AVAILABILITY OF AGGREGATES IN SOUTHERN DISTRICT II

MARCH 1965

RESEARCH PROJECT NO. 34

STATE OF IDAHO DEPARTMENT OF HIGHWAYS

AVAILABILITY OF AGGREGATES

IN

SOUTHERN DISTRICT 2

March 1965

District 2
Surveys & Plans Div - Materials Section
Research Division

State of Idaho
DEPARTMENT OF HIGHWAYS
Boise, Idaho

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This report was prepared by the District Two Materials Section, correlating the work with the Chief Geologist, the Materials Engineer and the Research Engineer of the Department of Highways Headquarters Staff.

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Personnel of the Planning and Traffic Division prepared the final geologic maps and the Research Division edited the final report.

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SUMMARY

A search of literature and materials records was made and correlated with geological features identified from air photos and field reconnaissance in determining the quantity and availability of aggregates in District Two. These studies indicate an abundance of material in areas in Blaine County north of Stanton Crossing, in Cassia County north of Oakley, on the Raft River Drainage, along the Snake River Drainage and in other geologic formations near the Little Salmon Drainage. Not all these materials are of good or even acceptable quality.

Considerable material available near future construction projects will require extensive processing and stabilization to upgrade the quality to acceptable standards. Materials suitable for use with minimum processing are available only in the Cassia and Blaine County areas and would require transportation to projects, increasing costs tremendously.

Basalt rock from the extensive lava flows is available in quantity. This material can be utilized, but will require further investigation to determine the specification limits that may be necessary for standard test values for a material which will provide satisfactory service.

Recommendations for further investigation of basalt and for obtaining comparative costs with shipping of aggregates from outlying areas are included. These recommendations also include suggestions for obtaining more complete knowledge of each geologic unit as a routine matter of materials source investigation.

I. - INTRODUCTION

A materials availability study was conducted in a portion of District Two in 1963 by Ron Scheuffele. This report entitled, District Two Materials Availability Study, consisted of an inventory of the material remaining in the presently known sources relative to the future needs for construction and maintenance requirements.

The information given in Appendix A indicates the seriousness of the problem. Some areas, as shown by the report, have abundant material for aggregate production; other areas have limited quantities of material or material which is of unsuitable quality for highway construction. Abundant material in other areas may be below specification standards for use even when treated or stabilized thus leaving a shortage of material capable of producing a surfacing aggregate.

The intent of this report is to relate qualitative information to the geologic units and to present the overall potential of each unit relative to the Highway Department's use as a source of aggregate. The criteria used in the qualitative approach is presented in Appendix B. This information provides a guide for the determination of quality of the material for any specific use. An attempt was made to suggest processes that might improve the quality of a material otherwise below specification standards.

Scope of Study

The objective of this study is to geologically map lithologic units for possible materials and to correlate known sources to these units. In this manner the quality of the material in any given unit is indicated.

Geologic field methods were, of necessity, employed. Existing geologic literature was reviewed to gain knowledge of the lithologic units within the area and to determine those parts of District Two that had previously been mapped. Air photos were studied as an aid to the field investigation.

Special consideration was given to basalt rock since much of the area studied consists of basaltic lava flows. Chemical and physical properties of available basalts were analysed to determine suitability for use in roadway construction.

The preliminary boundaries for the investigation were a ten mile strip on each side of U.S. 93, Interstate 80N, and the major drainages, such as the Snake River, Raft River, and the Big and Little Wood Rivers. These boundaries were not adhered to strictly as field work often indicated other areas requiring additional investigation and areas which could be eliminated from consideration for future sources of material. Geologically mappable units were extended as far as practical. Generally, the entire area within the counties studied was mapped, but with variable degrees of accuracy. Because this project is concerned with construction materials, geologic problems not related to the search for construction materials are considered to be of secondary importance. They are, in fact, ignored if the validity of the information presented is not affected.

Emphasis was placed on the major drainages and their tributaries, because they reflect or give clues to the drainage patterns, and to the depositional basins of the geological past. Drainage onto the Snake River Plain in the geologically recent era was limited and it was suspected that detrital material would also be limited. The proof lay in tracing new and old stream channels.

