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by

Wyoming Water Research Center
University of Wyoming
Laramie, WY 82071

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The activities on which this report is based were financed in part by the Department of the Interior, U.S. Geological Survey, through the Wyoming Water Research Center.

ABSTRACT

Four research projects were funded under the FY 1986 program which included:

A field study on the movement of organic contaminants through groundwater to surface streams created by a wood-treating facility and an oil refinery's NPDES discharge indicated that oily seeps or surface discharge can occur into the surface stream and adversely affect the biological activity in the stream. Use of EPA ambient toxicity tests were found to be sensitive enough to detect migration of contaminated surface or ground water into surface streams.

A recreational based valuation method was developed and tested to estimate the effects of change in water quality due to eutrophication of a reservoir on recreational benefits and uses. The method used sampled recreationalists on direct and indirect contact at the reservoir site with a follow-up questionnaire. The data indicated a change in some users recreational activities due to eutrophication.

A field study is being conducted to investigate stream-aquifer interaction phenomena in fracture permeable Paleozoic rock outcrops. Using streamflow discharge measurements above and below the fracture permeable rock outcrop areas along with well level measurements, quantification of recharge due to streamflow during the entire year has shown that the groundwater system is being recharged directly from the stream at different rates during different times of the year.

A study was undertaken to investigate the applicability of crop yield-water use models on crops (winter wheat) grown in high altitude locations (Wyoming). The FAO yield-water use model by Doorenbos and Kassam was found to predict actual yield of winter wheat as a function of maximum yield, a crop response factor and the evapotranspiration ratio with fairly good reliability considering that agronomic and soil unknowns were not present in the prediction.

Information transfer was done principally through a symposium proceedings on Wyoming water problems, extension activities, mailings on available publications, through a newsletter, and participation at several meetings held by groups in the State of Wyoming on water issues.

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WATER PROBLEMS AND ISSUES OF WYOMING

Wyoming's heritage stems from her abundance of natural resources. Vast areas of range and pastureland interspersed with fertile, irrigable stream valleys have enabled the agricultural and livestock industry to become a major driving force of the State's economy. The recreation and tourism industry thrives in Wyoming as visitors come to share our wealth of scenic beauty. Beneath the land surface lies such mineral resources as coal, oil and gas, uranium, oil shale, trona, gypsum, and iron ore. Their abundance has enabled Wyoming to become a national leader in mineral production.

Water is the key natural resource controlling the development of each of these industries. As the saying goes, "in Wyoming, water is life". The rancher could not survive our semi-arid climate without water for livestock and irrigation. Without our streams, lakes and reservoirs, the quality of the recreationists' experience could be diminished. If the mineral industry is to continue to provide a major source of income in the State, water will be required. As our cities and towns continue to grow, adequate supplies of good quality water must be available.

Water availability and allocation for agriculture, mineral extraction, industrial development, recreation, and municipal consumption continue to be the center of water related problems in Wyoming. The development of new water resources through impoundment, while complying with existing interstate water compacts, is a challenge in planning and implementation. Once additional surface and groundwater supplies are

available, the equitable distribution, conservation and maintenance of quality are important and complex issues facing the State.

The State of Wyoming is considered to be a water producing state to the Colorado River Basin, the Snake River Basin, and the Missouri River Basin. Approximately 15.5 million acre feet of water is produced in Wyoming annually, with approximately 12 million acre feet obligated for downstream use through compacts and treaties. Wyoming has embarked on a large-scale water development program with the intended purpose of capturing for its use as much of the excess water produced as possible. The problems associated with the capture, diversion, dispersal, and re-use of these water resources are encompassing. In addition, being better able to forecast quantity and quality of water availability to downstream users is extremely important.

To address the problems and generate needed information associated with water conservation, development, and re-use, a truly interdisciplinary effort, well-managed and coordinated, is essential. The Wyoming Water Research Center is organized in such a manner and can call upon the diverse set of disciplinary expertise necessary to address key issues for the state and the region.

PROGRAM GOALS AND PRIORITIES

Effective administration and management of Wyoming's water resources depend on an understanding of the economic and social effects related to water development and utilization. For elected and appointed state officials to protect the public's interest in water development and utilization, there must be a means of assessing the social and economic impacts emanating from water development projects. Likewise, for the state to utilize its water resources to achieve social and economic goals, it must have legal and institutional tools to initiate, control and finance water development actions and programs.

Effective administration and management of Wyoming's water resources are also dependent upon an understanding of the numerous physical relationships explicit in the hydrologic cycle. Efficient and equitable administration of Wyoming's water law presumes a working knowledge of many hydrologic processes. The hydrologic processes that explain or account for the yield of water from precipitation and snowmelt, groundwater recharge relationships to precipitation, snowmelt and movement of water from saturated topsoil and aquifers to stream channels is important. Improvement in the efficiency of water administration and management is dependent upon the development of working relationships of the hydrologic processes operating on the movement of water in streams, i.e. stream losses, return flows, groundwater recharge interconnections, riparian relationships and streamflow/channel dynamics. Effective water conservation measures for irrigation and other water uses such as energy and mining cannot be devised without taking into account the effect such

practices may have on groundwater recharge, return flows, ecological conditions and flow regimes. Control of the distribution and fate of water pollutants is often times a function of being able to control the hydrologic processes operating on the contaminated water.

The research program priorities established by the Research Review and Priorities Committee are:

1. Evaluation of Historical and Current Water Use Practices
    a. Stream Structure and Management
    b. Examination of Wyoming Water Law
    c. Agricultural Uses
    d. Water Quality
    e. Multiple Use Scenarios
    f. Trans-basin Diversions
2. Demand Analysis for Water Resources Development
    a. Economic Analysis for Water Development
    b. Planning for Growth: Municipal, economic, industrial, agricultural, recreational
    c. Hydroelectric and Geothermal Potentials
3. Development of Water Resources
    a. Watershed Developments, Restoration, Management
    b. Underground Water Resources
    c. Precipitation Augmentation and Manipulation
    d. Construction and Development Modification of Waterways

Emphasis on these priorities provides a logical step-wise approach to addressing water research needs in the State of Wyoming. In keeping with the Center's attempt to implement priority research, we have indicated how our projects relate to the various subjects falling under

our major priorities. Figure 1 is a schematic of how our federal projects meet some of our state priorities.

Figure 2 illustrates the categories of research under which specific projects fall for the federal program. These categories are based on the five-year plan and priorities set under the Office of Water Policy program and are reflective of our continuous priority listing.

