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LANDSAT-4 IMAGE DATA QUALITY ANALYSIS
FOR ENERGY-RELATED APPLICATIONS*



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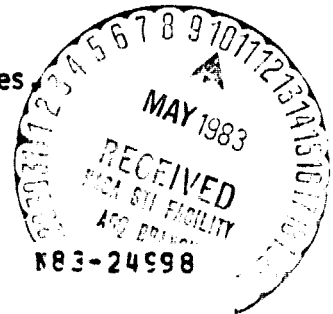
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FIRST QUARTERLY REPORT
April 11, 1983

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George E. Wukelic - Principal Investigator ID# 050

Objective/Scope: The objective of this investigation is to evaluate Landsat-4 Thematic Mapper (TM) data performance and utility characteristics from an energy research and technology perspective. The program focuses on evaluating applicational implications of using such data, in combination with other digital data, for current and future energy research and technology activities. Prime interest is in using TM data in efforts relating to the siting, development and monitoring of nuclear facilities. Secondary interests involve the use of such data for resource exploration, environmental monitoring and basic scientific initiatives such as in support of the Continental Scientific Drilling Program.

Approach: To utilize digital remote sensing/image processing and data integration techniques developed at the U.S. Department of Energy's Pacific Northwest Laboratory for processing, analyzing and evaluating Landsat-4 Thematic Mapper data. Data analysis and evaluation emphasis is on Landsat-4 data use for the Columbia Plateau region in eastern Washington in general and the Hanford site in specific. However, Landsat TM data for other representative energy research and production sites are being analyzed and evaluated as well. Table 1 identifies the main image data quality characterization areas of investigation and the prime application areas of interest.

Data Status: To date, no useable Landsat-4 TM data have been obtained for our prime study site in the Columbia Plateau region of eastern Washington

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TABLE 1. PNL Landsat-4 TM Image Data Quality and Utility Characterization Interests

DATA QUALITY			DATA UTILITY				
Radiometry	Spectral Information	Detector Replacement Algorithms		Renewable Resources	Agriculture		
		Band Compression Algorithms			Soils		
	Radiometric Information	Internal Calibration Algorithms	Channel-to-Channel			Forests	
			Band-to-Band			Range	
		Scene Histogram Calibration Algorithms (Radiometric Striping)				Irrigation	•
		Absolute Scene Radiance Calibration Algorithms	Reflective Band		Non-Renewable Resources	Geology	•
	Thermal Band		•	Image Science		•	
	Noise Correction Algorithms			Other			
	Radiometry	Geometry of Pixel	Ground IFOV	•	Planning/ Environmental Management	Regional/Urban Land Use	•
			Geometry of Image (Pixel Location)	Systematic Correction		Scan Profile	
Detector Location						Hydrology	•
Between Scan Alignment						Wildlife Habitat	
Ephemeris						Oceans	
Attitude						Other	
Geometric Correction with GCPs		Reference Library Build					
		Scene-to-Reference Registration	•				
Resampling							

state. Table 2 summarizes Landsat-4 data acquired to date and relational data sets being utilized.

Preliminary Results:

1. TMS Data Analysis. Prior to the receipt of Landsat-4 TM data, NASA ERL provided PNL with Thematic Mapper Simulator (TMS) data for a nuclear power plant (Virginia Electric Power Company-North Anna Plant) to test PNL image processing algorithms.

Principal component analyses of this data set clearly indicated that thermal plumes in surface waters used for reactor cooling

