AIR PHOTO INTERPRETATION REDUCES COSTS FOR A WIDE VARIETY OF OILFIELD PROJECTS

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AIR PHOTO INTERPRETATION REDUCES COSTS FOR A WIDE VARIETY OF OILFIELD PROJECTS.

By

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This paper is to be presented at the 19th Annual Technical Meeting of the Petroleum Society of CIM in Calgary, May 7-10, 1968. Discussion of this paper is invited. Such discussion may be presented at the 19th Annual Meeting and will be considered for publication in CIM journals if filed in writing with the Technical Program Chairman prior to the conclusion of the meeting.

ABSTRACT

Air photo interpretation and photogrammetry are two of the most effective and versatile tools available to the petroleum industry. The techniques have proven successful in providing solutions to many of the problems encountered in the design and construction of oilfield projects.

While most technical personnel are aware that air photo interpretation and photogrammetry are useful in the selection of routes for roads and pipelines, few realize the true scope of the techniques or the wide variety of areas in which they are applicable.

This paper briefly describes the principles involved, and reviews a number of typical applications of particular interest to petroleum companies. Excessive detail is avoided, rather the emphasis is placed upon the wide spectrum of possible applications. It is stressed that on-the-ground examination generally is a necessary adjunct, and that there are certain limitations to the techniques discussed.

Properly applied, however, air photo interpretation and photogrammetry can offer significant advantages in terms of time, flexibility, secrecy and economy.

EXPLANATION OF PRINCIPLES

The principles of photo stereoscopy are based upon the fact that if an object is viewed from two different positions simultaneously, the visual effect is stereoscopic, or three dimensional.

Air photographs normally are taken along consecutive lines, with a 60 per cent forward overlap and 30% sidelap. Thus a permanent record of the ground is obtained at a certain scale and at a particular time. These photographs are projected through stereo plotting instruments, the lenses of which are similar to those of the aerial camera. When the projectors are positioned so that they exactly match the position of the taking camera at the moment of exposure, a three dimensional image is formed, and the original conditions during the film exposure are reproduced in model form.

If an object is viewed alternately with the left and right eye, its location will appear to shift from one position to another. This apparent displacement, caused by a change in the point of observation, is known as parallax, and it is this phenomenon which allows extremely accurate measurement of the elevations within the stereoscopic model. The apparent height of an object is therefore determinable from the difference in its image displacement on adjacent airphotos.

The accuracy of measurement is directly related to the focal length of the camera lens and to the altitude above ground at which the photographs are taken. For example, photographs taken 18,000 feet above ground can yield accuracies of ± 1.8 feet; 1,200 foot altitude photography can result in measurements accurate to ± 1.5 inches.

It is important to distinguish between stereo photos, which allow viewing of the terrain in three dimensions, and photo mosaics, which consist of the same aerial photos attached to a flat surface and forming a map visible in only two dimensions.

Photogrammetry is the technique of making horizontal and vertical measurements from air photos and producing maps which present these details.

ANALYSIS AND INTERPRETATION

Air photo analysis and interpretation are necessarily complementary to one another. The analysis comprises a study of the photographs to determine all relevant information. The interpretation consists of the application of this information, and perhaps other data, to the solution of a particular problem.

Air photo analysis and interpretation requires the ability to relate photographic detail with physical features of the terrain, a firm base in the geological sciences, detailed geological knowledge of the locale, and finally the ability to combine the data and to apply the results to the solution of a specific engineering problem.

ROUTE SELECTION

The process of route selection illustrates many of the steps and procedures involved in typical photogrammetric projects. While route selection may be carried out for roads, pipelines, electric transmission lines and so forth, the differences in technique are minor and vary only to the extent imposed by the particular design.

PROCEDURE

1. Acquisition and examination of existing data. This will include aerial photographs, topographical maps, soils maps, regional geology and any other applicable data. Aerial photographs usually are available from government or private agencies, but may have to be specially taken in some cases.

2. A broad corridor containing possible routes is outlined on a strip mosaic. A general photo examination is carried out with regard to topography, soils and geology. Such factors as muskeg, rock, river crossings, permafrost and the necessary amount of clearing are examined. The examiner must consider any factor which will affect the eventual design or cost of the project. At this stage a trial route is selected, which generally represents the shortest economic distance between the initial and terminal points of the line, having regard to the general character of the terrain.

3. Stereo photo interpretation is carried out, with attention being given to the economics involved in

any route diversions.