FIGURE 1

STATE OF WYOMING RESEARCH PRIORITIES AND PROJECTS
FUNDED BY USGS THROUGH THE WYOMING WATER RESEARCH CENTER
Fiscal Year 1986

RESEARCH PROJECTS FY86	STATE OF WYOMING RESEARCH PRIORITIES												
	Stream Structure & Management	Water Quality	Watershed Development & Management	Agricultural Uses	Information Coordination & Transfer	Underground Water Resources	Hydroelectric & Geothermal Potential	Water Quantity	Waterways Construction & Development	Economic Analysis	Trans-basin Diversion	Water Law in Wyoming	Multiple Uses
Project No. 02 - Organic Contaminant Transport in Groundwater		X				X							
Project No. 03 - Reservoir Eutrophication - Flaming Gorge		X	X						X	X			X
Project No. 04 - Stream Aquifer Interaction - Laramie Mountains	X		X			X		X					
Project No. 05 - Crop Yield-Water Use Relations for Wyoming			X	X						X			

FIGURE 2

FEDERAL RESEARCH PRIORITIES AND PROJECTS
FUNDED BY USGS THROUGH THE WYOMING WATER RESEARCH CENTER
Fiscal Year 1986

FEDERAL RESEARCH PRIORITIES									
	Hydrologic Processes					Legal, Institutional & Economic Consideration in Water Management & Development			
RESEARCH PROJECTS FY86	Montane Zones	Stream Systems	Groundwater/ Groundwater Recharge	Agriculture/ Conservation	Water Quality	Trans-basin Diversions Legal, Institutional and Economic Concerns	Financial Alternatives for Water Development Efficiency/Equity Consideration	Conservation/ High Energy Cost Adjustments in Agriculture	Water Planning Models
Project No. 02 - Organic Contaminant Transport in Groundwater			X		X				
Project No. 03 - Reservoir Eutrophication - Flaming Gorge					X				X
Project No. 04 - Stream Aquifer Interaction - Laramie Mountains		X	X						
Project No. 05 - Crop Yield-Water Use Relations for Wyoming				X					X

RESEARCH PROJECT SYNOPSES

SYNOPSIS

PROJECT NUMBER: 02

Start: 5/15/85
End: 5/31/87

TITLE: Evaluation of Ambient Toxicity Tests for Detecting Groundwater Pollution Entering Streams and Rivers

PRINCIPAL INVESTIGATORS: Harold L. Bergman and Joseph S. Meyer, Department of Zoology and Physiology, University of Wyoming, Laramie

COWRR: 05B

CONGRESSIONAL DISTRICT: One

DESCRIPTORS: groundwater, surface water, sediment, contamination, pollution sources, creosote, ammonia, ambient toxicity tests, fathead minnow, Pimephales promelas, Ceriodaphnia dubia, survival, growth, reproduction, mini-piezometers

PROBLEM AND RESEARCH OBJECTIVES

Groundwater pollution is an emerging environmental concern in the Rocky Mountain region. Chemical analyses of water from monitoring wells can be used to trace the transport of groundwater pollutants. However, identifying and quantifying all potential inorganic and organic pollutants can be time-consuming and expensive. And a major question still arises: Do contaminant levels identified in those analyses pose environmental hazards in receiving waters?

This study adopted two relatively quick, sublethal toxicity tests using fish and invertebrates to evaluate potential effects of contaminated ground water. These tests were recently developed by the U.S. Environmental Protection Agency (EPA) for monitoring effects of industrial and municipal effluents discharged into surface waters. The objectives in this study were to: (1) evaluate EPA ambient toxicity tests as monitors of effects of groundwater pollutants, (2) compare the sensitivity of those biological tests to the sensitivity of chemical

analyses for detecting the presence of groundwater contaminants, and (3) assess temporal variability of groundwater and surface-water contamination in two Wyoming streams.

METHODOLOGY

During this two-year study, water samples were tested from two study sites: 1) the Laramie River as it flowed past a former railroad tie treating plant south of Laramie, Wyoming, from June 1985 to October 1985; and 2) Crow Creek as it flowed past an oil refinery in Cheyenne, Wyoming, from June 1985 to September 1986. Surface-water samples were collected from five locations at the Laramie River study site and six locations at the Crow Creek study site. Additionally, ground water was collected adjacent to the tie treating plant on the Laramie River and at four locations near the oil refinery on Crow Creek, using Teflon mini-piezometers. Each water sample was tested for its effects on survival and growth of fathead minnow (Pimephales promelas) larvae and survival and reproduction of Ceriodaphnia dubia (an aquatic invertebrate). Chemical analyses of water samples included routine water chemistry parameters, major inorganic ions, 11 trace elements, dissolved organic carbon, reverse-phase HPLC gradients, and GC-MS analyses of organics (one sample).

PRINCIPAL FINDINGS AND SIGNIFICANCE

At the Laramie River, interstitial water drawn from a piezometer set 1 m into the river sediments and just above a creosote oil seep killed all fathead minnow larvae and Ceriodaphnia adults in June 1985 and significantly reduced fathead minnow growth ($P < 0.05$) in July and August 1985, compared to the upstream control. River water flowing

directly over the oil seep and at two downstream locations did not adversely affect survival, growth or reproduction compared to the upstream control during those three months. The Laramie River was rechanneled in September 1985 to avoid oil seeps and contaminated ground water. Ground water and river water collected at corresponding locations in the new river channel in October 1985 did not adversely affect survival, growth or reproduction, but river water below the downstream confluence with Spring Creek significantly decreased fathead minnow growth relative to the upstream control. Low concentrations of anthracene, phenanthrene and chrysene were detected in the toxic piezometer water in June 1985, using reverse-phase HPLC gradients. However, organics were not detected using HPLC on the other sampling dates. And no trace elements, major inorganic ions or routine water chemistry parameters differed considerably from the upstream control on any sampling date.

Crow Creek water and interstitial sediment water collected 50 m downstream from the oil refinery's NPDES discharge either killed all fathead minnows or Ceriodaphnia or significantly reduced fathead minnow growth or Ceriodaphnia reproduction relative to the upstream control ($P < 0.05$) on every sampling date. This toxicity was predominantly caused by high ammonia concentrations allowed in the NPDES permit for that discharge. Occasionally, surface water and interstitial water collected upstream from the NPDES discharge, but still adjacent to the oil refinery property, were toxic to fathead minnows and Ceriodaphnia. Toxicity in those waters may have been caused by contaminated ground water or storm-sewer runoff. However, no inorganic or organic contaminants could be identified as possible toxicants, and it could not

be shown that contaminated ground water had migrated into surface waters.

These results indicate that: (1) ambient toxicity tests can be used in alkaline surface waters of the western U.S.; (2) they are sensitive enough to detect contaminated ground water and surface waters; (3) they may be more sensitive in some cases than routine, inexpensive chemical analyses for detecting the presence of contaminant; and (4) toxicity of contaminated ground water and an industrial discharge varied considerably during the study.

PUBLICATIONS AND PROFESSIONAL PRESENTATIONS:

Crossey, M.J., J.S. Meyer and A. Boelter. 1987. Evaluation of Ambient Toxicity Tests for Detecting Groundwater Pollution Entering Streams and Rivers: Year 2 Progress Report. Report to Wyoming Water Research Center (USGS G1262-02), University of Wyoming, Laramie.

