Use of Soil Survey Data by the Small Highway Organization

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THE small state or county highway organization is often reluctant to adopt methods being used by highly trained technicians in large highway organizations. Usually benefits can be derived in the small organization simply by changing from negative to positive thinking and "getting started." It is practical to enter into the use of some of these methods with existing personnel and very little initial investment. The purpose of this article is to show that a start can be made by any individual or small organization and that even the relatively inexperienced can make practical application with gratifying results.

Wyoming sent one employee to the "Airphoto Short Course" at Purdue University in Lafayette, Indiana in April of 1948. This course was for the duration of one week, and was designed to provide instruction in the techniques of interpreting soils and engineering problems from aerial photographs. Since that time, much interest has been aroused among the project engineers, due primarily to the time being saved by determining drainage areas on airphotos instead of the conventional traverse method, with costs dropping as much as 80 percent.

Some engineers have observed examples of poor alignment after having purchased airphotos for drainage area determination, and now insist on the purchase of airphotos prior to location, therefore their use is gradually being enlarged to include alignment, selection of stream crossings, location of land ties, determination of drainage areas, location of granular materials, soil survey, etc. Use of airphotos has developed an interest in geology and agricultural soil maps.

Geologic maps, agricultural soil maps, or aerial photographs often point out pertinent data, to the interested (although relatively untrained) state or county highway engineer, that are applicable to location, soil survey, location of construction materials, design, and maintenance. Some of these data are often overlooked during on-the-ground studies, and use of these aids usually results in less field work, more satisfactory results, and reduced costs. Where purchase of maps or photographs is not possible, due either to time or money, it is sometimes possible to secure them on loan from other local state or government agencies.

Interested engineers will improve their techniques with experience and occasional assistance. Mistakes will be made, limitations will be reached, but the overall level of efficiency will continue upward, and the entire organization will gain a feeling of satisfaction from the accomplishments made.

● THE project engineer in Wyoming makes his own materials survey and soil survey on preliminary projects, under the supervision of the construction engineer. Occasionally he asks for aid from the central laboratory, or aid is given him if there are special problems on the location. The central laboratory staff is small, so the time and assistance given to project engineers has been limited.

The laboratory has furnished project engineers a "Soils Manual" which explains briefly most phases including preliminary sampling, preliminary design, construction control, and construction redesign. The laboratory provides available agricultural soil maps, geologic maps, and airphotos for the engineers and gives instruction in their use.

The laboratory often makes a field

review of preliminary design with the project engineer after the soils and material samples have been tested. Frequently this is the first on-the-job contact made between the project engineer various pavement substructure components are taken to indicate the variations in each and submitted to the laboratory for testing in order to check preliminary design or make any indicated revisions.

SIXTH ANNUAL FIELD CONFERENCE—1951

THIRD DAY OF CONFERENCE

Friday, August 3, 1951

Separation Flats and South Side Sweetwater Uplift

Driving Distance — 175 miles

Road Log by George R Veronda, Ohio Oil Company, and Carney Soderberg, Carter Oil Company.

The final day's route will proceed through portions of Separation Flats, the northeast part of the Great Divide Basin, and will cross the southern edge of the Sweetwater Uplift, an expanse of granite hills protruding through slightly folded White River beds. Portions of the area are complexly faulted and folded, and the structure of Cretaceous and older rocks is in places completely masked by Tertiary sediments or by broad areas of migrating sand dunes. The rich potentialities, as well as the exploration problems inherent in the area, are illustrated by various producing fields which will be visited.

Road Log

0 0 Sinclair Hotel Proceed west on U S Highway 30

6 6 Fox Theatre Rawlins on left Turn right on U S Highway 287.

7 1 North gate Rawlins Cemetery Cars of participants staying in Rawlins will join caravan at this point Proceed north Route for next 15 miles will be over road covered by previous logs along east flank of Rawlins Uplift, with Permian to Cambrian sediments and pre-Cambrian granite well-exposed on the left side of highway and Triassic to Cretaceous beds visible on right Thin veneer of gravel covers bedrock in immediate vicinity of road for several miles

19 8 Right Forelle limestone across draw overlain by Chugwater and ledge-forming Alcova limestone

20 6 Left Dinwoody and Phosphoria overlying Tensleep

39 8 11 o'clock Lost Soldier field Wertz Dome on bench to right of Lost Soldier Both fields produce from numerous zones from Frontier to Cambrian and form one of the most prolific producing areas in the Rocky Mountain region Refer to Lost Soldier-Wertz photo-mosaic page 104

41 0 Lamont State secondary road leads left to Bairoil camp of Sinclair Oil and Gas Company Continue straight ahead Derricks to right are on Bailey Dome producing from Nugget and Tensleep sands

41 9 Right Sandstone in upper Steele shale

42.2 Road curves right and crosses Steele-Mesaverde contact along dugway Beds dipping north into Camp Creek syncline between Ferris Mountains and east-west trending producing areas

COURTESY OF WYOMING GEOLOGICAL ASSOCIATION

Figure 1. Use of geologic maps. A partial reproduction of a road log from a geological association guidebook. Such road logs are helpful to highway engineers, along with geologic maps, in familiarizing themselves with local formations. More detail can be obtained from the geologic atlas for the area or from publications listed on the state geologic-map index.

and the laboratory, so some adjustments may be required in the tentative preliminary design as set up by the laboratory. Consideration, at this time, of the use of local granular materials often suggests further investigation on the materials survey.

