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INTERDISCIPLINARY APPLICATIONS AND INTERPRETATIONS OF
ERTS DATA WITHIN THE SUSQUEHANNA RIVER BASIN

Resource Inventory, Land Use, Pollution

Office for Remote Sensing of Earth Resources (ORSER)
Space Science and Engineering Laboratory (SSEL)
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The Pennsylvania State University
University Park, Pennsylvania 16802

Type I Report for period 1 February, 1974 - 31 March, 1974
Contract NAS 5-23133
ERTS Investigation 082
Principal Investigators: G. J. McMurtry, G. W. Petersen
1082AA (UN159)

Prepared for
GOLDARD SPACE FLIGHT CENTER
Greenbelt, Maryland 20771

1082A

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I. PROGRESS ON TASKS

Inventory of Natural Resources and Land Use

ORSER-SSEL Technical Report 7-74 has been prepared and will be presented at the Ninth International Symposium on Remote Sensing of Environment, to be held on April 15-19, at Willow Run Laboratories, Environmental Research Institute of Michigan in Ann Arbor. This paper, entitled "A Method of Specifying Remotely Sensed Units for Soil Sample Points," is a report on an investigation designed to determine if soil sampling locations originally identified on ERTS computer output could be located in the field and again verified by the MSS data.

Scan line and element numbers for remote sensing units (RSU) from the multispectral scanner data were assigned sampling locations in predetermined training areas. Each training area was visually located in the proper agricultural field. Three points, identifiable by scan line and element number in the multispectral scanner data, were located in the field. A base line was drawn between two of these points and the third point used as a check in the surveying and calculations. Features that are permanent and were easily identified by a scan line and element number in the multispectral scanner data were selected for constructing the base line in the field.

Soil samples were collected within each training area. The angle and distance of each sampling point from the constructed base line was determined by a stadia rod. The angles and distances were input to an RSU identification program that outputs the scan line and element number (RSU) of each sampling point. The results from this program indicated that a high percentage of soil sampling locations were within previously designated training areas and duplication of soil samples within an RSU occurred at only one site.

Geology

Classification maps have been made of the glacial deposits in northwestern Pennsylvania, using the CANAL (canonical analysis) program, the ACLASS (supervised classification) program and the ACLUS (non-supervised, cluster analysis) program. Comparison of the results of these classifications with current data on known glacial deposits and their characteristics, indicates that a study of features within glacial deposits, as originally planned, is on too small a scale to be of value. The emphasis is, therefore, being shifted to large scale comparisons between deposits.

For fruitful comparison of the large amount of data available from an ERTS scene with the selected data obtained from previous studies and ground truth, methods of data reduction appropriate to the ERTS data are being investigated. These include Power Spectrum Analysis, Box-Jenkins Time Series Analysis, and Markov Chain Analysis.

Environmental Quality

Work is essentially completed on the study of vegetation damage by air pollution from a zinc smelter in the Palmerton area. Although ground truth revealed very striking differences between two white pine stands, these differences could not be seen from analysis of the ERTS-1 data. Elimination of possible interference from herbaceous undergrowth and deciduous trees, obtained by cluster analysis of merged data from a winter and a summer scene still did not provide spectral signatures capable of recognizing the differences between the two stands.

The results from this study show both the usefulness and weakness of the ERTS-1 remote sensing capabilities. The data produced a map accurately delineating areas which may be limited in vegetative production due to zinc emitted by the smelter. Herein lies the strength of the ERTS-1 system. The management of resources usually involves a three-step process of inventory, analysis, and allotment. This study has demonstrated the tremendous usefulness of the capability of the ERTS-1 system in inventorying present and potential resources. It provides synoptic views of the earth's resources that include a temporal factor, because the satellite passes over the same area every 18 days.

