LARS Information Note 122475

HIGHWAY ROUTE LOCATION UTILIZING REMOTE SENSING TECHNIQUES, FT. WAYNE, INDIANA

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1975

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ABSTRACT

Analysis of remotely sensed data from northeastern Ft. Wayne, Allen County, Indiana, provided evaluations of several route corridors for the Indiana Highway Commission currently planning a dual-lane by-pass around the city. Computer-assisted classification of LANDSAT imagery (June 8, 1973) was supplemented by the county engineering soils and agricultural soils maps, plus 9" x 9" aerial photography used as ground-based data.

Classification of the LANDSAT imagery did contribute positively to the selection of corridors. The growth pattern of the city in the past few years became readily apparent through the processing of the data. Poorly drained areas containing a significant amount of organic soil were detected which were not indicated on the available surface-materials maps. In addition, the poorly drained soil areas were designated as one spectral class in the computer-assisted process which suggests that these widely spaced deposits possess some common properties. The overall analysis allowed for delineation of corridors beyond troublesome areas at an early stage in the planning process.

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*This work was supported by the National Aeronautics and Space Administration, Office of University Affairs, under Grant No. N6L 15-005-186.

+Presented at the Indiana Academy of Science 1975 meeting. To be published in Volume 84, 1976.

INTRODUCTION

Remote sensing involves the identification and classification of physical objects through analysis of measurements taken at a distance by sensing devices which do not come in direct contact with those objects. To be sure, aerial photography, which has been used for decades in a number of scientific fields, falls within this definition. However, in this study the instrument involved is a multispectral scanner (MSS) which measures radiation intensities from selected portions of the electromagnetic spectrum. Data obtained from this device is converted to digital format in order to facilitate machine processing using a high-speed digital computer. At the Laboratory for Applications of Remote Sensing (LARS), Purdue University, such machine processing is accomplished, using a variety of computer software developed there which yields a map or classification of surface materials. For a more detailed discussion on the LARS analysis technique related to highway studies, refer to the publication by West, 1972.(5)

The project described in the following discussion was performed in conjunction with the Indiana Highway Commission. Using the beginning and end points supplied by the Commission as control points, a preferred route corridor for a dual-lane, interstate quality, by-pass around the northeast quadrant of Ft. Wayne, Allen County, Indiana was recommended on the basis of remotely sensed data analyzed and machine processed at LARS.

METHODS

The established objective was to determine the utility of using MSS data for a route selection and, in particular, for the by-pass around the Ft. Wayne area. Although resolution is limited for satellite data, past experience has shown that in some instances much greater detail than anticipated can be obtained from it. By working in an area where good surface information is available for comparison, it can be ultimately determined whether the technique would be useful in areas where ground control is lacking.

The data analyzed consisted of 1) Skylab IV imagery taken January 25, 1974 and 2) LANDSAT imagery of June 8, 1973. For purposes of ground truth, the following were used: 1) 9" x 9" black & white aerial photography flown April 29, 1975, 2) the agricultural soils map of Allen County (2)*, 3) the engineering soils map of Allen County (3) and 4) the USGS 7½ minute topographic quadrangle maps for the area surrounding northeastern Ft. Wayne.

In Allen County, there are, as illustrated in Figure 1, four major landforms: 1) the Maumee Lake Plain, 2) the Wabash and Ft. Wayne ridge moraines, 3) a series of ground moraines and 4) the Wabash-Erie and Eel river channels and flood plains. In addition to a few minor physiographic features with limited significanca to the study, only two of the four major landforms were included in the area of study. The proposed route, if constructed, must originate in the Maumee Lake plain, cross

*Numbers in ( ) refer to the references listed at the end of this paper.