TABLE 2. Landsat-4 and Ancillary Data Status

	<u>Path/Row</u>	<u>Date</u>	<u>Comments</u>
1) Landsat-4 TM data			
<u>Prime Study Site</u>			
Hanford Site	Day 44/28		No useful TM data acquired to date.
Richland, WA	Night 137/16		
<u>Secondary Study Sites</u>			
Savannah River Plant (SRP) South Carolina	Day 17/37	8/28/82	Received 1/31/83
	Night 116/207	12/24/82	Received 3/28/83
Portsmouth Ohio Facility	Day 19/33	9/11/82	GSFC Processing requested 3/83
	Night 115/211		
West Valley, NY (Buffalo, NY scene)	Night 112/214	8/28/82	Received 11/15/82
<u>Test Data Provided</u>			
Northeast Arkansas	Day	8/22/82	Received 10/1/82
2) TM Simulator (TMS) Data			
North Anna Nuclear Power Plant	Day	9/11/81	Received 4/82 from NASA ERL
3) HCMM Data			
	Day/Night	12/17/78	Tapes for Savannah River received from GSFC 3/83
4) Ground Truth Data			
Savannah River Plant	On Site Thermal	8/28/82 & 12/24/82	Also aircraft MSS (including thermal) over SRP 9/82 and 2/83

would be discernible. Figures 1 and 2 show the results of the TMS data analysis. Figure 1 is a conventional IR color composite (using TMS bands 1, 2 & 4) and Figure 2 shows the TMS thermal composite (using bands 5, 6 & 7). The thermal band on the TMS data was, however, not resampled to simulate the 120 meter TM band 6 data.

2. Landsat-4 TM Data Analysis. Shortly after the launch of Landsat-4, PNL image processing and analysis programs were successfully tested using the 7 band Arkansas test scene for August 22, 1982 (path 23/ row 35) provided by NASA GSFC. Upon receipt of the first requested TM data set in January 1983 for the DOE Savannah River Plant (SRP) in South Carolina (Augusta, GA scene for August 28, 1982, path 17/ row 37), preliminary analysis clearly indicated that current interactive, image enhancement, analysis and integration techniques can be effectively utilized for Landsat-4 data analysis and utilization. Moreover, thermal band data appear adequate for gross estimates of thermal changes occurring near operating nuclear facilities especially in surface water bodies being used for reactor cooling purposes. These qualitative results are documented in Figures 3 through 5.

Figure 3 is a map showing operating nuclear facilities and associated surface waters used for reactor cooling at the Savannah River Plant. Figure 4 is a TM IR color composite of the SRP area only of the Landsat scene (Bands 1, 3 & 4). Figure 5 is a thermal composite (Bands 1, 4 & 6) showing thermally altered surface water areas in red (pond in upper right and streams and marshes in lower left).

Since the initial analysis, additional PNL image processing software has been written and tested which provides for more rapid and effective analysis of the Landsat-4, 7 band TM data. Current efforts are directed at analyzing lower resolution HCMM data of the area provided by GSFC and the recently received thermal night-time coverage of the Savannah River Plant.

Conferences/Publications: PNL staff has participated in both the Landsat-4 Investigations Workshop and the Landsat-4 Scientific Characterization-Early Results symposium. Because of the lack of TM data over DOE study sites of interest, no publications or presentations have been authored to date.

Current plans include presenting initial results 1) in a Landsat-4 session at IGARSS '83 in San Francisco, CA, August 31 - September 2, 1983, and 2) at the Third National Conference on Resource Management Applications: Energy and Environment immediately preceding IGARSS '83 in San Francisco on August 23-27, 1983.

Problems: The major problem relates to obtaining the required TM data sets to satisfy increasing DOE interest in using these data for operational and research interests. Because of cloud cover problems typically experienced during the winter in the Pacific Northwest, no useable TM data has been acquired over our prime study site (DOE Hanford site) from the Canadian station prior to the failure of the Landsat-4 downlink. We will be re-evaluating our data quota requirements and resubmitting priorities based on what transpires relative to TDRS performance.