The ERTS-1 data, however, do not appear useful for evaluating the condition of vegetation, especially small acreages of damage similar to that investigated herein. Air pollution damage is often restricted to small acreages of scattered susceptible plants. The differences in spectral signatures from such damaged and healthy foliage are not large enough to be detected by the ERTS-1 remote sensing systems. The ERTS-1 system would be useful only on rare occasions when large areas of damage occur and the damage is severe enough to cause a high contrast between damaged and healthy vegetation. Even in such cases, the resolution of the system will not allow an adequate evaluation of the extent of damage that had occurred to the plants.

In the future, an ERTS-1 type satellite may effectively be used as a detection system capable of inventory but not particularly useful in evaluation.

Data Processing

Data from two cloud-free ERTS scenes have been successfully recalibrated to eliminate banding in the third and fourth MSS channels. It was found that for modulo six lines for one and sometimes two sensors, the mean, the standard deviation, or both, are not conformable with the rest of the data. Recalibration applied to the banded data sets has resulted in complete recovery of useful data. An investigation is now being launched to determine if recalibration of data for all sensors from one scene to match the calibration of data for all sensors for another similar scene can be used to successfully transfer signatures from one scene to another.

Four ORSER investigators traveled to Florida in February for an initial session with the General Electric Image 100 system. Primary concentration was focused on a portion of an ERTS scene of the East Branch

Reservoir of the Clarion River in northwestern Pennsylvania (scene 1028-15295, 20 Aug 72). As an interface between the interpreter and his data, the color CRT was clearly superior to the computer line maps ORSER has been using. Classification of this area using the Image 100 1-D classifier was visually judged to be reasonably accurate by an interpreter familiar with the scene. However, a second attempt, by the same interpreter, to classify the scene could not duplicate the results of the first classification. The problem here was the necessity of relying on the visual cursor to input training coordinates.

The only non-standard ERTS tape brought on this trip was one with recalibrated data from the East Branch scene. This was used to determine whether the system would accept ERTS format tapes generated by the SUBSET program. The system accepted the tape and some classification was performed. Limited time on the Image 100 prohibited a complete analysis.

The Applied Research Laboratory has recently authorized procurement of a color display system for ORSER. The system will be capable of displaying the results of standard ORSER software. It will be developed, installed, evaluated, and recommendations will be developed for its expansion with particular emphasis on speed-up procedures for more effective man-machine interaction and direct digitization, display, and enhancement of imagery and photography. All of the design, installation, and evaluation steps will take into account the flexibility, utility, speed, and cost of the display system.

ORSER has recently ordered a Bausch and Lomb Zoom 95 Zoom Stereoscope, to facilitate study of 9 X 9 inch aircraft and Skylab stereo photography.

A procedure for photographic reduction of 7 X 7 foot computer-generated maps from ERTS data has been developed. Both 35 mm slides and photographic prints can be made which preserve the identity of printed characters on the map.