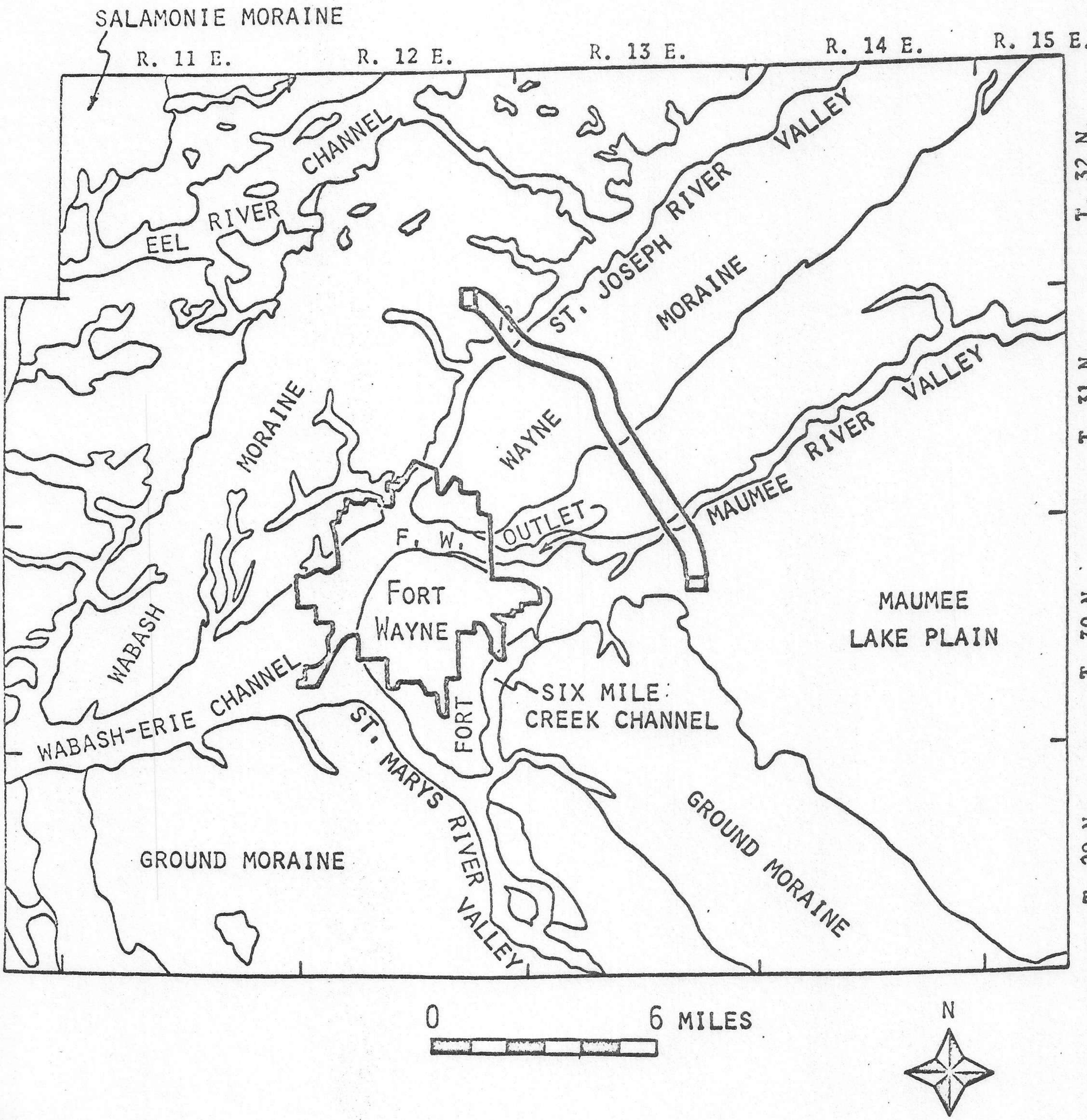

Figure 1. Landform map of Allen County, Indiana showing proposed corridor for dual-lane highway by-pass (base map after Bleuer and Moore (1)).

