POTENTIAL APPLICATIONS OF AEROSPACE EARTH OBSERVATIONS TECHNOLOGY TO THE PROBLEMS OF THE RIO GRANDE

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Abstract

Long range land use planning can only be done, in arid regions like New Mexico, when there is a fairly comprehensive accounting of the area's water resources and current water use practices. This in turn implies a large scale model of the area's water basin, with reasonable understanding of inflows, outflows, losses to evaporation and phreatophytes, and exchange with underground sources.

Large scale modeling, such as is being attempted with the Susquehanna river basin, requires large amounts of data to produce a significant predictive result. As is typical of most of the Western states, New Mexico is limited in the manpower and financial resources required to obtain and process this base data.

NASA's Earth Observation programs are now developing techniques for the acquisition of data from airborne and spaceborne imagery. In the long range land and water use planning, which the Rio Grande Regional Environmental Program (RGREP) is initiating, some of these techniques may be found to provide new or more rapidly obtained data sources. To that end, the NASA Manned Spacecraft Center has furnished RGREP with examples of imagery taken in the Rio Grande area in conjunction with other NASA missions and experiments.

Examples of this imagery, which include color, color-infrared, and other multispectral photography obtained from space and earth observation aircraft missions, are shown and briefly described.

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Scope of the Problem

The Upper Rio Grande basin may be defined as the portion of the Rio Grande river from the headwaters in the state of Colorado to a heavily faulted area, south of El Paso, Texas, (where the river essentially goes underground) where the old Frontier Fort Quitman was located. (Figure I). This portion of the Rio Grande watershed is, in area, about 32,035 square miles. It has a population of nearly 2,000,000, concentrated in two urban areas, Albuquerque and El Paso-Juarez. Its economy is based upon Federal Government Activity (Aerospace and nuclear energy R&D, military installations, and other agencies) agriculture, tourism, and light industrial manufacturing, in about that order. The only basic productivity, in agriculture, comes from irrigated lands and, to a much lesser extent, from rangeland stock grazing. Both of these activities are, of course, water-limited. There are those who predict that ranching, as an economic way of life, is about doomed in this generation; and the gradual salinization of the irrigated lands coupled with the known limits of water available seems to indicate a gradual decline in that activity as well. It is therefore fitting that those of you who are charged with the responsibility of allocating precious water resources should be seeking new methods of assessing our future in terms of water and land use planning.

The U.S. Water Resources Council, in their publication The Nation's Water Resources, stated that "... the water resources of the (Rio Grande) Region are fully appropriated and insufficient to meet present needs." The Council summarizes the water situation in this Region as follows:

> "The Rio Grande Region is confronted by five major water problems:
>
> 1. in nearly every part of the Region, the available water is not sufficient in quantity;
> 2. a significant amount of water is of poor quality because of high salinity;
> 3. heavy sediment loads are common in many tributaries;
> 4. excessive nonbeneficial consumptive use of water occurs; and
> 5. floods cause frequent and extensive damage to property and threats to human life."

Formation of the Rio Grande Regional Environmental Project (RGREP)

Recognition of this range of problems has been the driving factor in the organization of RGREP, currently under the impetus of the Bureau of Reclamation. The Governors of Texas and New Mexico have strongly endorsed this approach, and directed the Rio Grande Compact Commissioners and the appropriate state agencies and universities to participate. The project is still in the formative stages. A prospectus has been prepared and is available for review at the New Mexico Water Resources Research Institute.

FIGURE I. UPPER RIO GRANDE WATERSHED.

RGREP is presently composed of an executive body and a multi-disciplinary multi-agency advisory board. James Kirby of the Bureau of Reclamation is currently serving as Executive Director of RGREP. The scope, composition, membership, level of activity and funding, are all now in the process of being further defined.

