Fiscal Year 1990 Program Report

Idaho Water Resources Research Institute
University of Idaho
Moscow, Idaho

Report No.
G1559-01

Fiscal Year 1990 Program Report
Grant No. 14-08-0001-G1559

for

U.S. Department of Interior
Geological Survey

by

Idaho Water Resources Research Institute
University of Idaho
Moscow, Idaho

Leland L. Mink, Director

January, 1991

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

Table of Contents

Abstract

This report addresses the research and information dissemination activities of the Idaho Water Resources Research Institute during the 1988 fiscal year. Synopses are presented for the following research projects:

1. Fall Subsoil Tillage Effects on Runoff Abatement and Agrichemical Transport in Frozen Soils of the Palouse Region,

2. Geological and Hydrologic Investigation of Modern and Abandoned Municipal and County Landfills, Pocatello, Bannock County, Idaho,

3. Identification of Eutrophication Trends in Lake Pend Oreille, Idaho with Shoreline Periphyton Indices,

4. Modification of Phosphorus Transport through Soil Materials,

5. Municipal Groundwater Supply of the Boise, Idaho Area: Phase I, Geologic Framework, Delineation of Aquifers and Production, Preliminary Testing for Aquifer Parameters,

6. Offsite Ecologic Economic Impact Assessment of a Nonpoint Source Polluted Stream in Northern Idaho.

Information dissemination and workshop activities are also reported.

Water Problems and Issues for the State of Idaho

The quality of surface and ground water remains the most pressing water concern facing Idaho. Water quality in northern Idaho, with an abundance of lakes and rivers remains high on Idaho's water quality agenda. Continued commercial and residential development, as well as agriculture and the forest industry has placed an increased burden on the lakes and rivers. Attention is being focused on how to reduce the existing or potential degradation of these waters without severely impacting the economic benefits to the communities.

In addition, considerable regard is being focused on the Middle Snake River Reach. Water quality in the reach is impaired by the nutrient loads and extreme low flows experienced over the last four years. The Middle Snake River receives and transports sediments, nutrients, bacteria, and other chemicals from various point and nonpoint sources. Impacts from irrigated agriculture, aquaculture and hydroelectric use has resulted in this reach being listed as water quality limited by the Idaho Division of Environmental Quality. Studies are being conducted to collect, analyze, and assess the nutrient/nitrite loading in this reach of the Snake River.

Agriculture and tourism/recreation are Idaho's main industries. The continued development and success of these industries is dependent on water quality. Idaho's future success in protecting water quality will be dependent on investigations that provide greater knowledge and understanding of this resource.

Program Goals and Priorities

The basic goals and priorities of the Institute's program are as follows:

1. To promote research that is relevant to state and regional needs for conservation of water and related land resources with emphasis on economic resource development, preservation and enhancement of environmental quality and social well being of people.

2. To stimulate, coordinate and provide leadership for water resources research in the established units of the universities of the state of Idaho and to cooperate with sister institutions in adjoining states. Such research should utilize an interdisciplinary approach and provide opportunities for training of students.

3. To cooperate with and help local entities, state and federal government agencies to carry out their responsibilities concerned with water and related land resources and to provide public involvement in identifying research needs.

4. To provide for dissemination of research findings in an expeditious and comprehendible manner to interested persons.

5. To develop funding for needed research and to encourage cooperation with regional research organizations in conducting an efficient and productive research effort.

Solving any of these water resource problems in the state involves five steps:

1. The problem must be identified by consultation with people affected by the problem.

2. An individual or several individuals must be identified who have expertise that may solve the problem.

3. A funding source must be identified which may even be private individuals concerned with the problem.

4. The prospective researcher must develop a proposal and present it to the funding agency or individuals.

5. The research is accomplished and the information disseminated to any persons who may be involved in this or similar problems.

The majority of research expenditures are for operating expenses and graduate student support with very little for capital outlay or faculty salaries. The money for information dissemination supports a secretarial position and operating expenses for publications. The secretary answers all publication requests and maintains the publication list and reference library and types all the technical completion reports.

Most of the money for administration is partial salary for the associate director who maintains contact with state, federal and private agencies in southern Idaho.

