PROJECT MANAGEMENT PLAN

GROUND-WATER RECHARGE STUDY

Task 22
of the
Zero-Offsite Water-Discharge Study

Prepared For:

EG&G ROCKY FLATS, INC.
Facilities Engineering
Plant Civil-Structural Engineering
P.O. Box 464
Golden, CO 80402-0464

EG&G Job No. 401009
BOA Contract BA 72429PB
Purchase Order No. BA 79844GS

Prepared by:

ADVANCED SCIENCES, INCORPORATED
405 Urban Street, Suite 401
Lakewood, CO 80228

December 21, 1990

ASI Project No. 208.0122

December 21, 1990

James Ripley
Subcontract Administrator
EG&G Rocky Flats, Inc.
P.O. Box 464
Golden, CO 80402-0464

Subject: Project Management Plan, Ground-Water Recharge Study
ASI Project No. 208.0122

Dear Mr. Ripley:

EG&G Rocky Flats, Inc. issued a request for proposal (RFP) BA 79844GS for the subject study on July 19, 1990. Under Basic Ordering Agreement BA 72429BP in accordance with a July 18, 1990 Statement of Work entitled "Zero Offsite Water Discharge - Rev. 5" specifically addressing Attachment 1, Task 5, this Project Management Plan (PMP) is being written. In response to this request, Advanced Sciences, Inc. (ASI) is pleased to submit this PMP to conduct the subject study on and near the Rocky Flats Plant. ASI accepts the terms and conditions of the RFP.

Our PMP and associated budget is based upon the technical requirements as stated in the Statement of Work. We look forward to working with EG&G on this interesting and critical study effort. If you have questions or desire additional information regarding this PMP, please call.

Yours truly,

Michael G. Waltermire, P.E.
Project Manager

cc: R. A. Applehans, EG&G-FE/PCSE (10 copies, 1 with, 9 without appendices)
M. J. Rengel, ASI-Albuquerque
D. J. Hatz, ASI-F&A (Contracts)
Dr. E. P. Poeter, Colorado School of Mines
File/Library: ASI Project No. 208.0122

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1.0 INTRODUCTION

This study is one of several studies being conducted for, and in the development of, a Zero-Offsite Water-Discharge Plan. Specifically, this study would assess rates and fate of recharge to both the alluvial and bedrock aquifers underlying the Rocky Flats Plant (RFP).

This Project Management Plan (PMP) has been prepared in response to a request for the planning and implementation of a subordinate study in EG&G Rocky Flats, Inc's Statement of Work for the Zero-Offsite Water-Discharge Study dated May 30, 1990 (Revision 5). This PMP and associated work components are being completed under Letter Contract No. BA 79844GS dated August 13, 1990 (EG&G Job No. 401009) as part of Basic Ordering Agreement (BOA) Contract BA 72429PB. This PMP outlines several work elements for an effort required to evaluate ground-water recharge at the RFP.

Understanding the nature of recharge conditions in the Denver Basin, and in particular in the vicinity of the RFP is important relative to managing water resources, predicting contaminant migration and remediation of ground-water contamination problems. In regard to water management, the volume of water entering the bedrock system dictates the safe yield of the Denver Basin. Numerical models, such as MODFLOW (McDonald and Harbaugh, 1984) are being used by others to solve water management problems and (the currently uncertain) recharge rates are an input to these models. If the recharge rates are incorrect, other calibrated parameters of the model will also be in error if the model is to predict conditions observed in the field. Such a situation leads to erroneous basin simulations and poor management decisions. At contaminated sites, when contaminants are transported into the alluvial zone by infiltrating water, it is currently uncertain whether the contaminants migrate vertically downward into the bedrock

or move laterally in the alluvial zone. Different remedial actions are appropriate for each of these alternative transport paths.

Ongoing assessments of recharge, by others in the Denver Basin, suggest that the lateral flow path in the alluvial zone may be significant. Calibration of existing ground-water models of the Denver Basin indicate low recharge rates to the bedrock. The combined influence of soils, precipitation, vegetation and climate suggest that higher rates of recharge occur to the alluvial aquifer than the bedrock aquifers. If the recharge estimates from both of these assessments are correct, then infiltration to the alluvial zone may discharge from the ground-water system without flowing through bedrock. This discharge is likely to occur via lateral flow above the bedrock followed by evapotranspiration or seepage to a stream.