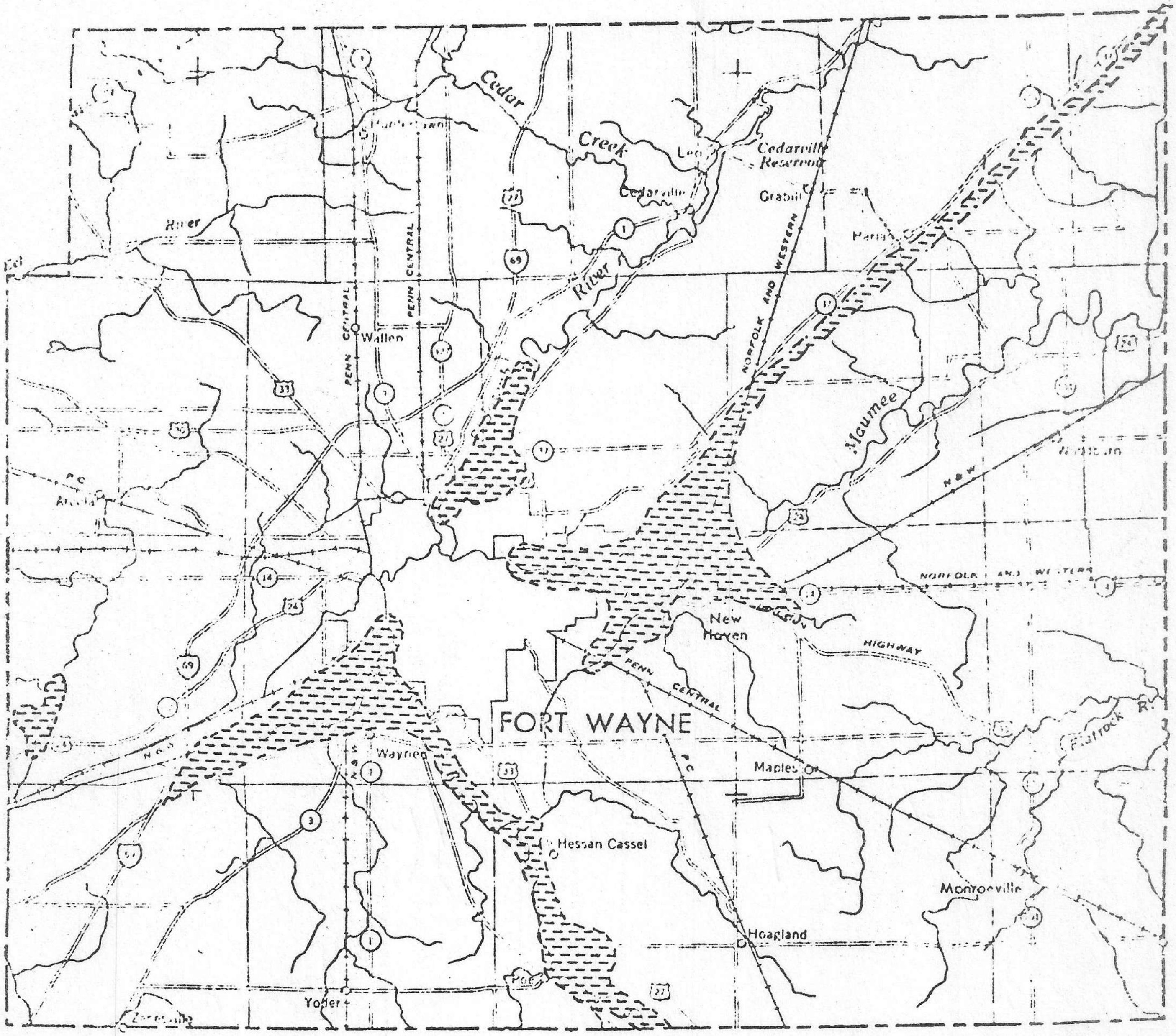

Figure 2. Map showing areas in which shallow excavation may encounter hard till of the Trafalgar Formation or silt of the Atherton Formation. Till may be thinly interlayered with sand and gravel, particularly in Wabash-Erie Channel and Fort Wayne Outlet areas.

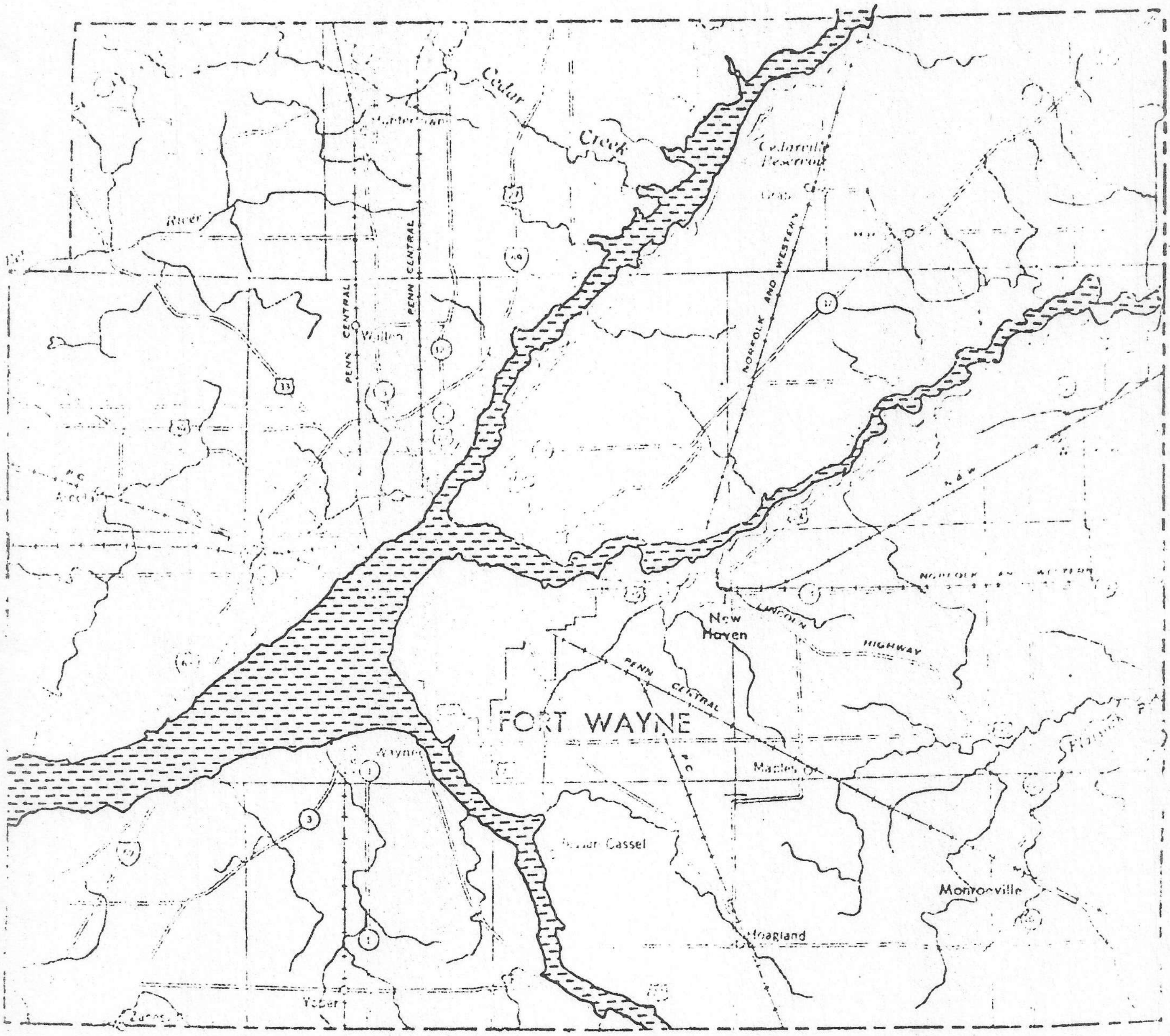

Figure 3. Map showing areas that may be underlain by runny wet sand that may require caissons or dewatering for excavation. Included are some areas of quick sand under high pore-water pressures.