4. Having examined the obvious natural factors controlling the route, and the economics of diversion, the merits of detailed photo engineering are considered. Should ground inspection show only difficulties of a minor nature, it is possible that the exercise may be terminated at this point. Construction drawings would be prepared, utilizing the existing information, and supplemented by data gathered from on-the-ground inspection. Should, however, major problem areas be evident, it is likely that the analysis would be further refined.

5. Detailed photo engineering is carried out in the problem areas. This generally requires that larger scale photographs be acquired, the scale being dependent upon the vertical accuracy required for mapping. It should be noted that the cost of "fresh" photography is usually small, relative to other costs of the project. Ground control requirements are minimal at this stage, however a few basic control points can be supplemented by methods of aerial triangulation carried out on the stereo plotter.

6. Detailed mapping, showing perhaps 2 foot or 5 foot contours, is constructed using the stereo plotter. This mapping is reproduced on Cronaflex working sheets, which are designed in a fashion such that engineering information (profiles, terrain characteristics, clearing required) can be clearly depicted.

7. Utilizing this working information, the final design is prepared. For a road system the route and centre line is laid out with the necessary curves, P.I.'s and stations to allow for the optimum design of grades. When the centre line has been selected, cross section data is read out in X, Y and Z co-ordinates, volumes calculated, costs estimated, and specifications prepared for construction. Pipeline projects generally require only a centre line location and profile.

Most of the output from the stereo plotter, and the subsequent computations, are amenable to computer processing. For example, cross-sections and profiles are easily digitized in three axes. When data such as soil types, haul distances, costs and other design restraints are tabulated, the computer can be used to examine alternatives and to determine the optimum solution for any of the design parameters, or for total cost. This marriage of the information obtainable from the photographs and the processing capability of the computer allows a large amount of information to be manipulated and stored.

The most significant point from the foregoing is that the degree of interpretation can be varied to suit the requirements of the project, thus maximizing the benefit-cost ratio. Simple pipeline locations in some cases require no ground access or field control prior to final route selection. More elaborate projects generally require some field inspection, however this is usually in the nature of confirmation in a few problem areas. Field survey work is greatly minimized because the majority of this work can be carried out by aerial triangulation procedures on the stereo plotting instruments, rather than by ground methods.

The advantages of this approach in reducing costs, especially in remote or difficult terrain, become obvious. Also, the confidential analyses possible with these procedures can be of great benefit in certain situations.

WATER SOURCE INVESTIGATIONS

A water supply may be required for secondary recovery operations, a temporary campsite, or other purposes. Air photo interpretation will save time and reduce costs in assessing the possible sources of supply.

An inspection of the site and utilization of other relevant data are always necessary adjuncts to a water source study employing aerial photos.

A. SURFACE WATER

The usual points of concern in the development of a surface water supply are:-

1. Distance to the point of delivery
2. Accessibility and terrain
3. Surface area of a body of water
4. Area and character of a watershed
5. The possibility of developing a dam-site and reservoir on a watershed, and the consequent effects.

Aerial photographs can provide valuable assistance in assessing these factors, and in deciding upon the extent of ground reconnaissance and surveys necessary. Data such as soil characteristics and water quality, obtained from the testing program, is then combined with the information from the aerial photos in the final analysis of the problem.

B. GROUNDWATER

Groundwater investigations require the intelligent use of many disciplines. Aerial photos are an extremely valuable tool in studies of this type, but they never should be used as the sole tool. Geophysics is a useful aid in some cases, and test drilling is always required.

A trained photo-geologist often can determine the presence of various groundwater host horizons such as:-

- buried bedrock valleys
- glacial deltas and outwash deposits
- glacial meltwater channels
- gravel bars and abandoned stream channels adjacent to existing stream systems
- alluvial fans

The aerial photos serve to narrow the field to the most favorable points for exploration. Continuous inductive and deductive reasoning is applied to the surface and down-hole information produced in the course of the investigation.

Following test drilling and pump testing to prove a suitable supply of water, the well must be completed to suit the water-bearing horizon. Very often it is at this stage that the entire program is unsuccessful. Many individuals fail to realize that a water well is a refined intake system requiring as much precision design as any other aspect of the project.

SITE LOCATIONS

Air photo interpretation is used extensively to select feasible sites for airstrips, processing plants, water reservoirs and construction camps. While special features such as level ground generally are required for these facilities, many additional factors can and should be examined by a capable interpreter. Natural features of the landscape, as they affect eventual design and construction, are especially important. The type and depth of soil, availability of aggregates, evidence of permafrost, presence of springs or high water tables and the prospect of adverse drainage are but a few of these factors which are determinable from air photos and which should be taken into account.