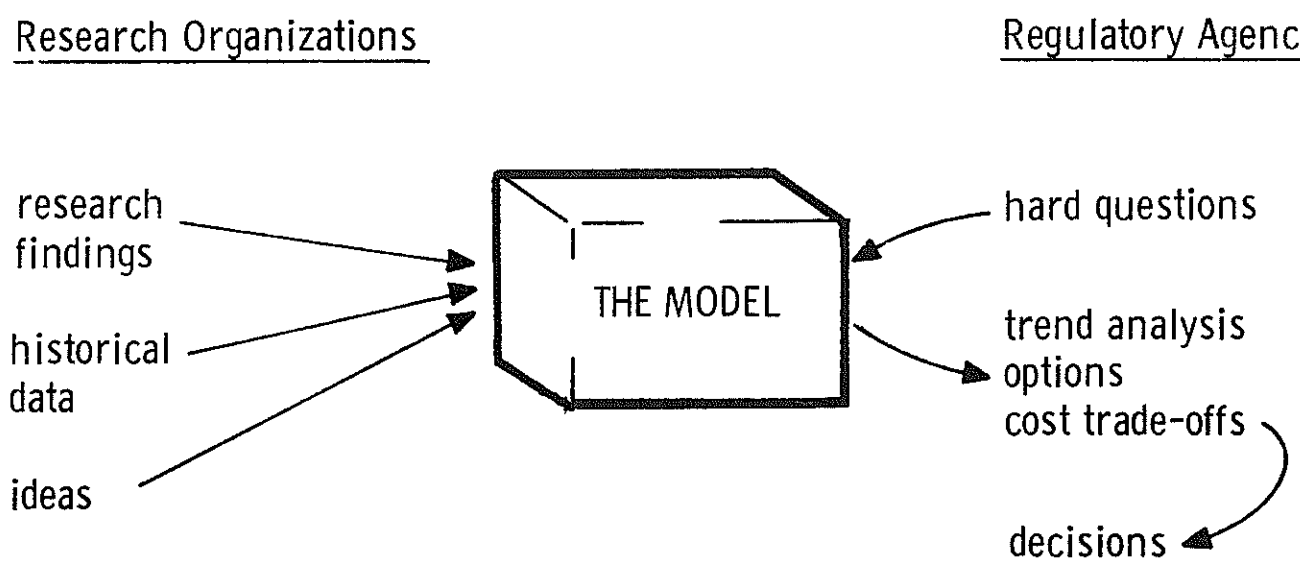
RGREP's Discussions with NASA-What technology is available and how could it be applied?

In November, 1971, after some preliminary discussions with the NASA, White Sands Test Facility, Mr. Jess Gilmer, Rio Grande Compact Commissioner, Mr. Kirby, and the heads of the three local Irrigation Districts, journeyed to the Manned Spacecraft Center at Houston for the puspose of discussing with the NASA the current techniques which NASA has developed in Earth Resources investigations. They were fortunate in their timing: The NASA is currently in the process of defining methods of applying the research techniques developed during the last decade in earth observations technology, and RGREP has the potential of being a very attractive applications program.

I should be very careful to stress, at this point, that the NASA has made no commitments in the ongoing support to RGREP. However, the NASA engineers in Houston were very interested in the RGREP problem, and arranged briefings for RGREP personnel of some of the NASA Earth Observations program activities. Finding some time available on one of the NASA Earth Resources aircraft, a specially-equipped RB-57, one flight was made to obtain some baseline photo coverage of the RGREP area. We will look at samples of this imagery later in the presentation. At the present time, NASA is continuing informal discussions with the RGREP director in the definition of RGREP's eventual program.

Approach: Large Scale Modeling

One of the most useful techniques, in any scientific investigation, is the development of a "model" of the phenomena to be investigated. A "model" can be a fairly simple description of a thing or a process, or an attempt to explain complex relationships not otherwise easily understood. The old "phlogiston theory" was a model in this sense. Once it was proposed, it was found to be inadequate. But, it was a necessary "first step" in the process of understanding combustion and other thermodynamic relationships because it served as a method of communication. Nowdays most large and complex investigations use models in the same sense, for communication, but they are most generally devised to be manipulated by analog or digital computer techniques. Computer-based modeling is largely mathematical in its techniques. It is sufficient here to consider the process as taking place in a "black box." (Figure II) Two basic different interests can be supported by the right "black box." The research community is interested in being able to test its findings against the model, and to communicate those findings to each other. Regulatory agencies, on the other hand, are looking for information in terms of trends, costs, and decision options, because they are called upon to answer hard questions and make far-reaching de-



The model as a "Black Box"

FIGURE II.

cisions. Let me give one example of a question which RGREP may be asked: "How many people, at what standard of living can be supported in the upper Rio Grande basin, based upon the known water limits?" The basic data needed to answer that question may already exist, but at present there is no way to get at it. Even if it does exist, it is not collected and formatted in such a way as to be able to demonstrate the problems which we all know, intuitively, are coming.

Long range land use and other economic planning can only be done in arid regions like ours, when there is a fairly comprehensive accounting of the area's water resources and current water use practices. This in turn implies a large scale model of the area's water basin, with reasonable understanding of inflows, outflows, losses to evaporation and phreatophytes, and exchange with underground resources. A large scale of the water resources then becomes a subset of a larger model of the region's economy, and relationships can be described between these models (Figure III).