FIGURE 1. False-color IR Composite of TMS data (Bands 1, 2 and 4) for a Nuclear Power Plant (Black Arrow)

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FIGURE 2. Thermal Composite of TMS data (Bands 5, 6 and 7) Showing surface water thermal distribution (in red) associated with nuclear power plant cooling (note arrows)

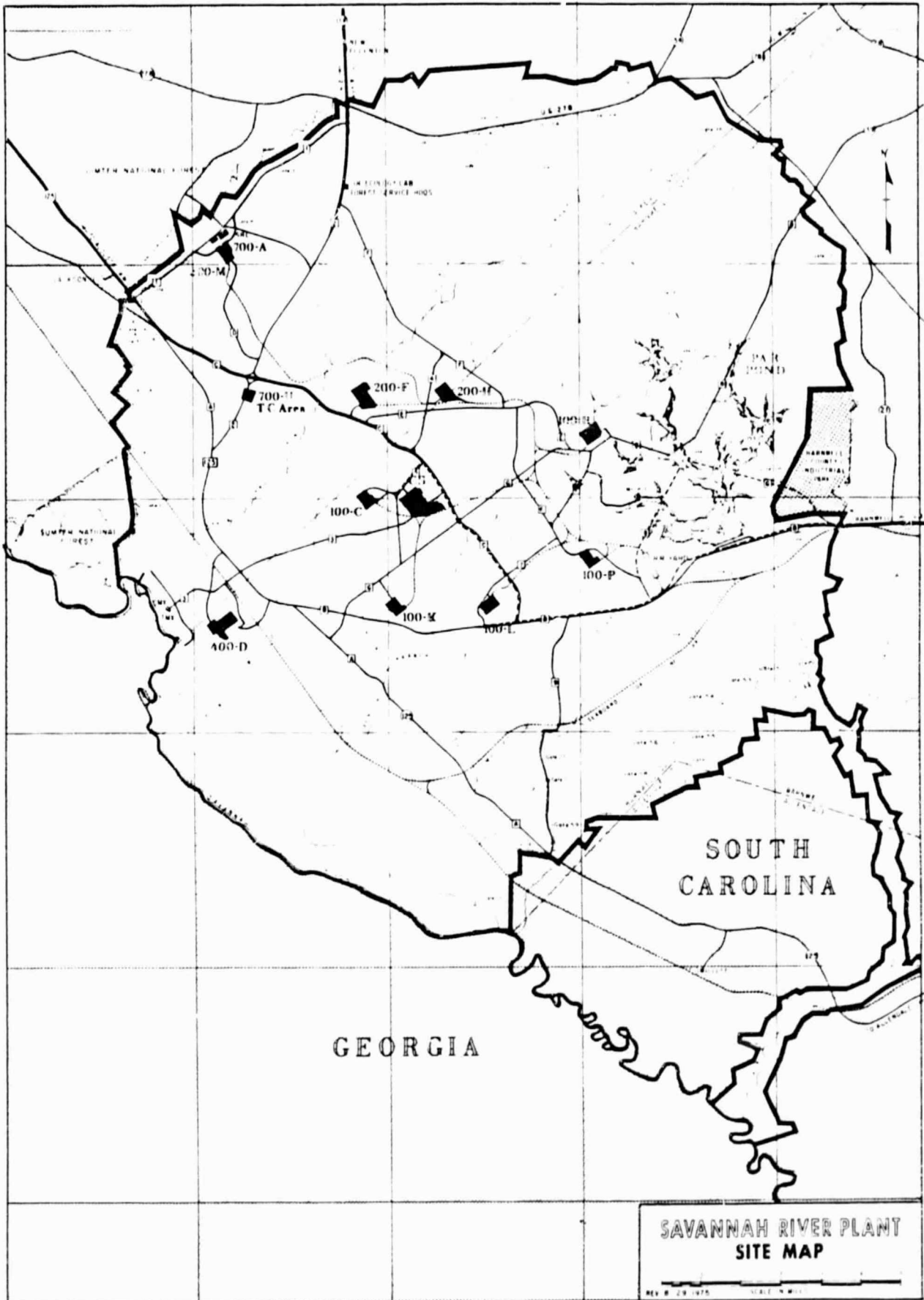


FIGURE 3. General site map for Savannah River Plant.

