adopted by some western States may serve as models for State and federal officials searching for water policy alternatives. These include farm-level irrigation water use efficiency programs in Nebraska; groundwater mining regulations in Nebraska; minimum streamflow legislation in several western States; procedures for resolving conflicts between surface and groundwater users in Colorado; and policies for conjunctive management of groundwater and surface water in Washington and California. These water law developments are described, and their relevance to other western States is evaluated. Social, economic, and political objections to reform objectives constitute the major obstacle to water law reforms. Alternatives which accommodate development as well as reform objectives are both necessary and possible. Better integration of federal water programs is perhaps the most important water policy contribution the federal government could make at this time.

13. Aiken, J.D., and Supalla, R.J., 1979, Ground water mining and western water rights law: the Nebraska experience: South Dakota Law Review, v. 24, no. 3, p. 607-648.

Depletion of ground water supplies due to irrigation is one of the major water policy questions facing the western States. Traditional responses have included ignoring the problem, or utilizing a supplemental water supply. Regulating ground water withdrawals has not been implemented, because it is perceived as too politically controversial. The 1975 Nebraska Ground Water Management Act (Act) is among the first administrative attempts to significantly reduce ground water withdrawals. The Act gives each local Natural Resource District (NRD) the option of regulating ground water use through the establishment of ground water control areas. Ground water controls authorized by the Act include: (1) well spacing restrictions; (2) rotation of pumping restrictions; (3) ground water allocation by establishing what quantities may be withdrawn; and (4) well drilling moratoria. In addition, an NRD may adopt other reasonable ground water controls. The Act also requires NRD's to establish and enforce regulations to control runoff from ground water irrigation. The blend of local and State responsibilities implicit in the Act has led to cooperation among State and local natural resource agencies and to an increased awareness of various aspects of ground water management.

14. Al-Azzawi, S. N., 1990, An integrated approach to subsurface heterogeneity measurement for three-dimensional groundwater flow and contaminant transport modelling: Golden, Colo., Colorado School of Mines.

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17. Allen, E.G., and Flot, T.R., 1978, Leasable mineral and waterpower land classification map of the Sterling Quadrangle, Colorado, Nebraska, Kansas: U.S. Geological Survey Open-File Report Map 77-856, scale 1:250,000, 1 p.

18. Allen, E.G., and Flot, T.R., 1980, Leasable mineral and waterpower land classification map of the Sterling 1 degrees by 2 degrees Quadrangle, Colorado, Nebraska, and Kansas (Supersedes Open-file report 77-856): U.S. Geological Survey Miscellaneous Investigations Series Map I-1224, 1 p.

19. Alley, W.M., 1979, Rainfall-runoff modeling of flow and total nitrogen from two localities in the Denver, Colorado, metropolitan area, *in* Storm water management model users group meeting, 1978: U.S. Environmental Protection Agency, p. 41.

20. Alley, W.M., Bauer, D.P., Veenhuis, J.E., and Brennan, R., 1979, Hydrologic effects of annually diverting 131,000 acre-feet of water from Dillon Reservoir, central Colorado: U.S. Geological Survey Water-Resources Investigations 79-2, 17 p.

Because of the increased demands for water in eastern Colorado, principally in the urbanizing Denver metropolitan area, increased diversions of water from Dillon Reservoir are planned. Estimates of end-of-month storage in Dillon Reservoir, assuming the reservoir was in place and 131,000 acre-feet of water were diverted from the reservoir each year, were reconstructed by mass balance for the 1931-77 water years. Based on the analysis, the annual maximum end-of-month drawdown below the elevation at full storage would have averaged 54 feet. The maximum end-of-month drawdown below the elevation at full storage would have been 171 feet. The mean-annual discharge-weighted dissolved-solids concentrations in the Colorado River near Glenwood Springs and Cameo, Colo., and Cisco, Utah, for the 1942-77 water years, were computed assuming an annual diversion of 131,000 acre-feet of water from Dillon Reservoir. The average increases in the dissolved-solids concentrations with the 131,000-acre-foot diversion were 15 to 16 milligrams per liter at the three sites.

21. Alley, W.M. and Ellis, S.R., 1978, Trace elements in runoff from rainfall and snowmelt at several localities in the Denver, Colorado, Metropolitan area, *in* Proceedings of the International Symposium on Urban Storm Water Management, July 24-27, 1978: Lexington, Ky., University of Kentucky, p. 193-198.

Concentrations of antimony, cadmium, chromium, lithium, manganese, mercury, nickel, and selenium have been determined in selected samples of rainfall runoff from several urban localities in the Denver metropolitan area. Multiple samples collected during periods of runoff from both rainfall and snowmelt were analyzed for arsenic, copper, iron, lead, and zinc. Of these trace elements, iron, lead, and zinc were predominant in runoff from the rainfall and snowmelt, with concentrations of iron at times exceeding 10,000 micrograms per liter and with concentrations of lead and zinc at times exceeding 1,000 micrograms per liter. The concentrations of trace elements were highest during the initial parts of the periods of rainfall runoff and then decreased with time. Trace-element concentrations in snowmelt runoff generally peaked during the middle of the day, corresponding with periods of maximum melting and runoff. Instantaneous loads of trace elements were largely a function of discharge for runoff from both rainfall and snowmelt. The trace elements were predominantly in the particulate phase, with the ratio of particulate to dissolved concentrations averaging 20. Between April 1 and October 31, 1976, estimated total loads of trace elements for a 606-acre residential site were: Arsenic, 0.8 pound; copper, 4.4 pounds; lead, 44 pounds; and zinc, 23 pounds.

22. Alley, W.M. and Veenhuis, J.E., 1979, Determination of basin characteristics for an urban distributed routing rainfall-runoff model, *in* Storm water management model users group meeting: Montreal, Canada, U.S. Environmental Protection Agency.

23. Alley, W.M., and Veenhuis, J.E., 1983, Effective impervious area in urban runoff modeling: Journal of Hydraulic Engineering, v. 109, no. 2 (Feb.), p. 313-319.

Methods of estimating impervious areas are described and some effective impervious area data is summarized. The ramifications of effective impervious area concepts in urban runoff modeling are analyzed. Results from many urban runoff models are sensitive to the value used for impervious area. Large differences in results can be obtained depending on whether total impervious area (TIA) or effective impervious area (EIA) calculations are used. TIA may be appropriate for black-box models but not for deterministic ones. Potential problems of using TIA in the more deterministic models include: runoff volumes and peak flows may be largely overestimated for ungaged watersheds; simulated changes in runoff, on a percentage basis, due to increasing intensity of land use may be smaller if TIA is used rather than EIA; and overestimates of the infiltration rates are likely if the model is calibrated using TIA and measured rainfall-runoff data. Impervious area data collected from 19 urban watersheds in the Denver metropolitan area suggest a large potential exists for developing relationships between EIA and TIA for an urban area, either through a regression equation between the two variables or through estimates of the ratio EIA-TIA as a function of land use.

24. Anderson, A., Miller, G.C., and Noonan, W., 1989, The Platte River system: a resource overview: Denver, Colo., U.S. Fish and Wildlife Service.

25. Anderson, D., 1991, Overview of surface water quality of the South Platte River Basin (abstract only), *in* Woodring, R.C., ed., South Platte resource management: finding a balance: Fort Collins, Colo., Colorado Water Resources Research Institute, p. 23.

26. Anderson, R.L., 1983, Discussion 'Municipal water supply restrictions as urban growth constraints,' by W. B. Lord: Water Resources Bulletin, v. 19, no. 1, p. 131-133.

In the original paper (Water Resources Bulletin, Vol. 18, No. 2, p 271-277, 1982) the idea was presented that limiting water supply does not inhibit urban growth. Various studies were cited to show that growth occurs in areas where water supplies are limited. The argument is stated that industrial and commercial growth can be accommodated within existing municipal supplies if residential demands can be reduced. The discussant maintains that the suggestion to homeowners that lawns can survive on 70% of the water they are capable of taking up is illusory; that to put watering or waste of water on lawn watering on a gallon-per-day basis is clearly inaccurate and misleading, as residents in Colorado's Front Range cities water their lawns only rarely at present anyway; and that raising prices for water could turn out to be a lawn tax, with far reaching effects on the older, fixed-income area residents rather than on new members of the community. The discussant suggests that the Denver Water Board pursue its historic course of expanding the water supply. While this course has been criticized by certain environmental groups, the disrupting effects of this course are no worse and perhaps less burdensome than depriving urban areas of adequate water.

27. Anderson, R.D., 1978, Summary report on the water quality investigation of the South Platte River, July 1, 1976-June 29, 1977: Denver, Colo., Colorado Department of Health, Water Quality Control Division, 51 p.

28. Anderson, R.L., 1967, Windfall gains from transfer of water allotments within the Colorado Big-Thompson project: Land Economics, v. XLIII, no. 3 (August), p. 265-273.

29. Anderson, R.M. and Nehring, R.B., 1982, The catch-and-release experience on the Fryingpan and South Platte Rivers, in Proc. Annu. Meet. Colo-Wyo. Chap. Am. Fish. Soc.: v. 17, p. 16-32.

30. Anderson, R.M., and Nehring, R.B., 1984, Effects of a catch-and- release regulation on a wild trout population in Colorado, USA and its acceptance by anglers: North American Journal of Fish Management, v. 4, no. 3, p. 257-265.

From 1979-1982, the trout population of the catch-and-release area on the South Platte River was dominated by rainbow trout (*Salmo gairdneri*), had a biomass as high as 667 kg/ha, and 50% of the trout were > 30 cm long. The trout population of an area with standard regulations (8 trout/day) was dominated by brown trout (*S. trutta*), had a maximum biomass of 219 kg/ha, and only 17% of the population were longer than 30 cm. The difference in trout population characteristics was attributed to the harvest rates of the respective areas. Rainbow trout were more vulnerable to angling than brown trout; age 3+ and older trout were more exploited than young/smaller fish. Catch rates averaged 48% greater in the catch-and-release area than in the standard-regulation section that had the benefit of catchable-trout stocking. The catch rate of trophy-sized trout (longer than 38 cm) was 38 times greater in the catch-and-release area than in the harvest area.

31. Anderson, R.M. and Nehring, R.B., 1985, Impacts of stream discharge on trout rearing habitat and trout recruitment in the South Platte River, Colorado, *in* F. W. Olson, R. G. White and R. H. Hamre, eds., Proceedings of Symposium on Small Hydropower and Fisheries: p. 59-64.

32. Anderson, R.L., Wengert, N.I., Heil, R.D., Williams, D., and Palmer, C., 1976, Physical and economic effects on the local agricultural economy of water transfer from irrigation companies to cities in the northern Denver Metropolitan area: Fort Collins, Colo., Environmental Resource Center and Economic Research Service, Completion Report 75, 53 p.

Rapid suburban growth north of Denver, Colorado, has caused developing communities to expand their municipal water systems. In order to obtain additional water supplies, the cities of Thornton and Westminster have initiated condemnation suits against three irrigation companies to obtain their water rights. The three irrigation companies have a service area of about 40,000 acres--30,000 are currently irrigated. Of this land, 80 percent is class II and III, the highest classes found in Colorado. Approximately 400 farms and small tracts receive water from these companies--200 are commercial farms. Total agricultural production from the irrigated lands is about $8 million per year. Economic input-output analysis shows that irrigated agriculture contributes 561 jobs to the economy and over $4 million in net income. The cities and irrigation companies should work together to develop joint use of water rather than drying up irrigated lands for municipal water supply.

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34. Andersson, K.A., 1979, Early lithification of limestones in the Redwater Shale Member of the Sundance Formation (Jurassic) of southeastern Wyoming: Contributions to Geology, v. 18, p. 1-17.

35. Andreu, J., Labadie, J.W. and Burns, A.W., 1982, Optimal stream- aquifer system management, *in* F. Kilpatrick and D. Matchett, eds., Proceedings of Conference on Water and Energy Technical and Policy Issues: New York, N.Y., Am. Soc. Civ. Eng., 578-586 p.

36. Andrews, K. W., 1970, The distribution and life history of the fathead minnow (*Pimephales promelas* Rafinesque) in Colorado: Fort Collins, Colo., Colorado State University, Ph.D. dissertation, 131 p.

37. Angevine, C.L., and Flanagan, K.M., 1987, Bouyant sub-surface loading of the lithosphere in the Great Plains foreland basin: Nature (London), v. 327, p. 137-139.

38. Water Environ. Technol., 1989, Control of stormwater runoff containing aircraft deicing fluids: Water Environ. Technol., v. 1, no. 1. (Anonymous author).

Since 1970, Stapleton International Airport (SIA), which is located 6 miles northeast of downtown Denver, Colo., has taken several steps to control industrial wastes discharged to the terminal-area storm sewers. Initially, an industrial waste interceptor system was constructed to collect dry-weather industrial waste flows for treatment at the Metropolitan Denver Sewage Disposal District No. 1 Central Plant. Later, a study of industrial waste sources and characteristics was completed; it led to the separation of the direct industrial waste connections from the storm sewers.

39. Water and Sewage Works, 1974, Highlights from the Denver WPCF meeting: Water and Sewage Works, v. 121, no. 12 (December)(Anonymous author).

40. Army [U.S.] Engineer District, 1983, Construction foundation report, South Platte River basin, Bear Creek Lake, Colorado. Volume 2. Drawings, final report: Omaha, Nebr., 266 p.

41. Army [U.S.] Engineer District, 1983, Construction foundation report, South Platte River basin, Bear Creek Lake, Colorado. Volume 1. Text and photos. Final report: Omaha, Nebr., 115 p.

Contents: Foundation Explorations; Geology; Excavation Procedures; Character of Foundation; Foundation Treatments; Recommendations.

42. Army [U.S.] Engineer District, 1977, Flood hazard information report: South Platte River, Volume II, Morgan County and Washington County, Colorado: Omaha, Nebr., Prepared for Morgan County-Washington County and Colorado Water Conservation Board, 19 p.

The study area involves the portions of Morgan and Washington Counties, Colorado, that are subject to flooding from the South Platte River. The flood plain consists primarily of agricultural land uses, with some residential and commercial development. Flood data were obtained from topographic maps, field studies, historic sources, and U.S. Geological Survey stream gage records from Morgan County. The main flood season occurs from May through September. Flooding results from heavy general rains, intense local thunderstorms, or snowmelt. The worst flood recorded at the gage at the Morgan-Washington County line occurred on June 18, 1965, discharging 123,000 cubic feet per second (cfs). At the same location, the 100-year flood would discharge 94,000 cfs and would crest at 4,104 feet mean sea level (msl), while the 500-year flood would discharge 240,000 cfs and would crest at 4,108 feet msl. Historic flood data and future flood projections are presented for the entire study area. This study is intended for use in making land use planning and management decisions concerning flood plain utilization.

43. Army [U.S.] Engineer District, 1970, Flood plain information: Crow Creek, Cheyenne, Wyoming: Omaha, Nebr., Prepared for City of Cheyenne, 24 p.

The drainage area of Crow Creek, a tributary of the South Platte River, is 253 sq mi including the southern portion of Cheyenne. The creek provides the city with its water supply and sewage disposal. Study area extends from Interstate Highway 25 downstream 6.3 miles to sewage disposal plant. Most of the channel has been straightened and confined by roads, levees, and fills and drops about 18 ft/mi in slope. Industrial, commercial and residential development in the flood plain is gradual but steady with pressures for development likely to continue. Eleven bridges cross the creek, possible obstructions to major flood flows. Elevated roadways and inadequate culverts also create problems. Intense thunderstorm rainfall during spring and summer months possibly preceded by heavy snowmelt causes most floods. Although it has been almost 40 years since the last major flood, June 1929, future floods of the same size are still possible. Intermediate regional flood with a peak discharge of 5,500 cfs would overtop all bridges except on Highway 25 and the railroad bridges, covering an area about 600 ft wide upstream of Morrie Avenue. A standard project flood with an estimated peak discharge of 17,000 cfs would inundate about 1,000 ft in the same reach. The depth of flood water, together with the rapidly rising waters, and high velocities can cause substantial damage to industrial, commercial, and residential areas. Recommendations for flood protection are not included.

44. Army [U.S.] Engineer District, 1972, Flood plain information: Upper St. Vrain Creek, Volume IV, Boulder County, Colorado: Omaha, Nebr., Prepared for City of Longmont and Boulder County, 24 p.

The study reach extends upstream from the confluence of two streams at Lyons (drainage area at Lyons 219 sq. mi.), 3.7 miles along the north St. Vrain Creek, and 1.5 miles along the south St. Vrain Creek, and downstream from the confluence point along St. Vrain Creek for 5.2 miles. St. Vrain Creek slopes between 42-48 ft/mi. The channel bed has cobbles and small boulders. Development in the flood plain includes residential and commercial uses. Pressure for more flood plain development is expected as Lyons (population 958) continues to grow due to the lack of suitably sloped land in the area plus the attraction of living near the stream. Eleven bridges, raised road surfaces and residential development can obstruct flood flows. Flooding (9 floods in the last 108 years) has occurred from May through September as the result of snowmelt runoff combined with rainfall. Peak flood is usually reached within several hours of the rainfall event. Flood duration is normally short but can be prolonged by continued rapid snowmelt. The intermediate regional flood and the standard project flood will have peak discharges of 10,700 and 28,300 cubic feet per second, respectively. In addition to scattered residences along the flood plains, the IRF can be expected to flood large portions of the town of Lyons.

Overbank flow velocities should be expected to be hazardous in Lyons and upstream. Downstream from Lyons, special care must be taken in road and building construction since modifications of the flood plain can alter flood patterns and inundate lands not now affected by flooding.

45. Army [U.S.] Engineer District, 1972, Flood plain information: Lower St. Vrain Creek, Volume III, Boulder County, Colorado: Omaha, Nebr., Prepared for Urban Drainage and Flood Control District, City of Longmont, Boulder County, Colorado, 26 p.

The study reach of St. Vrain Creek for this report extends 8.2 miles from a county road bridge crossing 3.1 miles west of Longmont, Co., to a road bridge 1.7 miles east of Longmont, at the Boulder County-Weld County line. Left Hand Creek, a major tributary, joins St. Vrain Creek from the south downstream from Longmont. St. Vrain Creek has a slope of 22 ft/mi and drains an area of 373 sq mi in the study area. The channel bed is from 200 to 320 feet wide and contains shifting sand bars. Above Longmont, flood plain development is limited to pasture and croplands. In and around Longmont (1970 population 23,009), flood plain development includes commercial, industrial, residential, and municipal sewage treatment uses. Obstructions to flood flows include 9 bridges, 3 culverts, vegetation, raised road surfaces and floatable materials from industrial development in the flood plain. Floods occur from May to September. Serious floods are most often caused by rainfall runoff augmented by snowmelt runoff. Peak flooding from a single rainfall event will usually occur within a half day after the rain, with the duration of flooding lasting from a few hours to a half day. The intermediate regional flood and the standard project flood will have peak discharges below Left Hand Creek of 13,200 and 39,000 cubic feet per second, respectively. Upstream from Longmont an area of rural land would be inundated 2,000 ft wide by an IRF; the SPF would average 4,300 ft. wide.

46. Army [U.S.] Engineer District, 1973, Flood plain information: North Platte, Nebraska; North Platte River and South Platte River: Omaha, Nebr., Prepared for City of North Platte and Nebraska Natural Resources Commission, 23 p.

Land in the floodplains of this study area include residential and commercial developments, but is primarily agricultural at present. There is pressure to continue developing in flood prone areas and large floods are possible. At the confluence of the North and South Platte Rivers, about 4 mi southeast of North Platte, NB, the combined drainage areas of the rivers is 59,200 sq mi. Most of the city lies between the rivers and almost all of it is subject to flooding which can last for several days. The floodplains of the rivers vary from 5,500 to 13,100 ft in width. There is higher ground suitable for development; the city originated on the floodplain and has continued to grow there. It is expected that floodplains will continue to be encroached upon unless control measures are imposed. Heavy rains combined with snowmelt, or snowmelt alone, can cause flooding. Peak flows generally occur in March through October. No record of floods exist for North Platte, but gaging records indicate that the estimated 7,000 cubic ft/sec capacity of the channel of the North Platte River has been exceeded numerous times. The 20,000 to 30,000 cfs capacity of the South Platte River has been exceeded only once. In an Intermediate Regional Flood, peak discharges of 13,500 and 60,000 cfs are predicted on the North Platte and South Platte Rivers, respectively. In a Standard Project Flood, peak discharges of

35,400 and 98,000 cfs are anticipated for the 2 rivers. Four bridges in the area will obstruct flood flows. Reservoirs on both rivers reduce flood waters, and levees in the area provide some protection.

47. Army [U.S.] Engineer District, 1978, Flood plain information: Big Thompson River, Weld County, Colorado: Omaha, Nebr., Prepared for Weld County Larimer-Weld Regional Council of Governments and Colorado Water Conservation Board, 33 p.

The study area is the Big Thompson River basin in Weld County, Colorado. This basin drains an area of about 830 square miles in north central Colorado. The most common form of development in the flood plain within the study area is agriculture, but overall development is relatively sparse. Flood data were gathered from 2 U.S. Geological Survey gaging stations, Corps of Engineer's flood records, topographic maps, and local newspaper. Intense rainfall of cloudburst magnitude occurs in the area. Floods generally occur from May through July, but peak discharges have been recorded from March through September. No effective flood control structures have been constructed. Olympus Dam, located in the upper part of the river basin, has negligible effect in reducing flood damages. The worst recorded flood near the Drake gaging station occurred in July 1976, discharging 31,200 cubic feet per second (CFS). The Intermediate Regional Flood at the Larimer-Weld County line would discharge 10,000 CFS, while Standard Project Flood (SPF) at the same location would discharge 18,500 CFS. Downstream from Little Thompson River, the SPF would discharge 20,000 CFS. This report was prepared as an aid to local officials in planning the use and regulation of the flood plain.

48. Army [U.S.] Engineer District, 1971, Special flood hazard report: to revise flood plain information, Metropolitan Region, Denver, Colorado; Volume II: Sand, Toll Gate and Lower Cherry Creeks, South Platte River Basin: Omaha, Nebr., 21 p.

Cherry Creek channel is alluvial, flat-bottomed, and follows a meandering course, sloping downstream from Cherry Creek dam at 25 ft/mi, with some channel improvements between the dam and Havana Street. Sand Creek has been improved by channel realignment while portions of Toll Gate Creek improved during interstate highway construction. Cherry Creek study reach is highly urbanized and is crossed by 38 bridges which can obstruct flood flow. Sand Creek and Toll Gate Creek are less urbanized, crossed by 17 and 5 bridges respectively. A zone of frequent cloudbursts over highlands at 6,000 to 7,000 feet covers major portions of these basins. Cloudburst storms cause floods from March through August. The Cherry Creek reservoir impounded a flood which had a peak inflow of 58,000 cfs in June, 1965, the greatest known are flood, saving an estimated $130 million in flood damages downstream. At Toll Gate Creek, flow was estimated to be 17,000 cfs, and at Sand Creek it was 18,900 cfs. Their flooding caused extensive damages, destroying nearly every bridge crossing. At the mouths of Cherry, Sand, and Toll Gate Creeks, discharges of an intermediate regional flood would be 10,900 cfs, 49,500 cfs, and 21,900 cfs, respectively, and of a standard project flood, 21, 200 cfs, 91,200 cfs, and 31,700 cfs.

49. Army [U.S.] Engineer District, 1977, Special flood hazard information report: South Platte River, Volume III, Logan-Sedgwick County, Colorado: Omaha, Nebr., 19 p.

The study area includes the South Platte River and its floodplain in Logan and Sedgwick Counties, Colorado. Land use in the flood plain is mostly agricultural except for the areas adjacent to incorporated communities. Flood data were obtained from topographic maps, aerial photographs, historical sources, field studies, and U.S. Geological Survey stream gage records. The main flood season occurs from March through September with the most frequent flooding occurring during June. Annual peak discharges have been recorded throughout the year. Flooding results from heavy general rainfall or intense local rainfall, with or without snowmelt. The worst flood recorded at the USGS gage near Julesburg occurred on June 20, 1965. The flood discharged 37,600 cubic feet per second (cfs). The flood of April 1973 is used for comparison purposes. At the downstream study limit, this flood discharged 22,000 cfs and crested at 3,435.3 feet mean sea level (msl). At the same location, the 100-year flood would crest at 3,439.9 feet msl, while the 500-year flood would crest at 3,441.7 feet msl. This study is intended for use in making land use planning and management decisions concerning flood plain utilization.

50. Army [U.S.] Engineer District, 1977, Special flood hazard information report: South Platte River, Volume 1, Weld County, Colorado: Omaha, Nebr., 26 p.

The study area includes the South Platte River and its flood plain in Weld County, Colorado. A large proportion of the flood plain contains agricultural land uses. Dense development patterns exist in the proximity of larger incorporated areas. Flood data were obtained from topographic maps, field studies, historical sources and stream gage records. The main flood season occurs from May through August, and results from heavy general rainfall or intense local thunderstorms, either of which may be augmented by snowmelt. The worst flood recorded at the Kersey gage occurred on May 8, 1973. The flood discharged 31,500 cubic feet per second (cfs), and crested at 4,586.3 feet mean sea level (msl). This flood is equivalent to the 100 year flood. At the same location, the 500 year flood would discharge 63,000 cfs and would crest at 4,588 feet msl. These floods would primarily affect public utilities, public roadways, and agricultural properties and associated developments. This study is intended for use in making land use planning and management decisions regarding flood plain utilization.

51. Arthur, M. A., 1990, The effects of vegetation on watershed biogeochemistry at Loch Vale watershed, Rocky Mountain National Park, Colorado: Ithaca, N.Y., Cornell University, Ph.D. dissertation.

52. Arthur, M.A., and Fahey, T.J., 1989, Mass and nutrient content of decaying boles in an Englemann spruce subalpine fir forest, Rocky Mountain National Park: Can. J. For. Res., v. 20, p. 730- 737.

53. Ashton, L. W., 1978, Influences on the geochemistry of ground water in Welby, Colorado: Boulder, Colo., Univ. of Colorado, MS thesis.

54. Asquith, G.B., 1968, Origin of large kaolinite crystals in the lower Almond Formation in southwest Wyoming Upper Cretaceous: J. Sediment. Petrology, v. 38, no. 3, p. 948-949.

55. Atomic Energy Commission, 1971, Public Service Company of Colorado's Application for an Operating License for the Fort St. Vrain Nuclear Generating Station Draft; Environmental Impact Statement: Washington, D.C., Submitted to Council on Environmental Quality, Washington, D.C., 163 p.

The report concerns a license for an AEC Power Reactor Demonstration Program Plant located in the South Platte River Valley in the southwest corner of Weld County, Colorado. The reactor is of the high-temperature gas-cooled (HTGR) type, with helium coolant and graphite moderator. The fission energy will be generated at a rated capacity of 842 megawatts thermal (MWt). The Station will use a closed-cycle, induced-draft, evaporative cooling tower. The environmental impact will include: No significant adverse effect on land or water use; There is reasonable assurance that State water quality standards will be met; The radiation dose to people is expected to be about 0.13 mrem/year at the closest boundary; Small quantities of radioactive materials will be discharged within AEC requirements to keep releases as low as practicable. There will be no detectable impact due to these releases. There will also be a small amount of water evaporated, a slight increase in the temperature of the water, conversion of a small amount of land from agricultural to industrial use, and a small amount of chemical waste will be released.

56. Aukerman, R., and Springer, W.T., 1976, Effects of recreation on water quality in wildlands: Eisenhower Consortium Bull., v. 2, p. 1-25.

57. Aull, G.H. Jr, and Zuelsdorf, R.J., 1973, Financial institutional arrangements for wastewater management - Denver, Colorado: Denver, Colo., Environmental Protection Agency, Region VIII, EPA contract 68-01-0734, 147 p.

Field studies and research were conducted to determine the existing institutional arrangements and financial practices of sixteen wastewater management agencies within the Denver standard metropolitan statistical area (SMSA). Data for each of the agencies portrayed types and amounts of current revenues and expenditures, projected revenues and expenditures, and how various classes of expenditures are financed. A wide range of institutional and financial arrangements are available to areas and units of government in the provision and operation of wastewater facilities. No optimum form of institutional or financial arrangements was sought, but various criteria are suggested by which the selection might be made. Ample legal authority appears to exist for meeting wastewater management needs within the Denver SMSA provided that the selection of appropriate arrangements can be made by the electorate. Policy and administrative considerations in selecting financial arrangements are more critical to satisfactory solution of needs than are statutory considerations. The scale and scope of the selected jurisdiction was more critical than the precise form of institutional arrangement. Strengthened roles for State, county and municipal governments are foreseen, as well as a continuance of the important function performed by the Denver Regional Council of Governments.

58. Avery, C., 1983, Pumpage data from irrigation wells in eastern Laramie County, Wyoming, and Kimball County, Nebraska: U.S. Geological Survey Open-File Report 83-29, 23 p.

Quantitative information concerning pumpage by irrigation wells is an integral component of the U.S. Geological Survey High Plains Regional Aquifer System

Analysis. Thus, operation time, discharge rate, and irrigated acreage were measured at approximately 450 randomly selected irrigation wells within 10 areas of the High Plains during the 1980 irrigation season. The data were used to estimate the seasonal mean application of water to crops and to project total pumpage by irrigation wells in 1980 throughout the High Plains area. As part of the sampling effort, 50 irrigation wells were randomly chosen from the area of eastern Laramie County, Wyoming, and Kimball County, Nebraska. Required information was collected on only 40 of the wells. For these wells, the seasonal mean application of water on the irrigated land was 15.2 inches. For the major crop types, the seasonal mean application, in inches, were as follows: alfalfa, 19.8; corn, 15.4; potatoes, 13.8; beans, 12.8; and small grains 10.2.

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61. Babcock, H.M., and Bjorklund, L.J., 1956, Ground-water geology of parts of Laramie and Albany Counties, Wyoming, and Weld County, Colorado: U.S. Geological Survey Water-Supply Paper 1367, 61 p.

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64. Baker, V.R., 1974, Paleohydraulic interpretation of Quaternary alluvium near Golden, Colorado: Quat. Res., v. Quat. Res. Cent 4, no. 1, p. 94-112.

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Aldrin was recommended and used to control the western corn rootworm (*Diabrotica virgifera* (LeConte)) (WCR) in Nebraska from 1952 to 1961. During that period, LD sub(50) values for adult WCR tested against aldrin were determined for 19 collection sites in Nebraska. Mean 24 h LD sub(50) values for these sites decreased from 1,539 mu g/g in 1962 to 355 mu g/g for 1981. A correlation existed between the amount of aldrin used for soil treatments and the aldrin and dieldrin residues, with decreasing LD sub(50) values for the WCR over the observation period.

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Channel erosion in tributaries of Colorado's Big Thompson River was studied following the 1976 flash flood. In two catchments, no measurable erosion occurred. Erosion in other catchments was intense (maximum observed sediment yield = 308 cu m/ha). Relationships between 'total' storm precipitation (P) and sediment yield give values for the maximum potential sediment yield at a given storm magnitude. Sediment mobilization begins when P = 140 to 150 mm, or when short-term rainfall intensity = 140 to 170 mm/h. Qualitative and quantitative evidence suggests that a large, rare event is needed to modify the Big Thompson tributaries geomorphically. Catchment denudation values were used to estimate the recurrence interval of the 1976 event; the results suggested the possibility that previously estimated recurrence intervals may be too long by factors of 1.6 to 8.

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The Arkansas-White-Red Region, an area of 265,000 square miles is characterized by diversity in geography, climate, and geology and, in turn, by diversity in water resources and water problems. The western semiarid part of the region is water deficient, that is, potential evapotranspiration exceeds precipitation. The eastern, humid part has a surplus. Water use in the region in 1970 averaged 10 billion gallons per day, of which more than 65 percent was ground water. The largest use of ground water was for irrigation of crops, mostly in the water-deficient areas of Texas, Oklahoma, Kansas, and Colorado. Because of its ready availability and widespread occurrence, ground water is used throughout the region to supply municipal and rural water needs. The most productive aquifers, capable of yielding more than 50 gallons per minute to individual wells are alluvium, carbonate rocks, gypsum, and sandstone. Fresh water in storage in aquifers in the region is estimated to be 2 billion acre-feet. In addition, a large unmeasured volume of saline water (containing more than 1,000 mg/liter of dissolved solids) underlies the fresh water at depths generally less than 500 feet.

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100. Bendix Field Engineering Corp., 1981, Uranium hydrogeochemical and stream sediment reconnaissance of the Denver NTMS quadrangle, Colorado: Grand Junction, Colo., Prepared for the Department of Energy, Washington, DC., GJBX-263-81, 160 p.

This report presents results of a Hydrogeochemical and Stream Sediment Reconnaissance of the Denver NTMS quadrangle, Colorado. In addition to this abbreviated data release, more complete data are available to the public in machine-readable form. These machine-readable data, as well as quarterly or semiannual program progress reports containing further information on the HSSR program in general, or on the Los Alamos National Laboratory portion of the program in particular, are available from DOE's Technical Library at its Grand Junction Area Office. Presented in this data release are location data, field analyses, and laboratory analyses of several different sample media. For the sake of brevity, many field site observations have not been included in this volume; these data are, however, available on the magnetic tape. Appendices A through E describe the sample media and summarize the analytical results for each medium. The data have been subdivided by one of the Los Alamos National Laboratory sorting programs of Zinkl and others (1981a) into groups of stream-sediment, lake-sediment, stream-water, lake-water, and ground-water samples. For each group which contains a sufficient number of observations, statistical tables, tables of raw data, and 1:1,000,000 scale maps of pertinent elements have been included in this report. Also included are maps showing results of multivariate statistical analyses.

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The likely consequences of detonating a nuclear weapon in Boulder County, Co, are predicted. Local and global fallout and radiation exposures are calculated following the hypothetical detonation of a nuclear bomb equivalent to 5,742 megatons of TNT. Under assumed wind conditions, agricultural crops would be contaminated with radionuclides for prolonged periods. Loss of animal life, flooding, increased sedimentation, and extensive soil erosion should also be expected.

102. Benniran, M. M., 1970, Stream-sediment sample results in search of Casper Formation limestones, southwestern Laramie Mountains, Albany County, Wyoming: Laramie, Wyo., Univ. of Wyoming.

103. Bergey, E.A., and Ward, J.V., 1989, Upstream-downstream movements of aquatic invertebrates in a Rocky Mountain stream: Hydrobiologia, v. 185, p. 71-82.

104. Berryman, A.D., 1991, Water budget for the South Platte (abstract only), *in* Woodring, R.C., ed., South Platte resource management: finding a balance: Fort Collins, Colo., Colorado Water Resources Research Institute, p. 23.

105. Bestgen, K.R., 1989, Distribution and notes on the biology of *Phoxinus eos (Cyprinidae)* in Colorado USA: Southwest Nat., v. 34, no. 2, p. 225-231.

Distribution of the northern redbelly dace, *Phoxinus eos*, in the South Platte River Basin, Colorado, was historically restricted to a narrow band of stream habitat in the transition zone along the Front Range of the Rocky Mountains. *Phoxinus eos* has been taken only in the West Plum Creek drainage since 1951, where it mainly occupies off-channel lentic habitats that are cool, clear, vegetated, and without large predaceous fishes. Age and growth, reproduction, and diet characteristics are similar to those known for population of *P. eos* in the center of the species' range. The naturally limited range and habitat of *P. eos* in Colorado has been much reduced by stream channelization, reductions in discharge, and changes in water quality. Continued urban development threatens remaining populations.

106. Bevans, H.E., 1989, Interior province; western region, *in* Britton, L.J., Anderson, C.L., Goolsby, D.A., and Van Haveren B.P., eds., Summary of the U.S. Geological Survey and U.S. Bureau of Land Management national coal-hydrology program, 1974-84: U.S. Geological Survey Professional Paper 1464, 53-61 p.

107. Biedleman, R.G., 1978, The cottonwood-willow riparian ecosystem as a vertebrate habitat, with particular reference to birds, *in* W.D. Graul and S.J. Bissell, eds., Lowland river and stream habitat in Colorado: a Symposium: Greeley, Colo., Colorado Chapter Wildlife Society and Colorado Audubon Council, p. 192- 195.

108. Biedleman, R.G., 1948, The vertebtate ecology of a Colorado plains cottonwood river bottom: Boulder, Colo., University of Colorado, MS thesis, 351 p.

109. Bigelow, D.S., Denning, A.S., and Baron, J., 1990, Differences between nipher and alter-shielded Universal Belfort precipitation gages at two Colorado deposition monitoring sites: Environ. Sci. and Technol., v. 24, p. 758-760.

110. Binns, A., 1981, Beaver Creek revisited: Wyoming Wildl., v. 45, no. 5, p. 22-23.

111. Bittinger, M.W., 1961, The role of ground-water reservoir management in the comprehensive development of the water resources of the South Platte River Basin, *in* 120th Meeting of the Missouri Basin Inter-Agency Committee (August 3, 1961), Fort Collins, Colo.

112. Bittinger, M.W., Danielson, R.E., Evans, N.A., Hart, W.E., Morel- Seytoux, H.J., and Skinner, M.M., 1979, Impact of irrigation efficiency improvement on water availability in the South Platte River Basin: Fort Collins, Colo., Colorado Water Resources Research Institute, Technical Report 13, 88 p.

113. Bjorklund, L.F., 1957, Geology and ground-water resources of the lower Lodgepole Creek drainage basin, Nebraska: U.S. Geological Survey Water-Supply Paper 1410, 76 p.

114. Bjorklund, L.J., 1959, Geology and ground-water resources of the upper Lodgepole Creek drainage basin, Wyoming: U.S. Geological Survey Water-Supply Paper 1483, 40 p. (With a section on chemical quality of the water by Krieger, R. A., and Jochens, E. R)

115. Bjorklund, L.J., and Brown, R.F., 1957, Geology and ground-water resources of the lower South Platte River Valley between Hardin, Colorado, and Paxton, Nebraska : U.S. Geological Survey Water-Supply Paper 1378, 431 p. (With a section on chemical quality of the ground water, by H.A. Swenson).

117. Blair, T.C., 1987, Sedimentary processes, vertical stratification sequences, and geomorphology of the Roaring River alluvial fan, Rocky Mountain National Park, Co.: Journal of Sedimentary Petrology, v. 57, no. 1, p. 1-18.

118. Blakely, S.R., 1984, Hydrologic data for the Larimer-Weld Regional Water-Monitoring Program, Colorado, 1975-1982: U.S. Geological Survey Open-File Report 84-139, 201 p.

The Larimer-Weld, Colorado, Regional Monitoring Program was begun in 1976 to provide information on the quality and quantity of the surface-water resources in the area. Three stations on the Big Thompson River and five stations on the Cache La Poudre River were selected for a data-collection network. Four previously established stations were added to complete the data-collection network: Horsetooth Reservoir, Joe Wright Creek above and below Joe Wright Reservoir, and Michigan River near Cameron Pass. Station description, location, and period of record are given for each station. A statistical summary of the water-quality data for each station is tabulated. Frequency of occurrence is given at the 95th, 75th, 50th, and 25th percentiles. Monthly water-quality data and daily average streamflow data are tabulated for each streamflow station for which this data was collected; Monthly contents data are presented for Horsetooth Reservoir. All data tabulated and summarized are from the period October 1, 1975, through September 30, 1982.

119. Blakely, S.R., Mustard, M.H., and Doerfer, J.T., 1983, Analysis of the August 14, 1980, rainstorm and storm runoff to the South Platte River in the southern Denver metropolitan area, Colorado: U.S. Geological Survey Water-Resources Investigations 83-4138, 35 p.

120. Bliss, J.D., 1983, Central and eastern United States; basic data for thermal springs and wells as recorded in GEOTHERM: U.S. Geological Survey Open-File Report 83-440, 87 p.

121. Bluestein, M.H., 1976, Response of South Platte to effluent limitations: American Society of Civil Engineers. Environmental Engineering Division Journal, v. 102, no. EE4, p. 745-768.

122. Bluestein, M., 1975, Study areas II and VI-C water quality analysis and environmental assessments, South Platte River: U.S. National Commission on Water Quality, Colorado State University, and Tetra Tech, Inc.

123. Bluestein, M., and Hendricks, D.W., 1975, Biota and water quality of the South Platte River; past, present, and projected (prepared for the National Comission on Water Quality as a subcontract to Tetra Tech, Inc.): Fort Collins, Colo., Colorado State University, Environmental Engineering Technical Report 2.

124. Boaze, J.L., 1977, An evaluation of the South Platte River fish population between Deckers and South Platte, Colorado: Salt Lake City, Utah, U.S. Fish and Wildlife Service, 30 p.

125. Boaze, J.L., 1977, An evaluation of the fish population North Fork of the South Platte Rivers: Salt Lake City, Utah, U.S. Fish and Wildlife Service, 18 p.

126. Boberg, W. W., 1970, Transportation and precipitation of uranium in the South Platte River, Colorado: University of Colorado, MS thesis.

127. Boberg, W.W., and Runnells, D.D., 1971, Reconnaissance study of uranium in the South Platte River, Colorado: Econ. Geol., v. 66, no. 3, p. 435-450.

Anomalously high uranium content, possible ore-body in the drainage basin

128. Bogardi, I., Kelly, W.E. and Fried, J.J., 1986, Risk versus cost in ground water nitrate pollution, *in* B. J. Graves, K. Butcher and M. E. Renz, chairpersons, Agricultural impacts on ground water; a conference: Dublin, Ohio, Natl. Water Well Assoc., p. 482-507.

129. Bohomont, B.L., 1991, Colorado pesticide use survey; estimated use - 1989: Fort Collins, Colo., Colorado State University, 43 p.

130. Bolivar, S.L., Broxton, D.E., and Olsen, C.E., 1978, Uranium hydrogeochemical and stream sediment reconnaissance of the Denver and Greeley NTMS Quadrangles, Colorado: N. Mex., Los Alamos Scientific Lab., Department of Energy, Internal Report LA-7177-MS, GJBX-60-78, 138 p.

Although this report covers two National Topographic Map Series 2 exp 0 quadrangles, the data for each quadrangle are presented separately. Evaluation of the data by quadrangle resulted in the delineation of areas in which water and/or sediment uranium concentrations are notably higher than surrounding background concentrations. The major clusters of anomalous water samples were found in areas of the Denver Basin underlain by the Pierre, Laramie, Fox Hills, Denver, and Arapahoe Formations. Most of the anomalous sediment samples were collected in areas of the Front Range underlain by Precambrian crystalline rocks, particularly granites of the Silver Plume-Sherman group. Many of the anomalous sediment samples are from sites located near fault zones. The data in this report are also presented by geologic/ physiographic province because background uranium concentrations in Front Range samples differ significantly from those in the Denver Basin. Denver Basin waters have higher mean uranium concentrations (mean 14.4 ppB) than Front Range waters (mean 3.3 ppB). Conversely, Front Range sediments are more uraniferous (mean 14.7 ppM) than those in the Denver Basin (mean 6.1 ppM). These differences in background uranium concentrations between Front Range and Denver Basin samples can be attributed to differences in regional geology, physiography, and (in the case of water) the ratio of surface water to ground water sites sampled. There is a significant northward increase in uranium concentrations in water samples from the Denver Basin. The higher uranium concentrations in water samples from the northern part of the basin are probably due to leaching of uraniferous strata in the Pierre and Laramie Formations which crop out in that area.

131. Booker, J., Young, R.A., Zhang, C.M. and Morel-Seytoux, H.J., 1990, HELM: An integrated model applied to the South Platte Stream Aquifer System, *in* Groundwater Engineering and Management Conference: Denver, Colo.

132. Boos, C.M., 1924, The geology of the Big Thompson River Valley from the Continental Divide to the foothills area: The University of Chicago Abstract of Thesis Sci. Serv., v. 11, p. 217-222.

133. Borchert, W.B., 1976, Geohydrology of the Albin and La Grange areas, southeastern Wyoming: U.S. Geological Survey Water-Resources Investigations 76-118 (Open-File Report), 72 p.

The Albin and La Grange areas in southeastern Wyoming are two adjoining different hydrologic areas. Since ground water is the only source of water for irrigation in the Albin area, 34 irrigation wells have been drilled since 1968 and developed in conjunction mostly with center-pivot sprinkler systems that in 1974 irrigated about 6,980 acres. Most irrigation wells are developed in channel deposits of the Ogallala Formation of late Miocene. Water levels in parts of these channel deposits have declined about 4 to 7 feet since pumping began in 1968. In the La Grange area, lands are irrigated by surface water, ground water, or a combination of both. The best producing wells are those completed in both the Brule Formation of Oligocene age and the alluvium. Secondary porosity was located and elevated in the Brule using caliper logs, an acoustic borehole televiewer and geophysical logs. From the spring of 1970 to the spring of 1974, hydrographs of wells in parts of the La Grange area show water-level rises of about 5 feet resulting from the net effect of surface-water recharge and groundwater pumpage. Throughout the La Grange area no significant annual water- table declines have occurred. It is unlikely that irrigation wells pumping near Horse Creek have caused significant direct streamflow depletion.

134. Borgman, L.E., Sever, C., Quimby, W.F., Andrew, M.E., and Karlstrom, K.E., 1981, Uranium assessment for the Precambrian pebble conglomerates in southeastern Wyoming: Laramie, Wyo., University of Wyoming, 154 p.

This volume is a geostatistical resource estimate of uranium and thorium in quartz-pebble conglomerates, and is a companion to Volume 1: The Geology and Uranium Potential to Precambrian Conglomerates in the Medicine Bow Mountains and Sierra Madre of Southeastern Wyoming; and to Volume 2: Drill-Hole Data, Drill- Site Geology, and Geochemical Data from the Study of Precambrian Uraniferous Conglomerates of the Medicine Bow Mountains and the Sierra Madre of Southeastern Wyoming.

135. Borman, R.G., 1979, Effects of a cattle feedlot on ground-water quality, *in* U.S. Geological Survey Research: U.S. Geological Survey Professional Paper 1150, 120 p.

136. Borman, R.G., 1981, Effects of a cattle feedlot on ground-water quality in the South Platte River Valley near Greeley, Colorado: U.S. Geological Survey Water-Resources Investigation 80- 83, 85 p.

Ground-water quality may be changed by leachate from feedlots because large quantities of wastes are generated. The potential for water quality to be affected is especially high in alluvial aquifers with a shallow depth to water. However, monitoring water quality in 19 observation wells in and near a feedlot stocked with 90,000 head of beef cattle from April 1974, before the lot was stocked, to June 1978, has shown little change in ground-water quality that can be attributed to the feedlot. Analyses of water from two lysimeters in the unsaturated zone indicate leachate from the feedlot has percolated to a depth of a least 5 feet but not to a depth of 20 feet. The small changes in ground-water quality caused by the feedlot are likely due to the limited available recharge, a relatively impermeable manure pack and soil clogging under the cattle pens resulting in slow vertical movement of leachate through the unsaturated zone, soil clogging under the unlined runoff-retention ponds, and denitrification in the unsaturated zone.

137. Borman, R.G., and Gaggiani, N.G., 1983, Generalized altitude and configuration of water table in parts of Larimer, Logan, Sedgwick, and Weld Counties, Colorado: U.S. Geological Survey Water-Resources Investigations Report 82-4055, 1 sheet, scale 1:250,000.

138. Botorff, R.L., 1974, Cottonwood habitat for birds in Colorado: Am. Birds, v. 28, p. 975-979.

139. Botorff, R.L., Hurley, N., Trainor, J., and Kingery, H., 1973, Floodplain cottonwood forest: Amer. Birds, v. 27, p. 996-997.

140. Botorff, R.L., Hurley, N., Kingery, H., Stotz, D., and Trainor, J., 1974, Floodplain cottonwood forest: Amer. Birds, v. 28, p. 1036-1037.

141. Boudreaux, J., 1982, Special report to Endangered Species Office, Region 6, Fish and Wildlife Service - Review and analysis of Platte River studies: Batchley Associates, Inc.

142. Boulder Area Growth Study Commission, 1973, Exploring options for the future: A study of growth in Boulder County. Volume X. Summary Final report: Colo., CPA-CO-08-00-0111-10, 90 p.

The volume contains a compilation of summaries authored by the Commission's supporting consultants. Each summary appears in the related volume. The intent of this volume is to provide the reader with a convenient method of reviewing recommendations made to the Commission by its consultants. The format of the summaries is not consistent; in most cases, the summary does contain findings and recommendations. Summaries from the following reports are included in this volume: Final commission report; Economic-demographic projections; Environmental constraints and opportunities; Land use aspects; Public finance and optimum size; Legal-political aspects; Solid waste, and Judgments about growth. Summaries were not prepared for Business Conditions, Economic Incentives and Disincentives, and Social Aspects.

143. Boulder Area Growth Study Commission, 1973, Exploring options for the future: A study of growth in Boulder County. Volume VII. Solid Waste Final rept: Colo., CPA-CO-08-00-0111-7, 87 p.

The report analyzes and forecasts solid waste generation and disposal for the four model futures selected by the Commission for research purposes. The report identifies suitable land fill sites remaining in Boulder County with recognition to appropriate land use and environmental suitability. The report forecasts county landfill requirements and recommends disposal techniques to reduce future site requirements.

144. Boulder Area Growth Study Commission, 1973, Exploring options for the future: A study of growth in Boulder County. Volume VI. Legal-political aspects and economic incentives and disincentives. Final report: Colo., CPA-CO-08-00-0111-6, 191 p.

The Legal-Political Aspects Report is concerned with legal issues relating to growth control. The report contains six papers; five of the papers address specific legal issues and the sixth evaluates the legal constraints and opportunities of policies developed for the four model futures selected by the Commission for research purposes. Issues addressed in the papers are legal restraint on land use zoning, transferable development rights credits, municipal extra-territorial powers, utility timing, and greenbelt as a growth control device. Business Incentives-Disincentives Report is concerned with two tax devices to control growth in the City of Boulder: employment opportunity tax and land appreciation tax.

145. Boulder Area Growth Study Commission, 1973, Exploring options for the future: A study of growth in Boulder County. Volume IV. Land use aspects. Final report: Colo., CPA-CO-08-00-0111-4, 229 p.

The report analyzes patterns of urbanization and population allocation in Boulder County as well as land use, density, open space characteristics, transportation, and housing aspects. It provides a regional overview of land use in the Front Range corridor of the State and the Denver metropolitan area. Based on population projections provided by the Economic-Demographic Consultants and consultation with municipal planning agencies in the county, the report allocates population to geographic areas and illustrates the resulting land use patterns. Land use is analyzed for each of the four model futures selected by the Commission for research purposes.

146. Boulder Area Growth Study Commission, 1973, Exploring options for the future: A study of growth in Boulder County. Volume III. Environmental constraints and opportunities. Final report: Colo., CPA-CO-08-00-0111-3, 388 p.

The report provides an environmental inventory of Boulder County and land use recommendations derived from the inventory. The inventory, which includes data on bedrock and surficial geology, vegetation, climate, soils, mineral and water resources, wildlife, and natural hazards, was compiled from existing data and augmented, where necessary, by information obtained from high altitude aircraft imagery.

147. Boulder Area Growth Study Commission, 1973, Exploring options for the future: A study of growth in Boulder County. Volume I. Commission Final Report: Colo., CPA-CO-08-00-0111-1, 175 p.

The report is based primarily upon the research performed by thirteen consultants contracted by the Boulder Area Growth Study Commission to analyze past and future legal, social, and economic factors relating to the four model futures (Model 1, Continuation of current trends and policies; Model 2, No-growth; Model 3, Emphasis on environmental factors; and Model 4, Emphasis on social, cultural, and economic aspects) selected by the Commission for research purposes. This report contains recommendations proposed by the Commission to ultimately manage growth in Boulder County in order to maintain a quality of life for all its citizens.

148. Boulding, K.E., 1976, Technology/Society: How nature herself frustrates our efforts to know her and to articulate her order: Technology Review, v. 79, no. 1 (October-November).

149. Boyd, D., 1897, Irrigation near Greeley, Colorado: U.S. Geological Survey Water-Supply Paper 9, 90 p.

150. Boyles, J.M., Cain, D., Alley, W.M. and Klusman, R.W., [n.d.], Impact of Argo Tunnel acid mine drainage, Clear Creek County, Colorado, *in* Water resources problems related to mining; proceedings: Golden, Colo., Colorado School of Mines, p. 41-53.

The Argo Tunnel acid mine drainage, Idaho Springs, Colorado, was investigated concerning its impact on the water quality of Clear Creek and possibilities for minimizing this impact. Laboratory studies indicated the following order of precipitation of Argo's heavy metals with rising pH: Fe, Cu, Zn, Cd, Mn. This order of precipitation was substantiated by data from extensive water sampling in the Argo area. On the basis of the USPHS drinking water standards, Fe and Mn were the most serious contaminants introduced into Clear Creek. However, the data indicates that Cu, Zn, and Fe from the Argo drainage will be detrimental to fish and other aquatic life downstream. Metal concentrations in Clear Creek downstream from the Argo drainage will generally be the greatest during the winter months when the flow of Clear Creek is low. The heavy metal content of limonite coatings on rocks downstream from the Argo drainage reflects the order of precipitation of heavy metals in the creek water. Fly ash, lime, limestone, and soda ash were used to neutralize Argo water, with lime giving the best results. Calculations indicated that neutralization of Argo water may be economically feasible if Cu, Zn, and possibly Mn, are recovered.

151. Braidich, T., 1973, Sediment oxygen demand study, South Platte River, Boulder Creek, and St. Vrain Creek, Colorado: Denver, Colo., U.S. Environmental Protection Agency, Region VIII, 4 p.

152. Bredehoeft, J.D. and Young, R.A., 1983, Conjunctive use of ground water and surface water for irrigated agriculture; risk aversion, *in* American Geophysical Union, Fall meeting. Eos, Transactions, Dec. 5-9, 1983: v. 64, San Francisco, Calif., American Geophysical Union, 708 p.

153. Bredehoeft, J.D., and Young, R.A., 1983, Conjunctive use of ground-water and surface water for irrigated agriculture: risk aversion: Water Resources Research Journal, v. 19, no. 5 (October), p. 1111-1121.

In the South Platte system in Colorado where surface water and groundwater are used conjunctively for irrigation, the actual installed well capacity is approximately sufficient to irrigate the entire area. This would appear to be an overinvestment in well capacity. The extent to which groundwater is being developed as insurance against periods of low streamflow is examined, using a simulation model which couples the hydrology of a conjunctive stream aquifer system to a behavioral-economic model which incorporates farmer behavior in such a system. The area modeled is patterned after a reach of the South Platte Valley in Colorado. Under current economic conditions the most reasonable groundwater pumping capacity is a total capacity capable of irrigating the available acreage with groundwater. Installing sufficient well capacity to irrigate all available acreage has two benefits: this capacity maximizes the expected net benefits and this capacity also minimizes the variation in annual income (it reduces the variance to essentially zero). The present Colorado plan of 5% flow augmentation may be small in really dry years. An augmentation capacity approaching 10% may be necessary in dry years such as occurred from 1953 to 1956. As pumping capacity is installed in a conjunctive use system, the value of flow forecasts is diminished. Poor forecasts are compensated for by pumping groundwater. It is questionable in systems such as the South Platte with a large installed well capacity for most of the area that one should spend much effort on improving flow forcasts for water supply purposes.

154. Bredehoeft, J.D., and Young, R.A., 1988, Risk aversion in conjunctive water use, *in* Efficiency in irrigation: the conjunctive use of surface and groundwater resources: Arlington, Va., Winrock International, p. 155-167.

The South Platte River system of Colorado uses surface and groundwater conjunctively for irrigation. Yet actual well capacity is approximately sufficient to irrigate the entire area. In order to examine the objectives of the individual farmers, a hydrologic model was coupled with an economic model. A simulation model that captured many of the essential elements of both the hydrologic system and the economics of allocating irrigation water was used to investigate a hypothetical reach of stream and interconnected aquifer which supported an agricultural economy. The evaluation attempted to determine the role of the vx8ah%=9 in water supplies in motivating farmers' investments in groundwater capacity. It was determined that using the groundwater aquifer as a reservoir in a conjunctive water system such as that typified by the South Platte in Colorado greatly increases the economic benefits to be derived from the system. The results suggest that under the current economic conditions existing in the area, the most reasonable groundwater capacity is a total capacity capable of irrigating all the available acreage with groundwater. It is further suggested that the additional costs of pumping groundwater are not significant. Installing sufficient pumping capacity to irrigate all available acreage has two benefits: it maximizes the expected net benefit, and it reduces the variance in expected income to nearly zero. The present Colorado plan of 5% flow augmentation may be small in really dry years. It is expected that augmentation capacity approaching 10% may be necessary in such dry years as occurred from 1953 to 1956. As pumping capacity is installed in a conjunctive use system, the value of flow forecasts diminishes since poor forecasts are compensated for by pumping from the wells.

155. Brewster, R. H., 1986, The distribution and chemistry of rare- earth minerals in the South Platte pegmatite district, Colorado, and their genetic implications: New Orleans, La., Univ. of New Orleans, 139 p.

156. Brewster, R.H., and Simmons, W.B., 1986, The distribution and chemistry of allanite and samarskite in the South Platte pegmatite district and their genetic implications; abstracts, short papers, and field guides from the Colorado pegmatite symposium, *in* Modreski, P.J., Fitzpatrick, J., Foord, E.E., and Kohnen, T.M., eds., Colorado Pegmatite Symposium: Denver, Colo., Friends Mineral., Colo. Chapter, p. 27-29.

157. Brey, H.L., 1991, Fort St. Vrain operations and future: Energy, v. 16, no. 1-2 (January-February).

158. Brey, H.L., Kantor, M.E., and Warembourg, D.W., 1982, Fort St. Vrain reaches full power: Nuclear Engineering International, v. 27, no. 323 (February).

159. Breyer, J., 1975, The classification of Ogallala sediments in western Nebraska studies on Cenozoic paleontology and stratigraphy in honour of Claude W. Hibbard, in Smith, G.R., and Friedland, N.E., eds., Papers on Paleontology: p. 1-8.

160. Bringley, F.J., 1950, Plankton populations of certain streams in the Rocky Mountain National Park: Ohio Journal of Science, v. 50, p. 243-250.

161. Britton, L.J., and Gaggiani, N.G., 1986, Water-quality assessment of Arvada Reservoir, Denver Metropolitan Area, Colorado: U.S. Geological Survey Open-File Report 86-489, 200 p.

Physical, chemical, and biological water-quality data were collected and compiled for five sites in Arvada Reservoir, one site in Ralston Creek, and two sites in Croke Canal, in the Denver metropolitan area, Colorado. The purpose of the data collection was to determine the water quality of Arvada Reservoir, evaluate the effect of source waters on the reservoir, and determine the trophic state of the reservoir. Data collected include reservoir profile measurements with depth and inflow measurements of water temperature, specific conductance, dissolved oxygen, and pH. Secchi disk depth measurements also are reported. In addition, water samples were analyzed periodically for concentrations of major chemical constituents, nutrients, trace elements, and selected radiochemicals; for densities and relative abundance of phytoplankton and zooplankton; and for concentrations of chlorophyll alpha. Results of algal growth potential determinations are included. This report describes sampling site locations and methods of data collection and analyses and presents qualitative and quantitative results of water-quality data collected during the study. Sampling began during June 1983 and continued through September 1985.

162. Britton, L.J., and Gaggiani, N.G., 1988, Water-quality assessment of Arvada Reservoir, Denver Metropolitan Area, Colorado: U.S. Geological Survey Water-Resources Investigations Report 87-4107, 200 p.

Water quality data were collected from Arvada Reservoir, Colorado, which completed filling in May 1984, and from its major inflows, Ralston Creek and Croke Canal, to assess the physical, chemical, and biological quality of the reservoir; to evaluate the effect of water from various sources on the reservoir; and to estimate the trophic state of the reservoir. Data were collected at five sites in Arvada Reservoir, one site in Ralston Creek, and two sites in Croke Canal. The study began in June 1983 and continued through September 1985. The reservoir was thermally stratified on most sampling dates, generally from April through September during the study period. Dissolved-oxygen concentrations ranged from 0 to 12.0 mg/L, and the reservoir was anaerobic below the 10 m depth during most of the summer. Secchi-disk-depth measurements ranged from 0.9 to 5.5 m and generally increased during the study period, possibly because of decreases in nonalgal turbidity after the reservoir was filled. The results of chemical analyses indicate that water from the reservoir generally is of suitable quality for a raw-water- supply source and for maintenance of aquatic life. Total- nitrogen and total-phosphorus concentrations were small, and both were growth-limiting factors in the reservoir. The phytoplankton community was diverse, and the most dominant taxa were diatoms. Phytoplankton densities ranged from 1,400 to 29,000 cells/milliliter, and chlorophyll a concentrations ranged from 0.0 to 20.4 micrograms/L.

163. Broadhurst, W.L., and Glover, R.E., 1972, Deep percolation in a sand hill area. Discussion and reply for original article by Glover, Robert E. see Water Resour. Bull., 8(2), p. 399-400, 1972 (Pap. No. TN72038): Water Resources Bulletin (Urbana), v. 8, no. 4, p. 834.

164. Brubacher, J.I., and Moore, T.R., [n.d.], Soil survey of Sedgwick County, Colorado: Julesburg, Colo., U.S. Dept. of Agriculture, Soil Conservation Service.

167. Bryant, B., and Hedge, C.E., 1978, Granite of Rosalie Peak, a phase of the 1700-million-year-old Mount Evans Pluton, Front Range, Colorado: Journal of Research, v. 6, no. 4, p. 447-451.

168. Bryant, B., McCrew, L.W., and Wobus, R.A., 1981, Geologic map of the Denver 1 x 2 degrees quadrangle: U.S. Geological Survey Miscellaneous Investigations Series Map I-1163, scale 1:250,000.

169. Bryant, B., McCrew, L.W., and Wobus, R.A., 1978, Preliminary geologic map of the Denver 1 x 2 degrees quadrangle, north-central Colorado: U.S. Geological Survey Open-File Report 78-397.

170. Buchholz, R.J., and Knotczynski, M., 1988, Sediment flushing experiences at Cherry Creek Dam, *in* Abt, S.R., and Gessler, J., 1988 National Conference on Hydraulic Engineering: New York, N.Y., Am. Soc. Civ. Eng., p. 1062-1067.

171. Bucknam, R. C., 1969, Structure and petrology of Precambrian rocks, Glen Haven quad, Larimer County, Colorado: University of Colorado, Ph.D. dissertation, 92 p.

172. Buckwalter, T. V., 1950, Geology of the southern part of the Never Summer Mountains, CO.: University of Colorado, Ph.D. dissertation.

173. Bunnell, D.B., and Peters, E.J., 1987, Habitat use by channel catfish (*Ictalurus punctatus*) and flathead catfish *(Pylodictis olivaris)* in the Platte River, Nebraska: Proc. Nebr. Acad. Sci., v. 97, no. 9.

174. Bureau of Land Management, 1977, Final environmental impact statement; proposed Foothills Project: Washington, D.C., Department of the Interior, 2 p.

175. Bureau of Outdoor Recreation, 1977, National urban recreation study: Denver, Boulder: NPS report 79-001610.

Existing parks and recreation resources in the Denver and Boulder areas are remarkably varied, numerous, and well dispersed. City and neighborhood parks are nearly adequate in numbers, well kept, and generally well located. Resources considered regionally significant include museums, zoos, botanical gardens, four State parks including three reservoir recreation areas, and a series of mountain parks operated by several municipalities and county governments. Although urban recreation development in both Denver and Boulder is progressing well, there are two significant problems: the present funding sources are inadequate to construct many of the desired kinds of facilities; and operation and maintenance funding on the local level often is not adequate and will become more of a problem as more development occurs. As a result of funding problems, many areas now owned by the various parks departments are not open to the public. Several funding assistance alternatives are presented, including various federal grant programs and federal tax incentives (numerous diagrams, maps, photos, references, tables).

176. Bureau of Outdoor Recreation, 1972, Proposed 1976 Denver Winter Olympic Games draft environmental impact statement: Washington, D.C., ELR-4676; DES-72-65, 95 p.

The attached environmental statement is general in nature, meant to cover the overall and cumulative impact of holding the 1976 Games in Colorado. The statement discusses the environmental impact at the five general site vicinities and the total Olympic effort. While the Olympics is intended to be neither an environmental improving nor environmental degrading project, it may have far-ranging environmental significance. Discussed are the environmental impacts which are thought to fall into six broad categories: Site alterations; Economic growth and development; General environmental and land use relationships; Related public works expenditures and facilities; Legislative and administrative action; and International.

177. Burke, J.C., Klusek, C.S., Volchok, H.L., and Heit, M., 1980, Time history of trace elements in sediments from Standley Lake, Colorado: Environment International, v. 4, no. 3.

178. Burkham, D.E., Dawdy, D.R., and Barnes, H.H., Jr., 1980, Flow resistance in cobble and boulder river beds. Discussion for original article by Simons, D. B.; Al-Shaikh-Ali, K.; and Ruh- Ming Li, see Vol. 105, No. HY5, 1979: Journal of the Hydraulics Division, v. 106, no. HY6, p. 1132-1138.

179. Burkhard, W.T., 1978, Vertebrate associations in lowland versus high elevation river and stream habitat in Colorado, *in* Graul, W.D., and Bissell, S.J., eds., Lowland river and stream habitat in Colorado: a symposium: Greeley, Colo., Colorado Chapter of Wildl. Soc. and Colorado Audubon Council.

180. Burns, A.W., 1980, Hydrologic analysis of the proposed Badger-Beaver Creeks Artificial Recharge Project, Morgan County, Colorado: U.S. Geological Survey Water-Resources Investigations 80-46, 90 p.

A hydrologic analysis of the proposed Badger-Beaver Creeks artificial-recharge project in Morgan County, Colo., was made with the aid of three digital computer models: a canal- distribution model, a ground-water flow model, and a stream-aquifer model. Statistical summaries of probable diversions from the South Platte River based on a 27-year period of historical flows indicate that an average-annual diversion of 96,000 acre-feet and a median-annual diversion of 43,000 acre-feet would be available. Diversions would sustain water in ponds for waterfowl habitat for an average of about 5 months per year, with a miximum pond surface area of about 300 acres with the median diversions and a maximum pond surface area of about 1,250 acres at least one-half of the years with the historic diversions. If the annual diversion were 43,000 acre-feet, recharge to the two alluvial aquifers would raise water levels sufficiently to create flowing streams in the channels of Beaver and Badger Creeks while allowing an increase in current ground-water pumping. The only area of significant waterlogging would be along the proposed delivery canal on the west edge of Badger Creek valley. If the total water available were diverted, the aquifer system could not transmit the water fast enough to the irrigation areas to avoid considerable waterlogging in the recharge areas. The impact of the proposed project on the South Platte River basin would be minimal once the ground-water system attained steady-state conditions, but that may take decades with a uniform diversion of the 43,000 acre-feet annually.

181. Burns, A.W., 1983, Hydrologic data from the Tamarack Wildlife area and vicinity, Logan County, Colorado: U.S. Geological Survey Open-File Report 83-139, 123 p.

182. Burns, A.W., 1985, Hydrologic description of the Tamarack Wildlife area and vicinity, Logan County, Colorado, and simulated effects of possible water-management activities: U.S. Geological Survey Water-Resources Investigations Report 85-4014, 42 p.

The stream-aquifer system of the Tamarack Wildlife Area and vicinity in Logan County, Colorado, is described using analyses of water level, water temperature, and specific conductance data. Correlation analysis indicated that water levels in the flood plain relate better to those in the river than those in the upgradient valley meadow. Water table surfaces showed that water moves parallel to the river with a small gradient toward the river. Water temperature data for the river had a large annual fluctuation. The temperature of well water from 0 feet below land surface had no fluctuation. The temperature of sloughs and shallow groundwater had intermediate fluctuations. Specific conductance data ranged from 264 microsiemens/cm at 25 degrees C in sandhill wells to 1,540 microsiemens in the river. A groundwater flow model and simplified slough-temperature model showed that additional groundwater pumpage or lower river stage caused by upstream diversions would decrease groundwater inflow to the slough, with a corresponding water temperature decrease. A simulated artificial recharge project would increase groundwater inflow to the slough and increase water temperature in the slough. The simulation of a plan to pump groundwater to create wildlife-habitat ponds indicated that this would cause stream depletions each month, except during the nonpumping period, June through August.

183. Burns, A.W., 1981, Simulated hydrologic effects of possible ground-water and surface-water management alternatives in and near the Platte River, south-central Nebraska: U.S. Geological Survey Open-File Report 81-1116, 41 p.

184. Burns, A.W., 1981, Simulated interactions between the proposed Narrows Reservoir and the water-table aquifer along the South Platte River, Morgan County, Colorado: U. S. Geological Survey Water-Resources Investigations 80-119, 67 p.

A computer model, including a ground-water-flow component and a mass balance reservoir-operations component, was developed to simulate the proposed Narrows Reservoir and the adjacent alluvial aquifer of the South Platte River, Morgan County, Colo. This model, using a weekly time step, simulated the transient interactions of these two systems for an initial-fill condition and general-operational condition. A sensitivity analysis was made to test the effects of possible errors in the description of aquifer characteristics on the model results. The initial-fill simulation indicated that to fill the reservoir when hydraulic connection between the surface-water system and the aquifer is simulated would take 2 additional years than if no connection was assumed. Simulated ground-water return flow to the river downstream of the proposed dam was about 85 percent of the estimated maximum values, computed under steady-state conditions in an earlier study. The general operation simulation indicated that during the period of lowest reservoir contents the aquifer provided about 80,000 acre-feet of recoverable storage to the reservoir's capacity. Average return flow was only about 70 percent of the estimated maximum values computed in the earlier, steady-state analysis. Monthly ground-water outflow from the reservoir to the aquifer ranged from 55,200 to -10, 400 acre-feet. Parameters tested for sensitivity, in order of decreasing sensitivity, were: hydraulic conductivity, specific yield, hydraulic connection between reservoir and aquifer, local recharge, boundary conditions, and dam permeability. The probable error in the parameters tested would not seem to warrant significant new data collection.