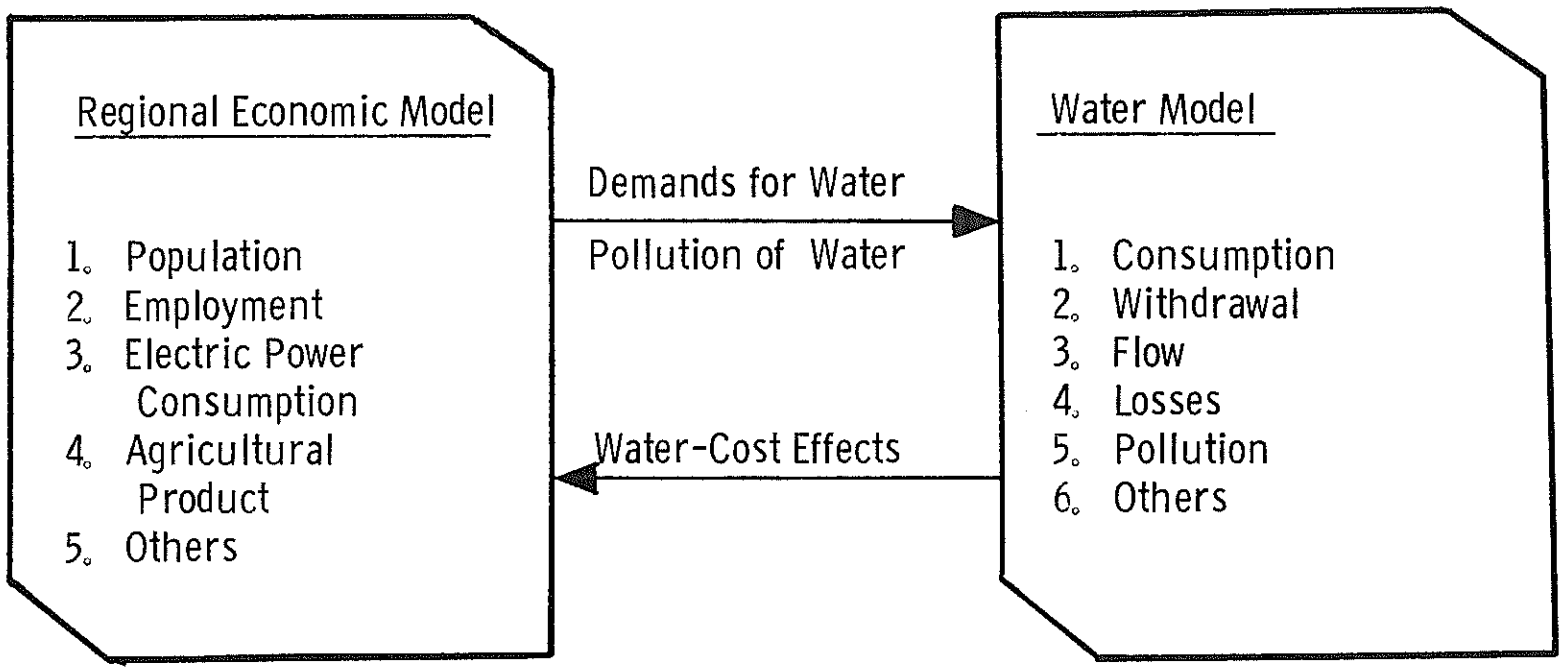
Without getting too detailed, it should be mentioned that even these sector models, such as the water sector model, are composites of submodels of discrete regions (Figure IV).

The upper Rio Grande basin might thus be described in three, four, or five submodels, depending on the physical geometry of the river and how the engineers and scientists choose to define the model.

Large scale modeling, such as has been attempted with the Susquehanna river basin, the lower Mississippi, and other rivers, requires large amounts of data, generally gathered by hand measurements, field trips, etc., in order to produce a significant predictive result. Here in the Southwest, we are limited in the manpower and money required to obtain and process this base data. NASA's Earth Observations programs are now developing techniques for the acquisition of data from airborne and spaceborne sensors, both remote instruments telemetering data to central data collection points, and with multispectral (photographic, infrared sensing, microwave) imagery. Both the data gatherings and the data reduction are evolving into semi-automated procedures. These techniques, then, become attractive to any large modeling program in the Southwest. In the long range land and water use planning envisioned by RGREP, there may well develop some significant applications of this aerospace technology.