Because the current assessment of the fate of recharge is based upon indirect evidence, it is appropriate to conduct field experiments to test the hypothesis that infiltration at the surface is higher than infiltration to the bedrock. This study would provide quantitative field measurements of recharge in that part of the Denver Basin in the vicinity of the RFP and provide data upon which to base the Zero-Offsite Water-Discharge Plan.

The following sections provide a subtask-level description of the activities which are proposed in response to EG&G's Statement of Work. A list and schedule of deliverables along with the anticipated levels of effort and associated costs to provide these services are included.

2.0 SUBTASK-LEVEL WORK ITEMS

2.1 SUBTASK 012210 - PROJECT PLANNING DOCUMENT

ASI, in conjunction with its identified subcontractor and EG&G staff, has developed this detailed PMP. This PMP delineates various task and subtask assignments, schedules, evaluation milestones, budgets, and specific study-team participants to be used for the various identified

work components of this study task. The PMP expands upon the original ASI (1990) proposal, which was previously submitted to EG&G for review and comment.

Several ASI key personnel as well as supporting staff members and a subconsultant have been identified as follows (with labor-rate categories indicated in parentheses):

ASI Key Staff:	Michael G. Waltermire, P.E., Project Manager (26) James R. Kunkel, Ph.D.,P.E., Principal Scientist (28) Nicholas J. Kiusalaas, Principal Technician (20)
ASI Supporting Staff:	Theresa M. Santangelo-Dreiling, Senior Engineer (24) Dawn A. Tschanz, Engineer (23) Cynthia Kyle-Fischer, Accountant (22) Douglas Martin, Senior Draftsman (19)
ASI Peer Review:	Michael J. Rengel, P.E., Project Director (31) Timothy D. Steele, Ph.D., P.H., Group Manager (31)
Subcontractor:	Eileen P. Poeter, Ph.D., P.E., Professor, Colorado School of Mines

The estimated ASI and subcontractor hours for this study are given in Appendix A. A resume of Dr. Poeter is attached to this PMP.

2.2 SUBTASK 012220 - LITERATURE REVIEW

Literature searches will include available reports, drawings, maps and applicable documents from EG&G personnel at the RFP. Data and literature searches also will include Federal, State and local agencies for both published and unpublished data and information. The local university libraries and Federal and State agency libraries will be used to search for relevant data and information regarding recharge to Denver Basin aquifers. The relevant literature will be compiled into an annotated bibliography. Certain references will be acquired permanently for the study plan.

Historic estimated recharge values typically used in ground-water models of the Denver Basin will be compiled and tabulated for later comparison with measured recharge. The geologic and geohydrologic characteristics of the alluvial and bedrock aquifers in the vicinity of the RFP will be compiled and tabulated for comparison to observed and measured characteristics.

2.3 SUBTASK 012230 - HEALTH AND SAFETY PLAN/IMPLEMENTATION

This subtask includes preparation and implementation of a site-specific Health and Safety Plan (HASP) for this study. ASI's corporate Health and Safety Officer will review and approve the HASP. We understand that excavation permits may be required to drill the instrument access holes and install the soil moisture equipment. Job Safety Analyses (JSA's) would be prepared, if necessary, in concert with EG&G construction management, health and safety, industrial hygiene, occupational safety and facilities engineering personnel. Representatives from these EG&G divisions will have input to the HASP and, if necessary, the JSA's. We envision that a draft of the HASP and JSA's will be reviewed and approved by EG&G prior to drilling the holes and equipment installation at the proposed locations at the RFP. Ten copies of the HASP and JSA's will be submitted to EG&G for approval.

2.4 SUBTASK 012240 - FIELD INVESTIGATIONS AND DATA COLLECTION

In order to assess the rates and fate of recharge, a field study is proposed. The rate of infiltration to the alluvial zone will be determined using shallow, box lysimeters. Deep percolation will be assessed by placing neutron moisture-probe tubes at up to eight locations in the alluvial materials. The moisture-probe tubes will extend from the soil surface into bedrock if possible. Soil and near-surface bedrock properties, required for moisture flow modeling in conjunction with the analyses in Subtask 012250 below, will be estimated from core samples. Cores will be sealed upon collection, moisture content of the core samples will be determined in the laboratory, and these data will be used to calibrate the neutron probe. Representative cores (assumed to be about 20 of the estimated 100 total core samples) will be tested to determine their moisture

characteristic curves and hydraulic conductivities as a function of saturation. Additionally, grain-size distribution, particle specific gravity, and bulk density of about 25 core samples will be determined as a result of laboratory analyses. The core samples not used for laboratory testing will be archived.