Procedure

All known geologic information relative to this investigation was obtained as an aid in the projection of formation, quantitative and qualitative evaluations and to correlate with published information. Aerial photos, well logs, and field mapping were all utilized to obtain information for correlation of the depositional units. Aggregate source records and service records of the material from these sources were then correlated to the proper geologic formation to predict the engineering properties for that formation. Projection of these properties throughout the formation is then possible if the lithology and depositional variations of the formation are known.

Geologic Mapping

Previous geologic mapping has been variable and sporadic. An attempt was made to obtain all the previously published literature to reduce the amount of field work required and, perhaps, produce a more complete geologic map. Publications were obtained from the United States Geological Survey and from State organizations. A variety of maps was used. The United States Geological Survey contour maps provided partial coverage and county topography maps completed the coverage.

The Highway Department did not own air photos for complete photo coverage of the area. The remaining photo work was accomplished at various U.S. Government offices having air photos.

Aerial photos were studied as an aid to planning prospective field trips. In this manner exact contacts of geologic units in areas which were either inaccessible or time-consuming to reach from the ground were obtained. Numerous potential materials sites that might have gone unnoticed were also located on the maps. Solid rock and other possible nonproductive areas were located and traced on maps to be eliminated from field investigations.

Use of Well Logs

Well logs were obtained from the Ground Water Branch of the United States Geological Survey located in Boise. They were used to help correlate gravel bearing units with material source information and to establish the depth of the gravel bearing unit. The majority of wells are logged by well drillers unfamiliar with geologic classifications and care must be employed with their interpretation. They are, however, an excellent tool for indicating location of new deposits and extending the area of known deposits.

Field Investigations

After review of literature, photos and maps were studied, and field trips made for the purpose of:

1. Geologic mapping
2. Collecting Samples
3. Checking the continuity of geologic units
4. Checking the accuracy of photo interpretations
5. Making identifications and field analysis of gravel units.
6. Observing and recording any information that might be pertinent to the overall investigation.

All mapping possible was done from aerial photos and previously published maps. The remainder of the mapping was accomplished in the field. Photo interpretations were spot checked to assure accuracy.

Very little testing was done of the gravel units. The quality of the material in these units was obtained from existing source records.

Basalt outcrops were sampled and tested, and two exploration test holes were drilled to a depth of 43 feet.

II. GEOLOGIC HISTORY

This report is concerned, primarily, with erosional and depositional processes that have produced units or formations having potential value as a source of material aggregates. The geologic history, for this reason, of an area to be studied must be interpretated, usually through field work and previously published information. It is for this reason that a broad, brief geologic history of this area is justified.

During Precambrian time the area was within a broad, shallow sea. Progressive sinking of the basin permitted the deposition of great thicknesses of sediments. These sediments were then folded and later rose above sea level. One such area is the mountain region in the northern part of District Two now occupied by the Idaho Batholith.

During the Paleozoic era (not shown on explanation in Appendix E), a subsiding sea basin occupied the southeastern part of central Idaho. Near the end of the Paleozoic era this fluctuating sea deposited sediments which became the great thicknesses of limestone and associated rocks of the Arco area.

The intrusion of the Idaho Batholith occurred in the Masozoic era. The emplacement of the Batholith was preceded, however, by regional folding of the Paleozoic sediments. The forceful injection of the main intrusive body of the Batholith then faulted and fractured these pre-existing rocks. These intrusive forces continued well into the Cenozoic era.

Early in Cenozoic time the Challis volcanics, a probable extension of the main magma body, was extruded onto the surface. The extrusion of the Challis volcanics was followed by a period of prolonged erosion and weathering. During this time the country was worn down, resulting in a far less rugged topography than exists today. A period of minor uplift and of stream rejuvenation followed. During this part of geologic time, the Payette Formation was deposited.

Extrusion of the young silicic volcanic rocks into the Snake River Basin followed, filling it with a tremendous mass of basaltic lava which was later overlaid by the Banbury Basalt Formation. The weight of this mass caused the basin to sink further and the mountains to the north rose and tilted northward. Thus, both major and minor drainages were disrupted. Drainage onto the Snake River Plain became minor and the Snake River meandered through the lava flows. During this period, lava flows dammed the Snake River long enough for massive lake deposits of the Glenns Ferry Formation to accumulate.