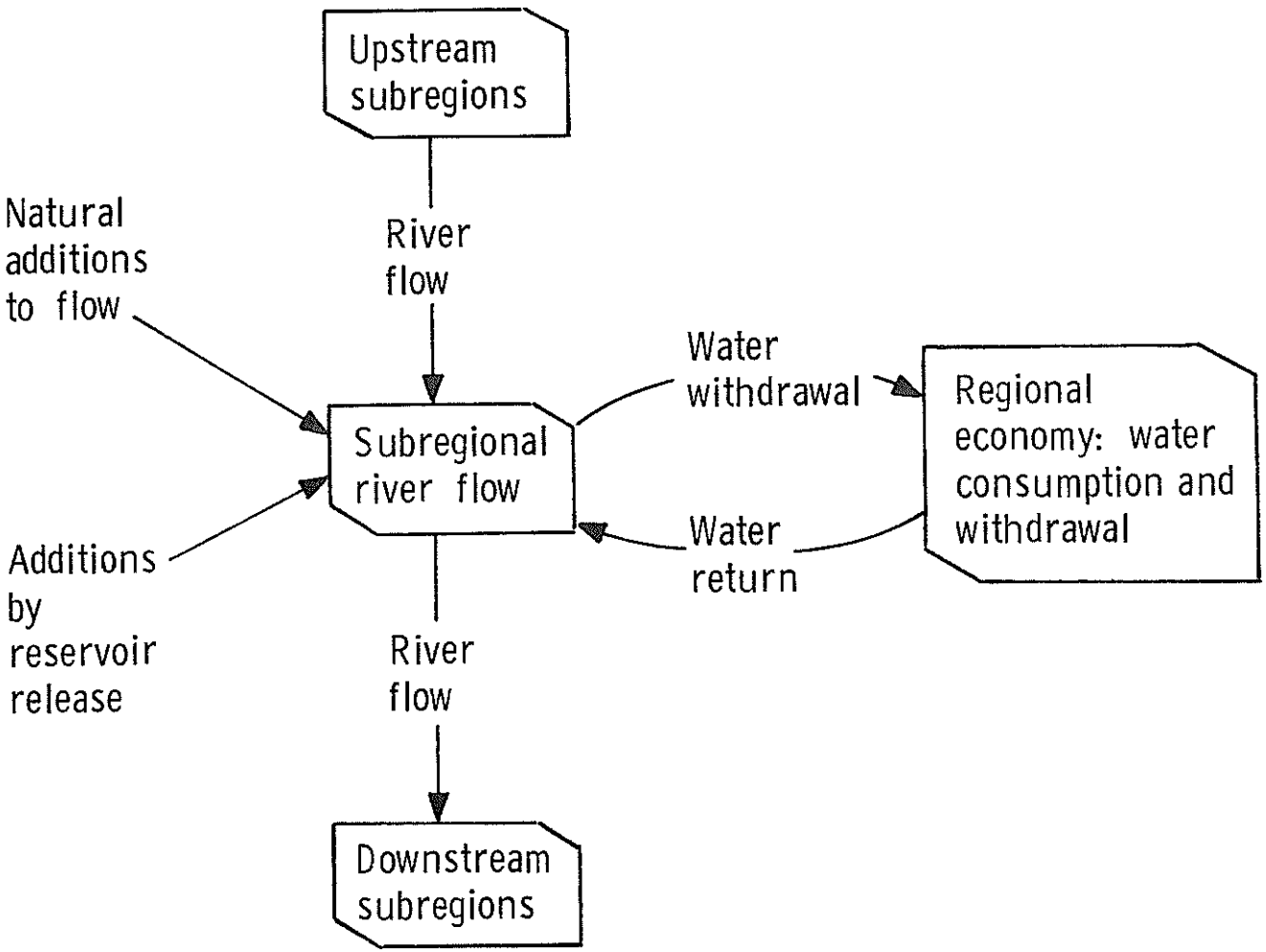
A Closer Look at RGREP

In Figure V, I have taken some liberties with the RGREP organization, to show the approach to the problem now under development. The lists of interested regulatory agencies and participating research agencies are not yet complete. There well may be more and different players in the game. This chart does, however, show the relationships required, and the use of the model as a communications device. The sketch shows a list of the submodels probably required (water, air, land use, economic, and population submodels), and, for illustration, the



Feedback between Models

FIGURE III.



Simplified Water Submodel

FIGURE IV.