Two sets of monitoring devices will be installed. Each set will be installed as a cluster at a sufficient number of horizontal and vertical locations so that trends in lateral migration can be evaluated. If conditions allow, tracers may be introduced to the system to verify the direction of flow. To keep costs down, the site(s) will be selected in that part of the RFP where depth to bedrock is minimal. The exact locations of the field equipment would be made in concert with EG&G. We propose that the locations of the two sets of monitoring devices be selected where Rocky Flats Alluvium (1) overlies claystone/siltstone material, and (2) overlies sandstone material. These materials would most likely be part of the upper Arapahoe Formation. At one of the sets of monitoring devices, the proposed neutron-probe hole(s) may extend through the sandstone material into the underlying claystone/siltstone material if such a site can be located.

We propose to drill about 6 to 10 holes, with each hole being up to 50-feet in depth. Each hole will be sampled at predetermined intervals (about every two to five feet for the soil and continuously cored for the bedrock) to obtain representative samples (estimated to be about 100 core samples) for the above laboratory analyses. Each hole will be completed with a vertical series of porous-cup tensiometers or soil moisture sensors and a neutron probe tube. One or more box lysimeters will be installed at the surface near the soil moisture tube hole. For purposes of this PMP, we have assumed that the holes would be either (1) drilled under an existing contract with EG&G-ER/EMAD; or (2) hand-augured if the depths were less than about 10 feet. Additionally, the holes used for the neutron-probe tubes may also be completed with a vertical series of porous-cup lysimeters to collect samples of interstitial water from the unsaturated zone. Surface runoff from each of the two sites would be measured by putting metal or plastic "flashing" around the site and collecting the runoff water in a plastic container embedded into the ground. A storing raingage at the sites would give a record of total

precipitation for comparison with the EG&G recording precipitation gage in the West Buffer Zone. The purpose of the above equipment would be to provide data for a total water balance at the sites including inputs, outputs and changes in soil moisture storage.

Laboratory tests from the core samples would include: (1) 20 moisture characteristic curves; (2) 20 unsaturated hydraulic conductive versus saturation curves; (3) 25 grain-size distribution tests; (4) 25 moisture content tests; (5) 25 particle specific gravity tests; and (6) 4 moisture characteristic/Bruce-Klute tests to be run in a second laboratory as a quality control/quality assurance check.

After completion of the recharge measurement facilities, a series of experiments related to measurement of recharge would be made. Because the depth to bedrock may be greater than 10 feet, and the timing of precipitation is uncertain in this part of Colorado, we may decide to spray water at the surface to artificially introduce a water pulse to the soil. This pulse would be measured as it infiltrates the soil surface, redistributes in the soil, and percolates toward and into the bedrock. A typical pulse may have a tracer added to it to better trace the progress of the water. The type of tracer, if any, would be discussed with EG&G prior to introducing it to the pulse. We propose that up to three such artificial water pulses be generated and monitored.

In addition to the artificial water pulses, naturally occurring water pulses from precipitation would be monitored at the recharge site. This monitoring would be after a significant rainfall or snowmelt event(s) and proceed similarly to the artificial water pulse experiments.

Although an interim report is expected to be submitted according to the schedule given below, continued monitoring throughout at least one year would be advisable to draw reliable conclusions regarding recharge.

2.5 SUBTASK 012250 - DATA INTERPRETATION AND ANALYSES

The flux of moisture through the system will be determined by modeling the changing moisture distributions as a function of time from the measurements made from the pulse experiments. The quantity of recharge will be assessed in both an area underlain by low hydraulic conductivity bedrock (claystone/siltstone) and an area underlain by high hydraulic conductivity bedrock (sandstone). Currently, we envision three to five nested monitoring stations at each of two sites, one in a high conductivity area and one in a low conductivity area.

A water balance of each site would be made. It is assumed that the on-site storing raingage and the existing EG&G meteorological station in the West Buffer Zone would be sufficient to provide data on precipitation and other meteorological variables for the water balances at the site(s).

Results of the analyses would provide the quantity of recharge to the bedrock aquifers for a given input pulse at the surface and the antecedent soil moisture condition(s) of the system. If a sufficient number of experiments are run or enough data are collected, a predictive relationship between precipitation inputs and recharge over a given time period may be possible (such as annual recharge given annual precipitation). It is envisioned that the experiments may continue past the end of the Zero-Offsite Water-Discharge Study if funding is available.

