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July 5, 1973 D22-1679

Mr. Frederick Gordon, Code 430
ERTS Technical Officer
National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

Re: BI-MONTHLY PROGRESS REPORT, PR-568/MMC# 200, Environmental Indices from ERTS-1, NAS 5-21482

Gentlemen:

The MITRE Corporation is pleased to submit a progress report for the period of May 1973 through June 1973. To promote consistency and facilitate NASA review, MITRE has adopted this format for all future Type I Progress Reports.

A. TITLE:

Investigation of Environmental Indices from the Earth Resources Technology Satellites, PR-568/MMC# 200.

B. PRINCIPAL INVESTIGATOR:

Mr. Edward A. Ward
Sub-department Head
Environmental Systems

C. PROJECT OBJECTIVES:

MITRE will develop environmental indices covering land, water and air quality compatible with ERTS-1 imagery. Two sites in Pennsylvania have been selected for examination. Such indices will reveal the trends occurring in the environment and will prove useful to Federal, state and local governments in their management of the environment in other areas.

D. SUMMARY OF PROJECT STATUS:

- o A project coordination meeting took place on June 25 at GSFC. In addition to yourself, Mr. David Nava and several GE personnel were in attendance. The purpose of the meeting was to discuss in detail our efforts to date with particular emphasis on our land use analysis in the Harrisburg, Pennsylvania area and our water quality efforts using the Potomac River as the test area.

A status report of our land use analysis is attached. It discusses the analysis of the greater Harrisburg area as determined from the October 11 overflight (1080-15185). Comparison with the land use information from the 1967 Tri-County Planning Commission shows differences in land use varying from 0.7% for transportation sites to 22.3% for commercial. As discussed in the Appendix A, further refinement of the October 11 imagery appears necessary.

As discussed in the water quality section below, it is believed that striping (banding) has prevented finer signature development. Comparison of the August 1 greater Harrisburg signature development report included in the MITRE Type II Progress Report and the October 11 signatures development reported in Attachment A leads MITRE to believe that this possibility exists. The August 1 date was quite hazy over the target area when compared with the October 11 date image. Yet the signatures were only moderately improved.

- As described in our Type II Progress Report it was felt that in order to develop good water quality signatures our initial water quality signature development should be performed in an area of more homogeneous nature. Thus we selected an adjoint image to the October 11 image of Harrisburg, the Washington, D. C. image (1080-15192) for our training area. (As discussed in our April 30 Type I Progress Report, a striping (banding) was inhibiting the development of good water quality signatures.) Also presented at GSFC on June 25, was a status report of our water quality analysis and presented our concern over striping in detail. Conversations with NASA and GE personnel now leads us to believe that the results shown in Appendix B are due both to a NASA data handling problem which GSFC now corrected by software and an error caused by overdriving the accuracy of the input data here at MITRE. It was determined at the GSFC meeting that the MSS data could be expected to have an accuracy of plus and minus 1.1 quanta and that MITRE had been attempting to drive these data to approximately one half this variation. Simulations with this reduced accuracy is now underway and will be reported on in the next progress report.

Redirection was received to close out this water quality signature effort on the Washington/Potomac test area as soon as possible and to return to the Harrisburg test area. This redirection

will be acted on early in the next reporting period after MITRE has confirmed that the two above corrective actions have removed the striping seen in the Washington/Potomac scene.

- Also reviewed at the June 25 GSFC meeting was MITRE's progress in air quality. Discussion centered around (1) the efforts of the recent rains on the air quality test site average greyness and (2) of the reasons for our extrapolating NOAA turbidity network data to Harrisburg from sites outside the state. Per your redirections MITRE will curtail its method of mesoscale air quality analysis until the land use and water quality analyses have been completed.

- During the time in which MITRE has been waiting for improved (striping removed) tapes, over two months, MITRE entered into a period of reviewing all imagery in hand for various point sources in air, land and water. The target areas selected for review are those listed in Figure 2, Page 2-11 of our first Type II Interim Report dated February 1973. All target areas reviewed are in the greater Harrisburg test site, Site Number 1. The images reviewed were as follows:

1 August 1972	1009-15241
6 September 1972	1045-15243
11 October 1972	1080-15185
16 November 1972	1116-15192
9 January 1973	1170-15191
10 January 1973	1171-15245
23 March 1973	1243-15260
9 April 1973	1260-15195

The target areas reviewed were as follows:

Holtwood Dam Lake
Conowingo Dam
Safe Harbor Lake
*Codorus Creek Lake
Brunner Island Effluent
Conewago Creek Mouth
Lime Kiln At Annville
*Harrisburg
*Susquehanna River - Sunbury to Maryland
Lancaster
York
*Swatara Creek Mouth
Conestoga Creek Mouth
*Juniata River Mouth
*Three Mile Island

However, only the October, November, January 10 and April images included all targets. The remaining dates cover those designated by asterisks (*) above.

Targets which appeared to have content and will be examined more closely are as follows:

(1) Water quality gradations above the Conowingo Dam in October

(2) Smoke plume extending over the Susquehanna River from the Brunner Island Power Plant for October only

(3) Susquehanna River Water gradations for October, March and April

(4) Several small turbid areas seen at the mouth of merging tributaries into the Susquehanna

None of the other targets appeared to have peculiar properties or content.