Throughout construction, samples of the Often the engineer is able to anticipate needed changes, through the tests made by his own field-laboratory personnel, and makes the necessary adjustments in subgrade width and grade, within practicable limits, prior to receiving the construction recommendations from the central laboratory.

AIRPHOTOS

The first airphotos were purchased by the Wyoming Highway Department in 1948 for use in location of granular materials (1). Next the engineers began to use air-

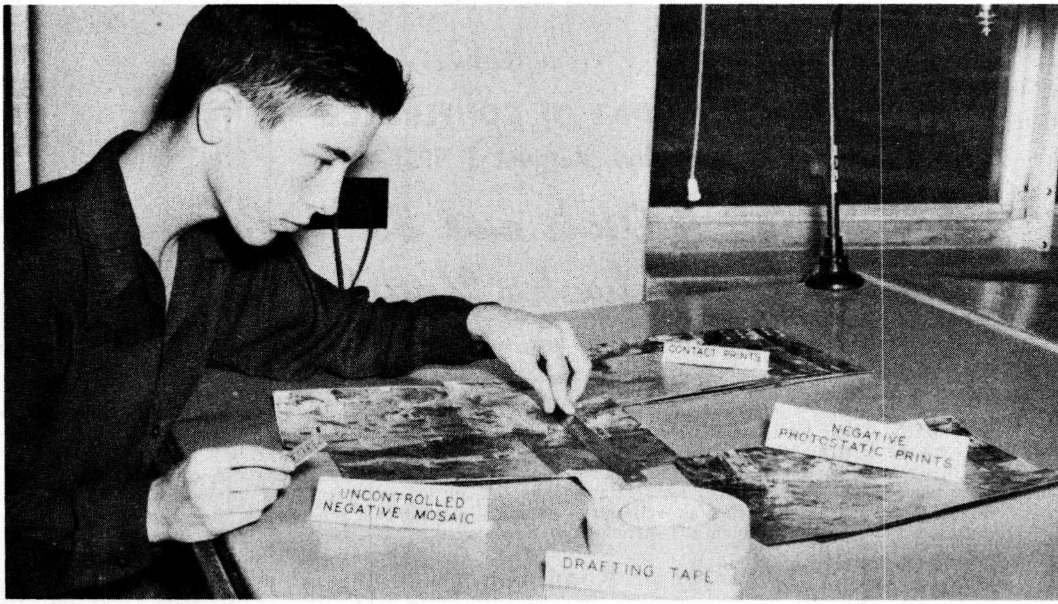


Figure 2. Preparation of an uncontrolled negative mosaic. Negative photostatic copies are made from the original contact prints, trimmed to match lines, and secured on the back with drafting tape. (Original airphotos, courtesy of Production of Marketing Administration).

photos for determination of drainage areas, estimating savings up to 80 percent over the conventional traverse method. Costs of airphoto coverage on most projects have ranged from $10 to $100.

Interest developed among the engineers in the use of airphotos slowly but increased as each engineer became more familiar with them. All project engineers now have pocket stereoscopes, costing approximately $10 each. As they continue to use the airphotos for the solution of one problem, the practical approaches to other problems have become evident.

The prominent surficial features displayed by stereostudy of the airphotos in this state have tended to create an interest in geology and agricultural soil maps.

GEOLOGIC MAPS

Some of the engineers have had limited training in geology, yet this has not eliminated them from gaining some knowledge in that field for their own practical use. Usually an engineer is concerned with only one county, and by using the county geological map, with road logs from one of the annual field geological

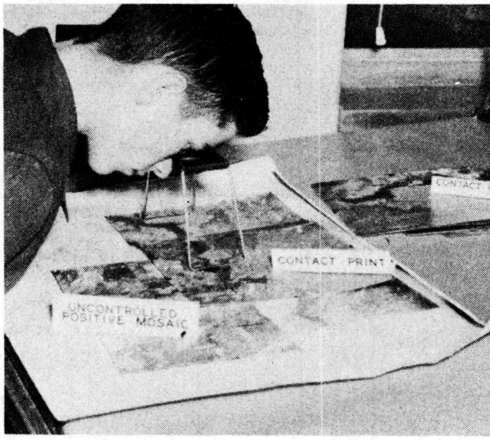


Figure 3. Uncontrolled positive mosaic. This uncontrolled positive mosaic is in the Harrison formation of eastern Niobrara County and was obtained by making a photostatic copy of the negative mosaic shown in Figure 2. Contact prints may be used on such a positive mosaic for stereostudy.

conference publications[1], Figure 1, plus the geologic atlas or folio for the area, he has acquainted himself with many different formations and is able to recognize some of their inherent characteristics as applicable to location, soil survey, design, construction and maintenance in his own area.

[1] The different state geological societies usually compile a guidebook for their annual field conferences, containing maps, airphotos, photomosaics, columnar sections, road logs, etc., of the areas involved. These are available at state libraries or USGS offices.