185. Burns, A.W., 1984, Simulated effects of an artificial-recharge experiment near Proctor, Logan County, Colorado: U.S. Geological Survey Water-Resources Investigations 84-4010, 17 p.

187. Burns, A.W., and Weeks, J.B., 1976, Simulated effects of the proposed Narrows Reservoir on the water-table aquifer along the South Platte River, Morgan County, Colorado: U.S. Geological Survey Open-File Report 76-379, 15 p.

A computer model was used to estimate the effects of the proposed Narrows Reservoir on the alluvial aquifer adjacent to the South Platte River near Fort Morgan, Colo. Changes in ground-water discharge to the river caused by the proposed reservoir were estimated assuming steady-state conditions. The proposed reservoir was simulated for two different reservoir pool altitudes. For the conditions simulated, the principal effects of the proposed reservoir on the ground-water system would be an increase in water-table altitude in the aquifer and a redistribution of ground-water discharge to the South Platte River. The change in water level at Fort Morgan was less than 1 foot for the two reservoir conditions simulated. No significant change in the ground-water system would occur downstream from Fort Morgan. Ground-water discharge would decrease by 24 cubic feet per second (cfs) above the proposed dam and increase by 24 cfs below the proposed dam for steady-state conditions with the reservoir pool at 4,404 feet. Ground-water discharge would decrease by 11 cfs above the proposed dam and increase by 15 cfs below the proposed dam for steady-state conditions with the reservoir pool at 4,383 feet.

188. Burritt, E. C., 1962, A ground water study of part of the southern Laramie Basin, Albany County, Wyoming: Laramie, Wyo., Univ. of Wyoming.

189. Butler, R., 1977, Hydrogeology of the Upper Drainage, Middle Fork, South Platte River, Park County, Colorado: Golden, Colo., Colorado School of Mines.

190. Cadle, S.H., Countess, R.J., and Wolff, G.T., 1980, The Denver winter aerosol: a comprehensive chemical characterization: Journal of the Air Pollution Control Association, v. 30, no. 11 (November).

191. Cady, R.E., and Peckenpaugh, J.M., 1985, Documentation of a regional aquifer simulation model, RAQSIM, and a description of support programs applied in the Platte and Republican areas, Nebraska: U.S. Geological Survey Water-Resources Investigation 85-4168, 239 p.

192. Cain, D., Helsel, D.R., and Ragone, S.E., 1989, Preliminary evaluations of regional ground-water quality in relation to land use: Ground Water, v. 27, no. 2, p. 230-244.

193. Cain, D., Helsel, D.R. and Ragone, S.E., 1989, Reconnaissance appraisals of anthropogenic effects on regional ground-water quality, *in* B.J. Franks, ed., Third technical meeting on U.S. Geological Survey program on toxic waste-ground water contamination, Pensacola, Fla., March 23-27, 1987: U.S. Geological Survey Open-File Report 87-109, p. 25-31.

194. Callam, M.A., and others, 1990, 1990 Nebraska water quality report: Lincoln, Nebr., Water Quality Division, Department of Environmental Control, State of Nebraska, 309 p.

195. Camargo, J.A., Ward, J.V., and Martin, K.L., 1992, The relative sensitivity of competing hydropsychid species to fluoride toxicity in the Cache La Poudre River (Colorado): Arch. Envir. Contam. Toxicol., v. 22.

196. Canton, S.P., Cline, L.D., Short, R.A., and Ward, J.V., 1984, The macroinvertebrates and fish of a Colorado stream during a period of fluctuating discharge: Freshwater Biology, v. 14, no. 3, p. 311-316.

197. Carnahan, C.T., 1949, Project effect on South Platte River Pollution: Denver, Colo., U.S. Bureau of Reclamation, Technical Editorial Office, Engineering Monographs 4, 20 p.

198. Carpenter, L.G., 1916, Seepage and return water: Fort Collins, Colo., Colorado State University Agricultural Experimental Station Bulletin 180; part 1.

199. Carten, R.B., Geraghty, E.P., Walker, B.M., and Shannon, J.R., 1988, Cyclic development of igneous features and their relationship to high-temperature hydrothermal features in the Henderson porphyry molybdenum deposit, Colorado: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 83, no. 2, p. 266-296.

200. Cech, T.V., 1984, Conjunctive use of ground water and surface water in the South Platte River Basin:a case study of the Central Colorado Water Conservancy District, *in* Proceedings of NWWA Western Regional Conference on Ground Water Management, San Diego, Calif., October 23-26, 1983: Worthington, Ohio, National Water Well Association, p. 16-21.

The Doctrine of Prior Appropriation was adopted in the late 19th century in Colorado, allocating surface water to irrigators based on the date of their appropriation. This law created poor management of scarce water resources. The 1957 Act instituted a permitting process and laid the framework for administration of groundwater in the State. The Ground Water Management Act of 1965 regulated non-tributary groundwater and formed districts to manage groundwater within the designated basins. The Water Right Determination and Administration Act of 1969 placed irrigation wells under the priority system. In effect, the law requires all tributary irrigation wells to shut down during periods when water is needed to maintain surface-water flow. Since the economy of eastern Colorado relies heavily on the 10,000 tributary irrigation wells of the South Platte River, these wells are allowed to pump only if they replace 5% of pumped water back into the river for surface irrigators. The Central Colorado Water Conservancy District formed a Ground Water Management Subdistrict in 1973 to provide a mechanism for administrating the allocation and replacement of this augmentation water so that irrigation wells could continue to pump. Six thousand acre-feet of water are acquired each year for augmentation. The district owns and leases ditch company stock, has a battery of wells that pump directly into the South Platte River, and is developing a series of small reservoirs to capture spring runoff for augmentation during low flow months.

201. Cech, T.V., 1987, Conjunctive use of surface and ground water in the South Platte River basin: a case study of the Central Colorado Water Conservancy District, *in* Fairchild, D.M., ed., Ground water quality and agricultural practices: Chelsea, Mich., Lewis Publishers, p. 47-56.

The mainstream South Platte River and its tributaries exhibit wide variation in water-quality characteristics. Most streams in the upstream part of the basin have small dissolved-solids concentrations, providing excellent stream quality for most water uses. Water quality declines in the South Platte as it flows through the metropolitan Denver area, probably due to municipal and industrial wastewater discharges and nonpoint source contributions such as lawn irrigation and urban runoff. Agricultural return flows and runoff from feed lots have affected water quality downstream of Denver. Large concentrations of nitrogen and phosphorous have been measured in the area in the South Platte River and in the adjacent aquifer. The existence of large amounts of dissolved-solids and sulfates have created some problems for downstream municipal and domestic water supplies. Degradation of ground water has been noted in several areas of the basin. Dissolved-solids concentrations in alluvial ground water are consistently greater than average concentrations in the adjacent South Platte River. Ground water administration in Colorado has developed into a complex network of permits, hearings, and legal doctrine. With the continued competition for water along the Front Range of the State, entities with large water demands and sizable revenues cities, will be best able to continue to develop and acquire valuable water rights. The implications for the ground water irrigators are great. Not only will they continue to be required to pay for augmentation water to offset the depletion of the river caused by out-of-priority pumping, but they will also be charged higher and higher fees to acquire such water for augmentation. The physical allocation and administrative tools of ground water in Colorado are in place, but the economic effects of the existing system may be devastating to the ground water irrigator of the future.

202. Cech, T.V., 1990, Ground water management in the South Platte basin of Colorado: Water Well Journal, v. 44, no. 6 (June), p. 52-54.

The Water Rights Determination Act of 1969 has resulted in improved management of scarce water resources in the South Platte River Basin. This law brought irrigators who were pumping from the alluvial aquifer of a stream within the priority system of surface users. To meet the requirements of this law, which was amended in 1975 to apply to only underground water, junior diverters using tributary wells are required to replace the resulting depletions to the river so that no injury occurs to senior water rights. This is generally achieved by purchasing replacement water to be used by senior diverters, or through groundwater recharge. Of these two practices, recharge has proven to be an economical method for groundwater users to augment their irrigation flows. Approximately 50 recharge projects are presently located in the basin and are responsible for artificially recharging 384,000 acre-feet of groundwater. This particular example of groundwater management in the South Platte Basin shows that legislation sensitive to the interrelationship of surface water and alluvial groundwater can encourage the development of groundwater projects, that recharge is an economical way to meet some of the augmentation requirements of 1969 act, and that significant amounts of water can be recharged in northeastern Colorado as long as adequate amounts of water are available during spring and winter months.

203. Cerny, P., Simmons, W.B., Chackowsky, L.W., and Chapman, R., 1986, Niobian rutile and ilmenite from the McGuire Pegmatite, Colorado, and their breakdown products, *in* Modreski, P.J., Fitzpatrick, J., Foord, E.E., and Kohnen, T.M., eds., Colorado pegmatites; abstracts, short papers, and field guides from the Colorado pegmatite symposium: Denver, Colo., Friends Mineral., Colo. Chapter.

204. Cerrillo, L. A., 1967, The hydrogeology of the Beaver Creek drainage basin, Larimer County, Colorado: Fort Collins, Colo., Colorado State University.

205. Chalmers, K.W., 1960, Future water requirements and supplies for the South Platte River Basin, *in* Western Resources Conference, August 22-26, 1960: Boulder, Colo., University of Colorado.

206. Chang, J.Y., and Guo, J.C. Y., 1989, Hydrologic data automation using AutoCAD, *in* Proceedings of stormwater and water quality model users group meeting, Denver, Colo., October 3-4, 1988: EPA Report No. EPA/600/9-89/001, p. 142-148.

CUHPCAD is a computer program developed for the promotion of hydrological data automation, which serves as a control program to link between AutoCAD and the CUHP program. The program was developed for the purpose of hydrologic data automation, and consists of two parts: (1) the CUHP.LSP program which analyzes and stores the data generated by using AutoCAD; and (2) the CUHPCAD.BAS program which can abstract the data from CUHP.LSP and perform data calculation and preparation of CUHP data input files. The CUHPCAD program has been tested and applied to a major drainage basin planning project for the study of Second, Third, and Box Elder Creeks in Adams County, CO. The study area is approximately 70 sq mi. Total sub-basin number is 390. Soil types include A, B, and C groups based on Soil Conservation Service's soil survey report. Land use for existing conditions are mostly agricultural. Three baseline hydrological conditions for the frequencies of 20, 5-, 10-, and 100-year need to be modeled by using CUHP which includes existing basin conditions, and future basin conditions with or without the proposed New Denver Airport. With the use of CUHPCAD, the hydrology portion of this project was completed within the allowable schedule and budget. After the manual preparation of the basin map, soil map, and the land use map, the input of all maps to the computer was completed.

207. Chatfield Basin Water-Quality Association, 1989, Annual water-quality monitoring data for Chatfield Basin, 1986-1989 (annual data summary): Data on file at Denver Regional Council of Governments, Denver, Colo.

208. Cheadle, L.J., and C.R. Thorne, 1988, Flow hydraulics and sediment transport of the Roaring River, Rocky Mountain National Park, Colorado: London, Queen Mary College and Colorado State University, M.S. thesis.

209. Cherry Creek Water Quality Authority, 1989, Annual water quality monitoring reports, 1988-1989 - Reports presented to the Water Quality Control Commission: [Denver, Colo.], Data on file at Denver Regional Council of Governments.

210. Choules, G.L., Russell, W.C., and Gauthier, D.A., 1978, Duck mortality from detergent polluted water: Journal Wildl. Mgmt., v. 42, no. 2, p. 410-414.

211. Christy, S., 1972, Plant communities of the South Platte River floodplain in Colorado: J. Colo-Wyo. Acad. Sci., v. 7, p. 31.

212. Christy, S., 1972, Woody vegetation along the South Platte River in northeastern Colorado: J. Colo.-Wyo. Acad. Sci., v. 7, p. 106.

213. Chronic, Felicie, and Chronic, John, 1974, Bibliography and index of geology and hydrology, Front Urban Corridor, Colorado: U.S. Geological Survey Bulletin 1306, 102 p.

214. City of Northglenn, 1977, Northglenn agricultural reuse service area facilities plan: Summary Report, 13 p.

215. Clarkin, K.L., Harvey, M.D., Elkin, A. and McIntyre, S.C., 1986, Sediment storage and delivery, eastern Colorado, *in* Proceedings of the Fourth Federal Interagency Sedimentation Conference, Volume I, Las Vegas, Nev., March 24-27, 1986: p. 3.54-3.62.

Differences in sediment delivery ratio at four small reservoirs in the Kiowa Creek watershed, Colorado, are related to basin storage capacity, measured as percent of total basin area in depositional sites. Storage capacity depends both on topography and the degree of integration of the incised channel network. In semi-arid areas, drainage network continuity, and therefore area available to store sediment, may change over time as a basin undergoes a cycle of high sediment production, storage and flushing. The results of this study illustrate the fact that delivery ratios estimated from empirical relationships with drainage area or channel or watershed slope can result in gross over- or underdesign of reservoir sediment pools. Watershed sediment budgets in conjunction with results from Cs-137 profiles in stored sediments suggest that long-term average delivery ratios have increased in the K41 basin, where drainage network degradation and concurrent loss of storage capacity have occurred since 1955. In the B9 subbasins, where loss of basin storage capacity has been negligible, delivery ratios appear to have remained approximately constant.

216. Clayton, J.L., and King, J.D., 1984, Organic geochemistry of Pennsylvanian-Permian oils and black shales, northern Denver Basin, *in* AAPG annual convention with divisions; SEPM/EMD/DPA. AAPG Bulletin, May 20-23, 1984: v. 68(4), San Antonio, Tex., AAPG, p. 463.

217. Clayton, J.L., and Michael, G.E., 1990, Controls on porphyrin concentrations of Pennsylvanian organic-rich shales, western U.S.A, *in* Freeman, D.H., ed., American Chemical Society, 19th national meeting , Symposium on Porphyrin geochemistry; the quest for analytical reliability. Energy & Fuels: [Colo.?], ACS.

218. Cline, L.D., Short, R.A., and Ward, J.V., 1982, The influence of highway construction on the macroinvertebrates and epilithic algae of a high mountain stream: Hydrobiologia, v. 96, p. 149-159.

219. Cline, L.D., and Ward, J.V., 1984, Biological and physicochemical changes downstream from construction of a subalpine reservoir, Colorado, USA., *in* A. Lillehammer and S. J. Salveit, eds., Int. Symp. on Regulated Streams, Aug. 8, 1982: Oslo, Norway, University of Olso Press, p. 233-243.

During construction of a subalpine reservoir, upstream reference sites and 4 downstream sites were sampled to evaluate alterations in physicochemical, hydrological, and biological parameters. Dam construction activities did not significantly change stream pH, dissolved oxygen levels, bound carbon dioxide, or dissolved-solids concentrations. However, in stream reaches immediately downstream from construction activities, mean monthly suspended solids values were 2-30 times greater. Sedimentation, evaluated by measuring substrate mean particle size, varied according to local flow regime (erosional or depositional). Epilithon organic content decreased by 50%, macroinvertebrate density decreased as much as 80-90%, and compositional changes occurred. *Plecoptera* and *Ephemeroptera* decreased in relative abundance, whereas *Diptera*, especially *Chironomidae*, increased. Evidence of downstream hydrological and biological recovery was attributed to the relatively steep stream channel gradient and the ameliorative action of tributaries.

220. Cochran, B.J., Hodges, H.E., Livingston, R.K., and Jarrett, R.D., 1979, Rainfall-runoff data from small watersheds in Colorado, October 1974 through September 1977: U.S. Geological Survey Open-File Report 79-1261, 673 p.

Rainfall-runoff data from small watersheds in Colorado are being collected and analyzed for the purpose of defining the flood characteristics of these and other similar areas. Data collected from October 1974 through September 1977 at a total of 18 urban stations, 10 Denver Federal Center stations, and 48 rural (or highway) stations are tabulated at 5-minute time intervals. Additional information presented includes station descriptions and methods of data collection and analysis.

221. Cochran, B.J., Minges, D.R., Jarrett, R.D., and Veenhuis, J.E., 1983, Rainfall-runoff data from small watersheds in Colorado, October 1977 through September 1980: U.S. Geological Survey Open-File Report 82-873, 748 p.

Rainfall-runoff data from small watersheds in Colorado are being collected and analyzed for the purpose of defining the flood characteristics of these and other similar areas. Rainfall-runoff collected from October 1977 through September 1980 at a total of 37 urban stations, 10 Denver Federal Center stations, and 41 rural (or highway) stations are presented in tabular form along with station descriptions and methods of data collection and analysis.

222. Cockerell, T.D. D., 1908, Fishes of the Rocky Mountain Region: University of Colorado Studies, v. 5, p. 159-178.

223. Code, W.E., 1943, Use of ground water for irrigation in South Platte valley of Colorado: Fort Collins, Colo., Colorado State College Agricultural Experimental Station Bulletin 483, 44 p.

224. Code, W.E., and Tobiska, J.W., 1952, Report on mineralization of ground and surface waters of the South Platte River in Colorado: Fort Collins, Colo., Colo. State Univ. Agr. Exp. Sta. Miscellaneous Journal Series 500.

225. Cohen, D.B., 1974, Metro Denver's experience with large scale aerobic digestion of waste activated sludge, *in* Proceedings of the National Conference on Municipal Sludge Management, Pittsburgh, Pa., June 11-13, 1974: p. 37-53.

In 1970, the Metropolitan Denver Sewage District no. 1 (Metro) converted excess secondary aerators to aerobic digestors in two steps. The first part involved plant scale aerobic digestion of dilute W.A.S. in four converted secondary aeration basins. The second part involved extensive research and development to compare pilot open tank oxygen systems using both slot and rotating diffusers with this plant scale system. V.S.S. reductions ranged between 11.2% and 47.2% for the air system. A correlation between V.S.S. reduction and S.R.T. X temperature was shown to be significant. When invertebrates (especially rotifers) comprised a significant fraction of the biomass, digestion was maximum. No correlation between dissolved oxygen concentration and V.S.S. digestion rates was observed. At loadings greater than 0.14 pounds V.S.S./cu.ft/day, oxygen performance is superior. Aerobic digestion reduced sludge disposal costs. The Denver Sewage Disposal District (Metro) is now planning to convert a one million gallon tank to an oxygen aerobic digester with rotary diffusers.

226. Cole, J.C., 1977, Geology of east-central RMNP and vicinity with emphasis on the emplacement of the Precambrian Silver Plume granite in the Longs Peak-St. Vrain Batholith: Boulder, Colo., University of Colorado, Ph.D. dissertation, 344 p.

227. Colorado Department of Health, 1972, Standards for the discharge of wastes: Denver, Colo., Water Pollution Control Commission.

228. Colorado Department of Health, 1986, Water quality in Colorado 1986: Denver, Colo., Water Quality Control Division, Prepared in fulfillment of Section 305(b) of the Clean Water Act of 1977, 58 p.

229. Colorado Department of Health, 1987, Water quality standards and stream classifications: Denver, Colo., Water Pollution Control Commission.

230 Colorado Department of Health, 1990, Water quality in Colorado, 1990: Denver, Colo., Water Quality Control Division, EPA 305 (b) Report, variously paginated.

231. Colorado Department of Health, 1991, Colorado primary drinking water regulations: Denver, Colo., Water Quality Control Division, 79 p.

232. Colorado Department of Local Affairs, 208 Coordinating Unit, 1987, Water quality management plan, northeastern region: Denver, Colo., Water Quality Control Division, 92 p.

233. Colorado State Engineer, 1978, A drought relief study in the South Platte River Valley emphasizing conjunctive use: Denver, Colo.,

234. Colorado Water Conservation Board, [1981?], South Platte River basin assessment summary: Denver, Colo., Department of Natural Resources, 16 p.

235. Colorado Water Conservancy District and U.S. Environmental Protection Agency, [1977?], Water pollution elimination regulations challenged: 559 F. 2d 1179-1182 (10th Cir., 1977).

Petitioners sought review of respondent Environmental Protection Agency's (EPA) water pollution elimination regulations. Petitioners argued that the regulations were promulgated unlawfully and sought a final injunctión directing respondent to withdraw and rescind the regulations from the Code of Federal Regulations and issue new regulations. The new regulations desired were to be in compliance with the requirements of the Federal Water Pollution Control Act Amendments of 1972. In addition, petitioners sought an injunction prohibiting respondent from extending the National Pollutant Discharge Elimination System permit program to certain agricultural sources of pollutants. Respondent filed a motion to dismiss on jurisdictional grounds. The court found the record insufficient to rule on the jurisdictional issue. Accordingly, the motion to dismiss was denied without prejudice to respondent's right to renew the motion on review. The court found the briefs and oral arguments to be incomplete as well. Opposing counsel were directed to assess the impact of E.I. duPont de Nemours and Co. v. Train, 430 U.S. 112 (1977), on their dispute and also to brief the merits of the review fully.

236. Colorado Water Quality Control Division, 1988, Colorado nonpoint assessment report: Denver, Colo., Colorado Department of Health, 160 p.

237. Colorado Water Quality Control Division, 1989, Rationale amendment number 1, City of Glendale, Arapahoe County, Denver: Denver, Colo., Colorado Department of Health, NPDES Permit Report CO-0020095, 4 p.

238. Colorado Water Quality Control Division, 1989, Summary of rationale, cities of Englewood and Littleton, Arapahoe County, Denver: Denver, Colo., Colorado Department of Health, NPDES Permit Report CO-0032999, 15 p.

239. Colorado Water Quality Control Division, 1989, Summary of rationale, Centennial Water and Sanitation District, Douglas County, Denver: Denver, Colo., Colorado Department of Health, NPDES Permit Report CO-0037966, 18 p.

240. Colorado Water Resources Research Institute, 1981, A five-year plan for water research in Colorado: Fort Collins, Colo., Colorado State University.

241. Colorado Water Resources Research Institute, 1986, Fiscal Year 1985 Program Report: Fort Collins, Colo., Program Report G-1006- 01, 58 p.

The Colorado Water Resources Research Institute is the designated management center in Colorado for the Federal water research program. The Institute's Federal FY1985 Program consisted of six research projects focused on the following Colorado problems: (1) Potential Groundwater Contamination from Chemigation; (2) Geochemistry of Aquifer Recharge in the Denver Basin; (3) Incentives for Improving Irrigation Efficiency in the South Platte Basin (Phase I); (4) Compensation for Basin-of-Origin for Water Exports; (5) Evapotranspiration of Phreatophytes in the

Closed Basin, San Luis Valley (Phase II); and (6) The Impact of Water Conservation on Quality of Residential Lawns. In addition, the Institute received a State appropriation of $67,000. This appropriation provided supplemental funding for the project on Evapotranspiration of Phreatophytes in the Closed Basin, San Luis Valley and for the completion and calibration of the South Platte Basin Simulation Model (SAMSON). The appropriation also helped provide an effective Institute technology transfer program, fully integrated with its water research and development program. This includes: newsletters; three publications series; a 'library list' of new water resources research reports and publications; Project AWARE, designed to keep State and federal agency personnel aware of proposed research; public water policy education (programs including slide presentations); and workshops, seminars, and small group consultations involving potential users of research products.

242. Colorado Water Resources & Power Development Authority, 1986, St. Vrain basin reconnaissance study: Denver, Colo., summary report, variously paginated.

243. Colton, R.B., 1978, Geologic map of the Boulder-Fort Collins- Greeley area, Colorado: U.S. Geological Survey Map I-855-G, scale 1:100,000.

244. Colton, R.B., and Fitch, H.R., 1974, Map showing potential sources of gravel and crushed-rock aggregate in the Boulder-Fort Collins-Greeley area, Front Range Urban Corridor: U.S. Geological Survey Miscellaneous Investigations Series Map I- 855-D, scale 1:100,000.

245. Colton, R.B., and Lowrie, R.L., 1973, Map showing mined areas of the Boulder-Weld coal field, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-513, scale 1:24,000.

246. Conklin, D.J., Canton, S.P., and Chadwick, J.W., 1991, Fisheries of the South Platte River in Colorado (abstract only), *in* Woodring, R.C., ed., South Platte resource management: Finding a balance: Fort Collins, Colo., Colorado Water Resources Research Center, p. 31.

247. Conklin, L.R., [n.d.], Cost and returns for irrigated crop production in the lower South Platte Valley, Colorado: Fort Collins, Colo., Cooperative Extension Service, Colorado State University, Bulletin 491A.

248. Conner, R.C., and Brown, S.S., 1987, West-central Colorado: Forest statistics for State and private land, 1983 Forest Service Resource Bulletin: Ogden, Utah, U.S. Forest Service, FSRB/ INT-44, 56 p.

The report presents land area, timberland area, woodland area, timber inventory, and growth and mortality data for 14 counties in west-central Colorado. Information and statistical tables are based on Forest Survey data collected from 1982 and 1983 and cover State and private resources.

249. Conybeare, C.E.B., 1976, Geomorphology of oil and gas fields in sandstone bodies, *in* Developments in petroleum science: Amsterdam, Netherlands, Elsevier Sci. Publ. Co.

250. Cooley, M.E., 1986, Divisions of potential fracture permeability based on distribution of structures and lineaments in sedimentary rocks of the Rocky Mountains-High Plains Region, western US: U.S. Geological Survey Water-Resources Investigations Report 85-4091, 1 sheet.

251. Cooley, M.E., 1987, Preliminary surficial geology map of the Cheyenne urban area, Laramie County, Wyoming: U.S. Geological Survey Open-File Report 87-559.

The geologic map of the Cheyenne Urban Area shows the following elements: (1) artificial fill at miscellaneous sites; (2) artificial fill in areas of large residential developments constructed since 1945; (3) artificial fill in areas of extensive construction activity; (4) undifferentiated alluvium (Holocene); (5) terrace alluvium (Holocene); (6) alluvial fan deposits (Holocene); (7) slope deposits (Holocene and Pleistocene); (8) tan sandy alluvium (Pleistocene); (9) pediment deposits (Pleistocene); (10) deposits of terrace Qt1 (Pleistocene); (11) deposits of terraces Qt1A, Qt1B, Qt1C (Pleistocene); (12) Deposits of Qt2 (Pleistocene); (13) Deposits of terrace Qt3 (Pleistocene); (14) brown gravelly deposits (Pleistocene); and (15) Ogallalla formation (Miocene).

252. Cooley, M.E., and Crist, M.A., 1981, Generalized fence diagram showing stratigraphy and potentiometric surface of the Tertiary formations in southeastern Wyoming and an adjacent part of Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I-1308, 1 sheet.

Shows the distribution and thickness, including the saturated thickness, of the Tertiary Ogallala Formation, Arikaree Formation, and White River Group, and in one area the Quaternary terrace deposits. The potentiometric surface shown is representative of the water level during March 1977 (from New Publications of the Geological Survey, May 1981).

253. Cooper, D.J., 1988, Advance identification of wetlands in the city of Boulder Comprehensive Planning Area: Golden, Colo., Thorne Ecological Institute. Prepared for EPA Region VIII and City of Boulder, Co., 53 p.

254. Cooper, D.J., 1989, Structure and classification of Rocky Mountain Wetlands, in Windell, J.T., and Willard, B.E.,An ecological characterization of Rocky Mountain montane and subalpine wetlands: Golden, Colo., U.S. Fish and Wildlife Service.

255. Cooper, D.J., 1990, An evaluation of the effects of peat mining on wetlands in Park County, Colorado: Boulder, Colo., Prepared for Park County, 31 p.

256. Cooper, D.J., 1990, Ecological studies of wetlands in South Park, Colorado: classification, functional analysis, rare species inventory, and the effects of removing irrigation: Boulder, Colo., Prepared for EPA Region VIII and Park County, Colo., 75 p.

257. Cooper, D.J., and Cottrell, T.R., 1989, An ecological characterization and functional evaluation of wetlands in the Cherry Creek Basin: Cherry Creek Reservoir upstream to Franktown : Golden, Colo., Department of Environmental Sciences and Engineering Ecology, Colorado School of Mines. Prepared for EPA Region VIII and City of Greenwood Village, Co., Vol. 1.

258. Cooper, D.J., and Cottrell, T.R., 1990, Classification of riparian vegetation in the northern Colorado Front Range: Boulder, Colo., Prepared for Nature Conservancy.

259. Cooper, D.J., and Lee, L.C., 1987, Rocky Mountain wetlands: ecosystems in transition: National Wetlands Newsletter, v. 9, no. 3, p. 2-6.

260. Copland, J.R., 1984, Laramide structural deformation at the interface between the Laramie Range and the Denver-Julesburg Basin, southeastern Wyoming: Laramie, Wyo., Univ. of Wyoming, 49 p.

261. Corbett, M.K., 1964, Tertiary igneous petrology of Mt. Richthofen --Iron Mountain Area, north-central Colorado: Boulder, Colo., University of Colorado, Ph.D. dissertation.

262. Corbett, M.K., 1966, General geology and structure of the Mt. Richthofen-Iron Mountain Area, north-central Colorado: The Mountain Geologist, v. 3, no. 1.

263. Corbett, M.K., 1968, Tertiary volcanism of the specimen Lulu --Iron Mountain Area, north-central Colorado: Cenozoic volcanism in the southern Rocky Mountains: Colorado School of Mines Quarterly, v. 63, p. 1-37.

264. Costa, J.E., 1983, Paleohydraulic reconstruction of flash-flood peaks from boulder deposits in the Colorado Front Range: Geological Society of America Bulletin, v. 94, p. 986-1004.

Nine watersheds with steep bedrock channels were selected. In each basin, three axes of the five largest boulders were measured, along with at least two profiles of the valley cross section. A simple arithmetic average was used to estimate average flood velocity using boulder size and shape. The computed paleohydraulic discharges generally underestimate conventional slope-area discharge estimates on small streams by as much as 75%. The Big Thompson River flood of 1976 was overestimated by 76%. Possible reasons for discrepancy are given.--Modified journal abstract.

265. Costa, J.E., and Bilodeau, S.W., 1982, Geology of Denver, Colorado, United States of America: Bulletin of the Association of Engineering Geologists, v. 19, p. 261-314.

Denver, known as the Mile High City, is the capital of the State of Colorado. The Denver area was originally occupied by American Indians at least 10,000 to 12,000 years ago. Precambrian granites, metamorphosed igneous and sedimentary and volcanic rock form the mountains of the Front Range west of Denver. In some parts of the Denver area, bedrock appears at the surface and is covered by thin colluvium and residuum formed by insitu weathering. However, most of the bedrock is covered by alluvial and eolian deposits to depths as great as 100 ft (30 m); collapse-prone soils; lateral spreading, compressible soils; mass movements; foundation types; sand and coarse aggregate; clay; building stone; limestone, silica sand, gypsum, zeolites, organic soils; coal, uranium, oil, and gas; subsidence; landfills and methane gas; clay and coal mine subsidence; rising water tables; flooding; seismicity; water supply; wastewater disposal; solid waste disposal; hazardous waste; radioactive spoils; use of underground space; engineering geologic practice in Denver.--Modified journal abstract.

266. Countess, R.J., Wolff, G.T., and Cadle, S.H., 1980, The Denver winter aerosol: A comprehensive chemical characterization: Air Pollution Control Association Journal, v. 30, no. 11 (Nov).

The sampling and chemical analysis of the ambient aerosol collected in Denver, Colorado, for a 40-d period during Nov. and Dec. 1978 are described. Parameters included 12-hr TSP measurements, 24-hr respirable and inhalable mass measurements, and 4-hr measurements of mass and chemical species (NO3-, SO4-2, NH4+, organic and elemental carbon, Al, Si, S, K, Ca, Ti, V, Mn, Fe, Zn, Br, Ba, and Pb) in 2 size fractions-<2.5 mm diameter (fine fraction) and >2.5 mm diameter (coarse fraction). On the basis of the chemical analyses, it was possible to account for all particulate mass in both size fractions. In the fine fraction, the major constituents were organic carbon (21.6%), NH4NO3 (20.0%), elemental carbon (15.3%), and (NH4)2SO4 (13.6%); the remainder consisted primarily of soil-like material, Pb salts, and adsorbed water. Three quarters of the coarse fraction consisted of soil-like material, with the remainder composed of the same species that dominated the fine fraction.

267. Crist, M.A., 1980, Effect of pumpage on groundwater levels as modeled in Laramie County, Wyoming: U.S. Geological Survey Open-File Report 80-1104 (WRI), 26 p.

Groundwater is being extensively developed for domestic, agricultural, and industrial use in a 2,320-square mile area in Laramie County, WY., bounded approximately by Horse Creek on the north, Nebraska on the east, Colorado on the south, and pre-Tertiary outcrops on the west. Currently (1977) about 47,300 acres of land are irrigated with groundwater. Groundwater levels are declining in some areas as much as 4 feet per year. The investigation was made to provide State water administrators with data on water-level changes resulting from present (1977) groundwater withdrawals and to provide a means of predicting the future effect of groundwater development. A digital model was developed of the hydrologic system in the post-Cretaceous rocks. The ability of the model to simulate the hydrologic system was determined by comparing the water-level changes measured at 37 observation wells located in areas of irrigation pumping with the water-level changes calculated by the model for 1971-77. Comparison of the measured and calculated changes showed agreement with a root-mean-square deviation of + or - 3.6 feet with 8 feet as the maximum deviation. It is concluded that the model adequately simulates present hydrologic conditions in the post- Cretaceous rocks and may be used to predict the effect of applied stress to the system.

268. Crist, M.A., 1981, Digital model of effects of ground-water withdrawals in Laramie County: U.S. Geological Survey Professional Paper 1175, 141 p.

269. Crist, M.A., 1983, Computer program and data listing for two- dimensional ground-water model for Laramie County, Wyoming: U.S. Geological Survey Water-Resources Investigations 83-4137, 137 p.

This is a supplement to the report, 'Effect of pumpage on ground-water levels as modeled in Laramie County, Wyoming', published as U.S. Geological Survey Water-Resources Investigations Open-File Report 80-1104. The computer program and data used to model ground-water conditions in post-Cretaceous rocks in Laramie County are listed.

270. Crist, M.A., 1985, Altitude and configuration of the water table, and depth to water near Cheyenne, Wyoming, May 1984: U.S. Geological Survey Water-Resources Investigations 85-4154, 1 p.

Altitude and configuration of the water table and depth to water were determined for an area near the southwestern corner of Francis E. Warren Air Force Base which is adjacent to the city limits of Cheyenne, Wyoming. Water levels in the Ogallala

Formation, of late Miocene age, generally are less than 20 ft below land surface in this area where there are many private residences on small-acreage lots. Landowners rely on their own wells for water supply and have installed their own septic systems.

271. Crist, M.A., and Borchert, W.B., 1972, The ground-water system in southeastern Laramie County, Wyoming: U.S. Geological Survey Open-File Report 72-0080, 49 p.

272. Cronoble, J. M., 1978, Stratigraphy and petroleum potential of Dakota Group, North Park, Laramie, and northwest Denver basins, Wyoming and Colorado: Golden, Colo., Colorado School of Mines, 503 p.

273. Crook, W.W., III, 1978, Texasite from Colorado: Mineral. Rec., v. 9, no. 4, p. 251-252.

274. Crosby, E.J., 1976, Map showing nonmetallic mineral resources (except fuels) in bedrock, Front Range Urban Corridor, Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map MF-1042, 2 sheets, scale 1:100,000.

275. Crosby, E.J., 1978, Landslides in the Front Range Urban Corridor, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1042, 2 sheets, scale 1:100,000.

276. Crouch, G. L., 1961, Wildlife populations and habitat conditions on grazed and ungrazed bottomlands in Logan County, Colorado: Fort Collins, Colo., Colorado State University, MS thesis.

277. Crouch, G.L., 1979, Changes in the vegetation complex of a cottonwood ecosystem on the South Platte River: Great Plains Agric. Council Publ. No 91, 19-22 p.

278. Crouch, G.L., 1979, Long-term changes in cottonwoods on a grazed and ungrazed plains bottomland in northeastern Colorado: Fort Collins, Co., U.S. Forest Service, Rocky Mountain Forest and Range Experimental Station, Research Note RM-370.

279. Crouch, G.L., 1982, Wildlife on ungrazed and grazed bottomlands on the South Platte River, northeastern Colorado, *in* J.M. Peek and P.D. Dalke, eds., Symposium Wildlife-Livestock Relationships: p. 186-197.

280. Crouch, G.L., 1984, Wildlife habitat on the lower South Platte River in Colorado: Great Plains Agric. Council Publ. No 111, 1- 4 p.

281. Crowley, K.D., 1982, High-flow geometry and internal stratification of large-scale bedforms in a fluvial environment, in J.O. Nriagu and R. Troost, comps., Eleventh international congress on sedimentology, Hamilton, ON, Canada, Aug. 22-27, 1982: v. 11, 71 p.

282. Crowley, K.D., 1982, Origin, structure, and internal stratification of three hierarchical classes of bedforms in unidirectional flows; examples from laboratory rivers and the channels of the Platte River basin in Colorado and Nebraska: Princeton, N. J., Princeton University, 248 p.

283. Crowley, K.D., 1983, Large-scale bed configurations (macroforms), Platte River basin, Colorado and Nebraska; primary structures and formative processes: Geological Society of America Bulletin, v. 94, p. 117-133.

Large-scale bed forms are not hydrodynamically equivalent to the regime bed forms but constitute a unique hierarchical class of bed configurations produced by turbulent vortices that involve the entire boundary layer. Three members of a continuum of geometries are recognized in the channels of the Platte River basin. The internal stratification for each of the three types is similar and in its simplest form consists of the coarsening-upward sequence apron laminae-foreset laminae-topset laminae, offering a potentially powerful tool for identifying these environments.--Modified journal abstract.

284. Current, W.L., Janovy, J., Jr., and Knight, S.A., 1979, *Myxosoma funduli* (Kudo) (*Myxosporida*) in *Fundulus kansae*: ultrastructure of the plasmodium wall and of sporogenesis: Journal Protozool., v. 26, no. 4, p. 574-583.

285. Currier, P.J., 1982, The floodplain vegetation of the Platte River: phytosociology, forest development, and seedling establishment: Ames, Iowa, Iowa State University, 177 p.

286. Currier, P.J., and Ziewitz, J.W., 1987, Application of a sandhill crane model to the management of habitat along the Platte River: Proc. 1985 Crane Workshop, p. 315-325.

287. Dames & Moore, Consulting Engineers, 1976, Narrows project eutrophication study: Denver, Colo., Dames and Moore Letter report, P.O. number 6-01-01-05830, 6 p.

288. Danielson, J.A., and Qazi, A.R., 1972, Stream depletion by wells in the South Platte basin, Colorado: Water Resources Bulletin, v. 8, no. 2 (April), p. 359-366.

Drought conditions combined with improved well technology resulted in a large amount of well development in the South Platte Valley of Colorado during the period 1952-56. These wells were used for supplemental supply in many cases, but the application of sprinkler irrigation brought many acres of dry land into irrigated production. As a result of the groundwater withdrawal, senior surface appropriators found a decreasing amount of water available in the streams. The legislature, observing the doctrine of prior appropriation, ruled that all surface and groundwater in a tributary would be treated and administered as one resource. Analysis of a segment of the river was made with careful determination of all inflow and outflow in the study reach to include correlations required to determine ungaged side-channel flow and unmetered irrigation wells. Wells have intercepted normal return flows to the river resulting in a decreased amount of surface water during the irrigation season. Stream depletion appears to equal the expected consumptive use of well water which ranged between 40% to 50% of the groundwater extraction.

289. Danielson, T.W., 1975, Map showing lakes in the Greater Denver area Front Range Urban Corridor, Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I-856-B, scale 1:100,000.

This map report of the greater Denver, Colo., area includes data for 49 lakes that have surface areas greater than 10 hectares (about 25 acres). These lakes have a total combined area of 3,686 hectares and a total shoreline of 185 kilometers (115 miles). The largest are Barr lake, 708 hectares; Standley lake, 492 hectares; and Chatfield lake, 465 hectares. Barr lake also has the longest shoreline, 15.6 kilometers, and Gross reservoir has the next longest, 14.9 kilometers. In addition, 113 lakes range in size from 2 to 10 hectares. These have a total area of 526 hectares and a total shoreline of 110 kilometers. Most of the lakes contain water of good quality. Most of the lakes contained water that was alkaline. Slightly acidic water occurred only in Marshall lake (pH = 5.5). The highest pH (10.3) was measured in water from reservoir E on the Rocky Mountain Arsenal grounds; Kendrick reservoir was nearly as high with a pH of 10.0. Values of pH of 8.5 or less occurred in 29 of the 49 lakes measured. Transparency, as measured by a Secchi disk, was less than 1.2 meters in 17 of the 51 lakes in which it was measured. It ranged from 1.2 to 5.5 meters in the other 34 lakes. Transparency was 5.0 meters in Gross reservoir, 5.5 meters in McClellan reservoir, and 0.5 meter or less in 8 of the lakes measured.

290. Darton, H., 1899, Part 4-Hydrography; Preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian: U.S. Geological Survey 19th Annual Report 1897-98, 719-785 p.

291. Darton, H., Blackwelder, E., and Siebenthal, C.E., 1910, Description of the Laramie and Sherman quadrangles, Wyoming: U.S. Geological Survey Geologic Folio 173, 17 p.

292. Darton, H., and Darton, N.H., 1903, Preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian: U.S. Geological Survey Professional Paper 17, 69 p.

293. Darton, N.H., 1905, Preliminary report on the geology and underground water resources of the Central Great Plains: U.S. Geological Survey Professional Paper 32, 433 p.

294. Daubert, J., 1978, Conjunctive ground and surface water allocations: the economics of a quasi-market solution: Fort Collins, Colo., Dept. of Economics, Colorado State Univ. MS thesis, 182 p.

This thesis compares the net farm benefits and corresponding ground and surface water allocation under an augmentation plan; an unrestricted pumping policy; a system which prevents pumping; and pumping quotas. Any change from the historical open access policy generates a gain to surface water right owners, a loss to those who must curtail their pumping, and an administrative cost. The goal is to determine the water resource policy that maximizes the net social benefits. A computer simulation model incorporating the legal, hydrologic and economic characteristics of the lower South Platte River Basin in Colorado evaluates the policies.In the legal submodel, surface water allocations must comply with the prior appropriation doctrine. The hydrologic submodel represents the physical interrelationships between a stream and aquifer. The economic submodels represent the intermediate and short-run farm decision making process. An intermediate model uses an expected income-variance model to determine the planted acreage of each crop. The short-run model allocates available surface and groundwater between crops according to a profit maximizing motive. The simulation combines all submodels to predict the net income for each alternative conjunctive water use policy. Comparing the simulation results of a policy which prohibits pumping and an open access policy indicates that groundwater withdrawals are responsible for much of the area net income. Unrestricted groundwater use increases the predicted net benefits from $11.3 to 33.1 million. However, during a year where river flows are below average pumping causes a significant depletable externality. Pumping, by reducing surface flows, reduces the income of farmers that use senior surface water rights by 39 percent. The most efficient simulated conjunctive use water policy is augmentation plans which generate the largest area net benefits, $36.4 million, and eliminate any loss to senior surface users.

295. Daubert, J.T., and others, 1979, Economics benefits from instream flow on a Colorado mountain stream: Fort Collins, Colo., Colorado Water Resources Research Institute, Completion Report no. 91.

296. Daubert, J.T., and Young, R.A., 1982, Ground-water development in western river basins; large economic gains with unseen costs: Symposium on ground-water management. Ground Water, v. 20, no. 1, p. 80-85.

297. Daubert, J.T., Young, R.A., and Morel-Seytoux, H.J., 1980, Measuring external diseconomies from ground water use in conjunctive ground and surface water systems, *in* Yaron, D., and Tapiero, C.S., eds., Operations research in agriculture and water resources; proceedings of the ORAGWA international conference: Amsterdam, Netherlands, North-Holland Publ., p. 525-536.

298. Davis, A., Olsen, R.L., and Walker, D.R., 1991, Distribution of metals between water and entrained sediment in streams impacted by acid mine discharge, Clear Creek, Colorado: Applied Geochemistry, v. 6, no. 3, p. 333-348.

Acid mine drainage from the Central City and Idaho Springs mining districts has been identified as a source of metal contamination impacting surface water along Clear Creek and North Clear Creek, Colorado. Based on a mass balance calculation along North Clear Creek, Al, Cd, Cl, F and Zn were found to behave conservatively, while Cu, Fe, Mn and Zn were all depleted in the water column. The field data also demonstrated that Al, Cu and Fe were associated with the particulate fraction in the water column, while Cd, and Zn occurred predominantly in the dissolved (< 0.45 microm) fraction. Microprobe analysis and geochemical modeling support the hypothesis that Fe precipitates as an amorphous hydroxide, bearing trace quantities of Mn. A series of batch studies using streambed sediments from North Clear Creek was used to assess the effect of thunderstorms on metal desorption from sediments entrained in the water column. Metal desorption increased as the pH decreased from 6.8 to 3.5. Mass balance constraints allowed the construction of desorption isotherms that demonstrated a metal-substrate affinity of Mn < Zn < Cu < Al, characterization by 50% desorption at pH 6.5, 5.5, 4.5 and 4.4, respectively. (Author's abstract)

299. Davis, J.R., 1967, Stratigraphy and depositional history of upper Mesaverde Formation (Cretaceous) of southeastern Wyoming, volume 1-text, vol. 2-measured stratigraphic sections: University of Wyoming.

300. DeBrey, L.D., and Lockwood, J.A., 1990, Effects of sediment and flow regime on the aquatic insects of a high mountain stream: Regul. Rivers Res. Manage., v. 5, no. 3, p. 241-250.

In 1984, a broad size range of sediment (boulder to sand) was introduced into a high elevation Rocky Mountain stream in southeastern Wyoming, U.S.A. In the spring of 1986, this stream was exposed to a high discharge of 7 X 5 cubic meter/second (?). From 1985 to 1987 a study was conducted to assess the impact of sediment deposition and flow regime on the aquatic insect community in context of the substrate occurrences of the insect fauna. Using a modified Surber sampler, samples were collected from June through September each year at nine stations which were rated as unimpacted, slightly-impacted, and impacted. The addition of the sediment had minimal effect on the abundance and diversity of aquatic insects. However, high water discharge severely reduced the abundance of aquatic insects and diversity was also negatively impacted. Recovery from these impacts was very rapid. The greatest insect abundance was found in samples taken in gravel and most taxa occurred predominantly on gravel or rubble substrates.

301. DeChadenedes, J.F., 1986, Shallow oil fields of the Denver Basin, Colorado and Nebraska, U.S.A, *in* Meyer, R.F., ed., United Nations Institute for Training and Research First International Conference on Shallow Oil and Gas Resources: Houston, Tex., Gulf Publ. Co., Book Div., p. 181-193.

302. DelManzo, D.D., Jr., 1968, The effect of seepage losses on stream regimen, in Myers, L.E., chairperson, Proceedings of the Second Seepage Symposium: Fort Collins, Colo., Colo. State University and U.S. Water Conserv. Lab., p. 30-34.

303. Dennehy, K.F., 1991, National water-quality assessment program: South Platte River basin: U.S. Geological Survey Open-File Report 91-155, 2 p.

304. Dennehy, K.F., 1991, The U.S. Geological Survey water-quality assessment program and the South Platte River basin, *in* South Platte River basin; Uses, values, research, and management ---current and future, Fort Collins, Colo., November 19-20, 1991.

305. Dennehy, K.F., 1992, Water-quality assessment of the South Platte River basin, Colorado, Nebraska, and Wyoming. Project description, *in* Proceedings of the Colorado Water Engineering and Management Conference, Aurora, Colo., March 2-3, 1992: p. 216.

306. Denning, A.S., Baron, J., and Mast, M.A., 1988, Effect of soil-water interactions on stream chemistry during snowmelt in an alpine-sub alpine watershed in Colorado: EOS, v. 69, p. 1,202.

307. Denning, A.S., Baron, J., Mast, M.A., and Arthur, M.A., 1991, Hydrologic pathways and chemical composition of runoff during snowmelt in Loch Vale Watershed, Rocky Mountain National Park, Colorado, USA: Water, Air, Soil Pollut., v. 59, p. 197-223.

308. Denson, N.M., 1969, Distribution of nonopaque heavy minerals in Miocene and Pliocene rocks of central Wyoming and parts of adjacent states: U.S. Geological Survey Professional Paper 650-C, p. C25-C32.

309. Denver Regional Council of Governments, 1977, Clean Water Plan: Denver, Colo.

310. Denver Regional Council of Governments, 1991, Clean water plan; policies: Denver, Colo., vol. 1, 43 p.

This document provides the policy direction for water-quality planning in the Denver region. Chapters include DRCOG's water-quality policy direction and institutional arrangements for water-quality control. The appendices contain technical supporting information.

311. Denver Regional Council of Governments, 1991, Clean water plan; assessments and management plans: Denver, Colo., vol. II, 151 p.

This document provides updated material on wastewater treatment facility management plans and service areas, and regional water-quality characterization.

312. Denver Regional Council of Governments, 1972, Interim plan for water-quality management in the Denver Metropolitan area: Denver, Colo., Addendum no. 2, 84 p.

Current status of the water-quality management program is first summarized. The area is delineated by sanitary sewer treatment areas, which are aggregated into basins and subbasins. Volume, character, and distribution of wastewater is largely determined by land use and population. Projected flows were made on this basis environmental, regulatory, and operational planning criteria to be used in the development and evaluation of alternative wastewater systems and in determination of the proposed areawide system are detailed. Water-quality management criteria, in terms of regional goals, objectives, planning premises and principles, are also listed. New discharge (effluent) standards, based on specific pollutant quantities rather than percentages of various pollutant factors, are being considered by the Colorado Water Pollution Control Commission. Environmental assessment should be on an areawide basis. Individual facilities impact on the immediately adjacent environment can be judged in terms of their compliance with areawide environmental parameters. Projects are organized by a newly defined set of major basins. The present stage of development for each project is set forth. Additional planning studies recommended are: (1) for mountain areas where effluent from small streams can have a detrimental effect on the quality of water in streams flowing into and through the Denver Metropolitan area; (2) possible storm runoff and snowmelt treatment prior to entry into the stream system; (3) evaluation of the impact of industrial discharges on water-quality; and (4) analysis of backwash from water treatment.

313. Denver Regional Council of Governments, 1986, Regional water study: Denver, Colo., 88 p.

This document assesses the region's water needs through the year 2010.

314. Denver Regional Council of Governments, 1990, South Platte River Segments 6 and 14 wasteload allocation study: Denver, Colo., Prepared for the cities of Englewood, Glendale, and Littleton, 53 p.

315. Denver Regional Council of Governments, 1973, Storm drainage and flood control for Metropolitan Denver: Denver, Colo., Project reuse summary report, 18 p.

The proposed 20-year storm drainage and flood control program under Project REUSE (Renewing the Environment through Urban Systems Engineering) encompasses three types of major drainage activities: (1) preventive master planning, for areas where flood plain regulation, land use controls, and other preventive action can be utilized; (2) design master planning, for areas where problems already exist and facility construction is known to be required; and, (3) construction, for developed areas where preventive measures are not feasible and where channels, culverts, sewers, and other structures are needed to provide protection. The system will provide for: delineation of flood plains on major drainage channels; regulation of all unoccupied 100-year flood plains; 100-year protection on occupied flood plains; national flood insurance program coverage on occupied flood plains where protection is not cost effective; the provision, by ordinance, for limitation of runoff from new real estate development; flood storage capacity and spillway protection on dams in the region; integration of major drainage measures with the regional water resource management system; and, a nearly flood warning system. Cost estimates and an implementation schedule by basin are included.

316. Denver Regional Council of Governments, Colo. and Environmental Protection Agency, 1983, Urban runoff quality in the Denver Region Final rept. Jul 79-Sep 83: Denver, Colo., Office of Water Program Operations, 162 p.

This report presents the findings of the three-year Denver Regional Urban Runoff Program. This program studied the nature of urban runoff, its influence on receiving waters, and possibilities for control in the Denver region. Urban runoff characteristics in relation to land use are discussed. The effects of urban runoff on receiving waters are evaluated and compared to municipal discharges over the same time period. The results were developed into predictive, planning tools which can be used to estimate urban runoff quality, quantity and receiving water effects. Best Management Practices (BMPs) for runoff control are also discussed along with strategies for assurance of the most effective regional solution.

317. Denver Regional Council of Governments and Urban Drainage and Flood Control District, 1972, Urban storm drainage and flood control in the Denver Region: Damage prevention, major drainage ways, master planning, regional management, situation, alternatives, program, strategy. Final report: Denver, Colo., DRCOG-72-008, 229 p.

The report includes a proposed twenty-year (1971-1990) regional program for major drainage in the Denver region, implementation strategy and recommendations for carrying out the program. The report also includes a regional perspective, urban system concept, description of the existing major drainage system, management responsibilities, criteria, alternative concepts for consideration, and an evaluation of those concepts. The program includes proposed short-range activities for 1971-1975, including the REUSE Project, and a long-range program to achieve 100-year frequency storm protection throughout the region by 1990, including preventive measures, facility construction, and flood insurance. The report is one of a series, related to urban drainage and flood control, resulting from Project REUSE (Renewing the Environment through Urban Systems Engineering). (Author Modified Abstract)

318. Detra, D.E., Hassemer, J.R., and Malcolm, M.J., 1985, Analytical results and sample locality map of stream-sediment, heavy-mineral-concentrate, and rock samples from the Beaver Creek Wilderness Study Area (CO-050-016), El Paso, Fremont, and Teller counties, Colorado: U.S. Geological Survey Open-File Report 85-701, 18 p.

319. Deweese, L.R., Smykaj, A.M., and Meisner, J.F., 1991, Preliminary environmental contaminant survey of the South Platte RIver in northeastern Colorado, 1988 (abstract only), *in* Woodring, R.C., ed., South Platte resource management: finding a balance: Fort Collins, Colo., Colorado Water Resources Research Institute, p. 29.

320. Dewitt, H.G., 1978, Downstream changes in bedload composition; Little South Fork and Cache la Poudre Rivers, Colorado: Fort Collins, Colo., Colorado State Univ.

321. Dice, J.C., 1985, Denver's seven decades of experience with chloramination: Journal of American Waterworks Association, v. 77, no. 1, p. 34-37.

The Denver Water Department has had nearly 70 years of success with the chlorine-ammonia process of disinfection of drinking water, having begun such treatment in 1916 or 1917. This method is used to control tastes and odors, bacterial concentrations, and growths in the distribution system. The success of this program can be attributed to a high quality raw water, a comprehensive monitoring program that provides data for studies, ongoing investigations, and a well operated distribution system maintenance program.Utilities that are investigating the use of chloramines should consider the quality of the source water and the extent of the monetary resources available for comprehensive monitoring and maintenance.

322. Dickinson, K.A., and Hills, F.A., 1982, Oligocene volcanic rocks as a uranium source for sandstone-type uranium deposits in central Colorado, *in* 35th annual meeting, Rocky Mountain Section of the Geological Society of America. Abstracts with Programs, Bozeman, Mont., May 7-8, 1982: v. 14, Geological Society of America, p. 309.

323. Diffendal, R.F., Jr., 1984, Comments on the geological history of the Ogallala Formation in the southern panhandle of Nebraska, *in* Whetstone, G.A., ed., Proceedings of the Ogallala Aquifer symposium II: Lubbock, Tex., Tex. Tech. Univ., p. 194-216.

324. Diffendal, R.F., Jr., 1983, Megaclasts in alluvial fills from the Ogallala Group (Miocene), Banner, Kimball, and Morrill Counties, Nebraska: Contributions to Geology, v. 22, no. 2, p. 109-115.

325. Diffendal, R.F., Jr., 1983, Megaclasts in channel fills in the Ogallala Group (late Tertiary), Banner, Kimball, and Morrill Counties, Nebraska, *in* C. B. Schuetz, ed., Ninety-third annual meeting of the Nebraska Academy of Sciences. Proceedings of the Nebraska Academy of Sciences and Affiliated Societies, Lincoln, Nebr., Apr. 15-16, 1983: v. 93, p. 46.

326. Diffendal, R., 1985, Overview of Nebraska's and the regional aquifer; Part I, *in* Aspects of groundwater quality; Proceedings of the 1985 Water Resources Seminar Series: Lincoln, Nebr., Nebr. Water Resour. Cent., p. 1-12.

327. Dille, J.M., 1976, Irrigation in Morgan, County: Fort Morgan, Colo., Farmers State Bank, 58 p.

328. Directorate of Licensing (AEC), 1972, Operation of the Fort St. Vrain Nuclear Generating Station of Public Service Company of Colorado, Docket No. 50-267. Final environmental impact statement: Washington, D.C., ELR-5041, 275 p.

The report describes the proposed issuance of an operating license to the Public Service Company of Colorado for the start-up and continuing operation of the Fort St. Vrain Nuclear Generating Station (Docket No. 50-267) located in the State of Colorado, County of Weld, near the city of Greeley. The Station will employ a high-temperature gas-cooled reactor to produce 842 megawatts thermal (MWt). A steam turbine-generator will use this heat to provide 330 megawatts electrical (MWe) net of electrical power capacity. The exhaust steam from the turbine will be cooled by water circulated from a mechanical-draft cooling tower. Makeup water for the cooling tower will be taken from St. Vrain Creek and the South Platte River. The report includes the adverse and beneficial environmental effects.

329. Dobbs, T.L., and Wedemeyer, W.G., 1972, An economic analysis of center-pivot sprinkler irrigation systems in southeastern Wyoming, with emphasis on financing alternatives: Laramie, Wyo., Dept. of Agricultural Economics, Wyoming University, Completion Report, 42 p.

Wyoming has experienced a rapid expansion in acreage irrigated by center-pivot sprinkler systems as a result of State-supported low-interest loans. This study determines alternative sources of financing and assesses the economic feasibility of center-pivot sprinkler systems. Cost and return flows were estimated, and financial and economic data were analyzed. More than one-half of the center-pivots in use by 1971 were financed by a low-interest State loan plan. Investments in sprinkler systems for production of cash crops (potatoes, sugar beets) can be highly profitable, and do not depend on low-interest financing for economic viability. Only under conditions of low-interest financing and relatively low-value alternative uses for land do investments in sprinklers strictly for alfalfa production become economically attractive. Profitability of sprinkler investments in corn-alfalfa rotations is influenced considerably by corn silage values and by financing utilized. Investments in sprinklers for production of forage crops are economically feasible only under particular sets of assumptions. Uncertainty issues of sampling size bias are noted.

330. Dodson, S.I., 1982, Chemical and biological limnology of six west-central Colorado mountain ponds and their susceptibility to acid rain: American Midl. Nat., v. 107, no. 1, p. 173-179.

331. Drever, J.I., and Blum, A.E., 1984, Processes controlling the composition of infiltrating water in forested mountain watersheds: Laramie, Wyo., University of Wyoming, G-879-04, 50 p.

332. Driver, N.E., Mustard, M.H., Rhinesmith, R.B., and Middelburg, R.F., 1985, U.S. Geological Survey urban-stormwater data base for 22 metropolitan areas throughout the United States: U.S. Geological Survey Open-File Report 85-337, 219 p.

The U.S. Geological Survey has been collecting urban rainfall, runoff, and water-quality data nationally for several decades. These data have been stored in many data bases and locations. A collective urban-stormwater data base has now been assembled on magnetic tape and contains data from the U.S. Geological Survey's urban-stormwater program, that includes data from the Nationwide Urban Runoff

Program. Stations having simultaneous rainfall, runoff, and water-quality data were selected for the data base. Rigorous quality-assurance procedures were followed to ensure that the data were of good quality. The resultant data base contains information for 723 storms from 99 stations in 22 metropolitan areas throughout the United States. Data for five or more storms are available for about two-thirds of the stations. This data base is available to the public in standardized format on magnetic tape. This publication explains the content and format of the tape.

333. Ducret, G.L., Jr., and Hansen, W.R., 1973, Storm of May 5-6, 1973, in the Denver Metro area: frequency and effect: Denver, Colo., Urban Drainage and Flood Control District and U.S. Geological Survey 40 p.

A light drizzle that began to fall on parts of the Denver metropolitan area late Saturday evening, May 5, 1973, was the forerunner of a general long-duration rainstorm which, by daylight Sunday, had saturated the soils of the area and sent creeks and gullies swelling with runoff. Rainstorm total precipitation ranged from 2.06 to 4.38 inches at U.S. Geological Survey rainfall-runoff stations in the Denver area. By midday on Sunday, the small streams had reached their peak discharge; many canal banks, weakened by capacity flows, broke; reservoirs were spilling; and lakes were flooding adjacent areas. meanwhile, the South Platte River and major tributaries within the storm area were rising toward peak discharges late Sunday night and early Monday morning. The main-stem South Platte River stations from Littleton to Henderson experienced peak discharges ranging in magnitude from that of a 50-year flood to 1.4 times the 50-year flood.

334. Dufford, R.G., Zimmermann, H.J., Cline, L.D., and Ward, J.V., 1987, Response of ephilithic algae to regulation of Rocky Mountain streams, *in* Craig, J.F., and Kemper, J.B., eds., Regulated streams: Advances in Ecology: Plenum Publ. Corp., New York, p. 383-390.

335. Dugan, J.T., 1986, Hydrologic characteristics of soils in parts of Arkansas, Colorado, Kansas, Missouri, Nebraska, New Mexico, Oklahoma, South Dakota, and Texas: U.S. Geological Survey Hydrologic Investigations Atlas 678, scale 1:500,000, 1 sheet.

336. Dugan, J.T., and Peckenpaugh, J.M., 1985, Effects of climate, vegetation, and soils on consumptive water use and ground-water recharge to the Central Midwest regional aquifer system, Mid-continent United States: U.S. Geological Survey Water-Resources Investigations Report 85-4236, 78 p.

337. Dugan, J.T., Schild, D.E., and Kastner, W.M., 1990, Water-level changes in the High Plains Aquifer underlying parts of South Dakota, Wyoming, Nebraska, Colorado, Kansas, New Mexico, Oklahoma, and Texas; predevelopment through nonirrigation season 1988-89: U.S. Geological Survey Water-Resources Investigations Report 90-4153, 29 p.

338. Duke, H.R., and Longenbaugh, R.A., 1966, Evaluation of water resources in Kiowa and Bijou Creek basins, Colorado.: Fort Collins, Colo., Civil Engineering Dept., Colorado State University, CER-66HD-RAL19, 87 p.

339. Dzubay, T.G., and Hasan, H., 1983, Apportioning light extinction coefficients to chemical species in atmospheric aerosol: Atmospheric Environment, v. 17, no. 8.

340. **Ebens, R.**, 1966, Stratigraphy and petrography of Miocene volcanic sedimentary rocks in southeastern Wyoming and north-central Colorado: University of Wyoming.

341. **Eder**, S., and Carlson, C.A., 1977, Food habits of carp and white suckers in the South Platte and St. Vrain Rivers and Goosequill Pond, Weld County, Colorado, USA: Trans. Am. Fish. Soc., v. 106, no. 4, p. 339-346.

Gut contents of carp (*Cyprinus carpio* L.) and white suckers (*Catostomus commersonia* [*Lacepede*]) collected by electrofishing from the South Platte and St. Vrain rivers, and Goosequill Pond near the Fort St. Vrain Nuclear Generating Station, Colorado, [USA], were analyzed by standard means to determine food habits. Chironomid larvae and pupae were the principle foods of both fish species in the streams. Carp and white suckers competed for this primary food source; both fish species fed primarily on chironomids and did not feed effectively on tubificid worms. White suckers supplemented their diets with species of *Simulium, Hydropsyche, Hyalella* and terrestrial invertebrates. Carp were more opportunistic and consumed more of the less-abundant food organisms than suckers did. Both streams supported limited numbers of benthic invertebrates. Consequently, large quantities of algae, sand, detritus and terrestrial invertebrates were found in the gut contents of both fish species. Carp in Goosequill Pond fed primarily on chironomids but also consumed many entomostracans and crayfish.

342. Edgerton, G.K., 1974, Ground-water quality and alluvial aquifer thickness in the Eaton area, north of Greeley, Colorado: University of Colorado.

343. Edmonds, J.S., and Ward, J.V., 1979, Profundal benthos of a multibasin foothills reservoir in Colorado, U.S.A: Hydrobiologia, v. 63, no. 3, p. 199-208.

The composition, temporal and spatial distribution, and productivity of profundal benthos were investigated in Horsetooth Reservoir, which covers 10.6 km x 1.0 km, and consists of three basins with depths greater than 50 m connected by two equalizing channels ca. 30 m deep. Water-quality parameters did not vary significantly between sites, but temperature, pH, and dissolved oxygen varied seasonally. The composition and organic content of sediment exhibited a gradient from inlet to outlet which significantly influenced faunal density and distribution patterns. Although 28 genera of macroinvertebrates were collected, the oligochaetes *Tubifex tubifex* and *Limnodrilus hoffmeisteri* comprised 97.6% of the total organisms. Chironomids comprised 2.2%. The relative contribution of chironomids to total biomass decreased with increasing depth the reverse was true for oligochaetes. Mean annual density ranged from 3,827 to 51,901 total organisms/sq. meter for six sampling sites. Mean annual biomass varied from 0.16 to 2.3 g ash-free dry wt/sq. meter. Annual turnover ratios ranged from 3.6 to 4.5. Annual production estimates varied from 7.2 to 82.8 kg/ha ash-free dry weight, averaging 39.3 kg/ha or 26.9 kcal/sq. meter.

344. Edmunds, G.F., Jr., and McCafferty, W.P., 1984, *Ephemera compar* an obscure Colorado, USA burrowing mayfly (*Ephemeroptera: Ephemeridae*): Entomol. News, v. 95, no. 5, p. 186-188.

E. compar (Hagen) is known only from the adult type specimen. The occurrence of this unique specimen and species in Colorado is discussed. Burrowing mayflies in the South Platte drainage area require investigation, and new collections are needed.

345. Effinger, W.L., 1934, The geology of Rocky Mountain National Park: Berkeley, Calif., U.S. National Park Service, 28 p.

346. Ehrman, R.L., 1987, Origin of "dissipation" structures, Nebraska Sand Hills: Lincoln, Nebr., Univ. of Nebraska, 88 p.

347. Ellinghouse, C., and McCoy G., 1982, The effects of water conservation on new water supply for urban Colorado utilities: Fort Collins, Colo., Colorado Water Resources Research Institute Completion Report no. 120.

348. Elliott, J.G., 1989, Regionalization of mean annual suspended- sediment loads in streams, central, northwestern, and southwestern Colorado: U.S. Geological Survey Water-Resources Investigations Report 87-4193, 24 p.

Regression analysis was used to develop models for estimating mean annual suspended-sediment loads for streams in Colorado. Mean annual suspended-sediment loads at 81 selected streamflow-gaging stations in the central, northwestern, and southwestern regions of Colorado were expressed as functions of geomorphic and hydrologic variables. A multiple-regression model that included mean basin elevation, mean annual streamflow, and drainage-basin area explained 78% of the variance in mean annual suspended-sediment load when all sites were analyzed together. The State was divided into four regions to decrease variance from spatial differences in geography and climate, and multiple-regression models were recomputed for each region. The best multiple-regression models for the central, northwestern, and southwestern regions of Colorado included mean annual streamflow and mean basin elevation. A multiple-regression model was not developed for eastern Colorado because few sites in this region had adequate sediment-load records. Regionalization of mean annual suspended-sediment loads resulted in improved multiple-regression models for the central, northwestern, and southwestern regions of Colorado. The regional multiple- regression models can be used to estimate mean annual suspended-sediment loads for other streams in these regions when mean annual streamflow and mean basin elevation are known. Regional regression models based only on drainage area also were developed, and they can be used to estimate mean annual suspended-sediment load when annual streamflow is unknown.

349. Elliott, J.G., and DeFeyter, K.L., 1986, Sediment-data sources and estimated annual suspended sediment loads of rivers and streams in Colorado: U.S. Geological Survey Water-Resources Investigation Report 86-4344, 148 p.

350. Elliott, J.G., Jarrett, R.D., and Ebling, J.L., 1982, Annual snowmelt and rainfall peak-flow data on selected foothills region streams, South Platte River, Arkansas River, and Colorado River basins, Colorado: U.S. Geological Survey Open-File Report 82-426, 86 p.

Peak flows in the foothills region of Colorado are attributable to two meteorological sources--snowmelt and rainfall. As part of a study of the hydrology of foothills streams in Colorado, charts from streamflow gages on unregulated streams were examined to determine the source of peak-flow events. Snowmelt-runoff peaks were distinguished from rainfall-runoff peaks on the basis of daily and seasonal occurrence, hydrograph shape, and local weather conditions. Peak-flow data for snowmelt runoff and rainfall runoff are presented for 69 streamflow-gaging stations in the South Platte River, the Arkansas River, and the Colorado River basins.

351. Ellis, M.M., 1914, Fishes of Colorado: University of Colorado Studies, v. 11, p. 1-136.

352. Ellis, S.R., 1978, Hydrologic data for urban storm runoff from three localities in the Denver Metropolitan Area, Colorado: U.S. Geological Survey Open-File Report 78-410, 135 p.

Urban storm-runoff data, collected from 1975 to 1977, on three catchment areas in the Denver, Colo., metropolitan area are presented. The catchments are predominantly a single-family residential catchment area in Littleton, a multifamily residential and commercial catchment area in Lakewood, and a high-density residential and commercial catchment area in Denver. Precipitation, rainfall-runoff, snowmelt- runoff, water-quality (common constituents, nutrients, biochemical oxygen demand, coliform bacteria, and solids, trace elements, and pesticides), and catchment-area data are necessary to use the U.S. Environmental Protection Agency's Storm Water Management Model II.The urban storm-runoff data maybe used by planning, water-management, and environmental-protection agencies to assess the impact of urban storm runoff on the hydrologic system.