E. SIGNIFICANT RESULTS:

None for this period.

F. PROBLEMS:

Delay in the production of CCT's with striping removed as slowed our water and land use analysis. Improved tapes for the October 11 Harrisburg and Washington scenes arrived but were found to contain striping and were returned to GSFC. The second set of improved tapes arrived and are being used at the present time. The lack of screening on specially handled products such as these caused us approximately 30 days delay on top of waiting for the improved tape the first go round. A second set of tapes (1170-15185) were received and found to contain garbled header information and were also returned to GSFC. These data also had not been screened at GSFC and caused several weeks delay in viewing the Harrisburg test site.

G. RECOMMENDATION FOR TECHNICAL CHANGES:

Suggest that a screening of CCT's be made in order to alleviate the problems discussed in Section F above.

H. ADEQUACY OF FUNDING:

As the statistics grow on the costs of digital computer analysis of each scene, it is becoming apparent that the funds available are inadequate. A separate report will be generated in July which will detail the funding to perform the tests proposed in the DAP.

I. CHANGES TO STANDING ORDER FOR DATA:

Change in standing order such that the four MSS images and the CCT's which pass MITRE criteria was requested and accepted during the period by the cognizant Technical Officer.

J. PUBLICATIONS IN THE REPORTING PERIOD:

None.

K. WORK PLANNED FOR NEXT REPORTING PERIOD:

- Complete the review of the improved CCT's (striping removed) for October 11, 1973 scene for the Potomac River reach. Move the water quality test area of analysis next to the mouth of the Susquehanna and begin signature development from the mouth up the river past Harrisburg up to as far as Sunbury.

- Review the land use analyses report in Appendix A to see if improved CCT's will improve the signature quality developed to date for this scene.

- Start the land use classification for a new date for the greater Harrisburg area.

- Reinitiate the land use analyses in the Wilkes-Barre/Scranton area for strip mines as discussed in the April 30 Type I Progress Report. This strip mine analysis had been tabled when

it was determined that the striping existing in the October 11 Washington scene existed in the Wilkes-Barre/Scranton area scene also.

Sincerely,

Edward A. Ward
Principal Investigator

Robert Ouellette for
R. P. Ouellette
Department Head
Environmental Systems Department

PRO/EAW/sdh

cc: (1) Mr. Michael Ciufolo
ERTS Contracting Office
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APPENDIX A

PROGRESS REPORT ON LAND USE ANALYSIS IN THE HARRISBURG, PENNSYLVANIA AREA AS OF JUNE 1973

MITRE's first Type II Report was submitted to NASA on 22 March 1973. That report covered the progress during the first six months of MITRE's efforts on the current ERTS-1 investigation of air quality, water quality, and land use indices through Phase I (Data Analysis Preparation) and Phase II (Preliminary Data Analysis). This progress report describes the results of the land use analysis effort thus far in Phase III (Continuing Data Analysis) during April and May 1973.

By the time the Type II Report was submitted, the data analysis plan for developing land use indices had been formalized, and preliminary operational analysis was underway. Very briefly, the land use data analysis plan calls for a complementary, reiterative process of (1) digital analysis of ERTS MSS data, (2) photo-interpretation of ERTS imagery and available aircraft photography, and (3) verification with existing ground truth in the form of local maps and studies (see Figure I). The objective of the complementary analysis is the optimum ERTS signature definition of land use categories in the test area. Once the ERTS land use category signatures have been derived and thematic digital maps and statistics generated, these are compared to "known" land use data to test the applicability of ERTS data for timely land use analysis.