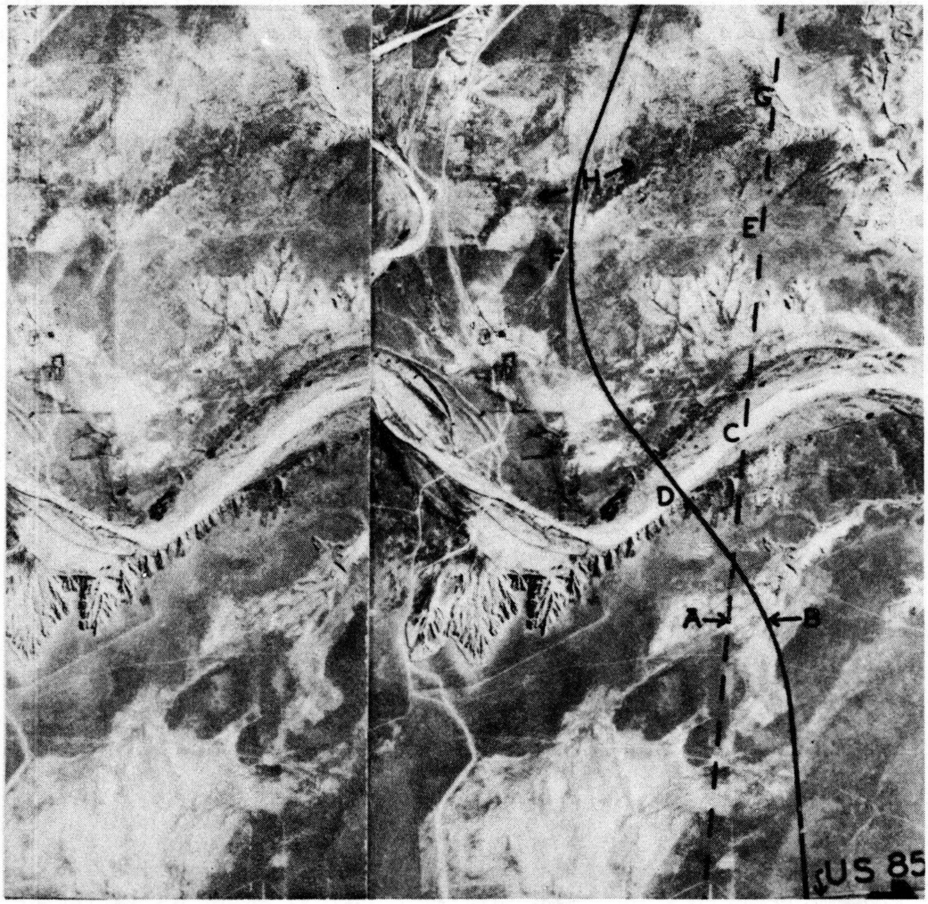


Figure 4. Airphotos on highway location. A stereopair in Niobrara County showing original alignment (A) at one end of a secondary location and the revised line (B). The revised line was developed by the engineer after securing airphotos for drainage area determination and deciding that the alignment could meet lower standards. The three-span, continuous, R.C. girder bridge required at D was at least one span shorter than required at C. Going through the saddle at F eliminated the adverse grades and deep cut that the hill at E would have necessitated. Alignment on the drainage division at H eliminated two drainage pipes required at G. This is in the Brule formation, Upper White River. (Courtesy of Jack Ammann, photogrammetic engineer.)

AGRICULTURAL SOIL MAPS

Agricultural soil maps have been compiled on very few areas in Wyoming, but where the soil maps are available some of the engineers have utilized them on location, soil survey (3), materials survey (1), design, construction, and maintenance.

LOCATION

Airphotos, geologic maps, and agricultural soil maps are being used advantageously on many locations by the highway engineers. In building up their knowledge of conditions and soil types through areal classification of soils by airphoto interpretation (2), or in different members of the geological formations, or the engineering interpretation of agricultural soil maps (3), the engineers are improving their methods of selecting the better terrain on the highway location where more than one route is practicable between any two points.

One method being used, when a controlled airphoto mosaic is not available, is to compile an uncontrolled airphoto mosaic by making negative photostatic copies from the contact prints (Fig. 2); the negative copies are trimmed to match lines and secured on the back with drafting tape; a photostatic copy is then made from the negative mosaic bringing it back to positive (Fig. 3). The original contact prints are used on this uncontrolled positive mosaic for stereostudy in transferring the geology (4), or soils data onto the mosaic.

