FRONTISPIECE. Aerial mosaic of "Eastland Topeka," Kansas, sample study area outlined in Figure 6.

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An Overview of Site Evaluation

The photo interpretation process is applied to a sample urban expansion problem.

(*Abstract on next page*)

INTRODUCTION

THE STATE HIGHWAY Commission of Kansas, as all states and many other units of federal, state and local governments, acquires large acreages of land for various purposes. The pre-purchase evaluation of such land has been accomplished by several methods of combination of methods. In recent years photo interpretation has been applied as a most useful tool for this purpose of land evaluation.

Although the evaluations discussed in this paper will primarily reflect the methods which have been used to evaluate land for highway rights-of-way, the methods may well be applied to evaluate sites for many other purposes. It is also noted that the methods presented have been applied to areas typical to the Mississippi Valley, but it is believed that they may well apply with perhaps some modification to the evaluation of sites in most any area. We will also use data developed for the purpose of a land use plan. Photo interpretation served as the principal tool, and photographs served as the primary source of data for this plan.

Even though photo interpretation is the main method of investigation, field work and the use of all available data are an integrate part of the investigation procedure. Nearly all facets of a land evaluation project can be investigated by photo interpretation procedures. Some detail may not become apparent through the use of photo intepretation. However, sufficient data with good accuracy can be expected, and appropriate decisions can be made from data obtained in this manner. Field work may not be eliminated by using this tool, but it can be substantially reduced. The primary role of field work is generally not to gather information but rather to check the data obtained from the photo analysis and possibly to extend such data. All data obtained in the field fortifies the development of any site analysis and can be a source from which photo interpretation may begin or may continue.

ABSTRACT: *As America continues to develop as an urbanized country, site evaluation and mapping for urban planning are being recognized as the necessary approaches for the methodical and orderly growth of urban areas. The overview illustrates the usefulness and application of photogrammetry and photo interpretation to various stages of urban planning and development. The approach is general in nature. Specific examples are cited, however, and references are made to other material to help illustrate the applicability of photogrammetry and photo interpretation to urban development analyses. Several examples of cost are also provided. Even though the experience background of the authors is predominantly in the highway engineering field, an attempt is made to expand and relate this experience to the general field of urban planning and development. Maps and photographs are used to illustrate possible ways of presenting data extracted from aerial photographs in report form.*

A number of specific types of analysis are possible with interests centered on one or more considerations. Most of the projects encountered in the work of land evaluation related to highways have had a specific consideration or a specific purpose as its primary objective. Even though the reported evaluations have not been conducted at one time on a single area, they could well be combined for the purpose of site evaluation. This paper will attempt to consider each type of evaluation and to combine them into a total sample evaluation prepared specifically for this paper. It is noted that the sample evaluation is not intended to be, nor is it an exhaustive study, of the area presented.

This paper then attempts to suggest some uses for photo interpretation in the selection of sites suitable for specific developments and specific requirements.

PHOTO INTERPRETATION AND LAND FORM

Land form as used in this paper is not used in the true sense of physiography or geomorphology but refers to the relief of the land or the "lay" of the land as it might affect future land development or utilization. However, land form, as a geomorphological term, is used during certain phases of a photo interpretation investigation.

Land form and area geology are generally considered as a unit; however, in the process of site location, a study of land form extends beyond that of geological formations. The slope of the site, the type of terrain, the problems of site clearing and site preparation can all be considered by photo interpretation. The use of geological beds as a clue to relative elevation is one means of determining land form (Stallard and Anschutz, 1963, p. 57). This technique is particularly adaptable in areas characterized by flat lying and consistent geological formations. Certain formations can be identified with relative ease on the photography and serve as an *index* to elevation, land form and geology. Such strata, in some instances, covers large areas. In Kansas, the Fort Riley limestone, *rim rock*, can be identified and correlated at points some 120 miles apart (Figure 1). Similarities, such as rock characteristics, inherent in index beds permit direct correlation of several sites.

Beds which are not easily identified on aerial photographs may be targeted and can be utilized as a base for geological photo

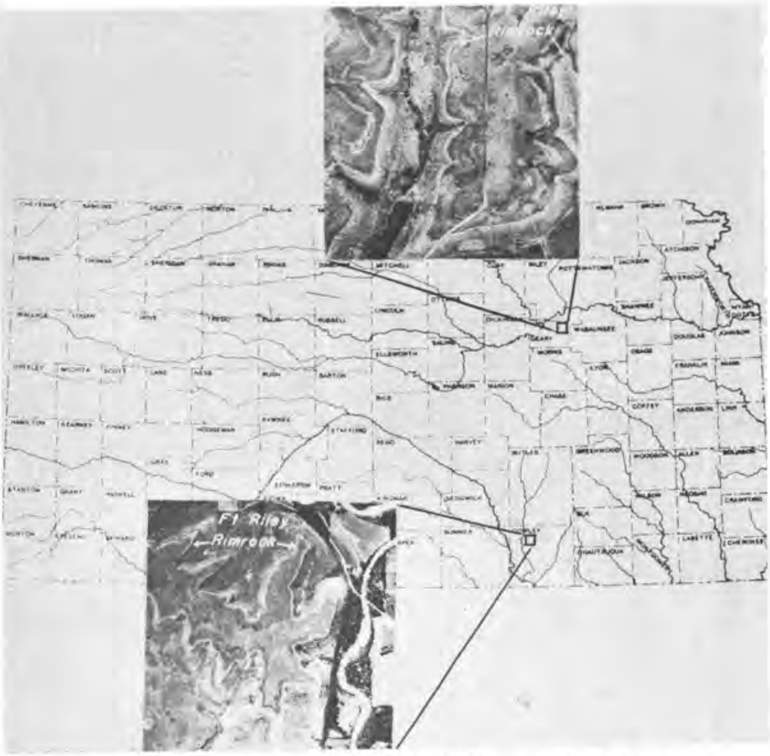

FIG. 1. Aerial views of the Ft. Riley Limestone "Rimrock" in Kansas. This ledge of rock is easily identified in Kansas and can be used as a "datum" for photo interpretation studies.

interpretation and for control when mapping is necessary with photogrammetric instruments. The ease and economy of such mapping procedures provide quantitative information which supplements data obtained from the photo interpretation process. (Stallard and Anschutz, 1963, p. 61).

Land use adds another method of aiding the photo interpreter in such analysis. A specific and very graphic example of such study is through the analysis of agriculture contour terraces. Since agriculture terraces are constructed along the contours of the land form, the number and spacing of such terraces indicate the relative change in elevation. Parallax measurements can be made to give the relative elevation of adjacent contour terraces and, therefore, supply the photo interpreter with an excellent index to elevation (Figure 2).