2.6 SUBTASK 012260 - REPORT PREPARATION

Based upon the results of the work completed in Subtasks 012220, 012240 and 012250 above, ten copies of the draft interim report would be prepared by ASI for submittal to EG&G for comment and review. The report for this study would consist of the field equipment installation, field recharge experiment procedures and data, soils characterization data, and recharge estimates available at the time of report preparation. After review and incorporation of the comments, 20 copies of the final interim report would be prepared and submitted to EG&G. An executive presentation report consisting of 50 paper copies of the viewgraphs, one reproducible of the

viewgraphs, and one set of overhead slides of the executive summary presentation would be submitted by ASI.

Typed hard copies of the text documentation would be delivered to the RFP as two sets of adequately and correctly labeled 3-1/2", 720K, not compressed, diskettes (original plus backup). The diskettes would be 100 percent IBM-PC-DOS compatible, and in "WordPerfect" 5.1.

2.7 SUBTASK 012270 - PROJECT MANAGEMENT

In order to monitor the progress of this study, an ASI representative would report on work accomplished, near-term plans, requests, and problems encountered during the performance of the study. These reports would be oral reports at weekly group meetings at the RFP to discuss options and follow-up participation with cognizant RFP personnel. Minutes of these weekly meetings would be prepared by ASI and submitted within three working days to EG&G.

In addition to the weekly group meetings, three other meetings have been budgeted in this proposal. The first meeting would be an in-progress review meeting at ASI's offices to be attended by RFP representatives at approximately 30 percent completion of the study. This meeting would be to assess the initial progress and direction of the study. The second meeting would be a report evaluation review meeting after submittal of the draft report for the study, but prior to the final report submittal. The third meeting would be the executive presentation of the final report summary, conclusions and recommendations. We envision that the second and third meetings would be held at the RFP.

3.0 DELIVERABLES AND SCHEDULE

The following is a list of deliverables and the associated estimated schedule for their completion:

- Final Project Management Plan - This document.

- Draft interim report from Subtasks 012220, 012240 and 012250 summarizing the equipment installation, data collection and results of the recharge experiments. The draft report would be submitted on or before May 17, 1991. Continued monitoring is recommended to complete at least a one-year period.

- Final interim report incorporating EG&G technical review comments, scheduled for submittal on or before May 31, 1991.

- Executive summary viewgraphs scheduled for submittal on or before May 31, 1991.

This schedule assumes a start-up date for field investigations of late January 1991.

4.0 PROPOSED LEVEL-OF-EFFORT AND ASSOCIATED COSTS

The level-of-effort showing proposed labor hours by labor category for this study is summarized in Appendix A. The project budget for the Ground-Water Recharge Study is given on the spreadsheet in Appendix B. Dr. Eileen Poeter, P.E., Department of Geology and Geological Engineering, Colorado School of Mines (CSM) will be used as a subcontractor for with this study. The overall study would be under the direction of ASI. Dr. Poeter's resume is attached to this PMP.

5.0 REFERENCES

Advanced Sciences, Inc. (ASI), 1990, EG&G Rocky Flats, Inc., Request for Proposal, BA 79344GS, Ground-Water Recharge Study, EG&G Job No. 401009: Prepared for Facilities Engineering, Plant Civil/Structural Engineering, August 3, 7 p., 2 appendices.

McDonald, M. G. and A. W. Harbaugh, 1984, A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model, Scientific Publications Co., Washington, D. C., 528 p.

RESUME OF DR. EILEEN POETER, P.E.

EILEEN POETER
GROUND WATER HYDROLOGIST
Department of Geology and
Geological Engineering
Colorado School of Mines
Golden, CO 80401
(303) 273-3829

EDUCATION

Ph.D., Engineering Science, Washington State University, 1980
M.Sc., Engineering, Washington State University, 1978
B.Sc., Geology, Lehigh University, Pennsylvania, 1975

EXPERIENCE

1987-Present COLORADO SCHOOL OF MINES, Golden, CO
Assistant Professor
Responsible for senior and graduate level instruction and research programs in groundwater. Emphasis is in the areas of groundwater modeling and borehole geophysics. A number of current projects involve research in identification and characterization of aquifer heterogeneities using a variety of hydraulic and geophysical techniques. Other projects involve simulation of ground-water flow and contaminant transport in heterogeneous aquifers. Additional research includes characterization and improved methods for simulation of stream/aquifer interaction. Research of the influence of groundwater hydraulics on the concentration of radon in well water is also underway.