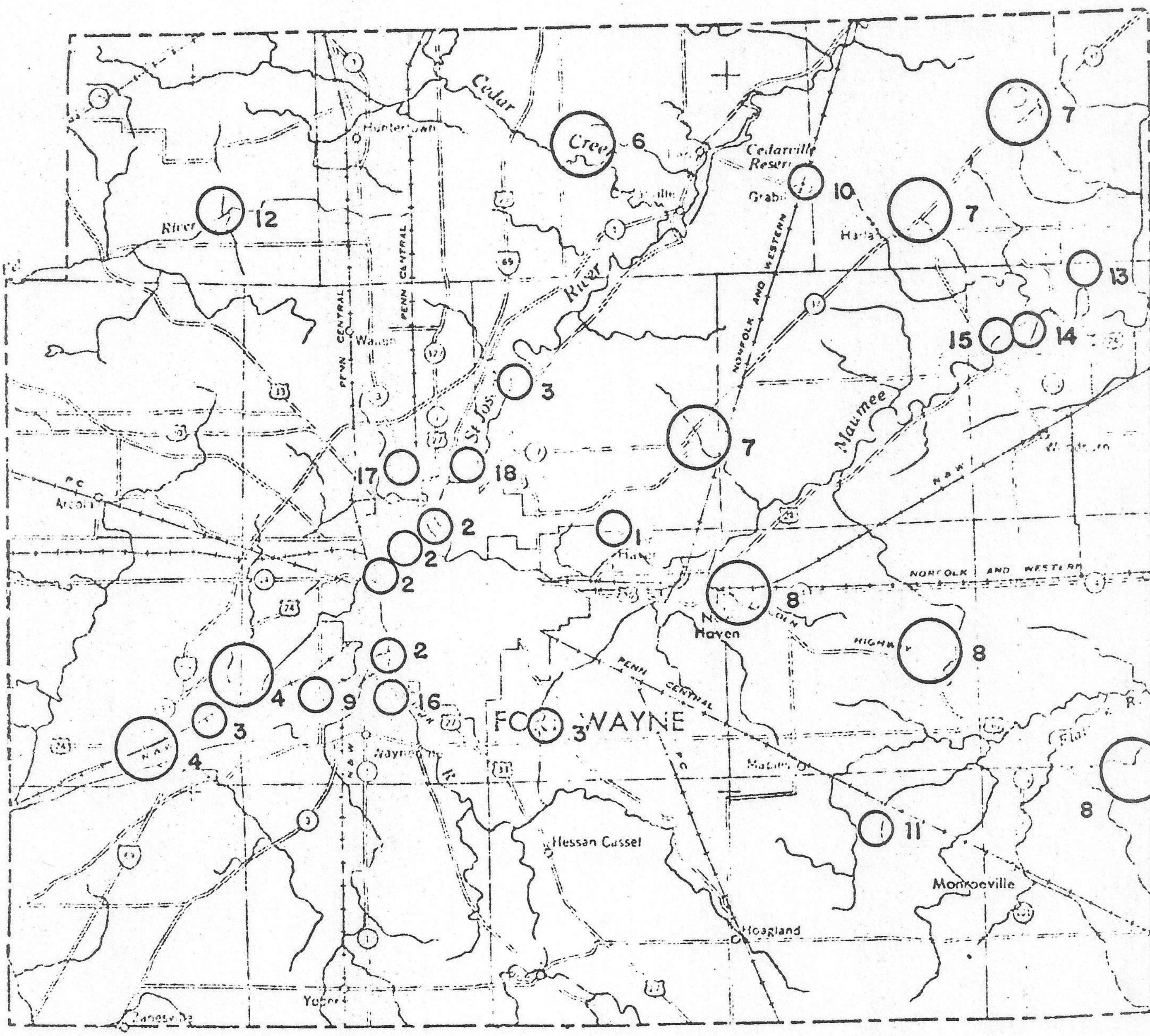

Figure 4. Map showing scenic or historic geologic sites.