By observing the density, shape, and size of erosional features and by utilizing the habits of growing vegetation often give important clues to land form. The tonal change on black-and-white photography may reflect a change in vegetation. This change is not accidental and can be used quite often as a clue to the change of soil type (Figure 3). Sites covered with timber growth can be evaluated with particular reference to clearing problems. The land form must be further studied to give some indication of its stability after the trees and other growth have been removed.

Land form must be known to consider access to a developable site properly. Appropriate alignment and grades of access routes can be reasonably computed and considered for adequacy. Estimates of earthwork volumes, sizes of cut and fill sections, rock excavation quantities and other construction problems may be obtained from data derived from the photo interpretation of the site areas and the use of reasonably accurate measurements of distance and elevation.

Areas in which stability problems may be anticipated can be identified and studied. For example, slide areas can be readily identified and mapped (Stallard and Anschutz, 1963, p. 73). In many cases, the relationship between the geology of the area and the ground water conditions which may be conducive to land slides may be ascertained (Figure 4).

FIG. 2. An aerial view of agricultural terraces ocated in northeast Kansas. The number of terraces is indicative of the relief of the area and in some cases, reveals the thickness of the soil mantle.

The location of bogs and seepage areas is another feature which can be identified and considered in site studies. Clues to such areas can come from color variations which may be the result of vegetation change or the presence of water (Stallard and Anschutz, 1963, p. 70). A knowledge of the geology of the area will again afford background for the possibility of the detection of problems in such areas.

Very often land forms as defined by the geomorphologist afford features which can be identified by a photo interpretation process. The sand dunes of arid regions is one land form which is recognized easily by most photo interpreters. Specific land forms can be associated with glacial deposits and alluvial depositions. Background information of such features must be known by the photo interpreter to give the most accurate analysis. The use of several photographic media such as color or infrared photography can, in some cases, aid immeasurably in the task of the photo interpreter. In other studies, a series of photographs taken at various dates over a period of years may also prove most useful. All sources of information must be used as background material prior to the photo interpretation to give the best possible results obtainable for any project.

Photo Interpretation for Transportation, Utilities and Access

The demand for site use is often contingent on access to highways, railroads, waterways and utilities. All of these facilities can be identified directly or located indirectly on aerial photographs. Only the location of underground utilities and the differentiation of power and telephone lines pose the most difficult problems. These facilities do, however, present some unique clues which can be used if field checks are used to fortify such identifications. A power pole is usually taller than that of poles used for telephone lines. Transformers may be located on power poles which may identify power lines in some instances. Soil discoloration showing old excavation scars for pipe lines and underground utilities of large size can be traced for miles. The location of pumping or metering stations often disclose the location of some utilities. The use of available utility maps should be made a part of the study of any site considered for development. Utilities, as defined

FIG. 3. An aerial photograph of an area in central Kansas portraying eolian silt deposits. In this area, residual soils are portrayed in a "banding" pattern corresponding to the underlying sedimentary rocks. The eolian silt is delineated by tonal changes and a distinctive gully pattern which develops in the deeper deposits.

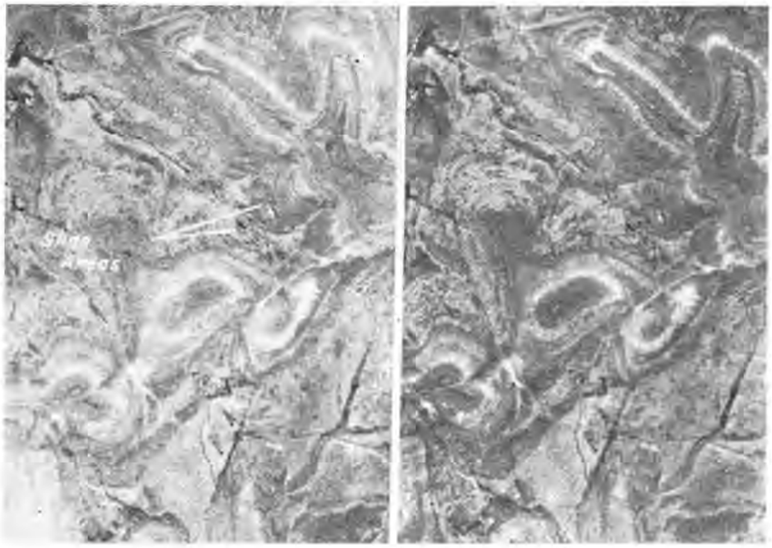

FIG. 4. A stereogram portraying slide areas that occurred in the Graneros Shale in central Kansas.

on a utility map, are graphically transferred to the photographs. Such definition of the utilities on the photographs becomes a ready reference as the photography is used in other areas of the study.

The identification of transportation facilities is readily made. In addition to such identification, the availability to controlled access roads, the location of off main line railroad tracks, and the stream bank conditions which do not deter the construction of dock facilities, may also be considered. The location and length of runways and current use of airfield should be determined if air transportation is a factor in site selection.

The usage of such transportation facilities may also give some indication as to their current or future usefulness. The fact that trucks are found using a certain highway or srreet generally indicates that such a highway or street is more suitable for such type of transportation than other highways or streets which are void of such truck traffic. Even where the photography does not show many vehicles, tire tracks and oil slicks do give an idea of the usage of such transportation facilities.

Through the use of photography, a transportation system rather than a single street or highway, an intersection, or a railroad segment, may be studied. Knowledge of such systems in general terms is often more valuable than detailed knowledge of a small portion of the area. Through the use of photographs taken at various times, growth and flow patterns may be determined which add to the usefulness of other specific data. Photographs taken at peak traffic hours will also determine traffic delay and congestion. (Jordan, 1963, p. 35.) Intersections can be studied to give some idea of the major street and, in some cases, the general volume of turning movements.

PHOTO INTERPRETATION FOR GEOLOGY

Many geologists use photo interpretation as an essential method of studying and mapping the geology of a given area. Usually the geology is determined to aid in the development of the material resources of the area. Recently, geology has become an essential and a very effective tool to evaluate the geo-engineering aspects of an area. After the geology of an area is determined by normal interpretation procedures, a more detailed and extensive geo-engineering study can be conducted by using the science of geology as an adjunct to the photo interpretation technique (Figure 5).