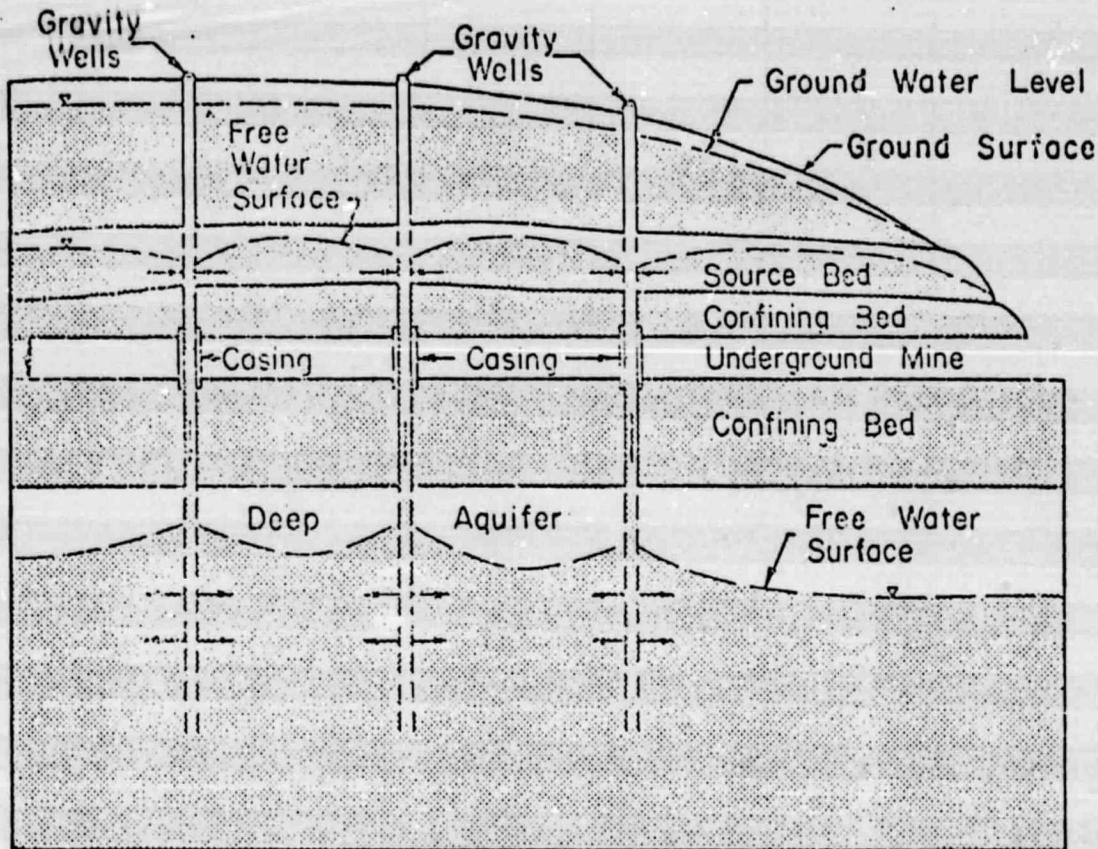
II. RELATED ACTIVITIES

Research

A service contract is being negotiated among the Pennsylvania Department of Environmental Resources, The Pennsylvania State University, and the Consulting Engineering firm of Skelly and Loy of Harrisburg, Pennsylvania. The demonstration study, funded by the Environmental Protection Agency on a matching basis with the Department of Environmental Resources, is designed to demonstrate that the connector well method of abating pollution derived from abandoned or active deep mines is feasible and cost competitive with existing abatement techniques. Seven candidate mines, now inactive, have been examined and are being considered in detail for possible use in the demonstration. An important criterion in their selection is that they contain the intersection of a number of lineaments within mined-out regions. Lineament intersections mapped on various scales using aircraft, Skylab and ERTS-1 data will serve as the sites for up to four connector wells planned in this pilot demonstration study. Observation wells will also be located on lineaments. The final mine named in the study will be subjected to detailed examination using remote sensing data. The concept demonstrated here (see accompanying figures) is receiving widespread interest and it is expected that the EPA will soon fund demonstrations of mine dewatering used to abate pollution from active mines.