353. Ellis, S.R., and Alley, W.M., 1979, Quantity and quality of urban runoff from three localities in the Denver Metropolitan area: U.S. Geological Survey Water-Resources Investigations 79- 64, 60 p.

Considerable variation in constituent concentrations was shown in urban runoff data for 1975-77 from three metropolitan Denver drainage basins. Constituent concentrations, greatest during initial rainfall runoff, generally peaked midday of snowmelt runoff, corresponding with maximum melting and runoff. Instantaneous loads of constituents were largely a function of discharge. Days since last street sweeping or antecedent precipitation had no apparent effect; snowmelt-runoff loads apparently increased with number of days snow had been on the ground. Urban storm runoff may significantly contribute total ammonia nitrogen, total nonfiltrable residue, total copper, total iron, total lead, and total zinc; and snowmelt runoff may significantly contribute sodium and chloride, to local receiving waters. Data from two basins were used for calibration and verification of U.S. Environmental Protection Agency's Storm Water Management Model II for rainfall-runoff modeling of flow and total nitrogen. The model assumption that land-surface loads of total nitrogen are directly proportional to number of days prior to storm during which accumulated rainfall was less than 1.0 inch was not substantiated.

354. Ellis, S.R., Doerfer, J.T., Mustard, M.H., Blakely, S.R., and Gibbs, J.W., 1984, Analysis of urban runoff data and effects on the South Platte River, Denver Metropolitan area, Colorado: U.S. Geological Survey Water-Resources Investigations 84-4159, 66 p.

Denver was selected for inclusion in the Nationwide Urban Runoff Program, sponsored by the U.S. Environmental Protection Agency and the U.S. Geological Survey. This report, prepared in cooperation with the Denver Regional Council of Governments, contains a synopsis of previous urban runoff studies in the Denver metropolitan area. The report includes a description of the monitored basins, a summary of storm runoff-to-rainfall ratios and estimates of impervious retention, and constituent loads and concentrations from seven small basins. The data from six small and five tributary basins to the South Platte River are analyzed using regression analysis, resulting in two sets of regression equations to predict storm-runoff volume and selected constituent loads. The regression equations may be used to estimate storm-runoff volume and constituent loads from unmonitored basins from 15 to 16,000 acres with effective impervious areas of 15 to 90 percent. The effects of urban runoff on the South Platte River in the Denver area are described in three ways. The three methods indicated that storm runoff was a significant contributor of total suspended solids, total organic carbon, total lead, and total zinc to the South Platte River.

355. Ellis, S.R., Linder, J.B. and Patterson, D.A., 1983, Effects of increased urbanization on the storm runoff from a small urban basin in Metropolitan Denver, Colorado, *in* Proceedings of the 10th International Symposium on Urban Hydrology, Hydraulics and Sediment Control: Lexington, Ky., University of Kentucky, p. 79-86.

356. Ellis, S.R., and Mustard, M.H., 1985, Summary of urban-runoff studies in the Denver Metropolitan area, Colorado: U.S. Geological Survey Water-Resources Investigations 84-4072, 31 p.

The Denver metropolitan area has been the subject of urban-runoff studies for several years. The first studies, started in about 1968, usually were concerned only with the quantity of urban runoff. In 1974, studies were begun that included both quantity and quality of urban runoff. In 1979, Denver was selected as one of the cities to be included in the Nationwide Urban Runoff Program. The Denver study was called the Denver Regional Urban Runoff Program and was a cooperative study between the Denver Regional Council of Governments and the U.S. Geological Survey. This report presents the major conclusions of the pre-Denver Regional Urban Runoff Program studies and a summary of the various elements of the Denver Regional Urban Runoff Program. The report summarizes and references urban-runoff studies in the Denver metropolitan area and is a reference guide for planners and other persons interested in urban runoff.

357. Ellsworth, P.M., 1983, Ecological seasonal cycles in a Colorado mountain pond: Journal Freshwat. Ecol., v. 2, no. 3, p. 225-237.

358. Emerick, J.C., and Kolm, K.E., 1988, Hydrogeology and phytogeomorphology of the mountains and foothills near Denver, Colorado, *in* Holden, G.S., ed., Geological Society of America field trip guidebook, 1988; Centennial meeting. Professional Contributions of the Colorado School of Mines: Denver, Colo., Geological Society of America, p. 300-304.

359. Engel, A.E.J., 1947, Geology of the central Owl Creek Mountains, Wyoming (abs.): Geol. Soc. Am. Bull, v. 58, no. 12, p. 1177- 1178.

360. Engineering Consultants, Inc., Toups Corporation, 1974, Comprehensive water-quality management plan--South Platte River Basin, Colorado: Denver, Colo., Report to the Colorado Water Quality Control Division, Colorado Department of Public Health.

361. Engineering Consultants, Inc., Toups Corporation, 1975, Executive summary of comprehensive water-quality management plan: South Platte River Basin, Colorado: Denver, Colo., Report prepared for the Colorado Water-Quality Control Division, Colorado Department of Health.

362. Engineering-Science, Inc., 1978, Wastewater facilities and the Clean Water Program. Volume 2. Analysis, comments and responses Denver regional environmental impact statement (Final): Berkeley, Calif., Environmental Protection Agency, Denver, Colo. Region VIII, EPA/905/5-77/001B, 469 p.

This is the final environmental impact statement (EIS) prepared by EPA for the Denver Region concerning actions to be taken on 10 wastewater facility plans and the Denver Clean Water Plan (208 Plan). This EIS addresses the regional effects of these projects and the 208 Plan considering both direct and secondary impacts. Emphasis is given to the regional and cumulative impacts of population growth and development through the year 2000 which these projects and plans anticipate. The regional impacts on air quality, water quality, recreation, sensitive lands, agriculture, economy, and energy are examined. Volume 2 contains the detailed analysis of impacts, comments received on the draft EIS and EPA's responses to comments.

363. Ensor, D.S., Jackson, B.S., Calvert, S., Lake, C., and Wallon, D.V., 1975, Evaluation of a particulate scrubber on a coal-fired utility boiler Final rept. Jun 74-Jun 75: Altadena, Calif., Meteorology Research, Inc. and Industrial Environmental Research Lab., MRI75-FR-1352; EPA/600/2-75-074, 213 p.

The report gives results of a performance test and engineering analysis of a mobile-bed scrubber on a full-scale coal-fired utility boiler. The scrubber nominally operated at the design particulate removal efficiency of 95%, but the concentration of submicron particles was greatly influenced by mist entrainment. The entrainment resulted in a difference of aerosol penetration through the scrubber as a function of elemental composition and outlet submicron particle concentration independent of pressure drop through the scrubber. The variable concentration of submicron entrained particles made the application of the penetration data as a function of particle size to development of performance models unfeasible. The engineering analysis showed that the 1972-installed cost was $29/kw and the annual operating cost is 0.5 mills/kwh (75% availability). An initial decline in scrubber availability after start-up resulted from now-corrected minor design problems. Steadily improving reliability is attributed to the utility's providing maintenance and solving operating problems.

364. Environmental Health Center, 1949, South Platte River basin water pollution investigation: Cincinnati, Ohio, Interim Report, 156 p.

The investigation was undertaken to review that portion of the Blue-South Platte River Project Report dealing with the effects of pollution on the usage of waters from the South Platte River Basin.

365. Environmental Health Center, 1951, Recent and current water pollution control activities: Cincinnati, Ohio.

An updating of the continuing water control activities of the Envir. Health Center is presented. Chemical and physical analysis of polluted waters are also presented and a study of the pollution and self-purification of Lytle Creek, Wilmington, Delaware is discussed. Biological effects of wastes on fish in the areas are presented. Biological indicators for the Lytle Creek area are evaluated. Other geographical areas of study include the South Platte River Basin, Mississippi River, Etowah River, Mahoning River and the Roanoke River. Industrial wastes are discussed and status reports are presented for a variety of this wastes.

366. Environmental Impact Center, Inc., Environmental Protection Agency, Office of Research and Development, Department of Housing and Urban Development, and Policy Development and Research., Council on Environmental Quality, 1974, Secondary impacts of infrastructure investments in the Denver Region. Final report: Newton, Mass., Environmental Protection Agency, EQC-317den3, 102 p.

Statistical correlations between the amount and form of land use changes and the location of new highways and wastewater facilities were established for four major metropolitan areas individually and in combination. The statistical findings were supplemented with results from a dynamic simulation model of land use in metropolitan Washington. The broader study (Secondary Effects of Public Investments in Highways and Sewers) emphasizes approximations which helped generalize results across different metropolitan areas. This report presents econometric analyses derived for the Denver region. These statistical analyses illustrate the historical influence of highways, water, and sewer facilities in shaping land use patterns in the Denver area and provide basic methods for forecasting impacts of future investments.

367. Environmental Monitoring and Support Lab., Colorado Dept. of Health, Denver., Colorado National Guard, Denver., Corvallis Environmental Research Lab., 1977, Barr Lake, Adams County, Colorado Final report: Las Vegas, Nev., Working Paper-766, 39 p.

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included.

368. Environmental Monitoring and Support Lab., Las Vegas, Nev., Colorado Dept. of Health, Colorado National Guard, Corvallis Environmental Research Lab., 1977, National Eutrophication Survey. Cherry Creek Lake, Arapahoe County, Colorado. Final report: Corvallis, Oreg., Working Paper- 768, 40 p.

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included.

369. Environmental Monitoring and Support Lab., Las Vegas, Nev., Colorado Dept. of Health, Colorado National Guard, and Corvallis Environmental Research Lab., 1977, National Eutrophication Survey, Milton Reservoir, Weld County, Colorado Final report: Corvallis, Oreg., Working Paper 774, 31 p.

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included.

370. Epis, R.C., and Chapin, C.E., 1974, Stratigraphic nomenclature of the Thirtynine Mile volcanic field, central Colorado: Contributions to Stratigraphy Bulletin, p. 23.

371. Epis, R.C., and Chapin, C.E., 1975, Geomorphic and tectonic implications of the Post-Laramide, Late Eocene erosion surface in the Southern Rocky Mountains, in Bruce, C., ed., Cenozoic history of the Southern Rocky Mountains: Geological Society of America Memoir 144, p. 45-74.

372. Eppinger, R.G., Theobald, P.K., and Sutley, S.J., 1985, Map showing the distribution of selected mineral assemblages in nonmagnetic heavy-mineral concentrates from stream sediments from the Vasquez Peak Wilderness Study Area and the Williams Fork and St. Louis Peak Roadless Areas, Clear Creek, Grand, and Summit Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map 1588-F, 1 sheet, scale 1:50,000.

373. Eschner, T.R., Hadley, R.F., and Crowley, K.D., 1981, Hydrologic and morphologic changes in channels of the Platte River basin; a historical perspective: U.S. Geological Survey Open-File Report 81-1125, 61 p.

374. Espey, W.H., Jr., Altman, D.G., and Graves, C.B., Jr., 1977, Nomographs for ten-minute unit hydrographs for small urban watersheds: New York, N.Y., American Society of Civil Engineers, Urban Water Resources Research Council Technical Memorandum 32, 22 p.

While characterizations of 30-minute generalized synthetic unit hydrographs have been available for some time, the 10-minute duration relations presented extend the usefulness of this basic tool for analysis of the smaller urban catchments. The synthesized equations and associated nomographs are derived from data for 41 urban watersheds in the U.S., of which 18 are in Texas. Reliability can be enhanced by validation with local field data. A validation example is included for Denver, Colorado. Being Addendum 3 of the report 'Urban Runoff Control Planning,' June, 1977 (NTIS: PB-271 548), new references for the latter are included. This technical memorandum is one of several that will contain additional, individual Addenda over the period 1977-1979. The principal intended audience is agencies and their agents involved in the preparation of areawide plans for water pollution abatement management under Section 208 of PL 92-500, for whom synthesized unit hydrographs are a potential supplementary tool.

375. Ethridge, F.G., Flores, R.M., Ethridge, F.G., Miall, A.D., Galloway, W.E., and Fouch, T.D., 1985, Reservoir characteristics of ancient fluvial deposits with emphasis on Rocky Mountain and Midcontinent regions, *in* Recognition of fluvial depositional systems and their resource potential, SEPM Short Course: p. 217- 240.

376. Eubanks, M.J., 1980, An evaluation of the Cache La Poudre Wild and Scenic Draft Environmental Impact Statement and study report: Fort Collins, Colo., Colorado Water Resources Research Institute, Information Series 43, 55 p.

377. Evans, H.E., and Evans, M.A., 1991, Cache La Poudre: the natural history of a Rocky Mountain river: Niwot, Colo., University of Colorado.

378. Fahey, T.J., 1979, Changes in nutrient content of snow water during outflow from a Rocky Mountain coniferous forest: Oikos, v. 32, no. 3, p. 422-428.

A comparative stand approach was used to study the influence of forest structure on nutrient outflow characteristics in the subalpine coniferous forest ecosystem of southeastern Wyoming, USA. Snow collected beneath the forest canopy is enriched in nutrients (N, K, Ca, Mg), compared with snow from the open, with enrichment being greater in the more dense stands. Ca and Mg are more concentrated in surface run-off than in snow water in all stands; N and K levels are generally lower in run-off than in snow. Nutrient content of subsurface flow is higher than snow and surface run-off concentrations. Between stand differences in outflow nutrient content may be explained by differences in volume of flow and surface soil characteristics as well as by forest structure. Control of nutrient loss from the subalpine forest ecosystem of the central Rocky Mountains is discussed.

379. Fahey, T.V., Yavitt, J.B., and Joyce, G., 1988, Precipitation and throughfall chemistry in *Pinus contorta* ssp. Latifolia ecosystems, southeastern Wyoming: Canadian J. Forest Research, v. 18, p. 337.

Precipitation, throughfall quantity, and chemistry were measured in several *Pinus contorta ssp.* Latifolia ecosystems. Bulk deposition was enriched chemically in comparison with wetfall, suggestive of dry deposition. With the exception of low S concentrations, atmospheric chemistry was comparable to other continental locations in North America. Concentrations of most solutes were much higher in canopy throughfall than rainfall. Throughfall was most enriched in K^+, Mg^{2+}, and organic anions, indicating the importance of canopy leaching. High spatial variation was observed within the forests, precluding the detection of annual or site differences in throughfall chemistry.

380. Farr, W.D., 1977, Challenge to innovation, in Colorado Drought Workshop, Denver, Colo., November 29, 1977: Colorado Water Resources Research Institute, p. 19-22.

381. Fellows, A.L., 1904, Investigations in Colorado: U. S. Reclam. Ser., Annual Report.

382. Ficklin, W.H., and Ryder, J.L., 1988, Arsenic species in groundwater and pore waters in stream sediments affected by mine drainage in Montana and Colorado, *in* S. E. Ragone, ed., U.S. Geological Survey program on toxic waste-ground-water contamination--Second Technical Meeting, Cape Cod, Mass., Oct. 21-25, 1985: U.S. Geological Survey Open-File Report 88-132, p. E9-E11.

383. Fitzgerald, J.P., 1978, Vertebrate associations in plant communities along the South Platte River in northeastern Colorado., *in* W. D. Graul and S. J. Bissell, eds., Lowland river and stream habitat in Colorado; a symposium: Greeley, Colo., Colorado Chapter of Wildlife Society and Colorado Audubon Council, p. 73-88.

384. Flowerday, C., 1986, The Brule as an aquifer; investigating the fracture zones: Resource Notes, v. 1, no. 2, p. 2-3.

385. Floyd, T., 1971, Survey of western states' underground water management provisions: The Cross Section, v. 17, no. 7, p. 1-3.

Statutory provisions of Arizona, California, Colorado, Idaho, Montana, Nebraska, Oklahoma, Oregon, Texas, Utah, Washington, and Wyoming were compared with regard to local control exercised over underground water. Six of the twelve States had provisions for local groundwater control, and only three (California, Nebraska and Texas) gave much power to local agencies. Three States (Colorado, Utah and Wyoming) give only advisory and administrative powers to local agencies. Texas gives the strongest provisions for local groundwater control. Statutes are cited. Waste regulations are reviewed.

386. Follansbee, R., 1922, Some characteristics of run-off in the Rocky Mountain Region: U.S. Geological Survey Water-Supply Paper 500-C, 19 p.

387. Ford, K.L., Schott, J.H., and Keefe, T.J., 1980, Mountain residential development-minimum well protective distances-well water quality: Journal of Environmental Health, v. 43, no. 3, p. 130-133.

Well water samples were collected and wells were inspected in 164 sites within a 300-square-mile area in a mountainous portion of Jefferson County, Colorado, an area which has experienced rapid population growth. Analysis for coliform bacteria and nitrate nitrogen revealed that coliform contamination was not related to lot size or distance from waste water effluent sources. However, there was a definite relationship between nitrate-nitrogen concentration and these factors. A statistical study showed that wells with a protective distance of 100 feet had a 21.8% probability of contamination (greater than 10 mg per liter of nitrate-nitrogen); a 200-foot distance reduced the probability to 9.4%. Therefore, a 200-foot minimum distance from the nearest effluent source was recommended. This requires a lot size of about 2 acres.

388. Foss, P.O., 1988, Institutional arrangements for effective water management in Colorado.: Fort Collins, Colo., Colorado Water Resources Research Institute, Completion Report no. 88.

389. Fremont, J.C., 1845, Report of the exploring expedition to the Rocky Mountains in the year 1842, and to Oregon and North California in the years 1843-44: Washington, D.C., U.S. Army Corps Topogr. Engs., republished in 1988 as "The exploring expedition to the Rocky Mountains" Smithsonian Inst. Press, Washington, D.C., 319 p.

390. French, R.D., 1991, Use of the index of biotic integrity to assess fish community response in the South Platte River - Segment 15 to staged improvements to secondary effluent quality at a wastewater treatment plant (abstract only), *in* Woodring, R.C., ed., South Platte resource management: Finding a balance: Fort Collins, Colo., Colorado Water Resources Research Center, p. 26.

391. Frey, E., 1946, Exploration of the Shanton iron-ore property, Albany County, Wyoming: U.S. Bur. Mines, Rpt. In. 3918.

392. Friedman, I., 1973, The isotopic analysis of water from the Henderson Mine, Clear Creek County, Colorado: U.S. Geological Survey Open-File Report 1845, 4 p.

393. Friedman, J.P., Alluvial terrace investigation along the North Fork of the South Platte River, and Horse Creek, east-central Front Range, Colorado, *in* W. P. Rogers and R. M. Kirkham, eds., Contributions to Colorado seismicity and tectonics--a 1986 update: Denver, Colo., U.S. Geological Survey Special Publication 28, p. 260-281.

394. Gable, D.J., 1985, Tabulation of modal and chemical analyses for Silver Plume Quartz Monzonite (Silver Plume Granite), Berthoud Plutonic Suite, Front Range, Colorado: U.S. Geological Survey Open-File Report 85-296, 11 p.

395. Gaggiani, N.G., 1991, Effects of land disposal of municipal sewage sludge on soil, streambed sediment, and ground- and surface-water quality at a site near Denver, Colorado: U.S. Geological Survey Water-Resources Investigations 90-4106, 163 p.

396. Gaggiani, N.G., 1984, Nitrogen, sulfate, chloride, and manganese in ground water in the alluvial deposits of the South Platte River Valley near Greeley, Weld County, Colorado: U.S. Geological Survey Water-Resources Investigations 84-4088, 2 plates, scale 1:50,000.

Ground water from the valley-fill deposits of the South Platte River Valley and its tributaries is used extensively for agriculture in the study area, about 10 miles east of Greeley and about 50 miles northeast of Denver, Colorado. The valley-fill deposits, which consist of alluvial and terrace deposits, are in a valley system eroded in Laramie Formation bedrock. Water samples collected from 53 wells during 1974 and 1980 were analyzed for nitrite plus nitrate nitrogen, sulfate, chloride, and manganese. Median concentrations changes in these constituents from 1974 to 1980 are as follows: 6.0 to 8.8 milligrams per liter for nitrite plus nitrate nitrogen, 850 to 900 milligrams per liter for sulfate, and 94 to 120 milligrams per liter for chloride. Manganese concentrations were greater than 1,000 micrograms per liter in both 1974 and 1980 in a small area at the mouth of Box Elder Creek.

397. Gaggiani, N.G., Britton, L.J., and Minges, D.R., 1987, Hydrology of Area 59, northern Great Plains and Rocky Mountain Coal Provinces, Colorado and Wyoming: U.S. Geological Survey Water-Resources Investigations Report 85-153, 124 p.

A nationwide need for hydrologic information in coal-mined areas and potential coal development areas was identified with the enactment of the Surface Mining Control and Reclamation Act of 1977 (Public Law 95-87). This report, one in a series of nationwide coal province reports, presents information thematically by describing single hydrologic topics through the use of brief texts and accompanying maps, graphs, or other illustrations. The report broadly characterizes the hydrology of Area 59 in north-central Colorado, and southeastern Wyoming. The report area, located within the South Platte River basin, covers a 16,000-square-mile area of diverse geology, topography and climate. This results in contrasting hydrologic characteristics.

398. Galat, D.L., and McConnell, W.J., 1974, A quantitative baseline inventory of the aquatic invertebrate and pheriphyton communities of the South Platte and Saint Vrain Rivers, Fort Saint Vrain Nuclear Generating Station: Fort Collins, Colo., Colorado State University, Cooperative Fishery Unit, Prepared for Thorne Ecological Institute, 188 p.

399. Gansecki, M.A., and Pigeon, P., 1981, Appendix to finding of no significant impact, Clear Creek Interceptor Project: Denver, Colo., Dames and Moore, Golden, Colo.; Environmental Protection Agency, Denver, Colo., Region VIII., EPA-*908/5-81-002.

The report evaluates the segment of Clear Creek from Golden, Co. to its confluence with the South Platte River. It was determined that additional study was necessary to define the waterflow changes, water quality, aquatic life and water rights changes that would occur with the implementation of the Metro District's Clear Creek Interceptor. The study also considered the added effect of the newly proposed Golden/Coors Wastewater Treatment Plant. The study effort developed a flow balance on Clear Creek, taking into account all diversions, return flows, etc. This balance was then used to predict effects on water quality and aquatic habitat.

400. Gardner, H., 1974, Goodbye, Colorado: Harpers Magazine, v. 248, no. 1487, p. 47.

401. Gardner, M.E., 1968, Engineering geology of the proposed Narrows dam and reservoir, Morgan County, Colorado (abs.): Geol. Soc. America, v. Spec. Paper 115, p. 420.

402. Gautier, D.L., 1985, Sulfur/carbon ratios and sulfur isotope composition of some Cretaceous shales from the Western Interior of North America: U.S. Geological Survey Open-File Report 85-514, 22 p.

403. GCA Corp., Technology Div., 1973, Environmental impact statement for Denver Transportation Control Plan. First Draft: N.C., Environmental Protection Agency, Research Triangle Park, 165 p.

'Transportation control measure' has been defined by the Environmental Protection Agency (EPA), to mean any measure such as reducing vehicle use, changing traffic flow patterns, decreasing emissions from individual vehicles, or altering existing modal split patterns, that is directed toward reducing emissions of air pollutants from transportation sources. Transportation control measures are required for any air quality control region where controls on stationary sources, combined with the Federal Motor Vehicle Control Program (FMVCP) placing emission standards on new cars, are inadequate to insure attainment and/or maintenance of the ambient standards.

404. Geological Institute (American), 1976, Bibliography and index of Colorado geology 1875 to 1975: Colorado Geological Survey and Dept. Natural Resources Bulletin 37, 488 p.

405. GeoMetrics, Inc., 1978, Aerial gamma ray and magnetic survey: Rock Springs, Rawlins, and Cheyenne Quadrangles, Wyoming and the Greeley Quadrangle, Colorado: Sunnyvale, Calif., Department of Energy, Final Report, 294 p.

Under the Department of Energy National Uranium Resource Evaluation Program, geoMetrics, Inc. conducted a high sensitivity airborne radiometric and magnetic survey of the Rock Springs, Rawlins, and Cheyenne 1:250,000 quadrangles in Wyoming, and the Greeley, 1:250,000 quadrangle within the State of Colorado. All field data were returned to the geoMetrics, Sunnyvale, California computer facilities for processing, statistical analysis, and interpretation. Data presented in this report are: corrected profiles of all radiometric variables, magnetic data, radar and barometric altimeter data, air temperatures, and airborne bismuth contributions. Radiometric data presented are corrected for Compton Scatter, altitude dependence, and atmospheric bismuth. These data are also presented on microfiche and digital magnetic tapes. This report contains anomaly maps and interpretation maps relating mapped geology to the corrected radiometric and magnetic data. Radiometric count rates in the basins were generally lower than over the Precambrian crystalline rocks. Notable exceptions are the Red Desert and Poison Basins and Miller Hill area within the Rawlins quadrangle. Interpretation of the statistical results succeeded in delineating several anomalous uranium trends in: (1) known uranium districts such as Miller Hill and extensions thereof and (2) new areas near Chalk Bluff in the Cheyenne and Greeley quadrangles. Magnetic pseudo-contour maps clearly outline the major structural features as well as provide more information about magnetic basement features that could generate new insight into the geologic structure of the area. Principal component analysis for each formation was attempted in each quadrangle. Results were mixed. Several overall patterns were discernible, but individual instances were apparently contradictory.

406. Gerlek, S., 1976, Present and future water supply sources of the South Platte River Basin (Section 3- Exogenous water sources): Omaha, Nebr., U.S. Army Corps of Engineers, Discussion draft report.

407. Gerlek, S., 1977, Water and related land resources management study - Metropolitan Denver and South Platte River and tributaries, Colorado, Wyoming, and Nebraska. Supporting technical report appendices: Water supply management analysis and alternative development: Water supply analysis.: Omaha, Nebr., U.S. Army Corps of Engineers, Vol V, Appendix J, Vol 2, and Technical appendix.

408. Gerlek, S., 1977, Water supplies of the South Platte River basin: Fort Collins, Colo., Colo. State Univ., MS thesis, 798 p.

409. Gibbs, J.W., 1981, Hydrologic data for urban storm runoff from nine sites in the Denver Metropolitan area, Colorado: U.S. Geological Survey Open-File Report 81-682, 142 p.

Urban storm-runoff data were collected April through September 1980, from nine urban runoff sites in the Denver metropolitan area, and are presented in this report. The sites consist of two single-family residential areas, two multi-family residential areas, one commercial area (shopping center), one mixed commercial and multi-family residential area, one native area (open space), and two detention ponds. Precipitation, rainfall-runoff, water-quality (common constituents, nutrients, coliform bacteria, solids, and trace elements) and basin-area data are necessary to use the U.S. Geological Survey's Distributed Routing Rainfall-Runoff Model, Version II. The urban storm-runoff data may be used to characterize runoff pollution loading for various land-use types in Denver and other semi-arid regions.

410. Gibbs, J.W., Arnold, L.M., and Reed, R.L., 1983, Hydrologic data for the drainage basins of Chatfield and Cherry Creek lakes, Denver metropolitan area, Colorado: U.S. Geological Survey Open-File Report 83-857, 244 p.

411. Gibbs, J.W., and Doerfer, J.T., 1982, Hydrologic data for urban storm runoff in the Denver Metropolitan area, Colorado: U.S. Geological Survey Open-File Report 82-872, 553 p.

Urban storm-runoff data collected from April through September 1981 from nine Denver Nationwide Urban Runoff Program sites, urban storm-runoff data collected from April 1980 through September 1981 from ten South Platte River Study sites, and rainfall-runoff simulation data from two sites for June 1980 and May 1981 are presented in this report. The Denver Nationwide Urban Runoff Program sites were two single-family residential areas, two multifamily residential areas, one commercial area (shopping center), one mixed commercial and multifamily residential area, one natural area (open space), and two detention ponds. The South Platte River Study sites were six tributaries of the South Platte River and four instream sites on the South Platte River. The tributary sites were Bear Creek at mouth, at Sheridan; Harvard Gulch at Harvard Park, at Denver; Sanderson Gulch at mouth, at Denver; Weir Gulch at mouth, at Denver; Lakewood Gulch at mouth, at Denver; and Cherry Creek at Denver. The instream sites were South Platte River at Littleton; South Platte River at Florida Avenue, at Denver; South Platte River at Denver; and South Platte River at 50th Avenue, at Denver. The rainfall-runoff simulation sites were North Avenue at Denver Federal Center, at Lakewood and Rooney Gulch at Rooney Ranch, near Morrison. Precipitation, rainfall-runoff, water-quality data, and basin characteristics were collected at the urban storm-runoff sites. The urban storm-runoff data may be used to characterize runoff loading for various land-use types in Denver and other semiarid regions.

412. Gibson, J. C., 1969, Lake sediment studies, Rocky Mountain National Park: Fort Collins, Colo., Colorado State University, MS thesis, 61 p.

413. Gibson, J.C., 1973, Ecology of a high mountain copepod (*Diaptomus shoshoni*) in aestival ponds and a permanent lake in Rocky Mountain National Park: Fort Collins, Colo., Colorado State University, Ph.D. dissertation.

414. Gibson, J.H. and Baron, J., 1984, Acidic deposition in the Rocky Mountain region, *in* T.A. Colbert and R.L. Cuany, eds., Proceedings: Hi altitude revegetation workshop no. 6. Information Series No. 53: Fort Collins, Colo., Water Resources Research Institute, p. 29-42.

415. Gilbertson, C.B., Large commercial feedlots - how wastes are handled in the west, *in* Proceedings of conferences on farm animal wastes, nitrates and phosphates in rural ecosystems, Madison, Green Bay, and Eau Claire, Wisconsin, Wisconsin, Feb. 1-5, 1971: Lincoln, Nebraska, Agricultural Research Service, p. 270-279.

Research is underway for determining design factors for construction, installation and management of runoff control facilities on outdoor feedlots. There are three requirements for a functional runoff control facility: (1) a debris basin, (2) a holding pond, and (3) disposal area. Two separate management designs are available for installation. They are the 'batch' system and the 'continuous flow' system. Both systems must be designed for removal of settleable solids from the runoff. Many factors must be blended in the design of a feasible feedlot operation which will yield good animal performance and, at the same time, control all wastes, including surface runoff, groundwater contamination and nuisances such as odors, dust, and flies. Several steps are listed for designing and constructing a runoff control facility for a beef feedlot. Assistance for design, layout and construction may be obtained from local health authorities, soil conservation service, extension agricultural engineers, and practicing consulting engineers.

416. Gilmer, T.H., Harmon, E.J., Kronig, D.M., Graves, B.J., Lehr, J.H., Butcher, K., Owen, T.E., and Mathews, M., 1986, Estimation of alluvial aquifer characteristics from resistivity soundings, *in* Surface and borehole geophysical methods and ground water instrumentation: Conference and exposition: Dublin, Ohio, Natl. Water Well Assoc., p. 163-186.

417. Glantz, M.H., and Ausubel, J.H., 1984, The Ogallala Aquifer and carbon dioxide; comparison and convergence: Environmental Conservation, v. 11, no. 2, p. 123-131.

418. Glover, R.E., 1980, A digital model applied to ground water recharge and management discussion: Water Resources Bulletin (Urbana), v. 16, no. 3, p. 514-521. 322

419. Glover, R.E., 1975, South Platte River flow correlations: Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, v. 101, no. Proceedings Paper 11563, p. 175- 186.

Administration of water resource management legislation on the South Platte River has been hindered by the lack of knowledge of surface water-groundwater relationships. Effective management of appropriation by surface diversion and groundwater pumping requires some advance knowledge of quantitative effects of policy decisions. A computation method for evaluating these effects was developed and applied to the South Platte; comparison of computed results to past performance of the river supported the method. Major computations were reduced to tabular form for ease of application. The effect of pumping in the valley was determined, by the method, to be depletion of the river flow by approximately one-fifth the yield of the watershed. Since the response of river flow to variation in pumping is demonstrably slow, it is futile to include wells in the priority allocations scheme; yet the surface and groundwater of the South Platte valley must be considered a single water supply, because no acceptable river flow correlations can be obtained while return flows of groundwater to the river are excluded.

420. Goddard, K.E., 1978, Availability and quality of ground water in the Lake George area, southeastern Park County, Colorado: U.S. Geological Survey Water-Resources Investigations Report 78-50, 28 p.

Water for domestic use in the Lake George area, Colo., is produced from four aquifers. Two of the aquifers, fractured- cyrstalline and volcanic rocks, have a water table ranging from 10 to 100 feet below land surface and well yields range from 0.08 to 6 gallons per minute. The consolidated sedimentary-rock and unconsolidated-alluvial aquifers have a water table ranging from near land surface to 60 feet below land surface and well yields range from 2 to 50 gallons per minute. The aquifers generally contain calciumbicarbonate water with concentrations of dissolved solids ranging from 101 to 636 milligrams per liter. In some areas, concentrations of iron as much as 18,000 micrograms per liter and concentrations of fluoride as much as 5.6 milligrams per liter affect suitability for domestic use. Chemical degradation of ground water has occurred in 18 of the 35 wells and in the 1 spring that were sampled. Bacterial contamination was found in water from six wells.

421. Goettl, J.P., 1980, Evaluation of sport fisheries potential in fluctuating plains streams: Fort Collins, Colo., Colorado Division of Wildlife, Job Progress Report F-77-R-1, 35 p.

422. Goettl, J.P., 1981, Evaluation of sport fisheries potential in fluctuating plains streams: Fort Collins, Colo., Colorado Division of Wildlife, Job Progress Report F-77-R-2, 36 p.

423. Goettl, J.P., 1982, Evaluation of sport fisheries potential in fluctuating plains streams: Fort Collins, Colo., Colorado Division of Wildlife, F-33-R-13.

424. Gomez-Ferrer, R.V., and Hendricks, D.W., 1983, Dissolved solids hazards in the South Platte Basin, Vol. I--salt transport in the river: Fort Collins, Colo., Colorado Water Resources Research Institute, Completion Report No. 128, 186 p.

This work demonstrates how river salinity may be characterized, in terms of both time and space variations. Fifteen years of daily and monthly salinity and flow data have been reduced to monthly, seasonal, and annual statistical characterizations for five river stations and three tributary stations for the lower South Platte River. From these characterizations, distance profiles were plotted for flow, TDS, and salt mass flows. The distance profiles and measurements of diversion flows, tributary flows, and point source discharges were the basis for a reach-by-reach materials-balance analysis for four reaches of the South Platte River between Henderson and Julesburg. Return flows and return salt mass flows were computed as residuals. The analysis showed that there is not a salt balance in the lower South Platter River. A net salt loss to the land of 380 tons per day occurs by irrigation. The analysis provided can be the basis for a more comprehensive materials balance model. But the results can be used to estimate the impact of new water resources developments upon the salinity regime of the lower South Platte River.

425. Gomez-Ferrer, R.V., and Hendricks, D.W., 1982, Salt transport in the lower South Platte River: Fort Collins, Colo., Dept. of Civil Engineering, Colorado State Univ., Technical Report 82-3141-01, 167 p.

This work demonstrates how river salinity may be characterized, in terms of both time and space variations. Fifteen years of daily and monthly salinity and flow data have been reduced to monthly, seasonal, and annual statistical characterizations for five river stations and three tributary stations for the lower South Platte River. From these characterizations, distance profiles were plotted for flow, TDS, and salt mass flows. Point source discharges were the basis for a reach-by-reach materials balance analysis for four reaches of the South Platte River between Henderson and Julesburg. Return flows and return salt mass flows were computed as residuals. The analysis showed that there is not a salt balance in the lower South Platte River. A net salt loss to the land of 380 tons per day occurs by irrigation. The analysis provided can be the basis for a more comprehensive materials balance model. But the results can be used to estimate the impact of new water resources developments upon the salinity regime of the lower South Platte River.

426. Gomez-Ferrer, R., Hendricks, D.W., and Turner, C.D., 1983, Salt transport by the South Platte River in northeast Colorado: Water Resources Bulletin, v. 19, no. 2 (April), p. 183-190.

The salinity of the lower South Platte River in Colorado is characterized by plotting the average annual flow, total dissolved solids, and salt mass flow against distance along the stream. The plots show that salts are being leached from the irrigated lands above Greeley and are being deposited on the irrigated lands below Greeley. The salt deposition on the lower lands will result in their salinization. The plots show also that fall and winter stream flows carry most of the salt loads. These fall and winter flows are stored in off stream reservoirs for use during the irrigation season. Therefore these salts are transferred to the lower irrigated lands where they accumulate. The salt balance for these lands can be improved by permitting the fall and winter flows to leave the basin, or by providing adequate land drainage coupled with supplemental irrigation water.

427. Gonzales, D.D., and Ducret, G.L. Jr., 1971, Rainfall-runoff investigations in the Denver Metropolitan area, Colorado: U.S. Geological Survey Open-File Report 71-0123, 39 p.

Definition of the magnitude and frequency of floods on small urbanized watersheds in the Denver metropolitan area requires the collection and analysis of rainfall-runoff data needed to synthesize long-term runoff records from precipitation records. Hydrologic models and synthetic unit hydrographs are the primary analytical methods used in the study. Analytical applications of the rational method are also investigated. Dual-digital recorders provide the detailed records of rainfall and runoff required in a form convenient for computer translation and tabulation.

428. Gorton, K.A., 1953, Geology of the Cameron Pass area, Grand, Jackson and Larimer Counties, Colorado, in Wyo. University Guidebook, 8th Field Conference: Wyoming Geology Assoc., p. 87-98.

429. Graff, P., 1986, Nuclear fuel and precious-metal occurrences in Precambrian rocks of southeast Wyoming, *in* American Association of Petroleum Geologists, Rocky Mountain Section meeting. AAPG Bulletin, Casper, Wyo., Sept. 7-10, 1986: v. 70, p. 1041.

430. Graff, P.J., Sears, J.W., and Holden, G.S., 1981, Investigation of uranium potential of Precambrian metasedimentary rocks, central Laramie Range, Wyoming; final report National Uranium Resource Evaluation Program: Grand Junction, Colo., U.S. Dep. Energy, Grand Junction Off., GJBX-22-81, 99 p.

431. Grant, J.A. and Olsen, S.N., 1987, Isocon analysis of migmatites, Front Range, Colorado , 1987 annual meeting and exposition, *in* W.R. Dickinson, chairperson, Geological Society of America, Abstracts with Programs, Phoenix, Ariz., Oct. 26-29, 1987: v. 19, Geological Society of America, p. 681.

432. Grant, M.C., and Lewis, W.M., Jr., 1981, Effect of the May-June Mount St. Helens eruptions on precipitation chemistry in central Colorado: Atmospheric Environment, v. 15, no. 9.

433. Gray, L.G., and Ward, J.V., 1982, Effects of releases of sediment from reservoirs on stream biota: Fort Collins, Colo., Colorado Water Resources Research Institute, Completion Report 116, 82 p.

434. Greer, P.L., 1985, Cyclic sedimentation in the Permo-Triassic Goose Egg Formation, southeastern Wyoming, *in* Rocky Mountain Section, 38th annual meeting. Abstracts with Programs, Boise, Idaho, Apr. 22-24, 1985: v. 17, Geological Society of America, p. 221.

435. Greer, P.L., 1985, Genesis and paleogeographic significance of evaporites and associated facies of the Goose Egg Formation (Permo-Triassic), southeastern Wyoming: Laramie, Wyo., Univ. of Wyoming, 67 p.

436. Grey, L., 1974, Economic and land use evaluation of piedmont alluvial deposits, Windsor area, Colorado: University of Colorado.

437. Griffin, J.R., and Warner, A. J., Jr., 1982, National Uranium resource evaluation, Cheyenne Quadrangle, Wyoming, Colorado, and Nebraska: Grand Junction, Colo., Bendix Field Engineering Corp. and the Department of Energy, Washington, D.C., PGJ/F-115(82), 186 p.

The Cheyenne Quadrangle, Wyoming, Colorado, and Nebraska, was evaluated for uranium favorability using National Uranium Resource Evaluation criteria. Examinations of surface exposures of known uranium occurrences, reconnaissance geochemical sampling, water sampling, and ground radiometric surveys were conducted. Anomalous areas recognized from airborne radiometric surveys were ground checked. Electric and gamma logs were used to determine subsurface structure, stratigraphy, lithology, and areas of anomalous radioactivity. Five areas were found favorable for uranium deposits in sandstone. The Lance Formation and Fox Hills Sandstone are favorable in the Goshen Hole, Pine Bluffs, and western Denver Basin. The Cloverly Formation is favorable in the southern Laramie Basin, and the Cloverly, Sundance, and Jelm are favorable in the northwest corner of the quadrangle. Precambrian granitic and metamorphic rocks of the Laramie and eastern Medicine Bow Ranges are unfavorable, as are Paleozoic formations, most Mesozoic units, and Tertiary post-Lance formations of the Denver and Laramie Basins. An area in the northern part of the Laramie Range was not evaluated.

438. Grigg, N.S., 1988, Fiscal year 1987 program report: Colorado Water Resources Research Institute. Annual rept. 24: Fort Collins, Colo., Colorado Water Resources Research Inst. and the U.S. Geological Survey, Reston, Va., Water Resources Div., USGS/ G-1411-01, 38 p.

The 24th annual report describes the Water Resources Research Institute's progress in research and technology development on priority problems which confront Colorado's water managers. The FY1987 program included the following research projects: Water-rights implications of water-quality regulation in Colorado; The economic role of water in Colorado; Incentives for improving irrigation efficiency in the South Platte Basin; Injection recharge in the Denver groundwater basin: operational alternatives. The report also describes the Institute's technology transfer program and other research funded by its State appropriation.

439. Grose, T.L.T., 1988, Overview of the geology of the east flank of the Front Range, in Holden, G.S., ed., Professional Contributions of the Colorado School of Mines. Field trip guidebook, 1988; Centennial meeting, Denver, Colorado: Geological Society of America, p. 79-81.

440. Grozier, R.U., McCain, J.F., Lang, L.F., and Merriman, D.C., 1976, The Big Thompson River flood of July 31-August 1, 1976, Larimer County, Colorado: Denver, Colo., Colorado Water Conservation Board, Department of Natural Resources, Flood Information Report, 78 p.

As much as 12 inches (305 millimeters) of rain fell on the Big Thompson River basin, a favorite summer-home and vacation area in Colorado, during the evening of July 31, 1976, causing a devastating flood on the Big Thompson River and its tributaries between Estes Park and Loveland, Colo. At the latest count (October 1976), Larimer County officials reported 139 persons lost their lives, with 5 still reported missing, and property damage of $16.5 million. Descriptions of the storm and flood, peak discharges, flood elevations, photographs of flooded areas, and aerial photographs of the Big Thompson and the North Fork Big Thompson Rivers, outlining inundated areas, are included in this report to assist public officials and private citizens in planning for reconstruction of the roads, homes, and vacation areas in the Big Thompson River basin. (Woodard-USGS)

441. Grozier, R.U., McCain, J.F., and Ducret, G.L. Jr., 1975, Potential flood hazard; North Avenue area, Denver Federal Center, Lakewood, Colorado: U.S. Geological Survey Open- File Report 75-45, 12 p.

A potential flood hazard has been created on the Denver Federal Center by development of property adjacent to the northwest corner of the center. Prior to development of the property, the 100-year 1-hour rainfall of 2.10 inches produced a peak discharge of 140 cubic feet per second at the west side of Union Street. This discharge entered Welch ditch and the combined discharge of 205 cfs flowed south into McIntyre Gulch without overflowing the east bank of the ditch. Under developed basin conditions, the same rainfall would produce a peak discharge of 212 cfs. The total storm runoff would enter the center through a 54-inch corrugated metal pipe recently constructed under Union Street and Welch Ditch. The 100-year flood discharge for developed basin conditions would cause damages to buildings 67, 56, and 48.

442. Grue, C.E., Tome, M.W., Swanson, G.A., Borthwick, S.M., and Deweese, L.R., [1988?], Agricultural chemicals and the quality of prairie-pothole wetlands for adult and juvenile waterfowl: what are the concerns?, *in* P. J. Stuber, ed., Proceedings of the National Symposium on Protection of Wetlands for Agricultural Impacts: v. Biological Report 88(16), U.S Fish and Wildlife Service, p. 55-64.

443. Gruntfest, E.C., 1982, Changes in flood plain land use and flood hazard adjustment in Denver and Boulder, Colorado 1958-1979: Diss. Abst. Int. Pt. A and Hum. & Soc. Sci., v. 43, no. 4, .

Floods in the United States cause more damage than any other natural hazard. Despite enormous federal expenditures for flood control, flood losses continue to rise. In particular, urban flood damages are rising rapidly and the trend is expected to continue. In 1958, a Chicago research team published an assessment of changes in urban flood plain land use in 17 American cities. Their 22-year study period began in 1936, the year of the first national flood control legislation. Their findings showed growth in the number of flood plain structures and a heavy reliance on structural flood control measures. The current study examines the impact of flood plain management policies from 1958 to 1979 in two of the American cities which were studied earlier: Denver and Boulder, Colorado. The assessment in the two cities is composed of a summary of local flood events and legislative policy, a look at the change in the number and types of flood plain structures, and an examination of the choice and cost of structural and nonstructural flood hazard adjustments.

444. Guilbeault, B.D., 1980, 1979 State-by-State assessment of low-level radioactive wastes shipped to commercial burial grounds: San Francisco, Calif., NUS Corp. for the Department of Energy, Washington, DC., NUS-3440-REV.1, 109 p.

This report provides, on a State-by-State basis, estimates of the quantities and characteristics of low-level radioactive wastes (LLW) generated in 1979 in the following sectors: commercial nuclear power plants, medical and educational institutions, industry (other than commercial nuclear power plants), and government and military. An estimated 79,914 cubic cm of radioactive waste, containing 477,437 Ci of radioactivity were buried in the three US commercial burial grounds in 1979. By the best approximation available at the time of this report, the volume that could be attributed to the industrial category is 17,881 cubic cm and the volume that could be attributed to the institutional category is 14,954 cubic cm. No curie breakdown is possible from available sources of information.

445. Gunow, A.J., Ludington, S., and Munoz, J.L., 1980, Fluorine in micas from the Henderson molybdenite deposit, Colorado: Econ. Geol, v. 75, no. 8.

447. Gutentag, E.D., Heimes, F.J., Krothe, N.C., Luckey, R.R., and Weeks, J.B., 1984, Geohydrology of the High Plains Aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming. Regional Aquifer-System Analysis: U.S. Geological Survey Professional Paper 1400-B, 63 p.

448. Gutentag, E.D., and Weeks, J.B., 1980, Water table in the High Plains Aquifer in 1978 in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U.S. Geological Survey Hydrologic Investigations Atlas HA-642, scale 1: 2,500,000, 1 sheet.

449. Haagenson, P.L., 1979, Meteorological and climatological factors affecting Denver air quality: Atmospheric Environment/An International Journal, v. 13, no. 1.

450. Hadeed, S.J., 1977, Potable water from wastewater-Denver's program: Water Pollution Control Federation Journal, v. 49, no. 8 (August).

The Denver water department will soon embark on an experimental program designed to determine whether potable water quality can be achieved by reclaiming wastewater. Plans call for the design of a 1-mgd potable quality demonstration plant this year, with construction commencing in 1978, and operation scheduled to begin in 1980. Extensive water-quality monitoring and health and toxicological studies will be performed over a period of 5-15 yr. If the program is successful, the full-scale 100-mgd plant will be scheduled for operation by the early 1990s.

451. Hadley, R.F., Emmett, W.W., and Glysson, G.D., 1987, Effects of dam construction on channel geometry and bed material in Bear Creek, Denver, Colorado, *in* Proceedings of the Advanced Seminar on Sedimentation. Circular, Denver, Colo., Aug. 15-19, 1983: p. 35.

452. Hadley, R.F., Karlinger, M.R., Burns, A.W., and Eschner, T.R., 1987, Water development and associated hydrologic changes in the Platte River, Nebraska, USA: Regul. Rivers Res. Manage., v. 1, no. 4, p. 331-341.

453. Haeffner, A.D., 1971, Daily temperatures and precipitation for subalpine forest, central Colorado: Fort Collins, Colo., USDA Forest Serv., Res. Pap. Rm-80, 48 p.

Daily maximum and minimum temperatures and precipitation are presented for two subalpine forest stations near Fraser, Colorado. Records were collected over a 33-year period at 9,070 feet. Mean annual temperature was 33 deg F., with the extremes ranging from -40 deg to 91 deg F. Annual precipitation ranged from 17 to 28 inches, with an average of 23 inches. Five years of record at 10,620 feet indicate lower maximum temperatures as well as higher minimums.

454. Haff, J.C., 1946, Features of geologic structure on the Blue River-South Platte Transmountain Diversion line (U.S.) (abs.): Geol. Soc. Am. Bull, v. 57, no. 12 (Dec.), p. 1199.

455. Hager, D.B., and Loven, C.G., 1983, How the Rocky Mountain Arsenal is handling groundwater contamination: Water/Engineering and Management, v. 130, no. 3(March), p. 18-19.

Groundwater contaminated with inorganic and organic chemical wastes from the operations at the Rocky Mountain Arsenal, Colorado, has been contained by slurry wall and hydraulic barriers and by treatment of water with a counter-current granular activated carbon adsorption system. Several dewatering and reinjection wells were installed as part of the activated carbon system. Di-isomethylphosphonate was found in highest concentrations, maximum 1,130 micrograms per liter. Other chemicals of particular concern were dicyclopentadiene, dibromodichloropropane, and pesticides. Monitoring of treated water-quality during 1982 indicated that levels of these chemicals in treated effluents were below detection limits.

456. Hall, D.C., Boyd, E.L., and Cain, D., 1979, Hydrologic data for wells, springs, and streams in Boulder County, Colorado: U.S. Geological Survey Open-File Report 79-979, 106 p.

Hydrologic data collected in 1975-77 as part of a comprehensive water-resources investigation of Boulder County, Colo., by the U.S. Geological Survey in cooperation with the Boulder County Health Department and the Colorado Geological Survey are presented in this report. The data, in tabular and graphic form, consist of water-quality analyses of selected constituents and geohydrologic-site, water-treatment, and sewage-treatment data for 609 wells and 48 springs; water-quality analyses for 102 of the wells and 9 of the springs; water-quality analyses of streamflow from 34 sites; and specific conductance and water-temperature measurements of streamflow from 3 sites. State and local officials in Boulder County may find these data useful in planning for residential, commercial, and industrial development.

457. Hall, D.C., and Duncan, A.C., 1982, Characterization of urban runoff from Grange Hall Creek at Northglenn, Adams County: U.S. Geological Survey Water-Resources Investigations 81-28, 59 p.

Quality and quantity of urban runoff in upper Grange Hall Creek basin was studied during 1978-79. For selected storms, a median of 54.5 percent of rainfall resulted in runoff in the urbanized upper subbasin and 24 percent in the entire basin; runoff volumes increased almost linearly with rainfall. Peak flows from thunderstorms also increased with rainfall but responses were two-phase linear. No simple relationships were observed between rainfall and runoff. In dry-weather flow, specific-conductance values in the creek ranged from 500 to 3,930 micromhos per centimeter and in the unnamed southern tributary ranged from 430 to 2,500. Specific conductances tended to be greater in winter and less in summer. Storm runoff decreased specific conductance, except during snowmelt runoff when streets were sanded with up to 7-percent salt. Lead, manganese, cadmium, chromium, and copper concentrations exceeded Colorado water-quality standards. During storm runoff, major ion concentrations usually decreased with increased flow.

458. Hall, D.C., and Duncan, A.C., 1980, Hydrologic data from Upper Grange Hall Creek Basin, Northglenn, Adams County, Colorado: U.S. Geological Survey Open-File Report 80-578, 132 p.

Hydrologic data collected during 1977-79 as part of a water-resources investigation of storm runoff in Upper Grange Hall Creek basin, Adams County, Colo., are presented in this report. Data presented in tabular form consist of: (1) Estimated daily precipitation at one site (April through October, 1978 and 1979); (2) mean daily streamflow at two sites (December 1977 through September 1979); (3) instantaneous streamflow at two sites along Grange Hall Creek and corresponding cumulative rainfall at one to three sites for 17 storms (April 1, 1978, to August 26, 1979); (4) concentrations of selected major ions, fecal-coliform bacteria, suspended sediment, nutrients, and trace elements at five sites during dry-weather flow, at three sites during rainfall runoff, and at five sites during snowmelt runoff; and (5) concentrations of pesticides and polychlorinated biphenyls at two sites during dry-weather flow and rainfall runoff.

459. Hall, D.C., Hillier, D.E., Nickum, E., and Dorrance, W.G., 1981, Effects of residential wastewater-treatment systems on ground-water quality in west-central Jefferson County, Colorado: U.S. Geological Survey Open-File Report 81-73 (WRI), 65 p.

The use of residential wastewater-treatment systems in Evergreen Meadows, Marshdale, and Herzman Mesa, Colo., has degraded ground-water quality to some extent in each community. Age of community; average lot size; slope of land surface; composition, permeability, and thickness of surficial material; density, size, and orientation of fractures; maintenance of wastewater-treatment systems; and presence of animals are factors possibly contributing to the degradation of ground-water quality. When compared with effluent from aeration-treatment tanks, effluent from septic-treatment tanks is characterized by greater biochemical oxygen demand and greater concentrations of detergents. When compared with effluent from septic-treatment tanks, effluent from aeration- treatment tanks is characterized by greater concentrations of dissolved oxygen, nitrite, nitrate, sulfate, and dissolved solids.

460. Hall, D.C., Hillier, D.E., Cain, D., and Boyd, E.L., 1980, Water resources of Boulder County, Colorado: Denver, Colo., Colorado Department of Natural Resources and U.S. Geological Survey Bulletin 42, 97 p.

Surface water is abundant in Boulder County, Colo., because large amounts of precipitation fall in the higher mountains and this precipitation feeds the streams directly or indirectly throughout the year. Ground water is an important source of water, mostly for domestic, stock, or limited-acreage irrigation needs. The most frequently used aquifers are flood plain, terrace, Laramie-Fox Hills, Pierre-Niobrara-Benton, and crystalline rock. Median well yields of 15 or more gallons per minute occur for the flood plain, terrace, and Laramie-Fox Hills aquifers. The chemical and bacterial quality of the surface water is best at higher altitudes and decreases as the streams flow easterly to the plains and leave the county. The changes in water quality are influenced by the hydrogeology and the activities of man such as mining, farming, and sewage disposal. Many sources of water examined failed to meet Colorado Department of Health water-quality standards for raw drinking-water use, for agricultural use, and for aquatic life. Chemical quality of the ground water, particularly dissolved solids, is better in water from the unconsolidated- and crystalline-rock aquifers in the mountains and decreases in the aquifers on the plains. Factors involved in <A decrease of quality are the geohydrology and the quality of associated surface water. Local contamination of ground water by subsurface wastewater disposal is a frequent problem.

461. Hall, D.C., and Johnson, C.J., 1979, Drinking water quality and variations in water levels in the fractured crystalline-rock aquifer, west-central Jefferson County, Colorado: U.S. Geological Survey Water-Resources Investigations 79-94, 52 p.

In parts of Jefferson County, CO, water for domestic use from the fractured crystalline-rock aquifer contained excessive concentrations of major ions, coliform bacteria, trace elements, or radiochemicals. Based on results of analyses from 26 wells, water from 21 of the wells contained excessive concentrations of one or more constituents. Drinking water standards were exceeded for fluoride in water from 2 wells, nitrate plus nitrite in 2 wells, dissolved solids in 1 well, iron in 6 wells, manganese in 8 wells, zinc in 2 wells, coliform bacteria in 4 wells, gross alpha

radiation in 11 wells and possibly 4 more, and gross beta radiation possibly in 1 well. Local variations in concentrations of 15 chemical constituents, specific conductance, and water temperature were statistically significant. Specific conductance increased significantly during 1973-75 only in the vicinity of Indian Hills. Annual range in depths to water in 11 observation wells varied from 1 to 15 feet. The shallowest water levels were recorded in late winter, usually in February. The deepest water levels occurred during summer or fall, depending on the well and the year. Three-year trends in water-level changes in 6 of the 11 wells indicated decreasing water storage in the aquifer.

462. Hampton, E.R., 1975 , Map showing availability of hydrologic data published by the U.S. Environmental Data Service, and by the U.S. Geological Survey and cooperating agencies, Greater Denver area, Front Range Urban Corridor, Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I-856C..

This map shows types and locations of the hydrologic data published as of January 1974 for the Greater Denver area by the U.S. Environmental Data Service and by the U.S. Geological Survey and cooperating agencies. The sources of the data are given in both the discussion and the reference. Climatological data include records of precipitation, temperature, and evaporation. Surface-water data include continuous record of stage and discharge of streams; crest-stage and low-flow discharge of streams; chemical quality of streams, lakes, and reservoirs; sediment load of streams; and stage of reservoirs. Locations of 46 surface-water data sites are shown on the map. Ground-water data sites plotted on the map represent 218 wells where water levels have been measured periodically for 4 or more years or monthly for at least 1 year, and 366 wells from which water samples have been analyzed for dissolved-chemical constituents.

463. Hansen, W.R., 1973, Effects of the May 5-6, 1973, storm in the Greater Denver area, Colorado: U.S. Geological Survey Circular 689, 20 p.

The Greater Denver area, Colorado, has had a long history of intensive rainstorms and infrequent but destructive floods. Rain began falling on the Greater Denver area the evening of Saturday, May 5, 1973, and continued through most of Sunday, May 6. Below about 7,000 feet altitude, the precipitation was mostly rain; above that altitude, it was mostly snow. Although the rate of fall was moderate, at least 4 inches of rain or as much as 4 feet of snow accumulated in some places. Sustained precipitation falling at a moderate rate thoroughly saturated the ground and by midday Sunday sent most of the smaller streams into flood stage. The South Platte River and its major tributaries began to flood by late Sunday evening and early Monday morning. Damage was generally most intense in areas where man had modified the landscape--by channel constrictions, paving, stripping of vegetation and topsoil, and oversteepening of hillslopes. Roads, bridges, culverts, dams, canals, and the like were damaged or destroyed by erosion and sedimentation. Streambanks and structures along them were scoured. Thousands of acres of croplands, pasture, and developed urban lands were coated with mud and sand. Flooding was intensified by inadequate storm sewers, blocked drains, and obstructed drainage courses. Saturation of hillslopes along the Front Range caused rockfalls, landslides, and mudflows as far west as Berthoud Pass.

464. Hansen, W.R., 1977, Geologic aspects of solid waste disposal in the urban environment: U.S. Geological Survey Special Publication 8, 43-51 p.

465. Hansen, W.R., 1976, Geomorphic constraints on land development in the Front Range Urban Corridor, in Coates, D.R., ed., Urban geomorphology: Geological Society of America Special Paper 174, p. 85-109.

466. Hansen, W.R., Chronic, J., and Matelock, J., 1978, Climatography of the Front Range Urban Corridor and vicinity, Colorado: U.S. Geological Survey Professional Paper 1019, 59 p.

467. Hansen, W.R., and Crosby, E.J., 1982, Environmental geology of the Front Range Urban Corridor and vicinity, Colorado, with a section on Physical properties and performance characteristics of surficial deposits and rock units, by R.R. Shroba: U.S. Geological Survey Professional Paper 1230, 93 p.

468. Hansink, J.D., 1976, Equilibrium analysis of a sandstone roll-front uranium deposit, in Exploration for Uranium Ore Deposits: Denver, Colo., I.A.E.A. and Rocky Mt. Energy Co., p. 683-693.

469. Hardaway, J.E., and Fox, R.L., 1974, Summary report on the long-term water-quality of the South Platte River Basin 1966-1972: Denver, Colo., Environmental Protection Agency, Region VIII, Report EPA-908/2-74-002, 117 p.

Analysis of water-quality data collected 1968-72 at 21 sampling stations in the South Platte River Basin (Colorado) shows that surface water quality significantly deteriorates as it passes through the Denver metropolitan area. At Denver, coliforms and BOD5 levels have increased in recent years, and dissolved oxygen has sometimes dropped below the acceptable limit of 5 mg/l. A monitoring system is proposed to improve data reliability and comprehensiveness. Highest coliform concentrations were usually at the Franklin Street station, averaging 550,000/100 ml for total coliforms, and 3000/100 ml for fecal coliforms. Levels have occasionally risen to 100 times the mean values. DO content decreased from a median upstream of about 8 mg/l to a median of 6 mg/l at Denver, with lows of 2 mg/l. BOD5 increased to a median of about 15 mg/l in the metropolitan area, with highs over 25 mg/l. Nitrate, phosphate, and ammonia all showed high levels from Denver as far as 100 km downstream to Kersey. Phosphate and ammonia were particularly high at 7 and 6 mg/l. Overall deterioration of water-quality in the main stem occurred throughout the metropolitan area, not just downstream from the major treatment plants. Over the study period, there was a general decrease in coliform bacteria, but an increase in recent years in the Denver area. DO has varied in a cyclical but unpredictable fashion. BOD5 have been relatively consistent, except at Henderson which doubled in the first quarter of 1973.

470. Harms, J.C., 1981, Lateral seals of small stratigraphic traps in Cretaceous rocks, western Nebraska, *in* 1981 AAPG annual convention with divisions; SEPM/EMD/DPA. AAPG Bulletin, San Francisco, Calif., May 31-June 3, 1981: v. 65, Am. Association Petroleum Geologists, p. 935.

471. Harris, J.B., 1980, The Six-State High Plains-Ogallala Aquifer area study: 1979-1982, *in* A quarter century of water research; 25th annual New Mexico water conference. Proceedings of the Annual New Mexico Water Conference, WRRI Report No. 124: [New Mexico?], High Plains Assoc., p. 123-133.

472. Harvey, M. D., 1980, Steepland channel response to episodic erosion: Fort Collins, Colo., Colorado State Univ., 283 p.

473. Harvey, M.D., Crews, S.G., Pitlick, J., and Blair, T.C., 1985, Field Trip 5; Holocene braided streams of eastern Colorado and sedimentological effects of Lawn Lake Dam failure, Rocky Mountain National Park, *in* Flores, R.M., and Harvey, M., eds., Field guidebook to modern and ancient fluvial systems in the United States. Third Int. Fluvial Sed. Conf.: Fort Collins, Colo., p. 87-105.

474. Harza Engineering Company and others, 1987, Cache La Poudre basin water and hydropower resources management study: Denver, Colo., Colorado Water Resources & Power Development Authority, Final report, vol. II, variously paginated.

475. Havens, J.S., 1983, High Plains aquifer study--Geological Survey research 1982: U.S. Geological Survey Professional Paper 1375, 107 p.

476. Hay, R., 1895, Water resources of a portion of the Great Plains-- Part 2: U.S. Geological Survey Annual Report 16, 535-588 p.

477. Hayes, J.R., 1962, Quartz and feldspar content in South Platte, Platte, and Missouri River sands: Jour. Sed. Petrology,

478. Haynes, C.V., Jr., 1965, Genesis of the White Cloud and related pegmatites, South Platte area, Jefferson County, Colorado: Geol. Soc. America Bull.

Large, concentrically zoned, rare-earth-bearing pegmatite bodies occur within granite of the Pikes Peak batholith and are associated with aplite dikes, quartz veins, deuteric wallrock alteration, and fluorite veins. Pegmatite emplacement took place by liquid segregation in a giant miarole, or autointrusion, or a combination thereof in the early stages of batholith crystallization.

479. Heaton, R.L., 1946, Engineering geology of Alve B. Adams Tunnel, Colo. - Big Thompson Project: Geol. Soc. of Amer. Bull., v. 57, p. 1200-1201.

480. Heaton, R.L., 1940, Geologic aspects of the Colorado - Big Thompson Project: Mine's Magazine (CSJM), v. 30, p. 257-264.

481. Hecox, G.R., 1977, Engineering geology and geomorphology in Northeast Clear Creek County, Colorado: Golden, Colo., Colorado School of Mines.

482. Heimes, F.J., and Luckey, R.R., 1983, Estimating 1980 ground- water pumpage for irrigation on the High Plains in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U.S. Geological Survey Water-Resources Investigations Report 83-4123, 40 p.

483. Heimes, F.J., and Luckey, R.R., 1982, Method for estimating historical irrigation requirements from ground water in the High Plains in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U.S. Geological Survey Water-Resources Investigations 82-40, 68 p.

484. Heinrich, E.W., 1958, Rare-earth pegmatites of the South Platte-Lake George area, Douglas, Teller and Park Counties, Colorado (abstr.): Geol. Soc. Am., Bull, v. 69, no. 12, p. 1579-1580.

485. Heinrich, E.W., Simmons, W.B., and Crook, W.W., 1978, Fractionation of rare-earth elements in granite-pegmatite systems, in The Geological Association of Canada, The Mineralogical Association of Canada, The Geological Society of America (91st annual meeting); 1978 joint annual meeting. Geol. Soc. Am., Abstr. Programs, Toronto, Ont., Canada, Oct. 23-26, 1978: v. 10(7), The Geological Society of America, p. 418.

486. Heisler, S.L., Henry, R.C., Watson, J.G., and Hidy, G.M., 1980, The 1978 Denver winter haze study. Volume I. Executive summary final rept: Westlake Village, Calif., Environmental Research and Technology, Inc., and Motor Vehicle Manufacturers Association of the United States, Inc., ERT/P-5417/2, 19 p.

A study of the nature and sources of the Denver winter haze was conducted over a 31-day period in November and December, 1978. Measurements were made of (1) optical properties of the air, (2) physical and chemical properties of suspended particles as a function of size, (3) the important pollutant gases (carbon monoxide, sulfur dioxide, nitrogen oxides, ozone and hydrocarbon vapors), and (4) meteorological parameters including winds, temperature, relative humidity and solar radiation. Elemental carbon was found to be the most important contributor (38%) to the particle light extinction coefficient. On the average, diesel emissions, natural gas combustion, coal combustion and unidentified sources of elemental carbon each contributed 12 to 15% of the particle extinction coefficient. Noncatalyst-equipped automobiles and unidentified sources of organic carbon each contributed 9 to 10%. Water, residual oil combustion and catalyst-equipped automobiles contributed about 4% each.

487. Heit, M., Klusek, C.S., and Baron, J., 1984, Evidence of deposition of anthropogenic pollutants in remote Rocky Mountain lakes: Water, Air, Soil Poll., v. 22, p. 403-416.

488. Heit, M., Klusek, C.S., Volchok, H.L., and Burke, J.C., 1980, Time history of trace elements in sediments. from Standley Lake, Colorado: Env. Intl., v. 4, no. 3, p. 229.

Eighteen trace elements in sections from a 50-cm-long sediment core from Standley Lake, Colo., were analyzed. The core was dated by the use of bomb-produced cesium-137. Ten of the elements measured appear to be enriched in the sediment; these include cadmium, copper, mercury, and zinc. Seven others are probably of local origin: aluminum, arsenic, beryllium, cobalt, chromium, nickel, and vanadium. Tellurium was not detected. The primary source of the excess elemental concentrations is local stream pollution.

489. Hendricks, D.W., and Bluestein, M.H., 1975, A picture essay of the South Platte Basin water resources system: Fort Collins, Colo., Department of Civil Engineering, Colorado State University, Report 8.

490. Hendricks, D.W., and Bluestein, M.H., 1976, Response of South Platte River to effluent quality limitations.: Journal of the Environmental Engineering Division (ASCE), v. 102, no. 4, p. 745.

A computer simulation model is used to project the water quality improvements resulting from implementation of 1977, 1983, and 1985 federal effluent quality limitation requirements for all water discharges in the South Platte River basin, Colo. Sufficient improvements of water quality in the plains zone will be achieved by 1983 to permit fish propagation and recreation. However, improvement in water quality alone is precluded by the modifications caused by intense human uses of the stream and associated lands and by the limiting characteristics of the plains system.

491. Hendricks, D.W., and Dehaan, R.W., 1975, Input-output modeling in water resources system planning: Fort Collins, Colo., Colorado State Univ., Environ. Engineering TR-3, 106 p.

Principles of input-output modeling of economic systems are adapted to the description of a water resources system. The major sectors of supply and demand are identified, such as 'native surface water flows,' 'imported water,' 'agriculture, 'municipal.' These sectors were disaggregated further into specific water transferring entities, such as particular streams, geographical regions of the agricultural sector, specific cities, etc. This resulted in an 81 x 80 matrix, displayed on a magnetic board. From this, the distribution of available supplies is seen on the rows from each supply source. How each demand entity satisfies its needs is seen as the sum of the entries for the respective column. From this, an entire water resources system is displayed at once. This was done for the year 1970 for the South Platte basin.

492. Hendricks, D.W., and Dehaan, R.W., 1981, The input-output water transactions model of supply and demand: Water Supply and Management, v. 5, no. 4/5, p. 317-330.

This paper focuses on the basic guidelines for input-output water planning and the general application of the model in basin-wide planning. The major purposes are to demonstrate how a simple tabular display, the input-output water transactions table, can be constructed to represent a complex water system, and to indicate the utility of the table in water planning. The 1970 input-output table of the South Platte Basin depicts the system structure for innumerable transfers of water. These transfers give the 'fits' between the sources of supply and the demand sectors shown. The structure, implicit in the matrix, is formed by the water rights priorities and the commensurate physical facilities for water storage, conveyance, and distribution. The input-output table ties together all of the diverse components of a water resource system such that the relationships between the parts and the whole can be discerned. Such a display provides a framework for making judgments about alternative water supply alternatives in the context of political, environmental, and legal questions, as well as physical ones. It is, at the same time, a planning methodology and a core of information.

493. Hendricks, D.W., Janonis, B.A., Gerlek, S., Goldbach, J.C., and Patterson, J.L., 1982, Modeling of water supply-demand in the South Platte River basin, 1970-2020: Water Resources Bulletin, v. 18, no. 2 (April), p. 279-287.