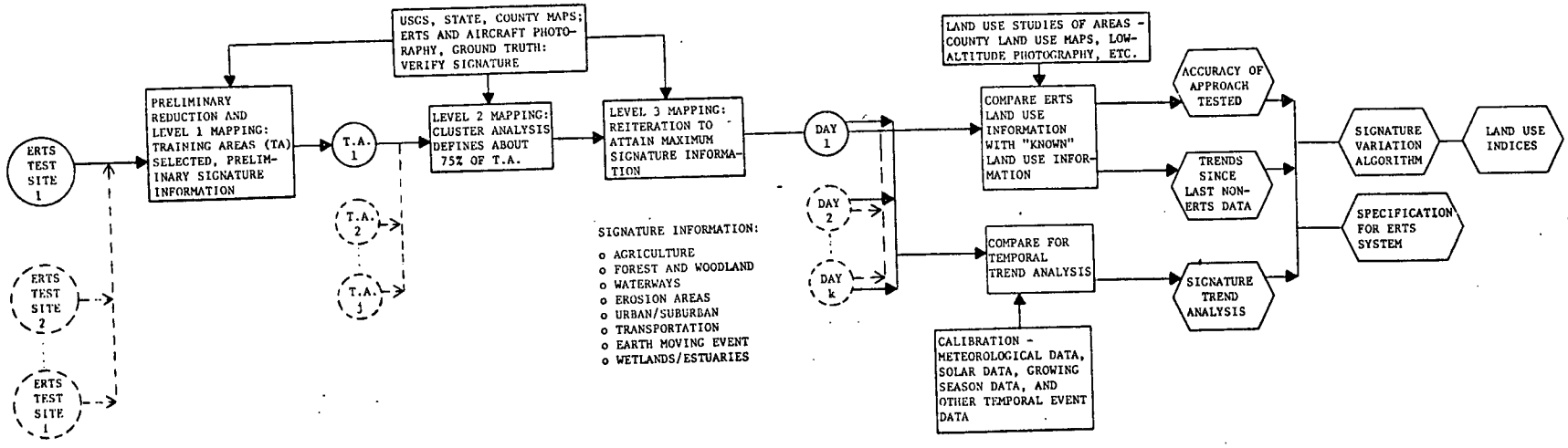

FIGURE 1

ERTS-1 DATA ANALYSIS PLAN: LAND USE

The present stage of MITRE's analysis is comparison of the first results of ERTS-derived land use categories by amount and distribution, with the results of the most recent (1967) land use study results from the Tri-County Regional Planning Commission at Harrisburg, Pennsylvania for Cumberland, Perry, and Dauphin Counties. Initially, MITRE has developed signatures for the following ten major land use categories in the test area:

- River
- Creek
- Forest
- Denuded Land
- Quarry
- Transportation
- Agriculture (three distinct types)
- Suburban Residential (three distinct densities)
- Urban Residential and Commercial
- Industrial
    - -- Parking Lots
    - -- Bare Concrete
    - -- Depots
    - -- Industrial Operations

The nine major categories into which the Tri-County Regional Planning Commission defines urban land use, because of the use to which the information is put, are somewhat more administrative in nature. The nine categories are as follows:

- Residential
- Industrial
- Transportation Terminals
- Transportation Facilities
- Retail
- Wholesale and Storage
- Services
- Public and Semi-Public
- Vacant

Clearly, the first task in an attempt to compare the ERTS land use data with the ground truth data is to define common categories. Since a good deal of the data required by a planning commission (e.g., the categories Services and Public and Semi-Public land) can at present be determined only by means such as building permits, tax records, and surveys, a way had to be found to combine these areas into a category that could be identified in ERTS data. Conversely, if a planning commission were only interested land use in populated areas and all else were to be classified as "Vacant", then the ERTS categories of forest, field, agriculture, etc., would have to be merged.

For the preliminary comparison attempt, MITRE is combining categories according to Table I .

This is the preliminary cut at defining comparable categories. Continued consultation with the state and regional planners will allow for a finer definition of categories that are both identifiable in

TABLE I

MERGED URBAN LAND USE CATEGORIES FOR COMPARISON PURPOSES

	ERTS-1 CATEGORY	PLANNING COMMISSION CATEGORY
1.	Industrial (4 sub-categories)	1. Industrial
2.	Transportation	2. Transportation Terminals; Transportation Facilities
3.	Forest; Quarry; Field; Agriculture; Denuded Area	3. Vacant
4.	Suburb (3 sub-categories)	4. Residential
5.	Urban	5. Retail; Wholesale and Storage; Services; Public and Semi-Public

ERTS data and useful for urban planning. At the present stage of the ERTS-1 investigation, however, the preliminary oommon categories have been accepted sufficiently valid to verify ERTS results and identify areas where further experimentation is needed.

Once the preliminary common categories were defined, the next step was to outline common geographical areas for comparison. The method employed was as follows:

First, after computer analysis of ERTS data covering the Harrisburg area had been completed, a large digital map was generated for the overflight of 11 October 1972. The map showed symbols for all the various land use categories, and was at approximately the same scale (1 inch = 2000 feet) as the Planning Commission maps.

The next step was to project the township and city political boundaries onto the computer-generated land use map. This was made difficult by several distortions inherent in computer mapping, but the distortions were corrected for and the boundaries were successfully transferred to the ERTS land use map. With townships outlined, it was then possible to compare Planning Commission land use tabulations by township with what was being observed by ERTS.

The final step, the one MITRE is currently in the process of completing, is a tabulation of the ERTS-derived land use symbols for each township, and then a comparison of these figures with the land use tabulations prepared by the Tri-County Regional Planning Commission. While this final step is just now in progress, some of the initial.

results are encouraging. The city of Harrisburg for example, has just been completed, with the following results:

CATEGORY	ERTS%	TRC%	% DIFFERENCE
Transportation	8.7	9.4	0.7
Vacant	27.6	23.2	4.4
Residential	29.1	32.2	3.1
Industrial	25.2	3.9	21.3
Commerical	9.1	31.4	22.3

Refinements and, calibration, and verification of trends in land use since 1967 are confidently expected to bring ERTS analysis of the first three categories precisely into line. For the last two categories, the problem is apparently one of input category definition. Before the land use analysis can be completed, a way must be developed to differentiate more distinctly between small industries and large commerical or storage enterprises.

All of the data currently available for the on-going analysis is presented in the following tables. Table II presents the Tri-County Planning Commission 1967 land use acreage data for those townships within the ERTS test area. Table III shows the actual count of ERTS-derived category symbols in the test area from the digital thematic map. Percentages of land use were calculated from these two tables and the results are shown in Table IV, a comparison of percentages by merged categories.