Project No. 02 *Start:* 06/90 *End:* 05/92

Title: FALL SUBSOIL TILLAGE EFFECTS ON RUNOFF ABATEMENT AND AGRICHEMICAL TRANSPORT IN FROZEN SOILS OF THE PALOUSE REGION

Investigator(s): Hammel, John

COWRR: 04 A *Congressional District:* First

Key Words: Soil physics; Subsoil; Agricultural chemicals; Field Test; Tracers; Soil Water; Soil Strength

Dr. Hammel's project implementation was dependent on additional funding being identified to supplement funding provided by the Water Resources program. Funding was not secured, therefore Dr. Hammel recommended returning Institute funding, because it was not sufficient to carry out the program goals. Funding was used by the Institute to support administrative and information dissemination costs.

Project No. 03 *Start:* 06/90 *End:* 05/91

Title: GEOLOGIC AND HYDROLOGIC INVESTIGATION OF MODEM AND ABANDONED MUNICIPAL AND COUNTY LANDFILLS, POCATELLO, BANNOCK COUNTY, IDAHO

Investigator(s): Kindel, Gary, Rodger, D. W., Link, P.K., Ore, H.T., and Welhan, J.W.

COWRR: 02 F *Congressional District:* First

Key Words: Geologic mapping; Hydrologic mapping; Saturation zone; Drilling; Parameters

Problem and Research Objectives: The objective of this research is to define the hydrology and its association with bedrock and other geology of the area around the existing Fort Hall Mine Canyon sanitary landfill. The landfill site has been proposed for an all county, or several county landfill, concomitant with federal guidelines covering operation and closure of landfills. The fundamental problem is to determine if there are geologic factors at the site which may mitigate against using the area for a long-term landfill. Such factors could be structural, related to the Scout Mountain Fault, stratigraphic, related to underlying Precambrian and Paleozoic bedrock configuration, Basin and Range Basin fill, related to the Mio-Pliocene siliciclastic and volcanigenic sediments deposited synorogenically with basin and range faulting, or surficial, related to the loess cover, its hydraulic conductivity and availability as a layering material. Further concerns about erodability of the landfill, because of its location in a major canyon leading into the Portneuf Valley drainage, and about leachate evolution and migration in the subsurface are also involved in the research objectives.

Methodology: Surface mapping of geologic units at a scale consistent with the landfill size, examination of the Salt Lake Formation sediments, examination of the loess; its character, thickness, distribution and hydraulic conductivity, drilling monitoring wells, learning of the subsurface stratigraphy of the area down gradient from the landfill site, conducting pump tests and interacting with local landowners, health department people and county planners and officials are all variously important in the investigation.

Principal Findings and Significance: Hydraulic conductivity values of the subsurface materials down gradient of the landfill, geochemical characterization of the waters in the monitoring wells, short- and long-term response recommendations, and geological characterization of the area were all accomplished.

Publications and Professional Presentations: A presentation at the Engineering Geology and Soils Engineering Symposium, Logan Utah, in the spring of 1991 was given by Kindel. The symposium volume contains the enclosed paper titled A preliminary hydrogeological assessment of the Fort Hall Landfill, Bannock County, Idaho. The entire volume is presumably available in the geology library, ISU and the University of Idaho.

M. S. Theses: Kindall, Gary. Hydrogeological Assessment of the Fort Hall Mine Canyon Landfill, Bannock County, Idaho. M.S. Thesis. In progress. University of Idaho, June, 1992.

Ph.D. Dissertations: None

Project No. 04 *Start:* 06/89 *End:* 05/91

Title: IDENTIFICATION OF EUTROPHICATION TRENDS INLAKE PEND OREILLE, IDAHO WITH SHORELINE PERIPHYTON INDICES

Investigator(s): Falter, C.M.

COWRR: 05 A *Congressional District:* First

Key Words: Eutrophication; Lakes; Littoral zones; Statistical analysis; Substrates

Problem and Research Objectives: With the exception of Kann and Falter (1989), all previous study on Lake Pend Oreille, has been done in the pelagic (open water) zone. These pelagic studies found oligotrophic conditions to exist. Reports by shoreline inhabitants of nuisance algal growth on docks, boats, and shoreline raised the questions of potential an increased rate of trophic change in Lake Pend Oreille. A large deep lake, such as Pend Oreille, has tremendous absorptive capacity. Early signs of eutrophication would not appear in pelagic waters, but in the shallow ,light rich littoral area. Pilot work in 1986 and 1987 by Kann and Falter (1989) found high production at inshore areas of enclosed bays and developed sites than open, exposed shoreline sites. Some sites had levels of production comparable to polluted, eutrophic lakes. Study was expanded in the summer of 1989 by increasing the number of littoral sites, sampling for nutrients, bacterial, and physical-chemical parameters, and aquatic macrophyte sampling. Objectives of this study were to assess littoral production via attached algae and aquatic macrophytes; determine nutrient levels and physical/chemical conditions, and assess bacteria levels in order to develop baseline data from which current and future trends can be monitored.