A water balance model was applied to the South Platte River basin, Colorado, to determine solutions to the supply/demand problem for both average and stress conditions for the years 1980, 2000, and 2020. The base year was 1970. The model was displayed in tabular form on 8-ft x 8-ft color-coded magnetic board. Solutions obtained for different conditions were produced for evaluation by different interest groups. Some of the information obtained from this model as applied to the South Platte Basin included: the present per capita water use of 220 gpcd could be reduced to 167 gpcd without severe difficulties, an additional 280,000 acre-feet could be imported from the Colorado River basin with minimum social and economic disruption, the potential role of large-scale water exchanges between urban and agricultural users should be explored, water reuse is necessary, irrigated acreage can be adjusted to the amount of available water, and increased storage facilities would capture excess flows.

494. Hendricks, D.W., and Morel-Seytoux, H.J., 1978, Models for system water planning with special reference to water reuse: Fort Collins, Colo., Colorado Water Resources Research Institute, Completion report 90, 168 p.

Research to delineate methods for water reuse planning in the context of a complex system with the following objectives is reported: (1) to develop the matrix format for depicting a complex water system; (2) to demonstrate the application of the matrix format and its application in water planning with reference to water reuse; and (3) to develop mathematical programming for a least-cost objective function using non-linear cost functions. A descriptive model for an overall water system called an input-output water balance model, and a least-cost computer optimization model were developed taking into account all sources of supply and all sectors of demand. Using empirical data from the South Platte River basin, both models are demonstrated. Alternative modes of water development to meet overall demands in the South Platte River basin to 2020 were delineated by the input-output model. Using the Cache La Poudre as the case situation the model is also demonstrated at the sub-basin level. The optimization model used the Cache La Poudre River basin for the case situation. It is concluded that both models can be used independently, or in a complementary fashion to evaluate water reuse in its systems context.

495. Hendricks, D.W., Morel-Seytoux, H.J., and Turner, C.D., 1979, Water for the South Platte Basin: Fort Collins, Colo., Colorado Water Resources Research Institute, Information Series 37, 13 p.

496. Hendricks, D.W., and Reitano, B.M., 1980, Input-output modeling for facility level water planning: Water Supply and Management, v. 4, no. 5-6.

497. Hendricks, D.W., Turner, C.D., and Klooz, D., 1982, Sequential water reuse effect on stream salinity: Water Resources Bulletin, v. 18, no. 2, p. 317-324.

A salinity model based on the water balance principle was developed to estimate the effects of sequential reuse of stream water on residual streamflow and salinity. The salinity increases and streamflow decreases caused by sequential water reuse in arid and semiarid western U.S. areas were shown in an application of the model to the South Platte River Basin, Colorado. The upper limit of total diversions based on minimum streamflow alone was 6,846,900 acre-feet per year, which corresponded with an intolerable 5,000 to 10,000 mg per liter dissolved solids. Considering a tolerable salinity of 2,600 mg per liter, the upper limit of total diversions was only 5,430,300 acre-feet per year. If it was possible to capture an additional 300,00 acre-feet per year of excess flow for reuse, 896,100 acre-feet more water would be available.

498. Hendricks, L.J., 1950, The fishes of Boulder County, Colorado: Boulder, Colo., University of Colorado, MS thesis, 55 p.

499. Hepworth, D.K., 1973, Results of stocking channel catfish in the South Platte River - an urban fishing program: Fort Collins, Colo., Colo. State University, MS thesis, 62 p.

500. Hepworth, K.W., Test, P.S., Hart, R.H., Waggoner, J.W., Jr., and Smith, M.A., 1991, Grazing systems, stocking rates, and cattle behavior in southeastern Wyoming: Journal of Range Management, v. 44, no. 3 (May).

501. Herrmann, S.J., Ruiter, D.E., and Unzicker, J.D., 1986, Distribution and records of Colorado Trichoptera: The Southwestern Naturalist, v. 31, no. 4, p. 421-457.

502. Hershey, L.A., and Schneider, P.A., Jr., 1972, Geologic map of the Lower Cache La Poudre River Basin, north-central Colorado: U.S. Geological Survey Miscellaneous Investigation Series I-687, 1 sheet.

503. Hershey, L.A., and Schneider, P.A., Jr., 1964, Ground water investigations in the Lower Cache La Poudre River Basin, Colorado: U.S. Geological Survey Water-Supply Paper 1669-X, 22 p.

Ground water is a major natural resource in the lower Cache la Poudre River basin of Colorado. Alluvial deposits overlying rocks of Late Cretaceous age constitute the principal aquifers and yield from a few gallons to 2,000 gpm. About 86,000 acre-feet of water was pumped for irrigation in 1959 from 1,300 irrigation wells. Included are maps showing location and distribution of irrigation wells, relative availability of ground water by areas, approximate boundaries of alluvial aquifers, and an analysis of representative water samples.

504. Herzog, D. J., 1982, Geologic influence on sensitivity of watersheds in Rocky Mountain National Park to acidification: Fort Collins, Colo., Colorado State University, MS thesis, 176 p.

505. Hestmark, M. C., 1988, Development and evaluation of a Lagrangian one-dimensional steady-flow trace-metal surface-water transport model: Golden, Colo., Colorado School of Mines, 137 p.

506. Hewett, D.F., and Fleischer, M., 1960, Deposits of the manganese oxides: Econ. Geology.

507. Higley, D.K., and Gautier, D.L., 1987, Median-porosity contour maps of the J Sandstone, Dakota Group, in the Denver Basin, Colorado, Nebraska, and Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-1982, scale 1:500,000, 1 sheet..

508. Higley, D.K. and Gautier, D.L., 1985, Regional trends in porosity and permeability of J Sandstone in Denver Basin; controls of burial history, in AAPG Rocky Mountain Section meeting. AAPG Bulletin, Denver, Colo., June 2-5, 1985: v. 69, p. 851.

509. Hill, G.M., 1977, Specification of environmentally significant areas in the Denver Region: Denver, Colo., Denver Regional Council of Governments and Urban Mass Transportation Administration, Washington, D.C., 436 p.

The report includes specific criteria for the designation of environmentally significant areas in the Denver Region. Environmentally significant areas are land and water areas that exhibit valuable and unique physical characteristics which have an important effect and influence on the quality of life for a community or individual. For the purposes of this study, environmentally significant areas include environmental hazard areas, environmentally sensitive areas, natural resource areas, park, recreation and open space areas. The technical information and documentation contained in this report relate to the regional development policies on environmental protection set forth in the Regional Growth and Development Plan for the Denver Region. These regional development policies provide direction and guidance to growth and development within environmentally significant areas and distinguished between those areas which should be left undeveloped and those which can be developed with restrictions or closer management.

510. Hillier, D.E., 1978, Water-table aquifers in the Boulder-Fort Collins-Greeley area of the Front Range Urban Corridor: U.S. Geological Survey Professional Paper 1100, 112 p.

511. Hillier, D.E., 1979, Well yields and chemical quality of water from water-table aquifers in the Boulder-Fort Collins-Greeley area, Front Range Urban Corridor, Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I-855-J, scale 1:100,000, 2 sheets.

512. Hillier, D.E., and Schneider, P.A., Jr., 1979, Depth to the water table (1976-77) in the Boulder-Fort Collins-Greeley area, Front Range Urban Corridor, Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I-855-J, scale 1:100, 000, 1 sheet.

513. Hillier, D.E., Schneider, P.A., Jr., and Hutchinson, E.C., 1979, Hydrologic data for water-table aquifers in the Greater Denver area, Front Range Urban Corridor, Colorado: U.S. Geological Survey Open-File Report 79-214, 68 p.

As part of the U.S. Geological Survey's investigations of the hydrology and geology in the Front Range Urban Corridor of Colorado, hydrologic data for water-table aquifers in the greater Denver area were collected and compiled during 1976-77. These data, consisting of records for 325 wells and 11 springs and chemical analyses of water for 272 of the wells and all 11 springs, are presented in tabular form. The tables contain data that were collected during the investigation, data compiled from reports published by the Colorado Water Conservation Board and the U.S. Geological Survey, and unpublished data from the files of the U.S. Geological Survey. State and local officials in the greater Denver area may find these data useful in planning for residential, commercial, and industrial development.

514. Hills, F.A., Dickinson, K.A., Nash, J.T., Otton, J.K., and Dodge, H.W., 1982, National uranium resource evaluation: Denver Quadrangle, Colorado: U.S. Geological Survey and Dept. of Energy, PGJ/F-078-82, 244 p.

Nine areas in the Denver 1 degree x 2 degree Quadrangle, Colorado have been identified as favorable for the occurrence of uranium deposits containing a minimum of 100 tons U sub 3 O sub 8 at grades of 0.01% or better. Six of these areas are in metamorphic and igneous rocks of the Front Range, one is in sedimentary rocks of South Park, and two are in sedimentary rocks of the Great Plains. Favorable areas and the classes of deposits for which they are thought to be favorable are: Area A, The Foothills Favorable Environment (700 sq km to a depth of 1500 m); Areas B-D, The Silver Plume Granite Favorable Environment; Area E, Southern Elkhorn Upthrust Favorable Environment; Area F, South Park Favorable Environments (27 sq km in units of variable thickness); Area G, Dawson Arkose Favorable Environment (3600 sq km with an estimated thickness of 50 m); and Area H, Fox Hills Formation Favorable Environment (700 sq km with an estimated thickness of 38 m). Other areas and environments in the Denver Quadrangle have uranium occurrences and some have yielded small amounts of uranium ore in the past (for example the Central City district). These areas are ranked as unfavorable because, in our judgment, the evidence does not suggest favorability for deposits of the minimum size. However, neither empirical data nor genetic models for uranium deposits are adequate presently to make determinations of favorability with confidence, and changes of rank are to be expected in the future.

515. Hofstra, W.E., and Hall, D.C., 1975, Hydrogeologic and water- quality data in western Jefferson County, Colorado: U.S. Geological Survey and Colorado Department of Natural Resources, Water Resources Basic-Data Release 36, 51 p.

Information is presented on the availability of water for domestic supply in the mountainous area in Jefferson County, Colo. The area covered by the study is roughly 300 square miles of mountainous Jefferson County extending from Clear Creek on the north to the Pike National Forest boundary on the south and from the east edge of the Front Range mountains to the western boundary of the county. The population of the mountainous part of the county was roughly 20,000 in 1974. Hydrologic data were collected at 34 streamflow sites. Bacteriological and chemical analyses of surface waters are given for 32 sites. During the study, 31 springs and 727 wells were sampled. Comprehensive bacteriological and chemical analyses of samples collected from 38 wells and 1 spring are given. Eleven test wells were drilled by air-percussion. Geologic logs and hydrologic test data for these wells are given.

516. Hofstra, W.E., Major, T.J., and Luckey, R.R., 1972, Hydrogeologic data for the northern High Plains of Colorado: U.S. Geological Survey , Colorado Water Conservation Board, Colorado Division of Water Resources, Office of the State Engineer, and the High Plains Management Districts, Basic-Data Release No. 23, 143 p.

517. Holliday, V.T., 1988, Geoarchaeology and late Quaternary geomorphology of the middle South Platte River, northeastern Colorado. Guidebook to the archaeological geology of the Colorado Piedmont and High Plains of southeastern Wyoming, *in* Donahue, J., ed., Reprinted from Geoarchaeology, Vol. 2, No. 4, 317-329, 1987: Denver, Colo., Geol. Soc. Am.

518. Hooper, R.M., 1968, Wetlands in Colorado: Denver, Colo., Department of Game, Fish and Parks, State of Colorado, Colorado Division of Wildlife Tech. Publ. 22, 89 p.

519. Hopton, N.R., and Mazhar, F.M., 1985, Geotechnical aspects of Strontia Springs, *in* Zagars, A., ed., Arch. Dam Hydropower, recent developments: New York, Am. Soc. Civ. Eng., p. 33-46.

520. Howe, C.W., 1987, Project benefits and costs from national and regional viewpoints: methodological issues and case study of the Colorado-Big Thompson Project: Natural Resources Journal, v. 27, no. 1(Winter).

521. Howe, C.W., Schurmeier, D.R., and Shaw, W.D., 1986, Innovations in water management: Lessons from the Colorado-Big Thompson Project and Northern Colorado Water Conservancy District, *in* Scarce water and institutional change: Washington, D.C., Resources for the Future, Inc., p. 171-200.

The Colorado-Big Thompson Project (C-BT) that transfers water from the western slopes of the Rocky Mountains to northeastern Colorado both required and inspired institutional innovation. The C-BT had to guarantee the repayment of project costs as required by Bureau of Reclamation laws, negotiate solutions to conflicts with the basin of origin, and allocate water among users with varied water needs. These challenges led to the establishment in 1937 of the Northern Colorado Water Conservancy District (NCWCD). Much credit for the success of the C-BT must be given to the unusual system of water markets that evolved within the district and the set of legal and administrative conditions that made these markets possible. The major methods for allocating large water supplies within the market system are priority allocation rules and proportional rules. Under a priority rule, the various users are assigned certain quantities of water per time period, and each of these quantities has a priority number. A proportional rule divides available water among a group of users according to a fixed set of proportions. The total amount of C-BT water available to the district each year is determined by the quota system. In the C-BT-NCWCD system, return flows are owned by the district. When a buyer and a seller wish to effect an allotment transfer, they submit an application to the district. Transfers can sometimes be facilitated by brokers of NCWCD allotments. Rentals (transfers of water among users for one season only) occur not only with NCWCD water but also with appropriated and ditch company water. The water markets used by the NCWCD are more efficient than methods currently used by federal and State water agencies and might by copied for many places in the West and elsewhere.

522. Hubert, W.A., 1988, Survey of Wyoming, USA crayfishes: Great Basin Nat., v. 48, no. 3, p. 370-372.

Collections of crayfish by Wyoming Game and Fish Department biologists and University of Wyoming staff in 1985-1987 included five species: *Pacifastacus gambelii*, the only species found in the Snake River and Bear River drainages of western Wyoming; *Orconectes neglectus neglectus*, collected from one reservoir in the South Platte River drainage in southeastern Wyoming (its first reported occurrence in the State); *O. immunis* and *O. virilis*, widespread east of the Continental Divide and in the Green River drainage of southwestern Wyoming; and *Cambarus diogenes diogenes*, collected from a tributary of the North Platte River in eastern Wyoming.

523. Huebert, B.J., Norton, R.B., Bollinger, M.J., Parrish, D.D., and Hahn, C., 1983, Gas phase and precipitation acidities in the Colorado mountains, *in* Acid rain: A water resources issue for the 80's: Bethesda, Md., American Water Resources Association, p. 17-23.

For the past few years, both the gas phase concentrations of nitric acid, its precursors, and nitrate aerosols and the precipitation concentrations of nitrate were measured at Niwot Ridge, a remote area field site located at 3-km elevation in the Colorado mountains west of the Denver metropolitan area. The measurements were made using a variety of techniques: filter collection, ion chromatographic analysis, direct pH and conductivity determinations, and chemiluminescence detection. An extensive wind speed/wind direction network, coupled with trajectory analyses, provided meteorological support. The prevailing winds at the site are from the west, although occasionally, the wind is from the east, across the metropolitan area in that direction. Correlations between the wind direction and the acidity levels, show that, despite the fact that east winds are atypical, the acidic components accompanying these winds are the likely major source of the relatively high acid deposition that occurs at the site. The observed nitric acid/precursor correlations are consistent with the current picture of the transformation chemistry. During the winter of 1980/81, it was shown that snow scavenges nitric acid and nitrate very efficiently.

524. Humble, D.E., 1991, Recovery of stressed aquatic communities - an incremental assessment approach to evaluation of water-quality and non-water-quality related factors (abstract only), *in* Woodring, R.C., ed., South Platte resource management: Finding a balance: Fort Collins, Colo., Colorado Water Resources Research Center, p. 24.

525. Huntoon, P.W., and Lundy, D.A., 1979, Evolution of ground-water management policy for Laramie, Wyoming, 1869-1979: Ground Water, v. 17, no. 5, p. 470-475.

526. Huntoon, P.W., and Lundy, D.A., 1979, Fracture-controlled ground-water circulation and well siting in the vicinity of Laramie, Wyoming: Ground Water, v. 17, no. 5, p. 463-469.

527. Hurr, R.T., 1973, The effect of transmountain diversions on the flow of the South Platte River between Henderson and Kersey, Colorado (abstract only), in Rocky Mountain Section, 26th Annual Meeting of the Geol. Soc. Am., Abstracts: v. 5(6), Geological Society of America, p. 485-486.

528. Hurr, R.T., 1976, Effects of water-management practices on the flow of the South Platte River, Colorado, in International Symposium on the Hydrological Characteristics of River Basins and the Effects on these Characteristics of Better Water Management, Tokyo, Japan, December 1975: v. 117, International Association of Hydrological Sciences, p. 611-618.

Water-management practices have affected the various components which make up the flow of the South Platte River in Colorado. Installation of wells and ground-water withdrawals that for many years were individual and unregulated farm-management practices, have reduced the return flow to the river. However, an increase in transmountain diversions that resulted in an increased return flow of irrigation water to streams tributary to the South Platte River, occurred simultaneously with a decrease in direct diversions from the river. The effect was little net change in annual streamflow of the South Platte River at the Colorado-Nebraska State line.

Design of effective and efficient water-management practices is directly influenced by the interrelations between ground water and surface water, and the effects of imported water on the system. Currently, a study of the South Platte River includes the calibration of a computer model of the study area based on observed hydraulic characteristics and interrelations. When calibrated, the model can be used to determine future effects of alternative management plans.

530. Hurr, R.T., and Burns, A.W., 1978, Water-management plans for the South Platte River valley: U.S. Geological Survey Professional Paper 1100, 112-113 p.

531. Hurr, R.T., and Luckey, R.R., 1972, Ground-water levels in the South Platte River Valley of Colorado, 1968-72: Denver, Colo., Colorado Water Conservation Board, Basic-Data Release 26, 33 p.

Water levels were measured for approximately 1,000 wells in November following the 1972 irrigation season in the South Platte River valley of Colorado. Measurements made each autumn during the 4 preceding years are included to serve as references illustrating declining or rising water levels. The valley extends from near Denver, Colo., to the Nebraska State line. The study area extends from Henderson, Colo., near Denver, to the State line, a distance of 190 miles, and occupies 1,000 square miles in parts of six counties. The valley-fill aquifer is adjacent to, underlies, and is in hydraulic connection with the South Platte River. This aquifer yields groundwater which is used as a supplemental supply for irrigation in the South Platte River valley. The valley fill ranges in thickness from 0 to about 300 feet; in much of the area, however, the thickness is about 50 to 200 feet. The valley fill consists of gravel, sand, silt, and clay of Pleistocene to Holocene ages. The valley fill ranges from 2 to 10 miles in width and rests in a broad trough cut into the bedrock.

532. Hurr, R.T., and Luckey, R.R., 1973, Ground-water levels in the South Platte River Valley of Colorado, spring 1973: U.S. Geological Survey Colorado Water Conservation Board Basic-Data Release 30, 33 p.

Water-level measurements made in March 1973 in the South Platte River valley of Colorado are published in a report released by the U.S. Geological Survey. The area covered by the report extends along the South Platte River from Henderson, Colo., near Denver, to the Nebraska State line, a distance of 190 miles, and occupies 1,000 square miles in parts of Adams, Logan, Morgan, Sedgwick, Washington, and Weld Counties. Water-level measurements were made in about 1,000 wells that tap the valley-fill aquifer. Water-level measurements made in the same wells during the 4 preceding years are included to serve as reference. The aquifer supplies nearly all of the groundwater used in the South Platte River valley as a supplemental supply for irrigation. The valley fill ranges in thickness from 0 to about 300 feet; in much of the area, however, the thickness is about 50 to 200 feet. The valley fill consists of gravel, sand, silt, and clay of Pleistocene to Holocene ages. The valley fill ranges from 2 to 10 miles in width and rests in a broad trough cut into the bedrock. In northeastern Colorado bedrock consists of pre-Pleistocene sedimentary formations. A list of 29 Colorado water resources basic-data releases is included.

533. Hurr, R.T., and Schneider, P.A., Jr., 1977, Ground-water resources of the alluvial aquifers in northeastern Larimer County, Colorado: U.S. Geological Survey Water-Resources Investigations 77-7, 31 p.

Ground water is a source of municipal, domestic, stock, and irrigation supply for most of northeastern Larimer County, Colo. A study of the alluvial aquifers in the northeastern part of the county was conducted to determine volume of water in storage, rate and location of ground-water withdrawals, and chemical quality of the water with particular attention to dissolved solids, hardness, sulfate, and selenium. There are 251 large-capacity wells in the study area. Well yields range from about 80 gpm (gallons per minute) to a little over 1,800 gpm. Total volume of water in storage is about 133,000 acre-feet--32,000 acre-feet in the alluvium of Buckeye terrace and 101,000 acre-feet in the valley-fill aquifer associated with Boxelder Creek. Ground-water withdrawals for irrigation are about 25,000 acre-feet annually. The municipal wells pumped 210 acre-feet in 1974. The factors affecting ground-water quality are the quality of applied irrigation water, the amount of water lost to evapotranspiration during irrigation, and, to a lesser degree, solution of soluble material in the alluvium and in the bedrock at the base of the alluvium. Ground water at the north end of the Buckeye terrace contains only about 300 mg/liter dissolved solids. Recharge is from surface water containing less than 90 mg/liter dissolved solids. Concentrations of all constituents increase downgradient to the south due to solution and evaporative concentration.

534. Hurr, R.T., and Schneider, P.A., Jr., 1972, Hydrogeologic characteristics of the valley-fill aquifer in the Brighton Reach of the South Platte River valley, Colorado: U.S. Geological Survey Open-File Report 72-0332, 2 p.

Maps showing location, wells, bedrock, water-table, saturated thickness, and transmissivity.

535. Hurr, R.T., and Schneider, P.A., Jr., 1973, Hydrogeologic characteristics of the valley-fill aquifer in the Brush Reach of the South Platte River valley, Colorado: U.S. Geological Survey Open-File Report, 2 p.

536. Hurr, R.T., and Schneider, P.A., Jr., 1973, Hydrogeologic characteristics of the valley-fill aquifer in the Weldona Reach of the South Platte River valley, Colorado: U.S. Geological Survey Open-File Report, 2 p.

537. Hurr, R.T., and Schneider, P.A., Jr., 1973, Hydrogeologic characteristics of the valley-fill aquifer in the Sterling Reach of the South Platte River valley, Colorado: U.S. Geological Survey Open-File Report, 2 p.

538. Hurr, R.T., and Schneider, P.A., Jr., 1973, Hydrogeologic characteristics of the valley-fill aquifer in the Julesburg Reach of the South Platte River valley, Colorado: U.S. Geological Survey Open-File Report, 2 p.

539. Hurr, R.T., and Schneider, P.A., Jr., 1973, Hydrogeologic characteristics of the valley-fill aquifer in the Greeley Reach of the South Platte River valley, Colorado: U.S. Geological Survey Open-File Report, 2 p.

540. Hurr, R.T., Schneider, P.A., Jr., and Minges, D.R., 1975, Hydrology of the South Platte River Valley, northeastern Colorado: Denver, Colo., Colorado Water Conservation Board, Water Resources Circular 28, 24 p.

The study area occupies about 950 sq mi along the South Platte River between Henderson, Colo., and the Colorado-Nebraska state line and is underlain by valley fill containing an unconfined aquifer which is in hydraulic connection with the South Platte River. The principal use of the water is for irrigation. During 1947-70 the surface-water diversions averaged 981,000 acre-ft annually, and groundwater diversions averaged 420,000 acre-ft annually. Groundwater seepage to the river decreased by about 250,000 acre-ft per year, and groundwater storage decreased by 456,000 acre-ft. About 45 to 50 percent of the applied irrigation water recharges the groundwater system, a large part of which ultimately seeps into the river. Owing to the consumption losses, however, the recharged groundwater is higher in dissolved solids than the applied irrigation water so that there is a general increase in dissolved-solids concentration in a down-gradient and a down-valley direction. There also tends to be an increase in dissolved-solids concentration in the river in a down-valley direction. In the South Platte River valley, surface water and groundwater are the components of one hydraulic system, and an analysis of water-management practices must consider the interrelation between them in quantitative terms. The description of the system and its operation as presented provide a foundation upon which such analysis can be made.

541. Hutchinson, E.C., and Hillier, D.E., 1978, Hydrologic data for water-table aquifers in the Colorado Springs--Castle Rock area, Front Range Urban Corridor, Colorado: U.S. Geological Survey Open-File Report 78-948, 41 p.

As part of the U.S. Geological Survey's investigations of the hydrology and geology in the Front Range Urban Corridor of Colorado, hydrologic data for water-table aquifers in the Colorado Springs--Castle Rock area were collected and compiled during 1976-77. These data, consisting of records for 157 wells and 47 springs and chemical analyses of water for 135 of the wells and all 47 springs, are presented in tabular form. The tables contain data that were collected during the investigation, data compiled from reports published by the Colorado Water Conservation Board, and unpublished data from the files of the U.S. Geological Survey. State and local officials in the Colorado Springs--Castle Rock area may find these data useful in planning for residential, commercials, and industrial development.

542. Idaho National Engineering Lab., 1982, 1980 State-by-State assessment of low-level radioactive wastes shipped to commercial disposal sites: Idaho Falls, Idaho, Department of Energy, DOE/LLWMP-11T, 113 p.

Information is presented on the volumes, curie values, sources, and disposal of low-level radioactive wastes (LLW) in each State. The wastes are segmented into 2 broad categories - institutional/industrial and commercial power reactor wastes. The volumes and curie values were obtained from the commercial site operators. The percentage of LLW disposed of at each of the 3 operating disposal sites located at Barnwell, SC, Beatty, NV, and Richland, WA, are included.

543. Illangasekare, T.H., and Morel-Seytoux, H.J., 1986, Algorithm for surface and ground-water allocation under appropriation doctrine: Ground Water, v. 24, no. 2, p. 199-206.

544. Illangasekare, T.H., and Morel-Seytoux, H.J., 1986, A discrete kernel simulation model for conjunctive management of a stream-aquifer system: Journal of Hydrology, v. 85, no. 3-4, p. 319-338.

A stream-aquifer simulation model was developed to conduct a conjunctive use management study in the South Platte River in Colorado. This model simulates both the physical and operational behavior of the system. The physical system modeled is comprised of the river and the saturated and unsaturated zones of the aquifer. A technique referred to as the "discrete kernel approach" was used to model the saturated zone of the aquifer. This technique is based on the classical Green's function method of solution of partial differential equations. The physical simulator was coupled to an allocation model which simulates the operational behavior of the system. The management model was applied to conduct a conjunctive use study involving the evaluation of a stream flow augmentation scheme. A summary of the results of this case study is presented.

545. Ingham, E.R., Trofymow, J.A., Ames, R.N., Hunt, H.W., Morley, C.R., Moore, J.C., and Coleman, D.C., 1986, Trophic interactions and nitrogen cycling in a semi-arid grassland soil. System responses to removal of different groups of soil microbes or fauna: Journal Appl. Ecol., v. 23, no. 2, p. 615-630.

546. International Engineering Company, Inc., Dames & Moore Consulting Engineers, and Taliesin Associated Architects, 1973, Appendix to Environmental Study; Upper South Platte Unit, Colorado: [Denver, Colo?], U.S. Bureau of Reclamation, variously paginated.

547. Ives, R.L., 1940, Rock glaciers in the Colorado Front Range: Geol. Soc. Amer. Bull., v. 51, p. 1271-1294.

548. Jack, J.G., 1900, Pikes Peak, Plum Creek, and South Platte reserves: Twentieth Annual Report, 1898-99; Part 5, 39-115 p.

549. Jackson, J.R., 1972, Vegetation of the floodplain of the South Platte River in the proposed Narrows Reservoir site: Greeley, Colo., MA. Thesis, University of Northern Colorado, 83 p.

A vegetational analysis of the proposed site of the Narrows Reservoir and surrounding prairie was initiated in 1971. Composition and distribution of flood plain communities were determined. Five distinct community types were present: the pure *Salix* spp. community occupying the most moist habitat and least important on the basis of area; the mixed *Salix* spp. and *Populus sargentii* (Doda.) community occupying the 2nd most moist habitat and 2nd most important on the basis of area; the open and closed *P. sargentii* communities occupying the 3rd most moist habitat and ranked 1st and 3rd on the basis of size; and the open park community occupying the driest habitat and the 4th most important on the basis of size. The importance of most species was dependent on the community type in which they occurred. Relationships between soil texture, relative wetness of sites and community type were also determined. No rare or endangered species were encountered.

550. Jackson, J.R., and Lindauer, I.V., 1978, Vegetation of the floodplain of the South Platte River in the proposed Narrows Reservoir site, Colorado: Trans. Mo. Acad. Sci., v. 12, no. 0, p. 37-46.

A vegetational analysis of the proposed site of the Narrows Reservoir and surrounding prairie was initiated in 1971. Composition and distribution of flood plain communities were determined. Five distinct community types were present: the pure *Salix* spp. community occupying the most moist habitat and least important on the basis of area; the mixed *Salix* spp. and *Populus sargentii* (Doda.) community occupying the 2nd most moist habitat and 2nd most important on the basis of area; the open and closed *P. sargentii* communities occupying the 3rd most moist habitat and ranked 1st and 3rd on the basis of size; and the open park community occupying the driest habitat and the 4th most important on the basis of size. The importance of most species was dependent on the community type in which they occurred. Relationships between soil texture, relative wetness of sites and community type were also determined. No rare or endangered species were encountered.

551. Jackson, W.L., and Van Haveren, B.P., 1984, Design for a stable channel in coarse alluvium for riparian zone restoration: Water Resources Bulletin (Urbana), v. 20, p. 695-703.

Geomorphic, hydraulic and hydrologic principles are applied in the design of a stable stream channel for a badly disturbed portion of Badger Creek, Colorado, and its associated riparian and meadow complexes. Critical shear stress equations were used to design a stable channel in noncohesive materials with dimensions which approximate those of less disturbed reaches. Gabion controls, spaced at approximately 300-m intervals, are recommended to help reduce the chance of lateral migration of the newly constructed channel. Controls are designed to allow for some vertical adjustment of the channel bed following increased bank stability due to revegetation. The flood plain is designed to dissipate flood flow energy and discourage multiple flood channels. The channel has approximately a 90-percent chance of remaining stable the first 2 years following construction.

552. Jacobson, M.I., and Francis, C.A., 1989, Fluocerite-(Ce) and other minerals from the Little Patsy Quarry, South Platte District, Jefferson County, Colorado, *in* Sixteenth Rochester mineralogical symposium. Rocks and Minerals, Apr. 7, 1989: [Rochester, N.Y.], v. 64, p. 471.

553. Jacobson, M.I., and Smith, M.W., 1990, Fluocerite-(Ce) and other minerals from the Little Patsy Quarry: The Mineralogical Record, v. 21, no. 5, p. 429-430.

554. Jacobson, N., 1982, Biological monitoring of water quality on Fall River, Big Thompson River and Boulder Brook in the Rocky Mountain National Park: [Colo.], National Park Service, 25 p.

555. Jannois, B.A., and Gerlek, S., 1976, 1970 and projected agricultural water demand determination for the South Platte River basin: Fort Collins, Colo., Colorado State University, Discussion and draft report, 203 p.

556. Janovy, J., Jr., Ruhnke, T.R., and Wheeler, T.A., 1989, *Salsuginus thalkeni* n. sp. (*Monogenea: Ancyrocephalidae*) from *Fundulus zebrinus* in the South Platte River of Nebraska: J. Parasitol., v. 75, no. 3, p. 344-347.

Salsuginus thalkeni n. sp. (*Monogenea: Ancyrocephalidae*) is described from the gills of the plains killifish, *Fundulus zebrinus*, in the South Platte River of Nebraska. *Salsuginus thalkeni* is distinguished from previously described species by measurements of sclerotized parts and by proportions (measurement ratios), differences between dorsal and ventral hamuli, and angles between deep and superficial hamulus roots.

557. Jansekok, M.P., and Urbonas, B.R., 1989, Hyetograph compositeing effects on urban runoff modelling, *in* Proceedings of Stormwater and Water Quality Model Users Group Meeting, Denver, Colo., October 3-4, 1988: v. EPA Report No. EPA/600/9-89/001, p. 183-195.

Rainfall and runoff data from a 3.08-sq.-mi. urban watershed in Denver, Colorado was used to investigate the effects of compositing several recorded rainstorm hyetographs on urban stormwater runoff modelling results. The watershed in this semi-arid region had data at five rain gages and two flow gages, which provided the basis for calibrating an Urban Drainage and Flood Control District version of the Storm Water Management Model (SWMM). The calibrated model was then used to examine the effects of runoff calculations using a single composite hyetograph for each storm. Compositing of hyetographs was performed using two types of area weighted techniques. The five hyetographs were then composited directly using the recorded rainfall depth at each clock time interval. In addition, the hyetographs were composited using a technique that first shifted the five gage records so the peak rainfall time increments of each hyetograph were aligned. In this study, very little difference was found in peak flow and runoff volume simulations between the two types of hyetographs compositing techniques, namely compositing straight across or compositing using peak preservation. However, the authors believe that it is premature to accept this finding as a general finding applicable under all conditions. Both methods tended to underestimate peak flows and volumes when compared against the calibrated multi-rain gage hyetograph runs using a calibrated SWMM model.

558. Jarrett, R.D., and Boyle, J.M., 1986, Pilot study for collection of bridge-scour data: U.S. Geological Survey Water-Resources Investigations Report 86-4030, 46 p.

559. Jarrett, R.D., and Costa, J.E., 1986, Hydrology, geomorphology, and dam-break modeling of the July 15, 1982, Lawn Lake Dam and Cascade Lake Dam failures, Larimer County, Colorado: U.S. Geological Survey Professional Paper 1369, 78 p.

At approximately 0503 Mountain Daylight Time on the morning of July 15, 1982, Lawn Lake dam, a 26-ft-high earthen dam located in Rocky Mountain National Park, Colorado, failed. The dam released 674 acre-feet of water and an estimated peak discharge of 18,000 cubic feet per second down the Roaring River valley. Three people were killed and damages totaled $31 million. Floodwaters from Lawn Lake dam overtopped a second dam, Cascade Lake dam, located 6.7 miles downstream, which also failed. Cascade Lake dam, a 17-ft-high concrete, 12.1 acre-foot capacity dam, failed by toppling with 4.2 feet of water flowing over its crest. The flood continued down the Fall River into the town of Estes Park, which received extensive damage from the overbank flow. This report presents the setting, a summary of the causes of the dam failures, the hydrologic data and geomorphic effects of the flood. A dam-break computer model was used to evaluate the model's capabilities on high-gradient streams, to enhance and provide supplemental hydrologic information, and to evaluate various hypothetical scenarios of dam-breach development and probable impact of the failure of Cascade Lake dam. Flood peaks were 2.1 to 30 times the 500-year flood for selected locations along the flood path. Geomorphic and sedimentologic evidence suggest that it probably was the largest flood in these basins, at least since the retreat of the glaciers several thousands of years ago. Geomorphic effects of the flood resulting from the dam failures were profound. Channels were widened tens of feet and scoured from 5 to 50 feet locally. An alluvial fan of 42.3 acres, containing 364,000 cubic yards of material, was deposited at the mouth of the Roaring River. Satisfactory results were obtained from the dam-break model, but not without significant difficulties in proper operation of the model. Peak discharges from dam-break modeling reflect water-only discharges; total discharge may have been considerably higher on the Roaring River and on the Fall River immediately downstream from Cascade Lake dam from sediment and debris. Comparisons were made for hypothetical breach widths of (1) 25 feet and (2) 200 feet. They were compared with model results of the actual breach width of 55 feet.

560. Jarrett, R.D. and Doesken, N.J., 1989, Anthropogenic effects on cloudiness in Colorado and Wyoming, *in* N. Harthill and W. Spence, chairmen, American Geophysical Union, 2d annual Front Range regional meeting. Eos, Transactions, Golden, Colo., Feb. 13-14, 1989: v. 70, American Geophysical Union, p. 186.

561. Jarrett, R.D., and Veenhuis, J.E., 1984, Evaluation of rainfall-runoff data for the Denver Federal Center, Lakewood, Jefferson County, Colorado: U.S. Geological Survey Water-Resources Investigations Report 84-4050, 6 p.

An investigation was made to monitor the storm runoff in McIntyre Gulch basin to determine the rainfall-runoff characteristics. Results may now be used to evaluate the effects of future development on storm runoff from the Denver Federal Center, which is located in the McIntyre Gulch basin in Lakewood, CO. Rainfall and runoff data were collected at eight streamflow stations and three auxiliary rainfall stations in and adjacent to the Denver Federal Center. The outflow peak discharges from McIntyre Gulch in the Denver Federal Center were higher than the inflow peak discharges for eight of the storms by an average of 38 percent. Outflow peak discharges for eight of the storms were lower by an average of 12 percent. The study demonstrated that runoff varies with location of a storm--even for a relatively small basin. Peak discharges of McIntyre Gulch outflow from the Denver Federal Center were 27 percent greater than the inflow for all storms, but only 15 percent greater for evenly distributed storms. Runoff from the Denver Federal Center increased storm-runoff volumes in McIntyre Gulch by an average of 46 percent. Proper management of storm runoff in the Denver Federal Center requires that proposed improvements to the existing storm-runoff system maintain peak flows at their present levels.

562. Jenkins, C.T., and Taylor, O.J., 1973, Special planning technique for stream-aquifer systems with discussion, *in* Conf. Int. Pianificazione, Acque, Atti.: p. 223-229.

563. Jenkins, E.D., 1961, Records and logs of selected wells and test holes and chemical and radiometric analyses of ground water in the Boulder area, Colorado: Colorado Water Conservation Board Basic-Data Report No. 5, 30 p.

564. Jennings, W., 1991, *Sisyrinchium pallidum*, and *Primula egaliksensis* in South Park: Prepared for the Nature Conservancy.

565. Jensen, D., 1982, An index for assessing the water-quality of Nebraska streams: Lincoln, Nebr, Nebraska Department of Environmental Control.

566. Joench-Clausen, T., 1978, Optimal allocation of water resources in an input-output framework: Fort Collins, Colo., Colorado State Univ., 223 p.

567. Johanson, P.A., 1976, Multi-parameter river basin model, in EPA Conference on Environmental Modeling and Simulation.

568. Johnson, J.H., 1925, Bibliography of Colorado maps: Colo. Sch. Mines Quart., v. 20, no. 3.

569. Johnson, J.H., 1927, Bibliography of the geology of north-central Colorado: Colo. Sch. Mines Quart., v. 22, no. 4.

570. Johnson, M.S., Goeke, J.W., and Engberg, R.A., 1986, Hydrologic data for the southern Sand Hills area, Nebraska: U.S. Geological Survey Open-File Report 86-411W, 136 p.

571. Johnson, T., 1980, Irrigated cropland, 1978, Laramie County, Wyoming: U.S. Geological Survey, Open-File Report 80-638, 1 sheet.

572. Johnson, W.D., 1902, Part 4; The High Plains and their utilization: U.S. Geological Survey Annual Report, 631-669 p.

573. Jones, C.V., and Morris, J.R., 1984, Instrumental price estimates and residential water demand: Water Resources Research, v. 20, no. 2 (Feb), p. 197-202.

When a commodity is sold at a schedule of rates depending on the quantity consumed, econometric analysis must consider questions not encountered for goods offered at uniform prices. Instrumental estimates of two price specifications, one motivated by the consumer decision problem given full information about rates and charges and the other an average price formulation, are developed to correct for measurement error when residential water sales are made at a schedule of rates, rather than at uniform prices. Annual water purchases of single-family residences are regressed on these instrumental price estimates, family income, and household size by ordinary least squares, based on a sample of 326 observations from metropolitan Denver, Colorado, for 1976. The resulting demand estimates are robust to the price concept specified, given proportional variation in all rates and charges, and are consistent with findings in the literature. The overall price elasticity estimates range between -0.14 in a linear model to -0.44 in a log-log model, while the estimated income elasticity varies between 0.40 and 0.55.

574. Jones, W.D., and Quam, L.O., 1944, Glacial landforms of the Rocky Mountain National Park: Journal of Geology, v. 52, p. 217-234.

575. Jordan, D.S., 1891, Report of explorations in Colorado and Utah during the summer of 1889, with an account of the fishes found in each of the river examined: U.S. Fish Comm. Bull., v. 9, p. 1-40.

576. Jorge, P.E., and Harrison, M.D., 1986, The association of *Erwinia carotovora* with surface water in northeastern Colorado, USA. The presence and population of the bacterium in relation to location, season, and water temperature: Am. Potato J., v. 63, no. 10, p. 517-531.

Erwinia carotovora was found consistently in surface water collected from the South Platte and Big Thompson Rivers in the state of Colorado from January 1982 through August 1983. Of 975 *Erwinia* strains identified *Erwinia carotovora subsp. carotovora* represented 97.5% of the strains recovered. *Erwinia carotovora subsp. atroseptica* was also isolated occasionally (2.5% of the strains), primarily during the cooler months. Populations of *F. carotovora* were related to temperature, time of year and location. Populations in water ranged from 0 to 144 colony-forming units per milliliter. Lowest populations were found during the winter months at mountainous (non-arable) sites on the rivers. Highest populations were found in late spring, summer and early autumn at sites located in agricultural areas.

577. Joslyn, J., 1975, E&R Center helps Denver paddle its canoe: Reclamation Era, v. 61, no. 2 (Summer).

578. Juday, C., 1904, Fishes of Boulder County: Univ. of Colo. Studies, v. 2, p. 113-114.

579. Juday, C., 1905, List of fishes collected in Boulder County, Colorado, with description of a new species of Leuciscus: U.S. Bur. Fish. Bull., v. 24, p. 225-227.

580. Judd, W.R., 1948, Supplementary geological report on Pando Damsite; Blue-South Platte Project, Colorado: U. S. Bur. Reclam., Eng. Geol. Branch.

581. Judy, R.D., 1985, Enhancement of urban water quality through control of nonpoint source pollution, Denver, Colorado, in Gore, J.A., ed., The Restoration of Rivers and Streams: Theories and Experience: Boston, Mass., Butterworth Publishers, p. 247-279.

Techniques were developed to quantify pollutant loadings in the South Platte River, Denver, Colorado, resulting from storm event generated nonpoint source pollution. Nonpoint source pollution is defined as pollution originating from many different sources, such as streets, parking lots, industrial and residential developments, atmospheric deposition, etc. Nonpoint source pollution is not presently governed by the National Pollution Discharge Elimination System or any type of wet weather water-quality criteria. The data show that the relationships between storm rainfall, runoff, effective impervious area, and pollutants are quantifiable. Urban runoff pollution is probably predictable, with these predictions based on the model presented here. The model itself requires careful testing, evaluation, and revision for other than conservative constituents. The results of the actual testing as well as testing by others in different geographical areas is necessary to determine its applicability to a wide variety of conditions. Predictive results of the model utilizing Best Management Practices data and data from the special studies may have serious implications for the future of water-quality management. These implications include implementation of a Best Management Practices program in conjunction with the

NPDES program. Also, wet weather quality criteria that are in developmental stages may greatly impact State water-quality standards and practice. This study is a step in determining the answers to these and other possible questions.

582. Jump, R.K., and Sappy, B.R., 1989, Soil test extractants for predicting selenium in plants, *in* Jacobs, L.W., ed., Selenium in agriculture and the environment; Selenium in irrigated agriculture. SSSA Special Publication: p. 95-105.

583. Kaback, D.S., 1976, Transport of molybdenum in mountainous streams, Colorado: Geochim. Cosmochim. Acta, v. 40, no. 6, p. 581-582.

584. Kappus, U., 1982, Water management strategies for energy development in the Western United States, in Engineering Bulletin: Los Angeles, Calif., p. 25-30.

585. Kastner, W.M., Schild, D.E., and Spahr, D.S., 1989, Water-level changes in the High Plains aquifer underlying parts of South Dakota, Wyoming, Nebraska, Colorado, Kansas, New Mexico, Oklahoma, and Texas; predevelopment through nonirrigation season 1987-88: U.S. Geological Survey Water-Resources Investigations Report 89-4073, 61 p.

586. Keen, K.L., 1987, Groundwater recharge from a summer precipitation event in a stabilized sand dune environment, western Nebraska Sand Hills, *in* Geological Society of America, North-Central Section, 21st annual meeting. Abstracts with Programs, St. Paul, Minn., Apr. 30-May 1, 1987: v. 19(4), Geological Society of America, p. 207.

587. Keelage, G., Young, R.A., and Sparling, E.W., 1982, Economic aspects of cost-sharing arrangements for federal irrigation projects: a case study: Fort Collins, Colo., Colorado Water Resources Research Institute Completion Report 118, 68 p.

The philosophy of the Reclamation Act of 1902 was that all reclamation project costs should be repaid in full except interest on construction costs. However, early reclamation cost-sharing policy was not successful in that repayments to the government fell short of planned levels. This led to a series of changes culminating with the Reclamation Act of 1939. It revised reclamation policy from total repayment of cost to repayment on an 'ability to pay' basis determined by USBR. Since that time, charges for USBR-supplied irrigation water have not been required to reflect the cost of water supply. Consequently, there has been a growing concern with the degree to which reclamation irrigation projects are subsidized. Critics believe that it is unlikely that water users would agree to contract for reclamation projects if they were to bear full cost.

588. Kennedy, V.C., 1968, Fluorescent sand as a tracer of fluvial sediment movement (abs.): Geol. Soc. America Spec. Paper 101, p. 108-109.

589. Kennedy, V.C., and Kouba, D.L., 1970, Fluorescent sand as a tracer of fluvial sediment, *in* Sediment transport in alluvial channels: U.S. Geological Survey Professional Paper 562, 13 p.

Description of method, equipment, results of test along a reach of Clear Creek west of Denver (Colorado), evaluation as a means of sand discharge measurement in gravel-bed stream.

590. King, D.L., and Sartoris, J.J., 1973, Mathematical simulation of temperatures in deep impoundments. Verification tests of the Water Resources Engineers, Inc. Model. Horsetooth and Flaming Gorge Reservoirs: Denver, Colo., Bureau of Reclamation, Engineering and Research Center, REC-ERC-73-20, 22 p.

Successful use of predictive mathematical models requires verification of the accuracy of the models by applying them to existing situations where the prediction can be compared with reality. A Corps of Engineers' modification of a deep reservoir thermal stratification model developed by Water Resources Engineers, Inc., was applied to two existing Bureau of Reclamation reservoirs for verification. Diffusion coefficients used for the Corps' Detroit Reservoir were found to apply to Horsetooth Reservoir in Colorado, for which very good computer input data were available. The Detroit diffusion coefficients gave a reasonable simulation of Flaming Gorge Reservoir in Wyoming and Utah, which has very complex and variable physical characteristics and for which only average-quality computer input data were available. (Author)

591. Kircher, J.E., 1983, Interpretation of sediment data for the South Platte River in Colorado and Nebraska, and the North Platte and Platte Rivers in Nebraska, *in* Hydrologic and geomorphic studies of the Platte River basin: U.S. Geological Survey Professional Paper 1277, p. D1-D25.

592. Kircher, J.E., 1981, Sediment analyses for selected sites in the South Platte River in Colorado and Nebraska, and the North Platte and Platte Rivers in Nebraska---suspended sediment, bedload, and bed material: U.S. Geological Survey Open-File Report 81-0207, 53 p.

Sediment samples were collected on the South Platte, North Platte, and Platte Rivers in Colorado and Nebraska during the 1979 and 1980 runoff seasons. Suspended-sediment concentrations ranged from 62 to 3,705 milligrams per liter and the maximum load was 45,547 metric tons per day. The percentage of suspended sediment smaller than sand (less than 0.062 millimeter) was as follows: 23 to 78 percent for the South Platte River, 9 to 30 percent for the North Platte River, and 2 to 89 percent for the Platte River. Bedload-transport rates ranged from 0.0085 to 0.67 kilogram per second per meter of channel width for the entire study area. The median grain size of bedload ranged from 0.6 to 2.6 millimeters for the South Platte River, 0.5 to 0.8 millimeter for the North Platte River, and 0.6 to 1.2 millimeters for the Platte River. The median grain size of bed material for the South Platte River ranged from 0.3 to 2.4 millimeters, compared to 0.5 to 0.9 millimeter for the North Platte River, and 0.4 to 3.1 millimeters for the Platte River.

593. Kircher, J.E., 1981, Sediment transport and effective discharge of the North Platte, South Platte, and Platte Rivers in Nebraska: U.S. Geological Survey Open-File Report 81-53, 26 p.

Sediment discharge was computed for four locations along the North Platte, South Platte, and the Platte Rivers between North Platte and Grand Island, Nebraska, in order to determine the effective discharge. The total-sediment discharge was computed by the Colby method and modified Einstein method so that comparisons could be made with the measured total-sediment discharge. The results agreed closely. The Colby method is the simplest and most convenient to use. The mean annual total-sediment discharge for the four sites investigated ranged from 150 tons per day for the South Platte River at North Platte to 1,260 tons per day for the Platte River near Grand Island. The effective discharge at the sites ranged from 41 to 158

cubic meters per second. The probability of the effective discharge being equaled or exceeded ranged from 1 to 30 percent for the four sites.

594. Kircher, J.E., and Karlinger, M.R., 1981, Changes in surface-water hydrology, Platte River basin in Colorado, Wyoming, and Nebraska upstream from Duncan, Nebraska: U.S. Geological Survey Open-File Report 81-0818, 83 p.

595. Kircher, J.E., and Karlinger, M.R., 1983, Effects of water development on surface-water hydrology, Platte River basin in Colorado, Wyoming, and Nebraska upstream from Duncan, Nebraska, *in* Hydrologic and geomorphic studies of the Platte River basin: U.S. Geological Survey Professional Paper 1277, p. B1-B49.

596. Kircher, J.E., and Karlinger, M.R., 1983, Streamflow changes in Platte River basin: U.S. Geological Survey Professional Paper 1375, 174 p.

597. Kircher, J.E., Moody, D.W., Chase, E.B., and Aronson, D.A., 1986, Effects of dams and reservoirs on surface-water hydrology; changes in the Platte River basin, *in* Moody, D.W., Chase, E.B., and Aronson, D.A., comps., National water summary 1985; hydrologic events and surface-water resources: U.S. Geological Survey Water-Supply Paper 2300, 89-95 p.

598. Kirkham, R.M., and Rold, J.W., 1986, Water resources of upper Crow Creek, Colorado: U.S. Geological Survey Special Publication (Colorado Geological Survey) 29, 102 p.

599. Kirsch, P.J., 1990, FERC's role in protecting non-consumptive water uses, *in* Moving the West's water to new uses: winners and losers: Boulder, Colo., University of Colorado School of Law.

600. Klein, E.J., 1988, The variations in wet precipitation chemistry with elevation in Colorado: Fort Collins, Colo., Colorado State University, 112 p.

601. Klein, J.M., Goddard, K.E., and Livingston, R.K., 1978, Appraisal of the water resources of the Park and Teller counties, Colorado: U.S. Geological Survey, Colorado Water Resources Circular 36, 79 p.

602. Klooz, D., and Hendricks, D.W., 1980, Planning water reuse: development of reuse theory and the input-output model, Vol II. Application: Fort Collins, Colo., Colorado Water Resources Research Institute, Completion Report 115, 154 p.

In order to facilitate the exploration of municipal water reuse alternatives, a water reuse methodology and an input-output water balance model have been developed in the research. Case study demonstrations in the South Platte River Basin of Colorado are used to document the application of the methodology and the input-output water balance model. Volume I of the research develops the reuse planning methodology and applies the methodology in two case studies. The water reuse planning methodology is based on: (1) a synthesis of reuse definitions from the literature; (2) an analysis of proposed and existing water reuse projects to discover new directions in reuse development; (3) identification of financial and regulatory incentives contained in the water-quality laws; and (4) the identification of mechanisms in appropriative water laws that influence water reuse. Volume II adapts basic input-output principles to the context of reuse in a water resources system. The depiction of water reuse by this methodology is based on two reuse schemes. One scheme focuses on the various

reuse forms employed in a river basin. The other one depicts the water-quality of the transferred and reused water and the water-quality requirements of the use systems.

603. Klooz, D., and Hendricks, D.W., 1982, Water reuse planning by means of an input-output table: Journal of the American Water Works Association, v. 74, no. 1, p. 51-56.

An input-output table analysis suitable for application in water reuse planning was developed and applied to the Cache La Poudre River basin in Colorado. Analysis is facilitated by the ability of the input-output table to organize and collate large amounts of complex data both structurally and operationally. Aggregated input-output tables were developed for proposals for new projects construction and intensified reuse for the year 2020. The tables facilitate comparison of the uses of virgin water and used water between the two solutions. Reused water is shown to represent a feasible means for meeting projected demands. The reuse factor, defined as the total water use divided by the total amount of virgin water supply, increases from 1.34 to 1.46 upon implementation of intensified reuse. Used water is prominent in satisfying industrial and agricultural water demands under the intensified reuse solution. Unplanned reuse maintains its important place in both solutions. Basin outflow is reduced by intensified reuse. The amount of water saved by intensified reuse is only about 8%, but this could spare the need for expensive new storage projects. This clearly organized evaluation format aids in assessing proposed projects for their ability to satisfy new water demands and in examining their positive and negative interactions on the rest of the system.

604. Knight, S.A., Janovy, J.,Jr., and Current, W.L., 1977, *Myxosoma funduli (Protozoa:Myxosporida)* in *Fundulus kansae* summer epiztiology: J. Parasitol., v. 63, no. 5, p. 897-902.

Occurrence and distribution of the myxosporidan *M. funduli* on the gills of the plains killifish (*F. kansae*) were investigated; F. kansae is reported as a new host. Host samples from various sites on the South Platte River, Nebraska [USA], were collected during the summer months of 1975 and 1976. The protozoan parasite population was overdispersed within the host population, and this distribution was similar to that described by the negative binomial equation. Demographic characteristics of the infected fish subpopulation were virtually identical to those of the whole fish population. Infection intensity was independent of gill bar number or side. Frequency of bilateral infections was 0.54, of left only infections 0.23 and of right only infections 0.22. Distribution of immature and mature plasmodia indicated that a pre-existing infection did not preclude a new infection, and suggested a prepatent period of < 2 mo.

605. Knight, S.A., Janovy, J.Jr, and Current, W.L., 1980, *Myxosoma-funduli (Protozoa:Myxosporida)* in *Fundulus kansae (Pisces: Cyprinodontidae)*; annual prevalence and geographic distribution: J. Parasitol., v. 66, no. 5, p. 806-810.

The occurrence and distribution of the myxosporidan *M. funduli* in the plains killifish (*F. kansae*) were investigated. Samples from sites on the South Platte and Platte River drainages in Nebraska [USA] were collected by seining during various months of 1976, 1977 and 1978. At a number of the localities no F. *kansae* were found; the remainder of the collecting sites showed the host population to be abundant, but the *M. funduli* infections to vary in prevalence. The protozoan parasite population in *F. kansae*, upstream from the Nebraska Tri-County Diversion Dam and Canal, at North Platte,

Nebraska, demonstrated year-long distributions and intensities similar to those reported for the summer months of 1975 and 1976 (Knight et al., 1977). Downstream from the diversion dam, the prevalence of *M. funduli* in *F. kansae* was considerably lower than that observed upstream. The demographic characteristics of the infected fish subpopulation were identical to those of the whole fish population upstream from the diversion; those infected fish downstream from the diversion were too few to establish conclusive demographic results.

606. Knopf, F.L., 1986, Changing landscapes and the composition of the eastern Colorado avifauna: Wildl. Soc. Bull., v. 14, no. 2, p. 132-142.

607. Knopf, F.L., 1991, Ecological succession and conservation confusion in the South Platte floodplain, *in* Woodring, R.C., ed., South Platte resource management: Finding a balance: Fort Collins, Colo., Colorado Water Resources Research Center.

608. Knopf, F.L., 1989, Riparian wildlife habitats: More, worth, less, and under invasion, *in* Restoration, creation and management of wetland and riparian ecosystems in the American west.: Boulder, Colo., Rocky Mountain Chapter, Society of Wetland Scientists, p. 20-21.

609. Knopf, F.L., 1985, Significance of riparian vegetation to breeding bird across an altitudinal cline, *in* Johnson, R.R., Ziebell, C.D., and others, eds., Riparian ecosystems and their management: Reconciling conflicting uses: Fort Collins, Co., Rocky Mountain Forest and Range Experimental Station, FS-Gen. Tech. Report RM-120.

610. Knopf, F.L., and Scott, M.L., 1990, Altered flows and created landscapes in the Platte River headwaters, 1840-1990, in Sweeney, J.M., ed., Management of dynamic ecosystems: West Lafayette, Ind., North Central Section, The Wildlife Society, p. 47-70.

611. Kochel, R.C., and Riley, G.W., 1988, Sedimentologic and stratigraphic variations in sandstones of the Colorado Plateau and their implications for groundwater sapping, *in* Howard, A.D., Kochel, R.C., and Holt, H.E., eds., Sapping features of the Colorado Plateau--a comparative planetary geology field guide: Colo., National Atmospheric and Space Administration, p. 57-62.

612. Kodadek, C. R., 1978, The distribution of aquatic macroinvertebrates in Boulder Creek, Colorado: Boulder, Colo., University of Colorado, PhD thesis, 161 p.

614. Konikow, L.F., 1974, Hydrogeologic maps of the alluvial aquifer in and adjacent to the Rocky Mountain Arsenal, Colorado: U.S. Geological Survey Open-File Report 74-342, 17 p.

615. Konikow, L.F., 1977, Modeling chloride movement in the alluvial aquifer at the Rocky Mountain Arsenal, Colorado: U.S. Geological Survey Water-Supply Paper 2044, 43 p.

616. Konikow, L.F., 1981, Role of solute-transport models in the analysis of groundwater salinity problems in agricultural areas: Agric. Water Management, v. 4, no. 1-3, p. 187-205.

617. Korbitz, W.E., 1981, Energy minimization at Metro Denver Sewage District: AICHE Symposium Series, v. 77, no. 209, p. 21-24.

Energy minimization efforts undertaken by the Metro Denver Sewage District are described. One of the major accomplishments lies in the secondary treatment process, where the original 370 million liters per day diffused air system was supplemented with a 272 million liters per day high purity oxygen system secondary treatment complex. The high oxygen transfer efficiency and lower total electrical power requirements have resulted in substantial savings. In the operation of the two secondary treatment complexes, flow has been sent to the high purity oxygen system at a rate such that it will be operated at capacity. The energy savings realized from close control over flow proportioning to the two secondary treatment complexes are considerable. Many cost savings as well as energy savings have also been made possible with the computer process control. Changes in operational procedures similar to the secondary treatment flow proportioning and consideration of electric motor retrofitting with capacitance equipment are methods of reducing demand. Other major successes are seen in the processing and disposal of sludge. Since 1971, sludge disposal has been in the form of land application. Anaerobic digestion of primary and waste activated sludge started in 1979 and is now part of the sludge processing line. There have also been revisions in water-quality standards and treatment requirements so as to provide not only cost effective treatment but also energy effective treatment.

618. Kromm, D.E., and White, S.E., 1984, Adjustment preferences to groundwater depletion in the American High Plains: Geoforum, v. 15, no. 2, p. 271-284.

619. Kromm, D.E., and White, S.E., 1987, Interstate groundwater management preference differences; the Ogallala region: Journal of Geography, v. 86, no. 1, p. 5-11.

620. Kromm, D.E., and White, S.E., 1986, Variability in adjustment preferences to groundwater depletion in the American High Plains: Water Resources Bulletin (Urbana), v. 22, no. 5, p. 791-801.

621. Krothe, N.C., Oliver, J.W., and Weeks, J.B., 1982, Dissolved solids and sodium in water from the High Plains Aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U.S. Geological Survey Hydrologic Investigations Atlas 658, 2 sheets, scale 1:2,500,000.

Brief description of the variation in the concentration of dissolved solids and sodium in water from the High Plains Aquifer, which includes an area of about 174,000 mi SUP 2. The effects of geology and mixing water from bedrock units on water chemistry in the aquifer are described and the salinity and sodium hazards associated with use of the water for irrigation are discussed.--from New Publications of the Geological Survey, August 1982.

622. Kuhn, G., Daddow, P.B., and Craig, G.S., 1983, Hydrology of area 54, northern Great Plains and Rocky Mountain Coal Provinces, Colorado and Wyoming: U.S. Geological Survey Water-Resources Investigations Report 83-146, 94 p.

Coal area 54, in north-central Colorado and south-central Wyoming, is one of contrasting geology, topography, and climate. This results in contrasting hydrologic characteristics. Streamflow quality is best in the mountains where dissolved-solids concentrations generally are least. These concentrations increase as streams flow through sedimentary basins. In the North Platte River, dissolved-solids concentrations usually are less than 300 mg/L; in the Laramie and Medicine Bow

Rivers, concentrations average 500 to 850 mg/L. Because of the semiarid climate of the basins, soils are not adequately leached. Consequently, flow in ephemeral streams usually has a larger concentration of dissolved solids than that in perennial streams, averaging 1,000 to 1,600 mg/L. Aquifers containing usable water are consolidated and unconsolidated Quaternary and upper Tertiary deposits; Mesozoic and Paleozoic sedimentary rocks; and lower Tertiary and Upper Cretaceous sedimentary rocks containing coal. These aquifers are used for municipal, domestic, irrigation, and stock supplies. Well yields range from about 5 to 1,000 gal/min and depend on type of aquifer, saturated thickness, and degree of fracturing. The best quality groundwater generally comes from aquifers that do not contain coal. Hydrologic problems related to surface mining are erosion and sedimentation, decline in water levels, disruption of aquifers, and degradation of water-quality. General lack of runoff from semiarid mine areas combined with buffer and dilution capacities of major streams minimizes effects on surface water. However, effects on groundwater systems may be much more severe and longlasting.

623. Kunkel, J.R., and Steele, T.D., Historical and future undeveloped stream flows, South Platte River, Colorado, *in* 18th Annual American Water Resources Association Conference, San Francisco, Calif., 10-15 Oct 82: AWRA.

624. Labadie, J.W., and Shater, J.M., 1980, Exploring ways of increasing the use of South Platte water: Fort Collins, Colo., Colorado State Univ., Water Resources Research Inst., Information Series 41, 8 p.

A computer simulation model was developed to test various alternative strategies of water management along the Colorado Front Range, where increasing population has resulted in ever-increasing demands for water by municipalities, industry and agriculture. This water management area uses a complex of high-mountain and plains reservoirs to store water, fulfill water-rights commitments, and provide water recreation opportunities. Two water management alternatives were tested using the computer simulation model. The first involved enhancement recreational facilities through a water-exchange plant to keep filled some high-mountain reservoirs (where recreation demand is greater), while drawing more heavily on plains reservoirs and the remaining high-mountain reservoirs. In the simulated program, three high-mountain reservoirs were kept full while meeting all water- rights commitments. In the second simulation treated sewage effluent was diverted from the city of Fort Collins to fill the 13,000-acre-foot cooling pond for the Rawhide Power Plant, scheduled for startup in 1985. If weather patterns of the past 25 years remain relatively stable, the model shows that the pond can be filled by 1985 and losses replenished without injury to other water-right owners.

625. LaBaugh, J.W., and Winter, T.C., 1984, The impact of uncertainties in hydrologic measurement on phosphorus budgets and empirical models for two Colorado reservoirs: Limnol. Oceanogr., v. 29, no. 2, p. 322-339.

626. Lamb, W.A., Freeman, W.B., Richards, R., and Rice, R.C., 1912, Surface water supply of the Missouri River basin, 1910: U.S. Geological Survey Water-Supply Paper 286, 308 p.

627. Lammering, M.W., 1975, Plutonium levels in the sediment of area impoundments. Environs of the Rocky Flats Plutonium Plant, Colorado: Denver, Colo., Technical Support Branch, Environmental Protection Agency, EPA/908/2-75/001; SA/TIB-29, 51 p.

Plutonium concentrations in the bed sediment of reservoirs (Great Western Reservoir, Standley Lake, Cherry Creek Reservoir, Marston Lake, and Ralston Reservoir) in the environs of the Atomic Energy Commission Rocky Flats Plant were determined by dredge and core sampling. Great Western Reservoir and Standley Lake were sampled during October 1973; the other three impoundments during April 1974. The baseline level of plutonium-239 in bed sediment attributable to worldwide fallout was found to be < or = 0.10 pCi/gram (dry weight). Correspondingly, the maximum concentrations in the top layer of sediment in Great Western Reservoir were approximately 4.0 pCi/ gram (dry weight). The thickness of the layer of plutonium-contaminated sediment in the reservoir was 5 cm or more at most sampling stations. Through 1973, Great Western Reservoir received liquid wastes (plutonium-bearing) from the Rocky Flats Plant via the tributary stream, Walnut Creek.

628. Lang, E.A., 1979, Assessment of new technology at Bear Creek Uranium Co: Mining Congress Journal, v. 65, no. 6.

629. Lanning, W.D., and Moses, D.L., 1986, Analysis and evaluation of recent operational experience from the Fort St. Vrain HTGR: Nuclear Safety, v. 27, no. 1.

630. Lappala, E.G., Emery, P.A., and Otradovsky, F.J., [1979?], Simulated changes in ground-water levels and streamflow resulting from future development (1970-2020) in the Platte River basin, Nebraska: U.S. Geological Survey Water-Resources Investigations 79-26.

631. Larimer-Weld Council of Governments, 1977, Larimer-Weld Council of Governments 108 area-wide water quality management plan--Nonpoint source pollution control: Loveland, Colo.,

632. Larimer-Weld Council of Governments, 1977, Water-quality impacts of irrigated agriculture--water quality management plan: Loveland, Colo., Toups Corporation, 208 p.

633. Larson, E. and Hoblitt, R., 1973, Nature of the early Tertiary intrusives between Golden and Lyons, Colorado, and their relation to structural development of the Front Range, *in* Geological Society of America, Rocky Mountain Section, 26th Annual Meeting. Guide for field trip no. 5: Boulder, Colo., Geological Society of America, p. 5.

634. Lauer, W.C., 1991, Water quality for potable reuse: Water Science and Technology, v. 23, no. 10-12.

635. Lauer, W.C., Johns, F.J., Wolfe, G.W., Myers, B.A., and Condie, L.Y., 1990, Comprehensive health effects testing program for Denver's Potable Water Reuse Demonstration Project: Journal of Toxicology and Environmental Health, v. 30, no. 4 (August), p. 305-321.

A project was designed to evaluate the relative health effects of highly treated reclaimed water derived from secondary wastewater compared to Denver's present high-quality drinking water. The 1 million gallon per day (1 mgd) demonstration plant provides water to be evaluated in the studies treating unchlorinated secondary treated wastewater with the following additional processes: high pH lime clarification, recarbonation, filtration, ultraviolet irradiation, activated carbon adsorption, reverse osmosis, air stripping, ozonation and chloramination. An additional sample is obtained from the identical treatment process substituting ultrafiltration for reverse osmosis. The toxicology tests to evaluate the possible long-term health effects are chronic toxicity and oncogenicity studies in Fischer 344 rats and B6C3F1 mice and reproductive/teratology in Sprague-Dawley rats. The results of these evaluations will be correlated with microbiological, chemical, and physical test results to establish the relative quality of reclaimed water compared to all established health standards as well as Denver's pristine drinking water.

636. Lauer, W.C., Rogers, S.E., and Ray, J.M., 1985, Current status of Denver's potable water reuse project: Denver, Colo., Denver Water Dep.

The feasibility of directly treating processed wastewater plant effluent to potable quality is being tested in Denver, CO, with a full-scale, 1-mgd (3.8-ML/d) demonstration plant. The complexity of putting the system into operation and the results to date are described, along with an outline of the plans for health effects research, economic studies, and programs to gain public acceptance of direct reuse. This project is expected to provide the information necessary to evaluate the feasibility of direct reuse, especially for cities located in water-scarce areas where development of more conventional water resources is becoming increasingly costly, both in terms of the environment and in capital investments.

637. Lauer, W.C., Rogers, S.E., LaChance, A.M., and Nealey, M.K., 1991, Process selection for potable reuse health effects studies: Am. Water Works Assoc. J., v. 83, no. 11, p. 52-63.

638. Laura, D., 1976, Interdisciplinary water resources decision evaluation model, *in* American Geophysical Union; 1976 spring annual meeting. Eos (Am. Geophys. Union, Trans.), Washington, D.C., April 12-15, 1976: v. 57, 249 p.

639. Lawrence, E., Wanty, R., and Poeter, E., 1991, Geohydrologic, geochemical, and geologic controls on the occurrence of radon in ground water near Conifer, Colorado, USA: Journal of Hydrology, v. 127, p. 367-386.

640. Lazaro, R.C., 1981, Adaptive real-time streamflow forecasting model for hydrosystem operational planning: Fort Collins, Colo., Colorado State University, 230 p.

641. Lazaro, R.C., Labadie, J.W., and Salas, J.D., 1982, State-space streamflow forecasting model for optimal river basin management-- Decision making for hydrosystems; forecasting and operation, *in* Unny, T.E., and McBean, E.A., ed., International symposium on real-time operation of hydrosystems: Littleton, Colo., Water Resour. Publ., p. 325-348.

642. Leaf, C.F., 1971, Areal snow cover and disposition of snowmelt runoff in central Colorado: Fort Collins, Colo., Rocky Mountain Forest and Range Experiment Station, Forest Service Research Paper RM-66, 25 p.

Areal snow-cover depletion and resultant snowmelt and water yield were studied on three small watersheds in the Fraser Experimental Forest. High water yield efficiencies were observed on two watersheds which had (1) almost complete snow cover when seasonal snowmelt rates on all major aspects were maximum; (2) a delayed

and short snow-cover depletion season; and (3) moderate recharge and evapotranspiration losses. Water yield efficiency in one watershed with low-elevation south slopes was least. In 1969, streamflow from the drainage area on this basin below 9,850 feet was less than 30 percent of that generated from above this elevation. Fourteen years of comparative streamflow indicated that water yields from the low-elevation subdrainage can vary from near zero in poor runoff years to a maximum during good years of about 50 percent of the flow generated from the high-elevation subdrainage.