CONCLUSIONS

ERTS-1 urban land use signature derivation techniques will need to be refined in all areas before ERTS becomes a truly useful tool for

regional planners. However, given the unavoidable crudity of 1967 data and experimental nature of the investigation approach to date, some very promising correlations do appear in the preliminary results. The residential, transportation, and vacant categories are reasonably close to most cases. A large discrepancy exists between ERTS data and Planning Commission data in the industrial and commercial/urban categories, however. The ERTS data shows consistently higher percentages of industrial land use, and consistently lower percentages of commercial/urban use. The training area used for industrial category signature identification was Steelton, which was known to have the largest amount of industry in the test area. As Table IV shows, the 1967 data showed Steelton was 29.6 percent industrial, while ERTS data shows a strikingly close 30.4 percent. Preliminary examination suggests that the industrial signatures are not sufficiently defined and repeatable, so that when ERTS data analysis moves from Steelton to other sections of the test area, other targets show up as industrial. Since the commercial/urban discrepancy is generally in the opposite direction and magnitude, it would appear that some urban concentrations and large commerical operations are appearing as industry in ERTS results; all of which could not be explained by land use change between 1967 and 1972.

Efforts are presently underway to tighten the industrial signature definition so that it will be unique to the category commonly regarded as industrial. Should these efforts be unsuccessful, an alternative approach will be to adjust the scope and definition of the categories

to fit the capability of the ERTS-1 data. As urban land use analysis proceeds through Phase III, several variations and combinations of the two basic approaches will be used in order to perfect the information that can be made available by ERTS-1.

TABLE II

SUMMARY OF 1969 LAND USE (ACRES) COMPILED
BY THE TRI-COUNTY REGIONAL PLANNING COMMISSION

Cumberland County Municipality	Residential 0	Industrial 1	Transportation Terminals 2	Transportation Facilities Land 3	Retail 4	Wholesale & Storage 5	Services 6	Public & Semi-Public Land 7	Vacant 8	Total
Camp Hill	680.50	8.10	4.40	4.54	49.53	27.06	10.66	79.43	147.14	1,011.36
East Pennsboro	1,498.40	74.21	263.28	10.19	12.62	---	9.43	504.84	2,209.19	4,582.16
Harrisburg	1,135.55	136.44	199.22	129.36	244.28	74.74	76.79	713.49	817.42	3,527.29
Highspire	169.75	.61	2.23	1.35	25.47	.40	2.50	9.16	153.79	365.26
Hummelstown	291.07	3.07	83.30	2.54	45.54	3.20	4.17	74.55	364.09	871.53
Lemoyne	289.71	43.47	4.74	34.40	43.74	23.08	16.39	21.73	224.87	702.13
Lower Allen	1,469.07	41.27	7.90	79.74	58.10	64.47	5.18	876.75	3,019.54	5,622.02
Lower Swatara	608.78	.10	83.93	343.51	30.77	1.60	3.04	979.39	3,911.04	5,962.16
Middletown	531.95	1.85	74.85	7.58	26.61	29.39	5.73	262.14	106.58	1,046.68
New Cumberland	603.80	7.79	9.66	3.14	7.66	.74	4.96	52.78	159.54	850.07
Paxtang	95.63	3.30	.37	1.91	2.29	---	6.05	43.83	29.66	183.04
Penbrook	149.88	1.74	---	1.25	9.41	9.92	5.06	46.56	10.35	234.17
Royalton	50.69	---	---	.65	1.11	---	.11	3.47	137.70	193.73
Shiremanstown	109.41	.09	---	4.91	1.12	.40	1.55	6.95	14.89	139.32
Steelton	188.90	208.71	13.94	15.59	17.39	.77	7.65	17.49	233.75	704.19
Swatara	1,897.51	87.47	112.60	633.36	98.28	300.10	52.40	348.35	3,700.96	7,231.03
West Fairview	76.92	---	---	.28	3.18	---	1.13	2.70	30.78	114.99
Wormleysburg	142.61	8.00	.08	.91	4.32	---	1.89	5.14	60.37	223.32
TOTAL SELECTED AREA	9,990.13	626.22	860.5	1,275.21	681.42	535.87	214.69	4,048.75	15,331.66	33,574.45

TABLE III

COUNT OF ERTS-1 CATEGORY SYMBOLS
IN HARRISBURG TEST AREA

AREA \ CATEGORY	Forest	Suburban	Agriculture	Quarry	Trans-portation	Fields	Bare Area	Industrial	Urban	TOTAL
Camp Hill	108	670	234	---	11	118	25	93	2	1,261
E. Pensboro	2,230	1,837	770	---	170	670	101	185	33	5,996
Harrisburg	334	1,300	167	1	390	679	54	1,125	405	4,455
Highspire	6	170	27	---	7	87	4	75	15	391
Hummelstown	116	315	108	---	3	173	23	46	7	791
Lemoyne	230	307	73	---	13	148	11	133	15	930
Lower Allen	1,174	2,080	903	9	62	849	233	175	14	5,499
Lower Swatara	1,263	2,349	1,376	11	147	1,389	431	340	25	7,331
Middletown	47	432	74	---	15	199	22	129	32	950
New Cumberland	161	519	136	---	1	119	7	34	1	978
Paxtang	44	97	41	---	---	42	---	14	1	239
Penbrook	14	143	20	---	---	52	3	21	2	255
Royalton	23	77	19	---	2	40	4	6	5	176
Shiremanstown	12	93	22	---	1	17	1	3	--	149
Steelton	41	214	30	---	70	145	3	292	89	884
Swatara	1,368	2,590	1,071	---	141	1,300	318	563	3	7,354
W. Fairview	26	52	7	---	2	37	---	10	4	138
Wormleysburg	54	222	39	---	16	58	14	14	5	422
TOTAL	7,251	13,467	5,117	21	1051	6,122	1,254	3,258	658	38,199