An abundance of material was deposited during Pleistocene time. The valleys formed by erosion were filled with glacial outwash material on the north and the Tuana gravels and the Bruneau Formation to the south. The Tuana gravels are overlying a hill and valley topography, unconformably, above the Glenns Ferry Formation. The Bruneau Formation is composed of massive lake beds of silt, clay and dolomite with some fan gravels and lava flows.

The Snake River Basalts were then extruded. The Snake River Basalts are lava flows which, for the requirements of this study, were not separated into component parts. Erosion followed the solidification of large quantities of lava, forming the Snake River Canyon and its terraces upon which were later deposited the Crowsnest and Melon Gravels.

The Pleistocene geology of the Snake River is to a large extent due to the Lake Bonneville Flood. It is believed a break near Red Rock Gap north of Malad about 30,000 years ago originated the flood, which at one time may have reached a discharge rate of 20,000,000 cubic feet per second. The Melon gravels were derived during this flood.

The topography near the Snake River Canyon west from Burley can best be described as scabland. It is a topography of basalt ridges and depressions mantled with deposits of eolian sand or loess and overlaid with a variety of geomorphic features. These features include abandoned canyons or coulees, dry waterfalls and cataracts, hanging valleys, barlike deposits of gravel, gravel terraces and slackwater deposits in tributary valleys.

Somewhere in the vicinity of the townsite of Milner, the flood waters exceeded the capacity of the Snake River channel and overflowed onto the surface of the basalt rock. The water picked up basaltic detrital material by abrasion and plucking action for later deposition. The entry points of the water back into the main Snake River channel are marked by dry falls and cataracts. Most of the waterfalls and the cataracts are confined to the north side of the canyon as are the Melon gravels.

The Melon gravels give an accurate trace of the flood waters, or conversely, the flood water gives an accurate trace of the Melon gravel deposits. The eastern limit of the gravel is about two miles north of Greenwood indicating that the flood waters left the channel somewhere near Milner. The nearest re-entry point is near the Devils Corral between the Hansen Bridge and U.S. 93 on the north side of the Snake River. Further west the water dropped into the canyon at the Blue Lakes Alcove. (See Figure 1.)

West from Greenwood, Melon gravels occur in depressions in the basalt and behind ridges. These "Melon Patches" are easily recognized by the large, round basalt boulders or when these boulders are absent, by

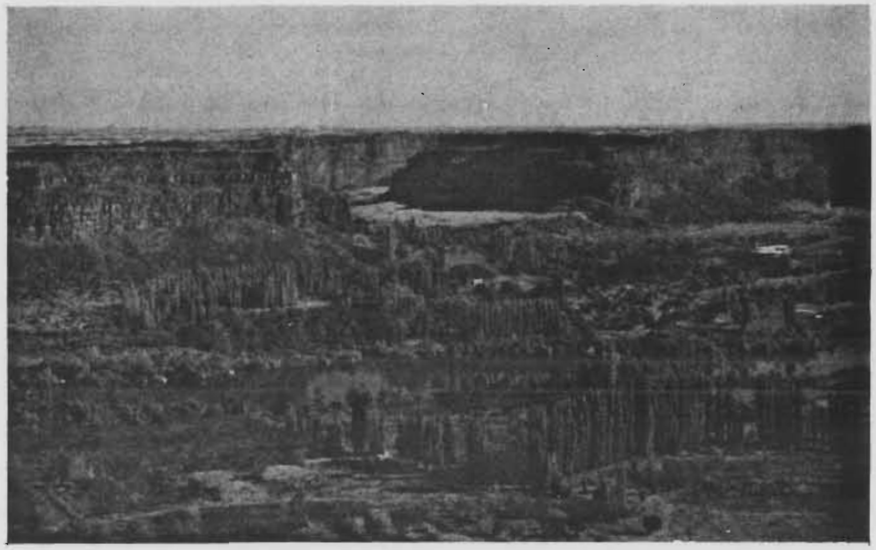

Figure No. 1 - The Blue Lakes Alcove where flood waters from Lake Bonneville re-entered the Snake River Canyon

Figure No. 2 - Melon Gravel bar on floor of Snake River Canyon showing marginal trough.

differences in vegetation. The Melon gravels frequently form long, low bars deposited on the downstream side of basalt knolls or pressure ridges. These topographic features are recognized by their "out of place" appearance. They are long, generally thin, 15-25 feet high, smooth, rounded, gravel bars covered with an abundance of vegetation.