By having a knowledge of the geological history of an area, one may be able to determine how and when geologic units were deposited, their parent bed, and the post-depositional events that may have altered the original bed. Such information can be used to ascertain the engineering characteristics of the geologic units separately or in total which in turn may affect the development pattern of an area. For example, by having knowledge of the parent bed and the mode of deposition, the composition and possibly the

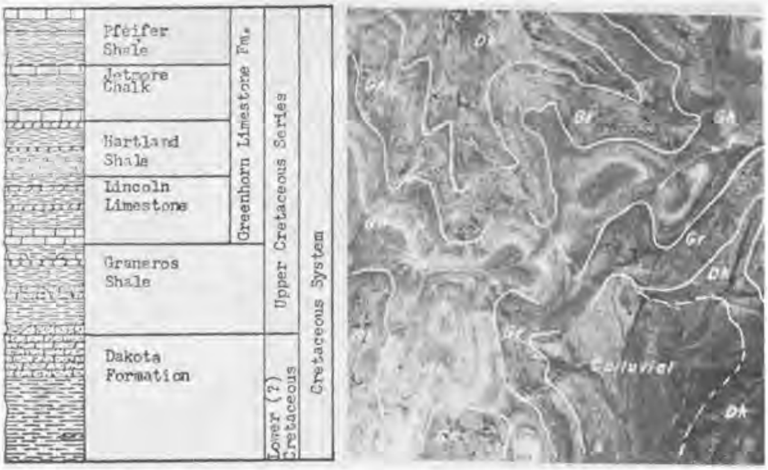

FIG. 5. An aerial view of a portion of central Kansas portraying the Greenhorn Linestone, Graneros Shale and the Dakota Formation. A generalized geological column representing the geology of the area is to the left of the photograph. The thin limestone units in the Greenhorn are portrayed as light bands on the aerial photograph. The uppermost limestone has been quarried extensively in this area. One such quarry is portrayed in the lower left of the photograph. The geologic contacts were mapped on a stereo-pair of aerial photographs on the bases of tone and topography of the area. Legend: *Gh*, Greenhorn Limestone Formation; *Gr*, Graneros Shale; *Dk*, Dakota Formation.

gradation of the material that comprises the geologic unit may be determined.

An area analysis can be conducted by using geology and aerial photographs in a combined photo interpretation program. Consolidated units which may be classified as rock excavation, and unconsolidated deposits such as alluvial valleys, can be depicted on an overlay, mosaic or an aerial photograph of the area being investigated. Aquifers may be mapped by utilizing geological information in conjunction with the aerial photographs or by discernible pattern elements on the aerial photographs. Construction material source beds may be mapped and described using the same procedures. The outcrop of clayey shales which may have a high swell factor or a low shear value, may be reported as possible problem areas.

Other geo-engineering information peculiar to an area may be reported either as an asset or a liability. The more ground information available, the more detailed the report can be.

Other engineering data closely associated with the geology of an area may be desired for a given area analysis. Some soil information may be provided by using available data and photo interpretation. Soil in this case is defined as unconsolidated material which overlies the bedrock in the area and is present in alluvial valleys.

Many times the characteristics of the soil may be ascertained by having a knowledge of its origin. For example, in some areas glacial till has fairly uniform engineering characteristics. Soil derived from clayey shales may have engineering properties similar to the parent bed.

The amount of information pertaining to the engineering properties of soil that can be reported, depends on the amount of ground information that is available and the experiences of the photo interpreter. Soil types can be and have been mapped; however, this operation is also dependent upon the experience of the photo interpreter and the amount of field information available.

Photo Interpretation For Hydraulics, Hydrology and Drainage

Information pertaining to hydraulics, hydrology and drainage of an area may be desirable. Such information may be required to determine the location of new improvements and the size of bridge structures. In many cases, the subsequent decisions based on this data may affect the overall plan for land utilization.

Drainage areas are easily delineated on stereo-pairs of aerial photographs. Separate drainage areas may be evaluated on the basis of run-off data which is reflected in land use, soil type and other factors.

Flood data may be used to supplement a drainage report concerning the flow of water during periods of high water. Subsequently, recommendations can be and are often made for flood control facilities such as dikes and channel changes.

A detailed history of major stream channel may be desirable to ascertain the streams activity during the past 30 or 40 years. Such information may be beneficial in determining the location of bridges, dock facilities or other improvements. Scour activity of the stream may be equally important for the same purposes. Such information can be determined on many occasions by studying photographs of the area taken at different time intervals over a period of years (Stallard and Anschutz, 1963, p. 99).

A special application of stream migration study is the study of stream activity before and after an improvement has been constructed to determine if the improvement contributes to detrimental stream action. Such studies form historical background for future studies in similar areas or situations. (Stallard and Anschutz, 1963, p. 57).

Photo Interpretation for Land Use

Land-use patterns are most important in evaluating site locations. A land-use forecast is a relatively precise image of how land will be used in the future. The image is based on the premise that land-use trends will continue and that land use controls will remain in the future as they are today. The current use of land can be determined by an analysis of current photography. Photographs taken of the area at different times afford the opportunity to study the land use over a period of years. "The most important aspect of any historical analysis, on which a future forecast is based, is the reliability of the source data. Where aerial photographic coverage is available and adequate interpretations and measurements have been made, there is no question about the reliability of the data." (Howlett, 1963, p. 15.)

The influences of both natural and man-made features on site development can be ascertained and, consequently, patterns of land use development can be predicted. Patterns may be developed into transparent overlay grid sheets, which permit observation of comparisons, growths and persistence of trends. Such overlay sheets which show land use growths will often appear as creeping ink forms. Where growth does not occur in some area, resistance to growth, either natural or man imposed, can usually be noted as the determent, and knowledge of such resistance gives significant data which is considered in the evaluation of sites in this area. Land use also can give important clues which can be used to determine geological conditions and soils problems. For example, small man-made drainage channels may be indicative of a clayey, impervious subsoil.

When considering sites for future development one must also consider the persistence of the growth of certain land uses. Often physical problems are overcome because the ever present need of land area exists. If this occurs, the land use trend is perhaps more important than the physical determents for development. Elevation changes, by site clearing and leveling, changes in drainage or protection from flooding, the opening of access routes or the construction of other transportation facilities, changes in zoning or law, and many other such condition alignments do affect the proper choice of sites for development. The selection of a site may also force changes in elevation, drainage, law, zoning, or protection improvements. When such alterations are forced, they must be considered in the cost of the site development.

Field work may be desired for land-use studies. "Office sources consist of topographic maps and aerial photographs, and where these are available, they provide a suitable basis for estimating the terrain characteristics of the large open areas and rural fringe sections of the planning area. The field survey is generally confined to the classification of the scattered vacant lots and parcels interspersed in the built-up portions of the urban area" (Chapin, 1957, p. 225). Land use can assist in the determination of legal boundaries. Property maps (sometimes called tax maps) are usually developed from aerial photographs because of the ease in identifying fence lines, structures, and other physical features in the townscape which can be tied to property lines. (Chapin, 1957, p. 196). The use of photography before and during actual surveying operations should not be overlooked. Much of the physical evidence of a land line can be seen on aerial photography. Such photography also gives a broader view of the area, and the planning of surveys can be enhanced through its use. It becomes an invaluable document of the conditions as they existed on the date the photographs were taken.