Quantities of material to be excavated, and haulage distances, can be estimated with reasonable accuracy from photogrammetric mapping, and eventual economics of the project determined.

It is stressed that in most cases this data can be obtained without clearing the tree cover or surveying the property.

It should also be noted that site inspection by airplane or helicopter, while often desirable, cannot fully replace photo-interpretation, because orientation becomes difficult, the overall view of the project can be lost at low altitudes, and one must rely upon memory to provide details.

CONSTRUCTION MATERIALS

The use of aerial photos in the search for construction materials has been common practice for a number of years. Typical materials which might be the object of a search are:-

- gravel and sand for concrete aggregates, roadbeds, fill, and bedding in pipeline ditches

- impervious clays for lining water reservoirs, earth fill dams and dykes

- rock for railway ballast, roadbed fill, crushed aggregates and rip-rap

Aerial photos permit a rapid geological appraisal of a large area, and the delineation of what are sometimes relatively small areas for specific testing of material quality and quantity. Haul distances and accessibility affect the economics of material retrieval, and these are easily determinable from the photos.

In many cases, geological knowledge of landforms, erosional features, stratigraphy and lithology is sufficient to partly assess the quality and quantity of the deposits, even before ground examination.

LOCATION OF BURIED PIPELINES

Under certain circumstances, buried pipelines, or more properly the pipeline ditch, can be located from aerial photographs. The ground disturbance caused by original ditching and backfill operations may retain its character for a very long time - cases have been noted where unsurveyed pipelines are clearly detectable in farmed fields over 10 years after the original installation. On-the-ground inspection yields no sign of this disturbance.

As noted before, the sophisticated photogrammetric machines in use today can plot the location of these features with great accuracy.

The type of sub-soil is a critical factor in analyses of this sort. A pipeline ditch is likely to leave a more detectable scar in rocky sub-soil for example, than in sand or clay.

A typical application of this technique occurs in cases where gas or two phase pipelines are to be installed under unsurveyed existing flowlines, perhaps as part of a battery consolidation or gas gathering scheme. A narrow corridor can be examined and intersection points with existing lines plotted and related in terms of the distance to various ground control points. The usual problems of contact with existing lines or of excess hand digging during construction are therefore minimized.

RIVER CROSSINGS

Comprehensive and detailed examinations of sites for river crossings are easily made from aerial photographs. The following data generally are required:-

- width of the crossing

- character of the river bed, water flow patterns

- gradient of the river

- soil type, evidence of sliding tendencies, presence of permafrost

- profiles of the river and banks

In cases where there are several possible sites for a river crossing, enough of the required information usually can be gained from air photos to select the best site before detailed testing is commenced.

MISCELLANEOUS

Many other applications are possible as a result of intelligently applied interpretative techniques:-

- river flow patterns often can be established and related to future behaviour

- muskeg depths can be estimated from analysis of the type of the deposit and the character of the surrounding terrain

- areas of permafrost can be delineated and mapped. This data generally is presented in terms of probability of occurrence, then confirmed with shallow tests

- inventory control can be accomplished by accurately measuring the dimensions, then computing quantities, for such materials as stockpiled sand, gravel or construction materials

- land use and resource studies often assume more relevance when reviewed at regular intervals by the aerial camera

New techniques, such as color and infra-red photography, are being used more extensively and show much promise for the future.

SUMMARY

Air photo interpretation and photogrammetry, in common with most investigative techniques, cannot be viewed as the solution to all problems. They are often relevant only insofar as they are applied properly and combined with other methods of investigation. Properly utilized, however, they can provide the following unmatched advantages:-

1. Low cost, especially in remote or difficult terrain

2. Adaptability to a wide variety of problems

3. Accuracy, which can be easily varied to suit the requirements of the project

4. Secrecy in the initial stages of a project, since detailed ground examination is seldom required at this point

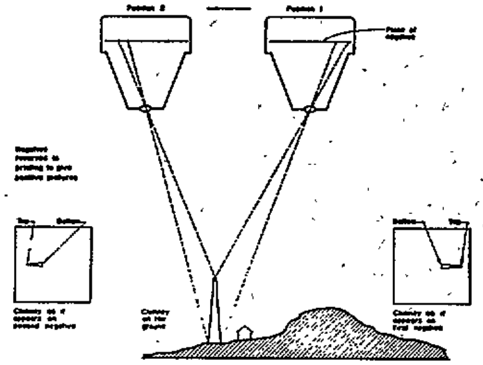
5. Speed of data acquisition

It is stressed that while precision photography provides a record containing an infinite amount of information in visual form, the full potential of this medium can only be developed by way of the interpretational capabilities of skilled operators.