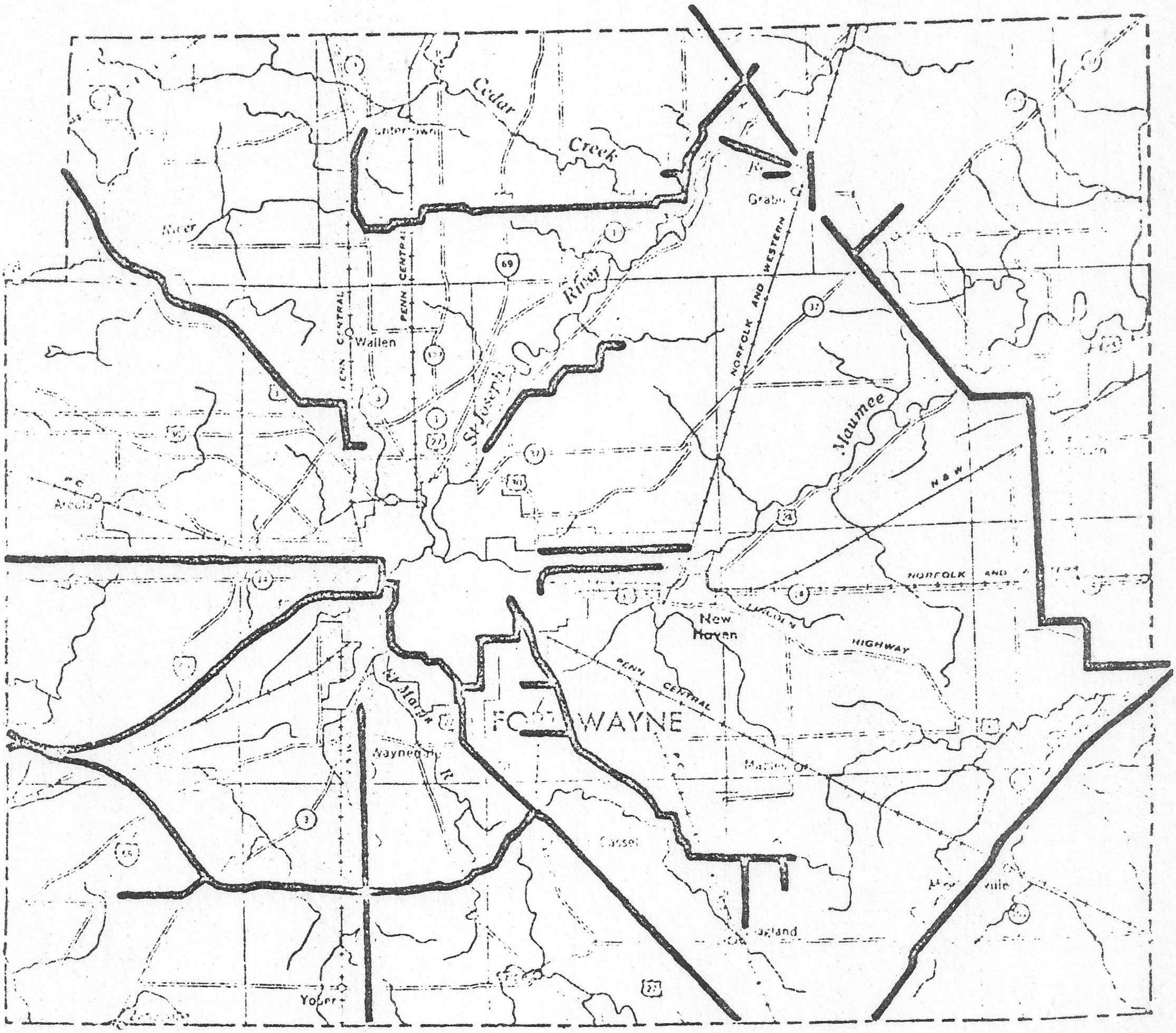

Figure 5. Map showing locations of natural gas pipelines.