643. Leaf, C.F., 1966, Sediment yields from high mountain watersheds, central Colorado: Fort Collins, Colo., Rocky Mountain Forest and Range Experiment Station, Forest Service Research Paper RM-23, 20 p.

A study of annual sediment yields from one carefully logged and two undisturbed watersheds in the Fraser Experimental Forest showed good correlation between peak streamflow and accumulated sediment volume. The relationships indicate that a major part of the sediment load is derived from channel erosion. The effects of logging on sediment yields are discussed, and magnitude-frequency relationships are developed for estimating long-term sediment yields.

644. Leaf, C.F., 1970, Sediment yields from the central Colorado snow zone: Journal of the Hydraulics Division, Proceedings of ASCE, v. 96, no. 1, p. 87-93.

To determine the effects of roads and forest-cover changes on sediment yields, measurements were made on one carefully logged and two undisturbed watersheds in the Fraser Experimental Forest, Colorado. Annual sediment yield averaged 200 pounds per acre immediately following road construction in 1950-52 and logging in 1954-56. In the period 1958-66, sediment yield averaged 43 pounds per acre, despite an estimated 25 percent increase in annual runoff caused by the harvest, compared with yields of 11 and 21 pounds per acre on the undisturbed watersheds.

645. Leaf, C.F., 1971, Sediment yields from central Colorado snow zone: Journal of the Hydraulics Division. Proceedings of ASCE, v. 97, no. 2, p. 350-351.

Specific weight (dry unit weight) is summarized with sediment class and particle size for sediments deposited in small debris basins on three headwater streams at the Fraser Experimental Forest. The effects of vegetation removal on water yields from the Fool Creek Experimental Watershed are discussed.

646. Leaf, C.F., 1975, Watershed management in the central and southern Rocky Mountains--A summary of the status of our knowledge by vegetation types: Fort Collins, Colo., Rocky Mountain Forest and Range Experiment Station, Forest Service Research Paper RM-142, 33 p.

The report summarizes a series of comprehensive reports on watershed management in five major vegetation zones: (1) The coniferous forest subalpine zone; (2) the Front Range ponderosa pine zone; (3) the Black Hills ponderosa pine zone; (4) the alpine zone; and (5) the big sagebrush zone. The study includes what is known about the hydrology of these lands, what hydrologic principles are important for multiresource management, and what additional information is needed for each vegetation type.

647. Lee, C.Y., 1981, A digital model applied to ground water recharge and management, Reply (response to discussion by Glover, Robert E. on p. 3221, of original article by Lee, Chin Y., Qazi, A. Raziq, and Danielson, Jeris A., *in* Water Resour. Bull., 16(3), p. 514-521, 1980): Water Resources Bulletin (Urbana), v. 17, no. 2, p. 324.

648. Lee, C.Y., Qazi, A.R., and Danielson, J.A., 1980, A digital model applied to ground water recharge and management: Water Resources Bulletin (Urbana), v. 16, no. 3, p. 514-521.

649. Lee, M.T., and Simmons, W.B., 1986, Geochemistry and evolution of the South Platte granite-pegmatite system, Jefferson County, Colorado, in Modreski, P.J., Fitzpatrick, J., Foord, E.E., and Kohnen, T.M., eds., Colorado pegmatites; abstracts, short papers, and field guides from the Colorado pegmatite symposium: Denver, Colo., Friends Mineral., Colo. Chapter.

650. Lee, W.T., 1917, The geologic story of Rocky Mountain National Park: Washington, D.C., U.S. Geological Survey.

651. Lee, W.T., 1923, Peneplains in the Front Range and Rocky Mountain National Park: U.S. Geological Survey Bulletin 730A, p. 1-17.

652. Lee, Y., 1974, A conceptual discussion and an empirical analysis of commercial land-use succession: Environment and Planning, v. 6, no. 6 (November-December).

653. Leenheer, J.A., Wershaw, R.L., Brown, P.A., and Noyes, T.I., 1991, Detection of polyethylene glycol residues from nonionic surfactants in surface water by 1H and 13C nuclear magnetic resonance spectrometry: Environmental Science and Technology, v. 25, no. 1 (January).

654. LeGendre, G.R., 1973, Removal of molybdenum by ferric oxyhydroxide in Clear Creek and Tenmile Creek, Colorado: University of Colorado.

655. Lehnertz, C.S., 1991, Clear Creek basin--The effects of mining on water quality and the aquatic ecosystem: Denver, Colo., Colorado Division of Wildlife, 170 p.

656. Lehrer, M.G., 1982, Glacial geology of the upper Bear Creek drainage, Park Range, Colorado: Laramie, Wyo., Univ. of Wyoming, 123 p.

657. Leite, M.B., 1986, Depositional setting of Lemoyne Quarry (Ash Hollow Formation, late Miocene), Keith County, Nebr., *in* Proceedings of the Nebraska Academy of Sciences, including GNATS and TER-QUA divisions and nine affiliated societies; 96th annual meeting, Lincoln, Nebr., Apr. 11-12, 1986: v. 96, p. 50-51.

658. Lewis, W.L., Jr., and Saunders, J.F.,III, 1985, Physical, chemical, and biological characteristics of the South Platte River, Segment 15, in relation to classified uses: Boulder, Colo, University of Colorado, Prepared for the Metropolitan Denver Sewage Disposal District Number 1, 159 p.

659. Li, H.W., 1968, Fishes of the South Platte basin: Colo. Div. Game Fish Parks Fish. Res. Rev., v. 5, p. 41-42.

660. Li, H.W., 1968, Fishes of the South Platte basin: Fort Collins, Colo., Colorado State University, MS thesis.

661. Lindauer, I.E., 1978, A comparison of the plant communities of the South Platte and Arkansas River drainages in eastern Colorado, USA, *in* W.D. Graul and S.J. Bissell, eds., Lowland river and stream habitat in Colorado--A symposium: Greeley, Colo., Colorado Chapter Wildlife Soc. and Colorado Audubon Council, p. 56-71.

A comparison of the Arkansas and South Platte River floodplains in eastern Colorado revealed a number of common community types and notable differences which affected the plant associations found in this rapidly disappearing ecosystem. Six community types common to both drainages included: the cottonwood *(Populus sargentii)* community; the narrow-leaf willow *(Salix spp.)* community; a mixed community consisting of various combinations of *P. sargentii, Salix interior, Salix exigua, Salix amygdaloides, Tamarix chinensis,* and other tree species; an open park community; a cattail-marsh community; and a slough community. A 7th community type, the salt cedar (*T. chinensis*) community, was found only on the Arkansas River and covered approximately one-third of this floodplain. *Distichlis stricta* (salt grass) was the most common species found along both drainages; however, *P. sargentii* clearly dominated the floodplains. The vegetation of the South Platte drainage was relatively stable while that of the Arkansas drainage appeared to be undergoing a change to more alkaline-salt tolerant species. Flooding, grazing, and the invasion of *T. chinensis* were the 3 major factors influencing the composition and spread of species along both drainages.

662. Lindauer, I.E., 1983, A comparison of the plant communities of the South Platte and Arkansas River drainages in eastern Colorado, USA: Southwest Nat., v. 28, no. 3, p. 249-260.

A comparison of the Arkansas and South Platte River floodplains in eastern Colorado revealed a number of common community types and notable differences which affected the plant associations found in this rapidly disappearing ecosystem. Six community types common to both drainages included: the cottonwood (*Populus sargentii*) community; the narrow-leaf willow (*Salix spp.*) community; a mixed community consisting of various combinations of *P. sargentii, Salix interior, Salix exigua, Salix amygdaloides, Tamarix chinensis,* and other tree species; an open park community; a cattail-marsh community; and a slough community. A 7th community type, the salt cedar *(T. chinensis)* community, was found only on the Arkansas River and covered approximately one-third of this floodplain. *Distichlis stricta* (salt grass) was the most common species found along both drainages; however, *P. sargentii* clearly dominated the floodplains. The vegetation of the South Platte drainage was relatively stable while that of the Arkansas drainage appeared to be undergoing a change to more alkaline-salt tolerant species. Flooding, grazing, and the invasion of *T. chinensis* were the 3 major factors influencing the composition and spread of species along both drainages.

663. Lindauer, I.E., and Christy, S.J., 1972, An analysis of the woody vegetation on the South Platte River flood plain in northeastern Colorado: Greeley, Colo., Prepared for U.S. Bureau of Reclamation.

664. Linder-Lunsford, J.B., and Ellis, S.R., 1984, Calibration and verification of a rainfall-runoff model and a runoff-quality model for several urban basins in the Denver Metropolitan area, Colorado: U.S. Geological Survey Water-Resources Investigations 83-4286, 52 p.

The U.S. Geological Survey's Distributed Routing Rainfall-Runoff Model--Version II was calibrated and verified for five urban basins in the Denver metropolitan area.

Land-use types in the basins were light commercial, multifamily housing, single-family housing, and a shopping center. The overall accuracy of model predictions of peak flows and runoff volumes was about 15 percent for storms with rainfall intensities of less than 1 inch per hour and runoff volume of greater than 0.01 inch. Predictions generally were unsatisfactory for storm having a rainfall intensity of more than 1 inch per hour, or runoff of 0.01 inch or less. The Distributed Routing Rainfall-Runoff Model-Quality, a multievent runoff-quality model developed by the U.S. Geological Survey, was calibrated and verified on four basins. The model was found to be most useful in the prediction of seasonal loads of constituents in the runoff resulting from rainfall. The model was not very accurate in the prediction of runoff loads of individual constituents.

665. Lindner-Lunsford, J.B., 1988, Precipitation records and flood-producing storms in Cheyenne, Wyoming: U.S. Geological Survey Water-Resources Investigations 87-4225, 44 p.

Annual maximum precipitation data for Cheyenne, Wyoming, are presented for the years 1871-1986 for durations of 5, 10, 15, and 30 minutes and 1, 2, and 24 hours. Precipitation-frequency curves are developed on the basis of data collected before 1985 a second set of curves are developed on the basis of data collected through 1986. The data are plotted and analyzed three times, assuming: (1) The data are described by a Gumbel distribution (2) the logarithms of the data are described by a Gumbel distribution and (3) the logarithms of the data are described by a Pearson Type III distribution. The inclusion of data for the large storm of August 1, 1985, had the most noticeable effect on the prediction of the magnitude of storms of long average recurrence intervals for the 1-, 2-, and 24-hour durations. Seven intensity-duration curves were calculated for the August 1, 1985, storm. For durations greater than 30 minutes, the observed curve indicates greater intensity than do five of the seven calculated curves. Dimensionless hyetographs were developed for 10 flood-producing storms that have occurred in the Cheyenne area since 1903. The pattern index (integral of the dimensionless hyetograph curve) for the storm of August 1, 1985, is 3 standard deviations lower than the mean of the pattern indices for the remaining 9 storms, indicating that the distribution of precipitation with time for the August 1, 1985, storm was outside the normal range for Cheyenne.

666. Lindsey, D.A., Hassemer, J.R., Martin, R.A., Taylor, R.B., and Kreidler, T.J., 1986, Mineral resources of the Beaver Creek Wilderness Study Area, Fremont, El Paso, and Teller Counties, Colorado mineral resources of wilderness study area; south-central Colorado: U.S. Bureau of Mines and U.S. Geological Survey Bulletin 1716-B, map scale 1:50,000, B1-B17 p.

667. Lindstrom, L.J., 1979, Stratigraphy of the South Platte Formation (Lower Cretaceous), Eldorado Springs to Golden, Colorado, and channel sandstone distribution of the J Member: Golden, Colo., Colorado School of Mines.

668. Lines, G.C., 1976, Digital model to predict effects of pumping from the Arikaree aquifer in the Dwyer area, southeastern Wyoming: U.S. Geological Survey Water-Resources Investigations 8-76, 24 p.

A digital computer model was developed and used to simulate an unconfined sandstone aquifer (Arikaree aquifer) in about 340 square miles in southeastern Wyoming. The model was calibrated by comparing observed and calculated changes in the potentiometric surface and leakage from the aquifer along streams during water year 1974. The comparison was fairly good for changes in the potentiometric surface and was good for leakage. The calibrated model was used to predict changes in the potentiometric surface and leakage through water year 1979, assuming no new ground-water development after 1974 and 6.5 percent of the normal precipitation as recharge to the aquifer. Water-level declines of as much as 14 feet (4.3 meters) were predicted, but much of the area would be relatively unaffected. The total predicted decrease in leakage between water years 1974 and 1979 was about 500 acre-feet per year; the greatest decrease was predicted along streams closest to areas of pumpage.

669. Livingston, R.K., 1970, Evaluation of the streamflow data program in Colorado: U.S. Geological Survey Open-File Report, 72 p.

670. Lockridge, J.P., and Pollastro, R.M., 1988, Shallow upper Cretaceous Niobrara gas fields in the eastern Denver Basin, *in* Goolsby, S.M., and Longman, M.W., eds., Occurrence and petrophysical properties of carbonate reservoirs in the Rocky Mountain region: Denver, Colo., Rocky Mt. Assoc. Geol., p. 63-74.

671. Longenbaugh, R.A., and others, 1975, First Annual Report - South Platte Ditch recharge demonstration: [Denver, Colo.?], Colorado Division of Water Resources, 17 p.

672. Longenbaugh, R.A., and others, 1977, Second Annual Report - South Platte Ditch recharge demonstration: [Denver, Colo.?], Colorado Division of Water Resources, 22 p.

673. Longenbaugh, R. A., 1962, Statistical techniques for predicting river accretions as applied to the South Platte River (Henderson-Fort Lupton): Fort Collins, Colo., Colorado State University.

674. Longenbaugh, R.A., Chen, H.H., and Ghooprasert, W., 1976, Evaluation of artificial recharge to meet pumping demands, South Platte Canal, Colorado, *in* American Geophysical Union 1976 fall annual meeting. Eos Trans., San Franc., Calif., Dec. 6-10, 1976: v. 57(12), American Geophysical Union, p. 918.

675. Loomis, F.B., 1920, Pawnee Creek beds of Colorado (abstr.): Geol. Soc. Am. Bull., v. 31, no. 1, p. 224.

676. Lovering, T.S., and Goddard, E.N., 1950, Geology and ore deposits of the Front Range, Colorado: U.S. Geological Survey Professional Paper 223, 319 p.

677. Lowe, T.P., May, T.W., Brumbaugh, W.G., and Kane, D.A., 1985, National contaminant biomonitoring study program; concentration of seven elements in freshwater fish, 1978-1981: Archives of Environmental Contamination and Toxicology, 14, 363-388 p.

678. Lower South Platte Water Conservancy District, 1968, The Narrows Unit, Colorado: Sterling, Colo., 14 p.

679. Lowham, H.W., and Druse, S.A., 1986, Storm and flood of August 1, 1985 in Cheyenne, Wyoming, *in* Moody, D.W., Chase, E.B., and Aronson, D.A., comps., National water summary 1985; hydrologic events and surface-water resources: U.S. Geological Survey Water-Supply Paper 2300, 41-42 p.

680. Lowry, M.E., and Crist, M.A., 1967, Geology and groundwater resources of Laramie County, Wyoming: U.S. Geological Survey Water-Supply Paper 1834, 71 p.

Tabular data are presented on the effect of the development of groundwater on the hydrology of the area, the hydraulic properties of the aquifers and the extent to which water can be developed from them. The total amount of groundwater pumped from wells in Laramie County during 1964 is estimated to be 28,000 acre-ft, of which 6,000 acre-ft was used for municipal and industrial supplies, 17,000 for irrigation in the Pine Bluffs-Carpenter area, and about 5,000 for other purposes. Large quantities of water suitable for irrigation can be obtained by deeper wells drilled in the north- central part of the county. Groundwater supplies have been intensively developed for municipal use near Cheyenne and Federal, and for irrigation use in the Pine Bluffs lowland. The chemical quality of water from the principal aquifers and streams is generally suitable for domestic, irrigation, and industrial uses.

681. Luckey, R.R., Gutentag, E.D., Heimes, F.J., and Weeks, J.B., 1986, Digital simulation of groundwater flow in the High Plains Aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming Regional Aquifer-System Analysis: U.S. Geological Survey Professional Paper 1400-D, 57 p.

682. Luckey, R.R., Gutentag, E.D., Heimes, F.J., and Weeks, J.B., 1988, Effects of future ground-water pumpage on the High Plains Aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming Regional Aquifer-System Analysis: U.S. Geological Survey Professional Paper 1400-E, E1-E44 p.

683. Luckey, R.R., Gutentag, E.D., and Weeks, J.B., 1981, Water-level and saturated-thickness changes, predevelopment to 1980, in the High Plains Aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U.S. Geological Survey Hydrologic Investigations Atlas 652, 2 sheets, scale 1:2,500,000.

684. Ludwick, A.E., Reuss, J.O., and Giles, J.F., Distribution of soil nitrates in eastern Colorado fields prior to planting sugarbeets: Fort Collins, Colo., Colorado State University Agricultural Experimental Station Report PR73-40, 7 p.

685. MacDonnell, L.J., 1985, The endangered species act and water development within the South Platte basin: Fort Collins, Colo., Colorado Water Resources Research Institute, Completion Report 137, 128 p.

The Endangered Species Act (ESA) of 1973 prohibits any federal action that might adversely affect endangered animal and plant species. The purpose of the Act is to provide a means whereby the ecosystems upon which threatened and endangered species depend may be conserved and to provide a program for the conservation of protected species. Current attention in Colorado is focused on two endangered species, the Colorado River squawfish and the whooping crane. Implementation of the Act raises some very difficult problems. Efforts to accommodate both continued water development and endangered species protection are burdened by a major information deficiency: What are the habitat conditions essential to ensure protection of the particular species. Some believe it may take 20 years to produce complete and reliable information on this question; in the meantime, the statute directs that plans be based upon best available information. A focus of this research was on the scope of EAS as it is currently being implemented: (1) proposed water development within the South Platte Basin and expected impacts on the whooping crane; (2) the statutory basis for endangered species protection and subsequent judicial interpretation; (3) the key legal issues at stake; and (4) a management approach to resolving conflicts. It was found that the courts have emphasized an accommodation of interests pointing away from litigation by water development interests and toward cooperative management approaches to the required species restoration plan. Cooperative State-federal-private working groups on both the Colorado River and the South Platte River have been organized and have made some progress in both cases.

686. MacDonnell, L.J., 1988, Integrating tributary groundwater development into the prior appropriation system, the South Platte experience: Fort Collins, Colo., Colorado Water Resources Research Institute.

687. Mcmillan, L.T., 1974, Deltaic sedimentation, South Platte Formation (lower Cretaceous), Morrison area, Jefferson County, Colorado (abstr.) *in* Rocky Mountain Section SEPM, 5th Annual Meeting,: Am. Assoc. Pet. Geol. Bull., v. 58, no. 5, p. 914-915.

688. MacMillan, L.T., 1974, Stratigraphy of South Platte Formation (lower Cretaceous, Morrison-Weaver-Golden area, Jefferson County, Colorado): Golden, Colo., Colorado School of Mines.

689. MacPhail, D. D., 1972, Land use patterns, practices, and problems in the Poudre triangle of northern Colorado: University of Colorado.

690. Madole, R.F., 1976, Differentiation of upper Pleistocene and Holocene gravels along St. Vrain Creek, eastern Boulder County, Colorado, *in* J.T. Andrews and R.G. Barry, chairpersons, Fourth biennial meeting of the American Quaternary Association, Tempe, Ariz., Oct. 9-10, 1976: Am. Quat. Assoc., p. 146.

691. Madole, R.F., 1976, Glacial geology of the Front Range, Colorado, *in* Mahaney, W.C., ed., Quaternary stratigraphy of North America symposium: Stroudsburg, Pa., Dowden, Hutchinson & Ross, p. 297- 318.

692. Madole, R.F., and Shroba, R.R., 1979, Till sequence and soil development in the North St. Vrain drainage basin, east slope, Front Range, Colorado, *in* Ethridge, F.G., ed., Field guide, northern Front Range and northwest Denver Basin, Colorado: Fort Collins, Colo., Colo. State Univ., Dep. Earth Resour., p. 123-178.

693. Madole, R.F., Swinehart, J.B. and Muhs, D.R., 1981, Correlation of Holocene dune sands on the central Great Plains and their paleoclimatic implications, *in* D. L. Biggs, chairperson, The Geological Society of America, North-Central Section, 15th annual meeting; with the North-Central section of the Paleontological Society and the Pander Society. Abstracts with Programs, Ames, Iowa, April 30-May 1, 1981: v. 13, Geological Society of America, p. 287.

694. Mahaney, W.C., and Fahey, B.D., 1976, Quaternary soil stratigraphy of the Front Range, Colorado, *in* Mahaney, W.C., ed., Quaternary stratigraphy of North America symposium: Stroudsburg, Pa., Dowden, Hutchinson & Ross, p. 319-352.

695. Major, T.J., Kerbs, L., and Penley, R.D., 1975, Water-level records for Colorado: Colorado Water Resources Basic-Data Release 37, 356 p.

696. Major, T.J., Robson, S.G., Romero, J.C., and Zawistowski, S., 1983, Hydrogeologic data from parts of the Denver Basin, Colorado: U.S. Geological Survey Open-File Report 83-274, 425 p.

This report presents hydrogeologic data collected and compiled during 1956-81 as part of a comprehensive hydrogeologic investigation of the Denver basin, Colorado, by the U.S. Geological Survey in cooperation with the Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer. The data, in tabular and graphic form, consist of records for 870 wells which include water-level data for 158 wells and water-quality analyses for 561 wells; geophysical logs from three wells which include resistivity, self potential, and natural gamma logs; and gain-and-loss data of streamflow measured at 54 sites.

697. Mallory, E.C., Jr., 1968, Spectrochemical analysis of stream waters in geochemical prospecting, north-central Colorado: U.S. Geological Survey Professional Paper 600. Geological Survey research 1968, Chap. B, B115-B116 p.

A combined chemical concentration-spectrographic analysis method was used to determine variations in the molybdenum, lead, and zinc concentrations in Clear Creek and its tributaries, which drain known mineralized areas. The variations in concentration correlated closely with the location of the mineralized areas, and the data indicate that this method can be used for rapidly scanning large areas for the presence of mineral concentrations.

698. Mandole, R.F., 1976, Bog stratigraphy, radio carbon dates and Pinedale to Holocene glacial history in the Front Range, Colorado: J. Res. Geological Survey, v. 4, no. 2, p. 163-169.

699. Mandole, R.F., 1969, Pinedale and Bull Lake glaciation in Upper St. Vrain drainage basin, Boulder County, Colorado: Arctic and Alpine Research, v. 1, no. 4, p. 279-287.

700. Mandole, R.F., 1963, Quaternary geology of St. Vrain drainage basin, Boulder County, Colorado: Ohio, Ohio State University, Ph.D. dissertation, 288 p.

701. Mandole, R.F., 1980, Time of Pinedale deglaciation in north- central Colorado. Further considerations: Geology, v. 8, p. 119- 122.

702. Mangelson, K.A., and Schmidt, L.S., 1985, Ground water/surface water conjunctive use project in Beebe Draw, Adams and Weld Counties, Colorado, *in* Morel-Seytoux, H.J., and Doehring, D.O., eds., Joint proceedings of the Fifth annual AGU Front Range Branch Hydrology Days and Fourteenth annual Rocky Mountain groundwater conference: Fort Collins, Colo., Hydrol. Days Publ., p. 289-299.

703. Manuel, W.C., Hendricks, D.W., and Morel-Seytoux, H.J., 1971, Regional water quality-quantity systems analysis: Fort Collins, Colo., Larimer-Weld Regional Planning Commission, 90 p.

The broad objectives of this study were twofold: to develop and demonstrate a methodology for total planning of an integrated water supply-liquid waste handling system on a regional metropolitan scale; and to develop a river basin pollution control plan. The specific goal was to develop a plan to meet present and future water quality-quantity requirements for various water use categories. The study used a selected area falling under the jurisdiction of the Larimer-Weld Regional Planning Commission, including parts of the Poudre, Big Thompson and South Platte River Basins near Fort Collins, Colorado. A plan of operation is suggested, including an assessment of the wastewater treatment plant facilities for their effectiveness in the regional context, with location, size and expected on-line operating times carefully studied. A suitable framework for analysis and data use is next suggested, followed by a review of some data procurement practices for the selected area. Defining an array of initial alternatives is then discussed with guidelines for selecting the least cost solution and the use of that solution in the regional system. Finally, suggestions for project organization and the submittal of the actual comprehensive plan are presented, along with recommendations for site-specific facilities.

704. Marmonier, P., Meisch, C., and Danielopol, D.L., 1989, A review of the genus *Cavernocypris* Hartmann (*Ostracoda, Cypridopsinae*): systematics, ecology and biogeography: Soc. Nat. Luxemb. Bull., v. 89, p. 221-278.

705. Marmonier, P., and Ward, J.V., 1990, Superficial and interstitial *Ostracoda* of the South Platte River (Colorado, U.S.A.); systematics and biogeography: Stygologia, v. 5, no. 4, p. 225- 239.

706. Marr, J.W., 1967, Ecosystems of the east slope of the Front Range in Colorado: Boulder, Colo., University of Colorado, Ser. Biol. 8.

707. Marsh, S.P., and Sheridan, D.M., 1976, Rutile in Precambrian sillimanite-quartz gneiss and related rocks, east-central Front Range, Colorado, *in* Geology and resources of titanium in the United States: U.S. Geological Survey Professional Paper 959-A-F, p. 17.

708. Marshall, T. L., 1973, Trout populations, angler harvest and value of stocked and unstocked fisheries of the Cache La Poudre River, Colorado: Fort Collins, Colo., Colorado State University, Ph.D. dissertation, 91 p.

709. Marston, E., 1986, Treaty ends Colorado water wars: High Country News, v. 18, no. 24.

710. Martell, C., 1982, Petrology and geochemistry of a progressively metamorphosed sedimentary formation in Big Thompson Canyon, Larimer County, Colorado: Socorro, N. Mex., New Mexico Inst. of Mining & Technol., 133 p.

711. Martin, J.W., 1992, South Platte River, Colorado; biological inventory and reconnaissance; annotated literature review: Denver, Colo., Mountain-Prairie Region, U.S. Fish and Wildlife Service, 51 p.

712. Masek, J.M., 1979, A description of the wildlife resources of the South Platte River in Colorado and Nebraska: Denver, Colo., U.S. Bureau of Reclamation, 44 p.

713. Masek, J.M., 1979, Vegetation community descriptions for the South Platte River in Colorado and Nebraska: Denver, Colo., U.S. Bureau of Reclamation, 23 p.

714. Mast, M.A., Drever, J.I., and Baron, J., 1990, Chemical weathering in the Loch Vale Watershed, Rocky Mountain National Park, Colorado: Water Resources Research, v. 26, p. 2871-2978.

715. Mast, M.A., Drever, J.I., and Baron, J., 1988, Sources of solutes in the Loch Vale Watershed, Rocky Mountain National Park, Colorado: Eos, v. 69, p. 1213.

716. Matthai, H.F., 1969, Floods of June 1965 in South Platte River Basin, Colorado: U.S. Geological Survey Water-Supply Paper 1850-B, 64 p.

Heavy, intense rains in three areas, on June 14-17, 1965 caused, outstanding floods on many streams in the South Platte River basin from Plum Creek, just south of Denver, downstream to the Colorado-Nebraska State line. The flood-producing storms followed a relatively wet period, and rainfall of as much as 14 inches in a few hours was reported. Previous record high discharges on many tributaries with drainage areas on the plains were exceeded, sometimes severalfold. The attenuation of the peak flow by channel storage as the flood passed through Denver was considerable; yet the peak discharge of 40,300 cfs of the South Platte River at Denver was 1.8 times the previously recorded high of 22,000 cfs in a period of record starting in 1889. The 1965 peak would have been still higher except that all flow from Cherry Creek was stored in Cherry Creek Reservoir. Descriptions of the storms and floods, detailed streamflow records, and information on damages, flood profiles, inundated areas, and flood frequency are included in this report. Several comparisons of the magnitude of the flood are made, and all indicate that an outstanding hydrologic event occurred.

717. Maxwell, J.C., 1977, Raw data report of elemental analyses from hydrogeochemical and stream sediment samples taken near Sterling and Fort Morgan, northeastern Colorado, December 1976 and January 1977: N. Mex., Los Alamos Scientific Lab., Informal Report LA-6740-MS, GJBX-39-77, 30 p.

Water and sediment samples were collected from 125 sites near Sterling and Fort Morgan, Colorado, from Dec. 20, 1976, to Jan. 15, 1977. The samples were analyzed for U using fluorometry and delayed-neutron counting, and for various elements using emission spectrometry, energy-dispersive x-ray fluorometry, and neutron activation analysis. Several parameters were measured at each sample site during the sampling. The data from each sample site and for the elemental analyses are included in this document.

718. McBride, K., and Cooper, D.J., 1991, Heavy metals analysis of stream waters in Park County, Colorado: Prepared for Park County, Colorado.

719. McCain, J.F., and others, 1979, Storm and flood of July 31-August 1, 1976, in the Big Thompson River and Cache La Poudre River basins, Larimer and Weld counties, Colorado: U.S. Geological Survey Professional Paper 1115, 152 p.

720. McCain, J.F., and Ebling, J.L., 1979, A plan for study of flood hydrology of foothill streams in Colorado: U.S. Geological Survey Open-File Report 79-1276, 29 p.

721. McCain, J.F., and Hotchkiss, W.R., 1975, Map showing flood-prone areas, Boulder-Fort Collins-Greeley area, Front Range Urban Corridor, Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I-855-E, scale 1:100,000.

722. McCain, J.F., and Hotchkiss, W.R., 1975, Map showing flood-prone areas, Colorado Springs-Castle Rock area, Front Range Urban Corridor, Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I-857-C, scale 1:100,000.

723. McCain, J.F., and Hotchkiss, W.R., 1975, Map showing flood-prone areas, Greater Denver area, Front Range Urban Corridor, Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I-856-D, scale 1:100,000.

The rapid growth of population in the Front Range urban corridor of Colorado is causing intense competition for available land resources. One form of competition posing serious problems is indiscriminate development of flood plains along creeks and rivers. This map depicts a broad-scale view of flood-prone areas along principal streams in the greater Denver area of the urban corridor. Flood-prone areas identified are subject to inundation by the 100-year flood--a flood having a 1 percent chance of being equaled or exceeded in any given year. The magnitude and depth of this reference flood were derived for streams in the study area from streamflow records and reports of the U.S. Geological Survey, reports of the U.S. Army Corps of Engineers, and from reports prepared by various consulting engineering firms for the urban drainage and flood control district.

724. McCain, J.F., and Jarrett, R.D., [n.d.], Manual for estimating flood characteristics of natural-flow streams in Colorado: [Denver, Colo.?], Colorado Water Conservation Board, Technical Manual No. 1, 68 p.

725. McCann, T.P., 1949, Evaporites and sedimentary features of the upper Satanka Shale (Permian) of the Box Elder Creek-Sand Creek Region, Larimer County, Colorado: University of Colorado.

726. McCarty, M.K., and Scifres, C.J., 1972, Herbicidal control western ragweed in Nebraska pasture: Journal Range Mgmnt., v. 25, no. 4, p. 290.

727. McCaslin, J.L., 1981, Engineering report on drilling in the quartz-pebble conglomerates in southeast Wyoming: Grand Junction, Colo., Bendix Field Engineering Corp., GJBX-116(81), 128 p.

This report presents engineering data, statistics, and individual borehole histories of 28 holes drilled in this project. The project was drilled in two phases, with Phase I consisting of 20 holes completed in 1979 and Phase II consisting of 8 holes completed in 1980. Charts showing daily drilling progress are included in Appendix A and geophysical logs, on microfiche, are included in the pocket at the end of this report. A separate geologic report will be available through the Technical Library of Bendix Field Engineering Corporation (BFEC), P.O. Box 1569, Grand Junction, Colorado 81502.

728. McConaghy, J.A., 1964, Records of wells in Colorado: U.S. Geological Survey Colorado Water Conservation Board Basic- Data Report 17, 384 p.

729. McConaghy, J.A., Chase, G.H., Boettcher, A. J., and Major, T.J., 1964, Hydrogeologic data of the Denver basin, Colorado: Colorado Water Conservation Board Basic Data Report 15, 224 p.

730. McConnel, R., and Soldano, G., 1982, Mixing zone evaluation, Littleton and Englewood wastewater treatment plant: Denver, Colo., Colorado Department of Health, 22 p.

731. McCord, J.T., and Stephens, D.B., 1987, Effect of groundwater recharge on configuration of the water table beneath sand dunes and on seepage in lakes in the Sandhills of Nebraska, U.S.A. (Discussion of paper from Winter, T.C., J. Hydrol., v. 86, p. 221, 1986): Journal of Hydrology, v. 95, no. 3-4, p. 365-367.

732. McCoy, G., 1982, A study of municipal water management policies and effects on water supplies in northern Colorado.: Boulder, Colorado, University of Colorado, MS thesis.

733. McCray, K., 1982, The Ogallala; half full or half empty?: Water Well Journal, v. 36, no. 7, p. 53-62.

734. McCrone, J., ed., 1989, Fourth World Wilderness Congress - Acid Rain Symposium (part 2). Denver (Estes Park), Colorado, September 11-18, 1987: Environ Monit. Assess., v. 12, no. 3, p. 203-293.

735. McKee, E.D., Crosby, E.J., and Berryhill, H.L., Jr., 1967, Flood deposits, Bijou Creek, Colorado: Jour. Sed. Petrology.

736. McKnight, D., Brenner, M., and Baron, J., 1986, Seasonal changes in phytoplankton populations and related chemical and physical characteristics in lakes in Loch Vale, Rocky Mountain National Park, Colorado: U.S. Geological Survey Water-Resources Investigations Report 86-4101, 64 p.

737. McKnight, D., Miller, C., Smith, R., Baron, J., and Spudding, S., 1988, Phytoplankton populations in lakes in Loch Vale, Rocky Mountain National Park, Colorado: sensitivity to acidic conditions and nitrate enrichment: U.S. Geological Survey Water Resources Investigations Report 88-4115, 102 p.

738. McKnight, D., Smith, R., Bradbury, J.P., Baron, J., and Spaulding, S., 1990, Phytoplankton dynamics in three Rocky Mountain lakes, Colorado, USA: Arc. Alp. Resear., v. 22, p. 264- 274.

739. McLaughlin, P.W., 1988, The effect of storm trajectory on precipitation chemistry in Rocky Mountain National Park: Fort Collins, Colo., Colorado State University, 70 p.

740. McMillan, M.E., 1990, Soil development on a Pinedale moraine and erosion ten years after a burn, Rocky Mountain National Park, Colorado: Boulder, Colo., University of Colorado, MS thesis, 91 p.

741. McWhorter, D.B., 1984, Specific yield by geophysical logging potential for the Denver Basin: Fort Collins, Colo., Colorado Water Resources Research Institute, Technical completion report-132; OWRT-A-052-COLO(1), 40 p.

Management of the groundwater resource residing in the bedrock aquifers of the Denver Basin requires estimation of the volume of water ultimately recoverable from these formations. Management of the waters in the bedrock aquifers of the basin would be greatly expedited by a method that would permit objective estimation of specific yield on a routine basis. This report reviews the concept of specific yield, usual methods for its estimation, and the potential for use of borehole geophysical measurements as an alternate method for estimating specific yield. The nuclear magnetic log emerged as the most promising bore-hole geophysical technique. This

log measures the spinlattice relaxation time of hydrogen nuclei after being subjected to a magnetic field.

742. Meade, R.H., 1963, Factors influencing the pore volume of fine- grained sediments under low-to-moderate overburden loads: Journal of Sedimentology.

743. Mecom, J.O., 1972, Feeding habits of Trichoptera in a mountain stream: Oikos, v. 23, no. 3, p. 401-407.

744. Meeker, R.I., and Giles, J.M., 1907, Surface water supply of the Missouri River drainage, 1906: U.S. Geological Survey Water- Supply Paper 208, 190 p.

745. Mehan, D.B., 1991, Effects of urbanization on hydrology of the South Platte River (abstract only), *in* Woodring, R.C., ed., South Platte resource management: Finding a balance: Fort Collins, Colo., Colorado Water Resources Research Center, p. 17.

746. Mehls, S.F., 1984, The new empire of the Rockies: a history of northeast Colorado: Denver, Colo., Bureau of Land Management, Cultural Resources Series 16.

747. Meinzer, O.E., 1917, Ground water for irrigation in Lodgepole Valley, Wyoming and Nebraska: U.S. Geological Survey Water- Supply Paper 425-B, 37-69 p.

748. Michael, E., and Clayton, J., 1990, Application of porphyrin and other biological marker geochemistry to paleoenvironmental assessment; Pennsylvanian black shales, northern Denver Basin, *in* AAPG annual convention with DPA/EMD divisions and SEPM. AAPG Bulletin; technical program with abstracts, San Francisco, Calif., June 3-6, 1990: v. 74, p. 719.

749. Michener, J.A., 1976, Centennial: Greenwich, Conn., Fawcett.

750. Miller, A.D., Newey, J.M., Schleiger, T., McGaffic, V.J. and Borst, T., 1985, 10-CFR-61 Compliance at Fort St. Vrain, in 30th Annual Meeting of the Health Physics Society, Chicago, Ill., May 26-31, 1985.: Health Phys. 49, p. 146.

751. Miller, L.D., Tom, C., and Nualchawee, K., 1977, Remote sensing inputs to landscape models which predict future spatial land use patterns for hydrologic models: Greenbelt, Md., Goddard Space Flight Center, National Aeronautics and Space Administration Report, 41p.

Landscape modeling organizes and overlays information from existing maps, tabular sources, and from the analysis of remote sensing imagery into a computer framework. This critical endeavor provides higher-order inputs to the hydrological analysis of an area. Landscape modeling with attendant inputs from remote sensing is illustrated by two case studies. Application to the Denver, Colorado, urban area typifies use of the procedure to predict future spatial evolution of man-induced land use patterns of an urban area which can assist in the simulation of future urban hydrographs. A tropical forest site in Thailand illustrates application to more natural watersheds as the basis for analysis of the hydrological implications of alteration of land cover; primitive watersheds subject to change due to natural (e.g., drought) or man-made (e.g., forest cutting) alteration can be modeled to yield map-like projections of the future distribution of each land use or cover. Remote sensing imagery subjected to proper computer analysis provides input to hydrological models and practical data bases for planning large and small-scale hydrological developments. Combining available remote sensing imagery with map information in the landscape model substantially improves these applications. Coincident, registered overlays of the map information upon multispectral remote sensing imagery of Landsat provide a basis for marked improvements in the accuracy of the computer interpretation of land use and land cover maps to be used directly in hydrological analysis.

752. Miller, S.P., 1979, Geotechnical containment alternatives for industrial waste, Basin F, Rocky Mountain Arsenal, Denver, Colorado. A quantitative evaluation, Final rept. 1 Dec 77-30 Sep 78: Vicksburg, Miss., Army Engineer Waterways Experiment Station, WES/TR/GL-79-23, 96 p.

Rocky Mountain Arsenal (RMA), since its establishment in 1942, has produced chemical, biological, and incendiary munitions and destroyed chemical munitions. .Additionally, private corporations have used leased facilities at the Arsenal for pesticide production. Wastes from these operations have been placed in several basins at RMA. Discovery of off-post contamination led to Cease and Desist Orders from the State of Colorado, which required that off-post contamination by two organic substances cease. As a result of these orders and a continuing program to contain and treat migrating wastes and to identify, isolate, and treat pollution sources contributing to this migration, one of the waste basins, Basin F, was studied. The principal tasks of the study were to develop the geohydrologic setting in the area of the basin, select feasible containment alternatives, determine the effect of basin wastes on the construction materials of each alternative, recommend one alternative, and provide a conceptual design of the containment system and a monitoring system.

753. Minges, D.R., 1978, Effects of proposed "Narrows" Reservoir on South Platte River, *in* Geological Survey Research: U.S. Geological Survey Professional Paper 1100, 113 p.

754. Minges, D.R., 1983, Selected hydrologic characteristics of the South Platte River in the vicinity of the proposed Narrows Reservoir near Fort Morgan, Colorado: U.S. Geological Survey Water-Resources Investigations 82-4071, 25 p.

755. Missouri River Basin Commission, 1980, Missouri River basin water resources management plan; A comprehensive, coordinated, joint plan for water and related land resources and draft environmental impact statement; Appendix H, Water resources problems and opportunities; Appendix G, State planning objectives. In three separate texts; draft environmental impact statement: Omaha, Nebr., variously paginated.

756. Missouri River Basin Commission, 1977, Specific problem analysis; 1975 national assessment of water and related land resources; Missouri region: Omaha, Nebr., 16 p.

757. Mitchell, C.J., 1983, Differentiation of host-seeking behavior from blood-feeding behavior in overwintering *Culex pipiens (Diptera: Culicidae)* and observations on gonotrophic dissociation: Journal Med. Ent. Honolulu, v. 20, no. 2, p. 157- 163.

758. Mitchum, D.L., and Sherman, L.E., 1981, Transmission of bacterial kidney disease from wild to hatchery stocked trout: Can. J. Fish. Aquat. Sci., v. 38, no. 5, p. 547-551.

Natural, horizontal transmission of bacterial kidney disease (BKD) from infected wild brook trout (*Salvelinus fontinalis*) to newly stocked hatchery brook trout, brown trout

(*Salmo trutta*) and rainbow trout (*Salmo gairdneri*) was shown in a small lake and stream system in southeastern Wyoming, USA. Stocked trout were infected naturally with *Renibacterium salmoninarum* and died in 9 mo. or less after exposure to infected wild fish. Dead and live fish collected from each of 3 stations were necropsied. Fluorescent antibody techniques (FAT) were used to detect the BKD organism in all samples. Low severity infections were often detected by FAT at a higher rate when feces were examined as compared to kidney tissues from the same fish. Because other known pathogens were essentially absent, BKD was diagnosed as the cause of all deaths in both stocked hatchery fish and wild fish. Rainbow trout were the most refractory species.

759. Moran, D.T., Rowley, J.C., and Aiken, G., 1987, Trout olfactory receptors degenerate in response to water-borne ions: A potential bioassay for environmental neurotoxicology. 9., *in* International Symposium on Olfaction and Taste Snowmass Village, CO (USA). Ann. N.Y. Acad. Sci. Taste and Olfaction, July 20-24, 1986: v. 510, p. 509-511.

During the course of research on the ultrastructure of the trout olfactory system, it was observed that wild brown trout (*Salmo trutta*) experienced complete loss of their olfactory receptors after spending two days in a large, 250-gallon aquarium. When these same fish were returned to the North Fork of the South Platte River--their home stream--their olfactory receptors were found to have regenerated within a period of eight days. When these same fish were once again reintroduced into a laboratory aquarium, their receptors degenerated, once again, within two days. In the aquarium water, the levels of four ions, cadmium (Cd), cobalt (Co), copper (Cu), and zinc (Zn), were present at significantly higher levels than they were in stream water.

760. Morel-Seytoux, H.J., 1984, Conjunctive operation of a surface reservoir and of groundwater storage through a hydraulically connected stream: Fort Collins, Colo., Environmental Resources Center, Colorado State University Completion Report Series, 35 p.

761. Morel-Seytoux, H.J., 1977, Development of a subsurface hydrologic model and use for integrated management of surface and subsurface water resources: Fort Collins, Colorado., Colorado Water Resources Research Institute Completion Report 82, 27 p.

Two new concepts useful in studies of conjunctive management of surface and ground waters are introduced. In order to model, both accurately and cost-effectively the effect of initial aquifer drawdowns on the future state of the system, artificial pumping rates for one period prior to the initial time are introduced. With this approach, it is possible to simulate the effect of initial conditions in the same way pumping effects are predicted. In addition, for long-term simulation, the concept of sequential reinitialization is introduced. In this manner, daily simulation over many years can be carried with pumping and relaxation discrete kernels calculated for only a few periods. The concept of reach transmissivity introduced in earlier studies is verified by comparison with observations of return flows to a reach of the South Platte River. The study indicates the approach is sound.

762. Morel-Seytoux, H.J., 1987, Value and role of conjunctive use of surface and ground waters in river basin water management, *in* Wunderlich, W.O., and Prins, J.E., eds., International symposium on water for the future; water resources developments in perspective; proceedings: Rotterdam, Netherlands, A. A. Balkema, p. 515-524.

763. Morel-Seytoux, H.J., 1976, Water resources planning (an illustration on management of surface and groundwater), *in* Shen, H.W., ed., Stochastic approaches to water resources; Volume I: Fort Collins, Colo., privately published, p. 10.1-10.59.

764. Morel-Seytoux, H.J., Daly, C.J., Illangasekare, T., and Bazaraa, A., 1981, Design and merit of a river-aquifer model for optimal use of agricultural water: Journal of Hydrology, v. 51, no. 1-4(May), p. 17-27.

Important steps in the design of a river-aquifer model for optimal use of agricultural water are discussed. The area under study consisted of a 90-mile reach of the South Platte River in the eastern plains of Colorado and of its associated alluvial aquifer. Irrigated agriculture is widely practiced in this area, with the major crops being corn, sugar beets, beans and alfalfa. Irrigation water comes mainly from surface water supplied by three reservoirs and an extensive system of distribution canals. Groundwater is used as a supplementary source through pumped wells. The study was made to find an optimum strategy of managing the river-aquifer system under drought conditions. Considerations to be included in the model design included system size and geometry, length of time steps and the total time horizon, lumping of parameters and variables, water allocation, and water rights. Once designed, the model was successfully applied to the field problem. The design procedures used made it possible to apply the model at a very moderate cost of $350 (US) for a simulation and still maintain very high accuracies in simulating the physical behavior.

765. Morel-Seytoux, H.J., Illangasekare, T.H., and Peters, G., 1979, Field verification of the concept of reach transmissivity, *in* The hydrology of areas of low precipitation--L'hydrologie des regions a faibles precipitations: IAHS-AISH Publication, p. 355-359.

766. Morel-Seytoux, H.J., Illangasekare, T., Bittinger, M.W., and Evans, N.A., 1979, The impacts of improving efficiency of irrigation systems on water availability in the Lower South Platte River Basin: Fort Collins, Colo., Colorado Water Resources Research Institute Information Series 33, 9 p.

767. Morel-Seytoux, H.J., Illangasekare, T.H. and Simpson, A.R., 1981, Modelling for management of a stream-aquifer system: HYDROWAR Program, *in* Proceedings ASCE Specialty Conference, Water Forum 81, August 10-14, 1981: [San Francisco, Calif.?], p. 1342-1349.

768. Morel-Seytoux, H.J., Illangasekare, T., Bittinger, M.W., and Evans, N.A., 1981, Potential use of a stream-aquifer model for management of a river basin: case of the South Platte River in Colorado: Water Science and Technology, v. 13, no. 3, p. 175-187.

A computer simulation study was conducted to determine the best water management strategy, particularly under drought conditions, for conjunctive use of surface and groundwaters for a 90-mile section of the South Platte River. Five runs of the model were made. The Historical Run used data for 1952-1961. Calculated river flow at Julesburg agreed with recorded flows. The Lined Canals Run proposed lining canals with seepage losses of 25% or more. Water allocation strategy consisted of allowing the diversion of the minimum of four quantities: water need, water right, legal water availability, and historical diversion. The Farm Efficiency Run assumed that irrigation efficiency improved from a historical value of 40-50% to 75% under the same water allocation strategy as the Lined Canals Run. The Pumping-as Needed Run allocated surface water as before, but allowed pumping up to existing capacity to meet crop needs unsatisfied by surface water supplies. The fifth run was a Combination Run. The best remedy for water supplies was to draw supplemental water from the aquifer wherever and whenever needed during drought. The resulting lowering of the water table would reach an equilibrium state within two years if no more land is put into production. Canal lining and increased farm efficiency, depending on surface water, would save only small amounts of water in times of drought when surface water supplies are small. This model study confirms previous work which concluded that wells should be pumped during dry years and allowed to recharge during years with normal stream flow.

769. Morel-Seytoux, H.J., and Illangasekare, T.H., 1982, A river basin model suited for assessment of impacts due to managerial changes in the South Platte River Basin: HYDROWAR Program: Fort Collins, Colo., Colorado State University, CEP81-82HJM-THI31, 494 p.

770. Morel-Seytoux, H.J., and Illangasekare, T., 1979, Suitability of various management strategies for a reach of the South Platte stream-aquifer system under drought conditions. American Geophysical Union, 1979 Spring Annual Meeting: Eos, v. 60, no. 18, p. 251.

771. Morel-Seytoux, H.J., Illangasekare, T., and Daly, C.J., 1979, Water allocation management of a reach of the South Platte stream-aquifer system in Colorado., in XVIIIth IAHR Congress, Cagliary, Italy, September 10-15, 1979: v. 2, p. 179-186.

772. Morgan, A.M., 1947, Geology and ground water in the Laramie area, Albany County, Wyoming: U.S. Geological Survey, 35 p.

773. Morin, R.H., Barrash, W., Graves, B.J., Lehr, J.H., Butcher, K., Owen, T.E., and Mathews, M., 1986, Defining patterns of ground water and heat flow in fractured Brule Formation, western Nebraska, using borehole geophysical methods, *in* Surface and borehole geophysical methods and ground water instrumentation; Conference and exposition: Dublin, Ohio., Natl. Water Well Assoc., p. 545-569.

774. Morris, S.E., and Moses, T.A., 1987, Forest fire and the natural soil erosion regime in the Colorado Front Range: Annals of the Association of American Geographers, v. 77, no. 2, p. 245-254.

775. Morrison, S.M., 1978, Surveillance data. Plains segment of the Cache La Poudre River, Colorado 1970-1977: Fort Collins, Colo., Colorado Water Resources Research Institute Information Series 25.

776. Mountain Plains Federal Regional Council, Federation of Rocky Mountain States, Inc., Environmental Protection Agency, Denver, Colo. Region VIII., Law Enforcement Assistance Administration, 1971, First annual state-federal conference on May 12-14, 1971: Cheyenne, Wyo., Summary report, 104 p.

The Conference was a direct outgrowth of a 1970 Snowmass seminar and a later meeting between representatives of Regional Councils and legislative leadership. The Federation of Rocky Mountain States had been meeting with the Mountain Plains Federal Regional Council to investigate common problem areas on which the two regional organizations could cooperate. Participants included officials on the local, State and federal levels as well as representatives from the business sector and other civic organizations from the States of Wyoming, Colorado, Utah, Montana, Idaho, New Mexico, South Dakota, North Dakota and Nebraska.

777. Mueller, D.K., 1990, Analysis of water-quality data and sampling programs at selected sites in north-central Colorado: U.S. Geological Survey Water-Resources Investigations Report 90-4005, 87 p.

The report provides an analysis of the water-quality data at selected sites and provides an evaluation of the suitability of the current (1987) sampling programs at each site for meeting future needs of defining water quality within the area affected by CBT Project operations. Specific objectives of the report are to: provide summary statistics of water-quality data at each site for the period of record; identify significant trends for water-quality constituents or properties at each site; determine whether certain stations could be discontinued without substantial loss of information; determine whether the frequency of sampling for any individual constituent or groups of constituents at any of the sites could be decreased without substantial loss of information; and evaluate which water-quality constituents and properties need to be measured in order to meet the water-quality-data needs at each site. Fourteen streamflow and reservoir stations were selected for the analysis. These sites represent a network of water-quality sampling stations that can be used to evaluate the effects of CBT Project water transfers on both sides of the Continental Divide.

778. Muhs, D.R., 1985, Age and paleoclimatic significance of Holocene sand dunes in northeastern Colorado: Annals of the Association of American Geographers, v. 75, no. 4, p. 566-582.

779. Mundorff, J.C., 1964, Fluvial sediment in Kiowa Creek basin, Colorado; sedimentation in small drainage basins: U.S. Geological Survey Water-Supply Paper 1798-A, 70 p.

780. Mundorff, J.C., 1968, Fluvial sediment in the drainage area of k- 79 reservoir, Kiowa Creek basin, Colorado; sedimentation in small drainage basins: U.S. Geological Survey Water-Supply Paper 1798-D, 26 p.

Fluvial sediment in the drainage area of k-79 reservoir was studied as part of a national investigation of trap efficiency of detention reservoirs. During the study period, precipitation was significantly above normal during 4 yr, below normal 4 yr, and near normal 2 yr. From Aug. 1956 to July 1965, 7.5 acre-ft of sediment was trapped in the reservoir and 2.5 acre-ft was discharged. The efficiency was 75% based on volume, and 83% based on the weight of the sediment. About 80% of the sediment was discharged during 2 periods--3 days in 1957 and 2 days in 1965. Much of the sediment produced in a large part of the basin was trapped in upstream structures and never reached k-79 reservoir. Flocculation was not a significant cause of sediment deposition because the low mineralization of the water and the short detention time in the reservoir are not conducive to flocculation. A 1:1,200 scale map shows areas of deposition and erosion in the reservoir and a small map shows vegetation in the basin. Tables give monthly and annual summaries of water and suspended sediment discharge at the reservoir and the particle size of suspended sediment in inflow and outflow from the reservoir.

781. Mustard, M.H., Ellis, S.R., and Gibbs, J.W., 1987, Runoff characteristics and washoff loads from rainfall-simulation experiments on a street surface and a native pasture in the Denver Metropolitan area, Colorado: U.S. Geological Survey Professional Paper 1441, 30 p.

Rainfall simulation studies were conducted in conjunction with the Denver Regional Urban Runoff Program to: (1) Compare runoff quantity and quality from two different intensities of rainfall on impervious plots having identical antecedent conditions, (2) document a first flush of constituent loads in runoff from 1,000-square-foot street-surface plots, (3) compare runoff characteristics from a street surface subjected to simulated rainfall with those from a 69-acre urban basin of mixed land use subjected to natural rainfall, (4) perform statistical analysis of constituent loads in the runoff with several independent variables, and (5) compare the quantity and quality of runoff from 400-square-foot plots of native grasses used for pasture and subjected to simulated rainfall with that from a 405-acre basin covered with native grasses used for pasture and subjected to natural rainfall. A first flush of constituent loads occurred for most constituents in the runoff from most rainfall simulations on the street surface; however, a first flush did not occur in the runoff from simulated rainfall on the pasture. Intensity of rainfall and total rainfall are important variables determining constituent loads. The design of the experiment was such that intensity of rainfall and total rainfall were highly correlated, this precluding the development of useful regression equations to predict washoff loads. The quality of runoff from the simulated rainfall on the pasture was influenced by the disturbed perimeters of the plots; however, the runoff-to-rainfall ratios of the simulated storms fell within the range of ratios measured for natural storms over the adjacent 405-acre basin. (Author's abstract)

782. Nadler, C. T., Jr., 1978, River metamorphosis of the South Platte and Arkansas Rivers, Colorado: Fort Collins, Colo., Colorado State University.

783. Nadler, C.T., and Schumm, S.A., 1981, Metamorphosis of South Platte and Arkansas Rivers, eastern Colorado: Physical Geography, v. 2, no. 2, p. 95-115.

784. National Aeronautics and Space Administration, 1975, NASA Earth Resources Survey Symposium. Volume 1-a; Vol. 1-B N76-; Vol. 1-C N76-; Vol. 1-D N76-; Vol. 3 N76-. Agriculture, Environment First Comprehensive Symposium on the Practical Application of Earth Resources Survey Data, Houston, Tex., 9-12 Jun. 1975: Lyndon B. Johnson Space Center, 600 p.

A number of papers dealing with the practical application of imagery obtained from remote sensors on LANDSAT satellites, the Skylab Earth resources experiment package, and aircraft to problems in agriculture and the environment were presented. Some of the more important topics that were covered included: range management and resources, environmental monitoring and management, crop growth and inventory, land management, multispectral band scanners, forest management, mapping, marshlands, strip mining, water quality and pollution, and ecology.

785. National Eutrophication Survey, Environmental Monitoring and Support Lab., Las Vegas, Nev., Colorado Dept. of Health, Denver., Colorado National Guard, Denver., Corvallis Environmental Research Lab., Oreg., 1977, Barker Reservoir, Boulder County, Colorado, Final rept: Corvallis, Oreg., Working Paper 765, 37 p.

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included.

786. National Field Investigations Center, 1972, Effects of waste discharges on water quality on the Cache La Poudre and South Platte Rivers, Greeley Area: Denver, Colo., Environmental Protection Agency.

The Great Western Sugar Company operates a sugar-beet processing mill at Greeley, Co., on the Cache La Poudre River just upstream of its confluence with the South Platte River. Inadequately treated industrial wastes from this mill are discharged to the Cache La Poudre River. In addition to these discharges, a large volume of inadequately treated municipal wastes is discharged immediately upstream of the Great Western Mill. Stream surveys were conducted by the National Field Investigation Center during the months of Sept. to Dec. 1971, to define conditions in the receiving waters prior to the sugar-beet processing season. The report summarizes the results of the investigations.

787. National Field Investigations Center, 1972, Effects of waste discharges on water quality of the South Platte River, Denver Metropolitan Area: Denver, Colo., Environmental Protection Agency, 118 p.

A study of the South Platte River Basin was conducted to determine whether established State and federal water-quality standards were being met. Fifteen treatment plants were studied to determine whether treatment meeting established requirements had been effected, to determine the extent of water-quality improvement, and to determine any recommendations which might be made. Influent samples were collected and analyzed for BOD, total and suspended solids, volatile suspended solids, settleable solids, total organic carbon, chemical oxygen demand, nitrogen series, total phosphorus, and selected heavy metals. Final effluent samples from the Denver Metro facility were analyzed for total and fecal coliforms. Field measurements and residual chlorine were measured at the time of collection.

788. National Field Investigations Center, 1972, Investigation of the effects of the waste discharges from the Great Western Sugar Mill at Ovid, Colorado, *in* Water quality conditions in the South Platte River: Denver, Colo., Environmental Protection Agency, GRAI7602, 36 p.

Investigations of the water-quality in the reach of the South Platte River affected by the sugar mill waste discharges were conducted in order to define conditions prior to and during the sugar-beet processing season. Waste sources were also evaluated. Observed water-quality conditions are compared to applicable water-quality regulations. Violations of water quality standards are defined. Remedial measures to

abate existing interstate pollution that is in violation of water-quality standards are recommended.

789. National Field Investigations Center, 1972, Technical appendix on industrial waste-source evaluations; water-quality investigations in the South Platte River Basin, Colorado, 1971- 72: Denver, Colo., Environmental Protection Agency, 133 p.

Forty-four industrial plants were visited in order to ascertain water pollution control practices. Twenty-three of the plants were selected for in-plant sampling to determine both the waste load discharged and the adequacy of present water pollution control practices. Each report includes an introduction, water treatment facilities, discussion of plant evaluation and findings, summary and conclusion and recommendations.

790. National Field Investigations Center, 1972, Technical appendix on municipal waste-source evaluations; water-quality investigations in the South Platte River Basin, Colorado; 1971-72: Denver, Colo., Environmental Protection Agency Region VIII, EPA/330/2- 72-007, 156 p.

Twenty-three municipal plants were investigated in order to determine both the adequacy of present treatment practices and the waste loads being discharged. A report is included on each municipal WWTP evaluated, with the exception of the Metro Denver Sewage Disposal District #1 and the Greeley WWTP.

791. National Field Investigations Center, 1972, Water-quality investigations in the South Platte River Basin, Colorado, 1971- 72: Denver, Colo., Environmental Protection Agency, EPA report, 266 p.

A comprehensive water-quality investigation in the South Platte River Basin was conducted by the National Field Investigations Center-Denver. The objectives of the studies were to define water-quality conditions in the South Platte River, to evaluate water pollution abatement practices, to evaluate progress toward compliance with the 1966 Conference in the Matter of Pollution of the South Platte River Basin, to determine whether Colorado water-quality standards have been violated, and to determine the need for abatement proceedings.

792. National Oceanic and Atmospheric Administration, 1976, Big Thompson Canyon flash flood of July 30-August 1, 1976. A Report to the Administrator: Rockville, Md., NOAA Natural Disaster Survey Report 76-1, 48 p.

The Big Thompson flash flood struck on the evening of July 31, 1976. A few short hours separated the onset of heavy rain from the flood crest passing the canyon mouth to quickly subside on the plains below. The heroic efforts of law enforcement officers and rescue workers kept the loss of lives from being higher but at least 135 persons were killed and the search for the missing continues. The Big Thompson River is a tributary of the South Platte River. Its source is in Rocky Mountain National Park in north-central Colorado. On the evening of July 31, 1976, a very heavy rain fell over a 70-square mile area in the central portion of the watershed. The most intense rainfall, more than 12 inches, occurred over the slopes of the western third of the Big Thompson Canyon. More than four inches of rain fell over the entire canyon area. The resulting runoff exceeded the highest previously recorded by almost an order of magnitude, reaching an estimated 31,200 cubic feet per second at the mouth of the

canyon. Information is given on methods of data acquisition, the meteorological conditions and forecasts as the river began to rise. Finally, the methods of dissemination of warnings and the public response are detailed.

793. Nebraska Department of Environmental Control, 1991, Nebraska nonpoint source management program: Lincoln, Nebr., Water Quality Division, Annual NPS Report, 84 p.

794. Neff, D.J., 1957, Ecological effects of beaver habitat abandonment in the Colorado Rockies: J. Wildlife Manage., v. 21, p. 80-84.

795. Nehring, R.B., 1987, Stream fisheries investigations; Federal Aid Project F-51-R: Fort Collins, Colo., Colorado Division of Wildlife, Job No. 3 Special Regulations Evaluations.

796. Nelson, S.M., 1979, Archaeological investigations in the Chatfield Reservoir, Colorado Final rept. Nov. 75-Jan. 76: Denver, Colo., Denver Univ., Dept. of Anthropology. Heritage, Conservation and Recreation Service, Interagency Archeological Services., 72 p.

The Chatfield Reservoir Project was a mitigation project to excavate and test known archaeological sites that might be impacted in the Chatfield Reservoir Recreation Area. The results are reported here, along with a brief overview of prehistoric and protohistoric sites in the general region, and a summary of late Pleistocene and Holocene terraces as they may pertain to the archaeological finds. Intermittent occupation of the Chatfield Reservoir Area from about 5000 BC to perhaps AD 1000 is inferred from projectile point and mano types found in the area.

797. Nelson, W.C., 1972, Comparative limnology of Colorado Big Thompson Project reservoirs and lakes: Colo. Div. Game Fish Parks Fish Res. Rev., v. 7, p. 1-2.

798. Netoff, D. I., 1977, Soil clay mineralogy of Quaternary deposits in two Front Range-Piedmont transects, Colorado: Boulder, Colo., Univ. of Colorado, 178 p.

799. Nichols, S.R., [n.d.], Water pollution: South Platte River: Fort Collins, Colo., Dept. of Agricultural Engineering, Colorado State Univ.

This investigation examines the interrelation of federal- state-local political mechanisms, the related laws generated by these institutions, the means by which pollution is measured and water quality managed, and speculates on this system's shortcomings and needs. The South Platte River basin in Colorado is the target of this investigation because it contains most of the people in Colorado, has a history of serious water-quality problems, and faces increasing future water demands, which will require a greater recognizance of water-quantity and -quality management. Groundwater pollution problems seem less acute than surface water. Surface water resources have been fully appropriated for irrigation use. In summer, very low flows occur at many points along basin streams, where agriculture diversions may use all, or nearly all, of the available streamflow. These low flows exacerbate the pollution concentration by the absence of dilution water.

800. Nichols, S.R., Skogerboe, G.V., and Ward, R.C., 1972, Water quality management decisions in Colorado: Fort Collins, Colo., Environmental Resources Center, Colorado State University, Completion Report Series 38, 103 p.

An evaluation of Colorado's present water quality monitoring system was made, as well as the capability of present institutional programs to anticipate potential pollution problems, and recommendations have been made for alternative pollution enforcement methods. Both Federal and State legislative history pertinent to Colorado water pollution problems were delineated. Primary emphasis has been given to the South Platte River Basin, because it represents the most severe combination of municipal, industrial, and agricultural pollution problems in Colorado.

801. Nimmo, D.W., and Sutton, R., 1984, Toxicity studies on aquatic life; copper and silver in the Loveland municipal wastewater and the Big Thompson River.

802. Norris, J.M., Robson, S.G., and Parker, R.S., 1985, Summary of hydrologic information for the Denver coal region, Colorado: U.S. Geological Survey Water-Resources Investigations Report 84-4337, 68 p.

A literature review of available hydrologic information for the Denver coal region is presented. Where little information is available, data from the U.S. Geological Survey's WATSTORE data base are summarized. The information is divided into three categories: surface water, surface water quality, and groundwater. Data generally are lacking on surface water and surface water quality. The effects of man's activities on streamflow quantity and quality are not known. Considerable literature is available on the major aquifers in the area, but less is known about the shallow groundwater system.

803. Northern Colorado Water Conservancy District and Municipal Subdistrict, 1991, Draft report - Regional water supply study: Loveland, Colo.

804. Norton, S.A., Hess, C.T., Blake, G.M., Morrison, M.L., and Baron J., 1985, Excess unsupported 210Pb in lake sediment from Rocky Mountain lakes: a groundwater effect: Can. J. Fish. Aquat. Sci., v. 42, p. 1249-1254.

805. Nunes, H.P., 1978, NURE hydrogeochemical and stream sediment data release for pilot study samples from portions of the Sterling and Greeley NTMS Quadrangles, Colorado: N. Mex., Los Alamos Scientific Lab., U.S. Department of Energy, GJBX-140(78), LA- 7145-MS Informal Report, 124 p.

During four distinct time periods between December 1976 and August 1977, students collected samples from the two areas. One purpose was to determine the effect of seasonal variations upon the elemental concentrations, particularly uranium.

806. Nunes, H.P., 1978, Uranium hydrogeochemical and stream sediment reconnaissance data release for the Sterling NTMS Quadrangles, Colorado: N. Mex., Los Alamos Scientific Lab., U.S. Department of Energy, GJBX-90-78, SLA-7305-MS Informal Report, 57 p.

807. NUS Corp., 1980, Preliminary State-by-State assessment of low-level radioactive wastes shipped to commercial burial grounds: Rockville, Md., Department of Energy, NUS-3440, 115 p.

This report provides, on a State-by-State basis, estimates of the quantities and characteristics of low-level radioactive wastes (LLW) generated in the following sectors: commercial nuclear power plants, medical and educational institutions, industry (other than commercial nuclear power plants), and government and military. An estimated 83,800 cm exp 3 of radioactive waste, containing 886,000 Ci of radioactivity were buried in the four US commercial burial grounds in 1978. Data have been reported on wastes generated from reactor, institutional, and government/ military sectors but not from industrial users of radioactive materials. The non-industrial sources account for about 76% of all wastes by volume, and 54% of the recorded activity of the wastes buried. There is no survey information available on the producers of radioactive wastes from non-nuclear fuel-cycle industrial sources. In 1978, this segment may have produced an estimated 24% of the volume and as much as 46% of the activity shipped to commercial burial grounds. A significant portion of the estimates of the quantity and distribution of LLW contained in this report have been obtained by extrapolation or estimation from secondary sources of information. Therefore, the data are preliminary and subject to change or confirmation based on the findings of the extensive survey now underway.

808. Nyberg, R.C., and Fahey, T.J., 1988, Soil hydrology in Lodgepole Pine ecosystems in southeastern Wyoming: Soil Science Society of America Journal, v. 52, no. 3(May/June), p. 844-849.

The rates and pathways of water movement through the soil were examined in several Lodgepole pine (*Pinus contorta ssp. latifolia*) forests in southeastern Wyoming to improve our understanding of the dynamics of solute flux in forest ecosystems. We employed internal drainage and tracerpulse methods to determine hydraulic conductivity, and we examined snowmelt infiltration and drainage water chemistry on contrasting soils supporting lodgepole pine forests. Saturated hydraulic conductivity (K sub 0) values were lognormally distributed for 27 plots at each of two sites examined. The median value was significantly higher at a site on a gravel, loamy-sand (median K sub 0 = 1.20 cm/h) than on a bouldery, sandy-loam (K sub 0 = 0.49). At these sites, the high range in both K sub 0 values and in the transit time for a Cl- pulse were suggestive of highly variable water flow pathways through the soil. Early in the spring snowmelt period, much of the infiltrating water circumvented the soil matrix, probably flowing around entrapped air pockets and through macropores. Although large systematic differences in chemistry were not observed between soil solutions collected with tension and tensionless lysimeters, saturated flow (collected as drips from the ceiling of soil tunnels) contained about three times lower cation concentrations than the lysimeter solutions. To obtain more accurate estimates of nutrient leaching from the tree rooting zone, better quantification of the chemistry of percolating soil water is needed.

809. Oak Ridge Gaseous Diffusion Plant, 1981, Hydrogeochemical and stream sediment reconnaissance basic data for Cheyenne Quadrangle, Wyoming: Oak Ridge, Tenn., Department of Energy, GJBX-324-81; K/UR-365, 169 p.

Field and laboratory data are presented for 884 water samples and 598 sediment samples from the Cheyenne Quadrangle, Wyoming. Uranium values have been reported by Los Alamos National Laboratory in Report GJBX-106(78). The samples were collected by Los Alamos National Laboratory; laboratory analysis and data reporting were performed by the Uranium Resource Evaluation Project at Oak Ridge, Tennessee.

810. Office of the Chief of Engineers (Army), 1971, Project Eagle. Phase I. The disposal of chemical agent mustard at Rocky Mountain Arsenal, Denver, Colorado. Final environmental impact statement: Washington, D.C., Submitted to Council on Environmental Quality, Washington, D.C., 264 p.

The statement concerns the disposal of 3071 tons of excess chemical agent (mustard) at Rocky Mountain Arsenal, Denver, Colorado. The mustard will be destroyed by incineration under such controls as necessary to assure that any emissions will be below the permissible levels. A minimal impact on the local environment in the form of temporary air pollution will result from the demilitarization process. Two types of mustard are to be disposed of, Levinstein Mustard (containing 30% impurities, mostly sulfur) and Distilled Mustard (purified by vacuum distillation). Sulfur dioxide and hydrogen chloride will be generated and passed through a scrubber system where sodium sulfate, sodium sulfite and sodium chloride will be formed. Approximately 7,900 tons of salts will be generated. Current plans are to offer the salts for sale through the Defense Disposal Agency.