Air photos proved invaluable in locating the Melon gravels as did U.S.G.S. topography maps. Identifications from air photos were generally made by differences in texture variations as well as the prominent vegetation. The gravel deposits appear smooth and rounded in contrast to the rough basaltic topography. The U.S.G.S. maps depicted alluvial material by contour line differences being smooth and even around depositional areas, whereas lines around basalt ridges are jagged and uneven. These maps also gave indications where Melon gravels were deposited in slackwater areas. Such areas are obstructions in old channels, intersections of channels, and channels entering floodplains.

The larger deposits of the Melon gravels are found on the Snake River Canyon floor. These slackwater deposits were obviously deposited as a result of a decrease in the velocity of the water. Generally, these slackwater areas are found where the canyon widens as at Clear Lakes or adjacent to incoming streams such as Rock Creek. These deposits are in the form of huge bars characterized by a marginal trough between the bar and the canyon wall. (See Figure 2). The bars rise from 80 to 100 feet above the present river and range in length from a half mile to about two miles.

Volcanism has continued into recent times. The Snake River Plain is dotted with cinder cones and craters that extruded cinders and lava. The latest eruption in the area of the Craters of the Moon may have occurred less than 1,000 years ago.

Most topographic features of the Snake River Plains have resulted from the influence of basaltic lava flows. Cinder cones, small buttes from fissure eruptions, pressure ridges, and depressions from collapsed lava tubes form most of the local relief of the plains.

The rock derived from the lavas, in general, can be described as an aphanitic, vesicular, olivine basalt. Texture seems to be uniform. A columnar to laminar flow structure is exhibited depending, generally, upon the thickness of flow and the uniformity of the depositional surface. Characteristic vesicular features are found on both the top and bottom of each flow, although the basalt tends to be porous throughout the entire flow. The size of the vesicules is, however, much smaller toward the center of the flow. Denser basalt is evident in outcrops where the flow had filled a basin and attained a greater thickness. In recent times, the McKinney Basalt was extruded from a point eight miles northwest of Gooding.

Detrital material is constantly being worked and reworked by streams to form the present topography.

III. SUITABILITY OF MATERIALS FOR AGGREGATES

Melon Gravels

The Melon Gravels are composed of boulders and cobbles of basalt rock set in a fine basalt sand matrix. These gravels are the most widespread source of acceptable road building material in Jerome and Gooding Counties. They extend from Greenwood near the Jerome-Minidoka County Line, to Swan Falls near Melba, along the Snake River drainage, and they are accessible to any project in the vicinity of the Snake River.

The gradation of the Melon gravels varies with the types of deposits or the depositional characteristics. Floodplain deposits have a larger percentage of boulders while deposits in the canyon are finer and do not have as many large boulders. In floodplain deposits the water has a high velocity and can drop only the larger rocks. The boulders, once deposited, act as a check for the water and the finer material is then deposited. Natural gradation is usually poor because there is little material between the four and five foot boulders and the three inch cobbles. Experience has shown that about 75% of the natural sand must be rejected before curshing due to soft poor quality sands and siltstone. In deposits where the larger boulders are absent, the gradation is good. (See Figure 2).

The composition of the Melon gravels varies. Jr-38, a bar deposit south of Hazelton, (See Figure 3), is composed of basalt rock derived from the upper vesicular surface of the lava flows, with minor amounts of a soft, red limonitic silt material. The exact origin of the silts is unknown, but it is probably a baked soil material from between the lava flows. Downstream from Jr-38, near Shoshone Falls, the river has cut through the overlying basalts into the chemically altered andesites. The andesite has contributed to the composition of the Melon Gravels below