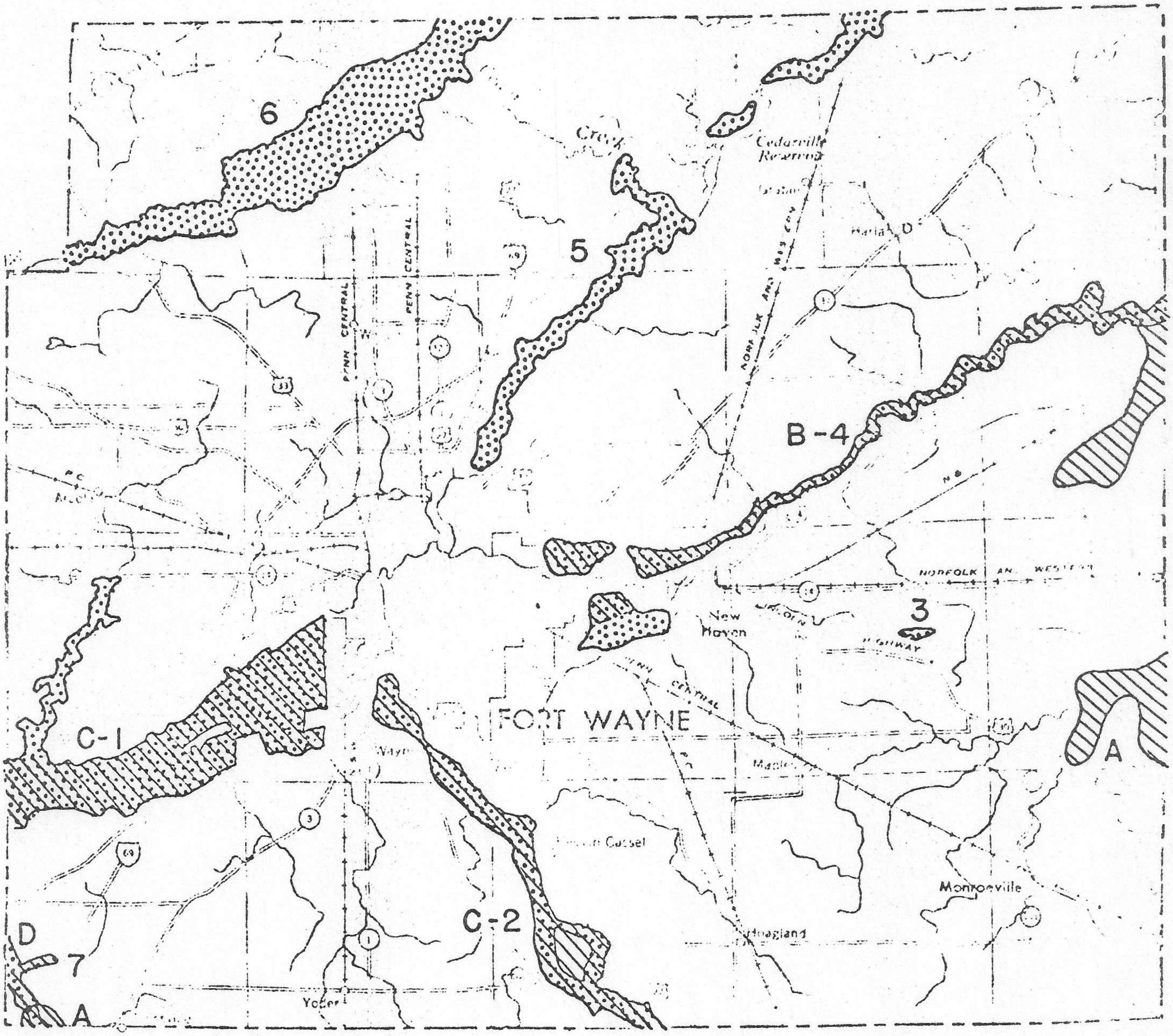

Figure 6. Map showing areas of potential quarry and sand and gravel pit development.

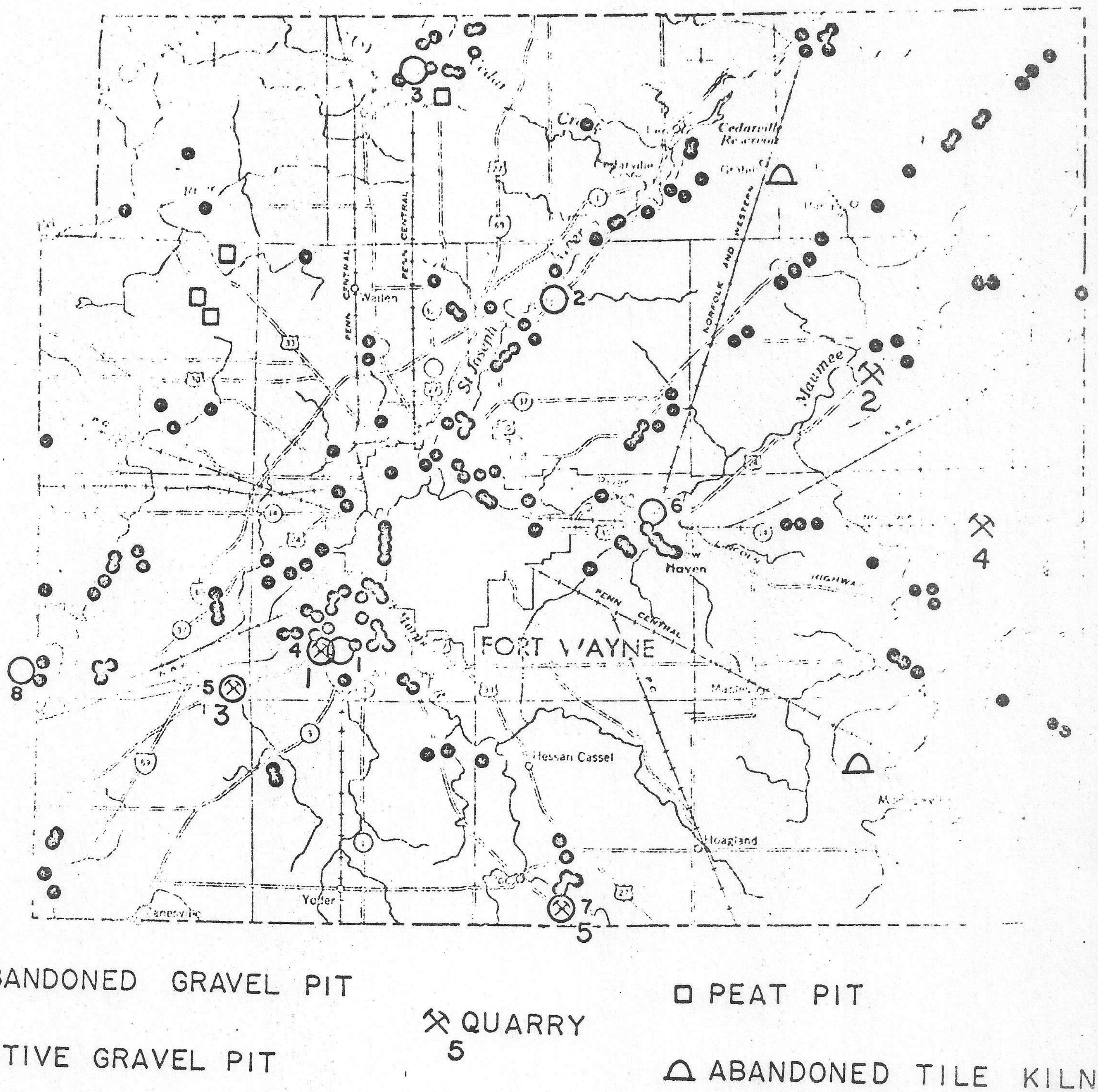

Figure 7. Map showing locations of abandoned and active gravel pits, stone quarries, peat pits, and abandoned tile kilns.

the Maumee River, cross the beach ridge which marks the contact between the Lake Plain and the St. Joseph River Valley to terminate in the Wabash moraine. The route would be required to cross these landforms regardless of the specific route configuration.