Other Factors

Other factors such as the community economy, population trends, community attitude and planning and many other features which are not shown on photography

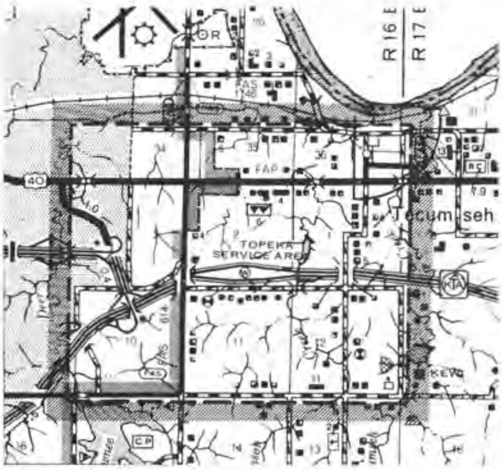

FIG. 6. Location map of "Eastland Topeka," Kansas. The sample photo interpretation study area is shown within the shaded border.

are to be considered and may be reflected in land use trends. An index to population can be determined to some degree by mapping from aerial photographs the dwelling units by type. By diagrammetrically portraying such allied data and considering land use along with access, geology, soil conditions, drainage, transportation, land form and other items, a better total picture can be determined and considered when making site evaluations.

In order to exemplify the numerous applications of photo interpretation to site surveys, an abridged report of an evaluation for an area near the city of Topeka, Kansas is affixed. Inasmuch as the purpose of this report is to illustrate general procedures and technique, detailed information which usually accompanies such investigations has been omitted.

Reports of this nature usually include all available data pertaining to the area being investigated and pertinent information extracted from aerial photographs. To present such information, the photo interpretation report may include or be supplemented by maps, overlays, and photographic illustrations. In order to illustrate the usefulness of a variety of maps and to utilize existing information, many of the figures used in the abridged report were taken from the "Preliminary Land Use Plan" of the Topeka-Shawnee County Regional Planning Commission. It should be noted that this plan was also developed through substantial use of aerial photography and photo interpretation techniques.

ABRIDGED EDITION SITE STUDY FOR TOPEKA'S "EASTLAND" EXPANSION

INTRODUCTION

The lower real estate values of "Eastland Topeka" has in recent years drawn the attention of developers in this area. The purpose of this investigation is to review and report pertinent data which may be used to evaluate prospective sites for such development.

The information contained in this abridged edition was obtained through the use of photo interpretation and limited field check investigations.

LOCATION

"Eastland Topeka" is defined as that area which is located east of the metropolitan limits of the city of Topeka, generally north of the Shawnee Lake development, and south of the Kansas River flood plain. Specifically, the report concerns itself with Sections 1, 2, 3, 10, 11 and 12 of Township 12 South, Range 16 East, and the south half of Sections 34, 35 and 36 of T11S, R16E (Figure 6).

ECONOMY OF THE TOPEKA AREA

Although the Topeka area is experiencing a period of moderate transition from agriculture to industry, growth is noted throughout the metropolitan area. The economic base is diversified with strengths found in light industry, grain storage, wholesale distribution, agriculture, retailing and publishing. As a state capital and a county seat, a high level of federal, state, and local government employment exists. The population growth indicates a continuing increase which exceeds the average for cities of similar size. All indices which normally depict such growth, such as manufacturing value, wholesale trade, assessed property value, bank debits, employment, number of dwelling units and others, indicate a continued and steady increase throughout the history of the city. Such general economic conditions are also reflected in and for the area under consideration.

The population growth of the "Eastland Topeka" area has not, however, increased as rapidly as other sections. Several features such as the separation of the "Eastland Topeka" area from the city proper by the Atchison, Topeka and Santa Fe and Missouri Pacific railroads and by Shunganunga Creek may be the major reasons for the reduced rate of population growth. Access to the area was slow to develop. The current trends, however, indicate that such restrictions have generally been removed or effectively reduced.

LAND FORM OF THE AREA

The land form or topography can best be illustrated by a topographic map (Figure 7). The area is not composed of severe slopes. Streams of the area drain small acreages and can be controlled. The flood plain of the Kansas River must be considered, however, in the evaluation of sites lying in the extreme north portion of the study area (Figure 8). Flood controls in the form of dams on many reaches and tributaries of the Kansas River and on the Shunganunga Creek and a system of dikes and drainage channels in the Kansas River flood plain in the Topeka area have been constructed. Such controls have reduced appreciably the flooding frequency and problems connected therewith.

Few problems relative to site clearance will be encountered. The grades are gentle, and access should be a minor problem if apprepriate facilities for transportation exist.

Geology and Soils

A discussion of the geology in the area being investigated should be considered in conjunction with the generalized geology-soil overlay (Frontispiece and Figures 9A and 9B) and the generalized geological column. (For the purpose of illustration, prints of overlays are being presented and are referred to as Figure 9A and Figure 9B. In practice, such overlays are transparencies which overlay the photograph presented as the Frontispiece. The overlays are of equal scale to the photograph and, therefore, can serve to increase the understanding of the features represented within the photograph itself.) When used in conjunction with other data provided in the evaluation, such information may be useful in the planning of improvements and in making cost estimates for the development of sites of the area.

The area under investigation is underlain by interbedded limestone and shale of Pennsylvanian age. The Topeka Limestone is present in the upland areas, and the Deer Creek Limestone is exposed along the lower valley walls.

Much of the high terrain is capped with glacial till which is composed of silty clay and clay. Residual soil mixed with glacial till and colluvial material characterizes the mantle elsewhere in the upland areas. Much of the residual soil is derived from thick shale units exposed in the area. The flood plains of the small drainage channels are composed of alluvium derived from glacial till and residual mantle.

Limestone outcrops are depicted on Figure 9A. In the northwestern portion of the area, the Topeka Limestone outcrop is fairly continuous; however, elsewhere it is masked by glacial till and colluvial material. The Deer Creek Limestone is exposed along the bottom of the flood plain in the western portion of the area.

Fig. 7. Topographic map of the Eastland Topeka area shown in Figure 6.

Fig. 8. Map of the Eastland Topeka area showing the flood plain including existing and proposed levees.

Relatively higher exposures are present in the eastern part of the area.