Methodology: Sixteen sites, representative of embayments and open-lake shore habitat, were established around Pend Oreille Lake mid-July 1989. At each site, water samples were collected for nutrient and bacteria analysis, physical/chemical field data was recorded, and six replicates of artificial substrate (unglazed tiles) were placed on the bottom at 1 m depths. At thirty-day intervals, mid August and mid-September, periphyton samples were collected from both artificial and natural substrate, six replicates each. Water samples were also collected for nutrient and bacterial analysis, and physical data were recorded. In mid-August, aquatic macrophytes were sampled at eight sites in north bay areas and outlet arm by SCUBA. Aquatic macrophytes were sampled again in mid-September at nine sites in the outlet arm and north bay areas using a Peterson dredge.

The sixteen sites were re-established mid-July 1990 and revisited in mid-August, 1990. Eight replicates of artificial substrate were placed in 1990 to decrease within-site variability. Data and samples were collected as in the previous summer except that eight samples of attached algae were also taken from artificial and natural substrate at each site.

Aquatic macrophytes were also sampled mid-August. Twenty sites were visited starting near Albeni Falls Dam across to the four north lake bays and east to Ellisport Bay.

Principal Findings and Significance: Highest fecal coliform counts were seen in August at Bayview (south lake) (50/100 ml) and Trestle Creek (10/100 ml), two developed sites. Conversely, fecal streptococci counts were high at Warren Island (>100/100 ml) and Talache (72/100 ml), two relatively undeveloped sites. Maximum summer transparencies were found in mid and south lake area, up to 11.1 m. Shallow north bays had the lowest transparency readings with a minimum of 0.35 m. Water chemistry indicates Lake Pend Oreille to be meso-oligotrophic. typical total phosphorus concentrations were 8 to 10 µg/1. Inshore periphyton (attached algae), however, shows localized advanced eutrophication. Mean chlorophyll *a* on natural and artificial substrate in developed areas was twice that found in undeveloped areas and was correlated to inshore water enrichment. Periphyton differences between sites were far more discriminating as indicators of inshore site enrichment. Periphyton differences between sites were far more discriminating as indicators of inshore site enrichment than were water chemistry parameters. Chlorophyll *a* values between sites differed by up to 25x while water chemistry parameters differed by up to 3x. Attached algae growth was higher at sites near developed shoreline areas than undeveloped, with statistically significant differences seen between the most productive and the least productive sites. Total (Aug. + Sept.) mean chlorophyll *a* on artificial substrate was 4.3 mg/m^2 for developed sites vs 2.1 mg/m^2 at undeveloped sites. Artificial substrate provided better separation of high and low productivity sites than did natural substrate. Attached algae chlorophyll *a* and biomass were better indicators of site enrichment than were total phosphorus and other nutrients. Our data indicate that periphyton monitoring can be a valuable indicator to detect changes in lake trophic status before obvious deterioration in pelagic (open water) areas of large, deep lakes were morphometric oligotrophy may mask early lake responses to nutrient loading. August and September aquatic macrophyte data showed poor growth int he 0 3.0 m band because of the 3 m drawdown over winter months. Highest macrophyte production was in the 3.0 to 4.9 m depth. The exotic Eurasian water milfoil was not found in Lake Pend Oreille, despite its very heavy occurrence just downstream in the Pend Oreille River.

Publications and Professional Presentations: None

M. S. Theses: None

Ph.D. Dissertations: None

Project No. 05 *Start:* 06/90 *End:* 05/92

Title: MODIFICATION OF PHOSPHORUS TRANSPORT THROUGH SOIL MATERIALS

Investigator(s): Naylor, D.V., and McGeehan, S.L.

COWRR: 05 B *Congressional District:* First

Key Words: Phosphorus; Soil physical properties; Soil chemistry; Sorption; Leaching

Problem and Research Objectives: The numerous pristine lakes and streams in Idaho are an important natural resource. Low population density makes many parts of Idaho well-suited to land application of wastes. A major concern associated with this method of waste disposal is the control of phosphorus (P) leaching. Shoreline and regional development places the water resource at risk due to the generation and disposal of associated waste materials. Septic tank drainfields and land application of liquid and solid wastes from municipal and industrial sources have, at times, diminished water quality. Seasonal soil saturation, organic amendments, and waste application rate and frequency have been shown to have dramatic effects on soil P mobility. A better understanding of soil and waste properties that enhance P sorption and minimize P transport will facilitate improved site selection and management of land applied waste.