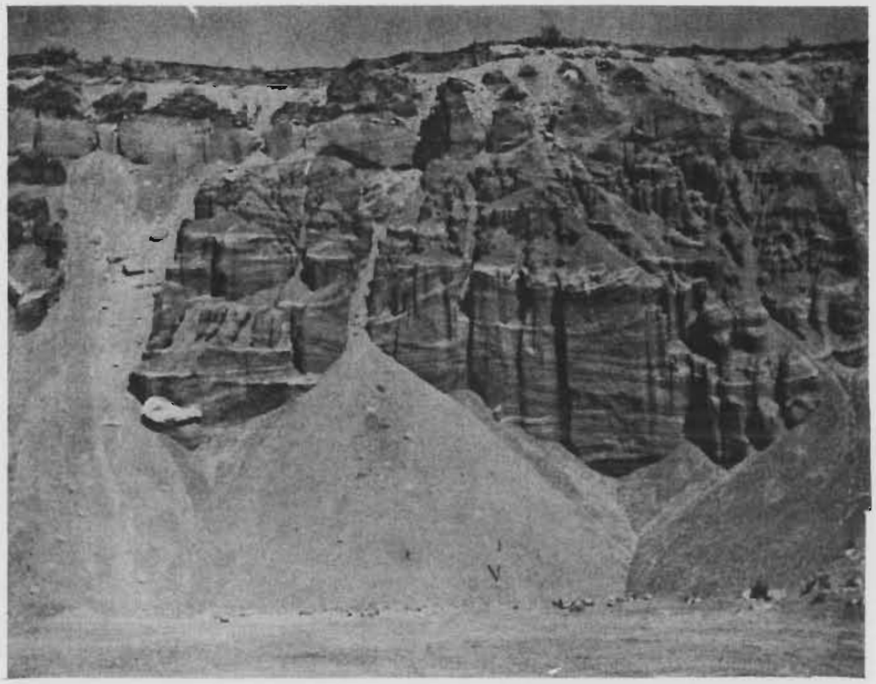

Figure No. 3 - Melon Gravels, note fineness and crossbeds.

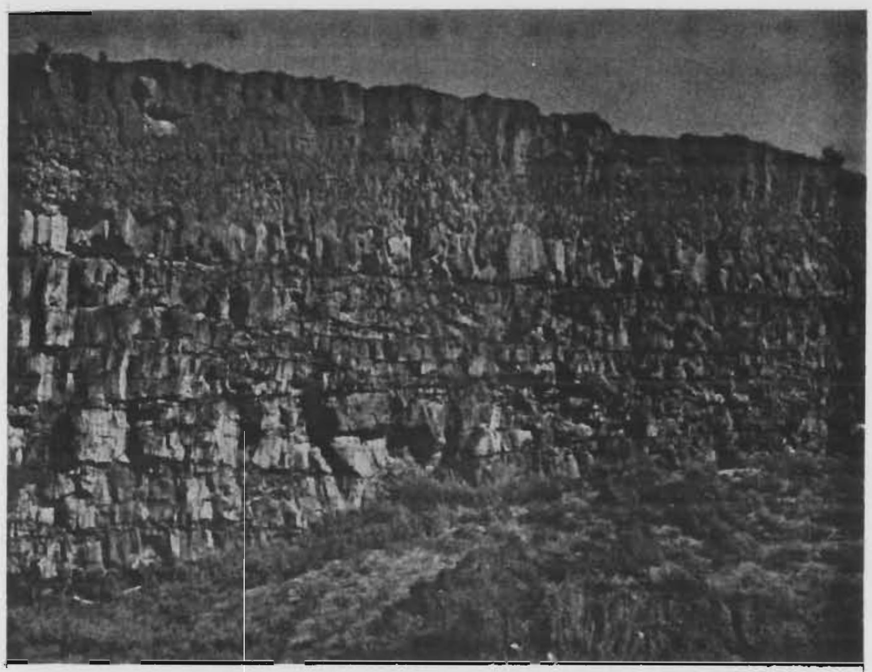

Figure No. 4 - Basalt face at Jr-38 showing diced columnar layers.

this point and is illustrated by TF-67. For this reason there is more material susceptible to deleterious degradation in TF-67 than in Jr-38. Both the limonitic silt and the decomposed andesites contribute to the material which reflects a high L.A. wear and high absorption (See TF-67, App. C.). If this poor quality material could be separated from the gravel, the values for L.A. wear and absorption might be reduced, indicating an improvement in quality.

The Melon gravels can be used for base and stabilized base material, although only a few sources can provide surfacing quality material. Unfortunately, the two known sources that can provide surfacing material are located in the Snake River Canyon, requiring a long, steep haul to the plains above.

I-80N-3(11)164 is to use material from TF-67 for a 0.15' lift of Class B plantmix and is to be overlaid by a 0.25' lift of Class D plantmix using aggregate from Ln-6, a source of high quality aggregate.