Crossey, M.J., J.S. Meyer and A. Boelter. 1986. Evaluation of Ambient Toxicity Tests for Detecting Groundwater Pollution Entering Streams and Rivers: Year 1 Progress Report. Report to Wyoming Water Research Center (USGS G1054-02), University of Wyoming, Laramie.

Crossey, M.J., A. Boelter and J.S. Meyer. 1986. Toxicological and Chemical Detection of Contaminated Ground Water Flowing into Streams and Rivers. Presented at the Eighth Annual Rocky Mountain Regional Meeting of the American Chemical Society. Denver, CO, June 8-12.

Crossey, M.J., A. Boelter and J.S. Meyer. 1986. Temporal Variability of Toxicity in a Stream Receiving Industrial Discharge. Presented at the Seventh Annual Meeting of the Society of Environmental Toxicology and Chemistry. Alexandria, VA, November 2-5.

Meyer, J.S., A. Boelter and M.J. Crossey. Temporal Variability of Toxicity in Stream Water and Interstitial Sediment Water Adjacent to an Industrial Discharge. (Manuscript in preparation).

PH.D. DISSERTATIONS:

Crossey, M.J. Determination of Contaminated Ground Water Using Chemical and Toxicological Parameters. (Expected completion date: December, 1987).

SYNOPSIS

PROJECT NUMBER: 03

Start: 5/15/85
End: 5/31/87

TITLE: Reservoir Eutrophication and the Value of Recreational Activities: A Case Study of Flaming Gorge Reservoir

PRINCIPAL INVESTIGATORS: David T. Taylor, James J. Jacobs, Edward B. Bradley, Department of Agricultural Economics, University of Wyoming, Laramie

COWRR: 05C

CONGRESSIONAL DISTRICT: One

DESCRIPTORS: eutrophication, recreation, economic benefits, travel cost method

PROBLEM AND RESEARCH OBJECTIVES

This study was motivated by the concern over eutrophication in the northern end of Flaming Gorge Reservoir. Eutrophication is the nutrient enrichment of water which results in increased algae production. One type of algae produced in the eutrophication process is Apahanizomenon, or bluegreen algae. Bluegreen algae is an undesirable algae growth due to its potential impact on a lake or reservoir. Some consequences of bluegreen algae growth are a degradation of fish habitat and risk of fish mortality due to oxygen depletion, an increase in municipal water treatment costs, and a marked reduction in use of a reservoir for recreational purposes. Phosphorus has been identified as the primary nutrient responsible for the dense, bluegreen algae blooms at the northern end of Flaming Gorge Reservoir in late summer and early fall.

From a recreational standpoint, economic losses would occur if individuals' recreational activities are altered or reduced as a direct consequence of the eutrophication process. The thick blooms of algae on

the water surface can discourage recreational activities such as boating, waterskiing, and swimming. Also, in a study done by the Wyoming Game and Fish (Wengert 1985), it was noted that oxygen and temperature measurements taken during the period 1977-1983 indicated a loss of summer trout habitat in parts of the northern end of the reservoir due to lack of oxygen in preferred temperature zones. Thus, there is a potential reduction in fishing activities due to the decreased fish population at this end of the reservoir.

Numerous measures for controlling the symptoms of eutrophication have been proposed. The possibility of control would be enhanced if further investigation were to find that the costs of control actions are less than the value of recreational activities affected by eutrophication. Estimating the costs imposed by eutrophication is synonymous to estimating the benefits from controlling eutrophication.

The primary objective of this study is to estimate the value of recreational activity at Flaming Gorge Reservoir. With this value the economic loss from any reduction in recreational activity associated with eutrophication can be assessed.

METHODOLOGY

The valuation method chosen to estimate the benefits from recreational activity at Flaming Gorge was the travel cost method. The travel cost method is developed by using actual observations on use and user characteristics from various origins to the recreational site. The wide range of costs facing individuals at different distances from a site provides considerable information about the influence of costs on

participation. This information can be used to generate a demand curve from which the benefits from recreation can be derived.

In order to estimate the value of recreational activity, and the potential loss in this value from eutrophication, it was necessary to conduct a survey of recreationists at Flaming Gorge. Information from recreationists is used to generate the demand curve for recreation at Flaming Gorge. Also, information from the survey regarding general recreational use of Flaming Gorge can be utilized in assessing management alternatives for the reservoir.

PRINCIPAL FINDINGS AND SIGNIFICANCE

Results of the survey showed that 26 percent of all users of Flaming Gorge Reservoir were aware of the excessive algae in the reservoir but only 13 percent indicated algae has adversely affected their recreational activity. If users of the northern end are focused upon, the survey data showed that 52 percent of the recreationists surveyed at the Buckboard and Firehole sites were aware of excessive algae and 27 percent had been adversely affected by it in their recreational activity. In identifying problems with eutrophication, recreationists were not restricted to 1986, the year they were surveyed. If a person responded positively to being adversely affected by algae it could have been for any one, or all, of the years he or she had used the reservoir.

A sensitivity analysis was performed to provide estimates of the loss in recreational benefits due to eutrophication for various time periods. Loss figures were estimated for the periods July-October, August-October, and September-October. These are the months eutrophication is normally at its worst. Since the severity of eutrophication has

varied from year to year, and from month to month, alternative scenarios were considered so as to provide a range of values with which potential costs of control measures for eutrophication can be compared. The time period used as a basis of comparison will depend on the predictions made about the future of eutrophication in Flaming Gorge.

The estimated annual loss in net benefits for the period July-October was $457,269. The annual loss in benefits for the period August-October was $288,323. The annual loss in benefits for the period September-October was $149,538. The net present values (NPV) of these losses are $11,203,091, $7,063,914, and $3,663,681 respectively. These loss figures can be compared with the cost of control measures in assessing the desirability of control measures from an economic standpoint. If the cost of possible control measures for eutrophication is greater than the estimated losses in benefits, from the economic standpoint, the control measures cannot be recommended.

REFERENCES

Dwyer, J.F., J.R. Kelley and M.D. Bowes. Improved Procedures for Valuation of the Contribution of Recreation to National Economic Development. University of Illinois at Urbana-Champaign, Water Resources Center, 1977.

Hubert, W., M. Parker and S. Greb. A Preliminary Assessment of Eutrophication on Flaming Gorge Reservoir. Wyoming Water Development Commission and Wyoming Water Research Center, January, 1984.

Wengert, M.W. Flaming Gorge Fisheries Management Investigations Six Year Completion Report (1977-1983), Wyoming Game and Fish Department, Fish Division, 1985.