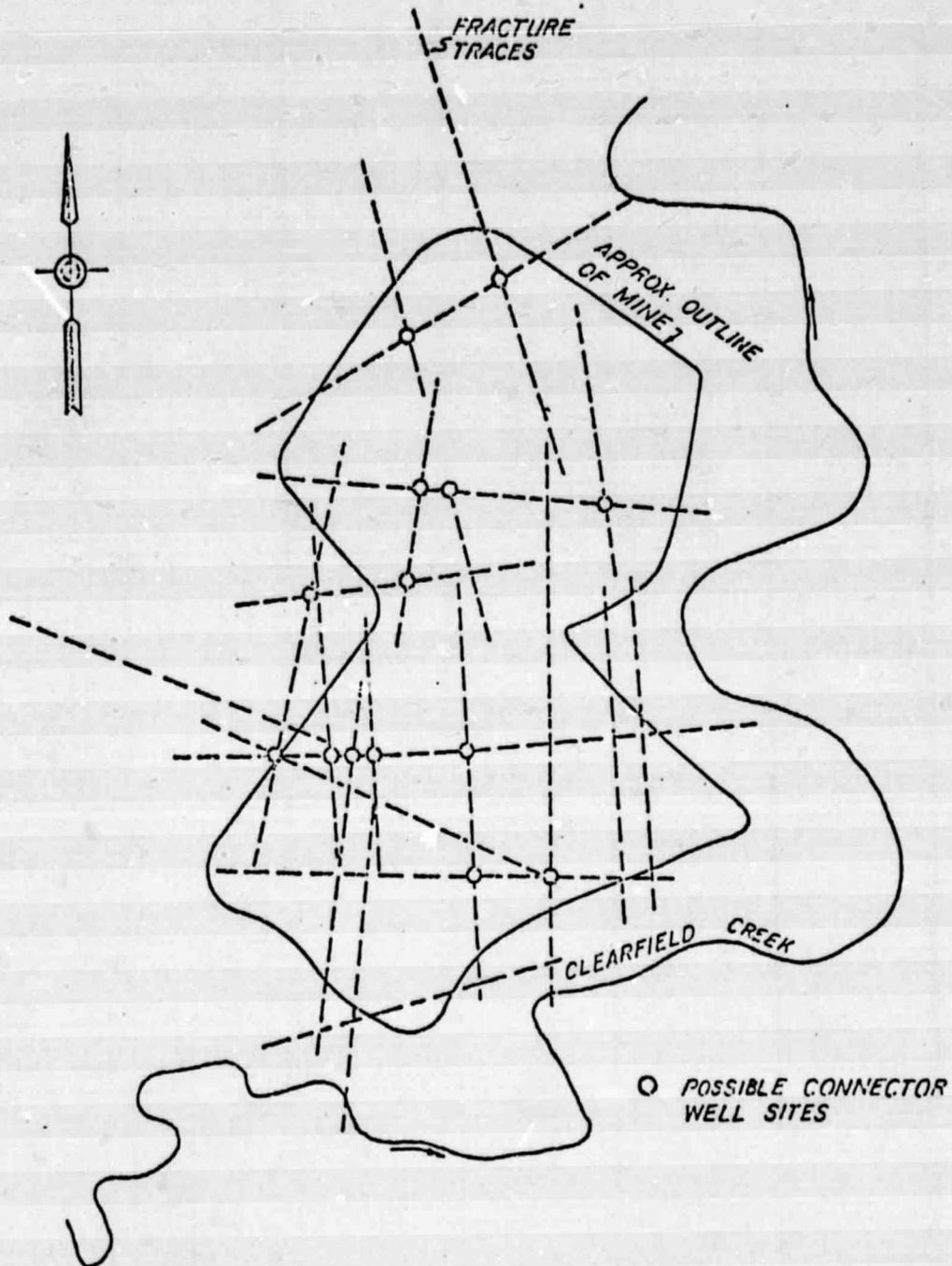
The project objectives are as follows:

1. To select a field site where a small scale demonstration study can be conducted and if successful, expanded to abate a significant amount of pollution derived from coal mine drainage.
2. To demonstrate the concept that connector wells can be used to reduce leakage to abandoned and active deep coal mines using a gravity drainage well scheme in a favorable hydrogeologic setting.
3. To demonstrate that ground water can be drained from aquifers above deep coal mines and recharged to deep aquifers underlying mines for a prolonged period of time without excessive losses in the flow rates which may be due to iron and other precipitates forming on the well bore face, air bubbles or bacterial activity plugging the formation, etc.
4. To design a well system that will not allow coal mine drainage to be channeled from the mine environment to the underlying aquifer along the well bore. This will entail placing a grout column to support the mine roof and casing around the connector well.
5. To demonstrate that the volume of acid mine drainage discharged from the deep mine is reduced and the quality of drainage improved after four or more demonstration wells have been completed in the test site.
6. To determine the optimum number, spacing, and cost of connector wells required to bring about a significant reduction in mine discharge, based on the hydrogeologic conditions defined for the test mine.