The physical parameters considered at the outset of the study were 1) soil properties and 2) optimum river crossings. Included in the right of way are locations where hard glacial till might be encountered in shallow excavations (Fig. 2) and others where wet, running sand, which could require dewatering, might be found (Fig. 3). (1)

Owing to the rapid growth of the Ft. Wayne area in the northeast direction, it became apparent that a route corridor selected only on the basis of soil conditions and river crossings would be inadequate. Additional factors considered were: 1) historic sites (Fig. 4), 2) pipelines located in the area (Fig. 5), 3) railroad crossings, 4) road crossings, 5) economic factors--including potential mineral sources such as possible quarry and sand and gravel pit development (Fig. 6) along with existing and abandoned gravel pits, stone quarries, peat pits and tile kilns (Fig. 7), and 6) urban growth. With these considerations added to the basic parameters, the data were analyzed to determine the utlity of this approach to highway siting.

A non-supervised classification was performed on the Skylab data. As the area under study consisted of two major landforms, the Maumee Lake plain to the southeast and the Ft. Wayne and Wabash ridge moraines in the northwest, it was subdivided into three portions, one for each of the prevalent zones and a third for the transitional zone around the beach ridge at the Lake plain - ridge moraine contact.

Each of the three zones was divided in half yielding six areas which could be individually clustered using every line and column of data. Unfortunately, the Skylab imagery was taken shortly after a period of heavy rains in the area. There was a large amount of local flooding, and it being winter time, large portions of the area under investigation were coated with ice and snow. Because of this and the coarse resolution of Skylab data, finding points of interest became an involved process. Gray scale printouts of light areas and the spots of snow on the photo imagery were matched and this information transferred to the cluster classifications. It was determined that the locations of dense snow cover coincided with wooded areas on the 9 x 9 black and white photos. It was extremely difficult to match bare soil fields between the Skylab imagery and the aerial photos because of the wet soils and abundant standing water during the Skylab mission. It was never determined for many fields whether they were bare soil, flooded, pasture, stubble or combinations thereof. Ratioing of channels in the visible versus reflective IR was applied in hopes of deciphering this complication but it, too, proved unsuccessful.

The net effect of the Skylab data analysis was that bare soil versus short vegetation could not be distinguished. This was caused by the poor surface conditions at the time of flight so that the MSS data were not very useful for cover-type determination. The only category easily discerned was the snow-woods class. If the Skylab data had been obtained under better surface conditions, it is assumed that much better results would have prevailed.

Although the Skylab data were not useful in discerning soil materials, the LANDSAT data proved to be much more suitable for the analysis. As in the case of the Skylab data, the area was divided into three portions. Each of these portions was further divided into two parts thus yielding a total of six areas which could be individually clustered using every line and column of data.

The areas were clustered resulting in gray scale printout cluster maps and fifteen classes of material. Ratioing of the spectral responses in the visible versus the reflective infrared was performed on all the classes to aid in delineating what each class represented. Definable areas on the gray scale printout cluster maps were matched to the aerial photographs. In this manner, the classes delineated by spectral response through the clustering algorithm were defined. Statistics on each subsection were calculated and stored in binary form on punch cards (known at LARS as a statistics deck). Classes not spectrally different in a significant way were combined and their statistics merged through the MERGESTATISTICS function of the LARS software system. Subsequently, the classes were passed through the SEPARABILITY program which determines how separable the newly merged classes actually are.

Similar classes were again combined and their statistics merged. The statistics decks for each half of the three major divisions were merged resulting in a single deck for each of the three major landforms. Next, total area of study was classified three times using each of the statistics decks in turn.

Of the three decks used for analysis only one successfully classified the entire area. That deck, containing statistics from the gorund moraine section alone, provided the best results, presumable because training areas for the classes were more distinct for that portion. A grey scale printout of that classification can be seen in Figure 8.

RESULTS

Classification of the LANDSAT imagery contributed positively to the selection of a corridor. Through examination of the imagery and the computer-assisted classification that was generated, the growth pattern of the area and the amount of new suburban development became evident. This allowed for an allocation of adequate room for future growth and development within the route barrier with routing at a prohibitive distance from the city proper. Also, two areas of poorly drained soil which were suspected of containing a moderate amount of organic material were detected. These sites were field checked which verified the conditions suggested by the classification. At the first site, a poorly drained area was found containing 1½ ft. of slightly organic silt with clayey silt below and the water table within 2 ft.