PUBLICATIONS AND PROFESSIONAL PRESENTATIONS

Oster, J.M., D.T. Taylor, J.J. Jacobs and E.B. Bradley. 1987. Reservoir Eutrophication and the Value of Recreational Activities: A Case Study of Flaming Gorge Reservoir. Year 2 Progress Report to Wyoming Water Research Center (USGS G1262-03), University of Wyoming, Laramie.

Oster, J. 1987. Reservoir Eutrophication and the Value of Recreation: A Case Study of Flaming Gorge Reservoir. Agency Coordination Meeting, U.S. Bureau of Reclamation, Salt Lake City, UT, April.

Oster, J.M., D.T. Taylor, J.J. Jacobs and E.B. Bradley. 1986. Reservoir Eutrophication and the Value of Recreational Activities: A Case Study of Flaming Gorge Reservoir. Year 1 Progress Report to Wyoming Water Research Center (USGS G1054-03), University of Wyoming, Laramie.

M.S. THESES: none

PH.D. DISSERTATION: none

SYNOPSIS

PROJECT NUMBER: 04

Start: 5/15/85
End: 5/31/87

TITLE: Stream-Aquifer Interaction as a Possible Source of Recharge to the Paleozoic Aquifer Along the Laramie Mountains, Laramie County, Wyoming

INVESTIGATOR: Steve A. Mizell, Wyoming Water Research Center and Department of Geology, University of Wyoming, Laramie.

COWRR: 02A

CONGRESSIONAL DISTRICT: One

DESCRIPTORS: surface-groundwater relations, natural recharge, groundwater, surface water, groundwater recharge, stream discharges, effluent streams, groundwater level

PROBLEM AND RESEARCH OBJECTIVES

Development of a ground-water resource requires complete characterization of the hydrologic system in order to facilitate proper management. Resource characterization must include quantification of groundwater flow parameters, recharge and discharge. The Paleozoic Aquifer, which has been identified as a potential water resource in Laramie County, has not been fully characterized, particularly with regard to recharge. Infiltration from perennial streams is likely to be a significant portion of recharge to the aquifer that crops out in a narrow band of steeply dipping rock on the west edge of the Denver-Julesburg Basin. This work estimates recharge to and from the Paleozoic Aquifer from flow loss/gain of a stream crossing the aquifer outcrop.

This work has four objectives:

1. Determination of stream flow losses in the reach that crosses the Paleozoic outcrop.

2. Evaluation of the vertical ground-water gradient from the stream into the aquifer.
3. Characterization of the local geology.
4. Assessment of stream and shallow ground-water quality.

METHODOLOGY

Ground-water recharge is quantified by characterizing ground-water fluctuations and stream flow variability at a location where a perennial stream crosses the aquifer outcrop. A stream flow monitoring station was established at each end of the study reach. Stream stage was monitored continuously using a servo-manometer design developed by the U.S. Geological Survey. Manual readings of stream stage were made weekly. During site visits stream discharge was measured to produce a stage-discharge rating curve. Five shallow ground-water level monitoring wells were installed near the downstream stage recorder. One well was instrumented with a continuous float-type recorder, and all wells were measured weekly to determine ground-water levels. Precipitation was measured near the downstream stage recorder and at a location in the stream headwaters using continuously recording gages. Data that were collected in the field were reduced to permit comparison of (1) discharge at the two stream gages, (2) stream stage and ground-water levels, and (3) precipitation and discharge. Quarterly water samples were collected at each well and each stream gaging station during the second year of the project. Major ion chemistry of each sample was analyzed in order to study the chemical relationships between the stream water and the groundwater.

PRINCIPAL FINDINGS AND SIGNIFICANCE

Stream discharge at the downstream site was often lower than discharge at the upstream site, particularly during summer and winter. Higher discharge frequently occurs at the downstream site in the spring. Stream discharge appears to respond to local precipitation or short-term snowmelt events. Seasonal runoff trends are seen in increased discharges observed initially in late February and becoming quite obvious after late March.

Comparison of ground-water levels and stream stage makes two points clear. First, the well hydrographs clearly mimic the stream stage elevations. Secondly, ground-water levels are consistently 0.66 ft. to 2.08 ft. lower than the stage in the stream. This implies a vertical downward gradient of about 0.1.

Based on water balance calculations, the ground-water system is discharging into the stream during the spring and fall months and is being recharged by the stream during the summer and winter months.

During the third year of funding, data collection will be continued. Additional work will be conducted to locate the principal areas of stream loss and consider the relationship between stream loss and fractured rock outcrop. Further characterization of the geology and potentiometric surface of the surrounding area will be carried out.

PUBLICATIONS AND PROFESSIONAL PRESENTATIONS

Mizell, S.A., U.M. Wiersma, and G.L. Kerr. 1987. Stream-Aquifer Interaction as a Possible Source of Recharge to the Paleozoic Aquifer Along the East Flank of the Laramie Range, Laramie County, Wyoming: Second Annual Report. Report to Wyoming Water Research Center (USGS G1262-04), University of Wyoming, Laramie.

Mizell, S.A., U.M. Wiersma, and G.L. Kerr. 1986. Stream-Aquifer Interaction as a Possible Source of Recharge to the Paleozoic Aquifer Along the East Flank of the Laramie Range, Laramie County, Wyoming: First Annual Report. Report to Wyoming Water Research Center (USGS G1054-04), University of Wyoming, Laramie.

M.S. THESIS

This project forms part of the research for Ursula M. Wiersma's Master of Science degree in Geology/Water Resources. Her research will continue through the third year of the project. All of her thesis and degree work is expected to be completed by January 1988.

SYNOPSIS

PROJECT NUMBER: 05

Start: 6/1/86
End: 5/31/87

TITLE: Crop Yield-Water Use Relations for Wyoming

PRINCIPAL INVESTIGATORS: Larry Pochop, K. James Fornstrom, Department of Agricultural Engineering, University of Wyoming, Laramie

COWRR: 06D

CONGRESSIONAL DISTRICT: One

DESCRIPTORS: crop, yield, water use, crop production, evapotranspiration, model testing, water use efficiency

PROBLEM AND RESEARCH OBJECTIVES

Assessment of the economic effects of proposed water projects as well as the on-farm management of Wyoming's water resources is dependent, in part, upon the ability to define the relative consequences on crop yields of various management alternatives. Irrigation scheduling, deficit irrigation, and improvement of water use efficiencies are examples of management practices which affect production costs and water consumption.

Considerable attention has been given to the study of crop response to water, however, the applicability of various models to specific locations and crops remains largely undefined. The transferability of crop response models between sites has met with varied success, even within the same study regions. A major difficulty in assessing model applicability has been the general lack of suitable data, especially long-term yield data. This project investigated the applicability of crop response models through use of existing University of Wyoming Plant Science winter wheat yield data from 1951 through 1984.