Gravity drainage wells used to dewater source beds above deep mines located in regional ground-water recharge areas. Three distinct water tables are shown which commonly occur in western Pennsylvania where less permeable coal bearing strata overlie more massive and permeable aquifers which serve as regional underdrains. The same systems would work if there was but one water table provided that ground-water flow is downward.

**ORIGINAL PAGE IS
OF POOR QUALITY**



FRACTURE TRACE DISTRIBUTION OF THE SHOFF MINE SHOWING POSSIBLE CONNECTOR WELL SITES.

Connector wells should be within the mine area, in uplands remote from outcrops and valley walls and at fracture trace intersections.

7. To determine the hydrogeologic data requirements necessary to select mines where this abatement procedure may be adopted for routine use.

8. To develop project costs versus effectiveness data to demonstrate that this procedure is economically viable as a mine drainage control method.

9. To develop a set of procedures for site selection and implementation of this technique for expanding its usage in the abatement of mine drainage from active and abandoned mines.

Several members of the ORSER staff visited Griffis Air Force Base in Rome, New York. They toured the facility and discussed the possibility of a joint crop yield prediction study using data supplied by the Air Force with ORSER computing facilities and capability. The image enhancement techniques used at Griffis are of considerable interest to ORSER, and Griffis personnel were invited to Penn State to give a seminar on this topic.

Preliminary discussions have been held with personnel from the Susquehanna River Basin Commission concerning a project involving land cover mapping of the Susquehanna River Basin. It has been suggested that ORSER use ERTS-1 data and available computer capabilities to generate land cover maps for 16 watersheds tributaries to the Susquehanna River.

Several agricultural land cover maps over selected areas in India have been completed for UNICEF, using data from ERTS overpasses and the ORSER data processing system.

Discussions have been held with the Susquehanna Economic Development Agency in Lewisburg, with a view toward initiating a feasibility study with ORSER for a land use inventory of their district. ORSER agreed to conduct this study.

Presentations

Late in February, ORSER gave a presentation in Harrisburg to the Department of Environmental Resources. Present were 17 members of that Department in such diverse fields as resources programming and flood recovery (see list of attendees, appended). Also present were personnel from the Pennsylvania Department of Highways, the Department of Commerce, several regional planning commissions, several institutions of higher education, and various federal agencies. Remote sensing in general was described, with particular attention paid to the ORSER system for processing data. Results of processing ERTS data to date were given, and suggestions were made of areas in which the State might be interested in using remote sensing to solve current problems.

It was emphasized in the discussions that ORSER considers the field of remote sensing to be in an applied research stage, that is: 1) the concept has been proven; 2) some research remains to be done; 3) applications are being sought; and 4) large aerial coverage is obtained quickly at decreasing cost, making it an essential tool in future land use and environmental management. ORSER is seeking increased interaction with local, state, and federal agencies for the following purposes: 1) to identify real world problems for which remote sensing solutions may be helpful; 2) to acquaint and train agency personnel with remote sensing and its potential applications; and 3) to help agencies develop working systems using remote sensing techniques for natural resource, environmental, and land use management purposes.

It was explained that ORSER stands prepared to provide the following services to governmental agencies: 1) training and education in the form of short courses, seminars, presentations, etc.; 2) use of ORSER facilities, such as the tape and imagery libraries, photointerpretation equipment, and remote terminal access to the computer; 3) opportunity to specify aerial photographic coverage by flights out of Wallops Island (NASA) and Rome, N. Y. (Griffis AFB); 4) analysis and interpretation of specific problems defined by the agencies, assisted in part by NASA (a recent proposal for such assistance was submitted to NASA); 5) advising on the applicability of remote sensing systems, methods, techniques, and equipment.