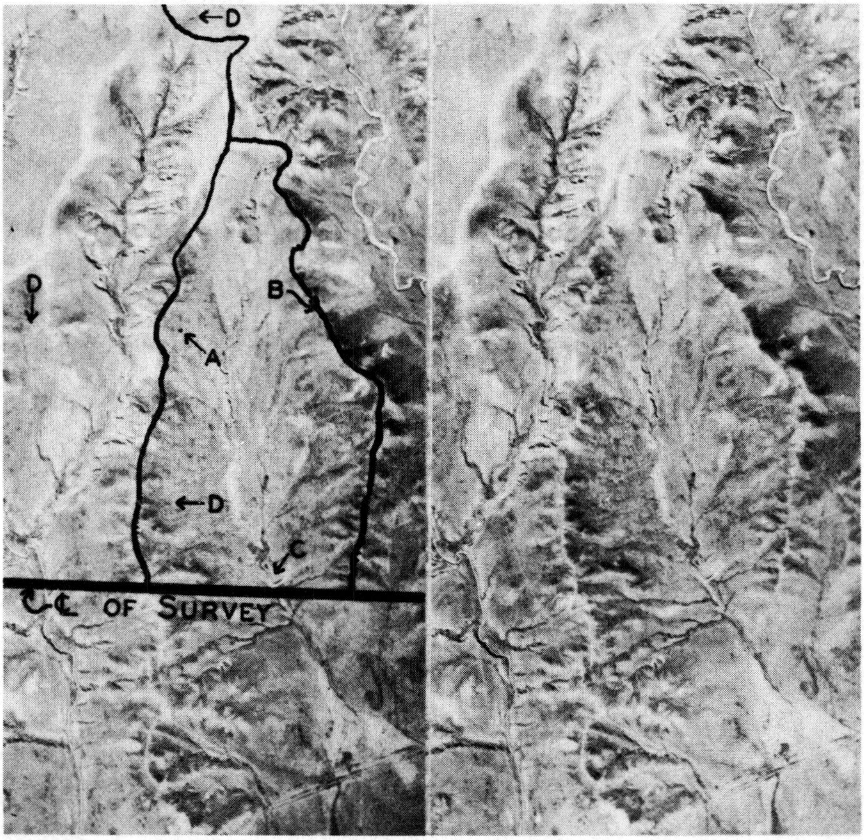


Figure 5. Airphotos for drainage areas. A stereopair in Converse County showing section corner at A; outline of drainage by line B; small dike at C just ahead of the proposed drainage structure; fence lines at D. Areas are computed by use of the planimeter, which requires no special setting, and formula $x/a = b/c$, where x = acreage of a specific drainage area, a = planimeter reading around the specific area, b = 640 acres in one sq, mi., c = planimeter reading around 1 sq. mi. This is in the Brule formation, Upper White River. (Courtesy U.S. Geological Survey.)

Much of the required reconnaissance can be made on this type of a mosaic, or with only the contact prints if the engineer does not prepare such a mosaic, and the different alignments are plotted as the survey progresses, including land ties, ownership, etc.

Figure 4 is an example of the changes in

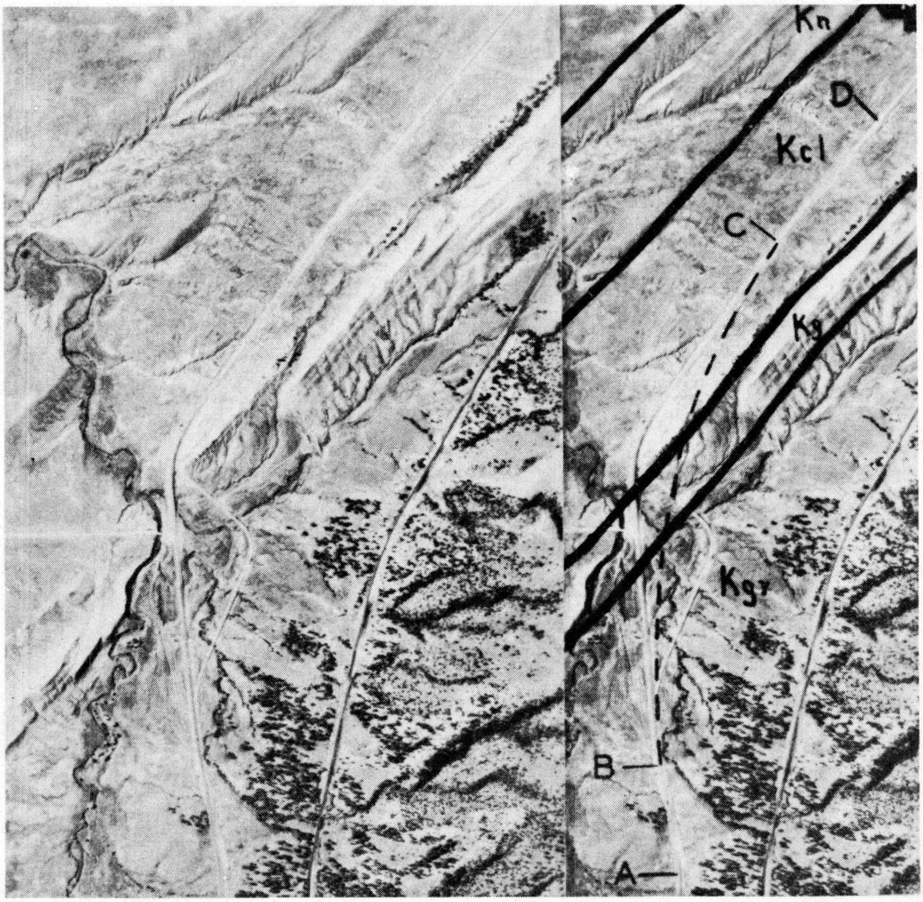
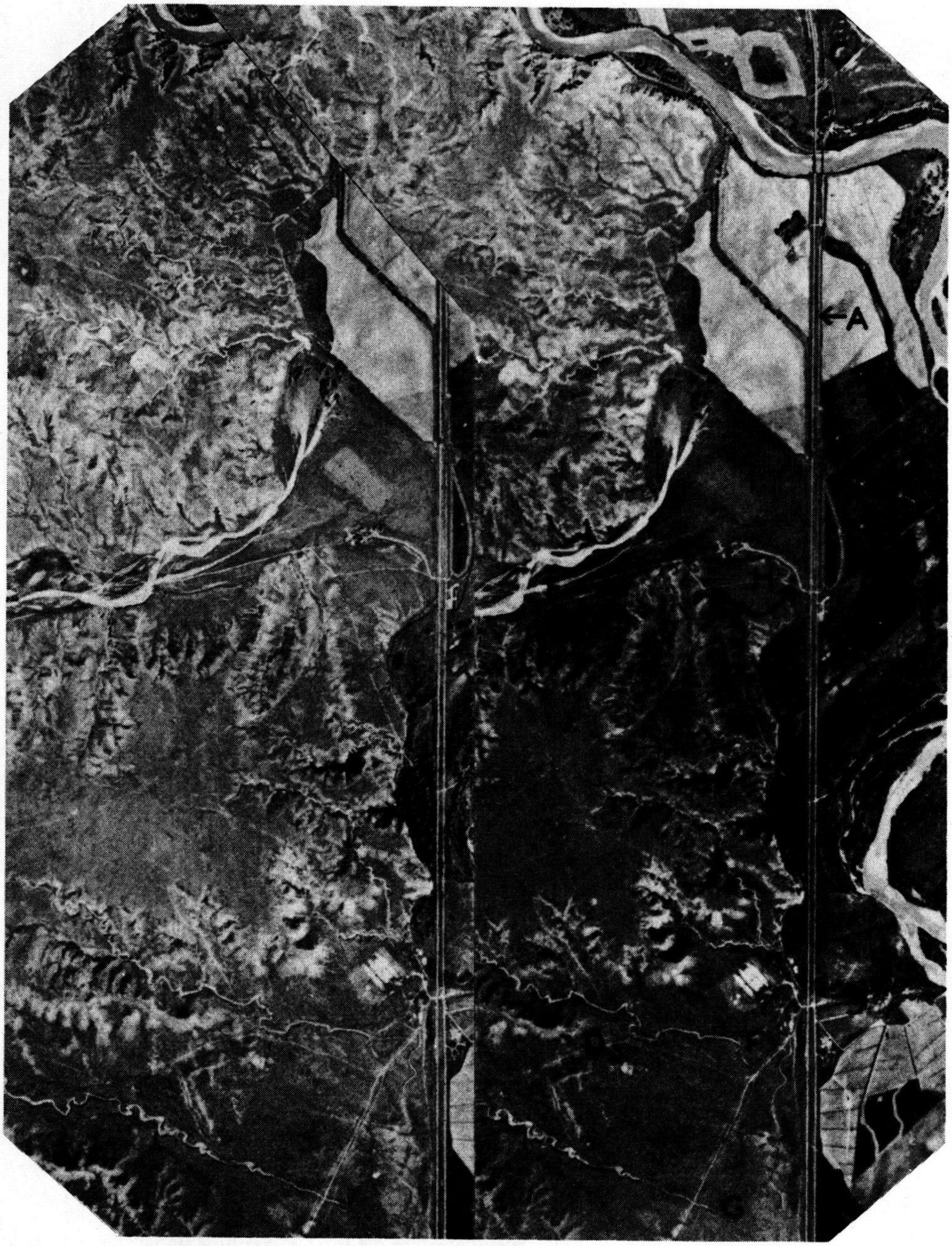