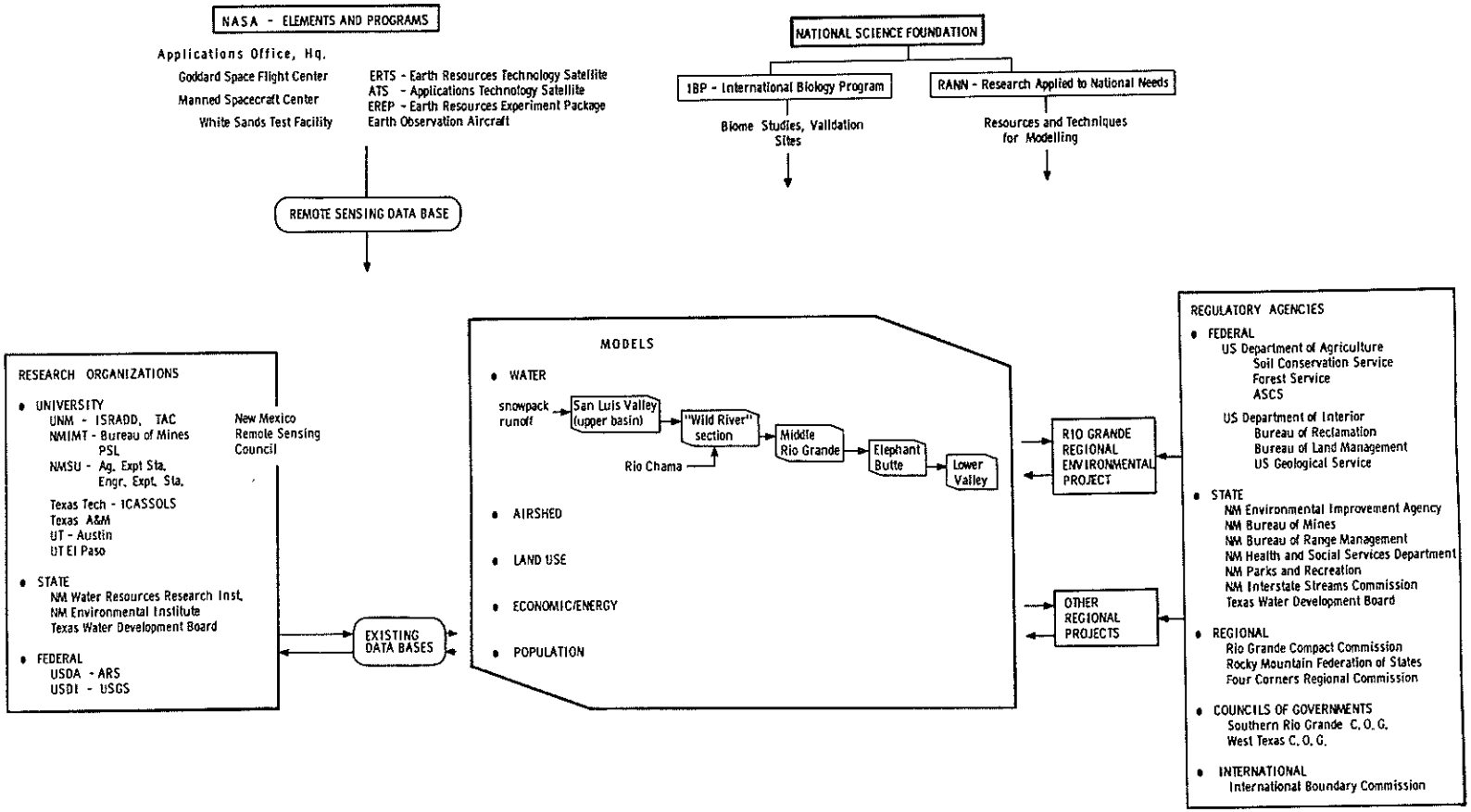

NASA - ELEMENTS AND PROGRAMS
Applications Office, Hq.
Goddard Space Flight Center
Manned Spacecraft Center
White Sands Test Facility
ERTS - Earth Resources Technology Satellite
ATS - Applications Technology Satellite
EREP - Earth Resources Experiment Package
Earth Observation Aircraft
NATIONAL SCIENCE FOUNDATION
IBP - International Biology Program
RANN - Research Applied to National Needs
Biome Studies, Validation Sites
Resources and Techniques for Modelling
REMOTE SENSING DATA BASE
RESEARCH ORGANIZATIONS
UNIVERSITY
UNM - ISRADD, TAC
NMIMT - Bureau of Mines
PSL
NMSU - Ag. Expt Sta.
Engr. Expt. Sta.
Texas Tech - ICASSOLS
Texas A&M
UT - Austin
UT El Paso
New Mexico Remote Sensing Council
STATE
NM Water Resources Research Inst.
NM Environmental Institute
Texas Water Development Board
FEDERAL
USDA - ARS
USDI - USGS
EXISTING DATA BASES
MODELS
WATER
snowpack runoff
San Luis Valley (upper basin)
"Wild River" section
Rio Chama
Middle Rio Grande
Elephant Butte
Lower Valley
AIRSHED
LAND USE
ECONOMIC/ENERGY
POPULATION
RIO GRANDE REGIONAL ENVIRONMENTAL PROJECT
OTHER REGIONAL PROJECTS
REGULATORY AGENCIES
FEDERAL
US Department of Agriculture
Soil Conservation Service
Forest Service
ASCS
US Department of Interior
Bureau of Reclamation
Bureau of Land Management
US Geological Service
STATE
NM Environmental Improvement Agency
NM Bureau of Mines
NM Bureau of Range Management
NM Health and Social Services Department
NM Parks and Recreation
NM Interstate Streams Commission
Texas Water Development Board
REGIONAL
Rio Grande Compact Commission
Rocky Mountain Federation of States
Four Corners Regional Commission
COUNCILS OF GOVERNMENTS
Southern Rio Grande C. O. G.
West Texas C. O. G.
INTERNATIONAL
International Boundary Commission

FIGURE V.

division of one submodel into sub-region "sub-sub-models". In addition, the figure shows the anticipated participation of two agencies

- the NASA for support in its areas of expertise; and,
- the National Science Foundation, for support in the areas of large scale modeling, under the aegis of the Research Applied to National Needs program (RANN).

Direct participation with NASA would probably involve cooperative study of the following items:

WATER

1. Periodic evaluation of snowpack - October through May.
2. Atmospheric meteorology for melt and for run-off prediction.
3. Periodic evaluation of streamflow conditions in Rio Grande and tributaries.
4. Periodic assessment of water stored in reservoirs, reservoir capacities, silting, etc.
5. Periodic assessment of soil moisture conditions, via microwave techniques.