Specific objectives of the proposed research are:

1. to determine the soil properties that can be used to predict P sorption from waste leachates and to recommend specific soil analyses that can evaluate these soil properties,

2. to evaluate the reliability of P sorption data for predicting P transport through soil materials, and

3. to determine the management and environmental factors which modify or enhance the transport of P through soil materials.

Methodology: A diverse group of soils, representing the broad spectrum of soil properties found in Idaho, is being investigated. Emphasis was placed on soils adjacent to streams, rivers and lakes or having shallow water tables where P transport to receiving bodies of water might be important. Samples of major horizons have been collected, air-dried and ground to pass a 2 mm sieve.

<u>Objective 1</u>: Phosphorus sorption isotherms and extractable P have been determined for each horizon sampled. Soil properties relevant to P sorption are being measured. The sorption of P by the soils will be correlated to the various soil properties using regression analyses.

<u>Objective 2</u>: A leaching column study is being used to evaluate P transport. The variables are P application (loading rate and frequency of application), soil organic matter content, and P sorption capacity. The columns are packed with soil and a 10 mg L^{-1} P solution, representing a median P concentration for municipal waste water, is added to the columns. All drainage solution are collected, measured for volume and analyzed for phosphorus species. At the conclusion of the leaching, the soil columns will be sectioned by depth and analyzed for P forms. The impact of P application on the ability of P sorption isotherms to predict P transport will be evaluated.

<u>Objective 3</u>: A leaching column study will be used to determine management and environmental factors which can modify or enhance P transport. Variables will be waste material, frequency and duration of a high water table, and P sorption capacity. Columns will be prepared as outlined in Objective 2. All drainage solution will be collected, measured for volume, and analyzed for P. Changes in effluent pH and concentrations of Fe and

Mn will also be monitored throughout the leaching study. At the conclusion of the leaching study, the soil columns will be sectioned by depth and analyzed for P, pH, and extractable Al, Fe, Mn, and Si. Sorption isotherms will be compared with sorption data collected in Objective 1 to evaluate the effect of the various treatments on alteration of P sorption capacity.

Principal Findings and Significance: Sites were selected for sampling and study. Criteria for site selection included (1) proximity to receiving bodies of water, (2) influence of high water tables, (3) accessibil ity for future field measurements, (4) the potential for development activities, (5) use or potential use for disposal of waste materials, and (6) a range in soil properties. A total of forty-one surface and subsurface soil samples were collected at seventeen sites covering the area from Lake Pend Oreille and Lake Coeur D'Alene in northern Idaho to Cascade Reservoir and the Caldwell area in southern Idaho. Approximately 0.5 kg of soil was collected. air-dried and lightly ground to pass a 2 mm sieve. Analyses conducted to characterize the soil samples included (1) pH to evaluate acidity or alkalinity, (2) sodium fluoride pH to evaluate reactive iron and aluminum, (3) total carbon and nitrogen to evaluate the organic materials, (4) iron, aluminum, manganese, and silica extracted by ammonium oxalate (pH 3) in the dark and citrate-bicarbonate-dithionite to evaluate noncrystalline and free aluminosilicates and hydrous oxides, (5) three forms of extractable P to evaluate naturally occurring P, (6) P sorption isotherms to evaluate the ability of the soil to adsorb P, and (7) particle size analysis to evaluate sand, silt, and clay content. A data base has been developed from the soil characterization analyses. This data base can be used to develop a model that relates P sorption to the measured soil properties.

The capacity of the soils to adsorb P at a common point was estimated from the adsorption data so P sorption capability of the soils could be compared. The adsorption of P measured above and below the 10 mg L^{-1} equilibrium solution P level was used to calculate a sorption curve slope. The slope was then used to calculate the P adsorbed at the 10 mg L^{-1} solution P level for each soil. The ability of the soils to adsorb P to a level that 10 mg L^{-1} of P remained in solution varied from 194 mg of P per kg of soil to 2638 mg of P per kg of soil. No relationship was evident between P sorption and location or depth of sample source. These data can be used in conjunction with the chemical characterization data to determine the soil properties that regulate P sorption capacity.