Geo-Engineering Aspects—Excavation Classification

In general, the limestone units will be classified as rock excavation. Usually the shale units that underlie the limestone units will be rock excavation depending upon local ground water and weathering conditions. The thinner limestone units that might be encountered can be ripped during excavation operations.

All mantle, which includes residual soil, glacial till, and the alluvial deposits will be common excavation. In some glaciated areas, large granite or quartzite boulders may be encountered; however, none are believed to present problems in this area.

Ground Water

Ground water problems may be encountered if construction traverses limestone units which are near the surface or which are exposed in this area. The most prominent aquifer in the area is the basal limestone of the Topeka Limestone. Some subsurface water problems may be encountered if water is being carried in the sandstone included in many of the larger shale units. (See Figure 10.)

Except in the lowlands, ground water resources of the area are limited. Water wells serve the rural residents; however, larger communities are served by water lines from the city of Topeka or rural water districts. Urban development would require such a water system. Figure 11 is a

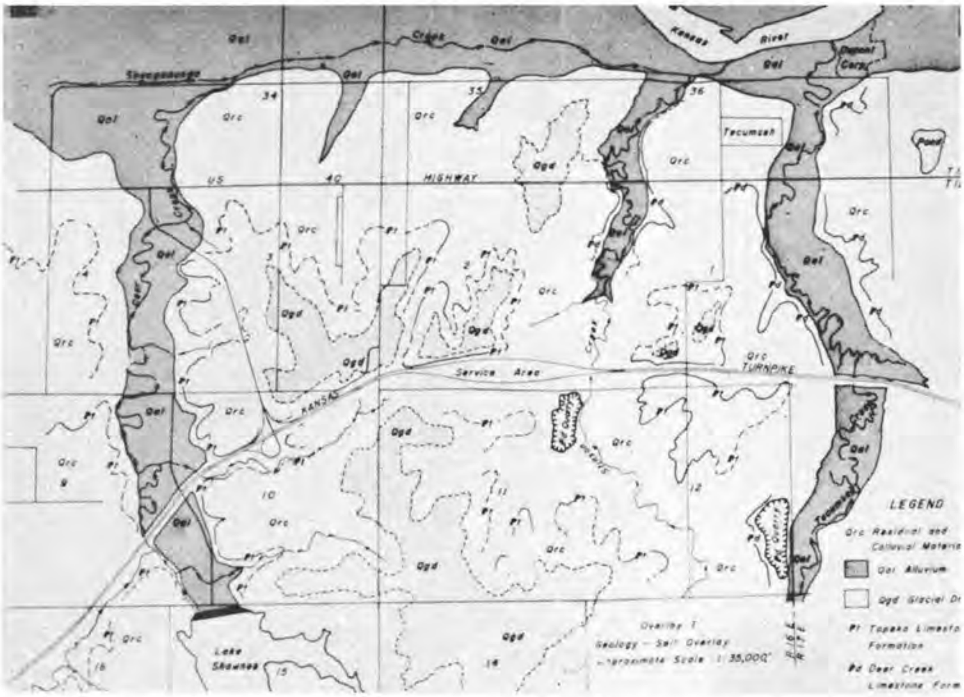

FIG. 9A. Geology and soil overlay for the area shown in the Frontispiece.

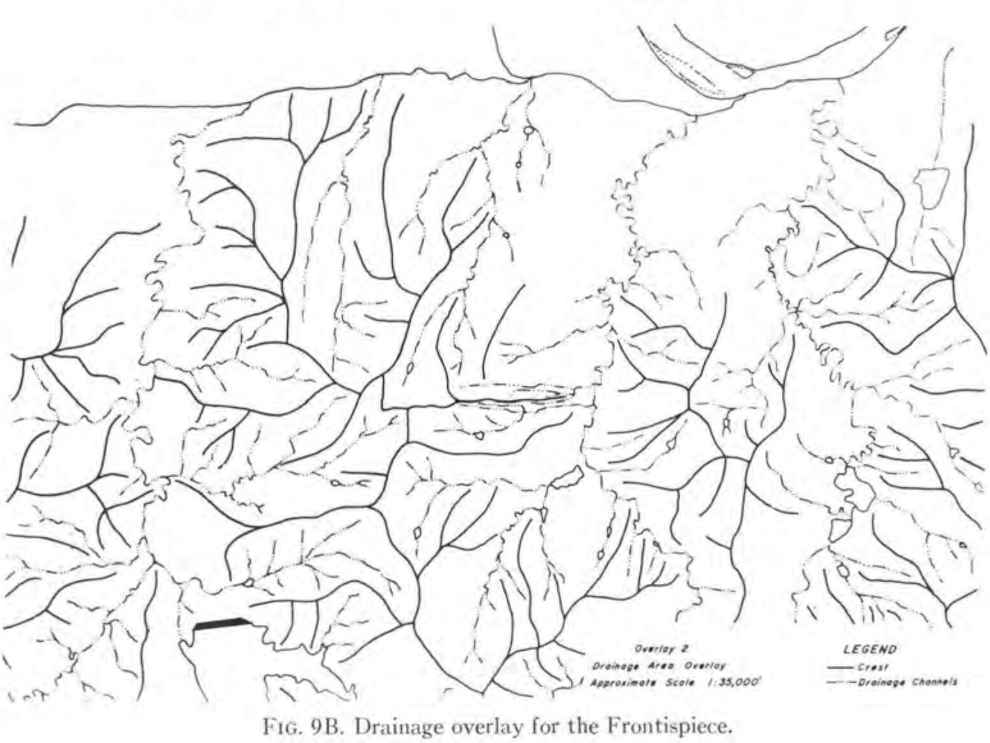

FIG. 9B. Drainage overlay for the Frontispiece.