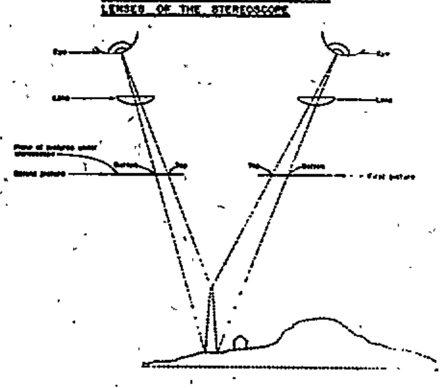
Also, while the degree of accuracy and the number of calculations can be optimized for any problem, the ultimate constraints always will be the permissible expenditures of time and money.

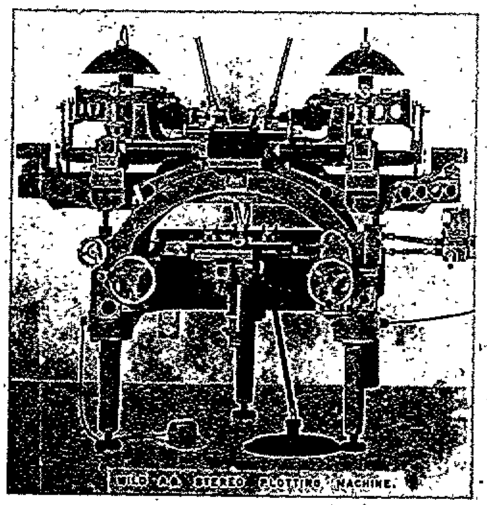
The application of air photo interpretation and photogrammetry to oilfield projects is still in its infancy. There is no question that this field will continue to grow rapidly, as the particular advantages which it offers are recognized more widely.