The P adsorption isotherms were evaluated using two common models, the Tempkin and Freundlich, to evaluate P sorption over a wide range of P concentration. The average r^2 over all the soils using the Tempkin model was 0.85 and the average r^2 for the Freundlich model was 0.84 indicating the data fit both models reasonably well considering the wide range of soils. However, negative adsorption (desorption) of P was observed from many of the soils at low levels of added P. Negative adsorption values cannot be used with the Freundlich model due to the log transformation employed for linear evaluation of the model. Therefore, the Tempkin model proved more useful in evaluating P sorption characteristics of the soils, particularly at the low P levels that are important to maintaining good water quality. The observed negative adsorption or desorption of P could have a negative impact on quality of the initial percolation water moving through the soils as they are leached, but should be a short term influence.

The amount of P adsorption at an equilibrium solution P level of 10 mg L^{-1} as predicted by the Tempkin and Freundlich models was compared to that calculated from a straight line connection between the two nearest measured points on each side of the 10 mg L^{-1} solution level on the adsorption isotherms. The average difference between the value predicted from the Tempkin model and the isotherm calculation was 22% and the average difference between the value predicted from the Freundlich model and the isotherm calculation was -17%. The Tempkin model generally overpredicted adsorption while the Freundlich generally underpredicted adsorption. Good correlation was observed between the curve slope adsorption data and the Tempkin (r^2 = 0.89) or the Freundlich (r^2 = 0.85) models. These adsorption models are used to evaluate and compare the ability of soil materials to adsorb P over a wide concentration range.

The data base was used to identify sites meriting more intensive study. Large (10 kg) samples of selected soils were collected for column leaching experiments from fifteen soil horizons at eight sites. The design work on the soil columns was completed. Under saturated leaching conditions, approximately two pore volumes of solution could be moved through a column of a medium-textured soil per day. Depending on the P sorption capacity and the hydraulic conductivity of the soil, it requires between two weeks and three months for predicted P breakthrough to occur in the columns. Since the soils in the columns will be sectioned and analyzed by depth, P breakthrough is not required to obtain meaningful data. However, sufficient P will be applied to the soils such that a significant portion of P sorption capacity is usurped.

Publications and Professional Presentations: None.

M. S. Theses: None.

Ph.D. Dissertations: None.

Project No. 06 *Start:* 06/90 *End:* 05/91

Title: MUNICIPAL GROUNDWATER SUPPLY OF THE BOISE, IDAHO AREA: PHASE I, GEOLOGIC FRAMEWORK, DELINEATION OF AQUIFERS AND PRODUCTION, PRELIMINARY TESTING FOR AQUIFER PARAMETERS

Investigator(s): Wood, S.H., and Osiensky, J.

COWRR: 02 F *Congressional District:* First

Key Words: Water supply; Groundwater basins; Aquifer characteristics; Geohydrology; Borehole geophysics; Test wells

Problem and Research Objectives: Groundwater from confined and semi-confined aquifers constitutes 90 percent of the public water supply for the city of Boise, Idaho. Little is known of the geologic framework, continuity, and sustainable yield from this system of aquifers, yet the vitality of the city and future economic development are dependent upon this resource. This first year, (Phase 1), of a comprehensive 2.5-year study has provided necessary data to design tell tests for aquifer parameters, and to develop a three-dimensional geometry of the system. This study provides a basis for the subsequent phases of building and refining a computer model of the groundwater system. Such a model, and supporting data are necessary for estimating the sustainable yield from the system, designing future well yields, and evaluating the effects of surface activities that could lead to pollution of drinking water supplies.

Boise Water Corporation, a public utility, depends upon the groundwater system beneath the Boise River Valley for river 90 percent of it's supply. Current annual production is about 11 billion gallons (33,700 acre-ft.). The corporation is already experiencing shortages during drought years in certain parts of it's distribution system. The system of confined and semi-confined aquifers appears to have boundaries related to regional facies changes of the lacustrine and fluvial sediments, and faulting. Interbedded sand, silt, and claystone of the upper Miocene and early Pliocene Idaho Group are the main water yielding strata. The supply is limited at depth by a relatively impermeable volcanic section, the occurrence of geothermal waters, and undesirable fluorine levels. Recharge is most certainly from the Boise River system and it's various artificial diversions, and from foothills streams, but the nature and amount of recharge have never been estimated. For long-term planning of the regional water resources, for location and design of future wells for protection of the resource from contamination, all water users and water regulatory agencies need a better understanding of the groundwater supply.