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FIGURE 4. Portion of Landsat-4 color composite (bands 1, 3 and 4) showing Savannah River Plant - August 28, 1982

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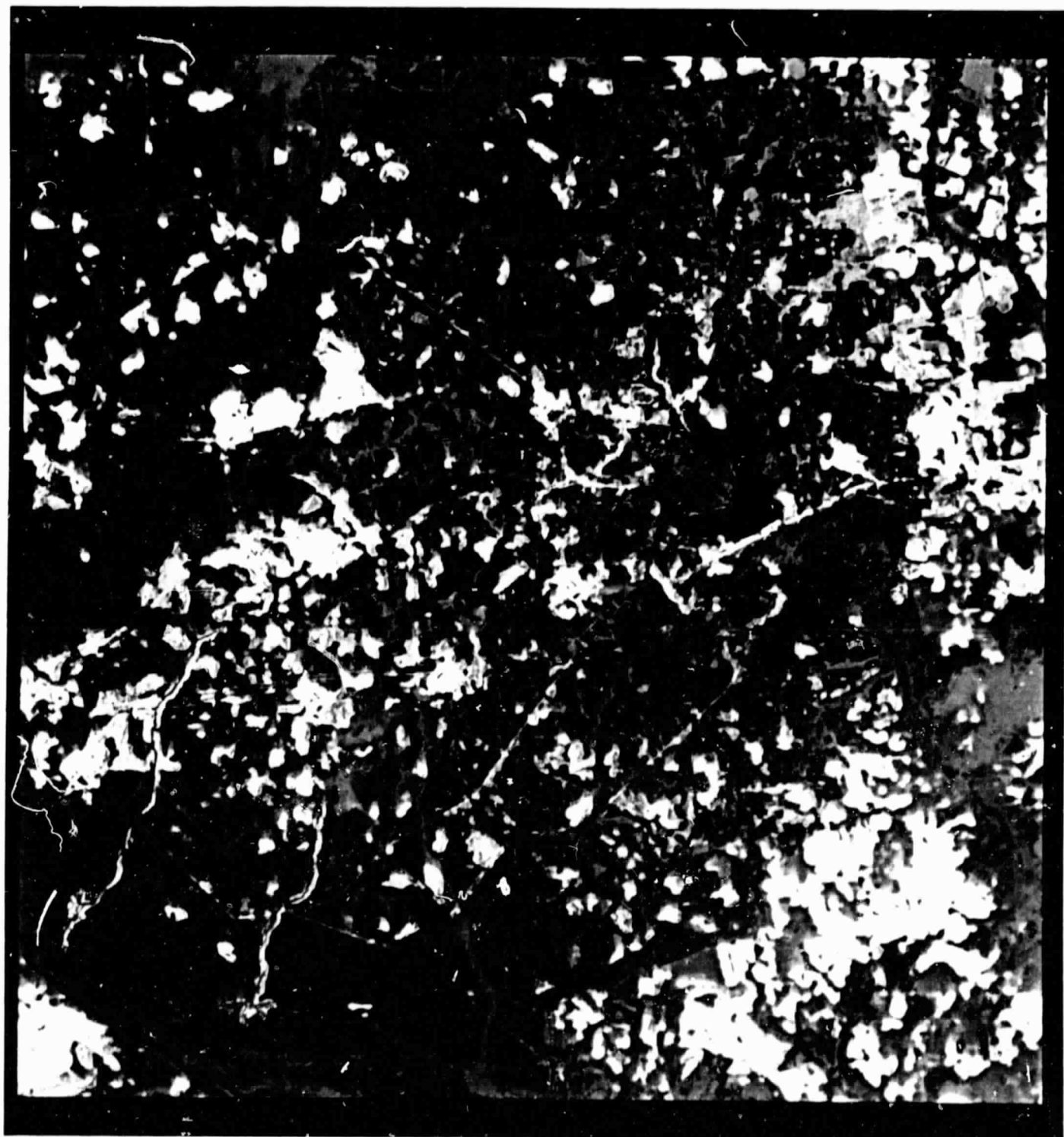


FIGURE 5. Portion of Landsat-4 thermal composite (bands 1, 4, and 6) showing surface waters being used for cooling at SRP. (Bright red areas) August 28, 1982.