The overall objective of the research was to investigate the applicability of crop yield-water use models to crops grown in high altitude locations. Specific objectives included: (1) gathering of historical crop-yield and climatic data which may be used in yield-water use models for the State of Wyoming, (2) testing of various production models for applicability in predicting yield response to water and the need for definition of growth stages and soil and climatic parameters, and (3) outlining the feasibility and/or need for additional studies to define the yield-water use relationships of various crops.

METHODOLOGY

Crop yield data were taken from University of Wyoming Plant Science variety trials. Data chosen were yields for the Cheyenne variety of winter wheat obtained at the dryland research centers at Archer, Gillette, and Sheridan. The Cheyenne variety was chosen because more years of yield data were available than for other varieties. Dryland locations were chosen because a record of the water input in the form of precipitation was available. A concern with these data was the inconsistency of a record of other yield reduction factors such as hail, disease, insect or weed problems.

The climatological data were from the National Oceanic and Atmospheric Administration (NOAA) as supplied by the Wyoming Water Center's Water Resources Data System. Data available for the dryland research centers included maximum and minimum temperatures and precipitation.

Soil water holding capacity is important in modeling soil water use to define the amount of soil water which can be stored and to define

depletion level amounts. Field sampling and laboratory analyses were conducted on the soils at the Archer, Gillette and Sheridan research centers and the available moisture range was determined for each of the soils. There were differences in available moisture between locations and at Sheridan there was a difference between fields used for the variety trials. Since the field locations were not noted with the yield data there was a problem in matching soil characteristics to crop yield data.

Most current water use/crop yield models are based on the evapotranspiration ratio, i.e. ratio of the actual evapotranspiration to the maximum evapotranspiration. Maximum evapotranspiration was estimated using a modified version of the Blaney-Criddle model. Actual evapotranspiration was estimated using an FAO model from which actual evapotranspiration is a percentage of the maximum evapotranspiration based on the level of the available soil water and the depletion level. The soil water balance included beginning soil moisture, crop water use, effective precipitation, and a growth model to define the root zone depth. Maximum and actual evapotranspiration for each growth period and for the season were then found by summing the appropriate daily values.

PRINCIPAL FINDINGS AND SIGNIFICANCE

The FAO yield-water use model by Doorenbos and Kassam has been tested. This model predicts actual yield as a function of maximum yield, a crop response factor and the evapotranspiration ratio.

Results using this model have been fairly good considering the agronomic and soil unknowns in the yield data. Approximately 60 percent of the wheat yield variations at Gillette and 40 percent of the yield

variations at Archer can be explained by using the calculated evapotranspiration ratios and the FAO model. No significant relationship was found for the Sheridan data. This is probably explained by lack of information on plot location and by possible runoff onto the plots. Combination of the Archer and Gillette data, use of constants suggested by FAO, and the evapotranspiration ratio found by including an initial soil moisture model predicted an average yield for 39 years of data of 2.24 m^3/ha. The actual average yield was 2.38 m^3/ha, or a difference of 0.14 m^3/ha.

It is felt that from this study with winter wheat data, the FAO model is a very good first step in modeling crop yield as a function of crop water use which is quantified by the evapotranspiration ratio. As indicated earlier, limitations of the data with respect to agronomic, soil and climate information limit the refinements which can be expected. Future studies which provide on-site soil water monitoring, agronomic limitations such as disease, insects or weeds, and climatic data such as hail would lead to more refined models being used.

PUBLICATIONS AND PROFESSIONAL PRESENTATIONS

Kottwitz, E., L.O. Pochop and K.J. Fornstrom. 1987. Estimating Response of Dryland Winter Wheat to Water Use for Wyoming. Paper presented at Rocky Mountain Region ASAE meeting, Grand Junction, CO, March 20-21.

M.S. THESES:

Kottwitz, E. Calibration of a Crop Yield-Water Use Model. (Expected completion date: July, 1987).

INFORMATION TRANSFER ACTIVITIES

DISSEMINATION OF RESEARCH RESULTS

'87 Wyoming Water Development and Streamside Zones Tour

A tour of some of Wyoming's water resources and streamside zones was organized to provide participants the opportunity to observe and discuss water and related resource issues of concern in the State. The caravan tour of the Cody, Wyoming area was conducted August 31 - September 1, 1987.

Sponsors for the tour included the Wyoming Water Research Center, University of Wyoming Agricultural Extension Service, Wyoming Game and Fish Department, U.S. Soil Conservation Service, Wyoming Association of Municipalities, Wyoming Water Development Commission, Bureau of Reclamation, Wyoming Department of Agriculture, Bureau of Land Management, Shoshone National Forest, and the Department of Environmental Quality.

Tour topics were: water storage, in-stream flow, riparian grazing, irrigation methods, irrigation return flows, channel erosion, siltation of reservoirs, fisheries habitat, municipal and industrial water, water supplies, state and federal water laws, and interstate water compacts.

Farmers, ranchers, land managers, water users, legislators, fishermen, and city planners will benefit from the tour. The tour was set up to provide a teaching and learning experience for the participants in an attempt to develop a more informed citizenry who can contribute to the future of Wyoming.

Water Resources and Water Law Seminar Held for Wyoming Legislators

The Wyoming Water Research Center and UW Cooperative Extension Service, in cooperation with the Legislative Service Office, conducted a Water Resources and Water Law Seminar for Wyoming Legislators. The Seminar was held January 8, 1987 in Cheyenne. Fifteen freshman legislators and five incumbents attended the one day session. The seminar opened with a session on reviewing water terms and Wyoming's ground and surface water supplies. State and federal water laws, compacts and decrees were discussed by the Assistant Attorney General. The State Engineer, and the Division I Water Superintendent covered the subject on how water laws are administered within the State of Wyoming. The Administrator of the Wyoming Water Development Commission and the Chief of the Water Division of the Economic Development and Stabilization Board reviewed the water programs of their respective state agencies.

A comprehensive folder containing information on Wyoming's water resources and water law was prepared for each legislator that participated in the seminar.

Similar seminars have been held in previous years preceding the legislative sessions. To date, over 70 legislators have attended.

Western Water Rights Symposium

Traditional western water law doctrine is undergoing change as the West's population grows and its various economies attempt to diversify. New reserve rights and apparent inadequacies in the basic prior appropriation system, as modified by statute, will greatly affect the marketing and allocation of water throughout the West. The Western Water Rights Symposium was held to examine these and other contemporary water

law issues through the insights of six noted water law authorities who offered practical legal analysis and suggestions for dealing with potential controversies these issues could raise.

The symposium, co-sponsored by the University of Wyoming College of Law and the Wyoming Water Research Center, was held in Jackson, Wyoming, February 26-27, 1987.

Water Resources Data System

The Water Resources Data System (WRDS) has provided water related data to Wyoming researchers for over a decade. The system, through the years, has developed into the most comprehensive single source of surface and ground water quantity and quality, snow quantity, well levels and climatological data available for Wyoming. The broad applicability of the system is attested to by the variety of its users. The system has provided information to many state, federal, county and municipal agencies and private firms. Requests were processed for over 113 different users.