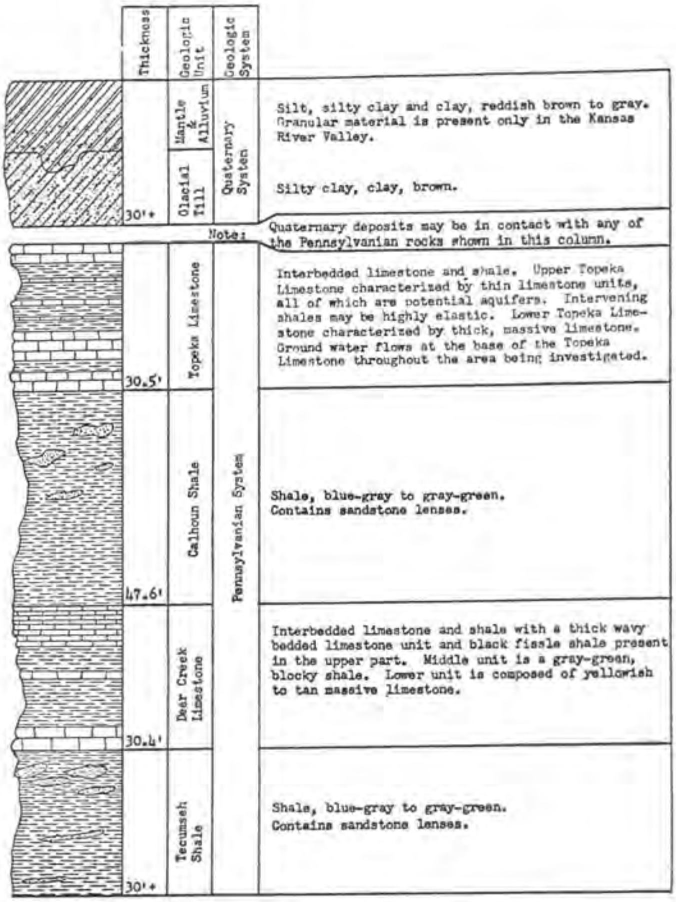

FIG. 10. Generalized stratigraphic soil section.

utilities map portraying present water accommodations.

Industries requiring large volumes of water would best be located in areas to the north in order to use the Kansas River as a source of water.

MATERIAL ASPECTS

Good quality siliceous sand and gravel can be produced from the Kansas River flood plain. Several companies conduct pumping operations in the Kansas River flood plain within a few miles of this area. No siliceous material is found in or near the area being investigated except from this source.

Crushed limestone aggregate can be produced from the basal part of the Topeka Limestone; however, results of quality tests conducted on samples taken from this source indicate the material is of low quality because of high absorption and wear properties of the limestone.

Better quality limestone aggregate can be produced from the upper ledge of the Deer Creek Limestone. Two quarries are currently producing from this source in this area. (See Figure 9A.)

Most of the unconsolidated material found in this area (residual soil from shale units, glacial till, and alluvium) have undesirable engineering properties because of its high swell factor and high plastic indices. Such material is character-

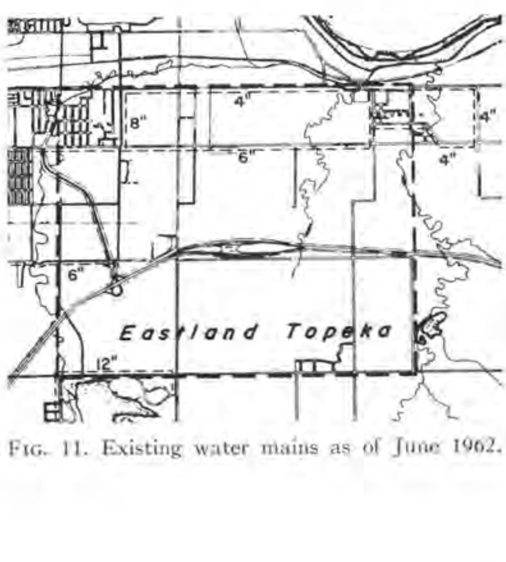

FIG. 11. Existing water mains as of June 1962.

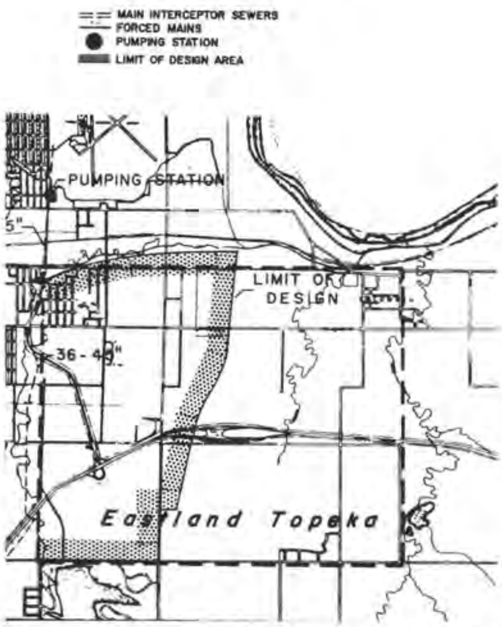

FIG. 12. Sewer lines 8 inches in diameter and larger as of January 1962.

ized by low permeability with the possible exception of the alluvial plains

Special consideration should be given to sewage disposal or industrial waste. If the area is to be developed at a gradual pace whereby individuals are responsible for the construction and operation of local sewage disposal units, local soil and geological conditions should be thoroughly investigated. Inasmuch as the soil mantle in this area is derived from glacial drift and shale, it is relatively impermeable and, therefore, several acres of land may be necessary to properly dispose of sewage. If local sewage disposal units are placed in or near limestone formations or other potential aquifers, contamination of water being carried in these geologic units may result. Consequently, care should be exercised in areas where the Topeka and Deer Creek Limestones are exposed or near surface or where permeable sandstone is encountered in shale units. Figure 12 is a map portraying present sewage lines in this area.

HYDROLOGY

The area under investigation is drained by three major drainage channels, Deer Creek, Stinson Creek and Tecumseh Creek. These channels flow north where confluence with the Kansas River occurs (Figure 9A). The drainage divides of this area are depicted in Figure 9B. This overlay may be useful in planning storm sewers and surface drainage avenues if extensive development of the area is being contemplated.

As indicated earlier, no major water problems are anticipated in this area. Figure 8 is a map portraying areas that are subject to flood waters. Even though some areas were inundated in the past by flood waters, a new dike system protects most of the low area included in this study.

The size of structures to be constructed over drainage channels can be determined by use of the drainage divide overlay, Figure 9A, and the soil-geology overlay, Figure 9B.

On occasion, minor flooding has occurred along Deer, Stinson, and Tecumseh Creeks; however, problems of this nature are relatively insignificant. Lake Shawnee serves as a flood control measure on Deer Creek, and if necessary, smaller dams could be constructed to serve the same purpose on the other two channels.

TRANSPORTATION AND UTILITIES

Transportation facilities in the form of streets and highways, railroads, and air facilities present a promising feature for the area. A review of the photography indicates considerable access to streets and minor highways. The Kansas Turnpike, although access controlled, is somewhat convenient to the area in that the east Topeka entrance is located in a strategic area and can become a focal point for transcontinental, intra, and interstate travel. The master plan for major traffic thoroughfares reflects the planning of adequate vehicular facilities for the area. Rail transportation and the possibility of off-track facilities exist, although this has not been developed greatly at this time. Good off-track facilities have been developed immediately to the northeast of the area and serve the Kansas Power and Light Company and the Du Pont industries. Air transportation is also a distinct possibility. The location of an airport and its current usage indicate that the growth of this facility and its increasing usage can be expected. The major problem preventing such expansion is the lack of adequate streets or highways serving the facility.