LAND

1. Assist in preparing a comprehensive report on the physical geology of the area.
2. Assist in preparing a comprehensive study of the geohydrology of the area.
3. Assist in monitoring the fluvial morphology of the Rio Grande and tributaries.
4. Assist in geothermal explorations.
5. Assist in evaluating the progressive sedimentation of storage and flood control reservoirs.
6. Establish land use maps and revise periodically to monitor changes.
7. Participate in studies for the evaluation of the effects on land and water by estimates of biomass, grasslands, phreatophytes, pinon-juniper highlands, and forested areas.
8. Assist with soil studies to determine soil types and particularly soil salinity.
9. Assist with irrigation efficiency studies.
10. Assist with agricultural studies and evaluations covering a broad range of applications by assessing plant pathology, and correlating use of insecticides with water pollutants.

AIR

1. Assist with studies to identify and assess sources of air pollution emanating from the RGREP area and pollutants entering the RGREP area from contiguous areas.
2. Assist with the improvement in weather forecasting, both long and short range.

ENERGY

1. Assist with the evaluation of the area as a potential prime source of solar energy.
   : Geothermal energy
   : Conversion of saline waters

HUMAN

1. Provide basic data and assist with the assessment of the entire human resource of the area.

Involvement in the above programs would necessitate cooperative efforts from a multitude of Federal, State, and other agencies.

Imagery Now On Hand of the RGREP Area

In the course of a number of experiments conducted from spacecraft and Earth Resources aircraft over the last several years, there have been some photographs taken of the RGREP area. This data is already available for viewing at the NASA Manned Spacecraft Center's Earth Observations Research Data Facility at Houston. Copies of most of the photographs, particularly those from space, are available at a nominal charge from the University of New Mexico's Technology Applications Center. One set of imagery, from the most recent aircraft flight, which I mentioned earlier, is available for viewing at the New Mexico Water Resources Research Institute at NMSU. In general, the best imagery from space of the RGREP area was obtained from the flights of Apollo 6 and Apollo 7 (Figure VI): the coverage available that has been taken by the NASA aircraft is shown in Figures VII and VIII, the latter Figure showing the coverage provided to RGREP for initial survey purposes.

(To those attending the 17th Annual Water Conference, I would like to give a brief tour of the Rio Grande Valley, from Bernalillo to Ft. Quitman, as seen in the infra-red. Sixteen selected slides, covering Albuquerque, the Socorro area, Elephant Butte and Caballo, the Rincon Valley, Mesilla Valley, El Paso, and the Lower Valley below El Paso, will be shown.)