Two papers were presented by ORSER personnel at the Third Annual Remote Sensing of Earth Resources Conference on March 25-27, held at the University of Tennessee Space Institute in Tullahoma. They were:

COMPUTER ANALYSIS AND MAPPING OF GYPSY MOTH DEFOLIATION
LEVELS IN NORTHEASTERN PENNSYLVANIA USING ERTS-1 DATA
D. L. Williams and B. J. Turner

THE PENN STATE ORSER SYSTEM FOR PROCESSING AND ANALYZING
ERTS AND OTHER MSS DATA
G. J. McMurtry, F. Y. Borden, H. A. Weeden, and G. W. Petersen

Dr. Turner and graduate student Darrel Williams visited the University of Georgia in Athens. While there, they gave several presentations; among them were a biometrics seminar, "Statistical Classification of Remotely Sensed Natural Resource Data," and a School of Forest Resources Seminar, "Computer Processing of Remote Sensing Data." A tape of ORSER programs has been requested by the University of Georgia.

Dr. Pennypacker gave a seminar in the Department of Plant Pathology at Cornell University in Ithaca, N. Y., entitled, "Computer Use in Epidemiological Research."

Education

Professors and students from departments not directly associated with ORSER are increasingly finding data in the ORSER laboratories and libraries of use in their projects and class presentations. This is not only true of people on the Penn State Campus, but ORSER has also been called upon to assist a group of students at the University of Pennsylvania, working on a project for the Department of Environmental Resources, using ERTS and aircraft data from northeastern Pennsylvania and southern New York.

The 35 mm slide collections provided with the C54 data from Wallops Island have proven to be very useful in courses for landscape architecture students, and have been on loan for class presentations. U2 photography from Mission 73-009 over Potters Mills has been useful for a study of land use jointly conducted by an instructor and an undergraduate student in landscape architecture. Graduate students in geology, forestry, landscape architecture, and regional planning have requested the use of ERTS, Skylab, and aircraft data for class and thesis related projects.

Various students have requested information about ordering ERTS data for non-Pennsylvania areas, such as South Carolina, Canada, South America, and Greenland. The ERTS microfilm library has been of considerable assistance in these instances.

Graduate student Ed Link gave a class presentation to a graduate course in civil engineering on, "Preliminary Investigation of the Effect of Conversion of ERTS Data to Radiometric Values on the Performance of the PSU Remote Sensing Classification Routines." This talk will be issued as an ORSER-SSEL Technical Report.

Dr. Borden's class in remote sensing has been using the ORSER laboratory every Monday, including the Tektronix terminal, for study and analysis of ERTS and underflight data.

Contacts

ORSER has had many contacts with persons and agencies interested in remote sensing data and data analysis. The Cornell University School of Civil and Environmental Engineering, for example, has requested a tape of ORSER programs for use in land use mapping of data from ERTS-1. The Lackawana County Planning Commission is showing a growing interest in using remote sensing data in a comprehensive land use planning process, and personnel from the Commission visited ORSER in March to discuss the possibilities.

Aircraft coverage of various areas in Pennsylvania has been used by the Pennsylvania Geologic Survey (for study of a site in Lackawana County), by the Tri-County Conservancy of the Brandywine (for land use in a drainage basin in the West Chester area), and by the Penn State Hike and Bike club to study possible bicycle traffic lanes in the State College area. These are just examples of the many uses of the NASA-supplied data in the ORSER libraries by persons and agencies not directly associated with ORSER.

Visitors to ORSER during this period have included Dr. Herman Frinking from the Laboratory of Phytopathology of the Agricultural University of Wageningen in The Netherlands. Dr. Frinking was hosted by Dr. Pennypacker.

The Department of Public Information at Penn State borrowed several ERTS images for use in an article about ERTS research and its relationship to the energy crisis.