Figure 6. Geologic maps for soil survey. A stereopair prepared for checking the design set up by use of a geologic map in an on-the-ground soil survey for a short reconstruction project in Weston County between A and D, including a line change between B and C, the geologic map indicated that the first portion of the survey was in the Granerous shale (Kgr) and the latter portion in the Carlile shale (Kcl). On other projects in this general area the residual soils from these formations had shown a modified C.B.R. of 3.0 percent or less, which required maximum design thickness based on a design curve selected by equivalent 5,000-lb. wheel loads and job conditions (5). The project was set up for maximum design as any other considerations would have been based on the narrow band of Greenhorn limestone (Kg) dividing these two formations and would depend on construction control, so they will best be worked out during construction. These conclusions were reached by two engineers in approximately ½ hr. on the ground with only the geologic map. (Courtesy of Jack Ammann, photogrammetric engineer.)

alignment made by an engineer near one end of a state secondary project, after the alignment was supposedly completed and airphotos had been purchased for drainage-area determination.



DRAINAGE AREAS

When the final alignment has been selected, the drainage areas are determined by planimeter after the drainage boundaries are traced out on either the airphoto contact prints (Fig. 5) or on an enlarged uncontrolled airphoto mosaic that includes all the drainage. Often the larger drainages have been determined from the airphoto-index sheets, county maps that have been prepared from airphoto bases, or topographic maps.

On one 9.25-mi. location, two engineers with airphoto contact prints computed all

Figure 7(b). Ground view of terrace face (foreground) in Figure 7(b) at H. There was no evidence of granular materials at or near the surface.

drainage areas in half a day where it was estimated that the standard practice of running field traverses around the areas would have taken 6 days in the field plus the office time required for reducing the notes.

Figure 7(a). Location of granular materials. Stereopair in the Brule formation and alluvium of southern Converse County where, for reconstruction of the highway (A), through B and C, the gravel deposits immediately adjacent to the river were not desirable due to the more valuable land, and the clean materials requiring the addition and processing of filler and binder from separate sources.

Terrace deposits near the old pit location at D, and a new location at E, were limited in quantity. By extensive ground reconnaissance, the project engineer located a large gravel deposit at F after first observing granular material near the end of the gully, Figure 7(c).

One engineer with some knowledge of airphoto interpretation (but without airphotos) called attention to the terrace at H, over which the country road (I) passed to reach the terrace deposits at E, and although there were no surface indications on the face of the terrace, Figure 7(b), investigation showed a soil profile of 5 ft. of silty overburden, 5 ft. of fine gravel, and 5 ft. of gravel.

An engineer with airphotos, and a little knowledge of their application to materials investigation, would have placed F, G, and H among the first places to investigate, for disappearing gullies usually end in a granular material, and prominent terraces, like that at H, almost always merit investigation. (Courtesy of U.S. Geological Survey.)