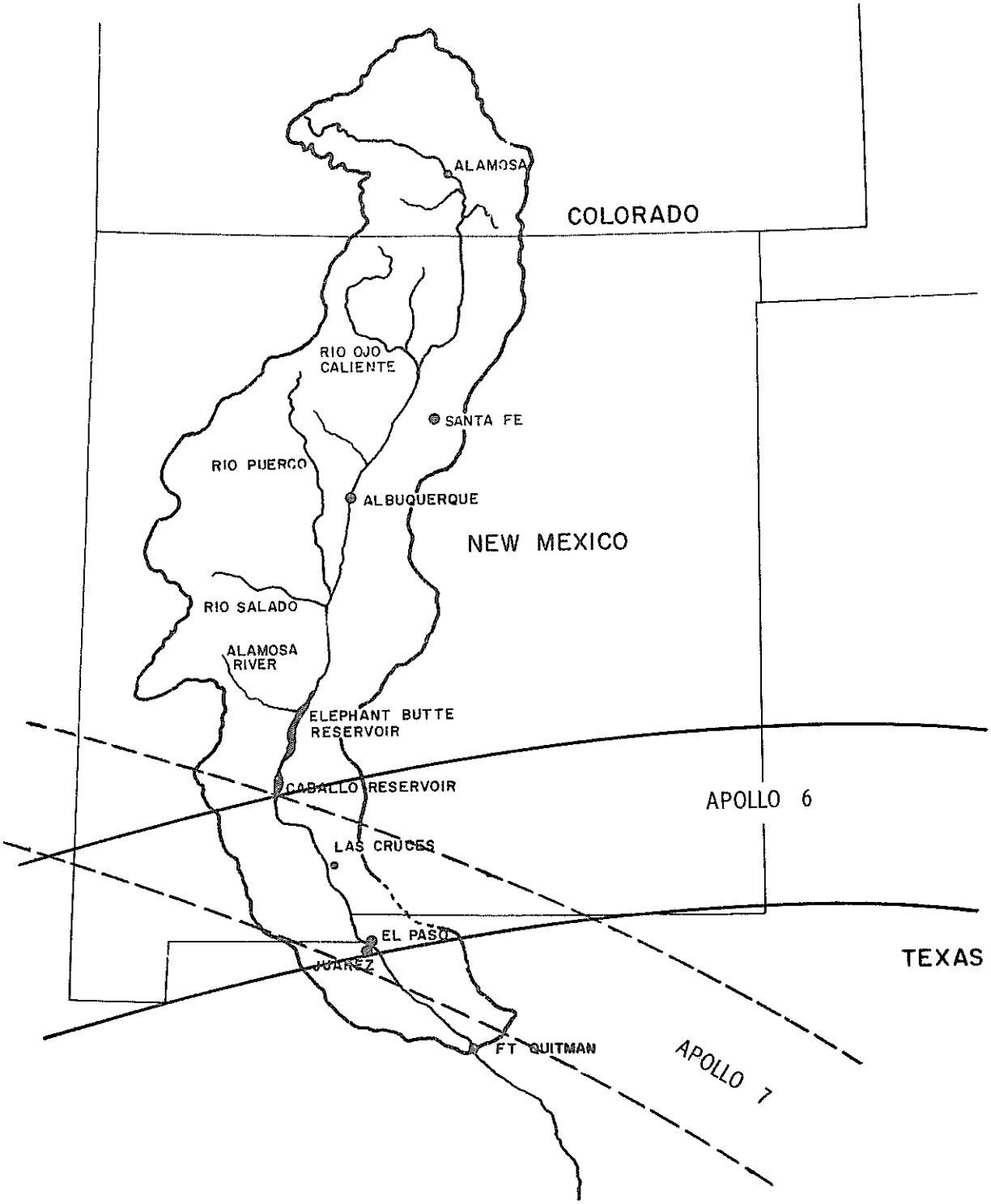


FIGURE VI. PHOTOGRAPHY FROM SPACE.