1984-1987 WASHINGTON STATE UNIVERSITY, Pullman, WA
Assistant Professor
Responsible for senior and graduate level instruction and research programs in the fields of groundwater and geophysics. Emphasis was in the areas of borehole geophysics and groundwater modeling. Projects included research in the nature of full acoustic waveforms in fractured media, investigation of groundwater contributions to phosphorus loading of lakes, and geohydrologic and borehole geophysical studies of hazardous waste sites and potential high level nuclear waste disposal sites.

1983-1984 GOLDER ASSOCIATES, Bellevue, WA
Senior Hydrologist
Involved in all phases of hydrologic, geohydrologic and borehole geophysical studies, and specialized in computer modeling. Managed a large project to assess geohydrologic conditions at seven potential high-level nuclear waste repository sites in salt environments. Previously, lead hydrologist of a large project to establish a methodology for studying, and to study the design and performance of engineered barriers for deep geologic nuclear waste repositories at three specific sites.

Responsibilities also included the continued development, maintenance, marketing, and user support of the Golder Groundwater Package computer software. This included conducting information seminars and short courses on the application of the software to groundwater modeling problems.

1980-1983 GOLDER ASSOCIATES, Bellevue, WA
Project Hydrologist
Projects involved analytical and numerical modeling evaluations of pump tests, tailings pond seepage, mine water inflow, dewatering for foundations and slope stability, and coupled heat and groundwater flow in the vicinity of deep geologic repositories for high-level nuclear waste. Project work also included design of storm drainage systems, landfill closures and dewatering systems.

1980 WASHINGTON STATE UNIVERSITY, Pullman, WA
Research Technician
Traveled to field sites, recorded geophysical logs, and performed preliminary interpretations on site. Log suites included caliper, wall resistivity, spontaneous potential, fluid temperature, fluid resistivity, fluid flow velocity, natural gamma, neutron-epithermal neutron, neutron-gamma, and gamma-gamma logs. Interpretations provided information pertinent to construction and development of water wells.

1976-1980 WASHINGTON STATE UNIVERSITY, Pullman, WA
Research Assistant
Responsible for interpretation and correlation of geophysical logs, mathematical modeling of radiation processes involved in nuclear

logging, computer programming of mathematical models, and designing calibration tanks for logging tools.

REGISTRATIONS Professional Engineer, No 25286, Colorado

AFFILIATIONS Adjunct Professor, Department of Geology, Washington State University
Member, Association of Ground Water Scientists and Engineers (AGWSE), NWWA
Member, American Geophysical Union
Member Colorado Ground Water Association

PUBLICATIONS IN PRESS

Poeter, E.P., Aug 1990, A New Tool: Delineating Aquifer Heterogeneities with Microgravity Surveys During Aquifer Testing, Bulletin of the Association of Engineering Geologists.

Poeter, E.P., and Gaylord, D.R., Jan-Feb 1991, Influence of Aquifer Heterogeneity on Contaminant Transport at the Hanford Site. Ground Water.

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Gaylord, D., and Poeter, E., 1989, "Geology and Geohydrology of the 300 Area: Recommendations for FY90-91 Research", Battelle Pacific Northwest Laboratories, Richland, WA, 99532, pp 206.

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Stream-Aquifer Model", Proceedings of the Association of Ground Water Scientists and Engineers: National Water Well Association's Conference on Solving Ground Water Problems with Models, Indianapolis, IN.

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Zlatev, P., Poeter, E., and Higgins, J., 1988, "Physical Modeling of the Full Acoustic Waveform in a Fractured, Fluid Filled Borehole", Geophysics, v. 53, no. 9, pp 1219-1224.

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Wood, T. and Poeter, E., 1986, "Geophysical Log Correlation of Five Wells in North Eastern Washington, Creston Area," Washington State University, College of Engineering Research Report 86/15-11.

Poeter, E., 1986 "Geophysical Analysis of Nob Hill Water Well #4," Washington State University, College of Engineering Research Report #86/15-2.

Taylor, T. and Poeter, E., 1986 "Borehole Geophysical Log Analysis of Colbert Landfill Site," Washington State University, College of Engineering Research Report #86/15-1.

Talbot, R.; Poeter, E.; Koplic, C.; Lestor, D.; Kirstein, B.; Stula, R.; Scott, J.; Nalbandian, J., 1984, Draft Final, "Performance of Engineered Barriers in Deep Geologic Repositories for High Level Nuclear Waste (HLW)," Volume 3 Basalt, Prepared for U.S. Nuclear Regulatory Commission, NUREG/CR-4026.