WRDS is responsive to state requests. Two examples of assistance during this past year were: (1) a request from the Wyoming Cooperative Fishery and Wildlife Research Unit on the University of Wyoming campus for the loading of daily streamflow data for a station located on the North Platte River below Kortes Dam and operated by the Bureau of Reclamation, Mills, Wyoming; and (2) research conducted with regard to setting up a mechanism for obtaining data on a regular basis from the Wyoming Department of Agriculture Chemical and Bacteriological Laboratories, for the purpose of loading the data on the WRDS Water Quality database.

Wyoming Water Bibliography

The Wyoming Water Bibliography, a service project requested by the State, is one of the most comprehensive, multidisciplinary, computer-based bibliographic storage and retrieval systems regarding Wyoming's water resources. Currently operational, the WWB contains approximately 12,500 citations which can be searched, free of charge, on a request basis. A User's Manual for the system is available and has been mailed to over 1,000 people in the State involved with water issues, including legislators, agency personnel, representatives of county and municipal governments, libraries, special interest groups and interested members of the private sector. Many requests were processed over the year.

The Wyoming Water Research Center continues to work with the State Library in Cheyenne to provide search and retrieval on the Wyoming Water Bibliography for other state agencies in addition to updating the data-base itself with state documents.

Other

Wyoming Climate Atlas. The Wyoming Climate Atlas was published by the University of Nebraska Press. The 432-page hard-cover book written by Brooks Martner of the University of Wyoming's Department of Atmospheric Science, with a foreword by University President, Donald Veal, is now available. A selling price of $35 a copy makes the book reasonably accessible to a large number of people. News releases and circulars announced the availability of the Atlas. A copy was placed in every county library in the State by the Water Center. Data compilation, analysis and manuscript preparation aspects of the project

conducted by Martner were funded by a grant from the Wyoming Water Research Center.

The Atlas is a reference book and a compendium of data and information on all facets of the state's climate. It provides a comprehensive summary of Wyoming's climatology. Data are presented in the form of maps, graphs and tables with accompanying narrative text. Most data compilations in the book are completely new, but it also offers previously published data heretofore difficult to obtain.

State Research Activities. The Wyoming Water Research Center uses several networks to inform the public and private sector of research activities in the State. UW faculty, working through the Wyoming Water Research Center, have reported their research results in professional journals and at conferences. Research results are also disseminated through technology transfer efforts by organized workshops, seminars, etc.

Specific documents are circulated among users in the State. These are:

1. Information brochure: An information brochure on the Wyoming Water Research Center was designed to inform the public, state, and federal agencies, faculty and students of the mission, organizational structure, and programs of the WWRC. To date, the brochure has been distributed to universities, industry, state and federal agencies, industrial organizations, and many other private and public entities.

2. "WWRC News": In "Wyoming Water Flow Newsletter", published monthly by the Wyoming Water Development Association. Subscriptions total approximately 700.

3. WWRC Progress Reports. Distributed annually to advisory committees and to the Wyoming State Legislature.

4. Water Center Series Publications List.

5. Directory of Water Resources Expertise, Wyoming Water Research Center and University of Wyoming, Issue No. 1, September 1985.

6. Capsule reports on projects funded with monies available through the Center are being produced.

In addition to the above activities, the following meetings were attended and presentations made by the Water Center director, associate directors and/or staff as listed below. This past year has been extremely busy with these activities and oriented toward transferring information to potential users as well as making individuals and organizations aware of the WWRC and its activities and products.

1986

- Colorado Stockgrowers Association Annual Meeting, June 17-19, 1986, Burlington, Colorado.
- Universities Council on Water Resouces Annual Meeting, Flagstaff, Arizona, July 30-August 2, 1986.
- Governor's 1986 Resource Tour, Natrona County, June 1986, Wyoming.
- ASCE "Water Forum '86: World Water Issues in Evolution," Long Beach, California, August 4-7, 1986.
- Wyoming Rangeland Management Coordinating Committee, Cheyenne, Wyoming, August 26, 1986.
- Rocky Mountain Section Conference of American Water Works Association/Water Pollution Control Federation, Breckenridge, Colorado, September 7-10, 1986.
- Ucross Foundation Roundtable Discussions on Wyoming Water Development, Buffalo, Wyoming, September 22-24, 1986.
- National Association of Water Institute Directors Annual Meeting, Arlington, Virginia, September 23-25, 1986.

- Wyoming Water Development Association Annual Conference, Cheyenne, Wyoming, October, 1986.
- Symposium on the Future of the Missouri River Headwaters, Billings, Montana, October 8-10, 1986.
- 99th Annual Meeting of the Geological Society of America in San Antonio, Texas, November 10-12, 1986.
- Irrigation Workshop, Twin Falls, Idaho, November 20-21, 1986.
- Annual Meeting of the American Society of Agronomy and Soil Science Society, New Orleans, Louisiana, November 30-December 4, 1986.
- 1986 National Symposium on Mining, Hydrology, Sediment, and Reclamation, Lexington, Kentucky, December 9-14, 1986.
- Wyoming Public Lands Council and Wyoming Wool Growers Association Annual Meeting, Rock Springs, November 13-14, 1986.
- Wyoming Stockgrowers Association Annual Meeting, Casper, Wyoming, December 5-6, 1986.

1987

- Society of Range Management meeting, Boise, Idaho, February 8-12, 1987.
- Western Water Rights Symposium, Jackson Hole, Wyoming, February 27-28, 1987.
- Stream Habitat Workshops, Fort Collins, Colorado, March, 1987.
- American Water Works Association and Water Pollution Control Association, Local Chapter Meeting, Casper, Wyoming, April 3, 1987.
- Annual Meeting of the Association of American Geographers, Portland, Oregon, April 20-26, 1987.
- National Society of Wetland Scientist Symposium, Seattle, Washington, May 25-29, 1987.
- ASA/EPA Conference on Sampling and Site Selection in Environmental Studies, Washington, D.C., May 14-15, 1987.

COOPERATIVE ARRANGEMENTS

ADMINSTRATION

As specified in its charter, the Wyoming Water Research Center has responsiblity for 1) Service, 2) Extension, 3) Research and 4) Instruction. The Director, in keeping with the Center's charter, and in cooperation with the State of Wyoming, has spent the majority of his time in organizing the following services.

1. Service:

Service to State Agencies

- Continual liaison with state agency officials. Table 1 lists cooperating state agencies and Table 2 lists specific projects performed in response to state requests.
- Basic technology transfer to state agencies and Wyoming water users and managers.
- Serve as advisor to Wyoming Water Development Commission.
- Continued attempts to integrate state and federal research programs.
- Attend Governor's Water Forum.
- Attend meetings regarding specific research projects.