TABLE IV

COMPARISON OF TRI-COUNTY REGIONAL PLANNING

COMMISSION (TRC) URBAN LAND USE DATA

WITH MITRE'S ERTS - DERIVED DATA

TRC CATEGORY(IES)	1		2		3		4		5	
	INDUSTRIAL		TRANSPORTATION: TERMINALS AND FACILITIES		VACANT % of PUBLIC - SEMI-PUBLIC		RESIDENTIAL		RETAIL; WHOLESALE STORAGE; SERVICES; % of PUBLIC AND SEMI-PUBLIC	
ERTS CATEGORY(IES)	INDUSTRIAL (4 SUB-CATEGORIES)		TRANSPORTATION: RUNWAYS AND RAILROADS		FOREST; QUARRY; DENUDED AREA: AGRICULTURE; FIELD		SUBURB (THREE SUBCATEGORIES); % of URBAN		% of URBAN	% of SUBURBAN
POLITICAL SUBDIVISION	PERCENT OF AREA (TRC)	PERCENT OF AREA (ERTS)	PERCENT OF AREA (TRC)	PERCENT OF AREA (ERTS)	PERCENT OF AREA (TRC)	PERCENT OF AREA (ERTS)	PERCENT OF AREA (TRC)	PERCENT OF AREA (ERTS)	PERCENT OF AREA (TRC)	PERCENT OF AREA (ERTS)
HARRISBURG	3.9	25.2	9.4	8.7	23.2	27.6	32.2	29.1	31.4	9.1
HIGHSPIRE	0.2	19.2	1.0	1.8	42.1	31.7	46.5	43.5	10.3	3.8
HUMMELSTOWN	0.4	5.7	9.9	0.3	41.8	52.8	31.4	39.6	14.7	0.8
LOWER SWATARA	-0-	4.6	7.2	2.0	65.6	60.8	10.2	32.0	17.0	0.3
MIDDLETOWN	0.2	13.5	7.9	1.6	10.2	35.9	50.8	45.3	30.8	3.4
PAXTANG	1.8	5.8	1.2	-0-	16.2	53.1	52.2	40.6	29.5	0.4
PENBROOK	0.7	8.2	0.5	-0-	4.2	34.8	64.0	55.8	30.5	0.8
ROYALTON	-0-	3.4	0.3	1.1	71.1	48.8	26.2	43.7	2.5	2.8
STEELTON	29.6	30.4	4.2	7.3	33.2	22.8	26.8	22.3	6.2	9.3
SWATARA	1.2	7.6	10.4	1.9	51.2	54.6	26.2	34.8	11.1	0.0
CAMP HILL	0.8	7.2	0.8	0.7	14.5	38.1	67.3	52.9	16.6	0.1
EAST PENNSBORO	1.6	3.1	5.9	2.8	48.2	62.9	32.7	30.6	11.5	0.5
LEMOYNE	6.2	14.2	5.6	1.3	32.0	49.4	41.3	32.8	14.9	1.6
LOWER ALLEN	0.7	3.1	1.5	1.0	53.7	57.3	26.1	37.6	17.8	0.2
NEW CUMBERLAND	0.9	3.4	1.5	0.1	18.8	43.0	71.0	53.0	7.8	0.1
SHIREMANSTOWN	0.1	2.0	3.5	0.7	10.7	34.7	78.5	62.0	7.2	-0-
WEST FAIRVIEW	-0-	7.2	-0-	1.4	26.8	50.6	66.9	37.6	6.1	2.8
WORMLEYSBURG	3.4	3.2	0.4	3.7	25.8	38.8	63.9	52.4	5.1	1.1
TOTAL HARRISBURG METROPOLITAN AREA	1.9	8.5	6.4	2.8	57.7	51.7	29.8	35.3	4.3	1.7

APPENDIX B

WATER QUALITY PROGRESS REPORT IN THE POTOMAC REACH

MITRE's training area for the identification of water quality parameters is centered along the Potomac River. The ERTS-1 imagery for 11 October 1972 shows a large plume of turbid water from the Washington area to south of Quantico, Virginia. Also visible are several gradations of water caused by merging streams. Since both of these conditions are easily recognized it was felt that water classification of this area could be done with minimum time and effort.

The first intensity map (an overall reflectance or gray scale map) of the area showed several types of water within the boundaries of the Potomac, especially around Quantico, and was chosen as the test site for developing signatures of water quality. A cluster analysis was run using a sample size of 150 pixels and a critical distance of 4.5. The resulting map, Figure 1, displays the levels of turbidity from IV, high turbidity, to I, clearest water.