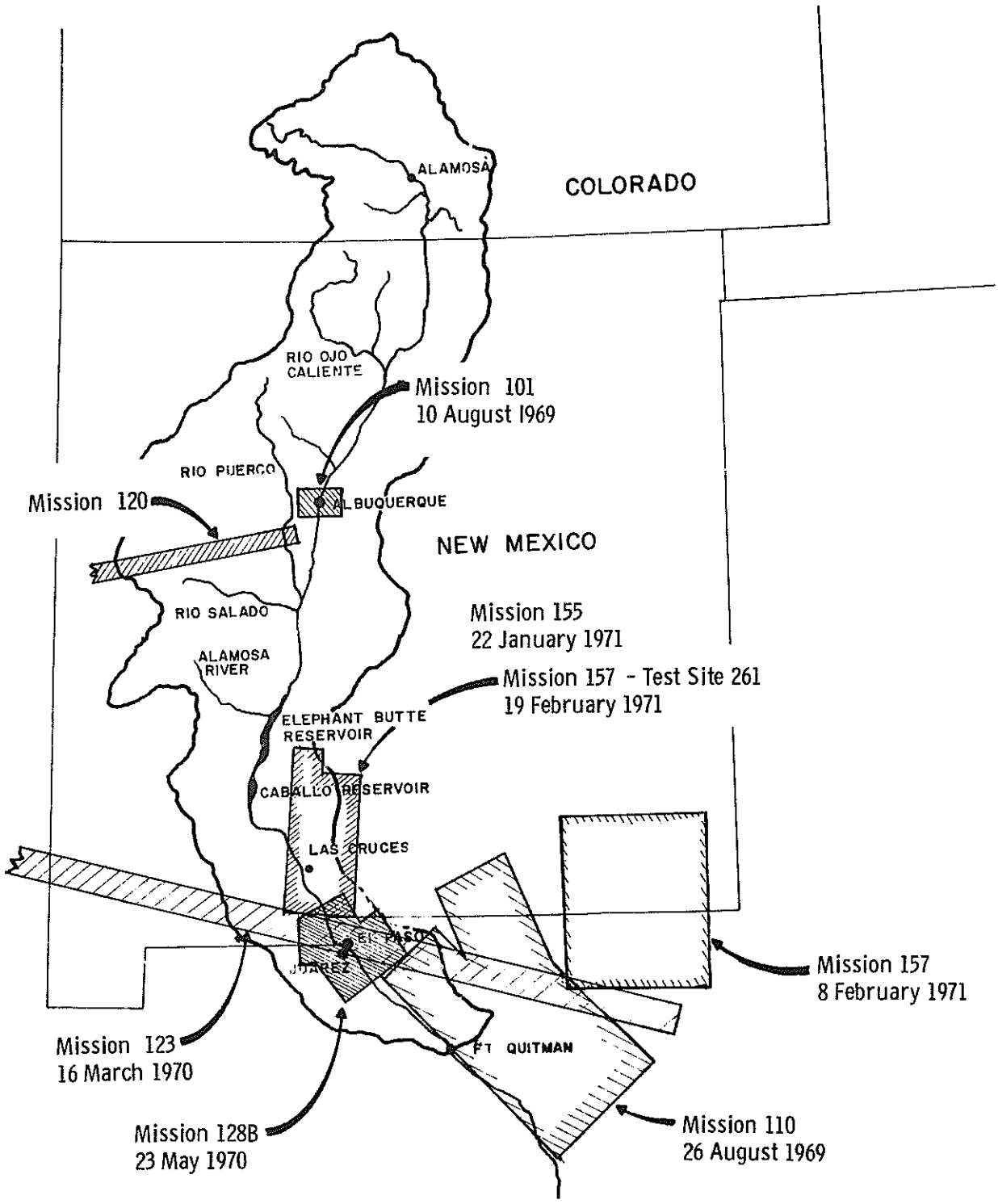


FIGURE VII. PHOTOGRAPHY FROM NASA'S EARTH OBSERVATIONS AIRCRAFT.

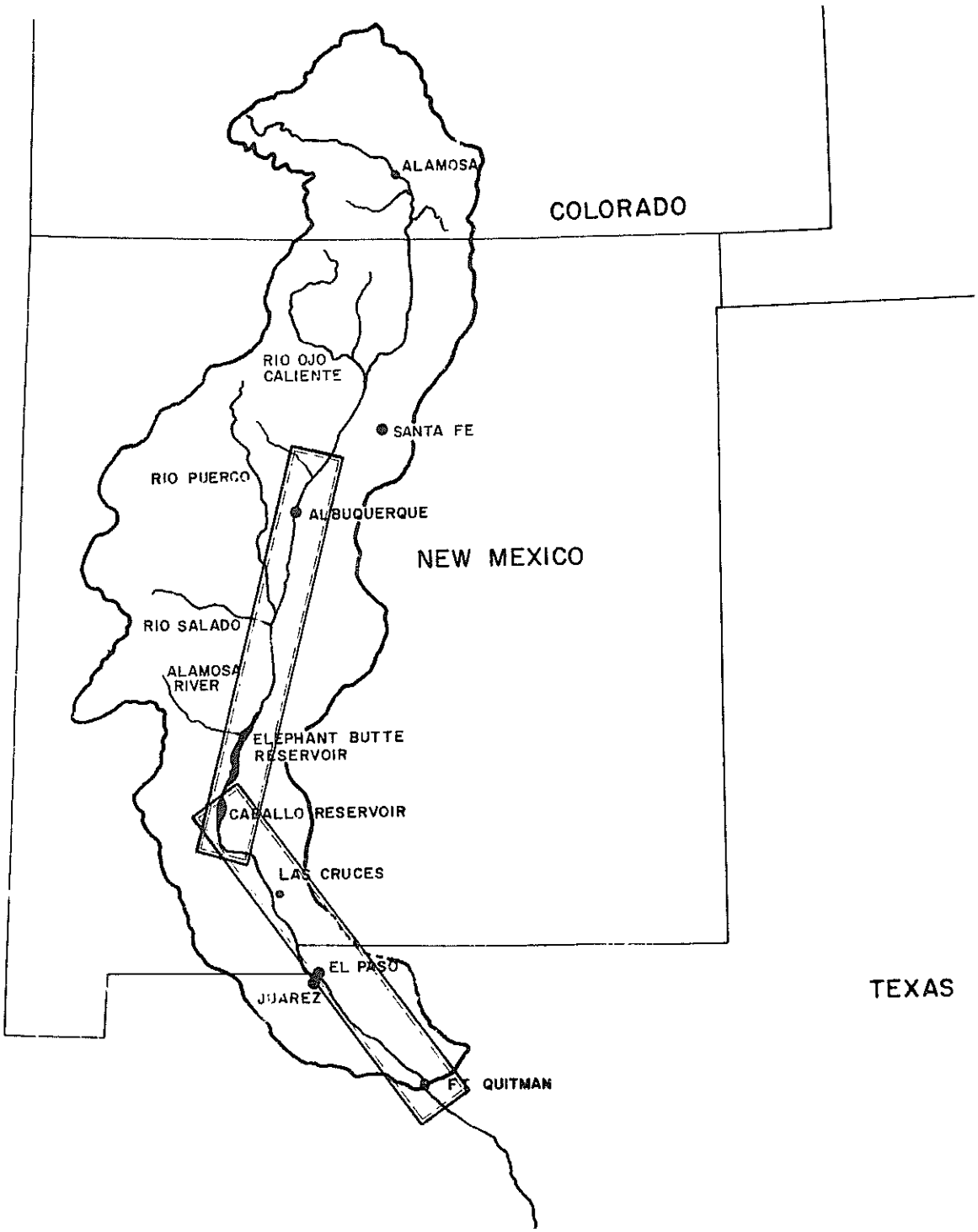


FIGURE VIII. PHOTOGRAPHY FROM NASA'S EARTH OBSERVATIONS AIRCRAFT - MISSION 191 - RGREP AREA.