University Service

- Serve on University committees.
- Continued effort to apprise faculty members of research needs and opportunities in water-related research.
- Work with academic standards committee on Water Resources curriculum.
- Serve on appropriate graduate student committees.
- Serve on appropriate national and international technical review panels and committees.

TABLE 1

COOPERATING WYOMING STATE AGENCIES

Attorney General's Office
Conservation Commission
Department of Agriculture
Department of Environmental Quality Air, Land and Water Quality Divisions
Disaster and Civil Defense
Economic Development & Stabilization Board
Game & Fish Department
Governor's Office
Highway Department
Industrial Siting Administration
Legislative Services Office
Oil and Gas Conservation Commission
Recreation Commission
State Engineer's Office
State Planning & Coordination
Travel Commission
U.S. Geological Survey District Office
Water Development Commission
Wyoming Geological Survey

TABLE 2

Service-to-State
FY1986

- Collection of field data involving evapotranspiration and associated climatic measurement-Upper Green River (Wyoming Water Development Commission and UW Agricultural Engineering) - continued financial support

- Reconnaissance Survey: Trace Metals Concentrations in Wind River Glaciers (Western Wyoming College, Rock Springs) - continued financial support

- Production of Input-Output Model, county-by-county water use in Wyoming (Economic Development and Stabilization Board, Wyoming Water Development Commission and Wyoming Recreation Commission) - continued financial support

- Evaluation of Irrigation Diversions and Bank Storage Return Flows, Pinedale, Wyoming (Wyoming Water Development Commission and State Engineer's Office)

- Development of Methodology to Determine Flushing Flow Requirements for Channel Maintenance Purposes (Wyoming Water Development Commission, Wyoming Game and Fish, and U.S. Forest Service)

- Flood Design Frequencies for Drainage Basins in Wyoming (Wyoming Highway Department)

- Snowy Range Watershed Laboratory - continued financial support

- Riparian Zone Management, Muddy Creek, near Baggs, Wyoming (Ranchers, Water Quality Division of Department of Environmental Quality, U.S. Department of Agriculture, Bureau of Land Management, Soil Conservation Service)

- Livestock Stocking Rates/Fifteen Mile Creek near Worland, Wyoming. (Ranchers, Water Quality Division of Department of Environmental Quality, U.S. Department of Agriculture, Bureau of Land Management, Soil Conservation Service)

- Enhancement of Aquatic/Riparian Ecosystems (Pole Mountain) (Wyoming Water Development Commission, Wyoming Game and Fish, and U.S. Forest Service)

TABLE 2
(continued)

Service-to-State
FY1986

- Conveyance Losses in Natural Stream Channels (Wyoming Water Development Commission, State Engineer's Office, Board of Control)

- Nutrient Loading to Flaming Gorge Reservoir-Limnology Study (Bureau of Land Management, Department of Environmental Quality, State of Utah)

- Summary report of materials collected by the Governor's Acid Rain Coordinating Committee (Department of Environmental Quality, Governor's Office)

- Water Resources Model Library - inventory of hydrologic and economic computer-based models (State Water Forum; i.e. all state and federal agencies in Wyoming involved in water)

- Compiling streamflow data for a portion of the State of Nebraska within the North Platte and Platte River Drainage (Wyoming State Engineer's Office, State Attorney General's Office)

- Distribution maps of more than 100 species of fish within the State of Wyoming (Wyoming Game and Fish)

- Water Expertise Directory (State Water Forum)

- Water Quality of Laramie's Water Supply (City of Laramie)

Other

- Continued effort to be cognizant of regional and national water issues and research opportunities.
- Transfer of research results to appropriate users.

2. Extension

One of the four major missions of the WWRC involves extension activities. The WWRC believes in a strong water resources extension effort. The Associate Director for Extension and Information works in cooperation with the UW Agricultural Extension Service to develop expanded education programs among researchers conducting water-related research. It is our intention that both state and federal research results be packaged and presented in a useful and satisfactory manner to maximize the utilization of research effort and results.

Problem Solving Program to Inspire Creative Thinking Among Youth

The "Wyoming Future Problem Solving Program", is a program aimed at developing creative and futuristic thinking skills among students from fourth grade through high school senior level throughout the public schools of Wyoming. There were 140 teams participating, each team consisting of four students and one school instructor.

The program, directed by the University of Wyoming's Science and Mathematics Teaching Center, began in fall 1986 with work on two practice problems. The first involved that of garbage disposal by an imaginary island community where the water supply was threatened by contaminant flows from the existing landfill. The second problem centered on changes in family structures in a mythical North American city between 1987 and the year 2017.

A third problem centered on the limited water supply available to the explorers and settlers of a planet one-fourth the size of Earth in the year 2020. The Wyoming Water Research Center participated as a resource center for students working on this particular problem. A group of students from Cheyenne's McCormick Junior High School visited the Water Research Center and were presented a discussion of current topics in water resources and the role of the WWRC. The students and accompanying instructors were also given a tour of the Engineering Hydraulics Laboratory, the Watershed Laboratory in the College of Agriculture (assisted by faculty of Range Management), and the Red Buttes Environmental Laboratory (assisted by staff of the Zoology Department).

Evaluation of team solutions to this third problem were expected to result in selection of those to compete in the "Future Problem Solving Bowl" at the University of Wyoming in April 1987. The state bowl problem will be dealt with nationally by all states participating in future problem-solving activities and will focus on illiteracy. Wyoming's top finishing teams will qualify for national competition later in the spring.

Cokeville Elementary Research Project

In April 1986, a researcher from the WWRC was invited to give a talk to a group of school children at Cokeville Elementary School in southwest Wyoming. The talk centered on scientific methods used in measuring weather and climate.

For hands-on experience in weather data collection, a weather station (on loan from WWRC) which monitors precipitation and temperature

data (minimum and maximum thermometers) was installed at the school. As part of their science class, fifth and sixth graders took the measurements at the station and sent the data to WWRC where it was loaded on the University of Wyoming mainframe computer. Simple listings of the data were generated, and a small program was written to create plots of all the data over time. All output was returned to the students.

Data generated from this station are also used to describe local weather conditions for the residents. The local Soil Conservation Service office helps maintain the station.

3. Research

- Federal Program FY86

Research accomplishments of the FY86 Federal Water Research Program were reviewed by the Director. The results of the projects sponsored with FY86 monies have been provided to the Center's advisory committees and presented at professional meetings.

- Federal Program FY87

The Director solicited proposals under the FY87 Federal Water Research Program from interested faculty on campus and the seven community colleges. Proposals were received and reviewed by state agencies and regional Water Institute/Centers--six were funded under the program.

4. Instruction

The Wyoming Water Research Center is cooperating with academic departments throughout the campus to provide master of science degree programs which contain high quality multidisciplinary training in water resources. The master of science degrees offered through these affiliations are awarded as specialty options within the existing master of

science programs currently housed within the sponsoring departments. The water resources emphasis will be acknowledged on the graduate transcript and thereby certify to potential employers that the candidate has completed an attractive in-depth multidisciplinary course program in the broad area of water resources. There are 15 students enrolled in the program at present.