SOIL SURVEY

In using geologic maps for soil survey, Figure 6 is an example of how they have been used to reduce, or eliminate, field sampling and laboratory testing. This stereopair, including the geologic contacts (4) was prepared later for checking the field work.

Geologic maps have proved more useful on soil surveys when used in conjunction with airphotos (2). Although they have been used together satisfactorily on projects up to 20 mi. long (6), their use has been

Figure 7(c). Ground view of gully bottom in Figure 7(b) at F prior to investigation of the area. Note the dense grass and brush adjacent to the gully.

limited to selected areas and formations in the state, which are being enlarged as experience is gained. There are many areas, where more detail is needed, wherein such methods for soil survey appear to be impractical.

LOCATION OF GRANULAR MATERIALS

The first location of granular materials through the use of agricultural soil maps and airphotos by the state highway department was initiated in the spring of 1948.

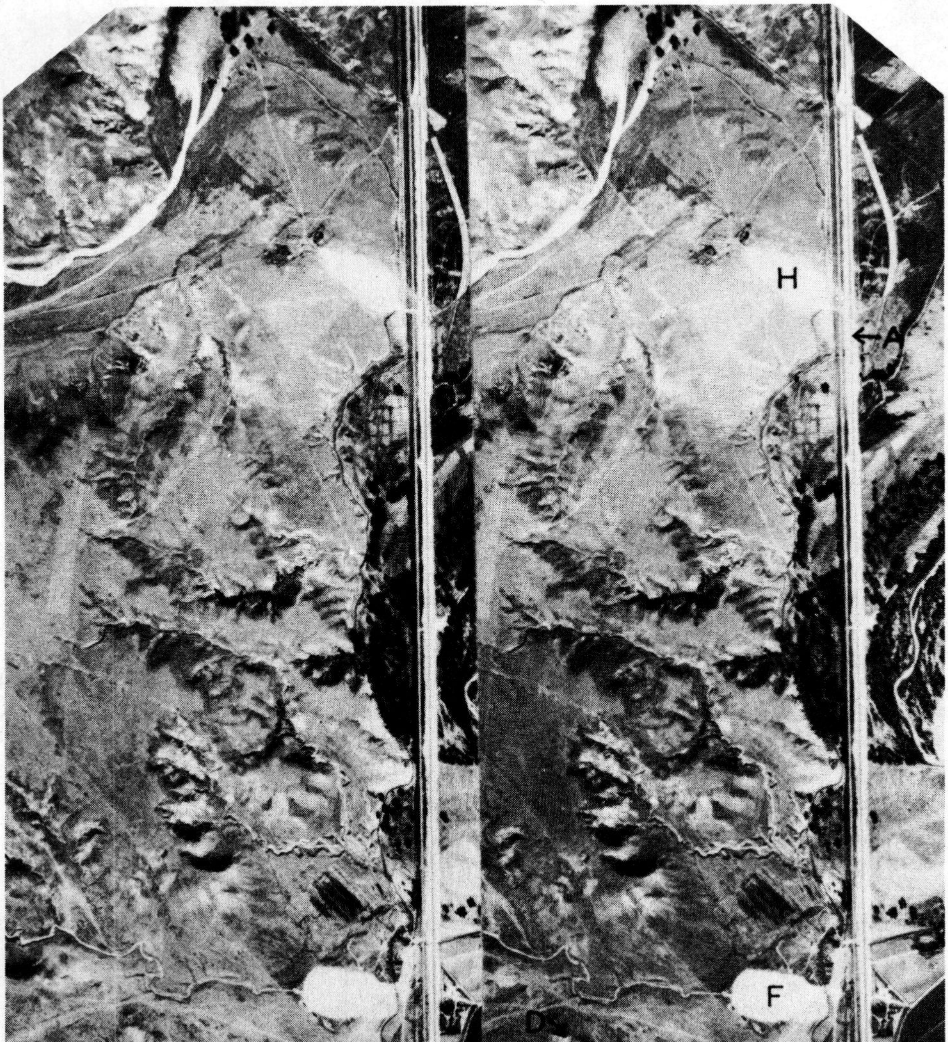


Figure 8(a). Same as Figure 7(a) but showing the area after the pits located at F and H had been used for subbase on the reconstruction of the highway (A). Figures 8(b) and 8(c) are ground views of pits at F and H respectively. A new terrace pit was developed at X with sufficient quantity of gravel for the crushed base. (Courtesy of Production and Marketing Administration.)