Utilities of the area have been greatly improved in recent years. Major gas mains are available (Figure 13). The existing water mains of the area are especially developed in the northern portion of the study area; however, additional facilities will be needed to serve the southern portion of "Eastland Topeka." The construction of a major sewer interceptor along the eastern metropolitan limits of Topeka has greatly enhanced the relief of a sewer utility problem. Consideration of the limit of design or service of this system should be noted (see Figure 12). A considerable amount of sewer construction will be needed in the eastern portions of the area to properly serve future development.

Using the utilities maps and a map of planned streets and highways, Figure 14, a composite picture of the capabilities of land development can be constructed (Figure 15). With such a map, it can be shown that a considerable portion of the area cannot be developed without a major expenditure for water and/or sewer services. There are certain small areas which could be developed immediately with low cost for facilities. Access to transportation facilities poses few problems for the entire area.

LAND USE

To evaluate land use properly, a study of current photography, together with photography taken over a series of past years, permits the development of a housing map which will locate the residential buildups, industrial areas, public use areas, and other such data. In some instances the study will also give the current conditions of such uses. Developed land masses can best be pictured from a map showing such current areas.

A third illustration produced from such a study may well be a land map which portrays land use. These maps are compared with a zoning map of the area, and conflicts are noted. "Eastland Topeka" is generally undeveloped. Few zoning restrictions exist and the current land use poses few problems. A suggested use plan for the Topeka area was developed by the Topeka-Shawnee County Planning Commission which was based upon the previously indicated studies. This plan was projected to the year 1980 and is suggestive or advisory in nature. The area under consideration in this report has generally been considered for residential development with several small portions being considered for industrial development. This study does not differ with this analysis.

Photo Interpretation and Photogrammetric Surveys

The evaluation of any site being considered for development involves the study of a great number of separate yet related disciplines. No evaluation excludes the use of a topographic map and eventually a cadastral survey. A natural relationship exists between the photo interpretation process to develop the quantity of data needed to evaluate a site and the photogrammetric methods for surveying. Photography is required for both uses, and with proper selection and some planning, the same photography can serve both purposes. The usefulness of photogrammetric surveys becomes increasingly apparent when consideration is given to this mutual source of documents. Because photography does play such an important part in the development of land use and in geological, soils, drainage, and transportation surveys, the extension of photography to the development of topographic and cadastral surveys can be accomplished with little extra cost.

FIG. 14. Master plan for major traffic thoroughfares with anticipated revisions.

The common source document will produce data which are mutually beneficial to each activity. Items which can be identified in the interpretation process may determine the need for ground measurements or perhaps may indicate no need for such measurements. The photographs can be most useful for the planning of ground surveys and by this means afford a savings of time and cost for such surveys.

Field work supplementary to the photo

FIG. 13. Existing gas mains as of January 1962.

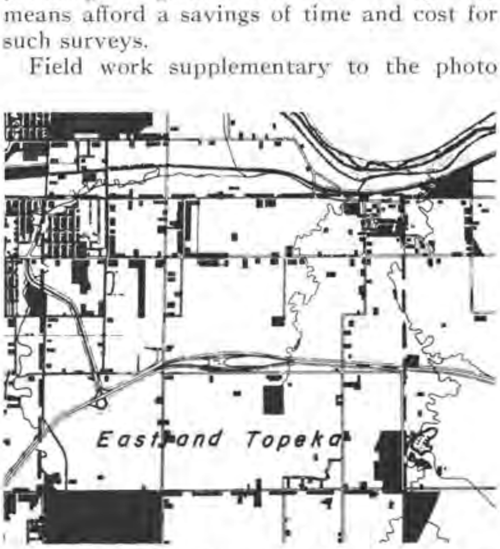

FIG. 15. Developed land in the Eastland Topeka area as of March 1962.

interpretation process can be properly aligned to the necessary photogrammetric ground control survey with a minimum of time and effort. In essence, field checks may be combined to serve both the photogrammetric survey and the photo interpretation process. A brief review of the photogrammetric survey procedures and requirements will indicate many possible areas where identical and mutual field work can serve several purposes.

In order to orient a given model properly on three dimension instruments, one distance and five points of elevation located at the center and corners of a model area must be determined. If two or more models are required, several spot elevations which are identifiable on the ground as well as on the photographs can be used as control points for adjoining models. If the area of the site being evaluated can be covered with one model, only five points need to be defined as to elevation, and the distance between any two of these points needs to be known for a complete minimum photogrammetric ground survey. The surveying procedures used to obtain the previously described ground control and the possible instrumentation to perform such surveys will not be repeated here; however, many references providing detailed information concerning photogrammetric procedures and techniques are listed in the latest edition (1964) of "A Selected List of References on Aerial Surveying and Mapping" compiled by the Highway Research Board Library staff. It should be noted that the type of equipment used and methods of survey followed may vary with the terrain, size of site, and plotting equipment available. Bridging procedures and aerial triangulation are methods which reduce field work and may be considered for some surveys.

Several features of surveys to study specific sites lend themselves especially to photogrammetric mapping. The shape of the area to be mapped is an item to consider when planning the mapping phase of any project. Generally, areas considered for site studies are rectangular or square in shape. The control required is often no more than would be required for a survey of a strip of land and is considerably less than that required for the normal ground survey. The topographic features of a site survey that often are scattered throughout the area, are easily mapped by photogrammetric procedures. The same mapping by conventional means can, and very often does, pose a quantity of effort and a most laborious survey.

In areas where the terrain is rolling to hilly or of great relief, the photogrammetric approach is generally the most feasible, and control with distance measuring devices is generally economical and performed with considerable ease.

The amount of time allotted for the completion of the project may be a significant factor in determining the method by which the project is accomplished. With acceptable weather for flying and controlling, the photogrammetric survey can initiate a project. From this point, however, most of the mapping is confined to an interior operation, and weather is not a factor.

Photogrammetric surveys afford a permanency which allows the resurvey or extension of survey with the minimum effort. The conventional survey does not afford this permanency.

Photogrammetric surveys have proven to meet accuracies required for site studies. They have been used to compute final pay quantities for highway earthwork projects. The accuracies can be extended to minute details if such accuracy is required. Care and diligence can not be disregarded, but with careful work, and with the realization that economics can be effected, the photogrammetric survey should be considered for any site evaluation project.

There are certain disadvantages however. Heavy vegetation and trees in full leaf are a perpetual problem to the photogrammetric engineer. Inclement flying weather poses problems in certain seasons and in certain areas. Snow cover is also a hindrance to surveying photogrammetrically.