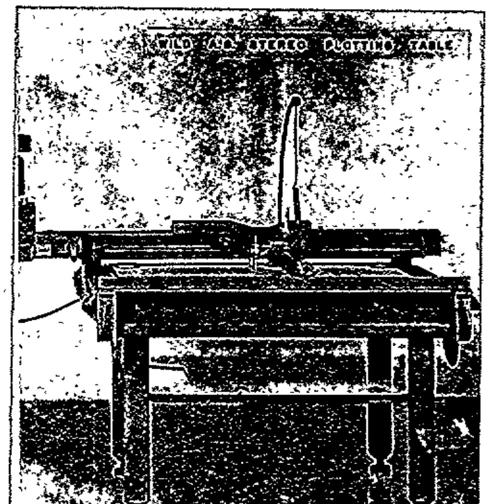
VIEW AS SEEN BY AERIAL CAMERA

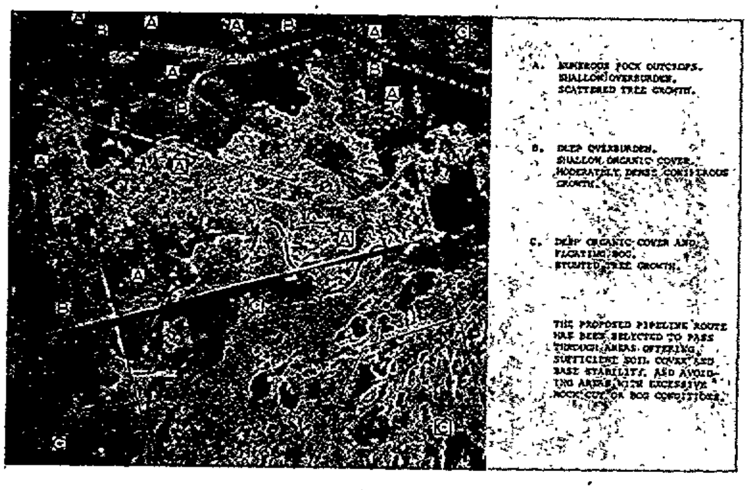


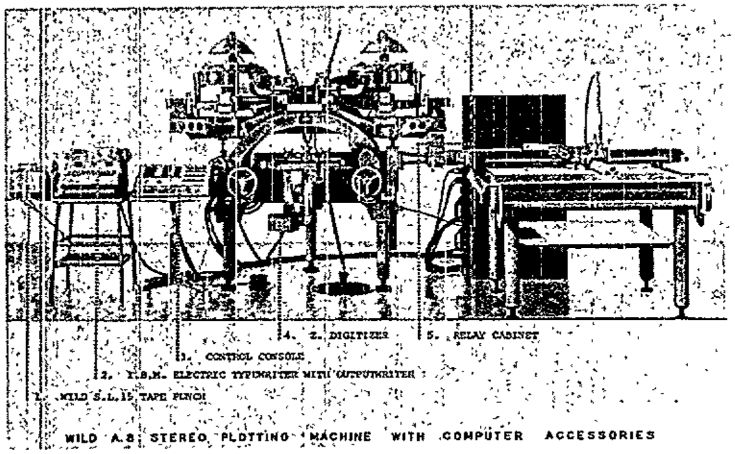
VIEW AS SEEN BY OBSERVER THROUGH LENSES OF THE STEREOSCOPE

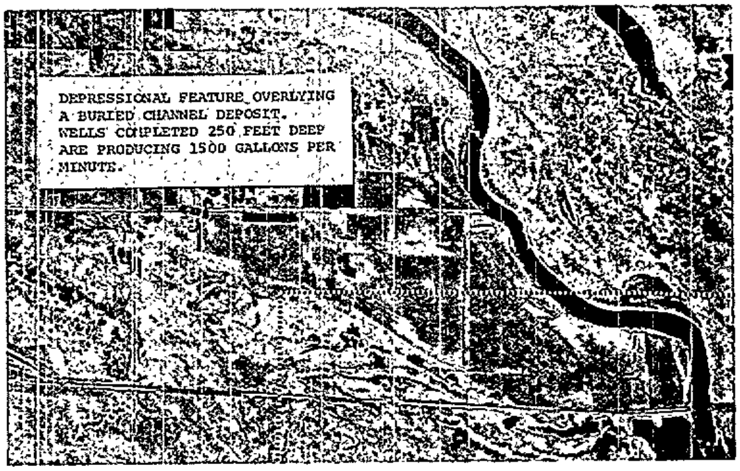


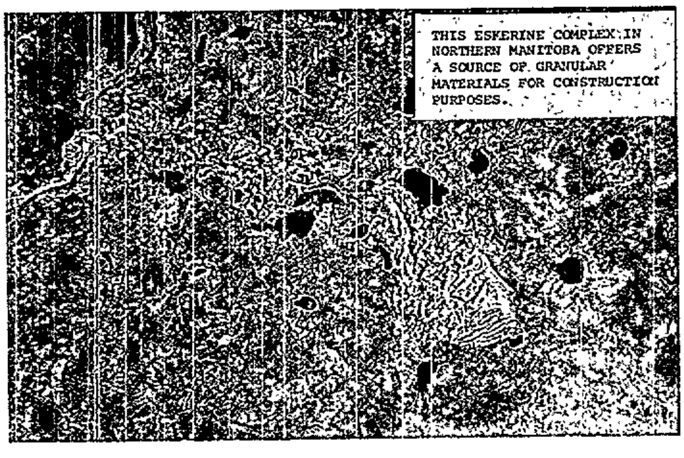


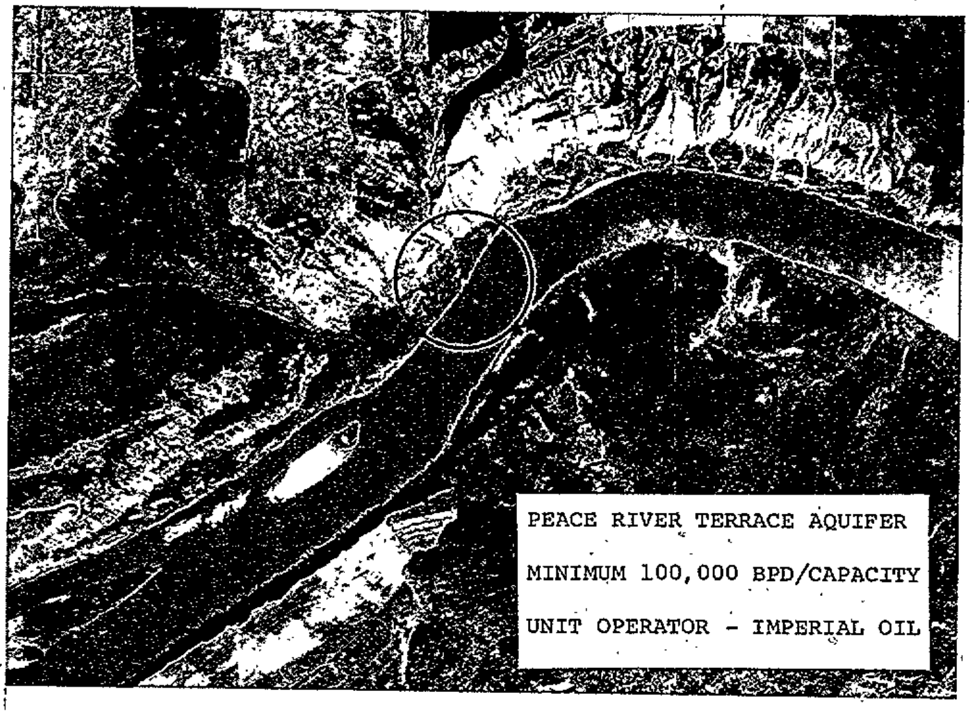


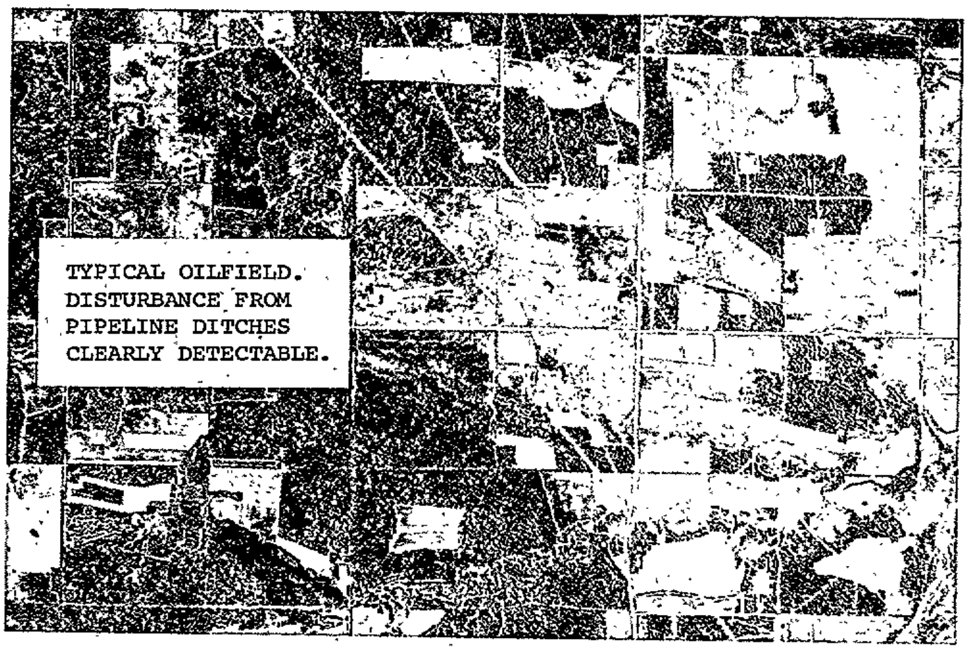



4. Z. DIGITIZER
5. RELAY CABINET
3. CONTROL CONSOLE
2. I.B.M. ELECTRIC TYPEWRITER WITH OUTPUTWRITER
1. WILD S.L.15 TAPE PUNCH
WILD A.8 STEREO PLOTTING MACHINE WITH COMPUTER ACCESSORIES


DEPRESSIONAL FEATURE OVERLYING A BURIED CHANNEL DEPOSIT.
WELLS COMPLETED 250 FEET DEEP ARE PRODUCING 1500 GALLONS PER MINUTE.


THIS ESKERINE COMPLEX IN NORTHERN MANITOBA OFFERS A SOURCE OF GRANULAR MATERIALS FOR CONSTRUCTION PURPOSES.


PEACE RIVER TERRACE AQUIFER
MINIMUM 100,000 BPD/CAPACITY
UNIT OPERATOR - IMPERIAL OIL


TYPICAL OILFIELD.
DISTURBANCE FROM
PIPELINE DITCHES
CLEARLY DETECTABLE.