811. Olsen, S.N., 1984, Mass-balance and mass-transfer in migmatites from the Colorado Front Range: Contributions to Mineralogy and Petrology, v. 85, no. 1, p. 30-44.

812. Osterkamp, W.R., and Hedman, E.R., 1982, Perennial-streamflow characteristics related to channel geometry and sediment in Missouri River basin: U.S. Geological Survey Professional Paper 82-52506, 37 p.

An analysis of data from the Missouri River basin provides equations that relate channel width to water discharge based on different conditions of sediment properties and gradient. The equations provide estimates of discharge characteristics at ungaged sites and suggest relationships of channel shape and relative stability.--from New Publications of the Geological Survey, May 1982.

813. Outtalk, S.I., 1965, The regimen of the Andrews Glacier in Rocky Mountain National Park, Colorado: Water Resources Research, v. 1-2, p. 277-282.

814. Outcalt, S. I., 1959, The ural-type glaciers in Rocky Mountain National Park: Boulder, Colo., University of Colorado, MS thesis, 81 p.

815. Outcalt, S.I., and Benedict, J.B., 1965, Photo-interpretation of two types of rock glaciers in the Colorado Front Range: Journal of Glaciol., v. 5, no. 42, p. 849-856.

816. Outcalt, S.I., and MacPhail, D.D., 1965, A survey of neoglaciation in the Front Range of Colorado. Series on Earth Sciences no. 4: Boulder, Colo., Univ. of Colorado Press.

817. Parshall, R.L., 1922, Return of seepage water to the lower South Platte River in Colorado: Fort Collins, Colo., Colorado Agricultural Experimental Station, Bulletin 279, 72 p.

818. Paschal J.E., Jr., and Mueller, D.K., 1991, Simulation of water quality and the effects of wastewater effluent on the South Platte River from Chatfield Reservoir through Denver, Colorado: U.S. Geological Survey Water-Resources Investigations Report 91-4016, 98 p.

819. Patton, P. C., 1973, Gully erosion in the semiarid west: Fort Collins, Colo., Colorado State Univ.

820. Paulson, C.L., and Sanders, T.G., 1987, Evaluation of design flow criteria for effluent discharge permits in Colorado: Denver, Colo., Denver Regional Council of Government, Final Report, 139 p.

821. Pearce, R., 1888, Supposed mixture of bornite and stromeyerite, Idaho Springs, Colorado: Proceedings of the Colorado Sci. Soc., v. 2, p. 188.

822. Pearl, R.H., 1971, Bibliography of hydrogeologic reports in Colorado: Colo. Geol. Survey Bull. 33, 39 p.

823. Pearl, R.H., 1974, Geology of ground water resources in Colorado; an introduction: U.S. Geological Survey Special Publication 4, 47 p.

824. Pennak, R.W., and Ward, J.V., 1985, *Bathynellacea (Crustacea: Syncarida)* in the United States, and a new species from the phreatic zone of a Colorado mountain stream: Transactions Am. Microsc. Soc., v. 104, no. 3, p. 209-215.

825. Pennak, R.W., and Ward, J.V., 1986, Interstitial faunal communities of the hyporheic and adjacent groundwater biotopes of a Colorado mountain stream: Arch. Hydrobiol. Monographische Beitrage, v. 74, no. 3, p. 356-396.

826. Pennak, R.W., and Ward, J.V., 1985, New cyclopid copepods from interstitial habitats of a Colorado mountain stream: Trans. Am. Microsc. Soc., v. 104, no. 3, p. 216-222.

Acanthocyclops plattensis n.sp. and *Microcyclops pumilis n.sp.* are described from hyporheic and phreatic waters along the South Platte River, Colorado. Both species are small but otherwise not especially adapted to subsurface aquatic habitats. The former is especially distinguished from its close relatives by the details of the caudal rami, the fifth legs, and the small accessory spines on the basal segments of the fourth legs. The latter is especially distinguished by the details of the caudal rami, the terminal endoped segment of the fourth leg, and the very small size range within the species.

827. Petsch, H.E., Jr., Rennick, K.B., and Nordin, C.F., Jr., 1980, Statistical summaries of selected streamflow data on the South Platte River in Colorado and Nebraska; North Platte and Platte Rivers in Nebraska: U.S. Geological Survey Open-File Report 80- 679, 278 p.

This report is a compilation of statistical summaries of streamflow data for 22 gaging stations on the South Platte River in Colorado and Nebraska, and the North Platte and Platte Rivers in Nebraska.

828. Petti, J.R. A., and Chen, H.H., 1984, Hydrologic characteristics and ground-water availability in the High Plains aquifer system in Nebraska, *in* Whetstone, G.A., ed., Proceedings of the Ogallala Aquifer Symposium II: Lubbock, Tex., Texas Tech. University, p. 238-264.

829. Phamwon, S., 1982, Network model for optimal management of stream-aquifer systems: Fort Collins, Colo., Colorado State Univ., 284 p.

830. Phillip E. Flores Associates, Inc., 1974, Environmental inventory and summary, alternate Weld County and Narrows Dam sites--Phase 1: Denver, Colo., U.S. Bureau of Reclamation.

831. Phillip E. Flores Associates, Inc., 1974, Environmental inventory and summary, Narrows Dam site--Phase 1: Denver, Colo., U.S. Bureau of Reclamation.

832. Phillip E. Flores Associates, Inc., 1975, Land suitability analysis for fish, wildlife, and recreation, Narrows and alternate Weld County dam sites--Phase 2: Denver, Colo., U.S. Bureau of Reclamation.

833. Phillips, J.D., 1989, Nonpoint source pollution risk assessment in a watershed context: Environ. Manage., v. 13, no. 4, p. 493- 502.

Nonpoint source pollution control requires assessment of the influence of dispersed runoff-contributing areas on downstream water quality. This evaluation must consider two separate phases: site-to-stream loading and downstream fluvial transport. Any model, combination of models, or procedure for making this assessment can be generalized to a simple spatial model or framework, which considers runoff or pollutant loading per unit area and downstream attenuation, with drainage area as a scaling factor. This spatial model has a probabilistic interpretation and can be used in conjunction with a standard dilution model to give a probabilistic estimate of the impacts at the basin mouth of runoff from a specific upstream contributing area. It is illustrated by applying it to an assessment of the probability that various copper concentrations at the mouth of the urbanized South Platte River basin in Denver, Colorado, USA, will be exceeded as a result of runoff from a subbasin within the city. Determining the probability that a concentration of a pollutant at the basin mouth can be attributed to runoff from a discrete area within the basin is useful for targeting and risk assessment because it enables quantitative risk-based comparisons. The spatial framework is also useful for evaluating management and control options, since actions within the basin can be directly linked to water quality at a downstream point.

834. Pitlick, J.C., 1984, Bedload transport and hydraulic geometry relations for Fall River, Rocky Mountain National Park, Colorado. June-August 1983: Fort Collins, Colo., Colorado State University, WRSFL Project Report 84-ROMO-1, 14 p.

835. Pitlick, J.C., 1985, Effect of major sediment influx on Fall River, Colorado: Fort Collins, Colo., Colorado State University, MS thesis, 127 p.

836. Pitlick, J.C., 1988, The response of coarse-bed rivers to large floods in California and Colorado: Fort Collins, Colo., Colorado State University, Ph.D. dissertation, 137 p.

837. Pitlick, J., Costa, J.E., Dymek, R.F. and Shelton, K.L., 1989, Sediment loads and flow hydraulics during floods, *in* Geological Society of America, 1989 annual meeting. Abstracts with Programs, Nov. 6-9, 1989: v. 21(6), St. Louis, Mo., Geological Society of America, p. A40.

838. Pitts, W.T., 1974, Comprehensive water quality management plan for South Platte River basin, in 47th Annual Conference of Water Pollution Control Federation - Abstracts booklet: v. 3, WPCF.

839. Platania, S. P., 1990, Ichthyofauna of four irrigations canals in the Fort Collins Region of the Cache La Poudre River valley: Fort Collins, Colo., Colorado State University, MS thesis, 231 p.

840. Platania, S.P., Cummings, T.R., and Kehmeier, K.J., 1986, First verified record of the stonecat, Noturus flavus (Ictaluridae), in the South Platte River system, Colorado, with notes on an albinistic specimen: Southwestern Nat., v. 31, no. 4, p. 553- 555.

841. Pollastro, R.M., and Scholle, P.A., 1986, Exploration and development of hydrocarbons from low-permeability chalks; an example from the Upper Cretaceous Niobrara Formation, Rocky Mountain region, *in* Spencer, C.W., and Mast, R.F., eds., Geology of tight gas reservoirs. AAPG studies in geology: American Association Petroleum Geologists, p. 129-141.

842. Pollastro, R.M., and Scholle, P.A., 1984, Hydrocarbons exploration, development from low-permeability chalks; Upper Cretaceous Niobrara Formation, Rocky Mountains region: Oil and Gas Journal, v. 82, no. 17, p. 140-145.

843. Polumbus (E.A.) Jr. and Associates Inc., 1961, Drilling of pressure injection disposal well, Rocky Mountain Arsenal Denver, Colorado. Sample description, pipe measurement record, electric logs, Baroid mud LOG, and Baroid core analysis: Denver, Colo., Volume III. Final report, 185 p.

Final report on drilling of pressure injection disposal well Rocky Mountain Arsenal Denver, Colorado, contains a sample description, pipe measurement record, electric logs, baroid mud log, baroid core analysis.

844. Polumbus (E.A.) Jr. and Associates Inc., 1961, Drilling of pressure injection disposal well, Rocky Mountain Arsenal, Denver, Colorado. Chronological LOG daily engineering report: Denver, Colo., Volume II. Chronological LOG Daily Engineering Report. Final report, 221 p.

The study contains a daily chronological log of drilling of pressure injection disposal well, Rocky Mountain Arsenal, Denver, Colorado. Also included is a daily engineering report.

845. Polumbus (E.A.) Jr. and Associates Inc., 1961, Drilling of pressure injection disposal well, Rocky Mountain Arsenal, Denver, Colorado: Denver, Colo., Volume I. Final report, 217 p.

The Rocky Mountain Arsenal Pressure Injection Disposal Well was drilled for the United States Army Chemical Corps by the United States Army Corps of Engineers, Omaha District. The well was drilled to provide access to underground strata which could be used as waste disposal reservoirs. Drilling operations on the well, which is located on the Rocky Mountain Arsenal grounds, commenced on March 10, 1961. Loffland Brothers Company was contracted to drill the well. The well was drilled to a total depth of 12,045 feet terminating in crystalline rocks of pre-Cambrian Age. The drilling rig was released on September 28, 1961, and the construction phase of the drilling well operation was considered completed on November 30, 1961, when the well head equipment was installed and the well turned over to the Chemical Corps. This report covers the operation to this stage. In the design and drilling of the well and in the identification, evaluation, protection, and testing of potential injection reservoirs, broad adaptations of tools, techniques and practices developed in the oil industry were required.

846. Porter, K.R., and Hakanson, D.E., 1976, Toxicity of mine drainage to embryonic and larval boreal toads *(Bufoneidae) Bufo boreas*: Copeia, v. 1976, no. 2, p. 327-331.

Chemical analyses and bioassays of mine drainage were made to determine if it could be a factor accounting for the absence of amphibians from Clear Creek County, Colorado [USA]. The concentrations of H+, Fe, Cu and Zn in the drainage were all individually much greater than the tolerance levels of premetamorphic toads. The lethality of the drainage was of such a magnitude that it required diluting approximately 1000 times before larvae could survive in it. Boreal toad (*B. boreas*) larvae are more resistant to acidity than most fish but are very similar to other anuran larvae and salmonids in their sensitivity to Cu and Zn.

847. Porter, L.K., Viets, F.G., Jr., McCalla, T.M., Elliott, L.F., and Norstadt, F.A., 1975, Pollution abatement from cattle feedlots in northeastern Colorado and Nebraska: Fort Collins, Colo., Environmental Protection Agency and Agricultural Research Service, EPA/660/2-75-015, 135 p.

Climatic factors, feedlot runoff, and organic material in the runoff were evaluated in experimental and commercial feedlots. The effects of slope, stocking rates, terraces, basins, and holding ponds were evaluated to obtain the best controls for containing runoff. In eastern Nebraska, 70 cm annual precipitation produces 23 cm of runoff; whereas, in northeastern Colorado, 37 cm annual precipitation gives only 5.5 cm of runoff. Large applications of runoff liquid, up to 91 cm on grass-Ladino and 76 cm on corn, in Nebraska did not decrease yields; however, in northeastern Colorado, the concentrated high-salt runoff required dilution before direct application to crops. The organic manure-soil interface severely restricts the movement of water, nitrates, organic substances, and air into the soil beneath feedlots. The amounts of NO3-N in soil cores taken from Nebraska feedlots and croplands ranked as follows: Abandoned feedlots > feedlot cropland > upland feedlots > river valley feedlots > manure mounds > alfalfa > grassland. Feedlots contribute NH3, amines, carbonyl sulfide, H2S, and other unidentified substances to the atmosphere. Ammonia and amine can be scavenged from the air by green plants and water bodies. Anaerobic conditions in feedlots are conducive to the production of carbonyl sulfide, H2S, and amines. Management practices, such as good drainage, that enhance aeration will decrease the evolution of these compounds.

848. Priestaf, I., 1984, Outlook for artificial recharge: Ground Water Age, v. 19, no. 2, p. 21-33.

849. Propst, D. L., 1982, Warmwater fishes of the Platte River Basin, Colorado; Distribution, ecology, and community dynamics: Fort Collins, Colo., Colorado State University, Ph.D. dissertation, 301 p.

850. Propst, D.L., and Carlson, C.A., 1986, The distribution and status of warmwater fishes in the Platte River drainage, Colorado: Southwest Nat., v. 31, no. 2, p. 149-167.

851. Propst, D.L., and Carlson, C.A., 1989, Life history notes and distribution of the Johnny darter *Etheostoma nigrum (Percidae)* in Colorado, USA: Southwest Nat., v. 34, no. 2, p. 250-259.

The johnny darter, *Etheostoma nigrum* (Rafinesque), reaches the western limits of its native range in the Platte River drainage of northeastern Colorado. In the South Platte River basin, it historically occurred throughout foothill stream reaches, but anthropogenic modifications have reduced its range in many streams and eliminated it from some. The Johnny darter remains common in the North Platte River basin. The species was most frequently found in shallow, slow-velocity water over a cobble-sand substrate. Chironomidae larvae were its most important food item throughout the year. Spawning peaked in July to early August. Development was rapid in the first year of life, and most growth was attained by the end of the second summer. In Colorado, few Johnny darters survived past age III. Greatest adult mortality appeared to be among age-II fish after spawning. Most life history traits we studied are similar to those reported for the Johnny darter in the central portion of its range. The difference in time of spawning among studies was probably due to the slower spring-warming of water in Colorado.

852. Propst, N.B., 1989, The South Platte trail: the story of Colorado's forgotten people: Boulder, Co., Pruett.

853. Psaris, P.J., and Hendricks, D.W., 1982, Fecal coliform densities in a western watershed: Water, Air, and Soil Pollution, v. 17, no. 3, p. 253-262.

This paper describes the areal distribution of fecal coliform densities within the stream system of the South Platte River basin in Colorado. Low densities, e.g., 0 to 99 fecal coliforms per 100 ml, were found in mountain streams, while higher densities, e.g., 10,000 to 100,000 and above were found in plains streams. About 49% of the plains stations and 3% of the mountain stations were not in compliance with the Colorado secondary contact recreation standard of 2000 fecal coliforms per 100 ml. The higher fecal coliform densities were associated with discharges from wastewater treatment plants. This is significant from a public health standpoint since the tainted waters are spread throughout the South Platte basin to irrigated lands via streams, canals, and reservoirs. Because of current federal and State policy encouraging land treatment and reuse, such practice should be reviewed with respect to compliance with proposed fecal coliform standards, and whether such standards should be adopted.

854. Public Health Service [Colo.?], 1965, Ground-water pollution in the South Platte Valley between Denver and Brighton, Colo.: Denver, Colo., Div. of Water Supply and Pollution Control, PR-4, 53 p.

855. Public Health Service [Colo.?], 1965, Municipal waste report Metropolitan Denver area South Platte River Basin. Appendix B: Denver, Colo., South Platte River Basin Project, PR-3, 122 p.

The appendix contains individual reports for all municipal sewage treatment plants investigated in conjunction with the Municipal Waste Study in the Denver Metropolitan area of the South Platte River Basin in 1964. Each plant report consists of a discussion, evaluation and flow diagram of treatment facilities. A record of sampling data and a bar graph of plant performance is included for those plants at which project sampling studies were conducted.

856. Public Health Service [U.S.?], 1963, Proceedings of the conference in the matter of pollution of the South Platte River basin, Denver, Colo., October 29, 1963: v. PHS-PUB-235;PHS-WPS-39, Washington, D.C., 81 p.

The report is a compilation of statements presented by attendees of a conference relative to water pollution sources in the South Platte River Basin in Colorado.

857. Public Health Service [Colo.?], 1965, Program review. South Platte River Basin Project (Enforcement): Denver, Colo., Div. of Water Supply and Pollution Control, 127 p.

The study represents a reply to a request for certain information to be presented at an annual program review of the South Platte River Basin project on April 6, 1965. It contains information relative to budget, personnel, and administrative and operational procedures encountered or likely to be encountered during project life.

858. Public Health Service [Colo.?], Region VIII, [n.d.], A regional reconnaissance of the South Platte River Basin. Volume I: Denver, Colo., 180 p.

The South Platte River Basin was selected as a region for a case study in application of the regional reconnaissance method since it illustrates many of the questions facing the practitioner in understanding such a study. This report first outlines population trends, then describes the environment in which those people live. This is essentially an inventory of resources available for use by the inhabitants of the area and the circumstances that condition their use. An economic activities inventory follows, which is an analysis of employment and production trends. In the final section on income, a measurement is ventured of how the people of this region have prospered relative to people in other regions.

859. Public Health Service [Colo.?], Region VIII, [n.d.], Regional reconnaissance of the South Platte River Basin. Volume II: Denver, Colo.

This report outlines population trends and describes the environment in which people live. This is essentially an inventory of resources available for use by the inhabitants of the area and the circumstances that condition their use. An economic activities inventory follows, which is an analysis of employment and production trends. In the final section on income, a measurement is ventured of how the people of this region have prospered relative to people in other regions. The volume II provides statistics and tabular data on production trends by industry, including agriculture, mining, manufacturing, trade, and services.

860. Public Health Service [U.S.?], 1953, A report of water pollution in the South Platte River basin. A cooperative State-federal report on water pollution: Kansas City, Mo., Missouri Drainage Basin Office in cooperation with Colorado Dept. of Public Health, Nebraska Dept. of Public Health and the Wyoming Dept. of Public Health, PHS-PUB-235; PHS-WPS-39, 60 p.

This report is produced under the cosponsorship of the Colorado Department of Public Health, the Nebraska Department of Health, and the Wyoming Department of Public Health, and the U. S. Public Health Service. It is based on data gathered and reported in the South Platte River Basin Water Pollution Investigation Report of 1950 and subsequent information. The report also presents information concerning use of

water resources, pollution entering water resources and resulting damages, benefits which may result from pollution prevention and abatement, pollution prevention measures in effect and those needed. Data and knowledge now available are sufficient to permit the immediate solution of most of the pollution problems within the South Platte River Basin without awaiting the results of additional surveys and studies. A sincere effort has been made to present a fair picture of the water pollution problems in the South Platte River Basin and to present reasonable conclusions and recommendations.

861. Public Health Service [Colo.?], Region VIII, 1965, Significant vector problems in the South Platte River Basin: Denver, Colo., PR-2, 36 p.

Significant vector populations of mosquitoes, rats, and flies exist in the basin and constitute a serious public health hazard. These vectors, especially mosquitoes and rats, are directly associated with the organic pollution present in the waters of the Basin. This pollution is instrumental in creating and supporting the present high population levels of disease- carrying vectors, particularly in the Denver Metropolitan area. Future vector population levels will remain high as long as significant quantities of organic pollutants are discharged to the waters of the basin. Reduction or elimination of present vector populations will best be accomplished through the abatement or elimination of the gross organic pollution now being discharged to receiving waters throughout the basin.

862. Public Health Service [U.S.?] and Missouri Drainage Basin Office, Kansas City, Mo., 1950, South Platte River basin water pollution investigation. Exhibits and appendices. Water pollution series: Cincinnati, Ohio, 193 p.

These exhibits and appendices to the main report include: stream designations; stream pollution survey of the portions of the South Platte River and Cherry Creek which lie within the City and County of Denver; sample reports on typical wastes investigations; State water pollution control legislation; beet sugar wastes investigations; bacteriological study of irrigated fruits and vegetables; project effects on low-flow conditions in the South Platte River Basin.

863. Public Health Service [U.S.?], [n.d.], Summary report on quality of interstate waters, South Platte River (Colorado - Nebraska): Washington, D.C., 18 p.

Water-quality data are reported for the stream stretch of the South Platte River from Sterling, Colorado, to North Platte, Nebraska. Tabular data are provided on: sources of pollution, stream flow, interference with water uses, adequacy of treatment measures, action of official agencies, Public Health Service grants for abating pollution, and waste treatment facilities, nature of delays in abating pollution, and time schedule for proposed remedial action. A brief bibliography is included, and water quality objectives and statutory powers are appended.

864. Public Health Service [U.S.?], 1963, Water pollution surveillance system. Volume 7. Missouri River Basin Annual compilation of data 1 Oct 62-30 Sep 63: Washington, D.C., Div. of Water Supply and Pollution Control, PHS-PUB-663-ED-1963-VOL-7, 166 p.

The report presents water quality data for major river basins in the Missouri River Basin. The data was compiled from October 1, 1962 through September 30, 1963, and covers radioactivity, plankton, organic chemicals, ammonia, chlorine demand, color, oxygen demand, temperature, minerals, turbidity, trace elements, coliform bacteria, and stream flow.

865. Public Health Service [Colo.?], Region VIII, [n.d.], Water-quality control study and public health aspects of the Cache La Poudre Project, Colorado: Denver, Colo.

866. Pye, V.I., and Kelley, J., 1984, The extent of groundwater contamination in the United States, in Bredehoeft, J.D., chairman, Groundwater contamination studies in geophysics: Washington, D.C., Natl. Acad. Press, p. 23-33.

867. Quam, L. O., 1938, The morphology of landscape of the Estes Park area, Colorado: Worcester, Mass., Clark University, Ph.D. dissertation, 165 p.

868. Rader, R.B., and Ward, J.V., 1987, Mayfly production in a Colorado mountain stream: an assessment of methods for synchronous and non-synchronous species: Hydrobiologia, v. 148, p. 145-150.

869. Rader, R.B., and Ward, J.V., 1987, Resource utilization, overlap and temporal dynamics in guild of mountain stream insects: Freshwater Biol., v. 18, no. 3, p. 521-528.

870. Ragsdale, J.O., 1982, Ground-water levels in Wyoming, 1971 through part of 1980: U.S. Geological Survey Open-File Report 82-859, 200 p.

Ground-water levels are measured periodically in a network of about 280 observation wells in Wyoming, mostly in areas where ground water is used in large quantities for irrigation or municipal purposes. The program is conducted by the U.S. Geological Survey in cooperation with the Wyoming State Engineer and the city of Cheyenne. This report contains maps showing the locations of selected wells, tables listing well histories and highest and lowest water levels for the period of record, and hydrographs for most of the wells.

871. Rainey, E.M., 1987, Sedimentary record of Pinedale ice recession in Horseshoe Park, Rocky Mountain National Park, Colo.: Greeley, Colo., University of Northern Colorado, MA thesis.

872. Ramirez-Rojas, A.J., 1976, Geochemistry of mine effluents in the Front Range mineral belt of Colorado: Golden, Colo., Colorado School of Mines.

873. Rapp, J.R., Warner, D.A., and Morgan, A.M., 1953, Geology and ground water resources of the Egbert-Pine Bluffs-Carpenter area, Laramie County, Wyoming: U.S. Geological Survey Water-Supply Paper 1140, 67 p.

874. Rauzi, F., 1978, High rates of nitrogen change composition of shortgrass rangeland in southeastern Wyoming: Journal of Range Management, v. 31, no. 5 (September).

875. Rauzi, F., 1975, Seasonal yield and chemical composition of crested wheatgrass in southeastern Wyoming: Journal of Range Management, v. 28, no. 3 (May).

876. Reagents of the University of Colorado, 1992, Effects of climate change in the Colorado Alpine. Ecosystem response to altered snowpack and rainfall regimes--A proposal to the National Science Foundation: Boulder, Colo., University of Colorado, 94 p.

877. Reddy, M.M., Liebermann, T.D., Jelinski, J.C., and Caine, N., 1985, Variation in pH during summer storms near the Continental Divide in central Colorado, U.S.A: Arctic and Alpine Research, v. 17, no. 1, p. 79-88.

Precipitation acidity was monitored continuously from July to September 1983 at a well-instrumented research site located near the Continental Divide in central Colorado. Rainfall amount, temperature, pH, and specific conductance were determined using a prototype device consisting of a modified wet-only precipitation collector with appropriate sensors. Data were recorded automatically with microprocessor control by preset time intervals. Weekly wet-only composite precipitation samples were also collected. Precipitation totaled 190 mm during the period, all as rain. Sixty-five percent of the continuous pH measurements were between 3.40 and 4.10, with an average of pH 3.80. Values of pH greater than 5.00 were rare. Composite samples were significantly less acidic, and averaged pH 4.36. Precipitation pH typically decreased rapidly as a storm began, was lowest near or slightly after the time of maximum rainfall intensity, then increased slightly. Paradoxical low pH and low specific conductance were recorded, and it is possible that some initial continuous pH measurements were too low. Acid loading varied widely among storms, and may have resulted largely from short bursts of high-intensity, low-pH rainfall.

879. Reed, P.B., 1988, Wetlands plants in Colorado: U.S. Fish and Wildlife Service.

880. Reid, W.H., 1978, A vegetative gradient along South Platte River, *in* Southwestern and Rocky Mountain Division of the American Association for the Advancement of Science 54th Annual/ Spring Meeting of the New Mexico Academy of Science, Albuquerque, N. Mex., April 26-29, 1978: Univ. of Texas, El Paso, American Association for the Advancement of Science.

881. Reid, W.H., and Bock, J.H., 1978, A vegetative gradient along the South Platte River, USA: N. Mex. Acad. Sci. Bull., v. 18, no. 1.

882. Reitano, B., and Hendricks, D.W., 1978, Input-output modelling of the Cache La Poudre system: Fort Collins, Colo., Environmental Engineering Program, Dept. of Civil Engineering, Colorado State University, Technical Report 78-168301.

883. Rettke, R.C., 1976, Clay mineralogy and clay mineral distribution patterns in Dakota Group sediments, northern Denver Basin, eastern Colorado and western Nebraska: Cleveland, Ohio, Case Western Reserve Univ., 147 p.

884. Rice, J.A., and MacCarthy, P., 1991, Composition of humin in stream sediment and peat, *in* Baker, R.A., ed., Organic substances and sediments in water; Volume 1, Humics and soils. American Chemical Society meeting: Chelsea, Mich., Lewis Publ., p. 35-46.

885. Richards, D.L., and Michalski, T.C., 1987, Catalog of thin sections available at the USGS Core Research Center, Denver, Colorado: U.S. Geological Survey Open-File Report 87-659, 220 p.

886. Richmond, G., 1960, Glaciation of the east slope of Rocky Mountain National Park, Colo.: Geol. Soc. Amer. Bull., v. 71, p. 1.

887. Richmond, G.M., 1972, Glaciation of the Rocky Mountains, *in* Wright and others, The Quaternary of U.S.: Princeton University Press, p. 217-230.

888. Richmond, G.M., 1974, Raising the roof of the Rockies: Rocky Mountain Nature Association, 81 p.

889. Richter, J.L., 1991, Incremental assessment of the benthic macroinvertebrate community as it is impacted by sewage effluent in Segment 15 of the South Platte River (abstract only), *in* Woodring, R.C., ed., South Platte resource management: Finding a balance: Fort Collins, Colo., Colorado Water Resources Research Center, p. 25.

890. Riedel, J.T., Schwarz, F.K., and Weaver, R.L., 1969, Probable maximum precipitation over South Platte River, Colorado, and Minnesota River, Minnesota: U.S. Weather Bureau, Hydrometeorological Report 44, 114 p.

The great rain and snowmelt floods on the upper Mississippi and its tributaries in April were among the most disastrous ever experienced in these areas. For example, at Carver on the Minnesota River, the previous high stage of 1952 was exceeded by 6 feet. Another flood resulted in great damage along the South Platte River in and near Denver from extremely heavy thunderstorm-type rainfall of about 6 hours duration centered on upstream tributaries to the south of Denver. Both floods were occasioned by intense examples of common meteorological processes in the respective regions and seasons--snowmelt over a broad area in spring over the upper Mississippi and intense short-duration storms to the immediate east of the Rockies during the May-June maximum storm period of that area. The hydrometeorological branch of the Weather Bureau prepared probable maximum precipitation estimates for these basins above prospective dam sites in order to revise and update spillway design floods. The basic method for estimating pmp is the transposition and moisture maximization of storms. The two reports to the Corps of Engineers have been incorporated into one volume in order to illustrate a variety of methods of estimating probable maximum precipitation.

891. Riedel, J.T., Wang, B.H. and Diebel, J.L., 1983, Site specific probable maximum precipitation estimates, Upper South Platte River basin, Colorado, *in* International Symposium on Hydrometeorology, Denver, Colo., June 13-17, 1982: American Water Resources Association, p. 517-522.

Probable maximum floods (PMF) at Antero, Eleven-mile and Cheesman Dams on the headwaters of the South Platte River in Colorado were estimated through a site specific hydrometeorological and hydrologic study. This study included estimation of probable maximum precipitation (PMP) by storm transposition and maximization and a determination of the rainfall-runoff relationship by the dimensionless graph-lag curve method. Drainage sites of interest are between approximately 200 and 2000 mi. Major rainfalls in the South Platte River basin and vicinity show patterns that are

closely associated with the terrain features. The storm rainfall history in the region is one of modest rainfall in the mountainous areas and very severe rainfalls in the areas where the plains meet the foothills. Due to the great difference in climate within a short distance, major efforts were needed to determine which storms should be transposed and how these storms should be adjusted in estimating PMP. The procedure and results of PMP analysis are presented.

892. Riley, G.T., Landin, M.G., and Bosart, L.F., 1987, Diurnal variability of precipitation across the central Rockies and adjacent Great Plains: Monthly Weather Review, v. 115, no. 6, p. 1161-1172.

The diurnal variation of precipitation across Wyoming, Colorado, South Dakota, Nebraska, and Kansas were studied using of a harmonic analysis of 35 yr of hourly precipitation data for 334 stations, and a regional probability of precipitation analysis for grouped stations. New findings include: (1) a pervasive 0300 LST maximum for the precipitation category > 0.25 mm that is most prominent during the cooler half of the year and partially masked in summer, (2) the transition from winter to spring is accompanied by an increase in measurable precipitation frequency but a decrease in precipitation frequency for rainfall amounts > 2.5 mm, and (3) the summer rainfall regime is made up of distinct local and mountain-generated signals. The summer heavier precipitation events tend to occur 1-4 hours earlier than all measurable rainfall events, particularly on the plains east of 101 degrees W. The implication of these results is that: (1) the winter regime is affected by large-scale circulation features as the 0300 LST maximum is found elsewhere, e.g., the northeastern U.S., (2) dynamically significant precipitation systems, although infrequent, do affect the five-state region in winter, and (3) heavy summer nocturnal precipitation systems over the eastern plains cannot be explained solely by the eastward propagation of mountain-generated systems from the previous afternoon.

893. Ringelmann, J.K., and Szymczak, M.R., 1991, Winter habitat use by mallards in the South Platte River Basin, *in* Woodring, R.C., ed., South Platte resource management--Finding a balance: Fort Collins, Colo., Colorado Water Resources Research Center.

894. Ringen, B.H., 1973, Summary of water-level and pumpage data in the Cheyenne and Federal Municipal well fields, April 1, 1972 to April 2, 1973, Cheyenne, Wyoming: U.S. Geological Survey, Basic-Data Report, 27 p.

Water-level data were collected April 1, 1972 to April 2, 1973, for the Cheyenne and Federal municipal well fields by the U.S. Geological Survey, in cooperation with the City of Cheyenne. Pumpage data for these well fields, April 1, 1972, through March 31, 1973, were provided by the City of Cheyenne. Water levels were measured monthly in selected wells in the Cheyenne and federal municipal well fields. In addition, graphic water-stage recorders were operated on three observation wells in the Cheyenne municipal well field.

895. Rink, L.P., Windell, J.T., and Rudkin, C., 1991, The Boulder Creek watershed non-point source pollution control and water-quality monitoring programs (abstract only), *in* Woodring, R.C., ed., South Platte resource management: Finding a balance: Fort Collins, Colo., Colorado Water Resources Research Center, p. 28.

896. Riter, J.R., 1959, Necessary elements in developing a water plan for the South Platte River Basin., *in* Western Resources Conference, University of Colorado at Boulder, 1959.

897. Robert A. Taft Sanitary Engineering Center, 1959, Public health aspects of the contamination of ground water in South Platte River basin in vicinity of Henderson, Colorado, August 1959: Cincinnati, Ohio, Engineering Section, 30 p.

The health hazard resulting from present or future use of contaminated ground water for drinking and culinary purposes is examined in this study. It includes a limited survey of private domestic wells in the area and considers the possible contamination of wells supplying the city of Brighton. It is concluded that a portion of the shallow ground water aquifer in the area between Derby and Henderson is contaminated, and that wastes discharged from the Rocky Mountain Arsenal from 1943-1955 are the principal source of such contamination. Sludge may also be a source of continuing contamination.

898. Robinson, C.S., Gallant, W.A., and Cochran, D.M., 1976, Land use and engineering geology of the Front Range, Colorado. Studies in Colorado field geology, *in* Epis, R.C., and Weimer, R.J., eds., Geological Society of America and associated societies, annual meeting. Colo. Sch. Mines, Prof. Contrib: p. 486-504.

899. Robinson, J. R., 1956, The ground water resources of the Laramie area, Albany County, Wyoming: Laramie, Wyo., Univ. of Wyoming.

900. Robson, S.G., 1989, Alluvial and bedrock aquifers of the Denver basin: eastern Colorado's dual ground-water resource: U.S. Geological Survey Water Supply Paper 2302, 40 p.

Federal government report in the semiarid Denver basin of eastern Colorado, large volumes of groundwater are found in alluvial and bedrock aquifers. The alluvial aquifer is recharged easily from flash floods and snowmelt runoff and readily stores and transmits the water because it consists of relatively thin deposits of gravel, sand, and clay located in the valleys of principal streams. The bedrock aquifer is recharged less easily because of its greater thickness and prevalent layers of shale which retard the downward movement of water. Although the bedrock system contains more than 50 times as much water in storage as the alluvial aquifer, it does not store and transmit water as readily as the latter. Because of these and other factors, the alluvial aquifer is used primarily as a source of irrigation supply, which is the largest water use in the area.

901. Robson, S.G., 1987, Bedrock aquifers in the Denver basin, Colorado--a quantitative water-resources appraisal: U.S. Geological Survey Professional Paper 1257, 73 p.

902. Robson, S.G., 1981, Computer simulation of movement of DIMP- contaminated groundwater near the Rocky Mountain Arsenal, Colorado, *in* Zimmie, T.F., and Riggs, C.O., eds., Symposium on permeability and groundwater contaminant transport. ASTM Special Technical Publication: Philadelphia, Pa., American Society for Testing and Materials, p. 209-220.

903. Robson, S.G., 1977, Ground-water quality near a sewage-sludge recycling site and a landfill near Denver, Colorado. Final report: U.S. Geological Survey Water-Resources Investigations 76-132, 152p.

The Metropolitan Denver Sewage Disposal District and the City and County of Denver operate a sewage-sludge recycling site and a landfill in an area about 15 miles (24 kilometers) east of Denver. The assessment of the effects of these facilities on the ground-water system indicated that five wells perforated in alluvium were found to have markedly degraded water quality. One well was located in the landfill and water that was analyzed was obtained from near the base of the buried refuse, two others were located downgradient and near sewage-sludge burial areas, and the remaining two are located near stagnant surface ponds. Concentrations of nitrate in wells downgradient from fields where sludge is plowed into the soil were higher than background concentrations due to the effects of the sludge disposal. No evidence of water-quality degradation was detected in deeper wells perforated in the bedrock formations.

904. Robson, S.G., 1983, Hydraulic characteristics of the principal bedrock aquifers in the Denver basin, Colorado: U.S. Geological Survey Hydrologic Investigation Atlas HA-659, 3 sheets, scale 1:500,000.

905. Robson, S.G., Wacinski, A., Zawistowski, S., and Romero, J.C., 1981, Geologic structure, hydrology, and water quality of the Laramie-Fox Hills aquifer in the Denver basin, Colorado: U.S. Geological Survey, Hydrologic Investigations Atlas HA-650, 3 sheets, scale 1:500, 000.

The Laramie-Fox Hills aquifer underlies an area of about 6,700 square miles in east-central Colorado and is an important water supply for many residents in the area. Population increases have produced increasing demands for ground water and have led to significant water-level declines in parts of the aquifer. Results of this study, which was undertaken to better define the water-supply potential of the aquifer, indicate that the aquifer consists of interbedded sandstone, siltstone and shale at depths of as much as 3,200 feet. The water-yielding sandstone and siltstone beds have a total thickness of more than 200 feet in some areas. The 1978 potentiometric-surface map indicates that ground water moves from the south-central part of the aquifer toward the margins of the aquifer where most of the water discharges to streams and alluvial aquifers. Some groundwater recharge occurs as downward movement of water from the overlying Arapahoe aquifer. Water-level declines between 1958 and 1978 exceeded 200 feet in an 80-square-mile area near Brighton, while in other parts of the aquifer only moderate changes have occurred. Water in the aquifer is generally of a sodium bicarbonate type with dissolved-solids concentrations commonly ranging from 400 to 1,200 milligrams per liter.

906. Rochette, E.A., Drever, J.I., and Sanders, F.S., 1988, Chemical weathering in the West Glacier Lake drainage basin, Snowy Range, Wyoming; implications for future acid deposition: Contributions to Geology, v. 26, no. 1, p. 29-44.

907. Rocky Mountain Forest and Range Experiment Station, 1981, Final environmental impact statement: Cheyenne stage II water diversion, Medicine Bow National Forest: Laramie, Wyo., Forest Range and Watershed Lab., 396 p.

Because of expanding energy development in Wyoming, the capital city of Cheyenne has foreseen a considerable increase in population, which would put demands on the municipal water system in excess of present supply. The Cheyenne Board of Public Utilities proposes to expand the water collection area in the Sierra Madre Mountains; increase the capacity of Hog Park and Rob Roy Reservoirs; collect water out of Douglas Creek and Lake Creek drainages; and install pipe for collection and transmission of water. Alternatives evaluated include: Alternative A (no action), Alternative B (Cheyenne Board of Public Utility proposed facilities with modification), Alternative C which is the preferred alternative (modify Stage I collection system to increase capacity), Alternative D (construct a lower reservoir in the North Fork of the Little Snake River and pump water into the existing system) and Alternative E (combine water conservation, agriculture water-right purchase and groundwater development.) The following public issues were identified: alternative water sources; stream flows; reservoir fluctuations; Colorado River salinity; new access into unroaded areas; fish habitat; downstream water users; threatened or endangered species; terrestrial wildlife impacts; water supplies to other communities; reservoir safety; allocated water; and water conservation.

908. Rogers, J.P., and Longman, M.W., 1988, Pennsylvanian carbonate facies and porosity types in Bird and Amazon fields, Cheyenne County, Nebraska, *in* Goolsby, S.M., and Longman, M.W., eds., Occurrence and petrophysical properties of carbonate reservoirs in the Rocky Mountain region: Denver, Colo., Rocky Mt. Assoc. Geol., p. 47-62.

909. Romero, J. C., 1965, Geologic control of ground water in the Kiowa-Wolf-Comanche Creek area in central Adams County, Colorado: Fort Collins, Colo., Colorado State University.

910. Romero, J.C., 1976, Ground water resources of the bedrock aquifers of the Denver basin Colorado: Denver, Colo., Colorado Dept. of Natural Resources, Div. of Water Resources, Planning and Investigations, 109 p.

The bedrock aquifers of the Denver Basin contain vast quantities of groundwater suitable, in most localities, for all beneficial purposes. The major problems which will confront both administrators and users of this groundwater include those associated with declining water levels and deterioration of water quality. Areas in which current water-level declines are rapid enough to cause concern are the South Platte River corridor, the Strasburg-Byers-Deer Trail area, and parts of metropolitan Denver. Water-quality problems of the Denver Basin's bedrock aquifers are confined predominantly to the Laramie Formation and Laramie-Fox Hill aquifer. Water from these units is locally known to contain troublesome amounts of hydrogen sulfide, methane, iron, fluoride and sodium. Many of these problems can probably be eliminated by avoiding multi-aquifer completions, particularly in the case of mixing Laramie-Fox Hill aquifer water with Dawson Group water. Successful management of the Denver Basin bedrock aquifers will require the collection and utilization of additional data. The importance of additional electric logs, geologic sample logs and aquifer test data cannot be over-emphasized. Also of major importance are water-quality testing, an observation well network and accurate measurements of water withdrawn from the aquifer. If managed with caution, the basin can supply the water needs of several generations. (Heiss-NWWA)

911. Romero, J.C., and Bainbridge, H.C., 1988, Water levels in the bedrock aquifers of the Denver basin, Colorado, 1988: Denver, Colo., Office of the State Engineer, Division of Water Resources, 24 p.

912. Romero, J.C., and Hampton, E.R., 1972, Maps showing the approximate configuration and depth to the top of the Laramie- Fox Hills aquifer, Denver basin, Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I-791, scale 1: 500,000.

913. Rosenlund, B.D., and Stevens, D.R., 1988, Fisheries and aquatic management, Rocky Mountain National Park, 1987: Golden, Colo., U.S. Fish and Wildlife Service and National Park Service, NPS Annual Report, 121 p.

914. Rosenlund, B.D., and Stevens, D.R., 1990, Fisheries and aquatic management, Rocky Mountain National Park, 1989-1990: Golden, Colo., U.S. Fish and Wildlife Service and National Park Service, NPS Annual Report, 188 p.

915. Roumph, B., 1982, Proposed Missouri River diversion to the High Plains-Ogallala Aquifer from Fort Randall Dam, *in* Current water issues in Nebraska; 1982 Water Resources Seminar: Lincoln, Nebr., Nebr. Water Resources Center, p. 83-94.

916. Rovey, E.W., and Woolhiser, D.A., 1977, Urban storm runoff model: Proc. Am. Soc. Civ. Eng. J. Hydraul. Div, v. 103, no. HY11, p. 1339-1351.

A surface-flow routing model based upon a kinematic cascade of planes and channels is combined with a parametric infiltration model to constitute a watershed model. The kinematic approximation is used to route flows through storm drains of trapezoidal or circular cross section. Model parameters are estimated from the hydraulic characteristics of the surface and soils. A Chezy friction relationship is used to model surface-flow resistance. The predictive ability of the watershed model is tested by simulating runoff hydrographs from a 67-ha urban watershed near Denver, Colorado.

917. Rubey, W.W., 1967, Introduction chemical composition of sedimentary rocks in Colorado, Kansas, Montana, Nebraska, North Dakota, South Dakota, and Wyoming: U.S. Geological Survey Professional Paper 561, 1-7 p.

918. Ruby, N.K., Sagmeister, R.J., Green, S.L., and Walgren, J.D., 1991, Index of surface-water discharge, water-quality, sediment, and biological records through September 30, 1990, for Wyoming: U.S. Geological Survey Open-File Report 91-497, 46 p.

919. Ruddy, B.C., 1986, Estimating sediment discharge in canals in Colorado, in Proceedings of the Fourth Federal Interagency Sedimentation Conference, Las Vegas, Nev., March 24-27, 1986: v. Volume II, p. 6.19-6.24.

Suspended-sediment concentrations were measured at the South Platte River and at four sites on each of three nearby irrigation canals of the South Platte River in northeastern Colorado during 1982-83. Suspended-sediment discharge was calculated and log linear-regression equations were developed at each site to estimate

suspended-sediment discharge when only water discharge is available. Analysis showed that the best estimate of suspended-sediment discharge in the canals was made using the water discharge at each canal site and the water discharge in the South Platte River. Measured suspended-sediment concentrations of the South Platte River were compared to measured suspended sediment concentrations at the upstream measurement site of each canal. The correlation coefficients indicated that suspended-sediment concentrations in the South Platte River are highly related to the suspended-sediment concentrations in the three canals and affect the suspended-sediment inflow to the canals.

920. Ruddy, B.C., 1984, Streamflow gain-and-loss and suspended- sediment characteristics of the South Platte River and three irrigation canals near Fort Morgan, Colorado: U.S. Geological Survey Water-Resources Investigations Report 84-4220, 82 p.

A 2-year study during 1982-83 was made to document the streamflow gain-and-loss and suspended-sediment characteristics of the South Platte River, Fort Morgan Canal, Upper Platte and Beaver Canal, and the Lower Platte and Beaver Canal near Fort Morgan, Colorado, prior to possible construction of the proposed Narrows Reservoir. Six streamflow gain-and-loss investigations, conducted in 1982 along a 25.8-mi. reach of the South Platte River, indicate an average downstream gain in discharge of 150 cu ft/sec during the irrigation season. The Fort Morgan Canal and the Lower Platte and Beaver Canal had decreasing discharges in the downstream direction. The Upper Platte and Beaver Canal had a slight increase in discharge at the second measurement site and decreases in the third and fourth measurement sites. Irrigation practices and some loss to the groundwater system account for the general decrease in discharge. Suspended-sediment data were collected at the streamflow-gaging station 06758500 South Platte River near Weldona and on the three irrigation canals: Fort Morgan Canal, Upper Platte and Beaver Canal, and Lower Platte and Beaver Canal. The data indicate that relations exist between the suspended-sediment concentrations at the South Platte River station and the suspended-sediment concentrations at the most upstream measurement site on each canal. Relations between suspended-sediment discharge and water discharge were developed at all canal measurement sites. For all the canals, suspended-sediment discharge decreased in a downstream direction. Slight increases in suspended-sediment occurred at the second measurement site on the Upper Platte and Beaver Canal and at the third measurement site on the Lower Platte and Beaver Canal. Laboratory analyses indicate that 75% of the suspended-sediment is silt and clay size (particles finer than 0.062 mm).

921. Runas, C.E., Martin, M., McDonough, D., and Parrish, L., 1984, Toxic hot spot study, South Platte River along the Front Range, August and October, 1982: Denver, Colo., Environmental Protection Agency, EPA/908/2-84/001, 70 p.

To implement a Consent Decree between the EPA and the National Resources Defense Council requiring that EPA identify waters which may have toxic pollution problems, a two-phase study was designed to determine if any toxic hot spots exist in selected reaches of the South Platte River and selected tributary and non-tributary streams along the Front Range. Phase I was designed to determine if such 'toxic hot spots' exist and Phase II would focus on those areas defined in Phase I as 'toxic hot spots' and would include additional sampling locations. Samples of water, sediment and aquatic invertebrates were obtained for chemical and biological examination.

922. Runnells, D.D., Brown, D. and Lindberg, R., 1974, Investigation of enrichment of molybdenum in the environment through comparative study of stream drainages, central Colorado, *in* Proceedings of the 1rst annual NSF trace contaminants conference, August 8-10, 1973: Oak Ridge, Tenn., U.S. Atomic Energy Commission, Office of Information Services, Technical Information Center, p. 599-614.

To define the natural background levels of molybdenum, Colorado areas which are geographically and environmentally similar to those which are experiencing man's influence, but which themselves have not been greatly disturbed, were chosen for investigation. Stream sediments and soils in the vicinity of streams were sampled in four sites: (1) the stream draining the area of the world's largest molybdenum mine, (2) a nearby river draining a non-mineralized and undisturbed area, (3) the river below the juncture of these two streams and (4) streams draining a highly mineralized but undisturbed area. Sediments of the non-mineralized stream ranged from 2 to 6 ppm while those of the mineralized, undisturbed area ranged from 8 to 30 ppm. Soils from a mineralized undisturbed area can be an order of magnitude greater than those of a non-mineralized area. Glaciation may tend to blur these distinctions. The mixing of the highly mineralized, disturbed materials with the stream from the non-mineralized area gave intermediate values. Plant materials offer less well defined differences in the content of molybdenum from area to area. Conifer do not seem to reflect all the abundance of molybdenum in alpine environments. Stream sediments are the best indicator of molybdenum mineralization.

923. Runnells, D.D., Lindberg, R., Lueck, S.L., and Markos, G., 1980, Applications of computer modeling to the genesis, exploration, and in-situ mining of uranium and vanadium deposits, *in* Rautman, C.A., comp., Geology and mineral technology of the Grants uranium region 1979. Memoir: N. Mex., Bureau of Mines and Mineral Resources, p. 355-367.

924. Ryding, J., 1985, Characterization of a static trapping technique for the analysis of soil and groundwater contamination: Golden, Colo., Colorado School of Mines, 84 p.

925. Saint-Fort, R., Schepers, J.S., and Spalding, R.F., 1991, Potentially mineralizable nitrogen and nitrate leaching under different land-use conditions in western Nebraska: Journal of Environmental Science and Health (Part A), v. A26, no. 3.

926. Sale, T., Stieb, D., Piontec, K., and Kuhn, B., 1988, Recovery of wood-treating oil from an alluvial aquifer using dual drainlines, *in* Proceedings on the Conference on Petroleum hydrocarbons and organic chemicals in ground water; prevention, detection and restoration: Dublin, Ohio, Natl. Water Well Assoc., p. 419-442.

927. Samuel, M.J., and Hart, R.H., 1985, Precipitation, soils and herbage production on southeast Wyoming range sites: Journal of Range Management, v. 38, no. 6(November).

928. Sayre, W.W., and Kennedy, J.F., 1978, Degradation and aggradation of the Missouri River. Workshop held in Omaha, Nebr., Jan. 23- 25, 1978: IIHR Report 215, 67 p.

929. Schmidt, P.W., and Pierce, K.L., 1976, Mapping of mountain soils west of Denver, Colorado for landuse planning, *in* Coates, D.R., ed., Geomorphology and engineering: Stroudsburg, Pa., Dowden, Hutchinson & Ross, Inc., p. 43-54.

930. Schmidt, R.A., 1983, Management of cottonwood-willow riparian associations in Colorado: [Denver, Colo.?], Colorado Chapter of the Wildlife Society.

931. Schmitt, C.J., Zajicek, J.L., and Peterman, P.H., 1990, National contaminant biomonitoring program: Residues of organochlorine chemicals in U.S. freshwater fish, 1976-1984: Arch. Environ. Contam. Toxicol., v. 19, p. 748-781.

932. Schneider, P.A., Jr., 1972, Hydrogeologic characteristics of the valley fill aquifer in the Brighton Reach of the South Platte River valley, Colorado: U.S. Geological Survey Open-File Report 72-332, 2 p.

933. Schneider, P.A., Jr., 1962, Records and logs of selected wells and test holes, and chemical analyses of ground water in the South Platte River basin in western Adams and southwestern Weld Counties, Colo.: Colorado Water Conservation Board Basic-Data Rept. 9, 84 p.

934. Schneider, P.A., Jr., 1983, Shallow ground water in the Boulder- Fort Collins-Greeley Area, Front Range Urban Corridor, Colorado, 1975-1977: U.S. Geological Survey Water-Resources Investigations Report 83-4058.

Shallow ground water may limit the location of construction and excavation projects in parts of the Front Range Urban Corridor. A shallow water table occurs from 0 to 50 feet below the land surface principally in the alluvial deposits along the streams and rivers in the Boulder-Fort Collins-Greeley area. This shallow water table underlies approximately 400 square miles and is maintained by natural recharge within the South Platte River basin and by the infiltration of irrigation water that is diverted into the basin from streams and reservoirs in the Colorado and the Laramie River basins. Return flow from irrigation, which is mostly ground water, helps maintain the flow of the South Platte River and its tributaries. The report includes a map from which depth to water table and the direction of ground-water movement can be determined. The map, compiled on a topographic base, shows the areal extent of the saturated materials and the altitude and configuration of the ground-water surface. The water-table contour map was prepared using data from approximately 400 wells. Monitoring of shallow ground-water within the study area shows depths to water have changed only slightly over the last 20 years, except for some seasonal and drought-related fluctuations. Gradients, computed from ground-water measurements, range from 27.7 feet per mile in Lone Tree-Spring Creek valley to 10.3 feet per mile in the South Platte River valley. The shallow ground-water underflow from the major tributaries in the basin is about 29, 000 acre-feet per year, and underflow calculated at a cross section near Kersey is about 12,000 acre-feet per year.

935. Schneider, P.A., Jr., and Hershey, L.A., 1961, Records and logs of selected wells and test holes, and chemical analyses of ground water in the lower Cache la Poudre River basin, Colorado: Colorado Water Conservation Board, Ground-Water Ser. Basic Data Rept. 8.

936. Schrader, L.H., 1989, Use of index of biotic integrity to evaluate fish communities in western Great Plains streams: Fort Collins, Colo., Colorado State University, MS thesis, 120 p.

937. Schroder, L.J., and Hedley, A.G., 1986, Variation in precipitation quality during a 40-hour snowstorm in an urban environment in Denver, Colorado: International Journal of Environmental Studies, v. 28, no. 2/3, p. 131-138.

Seventeen precipitation samples were collected during a 40-hour snowstorm in the northwestern part of the Denver, Colorado metropolitan area. Maximum concentrations of barium, calcium, cadmium, chloride, iron, potassium, magnesium, sodium, nitrate, phosphate, and sulfate occurred during the initial three hours of the storm. Maximum copper concentrations occurred nearly 6 hours after the storm began, maximum strontium concentration occurred 25 hours after the storm began, and maximum zinc concentration occurred 12 hours after the storm began. Concentrations of beryllium, cobalt, lithium, and vanadium were less than the analytical detection limits during the entire storm. The lowest pH value was determined in samples collected during or immediately after normal peak automobile traffic, occurring nearly 14 hours after the storm began.

938. Schroder, L.J., Willoughby, T.C., See, R.B. and Malo, B.A., 1989, Chemical composition of precipitation, dew and frost, and fog in Denver, Colorado, *in* Atmospheric Deposition--proceedings of a symposium held during the 3rd Scientific Assembly of the International Association of Hydrological Sciences, Baltimore, Md., May 1989.: IAHS Publication No. 179, p. 83-90.

Samples of precipitation, dew and frost, and fog were collected at a site in the northwestern part of the Denver, Colo., metropolitan area. Cluster analysis of the chemical composition of urban precipitation indicates that there is a relation among calcium, magnesium, sodium, chloride, and fluoride. The relation probably is related to the scavenging of soil-derived particulate matter by precipitation. Dew and frost samples indicate that the chemical composition is affected substantially by the dissolution of particulates on the collection surface. The pH of dew and frost had a median value of 6.4, which was greater than the median values of either precipitation or fog. The zinc concentration in dew and frost samples indicates that anthropogenic particulates are being dissolved by the dew and melting frost. The maximum pH was 4.4 in three fog samples collected, which indicates that urban fog samples are more acidic than either precipitation or dew and frost. Lead concentrations in the fog samples indicate that fog is scavenging aerosols produced by the combustion of leaded gasoline.

939. Schrupp, D.L., 1978, The wildlife values of lowland river and stream habitat as related to other habitats in Colorado, *in* Graul, W.D., and Bissell, S.J., eds., Lowland river and stream habitat in Colorado: a symposium: Greeley, Colo., Chapter Wildlife Soc. and Colorado Audubon Council.

940. Schumm, S.A., 1961, Effect of sediment characteristics on erosion and deposition in ephemeral-stream channels: U.S. Geological Survey Professional Paper 352-C, p. 31-70.

941. Schwartz, E.B., 1985, Water as an article of commerce: State embargoes spring a leak under Sporhase v. Nebraska,: Boston College Env. Affairs Law Review, v. 12, no. 1, p. 103.

In July 1982, the U.S. Supreme Court struck down a Nebraska statute which greatly limited the right of its citizens to export groundwater to another State. In Sporhase v. Nebraska, the court found that the Nebraska statute violated the commerce clause of the constitution. The development and nature of State water embargo statutes is examined, and the court's past decisions when faced with a commerce clause challenge to a State water embargo statute are recounted. Although the court was correct in finding that there are no available arguments which would entirely exempt water embargo statutes from commerce clause treatment, the clause is a clumsy tool with which to balance the complex, competing federal and State interests in this area.

942. Schwochow, S.D., Shroba, R.R., and Wicklein, P.O., 1974, Sand, gravel, and quarry aggregate resources, Colorado Front Range counties: U.S. Geological Survey Special Publication (Colorado Geological Survey) 5-A, 43 p.

943. Scott, G.R., 1978, Map showing geology, structure, and oil and gas fields in the Sterling 1 x 2 degrees quadrangle in Colo., Nebr., and Kansas: U.S. Geological Survey Miscellaneous Investigations Series Map I-1378, scale 1:250,000, 12 p.

944. Scott, G.R., 1982, Paleovalley and geologic map of northeastern Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I-1378, scale 1:250,000, 12 p.

Mapped paleovalleys in northeastern Colorado range from Oligocene to Pleistocene (Sangamon). Oligocene paleovalleys, characterized by conglomeratic stream deposits of the Chadron and Brule Formations, trend both southeastward and northeastward. Paleovalleys of the Arikaree Formation and the lower part of the Ogallala Formation trend east by northeast. In Quaternary time, the South Platte River migrated southward leaving four terraces that decrease in elevation as they decrease in age.--from New Publications of the Geological Survey, June 1982.

945. Sedgwick, J.A., and Knopf, F.L., 1989, Demography, regeneration, and future projections for a bottomland cottonwood community, *in* Sharitz, R.R., and Gibbons, J.W., eds., Freshwater wetlands and wildlife: Oak Ridge, Tenn., USDOE Office of Scientific and Technical Information, Symp. Ser. No. 61, 249-266 p.

946. Shafer, J.M., Labadie, J.W. and Jones, E.B., 1981, Firm water supply for a coal-fired power plant in north central Colorado through integrated multireservoir management., *in* Stefen, H.G., ed., Proceedings of the Symposium on Surface Water Impoundments: New York, American Society of Civil Engineers, p. 748-757.

947. Shaffer, F.B., 1976, History of irrigation and characteristics of streamflow in Nebraska part of the North and South Platte River Basins: U.S. Geological Survey Open-File Report 76-167, 98 p.

Statistics on streamflow for selected periods of time are presented for 28 gaging sites in the Nebraska part of the North and South Platte River Basins. Monthly mean discharges, monthly means in percent of annual runoff, standard deviations, coefficients of variation, and monthly extremes are given. Also tabulated are probabilities of high discharges for 1 day and for 3, 7, 15, 30, and 60 consecutive days and of low discharges for 1 day and for 3, 7, 14, 30, and 60 consecutive days. All statistics are based on records that are representative of 1973 conditions of streamflow. Brief historical data are given for 27 of the principal irrigation canals diverting from the North and South Platte Rivers.

948. Shannon, J.R., Bookstrom, A.A., and Smith, R.P., 1984, Contemporaneous bimodal mafic-felsic magmatism at Red Mountain, Clear Creek County, and Climax, Colorado, *in* The Geological Society of America, Rocky Mountain Section, 37th annual meeting. Abstracts with Programs, Durango, Colo., May 11-12, 1984: v. 16, The Geological Society of America.

949. Sharp, R.R., Jr., and Aamodt, P.L., 1976, Uranium concentrations in natural waters, South Park, Colorado: N. Mex., Los Alamos Scientific Laboratory, Informal Report LA-6400-MS, GJBX-35-76, 49 p.

950. Shelton, D. C., 1972, Thickness of alluvium and evaluation of aggregate resources in the lower Cache La Poudre River Valley, Colorado, by electrical resistivity techniques: University of Colorado.

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952. Shepherd, R.G., and Owens, W.G., 1981, Hydrogeologic significance of Ogallala fluvial environments, the Gangplank, in Ethridge, F.G., and Flores, R.M., eds., Recent and ancient nonmarine depositional environments. Special Publication: Society of Economic Paleontologists and Mineralogists, p. 89-94.

953. Sheridan, D.M., Marsh, S.P., Mrose, M.E., and Taylor, R.B., 1976, Mineralogy and geology of the wagnerite occurrence on Santa Fe Mountain, Front Range, Colorado: U.S. Geological Survey Professional Paper 955, 23 p.

954. Sherk, G., 1984, Controls over interstate transfers of ground water post-Sporhase; State and federal options, *in* Nielsen, D.M., and Aller, L., eds., Proceedings of the NWWA western regional conference on ground water management: Worthington, Ohio, Natl. Water Well Assoc., p. 187-193.

955. Shlemon, R.J., 1986, Late Quaternary stratigraphy, South Platte River, Two Forks area, east-central Front Range, Colorado, *in* Rogers, W.P., and Kirkham, R.M., eds., Contributions to Colorado seismicity and tectonics--a 1986 update: Denver, Colo., U.S. Geological Survey Special Publication (Colorado Geological Survey) 2B, p. 282-294.

956. Shoemaker, T.G., 1988, Wildlife and water projects on the Platte River, in Chandler, W.J., ed., Audubon Wildlife Report 1988/ 1989: New York, Academic Press, Inc., Harcourt Brace Jovanovich Publ., 284-334 p.

957. Short, R.A., 1983, Food habits and dietary overlap among six stream collector species: Freshwater Ivertebr. Biol., v. 2, no. 2, p. 132-138.

958. Short, R.A., Canton, S.P., and Ward, J.V., 1980, Detrital processing and associated macroinvertebrates in a Colorado mountain stream: Ecology, v. 61, no. 4, p. 727-732.

959. Short, R.A., and Ward, J.V., 1981, Benthic detritus dynamics in a mountain stream: Holartic Ecology, v. 4, p. 32-35.

960. Short, R.A., and Ward, J.V., 1980, Life cycle and production of Skwala parallela (Frison) (Plecoptera: Perlodidae) in a Colorado montane stream: Hydrobiologia, v. 69, no. 3, p. 273-275.

961. Short, R.A., and Ward, J.V., 1980, Macroinvertebrates of a Colorado high mountain stream: Southwest. Nat., v. 25, no. 2, p. 23-32.

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963. Showen, C.R., and Williams, O.O., 1973, Index to water-quality data available from the U.S. Geological Survey in machine-readable form to December 31, 1972, Central Region: U.S. Geological Survey Water-Resources Investigations 23-73, 954 p.

This report lists water-quality stations operated by the Geological Survey in the central U.S. for which data are available in machine-readable form. The data are the results of analyses of water samples and indicate the chemical and physical characteristics of surface water and groundwater. The stations are listed according to station number within each state. The water-quality data are identified by 5-digit parameter codes and are grouped into 21 parameter categories. The analytical results for all samples in any one year are then grouped within the parameter categories. The report lists the available retrieval options, the machine-readable output options, user charges, and how to obtain the data.

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965. Shroba, R.R., Rosholt, J.N. and Madole, R.F., 1983, Uranium-trend dating and soil B horizon properties of till of Bull Lake age, North St. Vrain drainage basin, Front Range, Colorado, *in* The Geological Society of America 36th annual meeting, Rocky Mountain Section; 79th annual meeting, Cordilleran Section. Abstracts with Programs, Salt Lake City, Utah, May 2-4, 1983: v. 15(5), Geological Society of America, 431 p.

966. Shroba, R.R., Schmidt, P.W., Crosby, E.J., and Hansen, W.R., [1977], Geologic and geomorphic effects in the Big Thompson Canyon area, Larimer County of storm and flood of July 31-August 1, 1976, in the Big Thompson River and Cache La Poudre River basins, Larimer and Weld Counties, Colorado: U.S. Geological Survey Professional Paper 1115, 87-152 p.

967. Shuter, K.A., 1988, Surface and subsurface hydrologic processes in Big Meadows, Rocky Mountain National Park: Golden, Colo., Colorado School of Mines, MS thesis, 136 p.

968. Siegenthaler, M., 1983, Stream discharge rating curves for the Fall River, Rocky Mountain National Park: Fort Collins, Colo., Colorado State University, WRSFL Report 83-5P, 26 p.

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970. Simmons, W.B., Jr., 1973, Mineralogy, petrology, and trace element geochemistry of the South Platte granite-pegmatite system: Ann Arbor, Mich., Univ. of Michigan.

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973. Simmons, W.B., Jr., and Heinrich, E.W., 1970, Rare-earth-fluorine pegmatites of the South Platte district, Jefferson County, Colorado (abstr.), *in* Geological Association of Canada-Mineralogical Association of Canada, Joint Annual Meetings, Abstracts of Papers: Winnipeg, Manitoba, p. 48-49.

974. Simmons, W.B., Jr., and Heinrich, E.W., 1980, Rare-earth pegmatites of the South Platte District, Colorado: Department of Natural Resources, State of Colorado, Resource Series 11, 131 p.

975. Simmons, W.B., [Jr.], Lee, M.T., Brewster, R.H., and Wayne, D.M., 1986, Chemical fractionation and evolution of the South Platte pegmatite suite, Jefferson County, Colorado, *in* Abstracts with program; Fourteenth general meeting of the International Mineralogical Association: Standford, Calif., International Mineralogical Association.

976. Simmons, W.B., [Jr.], Lee, M.T., and Brewster, R.H., 1987, Geochemistry and evolution of the South Platte granite-pegmatite system, Jefferson County, Colorado, *in* Papike, J.J., ed., International Mineralogical Association, 14th general meeting; symposium on Mineralogy and geochemistry of granites and pegmatites. Geochimica et Cosmochimica Acta: p. 455-471.

977. Simons, D.B., Matondo, J.I., and Simons, R.K., 1989, Sedimentation control measures at hydraulic structures; case study of Korty Canal, *in* Ding, L., chairperson, Proceedings of the 4th International Symposium on River Sedimentation: p. 1087-1094.

978. Simpson, D.H., and Doehring, D.O., 1977, Estimation of Manning's "n" for steep mountain streams using fabric analysis, *in* 1977 AGU fall annual meeting. Eos Trans., San Francisco, Calif., Dec. 5-9, 1977: v. 58(12), American Geophysical Union, 1136 p.

979. Skinner, M.M., 1964, Water resource management in the Prospect Valley area, Colorado: Ground water, v. 2, no. 2, p. 0-3.

980. Slichter, C.S., and Wolff, H.C., 1906, The underflow of the South Platte Valley: U.S. Geological Survey, Water Supply Paper 184, 42 p.

981. Sloane, C.S., Watson, J.G., Chow, J., Pritchett, L., and Richards, L.W., 1991, Size-segregated fine particle measurements by chemical species and their impact on visibility impairment in Denver: Atmospheric Environment, v. 25A, no. 5-6.

982. Smart, J.S., 1972, Statistical geometric similarity in drainage networks: Yorktown Heights, N.Y., IBM Watson Research Center, RC-3850; TR-7, 35 p.

The most commonly used quantitative parameters for characterizing channel networks are those derived from a Horton analysis. Although these parameters give useful information about individual networks, they are ineffective in distinguishing differences in network structure due to lithologic controls and degree of maturity. Parameters derived from considerations of statistical geometric similarity, on the

other hand, are relatively successful in characterizing network structure. An example is discussed.

983. Smedes, H.W., and Turner, A.K., 1974, Environment plan with computers, Jefferson County: Mines Magazine, v. 64, no. 4, p. 4.

984. Smith, A., 1977, Nebraska studies ways to recharge aquifer storage: Johnson Drillers Journal, v. 49, no. 5, p. 1-3 (September-October).

The importance of recharge studies to the national ground water situation is being demonstrated by current research in Nebraska. The problem of declining water levels in that State is so severe that the future of continued ground water use for irrigation in some regions depends largely on the results of injection well studies now being made in Hamilton County between Aurora and Grand Island. This project is being sponsored by Old West Regional Commission and conducted by the Nebraska Water Resources Center and the USGS. The experimental system consists of a withdrawal well located 3 miles west of an injection well; observation wells continuously monitor changes in aquifer levels as injection proceeds. In both the injection and the withdrawal wells, electric logs were valuable in accurately locating aquifer zones of best producing and recharge potential. The Nebraska study is only a part of a wide-ranging Old West Regional Commission artificial recharge project which includes Montana, North and South Dakota, and Wyoming as well.

985. Smith, C.B., McCallum, M.E., Coopersmith, H.G., and Eggler, D.H., 1979, Petrochemistry and structure of kimberlites in the Front Range and Laramie Range, Colorado-Wyoming, *in* Boyd, F.R., and Meyer, H.O.A., eds., Second International Kimberlite Conference; kimberlites, diatremes, and diamonds; their geology, petrology, and geochemistry. Proceedings Int. Kimberlite Conference: Washington, D.C., Am. Geophys. Union, p. 178-189.

986. Smith, F.A., 1969, Availability of groundwater for irrigation in Cheyenne County, Nebraska: Lincoln, Nebr., Nebraska University Conservation and Survey Division, 10 p.