SOIL CONSERVATION SERVICE

An agreement was signed with the Soil Conservation Service permitting access to the Centralized Forecasting System (CFS) in Portland, Oregon by WRDS personnel via terminal and modem. A computer account was established for such use and will provide a valuable service to WRDS requestors.

NATIONAL WATER DATA EXCHANGE

The Wyoming Water Research Center (WWRC) has entered into a cooperative agreement with the National Water Data Exchange (NAWDEX) to serve as an assistance center for the purpose of helping users of water data identify and locate the data they need. The Center has access to the computerized databases of NAWDEX, WATSTORE, and STORET.

WWRC ADVISORY STRUCTURE

The organizational structure and operational procedures of WWRC for a high degree of accountability and relevance to state and regional water research seems to be working well. In 1982, the WWRC was restructured to include a Research Review and Priorities Committee (RRPC) appointed by the Governor of the State of Wyoming and the President of the University. The membership was designed to reflect the

interests and inputs of the Executive Office, the legislative branch of government, the academic community and the University administration (Table 3). The Committee meets at least twice annually to discuss Water Center activities, research needs as they may have been perceived to change, and to approve projects presented.

Prior to presentation of projects to the Advisory Committee, a review process that includes relevant state agencies, in addition to scientific peer review, has been completed. This process has insured good science directed toward issues meaningful to water research needs in the state and the region.

A Citizens Water Issues Advisory Council (CWIAC) was formed in January 1984 and consists of members selected by the Governor (Table 4). The Council was formulated to represent a) agriculture, b) recreation, c) municipalities, d) National Forest Service, Bureau of Land Management, Bureau of Reclamation, U.S. Fish and Wildlife Service, e) consulting engineers, f) State Legislature, g) industry, h) environmental interests, i) private citizens, j) legal profession, k) political action groups (e.g., League of Women Voters), l) Wyoming Higher Education System, and m) state agencies. The Council is charged with collecting input from constituencies, water experts within and outside the State, and other available sources, identifying water concerns and transmitting those concerns to the Research Review and Priorities Committee. The Council meets at least once a year.

OTHER DIRECTOR'S OFFICE ACTIVITIES

Program Review: A Federal Evaluation

In compliance with Section 104(e) of the Amended Water Resources Research Act of 1984, Public Law 98-242, the Wyoming Water Research

TABLE 3

WYOMING WATER RESEARCH CENTER
Research Review and Priorities Committee

Chairman:

Paul Schwieger
Economic Development & Stabilization Board
Water Division
Herschler Building
Cheyenne, Wyoming 82002
(307) 777-7284

Executive Secretary:

Harold L. Bergman
Acting Director
Wyoming Water Research Center
Room 151, VA Building
University of Wyoming
(307) 766-2143

U.W. Appointees:

Donald L. Veal, President
Office of the President
Old Main, Room 206
(307) 766-4121

Ralph DeVries
Vice President for Research
Old Main
(307) 766-5353

Dennis H. Knight
Department of Botany
Aven Nelson, Room 135
(307) 766-3291

Quentin Skinner
Range Management
Agriculture Bldg., Room 2028
(307) 766-4139

(All University of Wyoming, Laramie, Wyoming 82071)

Executive Appointees:

Governor Ed Herschler
State Capitol Building
Cheyenne, Wyoming 82002
(307) 777-7434

Willard Rhoads
Water Development Commission
P.O. Box 637
Cody, Wyoming 82414
(307) 587-3787

Warren White
State Planning Coordinator
Herschler Building
Cheyenne, Wyoming 82002
(307) 777-7574

Legislative Appointees:

George R. Salisbury, Jr.
Representative, Carbon County
Savory, Wyoming 82331
(307) 383-2430

Donald R. Cundall
Senator, Goshen-Platte County
Wendover Route
Guernsey, Wyoming 82214
(307) 322-3311

TABLE 4

WYOMING WATER RESEARCH CENTER

Research Review & Priorities Committee

CITIZENS WATER JSSUES ADVISORY COUNCIL

Myron Goodson, Chairman
Citizens Water Issues Advisory Council
Box 429
Sundance, WY 82729
(307) 283-2407

Walter Yose, Jr.
P.O. Box 94
LaBarge, WY 82123
(307) 386-2322

Beryl Churchill
848 Road 10-A, Route 3
Powell, WY 82435
(307) 754-4865

Philip Hocker
P.O. Box 458
Wilson, Wyoming 83014
(307) 733-6116 or 733-6345

John Morris
10401 Experimental Farm Road
Cheyenne, WY 82009
(307) 634-7561

Jim Rumery
North Portal Road
Riverton, WY 82501
(307) 856-7477

Russell Michael
Route #2
Torrington, WY 82240
(307) 788-1139

Center was visited by the USGS State Water Institute Evaluation Team on April 8-10, 1987.

The agenda included an overview of the Center's programs; meetings with University of Wyoming administrators, deans and department heads of cooperating faculty; the Center's advisory groups; and principal investigators. A slide show of the Center's field laboratories was followed by a tour of WWRC and UW facilities.

The final report has been received by the administrators of the University and the Director of the WWRC. In addition to many favorable comments, it was the consensus of the evaluation team that the "program of the Wyoming Water Research Center meets, and in many cases, exceeds the performance expectations for the evaluation elements," and further recommends that "the Center's eligibility to receive grants be continued under the provisions of the Water Resources Research Act of 1984."

Director Search

During FY86, the Vice-President for Research and Graduate Studies appointed a search committee to fill the vacant position of Director of the Wyoming Water Research Center. A position announcement was circulated nationally in February, 1986 and advertising appeared in many professional journals during April through June. Over 58 applications were received and interviews were scheduled for July, 1987.

The Search Committee was chaired by the Associate Dean of the College of Agriculture and members included faculty from the University of Wyoming departments of Zoology/Physiology, Geology, Agricultural Engineering, Law, Economics, Geography/Recreation, and a state agency representative from the Wyoming Game and Fish Department.

TRAINING ACCOMPLISHMENTS

Shown by fields of study and training levels indicated, the number of students participating in projects financed in part through the Fiscal Year 1986 Program are indicated below.

Training Category	Training Level				
		Graduate			
	Under-Graduate	Master's Degree	Ph.D. Degree	Post-Masters	Total
Engineering					
Agricultural	1	1			2
Civil					
Environmental					
Biology					
Ecology					
Fisheries, Wildlife and Forestry					
Agronomy					
Chemistry					
Hydrology	1	1			2
Resources Planning					
Law					
Economics				1	1
Geography					
Other - specify					
Environmental Toxicology	3		1		4
TOTAL	5	2	1	1	9