With the success that was encountered at Quantico it was decided to investigate other areas along the Potomac where the plume can be seen in the imagery. In particular the following were selected:

	RM
Popes Creek	42.0
Cedar Point	49.0
Maryland Point	56.4
Clifton Beach	61.7

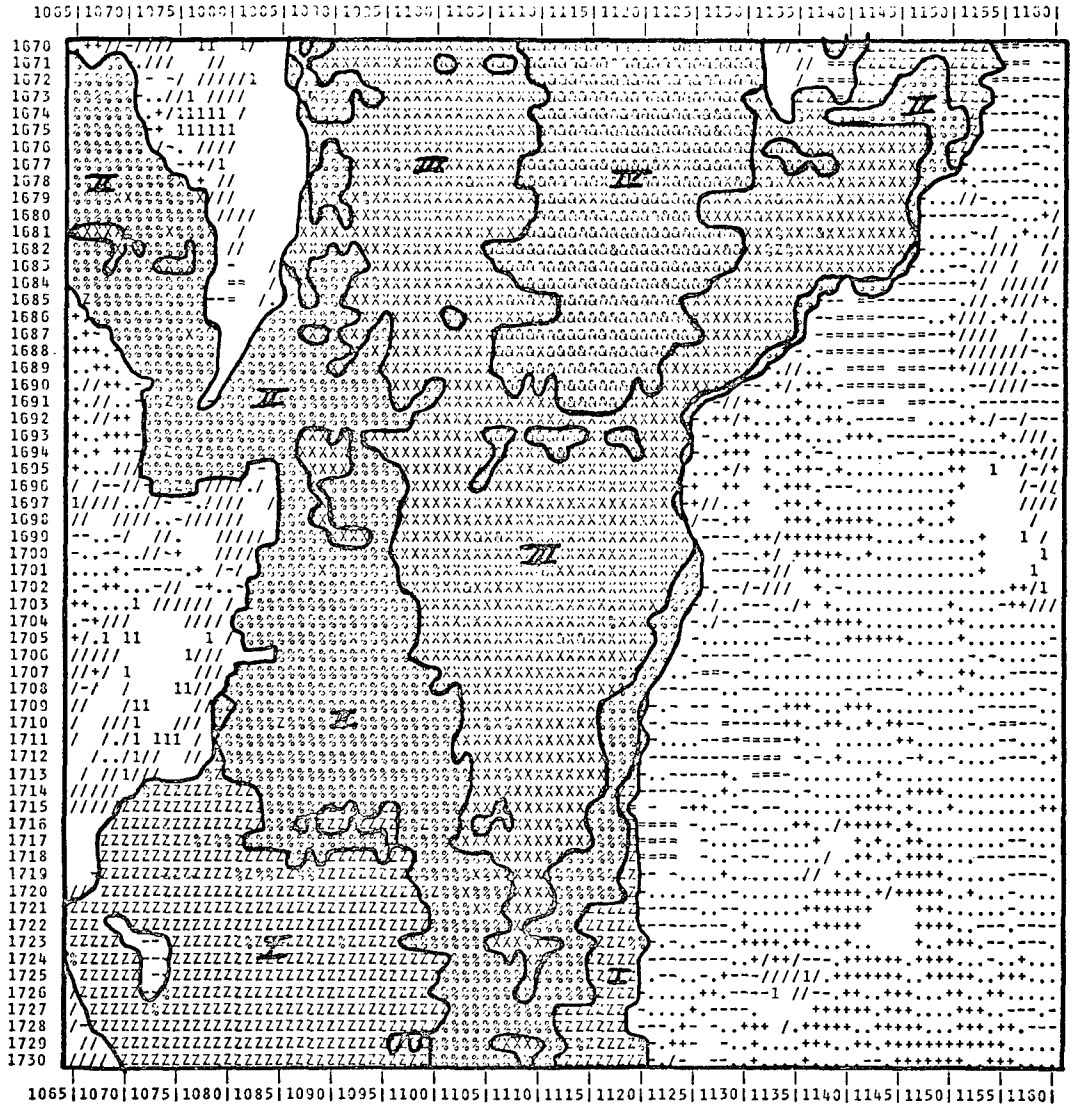

FIGURE 1

ERTS WATER QUALITY CATEGORIES

I - Clear Water

II - Low Turbidity

III - Moderate Turbidity

IV - High Turbidity

Quantico	67.5
Mason Neck	79.0
Fort Hunt	86.0
Wilson Bridge	90.8
Hains Point	94.7

Using a supervised classification program, MITRE used the signatures from the Quantico analysis and applied them to Clifton Beach and Maryland Point. At both points however only a single water category could be identified. Since this contradicted what could be seen from the images, it was decided to change the limiting parameters of the cluster analysis of Quantico and develop new signatures.

With the critical distance reduced to 1.0 and the sample size expanded to include 900 pixels, six categories of water were identified. Figure 2 shows the breakdown with VI representing the most turbid, decreasing to I which is again the clearest water. Despite this refinement of the signatures, the application to Clifton Beach and Maryland Point still resulted in the classification of just one water category.

The next attempt to overcome the problem was to vary the MSS channels that would supply input for the programs. It is generally held that channels 4 and 5 are better for water investigation. So a cluster analysis for Quantico was run for channel 4 alone and for channels 4 and 5. The results when applied to Clifton Beach were the same as above.