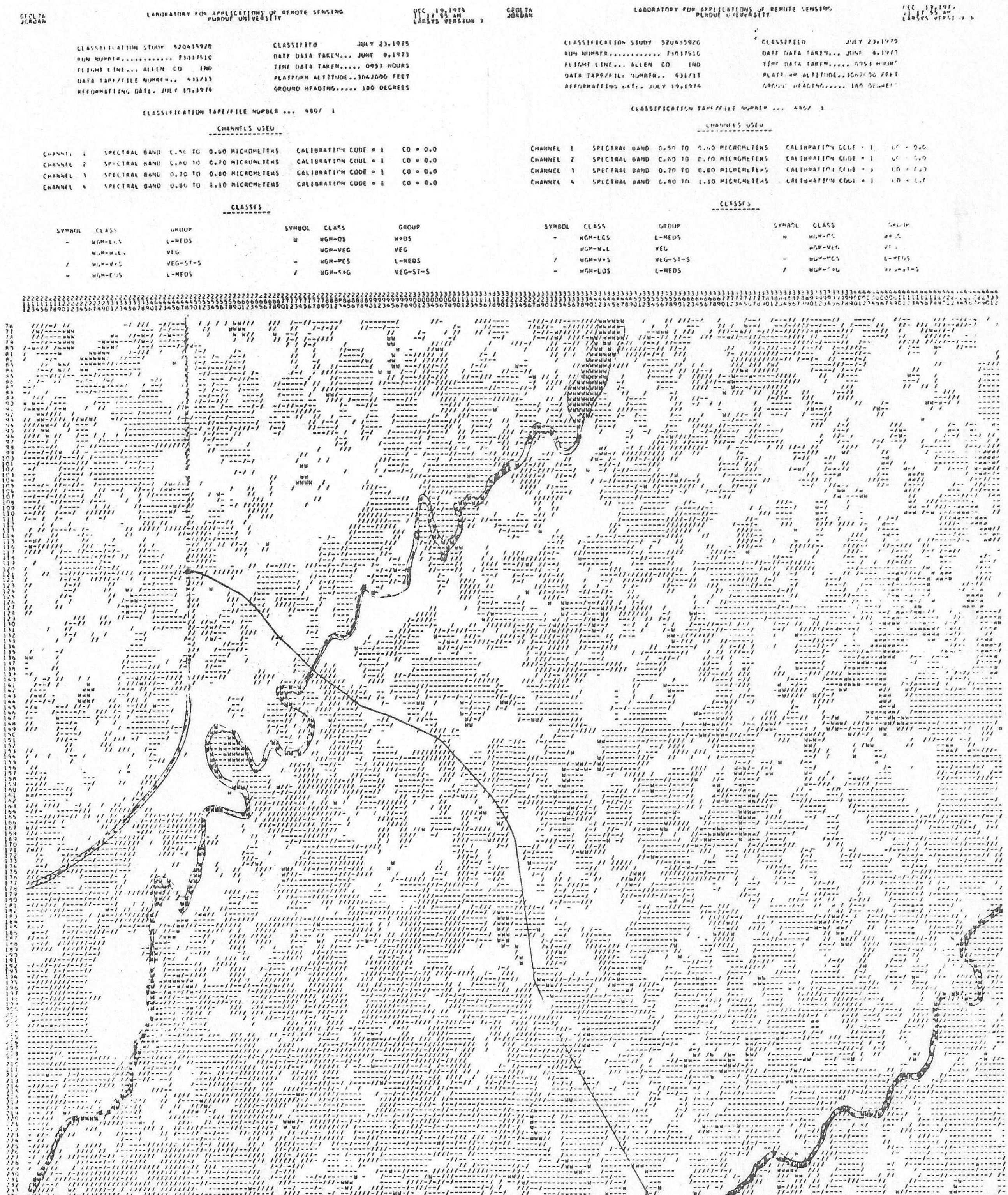

Figure 8. Land use classification, NE Ft. Wayne, Indiana area.

of the surface. The second site was much larger and more extensive. It contained 2 ft. of highly organic soil, again underlain by clayey silt with the water table within 4 in. of The surface.

The recommended highway corridor is outlined on Figures 1 and 8. The selection is based on routing the corridor around poorly drained soil areas along with minimizing the distance of intersection with the Lake Maumee beach ridge, while allowing enough area within the confines of the by-pass barrier to permit further expansion of Ft. Wayne but yet missing the existing developments of the area. The Lake Maumee beach ridge feature is preserved because of its aesthetic and cultural value relative to the glacial history of the area. No economically significant geologic materials (Quarriable stone, mineral deposits or gravel) underlie the recommended highway route.

CONCLUSIONS

The classification of the LANDSAT imagery allowed detection of poorly drained soils with moderate to significant amounts of organic matter based on their spectral response at spacecraft altitudes. This classification also provided for a direct comparison of these areas which is not possible from a map alone. For the Ft. Wayne study, significant information was added to the published material, and the feasibility of using MSS data in this situation was documented. It was also concluded that this method should prove of greater utility in remote and underdeveloped areas where a "data-gap" exists (relative to surface materials maps primarily) and this procedure could fill the gap of missing information. It is also anticipated that greater detail concerning the engineering properties of the exposed soil could have been determined in this study if lower altitude aircraft scanner data had been available for the site (4).

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