The objective of this first-year study has been to provide a detailed description of the three-dimensional geometry of the aquifer system, the geologic framework of the Boise Valley, and a preliminary description of hydrogeologic parameters of the system.

Methodology: The first-year study has developed a detailed geologic description of the three-dimensional geometry of the aquifer system. This has included the collection of all previous geophysical logs of wells, obtaining about 15 new geophysical logs, and information on lithology and wall construction from driller's logs and from files of Boise Water Corporation and various consulting groups in the area. Cuttings from five new wells drilled by Boise Water Corp. were logged in detail to provide calibration of geophysical log expression to the lithology. These logs of drill cuttings provide examples of thorough description of the geologic section which are essential for understanding depositional environments and facies distributions of aquifers and aquitards. In anticipation of Phase II: Aquifer Testing, "opportunistic" aquifer tests were carried out during the first-year study at any time that such testing was feasible, as in the case of new-well completion tests or shut down/start-up of continuous pumping wells for winter maintenance.

Principal Findings and Significance:

1. Recognition of thick (to 1100 ft.) alluvial fan/fan delta complex within upper basin subsurface

   a. absence of aquitards
   b. welter table (unconfined) aquifers
   c. recharge to the deep confined system
   d. single layer aquifer unit in computer model

2. Areal delineation of six major hydrogeologic settings

   a. first out at separating Boise aquifer system into units
   b. essential as parameters for computer model
   c. necessary for designing aquifer tests of system
      1) alluvial fan aquifer
         - unconfined
         - head of basin depositional system

      2) fan-to-lake-transition
         - interbedded fluvial and lacostrine sediments
         - semi-confined
         - major production zone

      3) lake deposits
         - confined sand aquifers
         - Boise's major aquifer

      4) deep lake deposits
         - highly confined artesian sand aquifers
         - fine well-sorted sands

      5) basin margin river sands
         - 0-600 ft. thick
         - semi-confined sand aquifers

3. Location of major subsurface structure

   a. basin-bounding normal fault
   b. 600 + feet of vertical offset
   c. truncates sand aquifers against impermeable volcanic rocks
   d. controls recharge within upper basin
   e. hydrogeologic boundary

4. Geophysical well logs calibrated to regional geology

   a. permit interpretation of old poorly recorded wells
   b. gravels more radioactive than clays and silts
   c. little-to-no clay present within study area
   d. no single widespread confining/protective clay layer

5. Meaningful aquifer testing can be carried out utilizing existing well field

a. geologic framework studies can be hydraulically tested
b. quantitative results provide aquifer parameters for model
c. effects of single-well constant discharge aquifer tests can be measured over extensive areas to high degree of accuracy
d. production system can be manipulated to eliminate interference from wells within test limits

6. Aquifers do not fully recover during winter season

a. water level decliner
b. mining of water from storage
c. changes in storage

Publications and Professional Presentations: None.

M. S. Theses: None.

Ph.D. Dissertations: None.

Project No. 07 *Start:* 06/89 *End:* 05/91

Title: OFFSITE ECOLOGIC-ECONOMIC IMPACT ASSESSMENT OF A NONPOINT SOURCE POLLUTED STREAM IN NORTHERN IDAHO

Investigator(s): Walker, D., Brusven, M.

COWRR: 05 C *Congressional District:* First

Key Words: Water pollution control; Streams; Economic aspects; Ecosystems; Mathematical models

Problem and Research Objectives: The problem focused on nonpoint pollution effects from agriculture on offsite impacts with the following objectives:

1. Conduct a water quality analysis for nonpoint source agricultural pollution, especially nutrients, and develop descriptive models of community structure and ecosystem processing for the purpose of determining levels of departure from the river continuum model for a nonperturbed stream, and

2. Develop and apply economic models which will assess offsite benefits for nonpoint source pollution mitigation.

Methodology: Field monitoring was conducted to assess water quality, organic input and storage, riparian vegetation, invertebrate leaf processing and community structure in Lapwai Creek. Samples were taken seasonally and totalled to give an annual yield along a river continuum. Conceptual and validated diagrammatic models were created to show energy pathways and departures from the unperturbed river continuum model. The economic assessment focused on erosion, erosion pathways and alternative farming practices to generate cost-effective BMP's using simulation modelling techniques for a subwatershed in Lapwai Creek. A GIS was used to spatially integrate the watershed. The universal soil loss equation (USLE), agricultural nonpoint source pollution model (AGNPS) and linear programming model were used to generate onsite damage functions which ultimately contributed to an offsite impact assessment.