Photogrammetric surveys must eventually be located on the ground. Proper planning is required to relate mapping data to the terrain; however, this operation can be accomplished at the most convenient time when it will be most useful for the development of the site. Without planning, the process of "putting the survey on the ground" could be considered a disadvantage of this method.

Cost Analysis

One of the main advantages of photogrammetric surveys and photo interpretation studies is the relatively low cost of conducting such operations. This advantage is especially apparent when the amount and type of information extracted and compiled from aerial photographs are compared to that obtained by conventional field surveys.

The cost of aerial surveys and conventional ground surveys as well, is contingent on many variable factors that cannot be considered until a project in a definite locale has been assigned. The distance of the project from operation headquarters, the size of the area, the terrain of the area and the objectives of the project are some of the more apparent factors that influence the cost of any such project. These and other contingencies are considered in more detail in the following discussion.

COST OF PHOTOGRAMMETRIC SURVEYS

Unless definite specifications are presented for a definite area, the cost of photogrammetric surveys can be discussed only in general terms. For example, urban areas are usually more time consuming and expensive to map than rural areas. The size of the area to be investigated, the terrain that characterizes the area, and the desired scale and contour interval are factors which would have considerable influence on the cost of any mapping operation.

In order to convey to the reader a general understanding of the cost to conduct photogrammetric surveys, several example projects are cited.

Example 1: TOPOGRAPHIC MAP OF CHANUTE, KANSAS, BUSINESS DISTRICT.

Aircraft operation	$ 36.60
Pilot & cameraman salary	16.50
Prints, negative & diapositives	5.40
16 manhours on plotter	44.00
Base sheet material	.65
	$103.15

The cost includes developing a topographic map covering an area of 2,700 square feet at a scale of 1 inch represents 100 feet. It does not include the cost of ground control or any enlargement or reduction of the base sheet. This cost would be approximately $405.00 per square mile.

Example 2: TOPOGRAPHIC MAP OF AUGUSTA AND OUTLYING AREAS

Aircraft cost	$ 54.90
Pilot & cameraman salary	24.75
Negatives, prints & diapositives	137.50
250 manhours plotter time	687.50
Base sheet material	10.80
	$915.45

This price includes the cost of compiling a topographic map covering an area of six miles by six miles at a scale of 1 inch represents 200 feet. The cost does not include the cost of ground control or any enlargement or reduction of the base sheet. The cost would be approximately $25.42 per square mile.

Other highway departments have reported a cost of approximately $500 per mile for rural, and approximately $800 per mile for urban, mapping when compiling detailed topographic maps or strips along major interstate routes. (Carigan, 1964, p. 39.) These maps were used for advance route determination purposes. This type of mapping was accurately and promptly completed, often at a cost of less than $200 per mile.

To compile a contour map approximately one-quarter mile by one-quarter in area, at a scale of 1 inch represents 50 feet with a two foot contour interval, the cost would be approximately $75. This price would include the cost of photography, diapositives and the salaries to operate the plotter. Not included is the cost of field control which would vary with the distance from the operation headquarters. However, if the area was nearby, the time required to obtain adequate ground control would be considerably less than one day for a survey crew of three men using modern surveying instruments and techniques.

Even though the examples cited are not exhaustive, they do illustrate several cost patterns which are generally true for photogrammetric surveys. For example, the cost of a given project will vary with contour interval, scale, size of the area to be mapped, and the detail that is required for each map. Usually the smaller the scale and the larger the contour interval, the less the cost. Larger areas are more economically mapped per unit area than smaller areas.

When considering the relative short time required to conduct photogrammetric surveys, the type of information provided, the ease at which such information can be extended, and the form in which the information is presented, the true savings that might be realized can only be estimated.

COST OF PHOTO INTERPRETATION STUDIES

The cost of photo interpretation studies may be more variable than that of the photogrammetric surveys in that a larger variety of data can be obtained; however, many of the factors that affect the cost of photogrammetric surveys affect the cost of photo interpretation studies. The amount and type of information that can be included in a photo interpretation report and the method of presentation depend on the natural conditions of the area, the objectives of the investigations and the amount of work previously completed in the area. If all facets of an area evaluation are to be considered, several photo analyses would have to be completed. The time required for each analysis would vary with urban and rural areas, and with the geology and topography of the area. More emphasis may be placed on geology and soil conditions in the rural areas while land utilization or transportation studies may be emphasized in urban areas. The amount of ground information available to the photo interpreter, and the experience of the interpreter would influence the amount of field work that would have to be conducted and, consequently, the overall cost of the project.

The cost of aerial photography (Cronar and Safety Film) is fairly consistent at $0.70 per print. The final cost of photography for any given project would depend on the number of prints required. This number would vary with the scale of the prints and the size of the area being investigated.

The cost to conduct a more detailed geologic analysis of the Eastland Topeka area would be approximately $50, or approximately $6 per square mile; however, the photo interpreter was familiar with the geology of the area. The cost includes photography and the cost of interpretation. It excludes the cost of conducting research field work which, in this case, would be negligible.

Preliminary geological profiles have been compiled on the Kelsh plotter at the same time that contour maps or preliminary centerline profiles are completed; however, such surveys are limited to areas where the geology is fairly discernible on the aerial photographs and there the geology is fairly consistent. After the preliminary field work is accomplished, it is estimated that this type of work would add less than $20 per mile to the overall cost of the photogrammetric survey.

In areas where the geology is fairly consistent, a generalized analysis of the geology of a county can be accomplished for approximately $4.50 per square mile. This cost includes photography, research, interpretation of the photographs, a limited amount of field work, and the compilation of a base map.

A land utilization or transportation study would be more time consuming per unit area because of the numerous detailed features that would have to be studied, measured, and plotted on maps or overlays. The compilation of the final map or overlay could be a very time-consuming and laborious job. The cost of conducting such surveys would be highly variable depending on the size of the city, the amount of ground information available, and the objectives of the project.

The cost of field work to accomplish the same tasks as that accomplished through photo studies would be considerably higher; however, no cost comparison has been completed because field analysis usually provides more detailed information but does not cover as large an area as the photo studies. Therefore, a true comparison would be impossible. In most cases the survey is completed by using both photo studies and field studies. It should be noted, however, that on occasion information is presented in photo interpretation reports that cannot be obtained by field methods. For example, the way a given piece of land has been utilized over a period of years can be determined by studying comparable photography taken at different time intervals. The value of such information cannot always be expressed in the amount of money spent to acquire it but may be better realized in making decisions concerning the area being investigated.

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