Papers

ORSER-SSEL Technical Report 9-74, "The Penn State ORSER System for Processing and Analyzing ERTS and other MSS Data," by G. J. McMurtry, F. Y. Borden, H. A. Weeden, and G. W. Petersen, was published in Vol. 3, pp. 697-720, of Remote Sensing of Earth Resources, university of Tennessee Space Institute, Tullahoma, Tennessee.

ORSER-SSEL Technical Report 7-74, "Method of Specifying Remotely Sensed Units for Soil Sample Points," by G. A. May, G. W. Petersen, F. Y. Borden, and D. N. Applegate, has been issued as paper #4636 of the Journal Series of the Pennsylvania Agricultural Experiment Station, University Park, Pa.

A paper on "Application of Remote Sensing to Natural Resource and Environmental Problems in Pennsylvania" is being prepared to help acquaint legislators and other potential users of the utility and limitations of remote sensing techniques and systems.

III. DATA ACQUISITIONS

U2 flight 74-016 was flown on February 5. In March, the photography from this flight was received, along with photography, preliminary MSS imagery, and Reconfax data tapes from C130 Mission 238.

List of Attendees

ORSER Presentation In Harrisburg

February 28, 1974

Harry Simms	DER-Office Legislation & Boards
George E. Fogg	DER-Div. of Outdoor Recreation
William Kutternik	DCA-Flood Recovery Team
W. Roy Newsome, Jr.	DCA Executive Office
Linford Harley	DER Bur. of Operations, Ofc. Res. Man.
Leo D. Sandvig	PennDot Bur. of Mat'ls, Testing Res.
Afton Schadel	DER Bureau of Soils and Water
Joseph J. Ellam	DER Div. Dams and Encroachments
Alan R. Geyer	DER Geologic Survey
William A. Gast	DER Bur. of Resources Programming
Eugene Eisenbise	DER Bur. of Master Planning
Louis Kirkaldie	U.S. Soil Conservation Service
Bruce A. Whyte	N.W.S. N.O.A.A. River Forecast Ctr.-Hrbg.
Donald Meagher	University of Pennsylvania
Sie Ling Chiang	DER, Bur. of Res. Programming
William G. McGlade	DER, Bur. Environmental Master Planning
Gary L. Merritt	DER, Div. of Water Quality
James W. Miller	DER, Mine Drainage Control
Raj N. Chadha	Ofc. of State Planning & Development
Stanley F. Gierlach	Fiscal Management
Dwight D. Worley	DER Div. of Solid Waste Management
Caren Glotfetty	DER Ofc. of Enforcement
Dallas A. Dollase	Dept. of Community Affairs
George Cook	Bureau of Plg. D.C.A.
Spencer C. Ryland	PennDot Dist. 2-0 (Clearfield)
W. C. Collins	Bureau of State Parks-Maintenance
Herb Gervin	Financial Management
J. W. Skovron	Financial Management
J. E. Barclay	U.S. Geological Survey
C. F. Merk	U.S. Geological Survey
D. M. Lohman	Bureau of Air Quality & Noise

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Robert D. Laughlin	Pa. Department of Commerce
Michael J. Lokert	Dept. of Earth Sci. Edinboro State College representing NW Regional Planning
Millard L. Haskin, P.E.	Dept. of Environmental Resources Bureau of State Parks
Bruno J. Chiega	DER Comptroller
Jose R. del Rio	DER, Bureau of Water Quality Management
Robert F. Mills	Dept. of Landscape Arch. & Regional Plan. University of Pennsylvania
Fred Wertz	Pa. Dept. of Agriculture
David M. Soulen	Pa. Dept. of Agriculture
John L. Longenecker	Pa. Dept. of Agriculture
Seong H. Kim	Pa. Dept. of Agriculture
Terry Krammes	Bur. Comm. Environmental Control DER
John Fedko	DER, Bureau of Systems Management
G. Kasmarch	OSPD
J. Richard Kumbach	Susquehanna River Basin Commission
Charles S. Takita	Susquehanna River Basin Commission