Riparian habitats were classified in the field using discrete, categorical units and employing a GIS format. Agricultural nonpoint source pollution influences were studied with regard to longitudinal gradient shifts in allochothonous organic impact and decomposition, particulate organic matter retention and transport, primary production and macroinvertebrate community composition. These parameters were measured seasonally and enumerated as annual production or input-output variables describing the bioenergetic properties of the system.

An integrated systems model has been developed that traces the impact of changing land use and farming practices in a watershed on erosion damage costs, on water quality and on farm income. This systems model incorporates as components a mixed integer mathematical programming farm optimization model, the Agricultural Nonpoint Source Pollution (AGNPS) watershed simulation model and an onsite erosion damage model (Soiloss). The extensive data base is maintained and integrated using a geographic information system (GIS).

Principal Findings and Significance: Litterfall from riparian vegetation, the primary source of particulate organic matter (POM) found in streams, occurred August-November. Litterfall was lowest for riparian habitat composed of herbaceous vegetation and highest for deciduous tree habitats. Extensive removal and thinning of climax riparian vegetation and its subsequent replacement by successional species has resulted in annual litterfall rates less than that reported for comparable streams. Between-site differences in the input, storage, and transport of POM were due primarily to location-specific characteristics of the riparian vegetation. As a result, detrital dynamics of Lapwai Creek deviated from the predictions of the river continuum model.

Chlorophyll a concentrations, a measure of primary production, were high at all sites and during all seasons, relative to values reported for comparable Idaho streams. High concentrations of periphyton chlorophyll a are attributed to increased availability of nutrients via runoff from cropland and increased light penetration with the removal of climax riparian vegetation. Nutrient concentrations for Lapwai Creek exceeded values reported for undisturbed streams and were similar to values reported for other agriculturally-impacted streams.

Macroinvertebrate community composition, as determined using random skewers analysis, did not change along a longitudinal gradient. Input of nutrients of agricultural origin and the removal of climax vegetation are largely responsible for the autotrophic nature of Lapwai Creek and the associated, grazer-dominated, macroinvertebrate community structure.

In an economic simulation run for the Tom Beall watershed, without incentives for soil conservation or water quality, the cost of erosion damage exceeded the cost of offsite sediment damage, \$54,147 and \$32,882, respectively. The results indicate that for moderate sediment reduction (up to 41% reduction) preventive practices are more cost effective than by mitigation. For sediment reduction beyond 41%, mitigation is more cost effective.

Publications and Professional Presentations: Brusven, M. A. and D. Walker. 1991. An integrated ecological-economic framework for assessing agricultural nonpoint source pollution. Presentation and Proceedings at the Washington-Idaho Nonpoint Conference, Tacoma, WA (Mar. 20-21,1991).

Brusven, M. A. and D. Walker. 1991. Nonpoint source monitoring and simulation modeling of environmental impacts in Lapwai Creek watershed. Presentation at First Annual Idaho Monitoring Workshop, Boise, ID (Jan. 15-16,1991).

M.S. Thesis: Yun Wang, An onsite and offsite economic analysis of erosion and nonpoint source pollution in Idaho's Tom Beall watershed.

Ph.D. Dissertation: Delong, Michael D. Ecosystem processing and community structure in an agricultural nonpoint source impacted stream. Unpublished Ph.D., Division of Entomology, Univ. of Idaho, Moscow, ID (1991).

Information Transfer Activities

The principal information dissemination/outreach activities were:

1. The Idaho Division of Environmental Quality (IDEQ) contracted with IWRRI to develop and coordinate a series of state-wide workshops aimed at individuals working under the Idaho Antidegradation Agreement. The workshop series was entitled Water Quality Education/Nonpoint Source Management: A Step Forward in the Antidegradation Process. These workshops were held August 6-7, 1990, Boise, Idaho; August 21-22, Coeur d'Alene, Idaho; August 23-34, Moscow, Idaho. The purpose of the series was to provide basic water quality education for individuals involved in water quality evaluation. The curriculum included information on identifying watersheds, identifying problems, and prescribing solutions, as well as familiarizing participants with terminology, nonpoint control strategies, fish habitat requirements, law and regulations, and other aspects of water quality protection. In addition to conducting the workshops, IWRRI filmed the Moscow workshop generating a set of tapes, and a workbook to use with the tapes. These tapes and workbooks are being used by IDEQ for additional training throughout the state.