Three different stratigraphic units are sources of water supplies in Cheyenne County, Nebraska. Most wells in valleys tap either alluvial deposits of Quaternary age or the underlying Brule Formation of Tertiary age; a few may tap the Ogallala Formation, also of Tertiary age but younger than the Brule. Most wells on the tablelands derive water from the Ogallala Formation alone. Generally, the alluvial deposits are mostly fine grained or thin and capable of yielding only small supplies to wells. Plans for development of irrigation supplies should take into consideration the fact that the groundwater resources will last only 30, 50, 100 years or more, depending on the intensity of the development. Well data, including drillers' logs, are tabulated. Maps, scaled about 2 miles per inch, show potential well yield, top of the Brule Formation, and the configuration and depth of the water table.

987. Smith, F.A., and Souders, V.L., 1971, Occurrence of groundwater in Kimball County, Nebraska including logs of test holes: U.S. Geological Survey Water-Supply Paper 29, 135 p.

Two test-drilling programs were designed to explore the availability of groundwater in Kimball County, Nebraska. The objectives of the investigation were to determine the availability of groundwater and to map and describe the rocks in which it occurs.

The test-hole information is also useful in an evaluation of soils, construction materials, oil and gas potential, and other geologic resources and their uses. This report includes logs of all the test holes drilled. Interpretation of information derived from the test drilling is presented on three maps and two geologic sections. The Ogallala Formation occurs throughout the county. The average thickness of the Ogallala Formation in the 52 test holes was 265 feet. Less than half the total volume of the Ogallala sediments contains water available to wells, and in some places the entire thickness of the formation is dry. Generally, the brule is more deeply eroded in the northern part of the county, and it is here that the Ogallala and the Arikaree sediments tend to be the thickest. Large-yield wells can be developed from water contained in the sand, gravel, and sandstone that fill the 'sags' and valleys eroded into the underlying Brule Formation or older rocks.

988. Smith, G.L., 1979, Proceedings workshop in instream flow habitat criteria and modeling: Fort Collins, Colo., Colorado Water Resources Research Institute Information Series 40, 244 p.

989. Smith, J.B., 1966, Mineral resources at Two Forks and Turkhead reservoir sites, South Platte River and tributaries, Upper South Platte Unit, Mount Evans Division, Jefferson and Douglas Counties, Colorado: [Denver, Colo.?], U.S. Bureau of Mines.

990. Smith, J.B., and Stinson, D.L., 1968, Mineral resources at Mt. Carbon Reservoir site on Bear Creek, South Platte River basin, Jefferson County, Colo. in Bear Creek basin, South Platte River and tributaries, Colorado, Wyoming, and Nebraska: U.S. Cong., 90th, 2d sess., Senate Doc. 87.

The proposed Mt. Carbon Dam site is on Bear Creek about 7 miles above its junction with South Platte River. The stratigraphic section includes Permian-Paleocene rocks, and the Golden thrust fault crosses the project area just west of the sediment pool. The dam and sediment pool would cover less than 1 percent of the sand and gravel reserves in the Denver area. Both abutments of the dam would be over abandoned coal mines, and the extent and condition of the workings should be investigated. Two active and two inactive sand and gravel pits, five other abandoned coal mines, and one abandoned clay pit would be inundated; some pits can be mined during low water. Flooding of this site would not interfere with oil or gas development in the one-well Soda Lakes field.

991. Smith, N.D., 1970, The braided stream depositional environment: comparison of the Platte River with some Silurian clastic rocks, north-central Appalachians: Geological Society of America Bulletin, v. 81, no. 10(October), p. 2993-3013.

Studies of the South Platte and Platte Rivers in Colorado and Nebraska show that braided patterns in streams are created mainly by accretion of longitudinal bars and dissection of transverse bars. Coarse, poorly sorted sediment favors formation of longitudinal bars, and finer grained, better sorted materials form transverse bars. The relative proportion of transverse to longitudinal bars increases downstream with the load increase of sediment of finer sizes downstream. This is accompanied by an increase in the ratio of planar cross-stratification to horizontal stratification and a decrease in cross-channel topographic relief expressed as a bed-relief index.

992. Smith, R.O., Schneider, P.A., Jr., and Petri, L.R., 1964, Ground- water resources of the South Platte River basin in western Adams and south western Weld counties, Colorado: U.S Geological Survey Water-Supply Paper 1658, 132 p.

993. Smith, Z.A., 1989, Groundwater in the West: San Diego, Calif., Academic Press, Inc. 308 p.

In large sections of the West, groundwater is the only dependable source of water available. For the 19 western States (AK, AZ, CA, CO, HA, ID, KS, MT, NB, NV, NM, ND, OK, OR, SD, TX, UT, WA, WY), 38% of the water consumed comes from the ground. This book examines the use, management, laws, and politics of groundwater in the West. The introductory chapter provides an overview of important groundwater management and policy issues that regularly present themselves. Each of the subsequent chapters is devoted to one of the 19 States, and the chapters are, for the most part, similarly organized. After a brief description of the water environment in the State and the presentation of a map showing the major groundwater regions in the State, the chapters provide a summary of groundwater use and consumption by type of consumption, an examination of groundwater problems in the State, and a summary of groundwater law, administration, and regulations. The chapters conclude with a section summarizing groundwater politics (where appropriate) and an evaluation of future potential groundwater management problems. A glossary and an extensive bibliography follow the concluding chapter.

994. Smullen, J.T. and Plant, H.K., 1979, Characterization of runoff pollution in Denver, *in* Proceedings of Th. Environmental Engineering Division Speciality Conference: San Francisco, Calif., American Society of Civil Engineers.

995. Snyder, W.D., 1991, Inventory of wildlife habitats along the South Platte River [abs.], *in* Woodring, R.C., ed., South Platte resource management: finding a balance: Fort Collins, Colo., Colorado Water Resources Research Center, 36 p.

996. Snyder, W.D., and Miller, G.C., 1991, Changes in plains cottonwoods along the Arkansas and South Platte Rivers, eastern Colorado, USA: Praire Nat., v. 23, no. 3, p. 165-176.

Photo interpretation was used to monitor 31-36 year changes in area occupied, canopy cover, and size class of plains cottonwoods (*Populus sargentii*) along the Arkansas and South Platte Rivers in eastern Colorado. Stands of cottonwoods deteriorate along the lower Arkansas with a loss of 5.6 ha/km (31%) in 31 years. Loss of cottonwoods along the South Platte was slower (3.5 ha/km, 9%). Opening of canopy covers occurred along both rivers, but size class changes were less dramatic. Shrubs increased 5.1 ha/km in areas occupied along the Arkansas and declined 2.2 ha/km along the South Platte River. Width of the Arkansas River channel declined (49.8%), whereas the South Platte showed evidence of widening. Land converted to agriculture and development increased 12.1 ha/km along the Arkansas River and 13.9 ha/km along the South Platte River. More dramatic depletion of water, a deeper, more narrow channel stabilized by reservoir releases, and invasion of tamarisk (*Tamarisk spp.*) have accompanied rapid loss of cottonwoods along the Arkansas River.

997. Soice, V.P., 1975, Application of a water-quality model to the Denver metropolitan area, *in* Symposium on modeling techniques, Volume II--2nd Annual Symposium of the Waterways, Harbors and Coastal Engineering, San Francisco, Calif., September 3-5, 1975: New York, American Society of Civil Engineers, p. 1165-1182.

The utilization of sophisticated digital computer models for analyzing alternative wastewater treatment systems is a relatively recent innovation in water resources engineering. Because of the complexity of the stream system and water use patterns in the Denver Metropolitan area, full dynamic simulation of water quantity and quality was utilized in a study of regional water-quality management. Complicating water quality and quantity factors and a desire to effect a regional approach to management of the region's quality resulted in selection of the hydrologic and water-quality programming packages offered by Hydrocomp International, Palo Alto, California. The model as adapted to the Denver area is known as the hydro-quality model and is characterized as a nonuniform, unsteady-state model that provides continuous dynamic simulation of water-quality and quantity constituents. The mode was calibrated utilizing an extensive meteorological data base, adjusting basin parameters to produce simulated stream flow and water quality and comparing this result with historically recorded values. A satisfactory calibration achieved, the model was utilized as an analytical tool to determine, through simulation, the resultant water-quality in the stream network under various alternative wastewater management systems. Model results for the various alternatives were compared against one another and against predetermined water-quality goals. This paper discussed the procedures utilized in applying this particular model and evaluated its effectiveness as a tool to manage regional water quality.

998. Soister, P.E., 1974, A preliminary report on a zone containing thick lignite beds, Denver basin, Colorado: U.S. Geological Survey Open-File Report 74-27, 46 p.

999. Sonnenberg, S.A., 1981, Tectonics, sedimentation, and petroleum potential, northern Denver Basin, Colorado, Wyoming, and Nebraska: Golden, Colo., Colorado School of Mines, 215 p.

1000. Soule, J.M., Rogers, W.P., and Shelton, D.C., 1976, Geologic hazards, geomorphic features, and land-use implications in the area of the 1976 Big Thompson flood, Larimer County, Colorado: U.S. Geological Survey Special Publication (Colorado Geological Survey) 10, 10 p.

1001. South Platte Research Team, 1987, Voluntary basinwide water management--South Platte River Basin, Colorado: Fort Collins, Colo., Colorado Water Resources Research Institute Completion Report 133, 160 p.

Demands for water in the South Platte River Basin area the most intense in Colorado and the result is increasing conflict over water use. The resulting litigation places financial burdens on water-right owners, increasingly impacts the judicial system and stresses the capacity of the State administrative agencies to make their decisions. A voluntary association of water-right owners is proposed as a mechanism to increase the options of water users and reduce conflict over water use. The initiative for organizing the association would be by the water-right owners themselves. The South Platte Research Team believes that such an association could help achieve voluntary integrated basinwide water management. An association of water-right owners would need information on management and exchange possibilities and the resulting

impacts on both surface and ground waters. Computer-based models can provide the information. The hydrologic and decision models which are available at Colorado State University for this purpose are described. Other hydrologic models and economic models can also be utilized by the association. Finally, the report sets forth a plan of implementation. Through workshops, water-right owners or representatives of their associations can become familiar with the potentialities of computer-based models for testing the feasibility of possible water exchanges and transfers. They can also consider the feasibility of a South Platte Federation in facilitating such actions with the help of technically available knowledge. If they deem these potentialities practicable and they accept them, further steps in implementation are proposed.

1002. Spahr, N.E., 1981, Variations in climatic characteristics as related to evapotranspiration in South Park, central Park County, Colorado: U.S. Geological Survey Water-Resources Investigations 80-86, 154 p.

Data collected from May through September in 1977, 1978, and 1979 at three stations were analyzed using an analysis of variance technique to determine variations in climatic characteristics in South Park, Colo. Knowledge of these climatic characteristics will aid in determining the amount of water that may be transferred from agricultural use in South Park to municipal use in the Denver metropolitan area. Daily minimum air temperature, daily average air temperature, cumulative wind, daily relative humidity, and daily solar radiation were statistically different between the three stations at the 1-percent level of significance. Daily maximum air temperature and daily pan evaporation were not significantly different between some stations. Daily precipitation was not significantly different between the three stations. Estimates of potential evapotranspiration made using the Penman equation were not significantly different between the three stations. The lack of spatial variations in the estimated potential evapotranspiration shows that no one climatic characteristic can be used as an indicator of spatial variation of potential evapotranspiration. Large variations in solar radiation between the three stations indicate that solar radiation needs to be measured at sites where evapotranspiration is being determined.

1004. Spahr, N.E., and Blakely, S.R., 1985, Effects of wastewater effluent on the South Platte River from Littleton to Denver: U.S. Geological Survey Water-Resources Investigations 85- 4124, 97 p.

The U.S. Geological Survey's one-dimensional steady-state water-quality model was used to investigate the effects of the effluent from the Bi-City WWTP (Wastewater Treatment Plant) on the South Platte River. The Bi-City WWTP is operated by the Cities of Littleton and Englewood. The model was calibrated from a 14.5-mile reach for 5-day carbonaceous biochemical oxygen demand, organic, ammonia, nitrite and nitrate using data collected during September 1983. Model verification was completed using data collected during October 1982 and January 1984 for all constituents except nitrite nitrogen. Nitrite nitrogen could not be verified for the cold temperature conditions of January of 1984. Measured benthic sediment oxygen demand used in model ranged from 1.01 to 2.77 grams per square meter per day. Model simulations were made for an estimated 7-day, 10-year discharge of 18 cubic feet per second, upstream from the outfall of the WWTP. Two groups of simulations were made for both warm and cold temperature conditions. In the first group of simulations, variations were made in effluent 5-day carbonaceous biochemical oxygen demand concentrations and flow rates. The second group of simulations varied the amount of

nitrogen discharged as ammonia and nitrate. The extent of the mixing zone downstream of the WWTP outfall was determined by injecting Rhodamine WT dye into the effluent. The mixing zone was found to extend 0.8 mile during low-flow conditions.

1005. Spahr, N.E., Blakely, S.R., and Hammond, S.E., 1985, Selected hydrologic data for the South Platte River through Denver, Colorado: U.S. Geological Survey Open-File Report 84-703, 225 p.

The U.S. Geological Survey, in cooperation with the cities of Littleton and Englewood, Colorado, studied the effects of the discharge of treated effluent from the Bi-City Waste Water Treatment Plant on low-flow conditions of the South Platte River. An 18-mile reach of the South Platte River, beginning below Chatfield Reservoir, through the Denver metropolitan area was studied. Chatfield Reservoir was used to regulate the flow of the South Platte River on four occasions between October 1982 and January 1984. Each flow-regulation period was used to achieve a stable, low-flow condition. Data collection during low flow allowed for the study of waste assimilation during both warm- and cold-water conditions. Water-quality, streamflow, channel-geometry, traveltime, mixing-zone, reaeration, and benthic-oxygen demand data were collected at selected instream, tributary, and effluent sites. This report presents data collected during four periods of low flow along the South Platte River.

1006. Spaulding, S.A., 1991, Phytoplankton community dynamics under ice-cover in The Loch, a lake in Rocky Mountain National Park: Fort Collins, Colo., Colorado State University, MS thesis.

1007. Spears, C.F., Amen, A.E., Fletcher, L.A., and Healey, L.R., 1968, Soil survey of Morgan County, Colorado: Washington, D.C., U.S. Dept. of Agriculture, Soil Conservation Service.

1008. Stednick, J.D., 1988, Comparative hydrochemistry of alpine and alpine-subalpine surface waters of Hourglass Creek, Colorado Rocky Mountains, *in* American Geophysical Union, 1988 fall meeting. Eos, Transactions, San Francisco, Calif., Dec. 6-11, 1988: v. 69(44), American Geophysical Union, p. 1203.

1009. Steele, E.K., 1986, Estimate of livestock water use in Nebraska during 1980: U.S. Geological Survey Water-Resources Investigations 86-4031, 38 p.

The estimated volume of 148,120 acre-ft of water used by livestock in Nebraska during 1980 is the second largest (after Texas) volume used for livestock production in the fifty States. Although water used by livestock is a small percentage of the total water used in Nebraska, this use has a major impact on the farm economy of the State, as livestock sales accounted for 59% of the total farm market cash receipts in 1980. About 16%, or 23,590 acre-ft, of this use is estimated to be from surface water sources, with the remaining 124,530 acre-ft pumped from the State's groundwater supply. The estimated livestock water use in Nebraska's 93 counties during 1980 ranged from 340 acre-ft in Hooker County to 6,770 acre-ft in Cherry County. Livestock water use by Hydrologic Units ranged from 20 acre-ft in the Hat Creek basin (10120106) to 10,370 acre-ft in the Elkhorn River basin, and the Natural Resources Districts' use ranged from 1, 880 acre-ft in the South Platte NRD to 17,830 acre-ft in the Lower Elkhorn NRD.

1010. Steele, T.D., and Doerfer, J.T., 1983, Bottom-sediment chemistry and water quality of the South Platte River in the Denver metropolitan area, Colorado, *in* Kavvas, M.L., Sterling, H.J., and de Vore, R.W., eds., Proceedings of 1983 International symposium on urban hydrology, hydraulics and sediment control. Bulletin Series: Office of Engineering Services, University of Kentucky, p. 195-206.

1011. Steele, T.D., Kunkel, J.R., and McDonald, J.W., 1981, Assessing water resources development alternatives in the South Platte River basin, Colorado, *in* AWRA Unified River Basin Management Symposium, Atlanta, Ga., October 4-8, 1981: American Water Resources Association, p. 114.

Studies are being conducted to evaluate, from a regional perspective, water availability and consumption in the South Platte River basin of Colorado. Under a compact agreement, the State is entitled to use more surface water from the basin than is currently being utilized. Public and private entities have been interested in development additional surface waters for beneficial use. Four major studies performed are profiled: basin streamflow characterization, selection of criteria to measure development impacts, preliminary analysis of development alternatives, and preliminary impact evaluation and option comparison.

1012. Stein, H.J., 1983, A lower crustal origin for molybdenum porphyry systems--lead isotope evidence from southern Cordilleran deposits, *in* The Geological Association of Canada, the Mineralogical Association of Canada, and the Canadian Geophysical Union joint annual meeting. Program with Abstracts, May 11-13, 1983: v. 8, Victoria, BC, Canada, Geological Association of Canada, A64 p.

1013. Steinheimer, T.R., Johnson, S.M., and Subitzky, S., 1986, Investigation of the possible formation of diethylnitrosamine resulting from the use of rhodamine WT dye as a tracer in river waters, *in* Selected papers in the hydrologic sciences 1986: U.S. Geological Survey Water-Supply Paper 2290, 37-49 p.

1014. Stevens, D.R., and Rosenlund, B.D., 1990, Greenback cutthroat trout restoration in Rocky Mountain National Park: Fish & Coastal Wetlands Res., v. 6, p. 104-118.

1015. Stewart, B.A., and others, 1967, Distribution of nitrates and other water pollutants under fields and corrals in the middle South Platte valley of Colorado: Fort Collins, Colo., Agricultural Research Service, U.S. Department of Agriculture, Northern Plains Branch and Colorado Agricultural Experiment Station, ARS 41-134, 206 p.

Cores representing nonirrigated fields in native grass, cultivated nonirrigated fields, irrigated fields in alfalfa, irrigated fields in crops other than alfalfa, and corrals were obtained from northeastern Colorado during 1966. Cultivated nonirrigated fields usually contained small accumulations of nitrate below the root zone. Native grass fields, ordinarily, did not show nitrate accumulation in core profiles. Significant quantities of nitrate were found in most cores from irrigated fields with row crops or cereal grains. Alternately, cores from irrigated alfalfa fields generally contained insignificant amounts of nitrate. Amounts of nitrogen as nitrate found under corrals were extremely varied, ranging from almost none to more than 5000 pounds/acre in a 20-foot profile. Evidence disclosed that denitrification was occurring under feedlots, even at several feet below the surface, consequently, much of nitrate under feedlots will probably never reach the water table. Water samples beneath several corrals contained large amounts of organic carbon and ammonia and possessed offensive odor. Bacterial counts under corrals were considerably higher than under other areas, especially at lower depths. These findings indicate some pollution of groundwater by deep percolation is occurring from corrals, but more studies are required before significance and magnitude of this pollution can be assessed.

1016. Stewart, B.A., Viets, F.G., Jr., and Hutchinson, G.L., 1968, Agriculture's effect on nitrate pollution of groundwater: Jour. Soil and Water Conser., v. 23, no. 1, p. 13-15.

Among agricultural sources of ground-water pollution, nitrogen has received particular attention because of increased use of fertilizers and the health hazard to livestock and humans, especially infants. Victims of nitrate poisoning show symptoms of oxygen deficiency. Natural sources cannot be neglected in appraising the nitrate problem created in a watershed or basin by adding large amounts in foods, feeds, fertilizers and legumes. Little is known about the relative contributions of domestic sewage effluents, fertilizers, and wastes from corrals to pollution of ground waters. Comparison of chemical data for water samples beneath feedlots and irrigated fields in Colorado suggests that leaching losses have been greatly underestimated. Profile differences are discussed and illustrated graphically; need for management is emphasized.

1017. Stoecker, R.E., 1978, The importance of shoreline length to improving wildlife habitat at gravel ponds, *in* Graul, W.D., and Bissell, S.J., eds., Lowland river and stream habitat in Colorado: a symposium: Greeley, Colo., Colorado Chapter of Wildl. Soc. and Colorado Audubon Council, p. 172.

1018. Street, F. A., 1971, A study of tors in the Front Range of the Rocky Mountains with special reference to their value as an indicator of non-glaciation: Boulder, Colo., University of Colorado, 242 p.

1019. Stuber, R.J., 1985, Trout habitat, abundance, and fishing opportunities in fenced vs unfenced riparian habitat along Sheep Creek, Colorado: U.S. For. Serv., Gen. Tech. Report 120, 310-314 p.

1020. Summer, R.M., 1980, Alpine soil erodability on Trail Ridge, Rocky Mountain National Park, Colorado: Boulder, Colo., University of Colorado, PhD dissertation, 187 p.

1021. Summer, R.M., 1990, Development and application of a method to estimate short-term alpine sediment transfer in the Colorado Front Range, USA: Mountain Research and Development, v. 10, no. 4, p. 321-332.

1022. Summer, R.M., 1982, Field and laboratory studies on alpine soil erodability, southern Rocky Mountains, Colorado: Earth Surface Processes and Landforms, v. 7, p. 253-266.

1023. Swan, F.H., 1975, Pleistocene and Holocene deposits of the lower Cache la Poudre River basin, Colorado: Johns Hopkins University, 232 p.

1024. Sweazy, R.M., 1985, Can we save the Ogallala?: Civil Engineering ASCE, v. 55, no. 8, p. 36-39.

1025. Sweet, A.T., Brown, L.A., and Haines, W.E., 1929, Soil survey of the Greeley area, Colorado: Fort Collins, Colo., U.S. Dept. of Agriculture, Soil Conservation Service.

1026. Sweet, A.T., and Dodson, C.H., 1930, Soil survey of the Longmont area, Colorado: Fort Collins, Colo., U.S. Dept. of Agriculture, Soil Conservation Service.

1027. Sweet, A.T., and Spencer, J.N., 1927, Soil survey of the Fort Collins area, Colorado: Fort Collins, Colo., U.S. Dept. of Agriculture, Soil Conservation Service.

1028. Tainter, P. A., 1982, Investigation of stratigraphic and paleostructural controls on hydrocarbon migration and entrapment in Cretaceous D and J sandstones of the Denver Basin: Boulder, Colo., Univ. of Colorado, 235 p.

1029. Tarlock, A.D., 1985, Lessons from the rest of the west--A survey of groundwater management in California, Colorado, New Mexico, and Nebraska, *in* Issues in groundwater management--Twelve water resources symposium.: Austin, Tex., Center for Research in Water Resources, The University of Texas, p. 165-173.

Groundwater has characteristics that make State intervention in its use necessary. These are: (1) relative scarcity, (2) absolute scarcity, and (3) contamination. This paper focuses on the first two characteristics. Relative scarcity occurs when pumpers in a basin cannot obtain required amounts at pre-existing pumping levels. Unlike surface streams, groundwater basins may not be sucked dry in any given year. Rather, any shortage that occurs is not to an absolute amount of water but to an amount of water at a given static pressure level. Economists advise that in order to promote the efficient allocation of resources, property rights must be well defined, enforced, and transferable. Well-defined rights are basically rights that make clear, exclusive assignments to one entity. The other two attributes, enforceability and transferability, follow from an exclusive assignment. Once an individual sphere of control is delineated, it is possible to determine what is an interference and to protect the right holder against it. Clear and enforceable rights are obviously saleable items, if the resource has value, and thus the right is transferable. With respect to groundwater, the sticky point is the first characteristic of property right. It is difficult to assign exclusive rights to a resource when, for physical reasons, one claimant's consumption inevitably interferes with another claimant's legitimate consumption. A survey of groundwater law and administration in California, Colorado, New Mexico, and Nebraska shows that no State has developed a perfect solution. However, each of these States has developed a solution to the twin problems of pressure declines and mining. Groundwater control is rooted in the needs of each State, and as a result, one State's institutions are not readily transferable to another State; but, taken together, the experience of the States surveyed here illustrate some realistic approaches to groundwater conservation.

1030. Tarlock, A.D., 1983, So it's not "ours"-why can't we still keep it? A first look at Sporhase v. Nebraska,: Land & Water Law Review, v. 18, no. 1, p. 137.

The U.S. Supreme Court decision in Sporhase v. Nebraska on the western States' attempts to control their water resources are discussed. In 1982, Sporhase v. Nebraska effectively overruled McCarter and held that a Nebraska groundwater export ban violated the negative commerce clause. This resulted in a major revision of the

Supreme Court's use of the negative commerce clause to provide the flexibility of the western States to allocate their water resources. A description is given of the origins of western claims on resource sovereignty and limitations on exclusive State control over water. The impact of a coal slurry pipeline on water rights is also evaluated.

1031. Tetra Tech, Inc., 1975, Appendices of draft final report--Study areas II and VI-c--Water-quality analysis and environmental assessments, South Platte River, Volume II.: [Fort Collins, Colo.?], Tetra Tech Report TC 458-10, variously paginated.

1032. Tetra Tech, Inc., and National Commission on Water Quality, 1975, Environmental impact assessment, water-quality analysis, South Platte--biota and water quality of the South Platte River, past, present, projected: Fort Collins, Colo., Dept. of Civil Engineering, Colorado State Univ., Environmental Engineering Technical Report. 2 (Final); NCWQ-75/78, 453 p.

A comprehensive water-quality analysis and environmental impact assessment at the South Platte River was undertaken as part of a national assessment of anticipated environmental impacts of theoretically achieving or not achieving the requirements of the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92- 500). Authors (1) characterized historical and existing water quality and environmental conditions; (2) projected resultant water quality, assuming specific levels of wastewater treatment to point source effluents entering the study site; and (3) anticipated biological, ecological and environmental effects, and impacts and benefits to result from projected changes in water quality. The site assessment is one of 41 similar studies conducted for the Environmental Sciences sector of the Commission.

1033. Thelin, G.P., and Heimes, F.J., 1987, Mapping irrigated cropland from Landsat data for determination of water use from the High Plains Aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming Regional Aquifer-System Analysis: U.S. Geological Survey Professional Paper 1400-C, map scale 1:2,500,000, 38 p.

1034. Thelin, G.P., Johnson, T.L., and Johnson, R.A., 1981, Mapping irrigated cropland on the High Plains using Landsat satellite hydrology, *in* M. Deutch, D.R. Wiesnet, and A. Rango, eds., Fifth annual William T. Pecora memorial symposium on remote sensing-- Satellite hydrology--Proceedings.: p. 715-721.

1035. Thornbury, W.D., 1928, Glaciation of the east side of Colorado Front Range between Long's and James' Peak: Boulder, Colo., University of Colorado, MA thesis, 69 p.

1036. Thorne, C.R., and others, 1983, Measurements of bend flow hydraulics on the Fall River at low stage: Fort Collins, Colo., Colorado State University, WRSFL Report 83-9P, 48 p.

1037. Thorne, C.R., and others, 1985, Measurements of bend flow hydraulics on the Fall River at bankfull stage: Fort Collins, Colo., Colorado State University, WRD Project 85-3, 71p.

1038. Thorne, C.R., and Bradley, J.B., 1984, Sedimentation problems in the Fall River following the Lawn Lake Dam failure--Data report.: Fort Collins, Colo., Colorado State University, Report to Sedimentation Section, USBR.

1039. Thorne, C.R., and Zevenbergen, L.W., 1982, Flow resistance of boulder-bed streams, *in* L.B. Leopold, ed., 1982 Conference of the American Geomorphological Field Group--Field Trip Guidebook, Sept. 5, 1982: Pinedale, Wyo., American Geomorphological Field Group, 134 p.

1040. Thornton, W.B., 1988, Distortion of stream channel responses in a semi-arid environment; Sand Creek, El Paso County, Colorado, *in* W. Bryson, chairperson, Association of Engineering Geologists 31st annual meeting; abstracts and program; Exploration methods and applications, new and revisited, Kansas City, Mo., Oct. 16- 21, 1988: v. 31, Association of Engineering Geologists, p. 60.

1042. Tischler, J., Huenefeld, B., and Irrgang, G.H., 1991, The long climb to remediation: Civil Eng. Special issue: Hazardous Wastes, v. 61, no. 4.

For 40 years, mustard gas, napalm, and pesticides were manufactured just 10 mi from downtown Denver at the Rocky Mountain Arsenal. Much of the chemical wastewaters flowed to the same destination, creating a potent and unusual mixture of water, organics and dissolved solids. Now, after more than a decade of studies and pilot programs, a downfired liquid incinerator has been tapped to destroy the resilient waste.

1043. Tom, C., Miller, L.D., and Christenson, J.W., 1978, Spatial land-use inventory, modeling, and projection/Denver metropolitan area, with inputs from existing maps, air photos, and LANDSAT imagery: Greenbelt, Md., Goddard Space Flight Center, National Aeronautics and Space Administration, NASA-TM-79710; G-7816, 215 p.

A landscape model was constructed with 34 land-use, physiographic, socioeconomic, and transportation maps. A simple Markov land-use trend model was constructed from observed rates of change and nonchange from photointerpreted 1963 and 1970 airphotos. Seven multivariate land-use projection models predicting 1970 spatial land-use changes achieved accuracies from 42 to 57 percent. A final modeling strategy was designed, which combines both Markov trend and multivariate spatial projection processes. Landsat-1 image preprocessing included geometric rectification/ resampling, spectral-band, and band/insolation ratioing operations. A new, systematic grid-sampled point training-set approach proved to be useful when tested on the four original MSS bands, ten image bands and ratios, and all 48 image and map variables (less land use). Ten variable accuracy was raised over 15 percentage points from 38.4 to 53.9 percent, with the use of the 31 ancillary variables. A land-use classification map was produced with an optimal ten-channel subset of four image bands and six ancillary map variables. Point-by-point verification of 331,776 points against a 1972/1973 U.S. Geological Survey (USGS) land-use map prepared with airphotos and the same classification scheme showed average first-, second-, and third-order accuracies of 76.3, 58.4, and 33.0 percent, respectively.

1044. Trexler, P.K., 1978, Uranium hydrogeochemical and stream sediment reconnaissance of the Cheyenne NTMS Quadrangle, Wyoming: N. Mex., Los Alamos Scientific Lab., Department of Energy, GJBX-106-78, LA-7237-MS Informal Report, 69 p.

Between June 1976 and October 1977, 1138 water and 600 sediment samples were systematically collected from 1498 locations in the Cheyenne NTMS quadrangle of southeast Wyoming. The samples were analyzed for total uranium at the Los Alamos

Scientific Laboratory. The uranium concentration in waters ranged from 0.01 to 296.30 parts per billion (ppB), with a median of 3.19 ppB and a mean of 8.34 ppB. The uranium in sediments ranged from 0.8 to 83.0 parts per million (ppM) with a median of 3.4 ppM and a mean of 4.5 ppM. Arbitrary anomaly thresholds were selected to isolate those water and sediment samples containing uranium concentrations above those of 98% of the population sampled. Using this procedure, 23 water samples above 54.50 ppB and 12 sediment samples above 14.0 ppM were considered anomalous. Several areas appear favorable for further investigation for possible uranium mineralization. High uranium concentrations were detected in waters from the northeast corner of the Cheyenne quadrangle. High uranium concentrations were detected in sediments from locations in the southern and central Laramie Mountains and along the southeast and east-central edges of the study area.

1045. Trimble, D.E., and Fitch, H.R., 1974, Map showing potential sources of gravel and crushed-rock aggregate in the Greater Denver area, Front Range Urban Corridor, Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I- 856-A, scale 1:100,000.

High-quality gravel in the Front Range Urban Corridor, Colo., is restricted largely to areas beneath flood plains of major streams and to low terraces along these streams. Rock suitable for processing into crushed-rock aggregate is plentiful in the older rocks of the mountains and in certain volcanic rocks of the foothills and plains. Potential sources of gravel or of aggregate have been grouped into seven map units--three of gravel and four of crushed-rock aggregate. A potential source of gravel, as here defined and mapped, contains 20 percent of more of granule- and pebble-size stones (smaller than 2.5 in. or 6.4 cm, but retained on a no. 10 U.S. Standard Sieve). The minimum gravel content was placed arbitrarily at 20 percent of the deposit because this is the most likely economic limit under the most adverse foreseeable conditions. The map units are based on differences in physical characteristics, which, in turn, determine relative quality for different uses.

1046. Trimble, D.E., and Machette, M.N., 1976, Geology of the Greater Denver area, Front Range Urban Corridor, Colorado: U.S. Geological Survey, Miscellaneous Investigations Series Map I-856-H, scale 1:100,000.

1047. Tucker, R.C., and Lemont, S., 1985, RMA Southern Tier contamination survey, *in* Groundwater contamination and reclamation, Proceedings of a Symposium, Tucson, Ariz., August 14-15, 1985: Bethesda, Md., American Water Resources Association, p. 27-36.

The City and County of Denver have advised the Federal Aviation Administration (FAA) that they would like to develop a new east-west runway for Stapleton International Airport to be located on the 'Southern Tier' of the Rocky Mountain Arsenal. The FAA is preparing an Environmental Impact Statement (EIS) for this proposed expansion. Though generally undeveloped and undisturbed, a number of areas were identified in the Southern Tier as known or potentially contaminated areas. There are three sites known to contain pesticide and mercury contamination. These are buried sludges dredged from nearby lakes and a pond where sediments were carried during a large storm. On other sites were located storage sheds for incendiary munitions. An environmental survey of the area was conducted to provide a concise explanation of the contamination condition present in these areas, for inclusion in the FAA's EIS. The survey involved aerial photo interpretation, soil brings and sampling, well installation, surface and groundwater sampling, sediment sampling, and laboratory analysis. Data analysis and contamination assessment focused on identification and quantification of volume and extent of known or suspected sources of contamination. The following conclusions were drawn with respect to conditions in the RMA Southern Tier: (1) no drinking water standards or guidelines were exceeded in any water samples collected, except for iron and manganese, which in almost all areas occur in naturally high concentrations; (2) other than in soil and sediment samples taken at three sites, no significant contamination was found in samples of groundwater, surface water, sediment, and soils collected; (3) there is little potential for offsite migration of contamination from the RMA Southern Tier; and (4) based on the 'worst case' scenario analysis, contamination requiring remedial action was detected at the same three sites. Remedial actions were identified where appropriate.

1048. Tudor Engineering Co., and Water and Power Resources Service, 1980, Western States inventory of low-head hydroelectric sites. Volume 2. Appendix D. Environmental Screening, Final rept. on Phase 2, Dec. 79-Oct. 80: San Francisco, Calif., 342 p.

The report presents a listing of 2628 potential low-head hydroelectric sites in the 17 Western States. It includes a preliminary evaluation of environmental considerations that could impact development of the sites.

1049. Tudor Engineering Co., and Water and Power Resources Service, 1980, Western States inventory of low-head hydroelectric sites: Denver, Colo., Engineering and Research Center, Volume 1. Final report and Appendix A (Site Data Listing), Appendix B (New Site Selection), Appendix C (Computer Screening) Final rept. on Phase 2, Dec. 79-Oct. 80. See also Volume 2, PB81-134959., 352 p.

The report presents a listing of 2628 potential low-head hydroelectric sites in the 17 Western States. It includes a preliminary economic sizing and analysis using the U.S. [Army] Corps of Engineers National Hydropower Study Form 1 procedures.

1050. Tudor Engineering Company, 1987, Clear Creek Project, phase 1 feasibility report: Denver, Colo., Colorado Water Resources & Power Development Authority, Final report, variously paginated.

1051. Turner, C.D., and Hendricks, D.W., 1983, Dissolved solids hazards in the South Platte Basin. Volume 2. Salt balance analysis: Fort Collins, Colo., Colorado Water Resources Research Inst. Completion Report 129, 140 p.

The first year of this project assessed the salt flows at five stations of the South Platte River between Henderson and Julesburg, and of the three main tributary streams, the St. Vrain, the Big Thompson, and the Cache la Poudre. The analysis of 15 years of data from 1965-1979 showed that salt is lost from the river between Kersey and Julesburg. The objective of the second year of the project was to explain the negative salt balance in the Kersey-Balzac reach and to understand better the mass flows of salt within the system. Another objective was to develop basic data in preparation for development of a salt balance model involving the major components of the lower South Platte system, the long-range objective. Study of the canal diversions in the Kersey-Balzac reach indicated that the reason for the salt imbalance is due to two major canal diversions.

1052. Turner, C.D., and Hendricks, D.W., 1980, Planning water reuse-- Development of reuse theory and the input-output model, Vol. I--Fundamentals: Fort Collins, Colo., Colorado State University, Colorado Water Resources Research Institute Completion Report 114, 316 p.

Municipalities in the West are searching for new sources of water at a time when very little undeveloped water remains. An increasing number of communities are planning to meet growing water needs through water reuse. In Denver, for example, a potable water reuse facility of 100 mgd is being planned for construction during the 1990's. An alternative to potable water reuse is the exchange of treated municipal wastewater for unused high-quality agricultural water. This type of water reuse promises to be less expensive than potable reuse, and it can be implemented today. In order to facilitate the exploration of municipal water reuse alternatives, a water reuse methodology is developed in the research. Two case-study demonstrations are used to document the application of the methodology. The water reuse planning methodology is developed using: (1) a synthesis of reuse definitions from the literature; (2) an analysis of proposed and existing water reuse projects to discover new directions in reuse development; (3) identification of financial and regulatory incentives contained in the water-quality laws; and (4) the identification of mechanisms in appropriative water laws that influence water reuse. The resulting methodology is designed to aid in the formulation of water reuse alternatives. An economic methodology is also developed for the evaluation and comparison of dual purpose water reuse alternatives with other water supply and wastewater treatment alternatives. The South Platte River Basin and the cities of Fort Collins and Greeley are used to demonstrate the alternative development methodology. The demonstration shows that water reuse exchange with agriculture has the potential to meet all but the very highest municipal water projections for the next 40 years in the basin.

1053. Turner, C.D., Hendricks, D.W., and Klooz, D., 1982, Water reuse models for the South Platte River Basin: Fort Collins, Colo., Center for Water Resources Research.

1054. Turner, P.N., 1988, Some rotifers encountered in Colorado, USA: Microscopy London, v. 36, no. 2, p. 174-180.

1055. Tweto, O., 1979, Geologic map of Colorado: U.S. Geological Survey, scale 1:500,000.

1056. U.S. Bureau of Mines, 1961, Mineral resources at Narrows Reservoir site, Morgan County, Colorado: Denver, Colo., Department of the Interior.

1057. U.S. Bureau of Reclamation, 1985, 1984 summary statistics--v. 1, Water, land and related data: Denver, Colo., Department of the Interior, 315 p.

1058. U.S. Bureau of Reclamation (Region 7), 1946, Blue-South Platte Project, Colorado--A potential transmountain diversion project: Denver, Colo., Department of the Interior, Project Planning Report 7-8a.1-0.

1059. U.S. Bureau of Reclamation, 1982, Colorado-Big Thompson Project: project data sheet: Denver, Colo., Department of the Interior, 42 p.

1060. U.S. Bureau of Reclamation, 1984, Colorado-Big Thompson Project brochure: Loveland, Colo., Department of the Interior, 9 p.

1061. U.S. Bureau of Reclamation, 1988, Colorado-Big Thompson Project, crop production and water utilization data for 1988: Loveland, Colo., Department of the Interior, 6 p.

1062. U.S. Bureau of Reclamation (Great Plains Region), 1983, Draft Narrows option joint resource management report: Billings, Mont., Department of the Interior.

1063. U.S. Bureau of Reclamation (Lower Missouri Region), 1983, Draft supplement to the final environmental statement - South Platte Division Narrows Unit, Colorado: Denver, Colo., Department of the Interior.

1064. U.S. Bureau of Reclamation, (Lower Missouri Region), 1976, Final environmental statement-South Platte Division Narrows Unit, Colorado: Denver, Colo., Department of the Interior, 500 p.

1065. U.S. Bureau of Reclamation, 1981, Final environmental statement, Colorado-Big Thompson/ Windy Gap Project, Colorado: Denver, Colo., Department of the Interior.

1066. U.S. Bureau of Reclamation, 1985, Final supplement to the final environmental statement, Pick-Sloan Missouri Basin Program, South Platte Division, Narrows Unit, Colorado: Denver, Colo., Department of the Interior.

1067. U.S. Bureau of Reclamation, 1988, Green Mountain Reservoir, Colorado, Water marketing program; final supplement to the final environmental statement; Colorado-Big Thompson, Windy Gap projects, Colorado: Billings, Mont., Department of the Interior, variously paginated.

1068. U.S. Bureau of Reclamation (Lower Missouri Region), 1974, Multiobjective planning of water and related land resources; field draft feasibility report: Denver, Colo., Upper South Platte Unit, Mount Evans Division, Pick-Sloan Missouri Basin Program, variously paginated.

1069. U.S. Bureau of Reclamation (Lower Missouri Region), U.S. Fish and Wildlife Serv., Colo. Div. Wildlife, Natl. Park Serv., and U.S. Army Corps Eng. Omaha Dist., 1983, Narrows Unit, Pick-Sloan Missouri Basin Program, Colorado Draft supplement to the final environmental statement: Department of the Interior, DES 83-52, variously paginated.

1070. U.S. Bureau of Reclamation, 1940, Report on Blue River-South Platte Project, Colorado: Department of the Interior, Project Investigation Report 42.

1071. U.S. Bureau of Reclamation, (Region 7), 1959, Report on the South Platte River basin, Colorado-Wyoming-Nebraska: Denver, Colo., Department of the Interior.

1072. U.S. Bureau of Reclamation, 1989, South Platte River, Colorado; agricultural lands (draft): Denver, Colo, Department of the Interior, 12 p.

1073. U.S. Bureau of Reclamation, 1989, South Platte River, Colorado, point flow study, 1931-1983: Denver, Colo., Department of the Interior, 11 p. and appendix.

1074. U.S. Bureau of Reclamation (Lower Missouri Basin), 1982, Water use and management in the Upper Platte River Basin: Denver, Colo., Department of the Interior.

1075. U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service and U.S. Geological Survey, 1983, Upper Platte River study; summary report; ecological studies, water use and management flow conditions and channel morphology: Washington, D.C., Department of the Interior, 122 p.

1076. U.S. [Army] Corps of Engineers, 1968, Bear Creek basin, South Platte River and tributaries, Colorado, Wyoming, and Nebraska: Washington, D.C., Department of the Army, U.S. 90th Congress, 2d Sess., Senate Doc. 87, 175 p.

To control flooding of Bear Creek, a left-bank tributary of the South Platte River in metropolitan Denver, Colorado, a multiple-purpose flood control and recreational reservoir is proposed. The recreational pool would have an area of 130 acres. The estimated cost is $20,851,000. Estimated annual flood damage potential is $1,103,000. Estimated annual flood protection benefit is $930,000.

1077. U.S. [Army] Corps of Engineers, 1969, Flood plain information, Dry Creek, Cheyenne, Wyoming - volume 1: Omaha, Nebr., Department of the Army, Flood Plain Report, 23 p.

Flooding of Dry Creek, Cheyenne, Wyoming is described in a report of flood plain problems based on records of rainfall, runoff, and historical and present flood heights. Maps, photographs, profiles, and cross sections indicate the extent of flooding that has occurred and which may be expected to occur in the future. The information is for use in study and planning ways to minimize vulnerability to flood damages by control of flood plain use by zoning and subdivision regulations, the construction of flood protection works, or by combinations of these approaches.

1078. U.S. [Army] Corps of Engineers, 1973, Flood plain information: Cache La Poudre River, Colorado, Volume I, Fort Collins, Larimer County: Omaha, Nebr., Department of the Army, Prepared for Larimer-Weld Regional Planning Commission, 25 p.

This study reach of Cache La Poudre River in Larimer County extends 15.4 miles from a point near the river gage upstream of Laporte to the Spring Creek confluence at Fort Collins. The river in this reach drains an area of 1,055 sq mi and has a slope of 16 ft/mi. The flood plain is not extensively developed; much of the included area could be used safely. Fort collins has acquired some flood prone lands for use as open space areas. Continued growth of Fort Collins (population 51,125) is expected to bring development pressure to the flood plains. Presently, thirteen bridges, roadway embankments, residential and commercial structures can obstruct flood flows. Flooding can occur from May through September as the result of intense rainfall. Flooding is most likely to occur in June when rainfall and snowmelt runoff combine to produce flood flows. The river through Fort Collins begins to exceed channel capacity at a peak discharge of about 5,000 cubic feet per second (cfs). The intermediate regional flood and the standard project flood would have peak discharges of 19,700 and 60,000 cfs, respectively, at the downstream limit of study reach and would subject residential, commercial, utility and public property to flooding. At Fort Collins, peaking will normally occur due to heavy rainfall in about 6 hours with 30-hour duration. Below Watson Lake where the flood plain is relatively narrow and velocities are high, overbank flows will be dangerous. A major flood last occurred in 1904.

1079. U.S. [Army] Corps of Engineers, 1974, Flood plain information: Cache La Poudre River, Colorado, Volume II, Greeley, Weld County: Omaha, Nebr., Department of the Army, Prepared for Larimer-Weld Planning Commission, 30 p.

This 14.8-mile study reach of the Cache La Poudre River, a tributary of South Platte River, extends from the mouth near Greeley to about a mile above Sheep Draw and drains an area of 1,890 square miles. The river has a slope of 6.6 ft/mile in this reach, with flood plain widths ranging from 3,500 to 4,000 ft largely without urban development, although a large number of buildings are located in the flood plain on the northeast side of Greeley. In Greeley, the flood plain is moderately developed. Fourteen bridges, roadways and vegetation can obstruct flood flows. Continued growth in Greeley (1970 population 38,902, projected 1990 population 75,000) is expected to exert further development pressure on the flood plain. Greeley presently has zoning ordinances which restrict development within an area less than 200 ft from the centerline of the river. Flooding can occur from May to September as the result of intense rainfall. Snowmelt can augment floodflows in May, June and July. Typically, floods will peak within 4 days of an intense rainfall and will last several days. Flooding in June 1965 with a peak discharge of 3,480 cubic feet per second did $700,000 damage to rural areas in the Poudre basin and $85,000 damage in the vicinity of Greeley. Standard project flood and the intermediate regional flood will have peak discharge of 29,000 and 9,000 cfs respectively at the 25th Ave. bridge.

1080. U.S. [Army] Corps of Engineers, 1978, Flood plain information; South Platte River and Pawnee Creek, Sterling, Colorado: Omaha, Nebr., Department of the Army, Prepared for Logan County and the Colo. Water Conservation Board, 40 p.

1081. U.S. [Army] Corps of Engineers, [1973?], Metropolitan Denver and South Platte River and tributaries--Colorado, Wyoming, and Nebraska; Vol 1. Summary Report: Omaha, Nebr., Department of the Army, 980 p.

1082. U.S. [Army] Corps of Engineers, 1973, Metropolitan Denver and South Platte River and tributaries-Colorado, Wyoming, and Nebraska; Preliminary draft plan of study: Omaha, Nebr., Department of the Army, 66 p.

1083. U.S. [Army] Corps of Engineers, 1975, Needs identification and supplement to the plan of study: Metropolitan Denver and South Platte River and tributaries - Colorado, Wyoming, and Nebraska; Water and related land resources management study: Omaha, Nebr., Department of the Army, 106 p.

1084. U.S. [Army] Corps of Engineers, 1972, Review report South Platte River and tributaries-Colorado, Wyoming, and Nebraska: Omaha, Nebr., Department of the Army, v. 1, Interim report on Bijou Creek, Colorado.

1085. U.S. [Army] Corps of Engineers, 1950, South Platte River basin, Cherry Creek Reservoir, Colorado; Reservoir regulation manual: Omaha, Nebr., Department of the Army, variously paginated.

1086. U.S. [Army] Corps of Engineers, 1973, An urban regional study; Water and related land resources; Metropolitan Denver, South Platte River and tributaries, Colorado, Wyoming, and Nebraska. Plan of study: Omaha, Nebr., Department of the Army.

1087. U.S. [Army] Corps of Engineers, 1975, Water and related land resource management study--Metropolitan Denver and South Platte River and tributaries-Colorado, Wyoming, and Nebraska: Omaha, Nebr., Department of the Army.

1088. U.S. [Army] Corps of Engineers, 1977, Water and related land resource management study, Metropolitan Denver and South Platte River and tributaries-Colorado, Wyoming, and Nebraska: Omaha, Nebr., Department of the Army, Vol. II, Background information; Vol. V, Supporting technical reports appendices; App. D, Characteristics and problems of the water supply system--Main report and appendix; App. E, Mountain and eastern plains water-quality study; App. F, USGS mine drainage study; App. H, Hydrology; App. J, Water supply management analysis and alternative development; Vol. 1, Main report - Water supply - Demand analysis; Vol. 2, Technical app., Water supply analysis, variously paginated.

1089. U.S. Department of Agriculture, and Colorado State University Experiment Station, 1980, Important farmlands of Colorado. State summary and map: U.S. Soil Conservation Service Special Series 17, variously paginated.

1090. U.S. Department of Energy, 1986, Environmental Assessment: Warren Air Force Base 115-KV Transmission Line, Cheyenne, Wyoming: Washington, D. C., Western Area Power Administration, DOE/EA-0291, 47p.

The Western Area Power Administration (Western), is proposing to construct a new electrical transmission line and substation in southeastern Wyoming. This proposed line, called the Warren Air Force Base Transmission Line, will supply power for Western's system to Francis E. Warren Air Force Base (F.E. Warren AFB) near Cheyenne. It would allow for increased transmission capacity to the air base. F.E. Warren AFB currently is served electrically by Western via a 13.8-kV line. It is a wood-pole, double-circuit line without an overhead ground wire, which extends from Western's Cheyenne Substation, through an urban area, and onto the air base. The Cheyenne Substation is located on the south side of the city of Cheyenne. The electrical load on the base is increasing from 4 megawatts (MW) to 11 or 12 MW, an approximate threefold increase. Voltage problems occasionally occur at the base due to the present electrical loads and to the age and inadequacy of the 13.8-kV line, which was placed in service in 1941. The existing line has served beyond its designed service life and requires replacement. Replacement would be necessary even without an increasing load. F.E. Warren AFB has several new and expanding programs, including additional housing, shopping centers, and the Peacekeeper Missile Program. Part of this expansion already has occurred; the remainder is expected by early 1988. This expansion has created the need for additional electrical service. The present 13.8-kV line is not capable of supporting the additional load. 28 refs., 4 figs., 2 tabs.

1091. U.S. Department of Health, Education, and Welfare, 1963, Conference on the matter of pollution of the South Platte River basin, October 29, 1963: Denver, Colo., U. S. Public Health Service.

1092. U.S. Department of Health, Education, and Welfare, 1965, Ground- water pollution in the South Platte River valley between Denver and Brighton, Colorado: U. S. Public Health Service

1093. U.S. Department of the Interior, 1966, Appendix D - Meat industry water study (supplement to: A Study of Industrial Water Pollution in the South Platte River Basin): Denver, Colo.

1094. U.S. Department of the Interior, 1966, Appendix B - Industrial plants visited and not sampled (supplement to: A Study of Industrial Water Pollution in the South Platte River Basin): Denver, Colo.

1095. U.S. Department of the Interior, 1966, Appendix C - Outfall study; location and sampling results (supplement to: A Study of Industrial Water Pollution in the South Platte River Basin): Denver, Colo.

1096. U.S. Department of the Interior, 1966, Appendix A - Industrial plants visited and not sampled (supplement to: A Study of Industrial Water Pollution in the South Platte River Basin): Denver, Colo.

1097. U.S. Environmental Protection Agency, 1972, Bacteriological investigations of the upper South Platte River basin. May 1972, July 1972, September 1972: Denver, Colo., Technical Support Branch, Report S and A-TSB-6, 46 p.

Bacteriological surveys were carried out in mid-1972 to determine weather present fecal and total coliform levels in the South Platte River above Denver, Colorado, comply with standards required for a proposed B3 reclassification to permit body contact water recreation (swimming and inner-tube floating). Fecal coliforms exceeded the Class B3 standards at one of four stations in May, four of 19 stations in July, and one of seven in September. Total coliforms were exceeded at no stations in May, one of 19 in July, and one of seven in September. Violations, attributed to storm runoff, can be eliminated, except during major runoff periods, by: (1) controlling the periodic discharge from the Centennial Racetrack horse barns by diversion into a leaching pond; and (2) construction of a settling pond for removal of suspended solids from wastewater from the Kassler Water Treatment Plant filter sand-washing operation. The proposed reclassification area extends from Union Avenue in Littleton, Colorado, to Waterton, Colorado. Class B3 standards require total coliform density not to exceed 1000/100 ml average per month, nor to exceed this figure in 20% of samples; the single sample maximum is 2400/100 ml. Fecal coliforms shall not exceed 100/100 ml, and fecal streptococcus shall not exceed 20/100 ml; both are monthly sample averages. Bear Creek, which joins the South Platte downstream of the study area, was also sampled.

1098. U.S. Environmental Protection Agency, 1972, Evaluation of the effectiveness of chlorination at the Littleton Wastewater Treatment Plant Littleton, Colorado, May 15-23, 1972: Denver, Colo., Technical Support Branch, SA/TSB-3, 35 p.

The purpose of this study is to evaluate the effectiveness of chlorination at the Littleton plant in providing satisfactory disinfection before discharge to the South Platte River. An evaluation was also made of chlorine residuals downstream from the Littleton outfall.

1099. U.S. Environmental Protection Agency, Region VIII, 1977, Final environmental impact statement: Water-quality management plan for El Paso and Teller Counties, Colorado: Denver, Colo., Report EPA-908/5-77-004, 35 p.

This EIS uses a modification of the standard EIS format because the water-quality management plan developed by the Pikes Peak Area Council of Governments (PPACG) includes the requirements of NEPA as an integral part of the plan. NEPA requirements were integrated into the planning process, with EPA personnel participating in the plan's development. This EIS consists of the following documents: a summary of the significant environmental issues and EPA's recommended course of action; a summary of the PPACG water-quality management plans; a study of land use alternatives considered in the plan; and a summary report of an environmental resource study prepared by PPACG. EPA's certification of the State's official water-quality resource management plan for El Paso and Teller Counties was conditioned on the resolution of the following issues: stream classification, sludge handling facilities, effluent monitoring, stream monitoring, re-evaluation of stream classification and water-quality criteria exceptions, State action on stream classification and water-quality criteria, priorities for construction grants, population projections, the management agency for the Upper Fountain Subbasin, and local ratification of the 208 plan. The report presents in detail a statement of each issue relating to the water-quality management plan for the two counties, and EPA's recommended action and rationale. Finally, comments on the draft EIS and EPA responses are included.

1100. U.S. Environmental Protection Agency, 1972, Longmont Wastewater Treatment Facility, Longmont, Colorado. Technical assistance project, Mar.-May 72: Denver, Colo., Technical Support Branch, SA/TSB-2, 30 p.

The purpose of the report is to summarize the results and findings of the technical assistance project that was conducted at the Longmont, Colorado, waste water treatment facility. The initial objective to improve the plant's operations and the effluent quality was successful to a degree and is documented in this report.

1101. U.S. Environmental Protection Agency, 1990, Recommended determination to prohibit construction of Two Fork Dam and Reservoir Pursuant to Section 404(c) of the Clean Water Act: Denver, Colo.

1102. U.S. Environmental Protection Agency, 1972, Summary of plant evaluation city, and County of Denver's Northside Wastewater Treatment Facility, August-September 1972: Denver, Colo., Technical Support Branch, SA/TSB-7, 18 p.

The purpose of the evaluation was to determine through discussions with the personnel involved with the Denver Northside Wastewater Treatment Plant, whether or not the facility was being operated and maintained satisfactorily to achieve the best protection for the waters of the South Platte River. The evaluation of the Northside plant led into areas including: industrial wastes, plant operations, administrative controls, sewer ordinances, etc.

1103. U.S. Environmental Protection Agency, 1974, Summary report on the long-term water quality of the South Platte River Basin 1966-1972: Denver, Colo., Technical Investigations Branch, EPA-908/2-74-002; SA/TIB-19, 141p.

An analysis of water quality data from 21water-quality surveillance stations located in the South Platte River Basin of Colorado was conducted. The data collected from 1968 through 1972 indicate significant deterioration of surface water quality in the Denver Metropolitan Area. Total and fecal coliform concentrations have increased by two to three orders of magnitude in recent years along with increased BOD5 concentrations, and dissolved-oxygen concentrations have sometimes dropped below acceptable limits (less than 5 mg/l). The analysis indicates a need to improve water-quality with respect to these parameters in order to achieve proposed water-quality objectives. A monitoring system is proposed to improve data reliability and provide information on previously undefined variables.

1104. U.S. Environmental Protection Agency, 1986, Superfund record of decision (EPA Region 8): Marshall Landfill Site, Boulder County, Colorado, September 1986. Final report: Washington, D.C., EPA/ ROD/R08-86/008, 57p.

The Marshall Landfill accepted unstabilized sewage sludge and many unidentified and potentially hazardous wastes. Septic wastes and liquid industrial wastes were also disposed offsite in two, now closed, septic ponds. The primary contaminants of concern include: VOCs including TCE, PCE, DCE, and benzene, and heavy metals including cadmium and lead. The selected remedial action includes: installation of a subsurface collection system using natural ground water gradients to collect all contaminated ground water leaving the Marshall Landfill site; treatment of contaminated ground water by sedimentation, air stripping, and off-gas carbon adsorption; landfill improvements, including regrading, revegetation, perimeter ditches, and fences, to minimize future environmental and public health impacts from the site, and ground and surface water monitoring.

1105. U.S. Environmental Protection Agency, 1987, Superfund record of decision: Central City/Clear Creek, Colo.: Washington, D.C., Office of Emergency and Remedial Response, Report EPA/ ROD/ R08-87/018, 159 p.

The Clear Creek/Central City site encompasses portions of Clear Creek County and Gilpin County in the Colorado mineral belts, Colo. More specifically, the focus is on five abandoned mines/tunnels proximal to the cities of Idaho Springs, Black Hawk and Central City and the influence of acid mine drainage from those tunnels on adjacent stream courses. Surface water contamination results from acid mine drainage emanating from the five tunnels and from seepage of groundwater through tailings piles both proximal to these tunnels and along stream courses. Approximately 1,200 lbs/day of dissolved and suspended metals are discharged to the Clear Creek drainage from the five mine tunnels. These dissolved and suspended metal loadings have resulted in a significant depletion of aquatic life and have potential impact to sediments and downstream users of surface and groundwater. There are ten contaminants of concern including aluminum, arsenic, cadmium, chromium, copper, fluoride, lead, manganese, nickel, silver and zinc. The selected interim remedy for this site includes: construction of passive treatment systems to treat mine tunnel discharge prior to discharge to surface water. This is the preferred alternative and is contingent

upon results of ongoing pilot plant studies. If water-quality concentrations cannot be achieved by passive treatment, either a combination system of passive and active treatment systems will be constructed or two active treatment systems (chemical precipitation or electrochemical precipitation) will be constructed to treat mine tunnel discharge. The estimated capital cost for passive treatment only is $1,663,000 with annual operation and maintenance costs of $115,000.

1106. U.S. Environmental Protection Agency, 1990, Superfund record of decision (EPA Region 8): Rocky Mountain Arsenal (Operable Unit 23), Adams County, Colorado (Seventh Remedial Action), Final Draft: Washington, DC., Office of Emergency and Remedial Response, EPA/ROD/R08-90/042, 76 p.

The 17,000-acre Rocky Mountain Arsenal (RMA) (Operable Unit 23) site is a former U.S. Army chemical warfare and incendiary munitions manufacturing and assembly plant in Adams County, Colorado. Operable Unit 23 (OU23), the Shell Section 36 Trenches, is one of several areas being addressed as part of the Other Contaminated Sources Interim Remedial Action. Approximately 31 trenches occupy an 8-acre area of Section 36 in the central portion of the RMA. From 1952 to 1965, liquid and solid waste including bulk or drummed process intermediates, off-specification product, laboratory sample filters, and other debris from the manufacture of pesticides was disposed of and buried in the trenches. Investigations by the Army from 1987 through 1989 have identified ground water contamination in a surficial unconsolidated sand aquifer underlying the site. A plume of dense non-aqueous phase liquids (DNAPLs) was also detected and is believed to have originated from the Shell Section 36 trenches. The primary contaminants of concern affecting the soil and ground water are VOCs and other organics including pesticides.

1107. U.S. Environmental Protection Agency, Region VIII, 1972, Accomplishment Plan - Water Quality. South Platte River Basin: Denver, Colo., 122 p.

The South Platte River Basin has been selected as one of Region VIII's highest priority areas for an abatement and control program. The basin encompasses the largest metropolitan area in the region (Denver) as well as major portions of the urbanizing Front Range in Colorado. A program is defined to achieve by 1976 existing dissolved oxygen and bacteria standards and to upgrade the quality of specific reaches of the basin.

1108. U.S. Environmental Protection Agency, Region VIII, 1972, Accomplishment Plan, South Platte River Basin - Denver Area: Denver, Colo., 56 p.

A strategy to obtain recreation use classification upstream from Denver and a public water supply classification for the entire main stem is discussed.

1109. U.S. Environmental Protection Agency, Region VIII, 1973, Metropolitan Denver Sewage Disposal District No. 1. Commerce City, Colorado. Project No. C80317, and C080327 Draft environmental impact statement: Denver, Colo., ELR-73-1700, 209 p.

The wastewater treatment plant of the Metropolitan Denver Sewage Disposal District No. 1 (Metro) is located adjacent to the South Platte River in Commerce City, CO. Metro is responsible for providing sewage treatment service to a major portion of the

Denver metropolitan area. The present Metro treatment plant has a total capacity of 98 million gallons of sewage per day (mgd) to meet 1978 effluent standards. The proposed project at the present plant site would increase the treatment plant's capacity by 70 mgd, to provide a total treatment capacity of 168 mgd. New systems to be added include: modification of existing secondary scum clarifiers, four 150-foot-diameter primary clarifiers, ten 140-foot-diameter secondary clarifiers, a pure oxygen aeration system and facilities for mechanical screening, grit removal, sludge pumping and treatment, and chlorination. These additions would be located south of the existing plant facilities in the area presently occupied by the ash lagoons. The effluent from the proposed plant expansion would discharge into the South Platte River at the present plant outfall site. Environmental impacts include water quality; an improvement in the aquatic environment of the river and consequent enhancement of recreational and aesthetic values; and some odor and noise problems.

1110. U.S. Environmental Protection Agency, Region VIII, 1972, South Platte River Basin Accomplishment Plan: Denver, Colo., 174 p.

This Accomplishment Plan applies to the headwaters of the South Platte River Basin near the Colorado/Nebraska border, covering 350 main stem stream miles plus 469 tributary stream miles. The basin encompasses Denver and surrounding counties, containing the largest metropolitan area in Region VIII. Municipal discharges and wastes from sugar-beet processing plants and other industrial operations are the major waste sources. Present Colorado wastewater treatment plant standards are not adequate to meet ambient stream standards in most areas. The report discusses pollutant loadings, water-quality standards, and tactical solutions to pollution problems so that water quality in the basin would meet proposed standards by July 1, 1976. Tables of basin load summaries are presented listing 5 day BOD and coliform levels, proposed decreases of these levels over FY's 73- 76, water-quality objectives, and the year in which the minimum acceptable water-quality levels are to be achieved. A chronological ordering of planned accomplishments is shown outlining specific actions EPA officials should take to insure adequate water quality in the region. Principal point source loads and locations are listed along with the type and amount of pollutant each source discharges. Tactical solutions are offered based on particular situations and problems with a timetable and manpower schedule for instituting the proposed solutions. The report ends by listing each discharger and the schedule for pollution reduction levels required by each to meet ambient water-quality standards by July FY '76.

1111. U.S. Environmental Protection Agency, Region VIII, 1972, Technical appendix on municipal waste-source evaluations--Water-quality investigations in the South Platte River basin, Colorado 1971-1972: Office of Enforcements.

1112. U.S. Environmental Protection Agency, Region VIII, 1977, Wastewater facilities and the Clean Water Program. Appendices Denver regional environmental impact statement: Denver, Colo., 141 p.

Contents: Supplemental information on existing environment; Growth-induced impacts on the region's environmentally sensitive area; Clean water plan; Technical report summary draft clean water program.

1113. U.S. Environmental Protection Agency, Region VIII, 1977, Wastewater facilities and the Clean Water Plan Denver regional environmental impact statement, draft: Denver, Colo., 303 p.

Contents: Introduction--(Background, actions under consideration in this EIS, the need for this EIS, the options available in this EIS, the objectives of this EIS, and report organization); The existing environment--(Situation and description of the Denver region, environmental sensitivities, and socio-economic environment); The proposed projects and alternatives--(Proposed projects, background, EIS alternatives - point sources, alternatives to stream discharge, and clean water plan management alternatives); Probable environmental impacts--(Socio-economic impacts, cost considerations, land use change to the year 2000, conversion of agricultural lands, air quality impacts, water quality, growth-induced impacts on the region's environmentally direct environmental impacts); Mitigation measures--(Mitigation measures for socio-economic impacts, mitigation measures for air quality, mitigation of water-quality impacts, mitigation of agricultural impacts, mitigation of energy impacts, mitigation measures for adverse growth-induced impacts, and mitigation measures for direct impacts); Unavoidable adverse impacts--(Regional unavoidable adverse impacts, and unavoidable adverse impacts of wastewater facility construction and operation); Local short-term uses versus maintenance and enhancement of the long-term productivity of the environment; Irreversible and irretrievable commitment of resources; Coordination and public involvement; Significant issues to be resolved.

1114. U.S. Environmental Protection Agency, Region VIII, 1977, Wastewater facilities and the Clean Water Program Denver regional environmental impact statement, Draft Summary: Denver, Colo., 42 p.

Topics discussed in this report include the following: The need for this EIS, Actions under consideration in this EIS, Environmental impacts, Mitigation of impacts, Major unavoidable adverse impacts, and, Significant issues to be resolved.

1115. U.S. Environmental Protection Agency, Region VIII., 1978, Wastewater facilities and the Clean Water Program. Volume 1. Issues and actions Denver regional environmental impact statement (Final): Denver, Colo., EPA/908/5-77/001A, 108 p.

This is the final environmental impact statement (EIS) prepared by EPA for the Denver Region concerning actions to be taken on 10 wastewater facility plans and the Denver Clean Water Plan (208 Plan). This EIS addresses the regional effects of these projects and the 208 Plan considering both direct and secondary impacts. Emphasis is given to the regional and cumulative impacts of population growth and development through the year 2000 which these projects and plans anticipate. The regional impacts on air quality, water quality, recreation, sensitive lands, agriculture, economy, and energy are examined. Volume 1 addresses the most important issues and EPA proposed actions.

1117. U.S. Federal Highway Administration, 1971, Project I-80-1(8A), Kimball Southeast-Dix. Kimball County, Nebraska. Project I-80-1(9), Dix-Potter, Kimball and Cheyenne Counties, Nebraska, and Project S-590-B, Dix Spur, Kimball County, Nebraska. Final environmental impact statement: Lincoln, Nebr., ELR-1541, 38 p.

Projects I-80-1(8) and I-80-1(9) represent 14.5 miles of construction of Interstate 80 in Kimball and Cheyenne Counties, Nebraska. Acquisition of 400 acres of right of way will be required for the construction. Relocation impacts on wildlife are unavoidable but they are expected to minimal and many of them temporary. Water pollution during construction is unavoidable. Grading will expose large areas of soil. There will be some increase in noise level. Acquisition will be required of an abandoned beef processing plant and water well at one site and the removal of a barn, machine shed-granary, and two storage buildings at another. Relocation is necessary of an electrical substation located in proximity of the Dix interchange.

1118. U.S. Federal Highway Administration, 1971, Project I-80-1(10), Potter-Brownson, Cheyenne County, Nebraska, and Project S-921(3), Potter South to I-80, Cheyenne County, Nebraska. Final environmental impact statement: Lincoln, Nebr., ELR-1388, 31 p.

The project represents 8.5 miles of construction of Interstate 80 in Cheyenne County, Nebraska. Acquisition of right of way will be required since the construction of both the Interstate and the spur road is on new alignment. Relocation impacts on wildlife are unavoidable in construction on new alignment. These impacts are expected to be minimal and many of them temporary. Water pollution during construction is unavoidable. Grading will expose large areas of soil. Severe roadway cuts will be incorporated. An existing retention dam will require relocation.

1119. U.S. Federal Highway Administration, 1971, Project I-80-1(8), Kimball Southeast-Dix. Kimball County, Nebraska. Project I-80- 1(9), Dix-Potter, Kimball and Cheyenne [Counties?], Nebraska, and Project S- 590-B, Dix Spur, Kimball County, Nebraska. Draft environmental impact statement: Lincoln, Nebr., 34 p.

Two projects represent 14.5 miles of construction of Interstate 80 in Cheyenne County, Nebraska. Relocation impacts on wildlife are unavoidable in construction on new alignment. Water pollution during construction is unavoidable. Grading will expose large areas of soil. Acquisition of an abandoned beef processing plant and a water well, and removal of a barn and vacant basement dwelling, will be required.

1120. U.S. Federal Highway Administration, 1971, Project S37(11), Paxton South to I-80, Keith County, Nebraska. Draft environmental impact statement: Lincoln, Nebr., 16 p.

Project S-37(11) represents 1.0 mile of proposed construction along the existing horizontal alignment of the spur road connecting Interstate 80 and U.S. Highway 30. The project will essentially consist of: construction of a new 40-foot roadway bridge spanning the South Platte River, grading, drainage structures and surfacing. Some disruption of the local ecology is inevitable, since the construction and new right of way will take lands from the game habitats. To some extent, vehicular traffic and increased noise levels may reduce the effective area of the habitats in the area of the taking. As traffic increases, the noise level will understandably increase. However, inasmuch as the proposed improvement lies along the existing location, the

improvement proper will not materially shift or affect the noise level. School bus routes, farm-to-market facilities, fire routes will not be affected by the improvement. Wildlife in the area will not be adversely affected by the improvement. There will be no adverse effect on the water table and the improvement will not present the possibility of contamination of the public water supply treatment facility of distribution system. In general, there will be no disruption of the ecological balance of land or water area. There are no probable adverse environmental effects which cannot be avoided if this project is implemented.