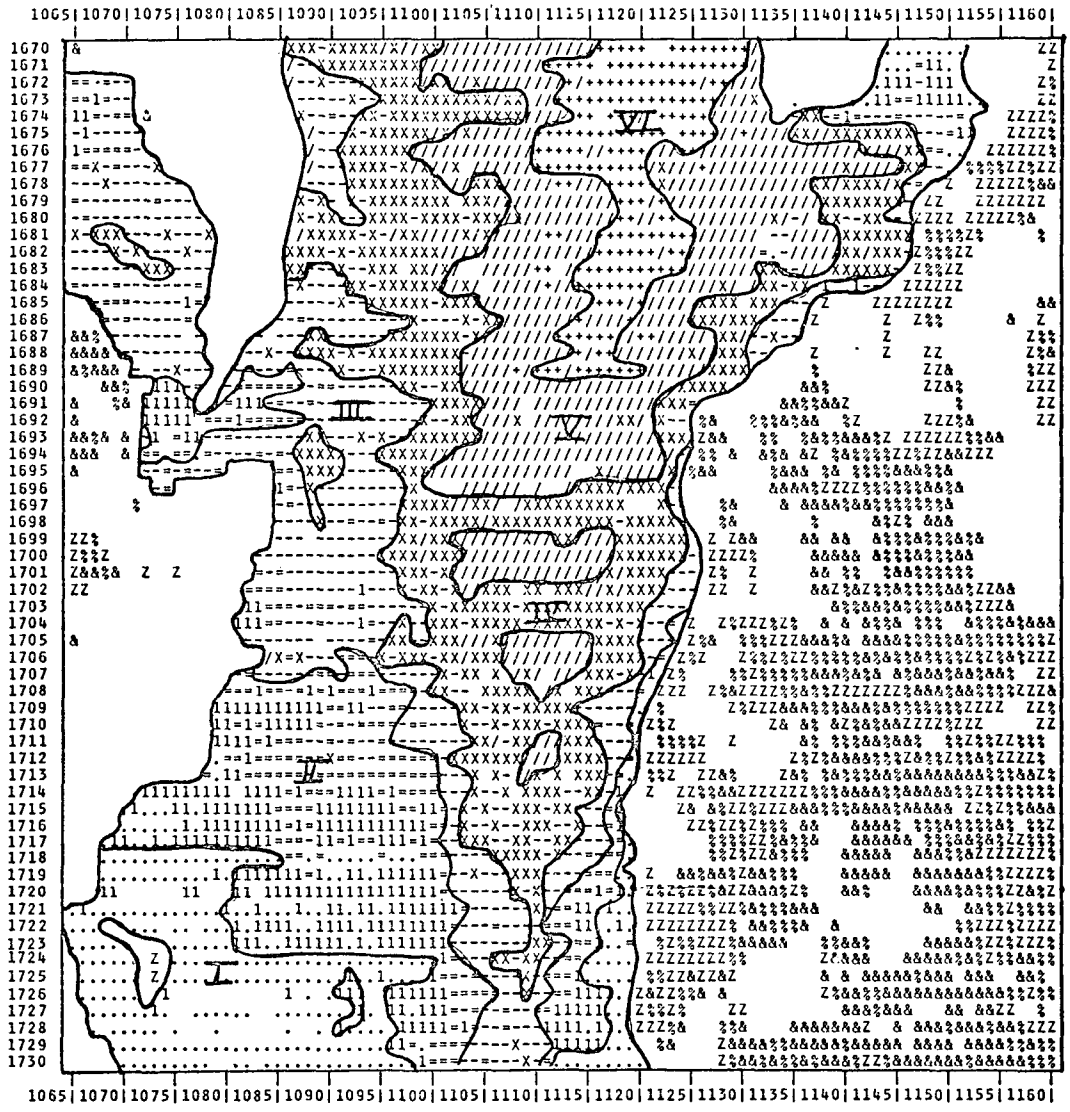

FIGURE 2

ERTS WATER QUALITY CATEGORIES

I	Clear Water	IV	Moderate Turbidity
II	Low Turbidity I	V	High Turbidity I
III	Low Turbidity II	VI	High Turbidity II

At this point the image was rechecked at Clifton Beach as was the original 4-channel intensity map of the Potomac scene. It was found that the gradations of water seen on the image were evident on the intensity map at Quantico but not at Clifton Beach. Therefore, separate MSS channel intensity maps of Clifton Beach were run to see if the turbidity would show up in the smaller population. Figures 3 and 4 are MSS channels 4 and 6 respectively.

Analysis of these maps showed no vertical turbidity pattern, rather a horizontal six line pattern. A closer study of the maps pointed to the possibility that the poor data was due to banding. A cross-check with the images, this time looking specifically for banding, proved this to be quite evident in each channel and throughout each image. Since the north-south banding intensity changes were of the same order as the turbidity in the east-west direction the banding had to be eliminated.

In order to overcome the problem, MITRE discarded the suspected lines using the separate channel intensity maps (those indicated by ● in Figures 3 and 4). The intensity program was then rerun on the reduced population. This produced a small improvement in the map with two categories of water being identified. However the improvement was overshadowed by the fact that 60% of the population had been eliminated. This method, therefore, proved to be completely impractical.