2. In February of 1991, IWRRI and Idaho Council on Industry and Environment cooperated with over 40 state and federal agencies, industry, organizations and groups to produce a conference entitled Wetlands Protection in Idaho: Living with "No Net Loss". This conference was motivated by an extreme interest expressed by agencies, industry, private organizations, and individuals about the impacts of the No-Net Loss policy . Over 400 people throughout the Northwest attended the conference held in Boise. The purpose of this conference was to present information on wetlands definitions, legal issues and questions, permitting and agency responsibilities, as well as wetlands case studies in agriculture, commercial development, wildlife habitat, and others.

3. Nonpoint source pollution continues to remain a high profile issue in our region. In March of 1991 in Tacoma, Washington, IWRRI cooperated with the Pacific-Oceanic region institutes to present a technical conference entitled Nonpoint Source Pollution: The Unfinished Agenda. This conference received over 400 conference participants. The State of Washington Water Research Center published the proceedings from this meeting.

4. In May, 1991 IWRRI in cooperation with Clean Lakes Coordinating Council and the State of Washington Water Research Center presented a conference in Coeur d'Alene, Idaho entitled Idaho Lakes: A Clear Challenge. The purpose of this conference was to establish an information exchange among lake and watershed users, resource managers, and the general public about lake and watershed issues and opportunities. Over 100 people attended.

5. The Institute in cooperation with the University of Idaho Cooperative Extension Services published the inaugural issue of Idaho Water Project Update. The purpose of this project was to produce a comprehensive overview of research and information dissemination activities occurring throughout the state. Over 60 agencies contributed project overviews of research and outreach activities currently ongoing in the state. The first issue published 110 profiles on water and water-related projects. There will be one issue published in the spring of each year, with a fall supplemental issue.

6. The Institute in cooperation with the Institute for Molecular and Agricultural Genetic Engineering formed a partnership to create an infrastructure dedicated to multidisciplinary research in hazardous waste remediation. **The Center for Hazardous Waste Remediation Research.** The research center has three focus areas: biological remediation, geochemical remediation, and characterization of hazardous waste sites. Twenty-six faculty collaborate with selected institutions from outside the university, particularly the Idaho National Engineering Laboratory, Battelle Pacific Northwest Laboratories, and the Environmental Protection Agency.

7. Professional publications submitted during the year are as follows:

Brusven, M. A. and D. Walker. 1991. An integrated ecological-economic framework for assessing agricultural nonpoint source pollution. Presentation and Proceedings at the Washington-Idaho Nonpoint Conference, Tacoma, WA (Mar. 20-21,1991).

Brusven, M. A. and D. Walker. 1991. Nonpoint source monitoring and simulation modelling of environmental impacts in Lapwai Creek watershed. Presentation at First Annual Idaho Monitoring Workshop, Boise, ID (Jan. 15-16,1991).

Cooperative arrangements and projects are conducted with the following organizations:

Idaho Department of Water Resources
Bureau of Reclamation
Water District I
Bell Rapids Irrigation District
E.G. & G., Inc.
Aberdeen-Springfield Canal Company
A & B Irrigation District
City of Moscow
City of Pullman
Washington State University
Latah County/Idaho
Whitman County/Washington
Army Corps of Engineers
State of Washington Water Research Center
Oregon State Water Resources Research Institute
Montana Water Resources Research Center
Soil Conservation Service
Boise State University
Idaho State University
Idaho Council on Industry and the Environment
Idaho Division of Environmental Quality
U.S. Department of Energy
Idaho Power Company
U.S. Army Corps of Engineers
U.S. Environmental Protection Agency
U.S. Geological Survey
Idaho Department of Agriculture
Idaho Association on Commerce and Industry
Idaho Association of Soil Conservation Districts
Idaho Department of Commerce
Idaho Department of Fish and Game
Idaho Department of Park and Recreation
Wildlife Council, Region 3
Idaho Department of Lands
Idaho Department of Transportation
Idaho Farm Bureau
Idaho Health Districts
Idaho Water Users Association
Nature Conservancy
Idaho Wool Growers
Idaho Cattle Association

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Training Accomplishments

Field of Study	Undergraduate	M.S.	Ph.D.	Post Ph.D.	Total
Entomology		*1*	*1*		*2*
TOTAL		*1*	*1*		*2*