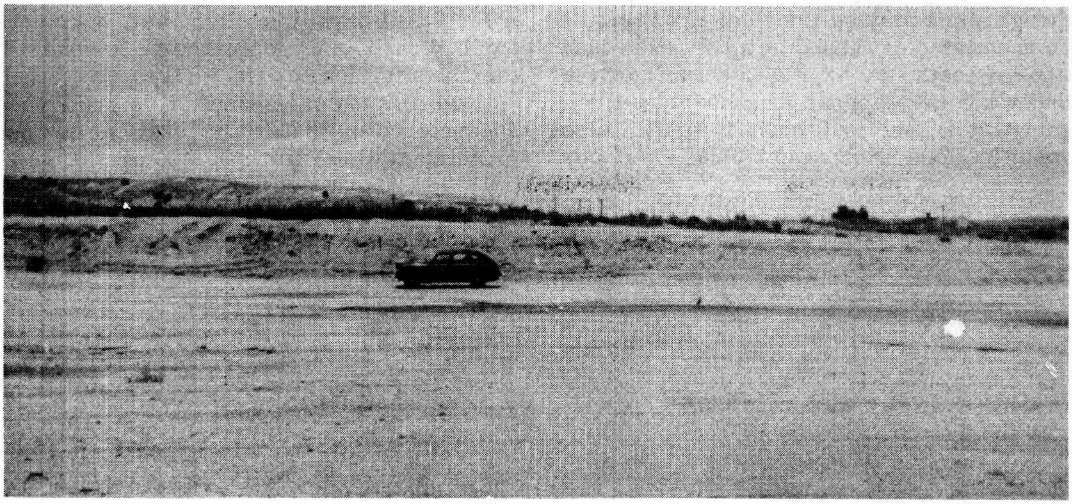


Figure 8(b). Ground view of pit that was developed at F in Figure 8(a).

The first 2 hr. in the field with the airphotos located a 25,000-ton deposit of quality gravel in the middle third of a 20-mi. project where previous investigation had only located deposits near each end of the project (1).

In the past 5 yr. many satisfactory granular materials have been located and used in areas that had previously been accepted as being without any such deposits. Airphotos are not always needed in these investigations, for once an engineer changes from negative to positive thinking and gets started, materials have been found adjoining or closely adjacent to the project. However, if it becomes necessary to investigate large areas the airphotos have proven to be invaluable in selecting the most-promising areas to investigate (7), as well as the necessary reconnaissance routes through the areas.

The technique used has been to make a hurried reconnaissance by car through the area to examine existing pits, contact the land owners, and attempt to locate materials. It is imperative that all known

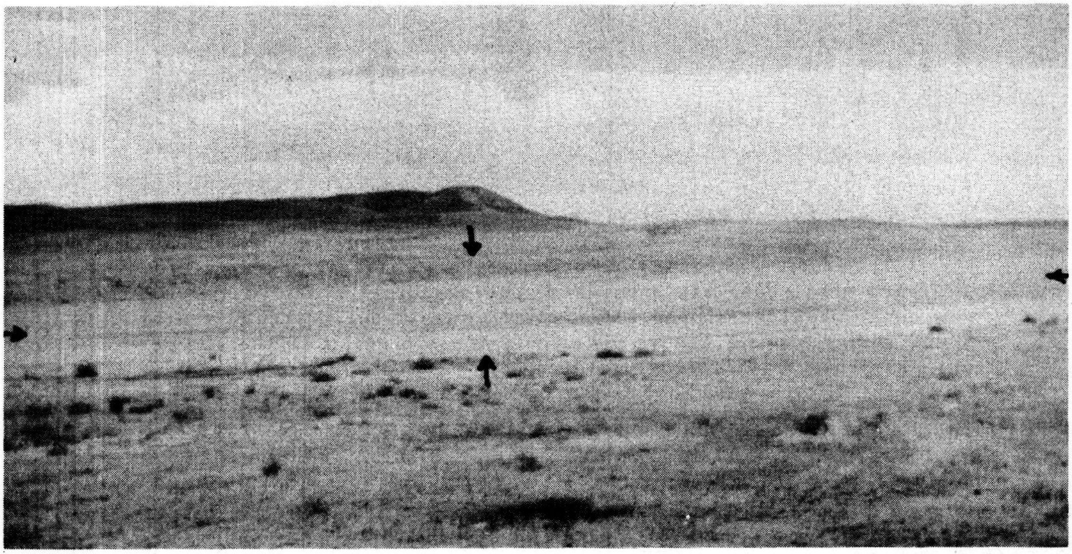


Figure 8(c). Ground view of pit developed on the north face of the terrace at H in Figure 8(a).

deposits be investigated at this time, even though some may be considered exhausted or unsatisfactory based on a past examination or tests, as experience has proven that what may appear unsatisfactory will sometimes test out satisfactorily, also specifications change periodically. If this fails, airphoto coverage is either borrowed from other local federal or state agencies, or purchased. Geologic maps and data are assembled, as well as any agricultural soils maps available, and a materials survey is started by briefly instructing the engineer in the use of these aids (8) as a more-thorough reconnaissance is begun. After 1 to 3 days the interested engineer has had sufficient understanding to conduct the investigation satisfactorily.

Figure 7 indicates some of the problems encountered in materials location on one project, while Figure 8 shows the pits after use.