At this point a check with NDPF User Services caused the problem to be referred to Mr. Robert Feinberg. Mr. Feinberg had knowledge

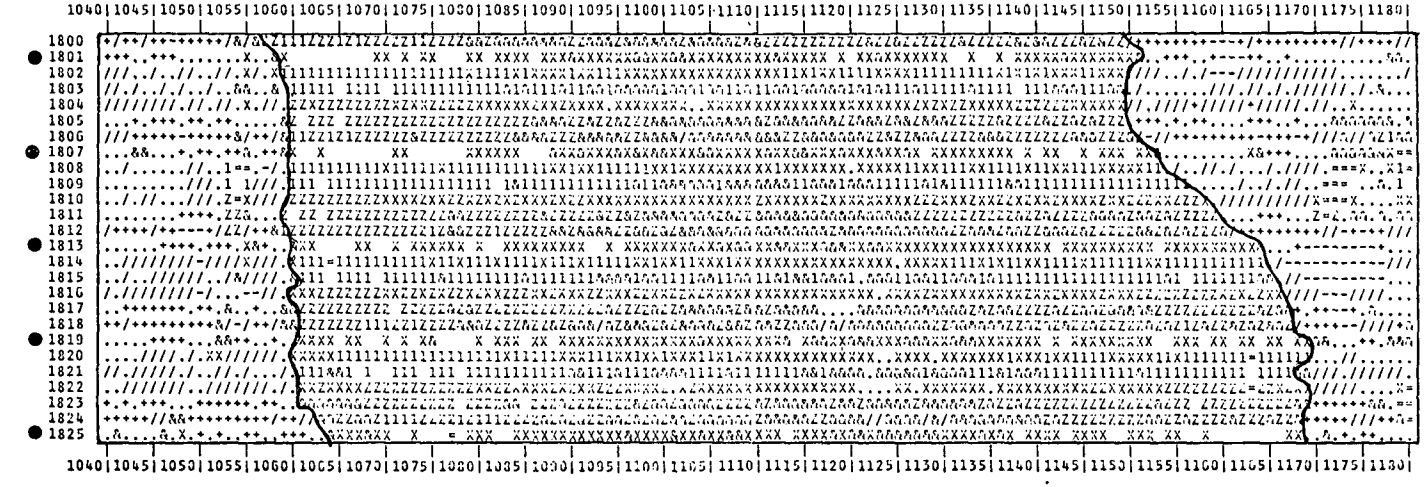

FIGURE 3

MSS CHANNEL 4 - CLIFTON BEACH
INTENSITY MAP WITH BANDING

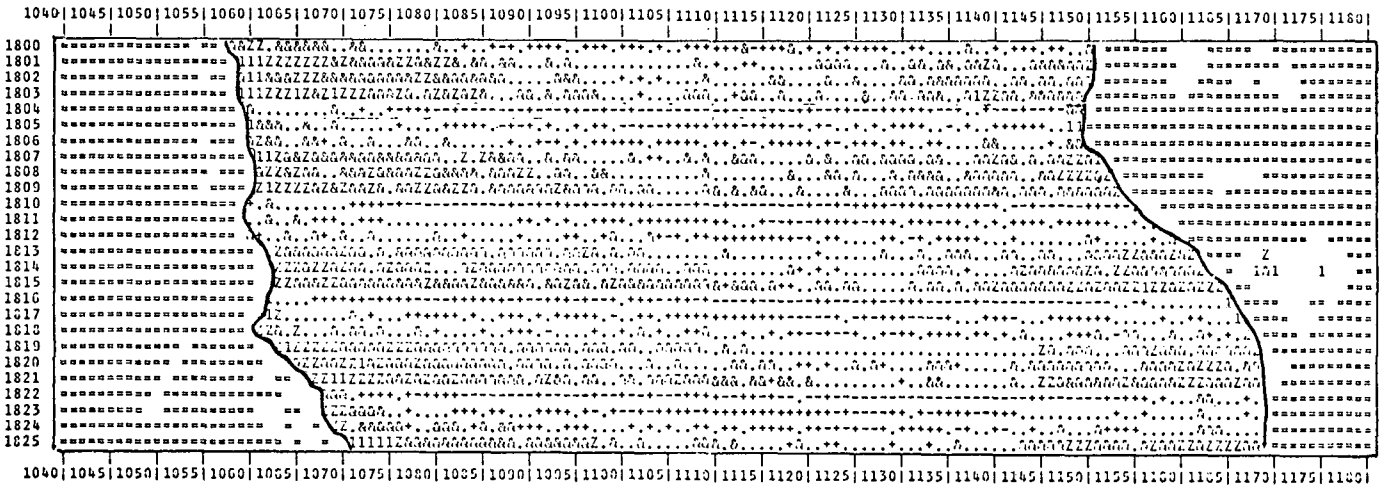

FIGURE 4

MSS CHANNEL 6 - CLIFTON BEACH
INTENSITY MAP WITH BANDING

of software that was being developed to correct the banding and he agreed to have MITRE's tapes reprocessed. It was decided to have both the Potomac scene (1080-15192) and the Harrisburg, Pennsylvania area (1080-15185) redone, the latter being our prime test area for water quality and land use.

While the reprocessing was being done it was decided to run separate MSS channel intensity maps of Quantico. The purpose was to develop signatures, from the reduced population, which could be compared with signatures from the tapes with banding and the corrected tapes. However, the same problem that arose with Clifton Beach was encountered, that is, losing too much of the population for the results to be considered worthwhile.

Since all efforts to circumvent the banding problem have produced no usable results, the only solution seems to be the corrected tapes. These are extremely necessary if the full capabilities of ERTS-1 for water investigation are to be explored.