1121. U.S. Federal Highway Administration, 1972, Project F-287-3(3), Central Fort Collins Expressway. Draft environmental impact statement: Denver, Colo., Colorado Div. Prepared in cooperation with Colorado Division of Highways, ELR-5210, 75 p.

Construction of an 8-9 mile section of highway near Fort Collins, Colorado, is proposed to relieve congestion on U.S. 287. The environmental impact is complex. It would include, among others, an impact on wildlife, land use and community values, noise, air pollution, and the displacement of families.

1122. U.S. Federal Highway Administration, 1972, Project S-406(6), Brule Connecting Link Road Improvement of Nebraska L-51A, Between Interstate 80 and U.S. Highway 30, Keith County, Nebraska. Draft environmental impact statement: Lincoln, Nebr., ELR-5089, 19 p.

The proposed improvement represents about 0.76 miles of highway construction beginning at the Brule Interchange on Interstate 80 and proceeding north to U.S. Highway No. 30 at the village of Brule, Nebraska. The project consists of (1) the improvement of a segment of highway, designated Nebraska Highway No. L-51A, and (2) the lengthening and widening of the existing bridge spanning the South Platte River. A summary of environmental impact and adverse environmental effects is given.

1123. U.S. Federal Highway Administration, 1972, Project S-568(5), Hershey Connecting Link Road Improvement of Nebraska L-56C, Between Interstate 80 and U.S. Highway 30, Lincoln County, Nebraska, Final environmental impact statement: Lincoln, Nebr., ELR-5082, 44 p.

The proposed highway improvement involves the reconstruction of a highway segment, designated Nebraska Highway No. L-56C, between U.S. Highway No. 30 on the north edge of Hershey and Interstate Highway 80 south of Hershey, and construction of a new bridge over the South Platte River. Adverse and beneficial environmental effects are briefly described.

1124. U.S. Federal Highway Administration, 1972, Project I-80-1(11), Brownson, West Sidney, Brownson Interchange; Project I-80-1(12), West Sidney Interchange; Project S-259(4), Brownson Connecting Link Road; Project S-620-A, West Sidney Connecting Link Road, Cheyenne County, Nebraska. Final environmental impact statement: Lincoln, Nebr., ELR-4879, 33 p.

The report describes the proposal for the Projects I-80-1(11) and I-80-1(12) which represents 10.70 miles of construction of Interstate 80 from Brownson to Sidney in Cheyenne County, Nebraska. Construction begins at the north-south section line common to Sections 9 and 10 of Township 14 North, Range 51 West of the 6th. P.M. and terminates at north-south section line common to Section 12 of Township 13

North, Range 50 West of the 6th. P.M. and Section 7 of Township 13 North, Range 49 West of the 6th. P.M. Project S-259(4) represents 1.69 miles of construction of a connecting road from the Interstate 80 interchange southwest of Brownson northeast to the intersection of U.S. 30 and the Ordville Spur Road. Project S-620-A represents 1.85 miles of construction of a connecting road from the Interstate 80 interchange approximately 2 miles southwest of Sidney north to its intersection with U.S. 30. A summary of environmental impacts and adverse effects is given.

1125. U.S. Federal Highway Administration, 1972, Project I-80-2(41), Sidney Airport-East Sidney Interchange, Cheyenne County, Nebraska, and Project F-130(15), Sidney South, Cheyenne County, Nebraska Final environmental impact statement: Lincoln, Nebr., ELR-4132, 357 p.

The interchange project represents a 3-mile segment of Interstate 80 in Cheyenne County, Nebraska. Acquisition of right of way will be required. Relocation impacts on wildlife are unavoidable but are expected to be minimal. Water pollution during construction is unavoidable. An existing business will be displaced, and a number of utilities will require adjustments or revisions.

1126. U.S. Federal Highway Administration, 1972, Project I-80-1(11), Brownson-West Sydney, Brownson Interchange, Project I-80-1(12), West Sydney-Sidney Interchange, Project S-259(4), Brownson Connecting Link Road, Project S-620-A, West Sydney Connecting Link Road, Cheyenne County, Nebraska. Draft environmental impact statement: Lincoln, Nebr., ELR-1685, 28 p.

Two projects represent 11 miles of construction of Interstate 80 in Cheyenne County, Nebraska. Relocation impacts on wildlife are unavoidable but expected to be minimal and many temporary. Water pollution during construction is unavoidable. Grading will expose large areas of soil. There will be an increase in ambient noise level and exhaust emissions.

1127. U.S. Federal Highway Administration, 1972, Projects in the Vicinity of Laramie in Albany County, extending westerly on Highways 230 and 130, from Clark Street Viaduct in Laramie to the vicinity of General Brees Municipal Airport. Draft environmental impact statement: Cheyenne, Wyo., ELR-5011, 42 p.

The report describes the statement, prepared in connection with Projects S-0103(9), Laramie-Centennial Road; S-0100(8), Laramie-West Road; and SU-0100(9), Laramie Streets; all in Albany County. Three projects are combined in this statement as they are inter-related, forming the principal westerly transportation artery for the city of Laramie from the west end of Clark Street viaduct over the Laramie River through West Laramie to General Brees Municipal Airport, a distance of approximately 7 miles. Projects SU-0100(9) and S-0103(9) are on new alignment, passing through undeveloped or uninhabited areas; while project S-0100(8) follows the existing roadway (requiring no additional right of way) through a quasi-commercial development. A brief summary of adverse and beneficial environmental effects is included.

1128. U.S. Federal Highway Administration, 1973, Project S-30-2(102)151 (Formerly S-406(6)), Brule Connecting Link Road Improvement of Nebraska L-51A Between Interstate 80, and U.S. Highway 30, Keith County, Nebraska Final environmental impact statement: Lincoln, Nebr., FHWA-NEB-EIS-72-13-F; ELR-0528, 49 p.

The proposed improvement represents about 0.76 miles of highway construction beginning at the Brule Interchange on Interstate 80 and proceeding to U.S. Highway 30 at the village of Brule, Nebraska. The project consists of (1) the improvement of a segment of Nebraska Highway L-51A, and the lengthening and widening of the existing bridge spanning the South Platte River. Acquisition of additional right of way will be necessary to accommodate design and safety features that will be incorporated into the proposed improvements. The proposed improvement will not require relocation of residences or places of business. Relocation impacts on wildlife are unavoidable, but most of the effects will be minimal and temporary.

1129. U.S. Federal Highway Administration, 1973, Projects in the vicinity of Laramie in Albany County, extending westerly on Highways 230 and 130 from Clark Street Viaduct in Laramie to the vicinity of General Brees Municipal Airport, Wyoming. Final environmental impact statement: Cheyenne, Wyo., FHWA-WYO-EIS-72- 04-F; ELR-0900. Supersedes report dated Jul 72, EIS-WY-72-5011-D. Prepared in cooperation with Wyoming State Dept. of Highways, 57 p.

Three projects are combined in this statement as they are all related to the westerly transportation artery of the city of Laramie for a distance of approximately 7 miles. Two are on new alignment, passing through undeveloped or uninhabited areas; the third follows an existing roadway through a quasi-commercial development. Environmental impacts, all of minor importance, are centered mainly around the new location of the roadway.1116.U.S. Federal Water Pollution Control Administration, [n.d.], Beet-sugar industry--the water pollution problem and status of waste abatement and treatment: Denver, Colo., South Platte River Basin Project, PR-8.

1130. U.S. Federal Highway Administration and Colorado State Div. of Highways, 1973, South Kipling Street from S.H. 26 (West Alameda Avenue), to S.H. 285 (West Hampden Avenue), City of Lakewood, Jefferson County, Colorado. Draft environmental impact statement: Denver, Colo., FHWA-CO-EIS-73-02-D; ELR-0401, 141 p.

The project proposes design and construction of a 4.3-mile segment of South Kipling Street to connect the U.S. 6-Kipling Interchange. The construction of this segment of South Kipling Street will affect the residential and small commercial development now existing, the economic activity in the area, land use, environment, ecology, and esthetics of the immediate area along the route, more as a part of long range planning than as an undesirable encroachment. There are four alternatives considered.

1131. U.S. Federal Water Pollution Control Administration, 1966, Conference in the matter of pollution of the South Platte River basin in the State of Colorado. 2d Session, Denver, Colorado. Reconvened on November, 10, 1966. Proceedings: Denver, Colo., South Platte River Basin Project, 180 p.

The session of the conference in the matter of pollution of the navigable waters of the South Platte River Basin within the State of Colorado is being held under the provisions of Section 10 of the Federal Water Pollution Control Act, as amended. Governor Love requested a conference on July 18, 1963, and conference sessions have been held on October 29, 1963, and April 27-28, 1966.

1132. U.S. Federal Water Pollution Control Administration, 1966, Conference in the matter of pollution of the South Platte River basin in the State of Colorado. 2d Session, Denver, Colorado, April 27 and 28, 1966. Proceedings. Volume I: Denver, Colo., South Platte River Basin Project, 282 p.

The purpose of the conference is to bring together representatives of the State Water Pollution Control Agency, representatives of the U.S. Department of Health, Education, and Welfare, and other interested parties to review the existing situation, the progress which has been made, to lay a basis for future action by all parties concerned, and to give the State, localities and industries an opportunity to take any indicated remedial action under State and local laws.

1133. U.S. Federal Water Pollution Control Administration, 1966, Conference in the matter of pollution of the South Platte River basin in the State of Colorado. 2d Session, Denver, Colorado, April 27 and 28, 1966. Proceedings. Volume II: Denver, Colo., South Platte River Basin Project, 331 p.

The report continues the proceedings of a conference on the South Platte's water quality in Colorado.

1134. U.S. Federal Water Pollution Control Administration, 1966, Conference in the matter of pollution of the South Platte River basin in the State of Colorado. 2d Session, Denver, Colorado, April 27 and 28, 1966. Proceedings. Volume III: Denver, Colo., South Platte River Basin Project, 335 p.

The report presents results on the following: Determine the legitimate water uses and locate the sources of pollution having an adverse effect on those uses; Through field investigations determine the physical, chemical, and biological responses of the river to pollution and evaluate the previously located sources of pollution with respect to the conditions in the river; and Compute the waste load reductions necessary to obtain desired water quality and recommend water-quality control measures needed to effect the desired waste load reductions.

1135. U.S. Federal Water Pollution Control Administration, 1967, Effects of pollution on the aquatic life resources of the South Platte River Basin Rept. from July 63-Jan. 67: Denver, Colo., South Platte River Basin Project, PR-11, 170 p.

The report contains the results of biological studies undertaken in the South Platte River Basin during the period of July 1963 through January 1967.

1136. U.S. Federal Water Pollution Control Administration, 1967, Effects of pollution on aquatic life resources of the South Platte River Basin in Colorado. Volume II. Technical Appendix Rept. for July 63-Jan. 67: Denver, Colo., South Platte River Basin Project, PR-11A, 93 p.

The report contains the various biological samples taken for the biological studies in the South Platte River Basin during the period from July 1963 through January 1967.

1137. U.S. Federal Water Pollution Control Administration, 1965, Ground water pollution in the South Platte River Valley between Denver and Brighton, Colorado: Denver, Colo., South Platte River Basin Project, PR-4, 71 p.

The investigation of ground-water conditions in the South Platte River Valley between Denver and Brighton in southwest Adams County was undertaken as a part of the water pollution study of the Denver metropolitan area currently being conducted by the South Platte River Basin Project. Ground water is used extensively in the area for public, domestic, industrial and irrigation supplies. The principal source of large ground-water supplies is the shallow valley-fill deposits which are very susceptible to contamination. The rapidly expanding urban and industrial growth of the area has resulted in continued development of water supplies from ground-water sources. The purpose of the ground-water study was to determine sources and extent of pollution in the water-bearing formations in the area. In assessing these conditions, the geology and water-bearing characteristics of the aquifers were considered.

1138. U.S. Federal Water Pollution Control Administration, 1967, Ground-water pollution in the middle and lower South Platte River basin of Colorado: Denver, Colo., South Platte River Basin Project, PR-9, 126 p.

On July 18, 1963, the Governor of Colorado requested the Secretary of Health, Education, and Welfare to assist the State in determining sources of pollution and quality of waters of the South Platte River Basin within the State of Colorado. Findings and recommendations from this study were to lead to a program of pollution abatement to be developed jointly by the South Platte River Basin Project and the Colorado State Department of Public Health. Specific water-quality objectives were recommended for the South Platte River and its major tributaries.

1139. U.S. Federal Water Pollution Control Administration, [n.d.], Ground-water pollution in the South Platte River Valley between Denver and Brighton, Colorado: Denver, Colo., South Platte River Basin Project, PR-4.

1140. U.S. Federal Water Pollution Control Administration, 1967, Immediate water pollution control needs, South Platte River basin: Denver, Colo., South Platte River Basin Project, 41 p.

Immediate pollution control needs covering the interstate as well as the major intrastate streams in the South Platte River Basin in Colorado are described. The prime purpose of this report is to focus attention on known sources of pollution which affect legitimate and beneficial water uses, including the aesthetic environment of the streams. The findings, conclusions, and recommendations are based on detailed engineering studies. The immediate needs identified have to do with municipal waste sources, industrial waste sources, outfalls as sources of pollution, and cattle feedlots.

Institutional practices are discussed, along with the cost of immediate pollution control and abatement, and recent progress. A bibliography is included.

1141. U.S. Federal Water Pollution Control Administration, 1968, Mining waste evaluation study South Platte River Basin, Colorado: Denver, Colo., South Platte River Basin Project, 35 p.

The report represents one in a series of working documents prepared by The South Platte River Basin Project for the purpose of recognizing certain information not previously published by the project. This particular report gives representative data and findings and conclusions developed from the Mining Waste Evaluation Study of 1966-1967.

1142. U.S. Federal Water Pollution Control Administration, 1965, Municipal waste report, Metropolitan Denver area, South Platte River basin: Denver, Colo., South Platte River Basin Project, PR-3, 56 p.

The long-range goals and objectives of the project are: Determine the legitimate water uses and locate the sources of pollution having an adverse effect on those uses; Through field investigations determine the physical, chemical, and biological responses of the river to pollution and evaluate the previously located sources of pollution with respect to the conditions in the river; Compute the waste load reductions necessary to obtain desired water-quality and recommend water-quality control measures needed to effect the desired waste load reductions.

1143. U.S. Federal Water Pollution Control Administration, 1968, Outdoor recreation, South Platte River Basin, Colorado: Denver, Colo., South Platte River Basin Project, 26 p.

The current and future picture of outdoor recreation in the South Platte River Basin as it may relate to, or be dependent on, water and land management and pollution prevention policies pursued over the region is evaluated. The report reviews the general prerequisites and the outdoor recreation available in Colorado, provides information and statistics on the current status of the outdoor recreation industry, and discusses future recreation, emphasizing problems that must be solved in the coming years.

1144. U.S. Federal Water Pollution Control Administration, 1966, Pollution of the South Platte River Basin in the State of Colorado: Denver, Colo., U.S. Department of Interior, vols. 1, 2, 3.

1145. U.S. Federal Water Pollution Control Administration, 1966, Report to the 2nd Session of the Conference in the Matter of Pollution of the South Platte River Basin: Denver, Colo., South Platte River Basin Project.

Pollution problems and solutions in two geographic areas--the Denver Metropolitan Area and the middle and lower basin of the South Platte River and its major tributaries from Brighton to the Colorado-Nebraska border--are discussed. In the Denver area, information is presented in the sources of pollution and the effects of these waste loads on the area's streams, and recommendations for pollution abatement are given. The 2d session discusses Barr lake pollution problems, wastes from feedlot operations within the basin, and waste discharges from beet sugar mills. Recommendations to deal with these problems are presented.

1146. U.S. Federal Water Pollution Control Administration, 1968, Sand and gravel waste evaluation study, South Platte River basin, Colorado: Denver, Colo., South Platte River Basin Project, 30 p.

A limited study of sand and gravel companies located in the South Platte River Basin was undertaken at various times throughout 1965 and 1966. The broad objectives were to determine the location and type of gravel operations; industrial procedures employed; degree of treatment and means of disposing of liquid wastes from these establishments; and to assess the general pollution problems and remedial measures indicated as necessary for the industry.

1147. U.S. Federal Water Pollution Control Administration, [n.d.], South Platte River Basin river mileage index: Denver, Colo., South Platte River Basin Project, PR-1.

1148. U.S. Federal Water Pollution Control Administration, 1967, South Platte River basin irrigation of vegetables with sewage-polluted water: Denver, Colo., South Platte River Basin Project, PR-12, 76 p.

The possible health hazard resulting from irrigation with sewage-polluted water of vegetables normally consumed raw has long concerned public health officials. Conflicting opinions have evolved on the degree of danger caused by this practice. Commonly accepted objectives for sewage irrigation practices have not been developed, nor have there been established generally approved standards for the quality of irrigation water. In the South Platte River Basin downstream from and north of Denver to Brighton, Colorado, the largest use of water is for agriculture. In the area immediately north of Denver, many varieties of 'salad vegetables' were raised. At the time of this study, these vegetables were irrigated with polluted water diverted via four main supply ditches from the South Platte River just below entry of the Denver Northside sewage treatment plant effluent. Other inadequately treated municipal and industrial effluents contributed to the overall pollution in this vicinity. During 1963-64, a field sampling and laboratory analysis program was conducted on vegetables, the soils in which they were grown, and the waters with which they were irrigated. Samples of vegetables, soils, and waters were analyzed for three bacterial indices of pollution.

1149. U.S. Federal Water Pollution Control Administration, 1967, Status of municipal waste treatment of the South Platte River Basin, Colorado, 1964-1967: Denver, Colo., South Platte River Basin Project, 142 p.

The status of municipal waste treatment in the metropolitan Denver area and in the remainder of the South Platte River Basin, Colorado, is reported. A survey was made of municipal waste treatment facilities, including, in part, treatment systems operated by private organizations receiving domestic wastes from trailer courts, recreational facilities, food service establishments, etc., in order to determine sources of municipal waste discharges, quality of effluent, and general status of the communities relative to needs.

1150. U.S. Federal Water Pollution Control Administration, 1966, Study of industrial waste pollution in the South Platte River Basin. Appendix B. Industrial plants visited and not sampled: Denver, Colo., South Platte River Basin Project, PR-6B.

1151. U.S. Federal Water Pollution Control Administration, 1966, Study of industrial waste pollution in the South Platte River Basin. Appendix D. Meat industry and waste study. Supplement to basin report.: Denver, Colo., South Platte River Basin Project, PR-6D.

1152. U.S. Federal Water Pollution Control Administration, 1966, Study of industrial waste pollution in the South Platte River Basin. Appendix C. Outfall study, location and sampling results: Denver, Colo., South Platte River Basin Project, PR-6C.

1153. U.S. Federal Water Pollution Control Administration, 1966, Study of industrial waste pollution in the South Platte River Basin. Appendix A. Industrial plants visited and not sampled: Denver, Colo., South Platte River Basin Project, PR-6A.

1154. U.S. Federal Water Pollution Control Administration, 1950, Survey of sanitary facilities and pollution contributed to reservoirs and lakes of the Colorado-Big Thompson Project South Platte River District: Kansas City, Mo., Bureau of Reclamation, Missouri Basin Region, 35 p.

Results are presented of a survey made in August 1950 of sanitary facilities of Bureau of Reclamation installations and pollution contributed to reservoirs and lakes involved in the development of the Colorado-Big Thompson Project in order to observe sanitary defects and to make recommendations for their correction. Three general areas are considered: Lake Estes-Marys Lake, Shadow Mountain Lake-Cranby Reservoir, and Green Mountain Lake.

1155. U.S. Federal Water Pollution Control Administration, 1967, Water quality, middle basin tributary streams, South Platte River Basin, summer 1965: Denver, Colo., South Platte River Basin Project, PR-7, 69 p.

The primary objectives of the study were to: Develop knowledge of the water quality in the Cache la Poudre River, Big Thompson River, and St. Vrain Creek sub-basins during the summer months; Evaluate water quality in terms of present and future water uses; Determine water-quality control needs. It was important to determine water quality during a time when beet sugar factories were not operating; the masking effects of beet sugar wastes could be eliminated and other causes and effects analyzed.

1156. U.S. Fish and Wildlife Service, 1983, Fish and wildlife coordination report for the Narrows Unit, South Platte Division: Salt Lake City, Utah, Department of the Interior.

1157. U.S. Fish and Wildlife Service, 1981, The Platte River ecological study - special research report: Jamestown, N. Dak., U.S. Dept. of Interior Northern Prairie Wildlife Research Center.

1158. U.S. Fish and Wildlife Service, 1992, A proposal for Centennial National WIldlife Refuge along the South Platte River located in Morgan and Weld Counties, Colorado: Denver, Colo., Department of the Interior, 21 p.

1159. U.S. Geological Survey, 1971, Chemical quality of water in southeastern Wyoming: Water Resources Division, Basic data report, 67 p.

As a guide for water users, the U.S. Geological Survey, in cooperation with the Wyoming Natural Resource Board (now Department of Economic Planning and Development), compiled in this report chemical analyses, dating from 1895 to 1966, of

surface and groundwaters for southeastern Wyoming. The area consists of approximately 24,000 square miles and includes the drainage basins of the North Platte, South Platte, and Niobrara Rivers in Wyoming. Most of the area is in the North Platte River basin. The source of each analysis is shown in the tables of analyses. The substances determined by analytical methods and expressed as ions are the cations calcium, magnesium, sodium, and potassium, and the anions are sulfate, chloride, fluoride, nitrate, and those contributing to alkalinity, which are usually expressed in terms of an equivalent amount of carbonate and bicarbonate. Other substances determined, but not as routinely, are boron, chromium iron, manganese, phosphate, silica, and selenium. Other properties given in the analyses in this report are color, concentration of hydrogen ions, dissolved solids, hardness expressed in terms of equivalent quantities of calcium-bicarbonate, percent sodium, sodium-adsorption ratio, and specific conductance.

1160. U.S. Geological Survey, 1958, Compilation of records of surface waters of the United States through September 1950; Part 6-B, Missouri River Basin below Sioux City, Iowa: U.S. Geological Survey Water-Supply Paper 1310, 619 p.

1161. U.S. Geological Survey, 1980, Evaluating methods for determining water use in the High Plains in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming; 1979: U.S. Geological Survey Water-Resources Investigations Report 80-111, 125 p.

1162. U.S. Geological Survey, 1983, Hydrologic and geomorphic studies of the Platte River basin: U.S. Geological Survey Professional Paper 1277, various pagination.

1163. U.S. Geological Survey, 1979, Land use and land cover and associated maps for Denver, Colorado: U.S. Geological Survey Open-File Report, 4 sheets.

1164. U.S. Geological Survey, 1980, Land use and land cover, 1972-76, Greeley, Colorado: U.S. Geological Survey Map L-188, 1 sheet, scale 1:250,000.

1165. U.S. Geological Survey, 1980, Land use and land cover map, 1973- 78, Sterling, Colorado; Nebraska, Kansas: U.S. Geological Survey.

1166. U.S. Geological Survey, 1981, Land use and land cover and associated maps for Cheyenne, Wyoming, Nebraska, Colorado: U.S. Geological Survey Open-File Report, 4 sheets, scale 1: 250,000.

1167. U.S. Geological Survey, 1961-1991, Water resources data reports, Nebraska; Water year 1961 to 1991. Published yearly on a water year basis (October to September): U.S. Geological Survey Water-Data Reports NE-XX-X.

1168. U.S. Geological Survey, 1961-1991, Water resources data reports, Wyoming; Water year 1961 to 1991. Published yearly on a water year basis (October to September): U.S. Geological Survey Water-Data Reports WY-XX-X.

1169. U.S. Geological Survey, 1971-1991, Water resources data reports, Colorado; Water year 1971 to 1991. Published yearly on a water year basis (October to September): U.S. Geological Survey Water-Data Reports CO-XX-X.

1170. U.S. National Park Service, Denver Service Center, 1990, Reconnaissance Survey, Rocky Mountain Foothills, South Platte River, & Pawnee Buttes, Colorado: Denver, Colo., Department of the Interior, 21 p.

1171. U.S. Senate, Subcommittee on Water and Power, 1984, Ground water recharge in the High Plains States; and delivery of water to the North Platte Irrigation Project: Washington, D.C., U.S. Govt. Print. Off., Ninety-Eighth Congress, first session on S. 1811, H.R. 71, and S. 1590, Sept. 29, 1983, S.HRG 98-469 PART 1, 135 p.

1172. U.S. Soil Conservation Service and Colorado Water Conservation Board, 1986, Missouri River Tributaries, Colorado--Cooperative River Basin Study. Potential for irrigation system improvements: Denver, Colo., Department of Agriculture, variously paginated.

1173. Union Carbide Corporation, 1981, Hydrogeochemical and stream sediment reconnaissance basic data for Cheyenne Quadrangle, Colorado: Oak Ridge, Tenn., National Uranium Resource Evaluation Program, Oak Ridge Gaseous Diffusion Plant, Report Number K/UR- 365, GJBX-324-81, 137 p.

1174. Union Carbide Corporation, 1981, Hydrogeochemical and stream sediment reconnaissance basic data for Limon Quadrangle, Colorado: Oak Ridge, Tenn., National Uranium Resource Evaluation Program, Oak Ridge Gaseous Diffusion Plant, Report Number K/UR- 372, GJBX-308-81, 129 p.

1175. Union Carbide Corporation, 1981, Hydrogeochemical and stream sediment reconnaissance basic data for Rawlins Quadrangle, Wyoming: Oak Ridge, Tenn., National Uranium Resource Evaluation Program, Oak Ridge Gaseous Diffusion Plant, GJBX-308-81; K/UR- 344, 157 p.

1176. Union Carbide Corporation, 1981, Hydrogeochemical and stream sediment reconnaissance basic data for Scottsbluff NTMS Quadrangle, Nebraska and Colorado: Oak Ridge, Tenn., National Uranium Resource Evaluation Program, Oak Ridge Gaseous Diffusion Plant, Report Number K/UR-147, GJBX-145-81, 39 p.

1177. Velehradsky, J.E., and Turner, C.D., 1975, Water reuse in the South Platte River basin: Omaha, Nebr., U.S. Army Corps of Engineers.

1178. Viard, J.P., 1977, Description of grain-size distribution curves from the Platte River system: Fort Worth, Tex., Tex. Christian Univ.

1179. Vincent, R.E., and Miller, W.H., 1969, Altitudinal distribution of brown trout and other fishes in a head water tributary of the South Platte River, Colorado: Ecology, v. 50, no. 3, p. 464-466.

1180. Vitanage, P.W., 1954, Sandstone dikes in the South Platte area, Colorado: J. Geol., v. 62, no. 5, p. 493-500.

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1182. Voth, D.R., Anderson, L.F., and Kleinschuster, S.J., 1974, The influence of water flow on brown trout parasites: Prog. Fish- Cult., v. 36, no. 4, p. 212.

1183. Waage, K.M., 1959, Stratigraphy of the Dakota Group along the northern Front Range Foothills, Colorado: U.S. Geological Survey, Oil and Gas Investigations Chart, OC-60.

1184. Waddel, W.W., Cole, C.R., and Baca, R.G., 1974, A water-quality model for the South Platte River Basin, Documentation Report: Richland, Wash., Battelle Pacific Northwest Labs, Prepared for Environmental Protection Agency, Washington, D.C., Office of Research and Monitoring, EPA-68-01-0702, 87 p.

The water-quality model PIONEER-I is a steady-state program that simulates the behavior of the following water-quality parameters: total nitrogen, total dissolved solids, zinc, dissolved oxygen, carbonaceous biochemical oxygen demand, fecal coliform bacteria, phosphorus, ammonia, nitrite, nitrate, and chlorophyll a. The model was set up on the entire length of the South Platte River from Eleven Mile Canyon Reservoir to its confluence with the North Platte River. In addition, ten major tributaries to the South Platte and a number of smaller streams were modeled. The model was calibrated using flow and water-quality data collected on the river in late summer 1971 and winter 1971-72. The model was successfully calibrated to describe dissolved oxygen-biochemical oxygen demand mechanisms and nutrient distributions. Study results have shown that it is practicable to set up and calibrate a mathematical water-quality model which considers numerous interactive constituents on a large and complex river basin such as the South Platte. It is recommended that every effort be made to encourage the use of this model by regional and local agencies and groups; it is only through this kind of repeated and continuous use that the model can be refined and developed into a reliable and trusted tool for water resource managers.

1185. Wahlstrom, E.E., 1941, Hydrothermal deposits in the Speciman Mountain, volcanics, in the Rocky Mountain National Park, Colorado: American Mineralogist, v. 26, p. 551-561.

1186. Wahlstrom, E.E., 1956, Petrology and weathering of the Iron Dike, Boulder and Larimer Counties, Colorado: GSA Bulletin, v. 67, p. 147-163.

1187. Waite, H.A., 1937, A study of the geology and ground water resources of Keith County, Nebraska: Lincoln, Nebr., Univ. of Nebraska.

1188. Walch, L.A., and Bergersen, E.P., 1982, Home range and activity patterns of lake trout in central Colorado: Fisheries Res., v. 1, no. 4, p. 311-318.

1189. Walker, G.T., 1985, High plains depressions in eastern Colorado; distribution, classification, and genesis: Denver, Colo., Univ. of Denver, 297 p.

1190. Walker, W., 1971, Interim plan for water-quality management in the Denver metropolitan area: Denver, Colo., Denver Regional Council of Governments, Storet Code 0910-B, 154 p.

The purpose of the Interim Plan is to identify immediate needs and begin the development of a long range program of sewage facilities construction and water quality management. The geographical scope of the report includes the Denver SMSA portion of the South Platte River Basin. Information from the major water-quality management agencies, both regulatory and operational, is presented in the study. Waste discharge information is shown for municipal, industrial, agricultural and storm water effluent. Sampling stations and Colorado water-quality standards are listed as well as problem areas and outfall locations. The needed and projected short-range improvements are documented for the regional study area. An outline of a proposed fully developed master plan, yet to be done, is presented in the final chapter.

1191. Walker, W.R., Ward, R.C., and Skogerboe, G.V., 1973, Evaluation of urban water management policies in the Denver Metropolitan area: Fort Collins, Colo., Colorado State Univ., Environmental Resources Center Completion Report Series, Partial Report 46, 145 p.

A management level urban water system model has been developed to answer basic questions relating to optimal management of water in the urban environment. The model which coordinates water supply, distribution, and wastewater treatment is applied to the water management problems of the Denver, Colorado metropolitan area. Denver presently supplements diversions from the South Platte River with interbasin transfers, agricultural water-right transfers, and groundwater. Although plans are being made to increase the capacity of these sources, increasingly stringent standards on wastewater effluents are enhancing the feasibility of reuse. In order to facilitate the implementation of optimal policies such as reuse, various institutional constraints must be evaluated. Certain of these, including the legal interpretation of water rights, public opinions, management consolidation, and water-quality control philosophies, are explored.

1192. Walsh, D.F., Berger, B.L., and Bean, J.R., 1977, Mercury, arsenic, lead, cadmium and selenium residues in fish: 1971-1976 National Pesticide Monitoring Program, Pesticide Monitoring Journal, v. 11, p. 5-34.

1193. Walsh, R.G., Ericson, R.K., McKean, J.R., and Young, R.A., 1978, Recreation benefits of water quality: Rocky Mountain National Park, South Platte River Basin, Colorado: Fort Collins, Colo., Colorado Water Resources Research Inst. Technical Report 12, 140 p.

A random sample of 141 households were interviewed in Rocky Mountain National Park during the summer of 1973 as part of a study to develop and apply a procedure for measuring the relationship between water quality and nonresident recreation benefits. Park visitors were requested to rank photographs of water quality according to the perceived amount of pollution contained in the water in each photograph, and then were questioned about their willingness to pay for high quality water for recreational purposes. The question were designed to measure consumer surplus benefits. Willingness to pay was measured in terms of a recreation entrance fee, the value of waterfront property, and travel time. Some of the results included: (1) park visitors were willing to pay more in recreation fees rather than have the water-quality decrease; (2) visitors were willing to travel 0.9% more to avoid a change in water-quality; (3) income was positively related to willingness to pay an entrance fee for improved water quality; and (4) income was negatively related to willingness to increase travel time; i.e., for every $1,000 increase in income, willingness to travel decreased by 10%. It is concluded that park visitors from industrially developed regions with a dense population would be willing to pay more for water quality in the park. Colorado residents reported that they would be willing to pay about the same rates as non-residents for water quality.

1194. Walsh, R.D., Greenley, D.A., Young, R.A., McKean, J.R., and Prato, A.A., 1978, Option values, preservation values and recreational benefits of improved water quality: A case study of the South Platte River basin, Colorado: Environmental Protection Agency, EPA-R-803206; EPA/600/5-78/001, 111 p.

This is believed to be the first empirical test of the concept of option value for any non-market good. Application of the bidding game technique was successful in meeting the primary study objective of measuring the option value of improved water quality. Also included in the study are improved estimates of the benefits to recreational users of enhanced water quality. The relationship between the value of improved water quality and several socioeconomic variables was tested with regression and other statistical procedures. The report is based on direct interviews with 202 residents of Denver and Fort Collins located in the South Platte River Basin, Colorado. Interviewees responded to the survey within the context of improving the quality of water degraded by heavy metals from post mining activities and preventing future degradation from such sources.

1195. Walthall, P.M., 1985, Acidic deposition and the soil environment of Loch Vale Watershed in Rocky Mountain National Park: Fort Collins, Colo., Colorado State University, Ph.D. dissertation, 148 p.

1196. Walton, G., 1959, Public health aspects of the contamination of ground-water in South Platte River basin in vicinity of Henderson, Colorado: Cincinnati, Ohio, U.S. Public Health Service.

1197. Walton, G., 1961, Public health aspects of the contamination of ground-water in South Platte River basin in vicinity of Derby, Colorado, in Ground water contamination - A symposium: Cincinnati, Ohio, U.S. Public Health Service, R.A. Taft Sanitary Eng. Center, Tech. Rept. w61-5.

1198. Waltz, J.P., 1969, Hydrogeology and water-quality studies in the Cache La Poudre Basin, Colorado: Fort Collins, Colo., Environmental Resources Center, Colorado State University, Completion Report Series, 33 p.

1199. Waltz, J.P., 1969, Hydrogeology and water-quality studies in the Cache La Poudre Basin, Larimer and Weld Counties, Colorado: Fort Collins, Colo., Natural Resources Center, Colorado State University Partial Completion Report, 34 p.

The Cache la Poudre Basin, Larimer County, Colorado, provides an ideal laboratory for study and documentation of the causes and effects of water-quality deterioration. It has been possible to correlate downstream changes in quality of surface water and groundwater to environmental factors including both natural and man-induced conditions. Approximately half of the basin lies in mountainous terrain on the eastern slope of the Rocky Mountains in northern Colorado. Here, the effects of man's activities on the movement and quality of water have been relatively minor. Applications of geophysics, analog modelling techniques and studies of clay mineralogy were used in defining the geologic framework in the basin and evaluating the effect of geology on the quality of groundwater.

1200. Ward, J.V., 1981, Altitudinal distribution and abundance of *Trichoptera* in a Rocky Mountain stream: Series Entomologica, v. 20, p. 375-381.

1201. Ward, J.V., 1982, Altitudinal zonation of *Plecoptera* in a Rocky Mountain stream: Aquatic Insects, v. 4, p. 105-110.

1202. Ward, J.V., 1986, Altitudinal zonation in a Rocky Mountain stream: Archiv fur Hydrobiologie Monographische Beitrage, v. 74, no. 2, p. 133-199.

1203. Ward, J.V., 1975, Bottom fauna-substrate relationships in a northern Colorado trout stream: 1945 and 1974: Ecology, v. 46, p. 1429-1434.

1204. Ward, J.V., 1976, Comparative limnology of differentially regulated sections of a Colorado mountain river: Arch. Hydrobiol., v. 78, no. 3, p. 319-342.

Studies of 1-yr duration were conducted from 1972-75 on 4 sections of the South Platte River in the Colorado [USA] mountains to elucidate the effects and extent of influence of deep release dams on stream macroinvertebrates. Study sites represented a gradient from highly regulated to unregulated by dams. Macroinvertebrates exhibited lower standing crops but much higher diversity at unregulated sites. Gammarus and gastropods were restricted to regulated sites, whereas filipalpian stoneflies, heptageniid mayflies and certain dipterans were not found below the dam. Restriction of taxa to regulated or unregulated sites is explained by differences in chemical limiting factors, distribution and abundance of submerged angiosperms and epilithic algae, diversity of organic matter inputs, predation pressure and competitive interactions, environmental stability and predictability and thermal signals.

1205. Ward, J.V., 1984, Diversity patterns exhibited by the *Plecoptera* of a Colorado mountain stream: Annales de Limnologie, v. 20, no. 1-2, p. 123-128.

1206. Ward, J.V., 1975, Downstream fate of zooplankton from a hypolimnial release mountain reservoir: Verh. int. Verein theor. angew. Limnol., v. 19, p. 1798-1804.

1207. Ward, J.V., 1976, Effects of thermal constancy and seasonal temperature displacement on community structure of stream macroinvertebrates, *in* Esch, G.W., and McFarlane, R.W., eds., Thermal ecology II: ERDA Symposium Series (CONF-740425), p. 302-307.

1208. Ward, J.V., 1977, First records of subterranean amphipods from Colorado, USA, with descriptions of 3 new species of *Stygobromus (Crangonyctidae)*: Trans. Am. Micros. Soc., v. 96, no. 4, p. 452- 466.

Three new species of an exclusively subterranean amphipod genus, which are the 1st records of hypogean amphipods in Colorado [USA], are described. *S. coloradensis sp. nov.* and *S. pennaki sp. nov.* were taken from the hyporheic zone of the North Fork of the South Platte River in central Colorado. *S. holsingeri sp. nov.* was collected near the source of a small spring in northern Colorado.

1209. Ward, J.V., 1976, Lumbricid earthworm populations in a Colorado mountain river: Southwest. Nat., v. 21, no. 1, p. 71-78.

1210. Ward, J.V., 1974, A temperature-stressed stream ecosystem below a hypolimnial release mountain reservoir: Archiv fur Hydrobiologie, v. 74, no. 2, p. 247-275.

1211. Ward, J.V., 1987, *Trichoptera* of regulated Rocky Mountain streams: Series Entómologica, v. 39, p. 375-380.

1212. Ward, J.V., and Berner, L., 1980, Abundance and altitudinal distribution of *Ephemeroptera* in a Rocky Mountain stream, *in* Flannagan, J.F., and Marshall, K.E., eds., Advances in *Ephemeroptera* biology: New York and London, Plenum Publ. Corp., p. 169-178.

1213. Ward, J.V., and Dufford, R.G., 1979, Longitudinal and seasonal distribution of macroinvertebrates and epilithic algae in a Colorado springbrook-pond system: Archiv fur Hydrobiologie, v. 86, p. 284-321.

1214. Ward, J.V., and Garcia de Jalon, D., in press, *Ephemeroptera* of regulated mountain streams in Spain and Colorado, *in* Alba-Tercedor, J., and Sanchez-Ortega, A., eds., Overview and strategies of *Ephemeroptera* and *Plecoptera*: Gainesville, Fla., Sandhill Crane Press.

1215. Ward, J.V., and Holsinger, J.R., 1981, Distribution and habitat diversity of subterranean amphipods in the Rocky Mountains of Colorado: Internat. J. Speleology, v. 11, p. 63-70.

1216. Ward, J.V., and Kondratieff, B.C., in press, An illustrated guide to the mountain stream insects of Colorado: Colo., University Press of Colorado.

1217. Ward, J.V., Rice, J.A. and MacCarthy, P., [1974?], Downstream fate of zooplankton from a hypolimnial release mountain reservoir characterization of a stream-sediment humin, *in* K. E. Marshall, ed., XIX Congress International Association of Limnology, August 22-29, 1974: 238 p.

1218. Ward, J.V., Short, R.A., and Canton, S.P., 1980, Detrital processing and associated macroinvertebrates in a Colorado mountain stream: Ecology, v. 61, no. 4 (August).

1219. Ward, J.V., and Short, R.A., 1978, Macroinvertebrate community structure of four special lotic habitats in Colorado, U.S.A: Vereinigung Int. Verein Theor. Angew. Limnol., v. 20, p. 1382-1387.

Macroinvertebrate communities of four dammed Colorado streams were compared to identify taxa useful as indicators of effects of stream regulation. Unregulated portions of the streams served as experiment controls. Stream sites included: (1) Joe Wright Creek below an irrigation reservoir, exhibiting great discharge fluctuations; (2) a spring brook site north of Horsetooth Reservoir, which lacks an upstream source of limnetic seston but has constant conditions similar to some sites below dams; (3) Trout Creek below a surface-release reservoir; and (4) the South Platte River below a deep-release reservoir (Cheesman Lake), which moderates major flow fluctuations. No sites were disturbed except by dams; fauna consist primarily of insects (except in the spring brook), especially *Ephemeroptera, Plecoptera, Diptera,* and *Tricoptera.* Most of the fauna can be classified in four groups; (1) euryokous, or tolerant, organisms found in virtually all regulated or unregulated streams, but which may become abundant with certain types of regulation, such as the mayfly *Baetis* in the South Platte, the spring brook, and Joe Wright Creek; (2) organisms present in unregulated streams and favored by certain types of regulation, such as the stonefly *Alloperla* in Joe Wright Creek; (3) intolerant organisms present in unregulated streams but reduced or absent in regulated streams, such as the trichopteran *Brachycentrus;* and (4) organisms not normally present in

unregulated mountain streams, but characteristic of regulated streams, such as amphipods in Trout Creek, the South Platte, and the spring brook.

1220. Ward, J.V., and Voelz, N.J., 1990, Gradient analysis of interstitial meiofauna along a longitudinal stream profile: Stygologia, v. 5, no. 2, p. 93-99.

1221. Ward, J.V., Voelz, N.J., and Harvey, J.H., 1989, Groundwater faunas as indicators of groundwater quality; The South Platte River System: Fort Collins, Colo., Colorado Water Resources Research Institute Completion Report 150, 39 p.

1222. Warner, J.W., Sunada, D.K., and Hartwell, A., 1986, Recharge as augmentation in the South Platte River basin: Fort Collins, Colo., Environmental Resources Center, Colorado State University, Completion Report 144, 125 p.

Artificial recharge is a newly emerging technology for water management in the South Platte River Basin of Colorado. Currently, there are about 44 recharge sites being operated, mostly for the purpose of augmenting streamflows. Augmentation is needed to offset the stream depletion caused by pumping from the alluvial aquifer in contact with the river. These augmentation/recharge projects have evolved from the quest for better basinwide water management in order to optimize the use of a limited water supply. Pilot recharge projects were first tried in the early 1960s. The analytical methods currently being used to calculate the timing and amount of return flow from a recharge site are evaluated. The two most popular methods are: (1) the Glover method; and (2) the Stream Depletion Factor method (based on the Glover method).

1223. Wayne, D.M., 1986, Electron microprobe analysis of rare-earth- element-bearing phases from the White Cloud Pegmatite, South Platte District, Jefferson County, Colorado: New Orleans, La., Univ. of New Orleans, 122 p.

1224. Wayne, D.M., and Simmons, W.B., 1986, Rare-earth-element mineralogy of the White Cloud Pegmatite, Jefferson County, Colorado, *in* Modreski, P.J., Fitzpatrick, J., Foord, E.E., and Kohnen, T.M., eds., Colorado pegmatites; abstracts, short papers, and field guides from the Colorado Pegmatite Symposium: Denver, Colo., Friends Mineral., Colo. Chapter, p. 22-26.

1225. Weatherford, G.D., 1968, Legal aspects of interregional water diversion (intrastate diversion of water from areas-of-origin in the west): UCLA Law Review, v. 15, no. 5(Sept.), p. 1311-1317.

The State water project of the early 1950's, designed to transport surplus northern water to southern California, focused attention on the county-of-origin and watershed-of-origin provisions of the California water code. Southern interests proposed bills to secure water contracts under the program, while northern interests demanded protection for their water supplies. The result was a law securing water contracts while the bonds financing the project were outstanding, and providing funds for development of water resources in the areas of origin. Arizona, Colorado, Nebraska, Oklahoma, Oregon and Texas provide protection for the needs of areas of origin by statute. North Dakota allows more liberal diversion of water from natural watersheds. All these States allow diversion of water under clear conditions of surplus. Some require the consent of local water boards as a condition of diversion from the boards' areas.

1226. Weaver, G.D., 1983, Effects of wilderness legislation on water project development in Colorado: Fort Collins, Colo., Colorado Water Resources Research Institute Completion Report no. 124, 156 p.

Environmental policies embodied in the Wilderness Act, Wild and Scenic Rivers Act, and Endangered Species Act impose certain restrictions on the development of Colorado's water resources. Planning costs are unavoidably increased because time and personnel must be invested in complying with procedural requirements of the laws. Capital or operating costs may be increased because of construction delays, required engineering design changes, or spatial relocation of project facilities. In some cases, development opportunities will be completely foregone. The most pervasive conflicts identified in this study involve the endangered whooping crane and Colorado River fishes. New streamflow depletions in the Platte River system will adversely affect the whooping crane habitat in central Nebraska if such depletions occur between February 1-May 10 or September 16-November 15. Accordingly, new development will be given nonjeopardy biological opinions only if they can meet the required flow regime, either by providing storage releases or replacement waters, or if they can offset the effects of small depletions by funding habitat improvement programs. Approval of projects affecting the Colorado River fishes have already been made contingent upon project operators adopting or funding various conservation measures, including the bypassing of minimum flows during critical months of the year.

1227. Weber, W.A., 1990, Colorado fauna: Eastern Slope: Colo., Colorado Associated University Press.

1228. Weber, W.A., 1961, Handbook of plants of the Colorado Front Range: Boulder, Colo., University of Colorado Press.

1229. Wedemeyer, W.G., [n.d.], An economic analysis of center-pivot sprinkler systems in southeastern Wyoming, with emphasis on financing alternatives: Laramie, Wyo., Wyoming University.

Economics and financing of center-pivot sprinkler irrigation systems were studied. Financing arrangements available and being utilized in Wyoming are described, and a feasibility analysis is carried out assuming various financing arrangements and crop plans. The concept of discounting is used in the analysis. Results show that the State is the major source of center-pivot sprinkler financing at the present time, its loans providing the most desirable financing alternatives available with the highest discounted present values. FHA loans are nearly comparable, but are available on to individuals unable to obtain adequate financing elsewhere. Results also indicate that an investment in a center-pivot sprinkler system is most profitable when a cash crop, such as potatoes or sugar beets is included in the rotation irrigated by the system. Low present values were generated when only forage crops were included in the rotation. The analysis of economic feasibility for all the cropping plans in this study was based on the assumption that the land use displaced by the center-pivot system was dryland wheat production. The investment would possibly appear more profitable if the displaced use were assumed to be native pasture.

1230. Weeks, J.B., and Gutentag, E.D., 1981, Bedrock geology, altitude of base, and 1980 saturated thickness of the High Plains Aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U.S. Geological Survey Hydrologic Investigations Atlas HA-648, 2 sheets, scale 1:2,500,000.

1231. Weeks, J.B., Gutentag, E.D., Heimes, F.J., and Luckey, R.R., 1988, Summary of the High Plains Regional Aquifer-System Analysis in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U.S. Geological Survey Professional Paper 1400, 30 p.

1232. Weeks, J.B., and Luckey, R.R., 1987, Simulated effects of future pumpage on the High Plains Aquifer, west-central United States, *in* S. Awadalla and I. M. Noor, eds., Groundwater and the environment; proceedings of the International groundwater conference: Selangor, Malaysia, Univ. Kebangsaan, p. G79-G87.

1233. Wegemann, C.H., 1944, A guide to the geology of Rocky Mountain National Park: Washington, D.C., U.S. Government Printing Office.

1234. Wegemen, C.H., 1961, A guide to the geology of Rocky Mountain National Park: Washington, D.C., U.S. Government Printing Office.

1235. Weimer, R.J., 1983, Relation of unconformities, tectonics, and sea level changes, Cretaceous of the Denver Basin and adjacent areas, *in* M.W. Reynolds and E. D. Dolly, eds., Rocky Mountain paleogeography symposium 2; Mesozoic paleogeography of the west- central United States: v. 2, p. 359-276.

1236. Weimer, R.J., 1988, Sequence stratigraphy and paleotectonics, Denver Basin area of Lower Cretaceous foreland basin, USA, Cretaceous resources, events and rhythms; background and plans for research, in Ginsburg, R.N., and Beaudoin, B., eds., NATO advanced research workshop on Cretaceous resources, events, and rhythms. NATO Advanced Study Institutes Series. Series C; Mathematical and Physical Sciences: p. 23-32.

1237. Weimer, R.J., and Sonnenberg, S.A., 1983, Codell Sandstone; new exploration play, Denver Basin: Oil and Gas Journal, v. 81, no. 22, p. 119-125.

1238. Weir, R.K., and Chapman, R.L., 1987, Foothills: A state-of-the- art water treatment plant: Journal of the American Water Works Association, v. 79, no. 9, p. 66-73.

After 3 years of operation, the showcase Foothills water treatment plant, serving the basic needs of the Denver, Colorado, metropolitan area, has been performing at, or above, expectations. Taking hydraulic advantage of its location above the city, the plant's pumping costs are minimal and the plant's hydro turbine generates enough power to operate the facilities and sell excess electricity. A minimum staff can operate the automatically controlled processes. The design enables operators to choose the total treatment process or bypass coagulation, flocculation and sedimentation to minimize operation and maintenance costs, depending on seasonal water quality. Solids drying beds take advantage of the climate, further lowering treatment costs, which in 1986 averaged only about 0.03 dollars per thousand gallons.

1239. Wells, J.D., 1961, Petrography of radioactive Tertiary igneous rocks, Front Range mineral belt, Colorado: Bulletin, p. 223- 272.

1240. Wentz, D.A., 1974, Effect of mine drainage on the quality of streams in Colorado, 1971-72: Colorado Water Resources Circular 21, 117 p.

1241. Wentz, D.A., 1977, Quantity and quality of drainage from the Argo Tunnel and other sources related to metal mining in Gilpin, Clear Creek, and Park counties, Colorado: U.S. Geological Survey Open-File Report 77-734, 61 p.

1242. Wenzel, L.K., and Waite, H.A., 1941, Ground water in Keith County, Nebraska: U.S. Geological Survey Water-Supply Paper 848, 68 p.

1243. Wesche, T., 1989, Surface and ground water dynamics critical to maintenance of subalpine riparian wetlands. A proposal submitted to the Wyoming Water Research Center: Laramie, Wyo.

1244. Wesche, T.A., Goertler, C.M., and Frye, C.B., 1987, Contribution of riparian vegetation to trout cover in small streams: N. Am. J. Fish. Manage., v. 7, no. 1, p. 151-153.

Cover is an important trout habitat component resulting from the geomorphologic characteristics of a stream channel, the stream-bank interface with the riparian community, and the stream flow. By means of regression analysis, this study quantitatively describes the relative importance of three cover parameters (overhead bank cover, rubble-boulder-aquatic vegetation areas, and deepwater areas) and two cover models as indicators of trout standing stock (Salmo trutta, S. gairdneri, Salvelinus fontinalis) in eight small streams in southeast Wyoming. Results indicated that overhead bank cover, provided primarily by riparian vegetation, is the cover parameter that explains the greatest amount of variation in trout population size.

1245. Wesche, T.A., Goertler, C.M., and Hubert, W.A., 1987, Modified habitat suitability index model for brown trout in southeastern Wyoming: N. Am. J. Fish. Manage., v. 7, no. 2, p. 232-237.

The habitat suitability index (HSI) model for brown trout Salmo trutta in stream systems, developed by the U.S. Fish and Wildlife Service, was tested with data from 30 reaches on nine streams in southeastern Wyoming. The HSI was not significantly correlated ($P > 0.05$) with brown trout standing stock.

1246. Weston, L.K., and Swain, R.E., 1979, Artificial Recharge in South Platte River Basin: Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, v. 105, no. IR2, Proceedings paper 14606, p. 117-127.

A reconnaissance study of the potential for artificially recharging the alluvial aquifer along 110 miles of the South Platte River from Fort Morgan to Julesburg, Colorado, was made based on published hydrologic and geologic information. Analyses were made to determine the availability of water for recharge; anticipated infiltration rates; potential storage capacity of the groundwater reservoir; the degree of groundwater mounding beneath potential recharge sites; the magnitude of annual drain-out loss to the river; possible water-quality problems; and the potential effects on the South Platte River flows. Artificially recharging the alluvial aquifer appears technically feasible. Water-logging conditions are likely to develop in areas that lie within 1 mile or 2 miles of the river. Due to the high dissolved-solids concentration of the recharge water, the quality of the groundwater in some areas may deteriorate and preclude its use for domestic and municipal water supplies.

1247. Weston, L.K. and Swain, R.E., 1978, Ground-water recharge potential in the lower South Platte River valley from Fort Morgan to Julesburg, Colorado, *in* American Geophysical Union; 1978 spring annual meeting. Eos, Miami Beach, Fla., April 17-21, 1978: v. 59(4), Am. Geophys. Union, p. 275-276.

1248. White, S.E., 1971, Rock glacier studies in the Colorado Front Range, 1961-1968: Artic and Alpine Research, v. 3, no. 1, p. 43- 64.

1249. Wildeman, T.R., Cain, D., and Ramiriz, R.A.J., [n.d.], The relation between water chemistry and mineral zonation in the Central City Mining District, Colorado, in Water resources problems related to mining; Proceedings: Colorado School of Mines, p. 219-229.

The analyses of water draining from eight mines within the Central City Mining District, Colorado, were reported. The Central City District is a complex sulfide mineral deposit classified as a mesothermal type. There is a well-defined concentric zoning of the ore minerals in the district consisting of a central zone of pyrite veins surrounded by a peripheral zone of shalerite-galena veins, with an intermediate zone between the other two zones. It was found that concentrations of the base metals in the mine drainage change in a direct way within the zonation. Fe, Mn, Zn, Cu, Cd, and Pb are in highest concentration in drainages from the central zone and in lowest concentrations in drainages from the peripheral zone. It was suggested that the cause of this zonal variation is the weathering of pyrite which is in greatest abundance in the central zone, and which releases Fe(iii) and H(+) which promote the dissolution of the other base-metal sulfides. So far, samples have been collected in the summer, fall, and winter; there are no significant seasonal variations in the water chemistry.

1250. Wiley, R.D., 1979, Denver, import and reuse conservation lessons, *in* Proceedings of the Conference on Water Conservation Needs and Implementing Strategies, Franklin Pierce College, Rindge, N.H., July 9-13, 1979: p. 165-173.

The Denver Water Department which provides treated water service to over 900,000 people is having to make hard decisions concerning the realities of conservation versus the expense and environmental unpopularity of further development of Colorado River waters. Denver, located on a semi-arid plain, has an average rainfall of only 15 inches. Approximately 70% of Colorado's surface water flows away from Denver down the sparsely populated Western Slope of the Continental Divide. The South Platte River, which flows past Denver, collects only 10% of the State's water. At present, Denver gets 60% of its water supply by diverting water flow from the Western Slope. There is much negative sentiment concerning future increases in diversion from the Western Slope and the Colorado River. One conservation measure being conducted is successive use or reuse. A one million gallon-per-day reuse demonstration plant is being designed for future construction. A full-scale reuse program could be implemented by about the year 2000 if the demonstration plant is successful. Even with conservation and successive use, the demand for water will exceed supply sometime around the turn of the century. Also, if water rights to Western Slope water are not utilized, they will be lost to downstream urban areas.

1252. Williams, F., 1989, Trying to keep that old-time faith: High Country News, v. 21, no. 23(December 4).

1253. Williams, G.P., 1978, Historical perspective of the Platte Rivers in Nebraska and Colorado, *in* W. D. Graul and S. J. Bissell, eds., Lowland river and stream habitat in Colorado: a symposium, October 4-5, 1978: Greeley, Colo., Colorado Chapter Wildlife Society and Colorado Audubon Council, 120 p. 11-41.

1254. Williams, G.P., 1978, Historical perspective of the South Platte River in Nebraska and Colorado: U.S. Geological Survey Open-File Report 78, 31p.

1255. Williams, G.P., 1979, Historical perspective of the South Platte River: U.S. Geological Survey Professional Paper 1150, 120 p.

1256. Wilson, M.P., 1986, Groundwater contamination by the herbicide atrazine, Weld County, Colorado: Fort Collins, Colo., Colorado State University, 208 p.

A field study was conducted and a groundwater transport model was developed to investigate potential contamination of groundwater underlying and downgradient from an atrazine treated site in the South Platte River Valley, Colorado. Groundwater from wells was monitored and whether atrazine is or is not a conserved species in the groundwater and the likelihood of N-nitrosatrazine formation from leached atrazine were assessed. The transport model was used to determine the transport rate, dilution, and attenuation of atrazine in groundwater. Atrazine residues were identified in samples beneath and downgradient from atrazine-treated fields in concentrations to 2.3 ppm. A significant decline in the downgradient groundwater concentrations of atrazine was observed. The highest concentration measured was less than one-third the suggested adverse-effect level proposed for atrazine by the National Academy of Science when 1 percent of the allowable daily intake is obtained from drinking water. Conditions at the site indicated the unlikelihood of N-nitrosatrazine formation. The steady-state model of atrazine transport through the aquifer underlying the site revealed a marked influence by adsorption and degradation. Assumed values of atrazine adsorption to aquifer solids yielded a significant delay in atrazine mass breakthrough.

1257. Windell, J.T., and others, 1986, An ecological characterization of Rocky Mountain montane and subalpine wetlands: U.S. Fish and Wildlife Service, Biological Report 86(11), 298 p.

1258. Winkle, P.L., Hubert, W.A., and Rahel, F.J., 1990, Relations between brook trout standing stocks and habitat features in beaver ponds in southeastern Wyoming: N. Am. J. Fish. Manage., v. 10, no. 1, p. 72-79.

Relations between abundance of brook trout Salvelinus fontinalis and habitat features of ponds made by beavers Castor canadensis were determined in 1986 and 1987 from observations of 25 southeastern Wyoming ponds. Standing stocks of fish longer than 100 mm in total length ranged from 5 to 313 kg/hectare, and densities ranged from 27 to 9,812 fish/hectare among 0.02-0.51- hectare ponds at elevations from 2,341 to 2,969 m above mean sea level. Of 25 habitat features, 6 were correlated with brook trout standing stock or density: surface area, mean water depth, water volume, discharge into pond, elevation, and morphoedaphic index (total dissolved solids (mg/L)/mean depth (cm)). The presence of young-of-year brook trout in beaver ponds was also related to both standing stock and density of brook trout longer than 100 mm in total length. Two multiple-regression models based on a rating of natural recruitment potential and pond surface area accounted for significant variation in brook trout standing stocks (adjusted R super(2) = 0.42) and densities (adjusted R super(2) = 0.50). The models provide a potential tool for assessment of beaver ponds as habitat for brook trout in southeastern Wyoming.

1259. Winters, D.S., Chadwick, J.W., Conklin, D.J., Jr., and Miller, W.J., 1988, Winter field methodologies for determination of habitat utilization of brown and rainbow trout in two Colorado mountain rivers.: Washington, D.C., U.S. Fish and Wildlife Service, Biol. Report 88(11), 212-221 p.

1260. Woodling, J., and Brumby, R., 1985, Colorado's little fish; a guide to the minnows and other lesser known fishes in the State of Colorado: Denver, Colo., Colorado Division of Wildlife, Dept. of Natural Resources, 77 p.

1261. Woodring, R.G., 1991, South Platte River resource management; finding a balance. Conference Proceedings: Fort Collins, Colo., Colorado Water Resources Research Institute, Information Series 66, 70 p.

1262. Woodward-Clyde Consultants, 1982, Final report, South Platte River basin assessment, Colorado: Denver, Colo., Prepared for the Colorado Water Conservation Board, variously paginated.

1263. Woodward-Clyde Consultants, 1981, Interim report, South Platte River basin assessment: Denver, Colo., Prepared for the Colorado Water Conservation Board, variously paginated.

1264. Woodward, D.G., 1973, A hydrogeologic investigation of the Cache la Poudre River alluvium in the Windsor Project area, Colorado (abstr.), in Geological Society of America, Rocky Mountain Section, 26th Annual Meeting: v. 5(6), Geological Society of America, p. 524.

1265. Woodward, D.G., 1975, A hydrogeologic investigation of the Cache La Poudre River alluvium in the Windsor Triangle area, Colorado: University of Colorado.

1266. Woodward, D.F., Farag, A.M., Little, E.E., Steadman, B., and Yancik, R., 1991, Sensitivity of greenback cutthroat trout to acidic pH and elevated aluminum: Transactions of the American Fisheries Society, v. 120, no. 1(January), p. 34-42.

The greenback cutthroat trout *Oncorhynchus clarki stomias* is a threatened subspecies native to the upper South Platte and Arkansas Rivers between Denver and Fort Collins, Colorado, an area also susceptible to acid deposition. In laboratory studies, this subspecies was exposed to nominal pHs of 4.5-6.5 and to nominal aluminum concentrations of 0, 50, 100, and 300 micrograms/L; the control was pH 6.5 treatment without Al. Soft water was used that contained 1.3 mg Ca/L. Exposures of 7 d each were made for four early life stages: fertilized egg, eyed embryo, alevin, and swim-up larva. Effects were measured at the end of exposure and again after a recovery period lasting until 40 d posthatch. The alevin stage was the most sensitive: at pH 5.0 with no Al, survival was reduced by 68% and swimming duration by 76%; at pH 6.0 and 50 micrograms Al/L, swimming duration was reduced by 62%, but survival was not affected. Reductions in whole-body concentrations of Na, K, and Ca indicated organism stress. Sodium was reduced most: about 50% in alevins exposed to pH 5.0 without Al and to pH 6.0 with 50 micrograms Al/L. Growth and the ratio of RNA to DNA were not affected by any exposure. All responses that were affected during exposure returned to normal by 40 d posthatch. Overall, it appeared that pH 6.0 and 50 micrograms Al/L might be detrimental to greenback cutthroat trout populations.

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1269. Wright Water Engineers, 1967, Preliminary report: Study of integrated water use South Platte River Basin: Denver, Colo., Coordinator of Natural Resources, State of Colorado.

1270. Wu, Shi-Kuei, 1989, Colorado freshwater mollusks: Boulder, Colo., University of Colorado Museum, Natural History Inventory of Colorado 11, 117 p.

1271. Yavitt, J.B., and Fahey, T.J., 1982, Loss of mass and nutrient changes of decaying woody roots in lodgepole pine forests, southeastern Wyoming: Canadian Journal of Forest Research, v. 12, no. 4(December).

1272. Young, R.A., Booker, J.F., Zhang, C.M., and Morel-Seytoux, H.J., 1990, Assessing hydrologic and economic impacts of rural to urban water transfers: An interdisciplinary analysis of the South Platte Stream-Aquifer System, *in* 26th Annual AWRA Conference, Denver, Colo., 4-8 Nov 1990: American Water Resources Association.

1273. Young, R.A., Daubert, J.T., and Morel-Seytoux, H.J., 1986, Evaluating institutional alternatives for managing an interrelated stream-aquifer system: American Journal of Agricultural Economics, v. 68, no. 4, p. 787-797.

1274. Yuhas, R.H., Forman, S.L., and Goetz, A.F.H., 1990, Using remote sensing of northeastern Colorado, USA, to understand landscape response to global change, *in* Geological Society of America, 1990 annual meeting. Abstracts with Programs, Dallas, Tex., Oct. 29-Nov. 1, 1990: v. 22, Geological Society of America, 23 p.

1275. Zahar, R.U., 1989, Stratigraphic study of the Skull Creek interval, Dakota Group, in the Golden-Morrison area, Colorado: Golden, Colo., Colorado School of Mines, 188 p.

The stratigraphic study of the muddiest interval of the South Platte Formation (Lower Cretaceous Dakota Group), named Skull Creek interval, was conducted to ascertain the origin of thickness variations within its strata. This investigation was established from six measured sections along the Colorado Front Range, Golden-Morrison area, Colorado. The sections, from north to south, are Lena Gulch, Interstate Highway 70 - north and south side, Alameda, Morrison and Turkey Creek. Each represents a sequence consisting of the genetically related underlying Plainview Sandstone Member and the Skull Creek. Analyses of depositional environments and correlations in those sections have yielded two significant results as follows: (1) the Plainview and Skull Creek form a depositional sequence within a paleovalley of low relief cut in flat, slightly uplifted coastal plain. This sequence exhibits transgressive and regressive cycles in the study area; (2) the thicknesses and sedimentation of strata within the valley were controlled by relative sea-level changes, and recurrent movement of a local basement-uplift in the southern study area (Turkey Creek). The erosional base of the valley was gently inclined upward at the south, where the basement uplift was located. It was caused by greater erosion to the north that occurred during a drop in sea level prior to the Plainview sedimentation. Consequently, the thickness of each unit within the Plainview-Skull Creek sequence, which filled the valley during the following rise in sea level, apparently decreases to the south. The Plainview Sandstone, composed of 11-58 ft of sandstone and mudstone, represents a coastal lagoon that developed behind a barrier during transgression. Laterally, it changes from thick, sand-dominated facies (subtidal to lower- intertidal zone) at the north, into thinner, muddier facies (mid- to upper-intertidal zone) to the south. This suggests proximity to the sea margin in the north direction. The contact with the overlying Skull Creek is a surface of erosion that signifies the continuation of the transgressive event of the Plainview, and the change in environment from coastal lagoon (Plainview) into marine bay or estuary (Skull Creek). The Skull Creek interval consists of 51-92 ft of gray shale, mudstone, and muddy sandstone, which are mostly....

1276. Zaslowsky, D., 1982, Urban run-off--Pollution storms into Denver rivers: High Country News, v. 14, no. 23.

1277. Zhang, C.M., and Morel-Seytoux, H.J., 1990, A model for studies of management alternatives in a stream-aquifer system, *in* Morel-Seytoux, H.J., ed., Proceedings of Tenth annual American Geophysical Union hydrology days. Annual Rocky Mountains Groundwater Conference: Fort Collins, Colo., Colorado State University.

1278. Zimmerman, D., 1977, Water research: Solving Colorado's water problems: Fort Collins, Colo., Colorado Water Resources Research Institute, PB-279 172, 36 p.

Several projects conducted by the Colorado Water Resources Research Institute are outlined. The report includes descriptive photographs and simplified procedural explanations designed for use by the general public. Sections of the report include: (1) High country irrigation reservoirs - Colorado's untapped recreation resource, (2) Colorado's economy - the role of water, (3) Answering the flood control benefit question, (4) Solving high country water and sewer problems - a planner's handbook, (5) Improving irrigation, (6) Heavy metals in groundwater - a mineral belt problem, (7) Urban runoff -a water pollution problem, (8) From cells to plants - a breakthrough in salt-tolerant varieties, (9) Stabilizing river channels, (10) Water conservation - a handbook for utility managers, (11) Water reuse - potential in the South Platte River Basin, and (12) Trapping the sun - to solve mountain sewage problems.

1279. Zimmermann, H.J., and Ward, J.V., 1984, A survey of regulated streams in the Rocky Mountains of Colorado, *in* Lillehammer, A., and Salveit, S.J., eds., Regulated Rivers: Oslo, Norway, University of Oslo Press, p. 251-262.

1280. Zinkl, R.J., Shettel, D.L., Langfeldt, S.L., Hardy, L.C., and D'Andrea, R.F., 1981, Uranium Hydrogeochemical and Stream Sediment Reconnaissance of the Sterling NTMS Quadrangle, Colorado. National Uranium Resource Evaluation: Grand Junction, Colo., Bendix Field Engineering Corp, GJBX-380(81), 111 p.

This report presents results of a Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) of the Sterling NTMS quadrangle, Colorado. In addition to this abbreviated data release, more complete data are available to the public in machine-readable form. These machine-readable data, as well as quarterly or semiannual program progress reports containing further information on the HSSR program in general, or on the Los Alamos National Laboratory (LANL) portion of the program in particular, are available from DOE's Technical Library at its Grand Junction Area Office. Presented in this data release are location data, field analyses, and laboratory analyses of several different sample media. For the sake of brevity, many field site observations have not been included in this volume; these data are, however, available on the magnetic tape. appendices A and B describe the sample media and summarize the analytical results for each medium. The data have been subdivided by one of the Los Alamos National Laboratory sorting programs of Zinkl and others (1981a) into groups of stream-sediment, lake-sediment, stream-water, lake-water, and ground-water samples. For each group which contains a sufficient number of observations, statistical tables, tables of raw data, and 1;1,000,000 scale maps of pertinent elements have been included in this report. Also included are maps showing results of multivariate statistical analyses. Information on the field and analytical procedures used by the Los Alamos National Laboratory during sample collection and analysis may be found in any HSSR data release prepared by the laboratory and will not be included in this report.

1281. Water and Sewage Works, 1974, Highlights from the Denver WPCF meeting: Water and Sewage Works, v. 121, no. 12 (December)

1282. Water Environ. Technol., 1989, Control of stormwater runoff containing aircraft deicing fluids: Water Environ. Technol., v. 1, no. 1.

Since 1970, Stapleton International Airport (SIA), which is located 6 miles northeast of downtown Denver, Colo., has taken several steps to control industrial wastes discharged to the terminal-area storm sewers. Initially, an industrial waste interceptor system was constructed to collect dry-weather industrial waste flows for treatment at the Metropolitan Denver Sewage Disposal District No. 1 Central Plant. Later, a study of industrial waste sources and characteristics was completed; it led to the separation of the direct industrial waste connections from the storm sewers.

COAUTHOR INDEX

SUBJECT INDEX

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