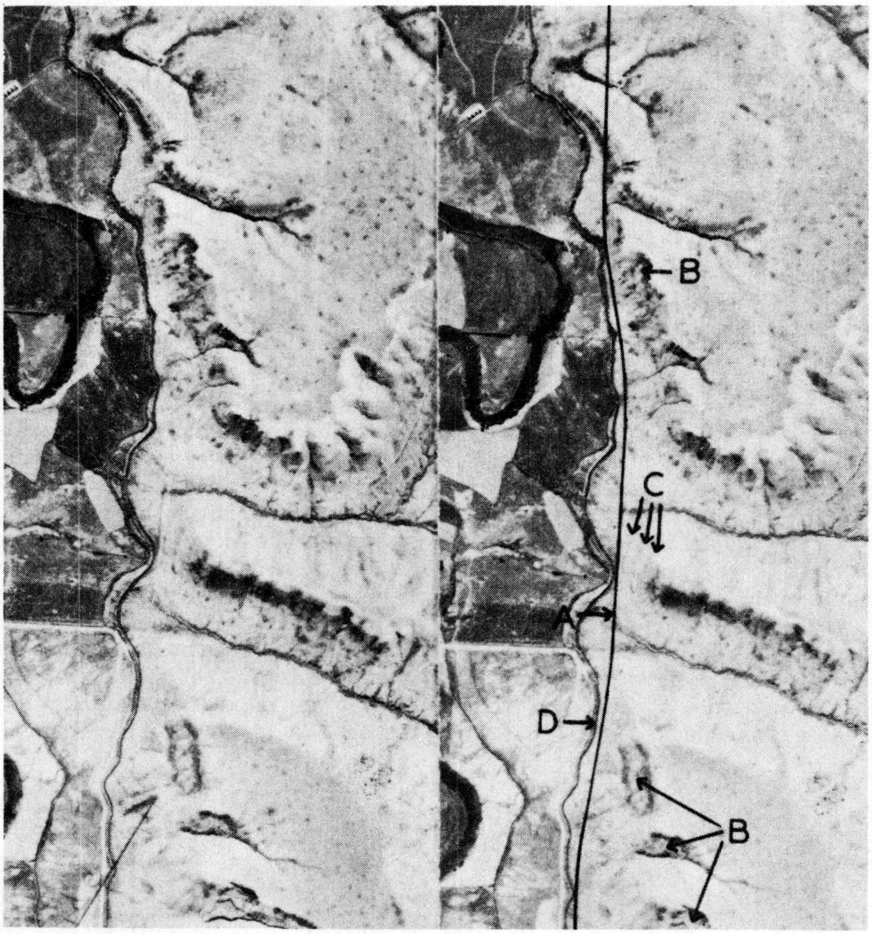


Figure 9(a). Applications to design. A stereopair showing the alignment (A) of a highway constructed in 1947 along the edge of the Browns Park formation; slides (B); vegetation contours (C) due to soil profile and moisture concentration; irrigation canal (D). Figure 9(b) shows the subsidence and cracking on the higher and steeper shoulder slopes after spring runoff due to heavy winter and spring snows. Figure 9(c) shows the sloughing of the steeper back-slopes, and filling of the uphill ditch sections. (Courtesy of Soil Conservation Service.)

A selection of airphotos and stereopairs of granular deposits are continually being enlarged, for they are invaluable for instructional purposes as the various formations throughout the state present a multiplicity of problems.

Figure 9(b). Ground view of cracking and subsidence adjacent to the higher and steeper fill-slopes, due to excessive spring runoff, on a highway constructed along alignment in Figure 9(a).

DESIGN

Use of airphotos, geologic maps, and agricultural soil maps has broadened the application of preventative and corrective measures for specific conditions in highway location, design, construction and maintenance. Figure 9 shows how information is accumulated for future application to design. The highway shown was constructed during 1947 in southern Wyoming along the edge of the Browns Park formation and above the contact with the alluvium. Heavy snows during the late winter and early spring of 1949 developed a moisture condition resulting in cracking and sloughing of the steeper back-slopes and fill-slopes. Application of this knowledge to design was made in 1953 on a location in northern Wyoming in the Willwood formation when a preliminary soil profile received from the project engineer called attention to the fact that 3,500 ft. of sidehill was subject to melting and sloughing during the spring

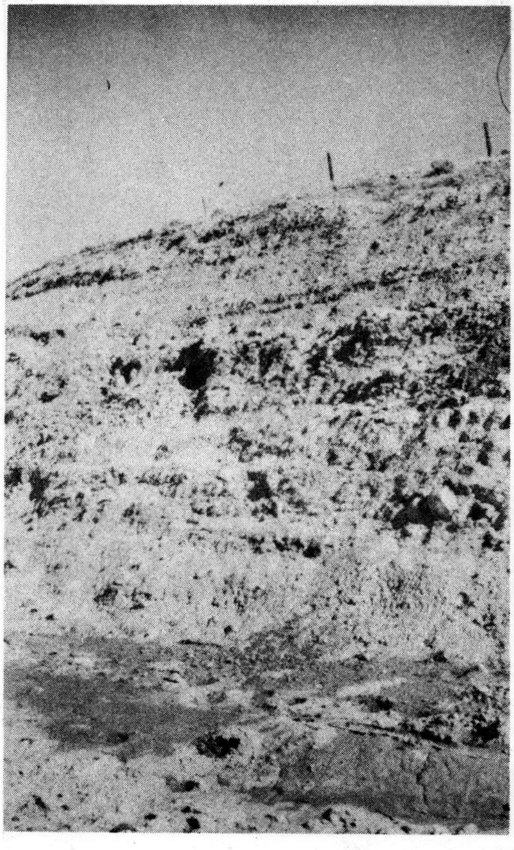


Figure 9(c). Ground view showing sloughing of the higher and steeper backslopes and filling of the uphill ditch sections, due to the excessive spring runoff, on a highway constructed along alignment in Figure 9(a).

runoff, developing large cracks and holes. Since the soil profile also indicated a relationship between the two projects, flat-backslopes, flat-fillslopes and wide, uphill ditch sections were designed throughout this 3,500-ft. section.

SUMMARY

It is evident from past results that interested engineers have been improving their work through the use of airphotos, geologic maps, and agricultural soil maps with only limited initial knowledge and instruction. In some instances mistakes have been made, and some applications have been considered as unorthodox, yet the engineers' own applications, plus the knowledge gained through association with other engineers and their methods of solving different or related problems, have contributed toward raising the overall level of efficiency.

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