Poeter, E.P. & T.L. Weber, 1984 "Borehole Geophysical Log Analysis of Test Wells Near Soda Springs, Idaho," Prepared for Golder Associates, College of Engineering Research Report #84/15-19, December 21, 1984.

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Poeter, E.J., 1979, "Borehole Geophysical Studies at Grand Coulee Dam, Part IV." Washington State University Research Report, 79/15-13.

Poeter, E.J., and Crosby, J.W., 1977, "Development of Quantitative Interpretation Techniques for Geophysical Logs of the Hanford Reservation." Washington State University Research Report, 77/15-16.

Jackson (Poeter), E.P., Robinette, M.J., and Crosby, J.W., 1976, "Geophysical Logging of the Hanford Reservation," Washington State University Research Report, 76/15-29.

Crosby, J.W., Jackson (Poeter), E.P., and Moe, L.M., 1976, "Techniques of Geophysical Logging on the Hanford Reservation," Washington State University Research Report, 76/15-29.

ABSTRACTS

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Poeter, E.P., and Ibrahim, W., "Characterizing Heterogeneities in Unconfined Aquifers with Microgravity Surveys During Pump Tests", Abstracts with Programs of Geological Society of America's 100th Annual Meeting, October, 1988.

Poeter, E.P., and Belcher, W. R., "Assessment of the Geology of Heterogeneous Aquifers Using Inverse Plume Analysis", Abstracts and Program of Association of Engineering Geologists 31st Annual Meeting, October 1988.

Poeter, E.P., "In Situ Fracture Characterization in Crystalline Rock", EOS Transactions of the American Geophysical Society, V68, N44, Nov. 3, 1987, p.1295.

PRESENTATIONS

Invited presentation for the Association of Engineering Geologist's 32nd Annual Meeting, <u>Current Approaches to Parameter Estimation Techniques, Practical Considerations</u>, October 1989.

Invited presentations for Shell Research, Houston, TX. Characterizing Heterogeneities of Unconfined Aquifers (with Emphasis on Geophysical Techniques) and Characterizing Heterogeneities of Unconfined Aquifers with Microgravity Surveys During Aquifer Testing, July 1989.

Presentation for the Environmental Protection Agency's Conference on New Field Techniques for Quantifying the Physical and Chemical Properties of Heterogeneous Aquifers, Delineating Geometry of Unconfined Aquifer Heterogeneities with Microgravity Surveys During Aquifer Testing, March, 1989.

Presentation for Geological Society of America's 100th Annual Meeting, Denver CO, Characterizing Heterogeneities in Unconfined Aquifers with Microgravity Surveys During Pump Tests, October, 1988.

Invited presentation for Association of Engineering Geologists 31st Annual Meeting, Assessment of the Geology of Heterogeneous Aquifers Using Inverse Plume Analysis, October 1988.

Presentation for AGU Fall Meeting, San Francisco, CA, In Situ Fracture Characterization in Crystalline Rock, December, 1987.

Presentation for AGWSE, NWWA Conference: Focus: Conference on Northwestern Ground Water Issues, Portland, OR, Perched Zone Evaluation with Radiation Logs, May 1987.

Invited presentation for University of Washington, Northwest Nonpoint Source Pollution Conference, Spokane, WA, Ground Water: Basic Science, March 1987.

Invited presentation for Colorado School of Mines, Golden, CO, Ground Water Modeling Applied to Lake Restoration Problems, February 1987.

Invited presentation for Mobil Research, Houston, TX, Physical Modeling of Tube Waves on Fractured Rock, April 1986.

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CONSULTING

Consultant to Woodward-Clyde Consultants on remediation of the Yak Tunnel (February-March 1990)

Consultant to The Lincoln Park Area Concerned Citizens on the Cotter Mill Superfund Site (1989-1990)

Consultant to Washington State Department of Ecology, Review of Summary Report on a Potential Hazardous Waste Disposal Site (December, 1988)

Consultant to Department of Energy, Chairman of a Licensing Assurance Review committee for the Site Characterization Plans of the Basalt Waste Isolation Project (December 1986-September 1987).

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Consultant to Mansfield, Reinbold & Gardner, Attorneys at Law, Assessment of impact of the Bureau of Reclamation dewatering project on local water levels (July-August, 1985).