I-80N-3(15)176 and I-80N-3(14)185 will use material from Jr-42 for Cement Treated Base with 4% cement. The Moscow Laboratory in THE FINAL REPORT ON TEST ANALYSIS OF VARIOUS TYPES OF TREATED BASE COURSE, recommends using crushed base material without rejection of the natural sands and treating the material with four percent cement to provide a satisfactory base course material. The alternate of rejecting natural sand and crushing sand as a replacement without cement treatment is not satisfactory, as not all silt and limonite material can be rejected.

The material used for these tests came from TF-67, however, all Melon gravel deposits in Jerome County have similar geologic characteristics and physical properties with the gradation of the material varying only slightly.

Tuana Gravels

The Tuana gravels overlie a hill and valley topography, unconformably above the Glenns Ferry Formation. These gravels consist of cobbles and pebbles set in a fine, brown and silt matrix. Small crossbeds are a dominant feature of the deposits (See Figure 5). The gravels are composed chiefly of silicic volcanics with some associated quartzitic material. The formation is capped by a caliche layer that ranges up to several feet in thickness and locally obscures the Tuana gravel. The caliche overburden has, in some areas, resulted in a partial lime coating of the underlying gravel.

The Tuana gravels have been used very little. The State has located few pits on the outer limits of the formation near Salmon Falls Creek. The Buhl Highway District has one pit near Balanced Rock. This formation is extensive, but haul distances to areas of need will restrict its use.

Gradation of the material in the existing sources varies slightly, generally two to six percent passes the No. 200 sieve and consistently a 3 inch maximum size cobble. A variation in the fine material is indicated by the large range of values for sand equivalent (See TF-27, App. C). The presence of small crossbeds indicates deposition in shallow water with localized sorting of the material. If large crossbeds should be encountered, uniform gradation of the aggregate might become a problem.

The quartzitic composition of the aggregate in this formation results in a very durable material for the final aggregate product. This is substantiated by relatively low wear results from the Los Angeles Abrasion Tests and from the Idaho Degradation test results conducted on samples from these existing pits. The local accumulation of altered and non-uniform silicic volcanics accounts for the variation in absorption. Previous tests

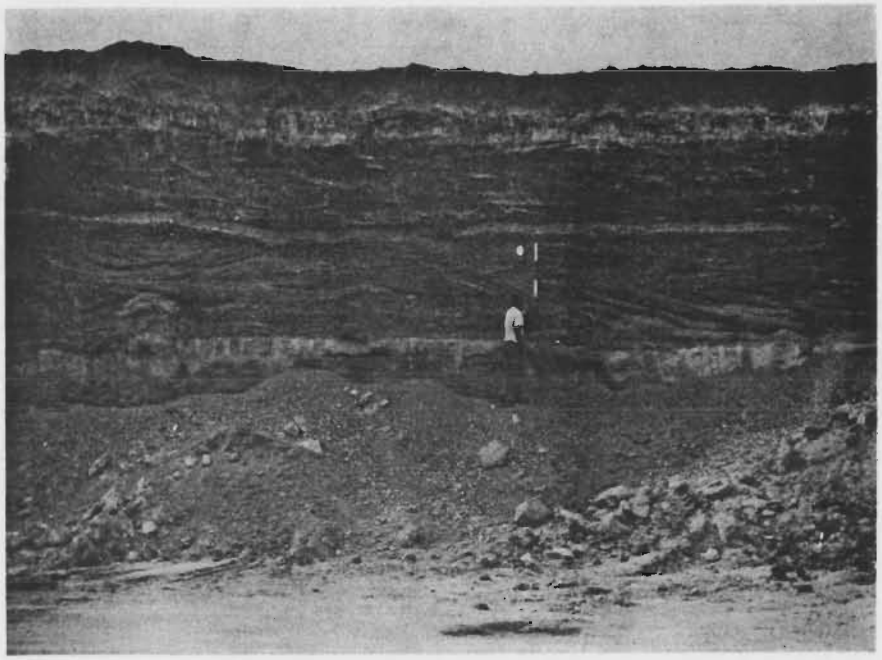

Figure No. 5 - Tuana Gravels. Vertical face indicates gravels are dirty. Note the crossbedding.

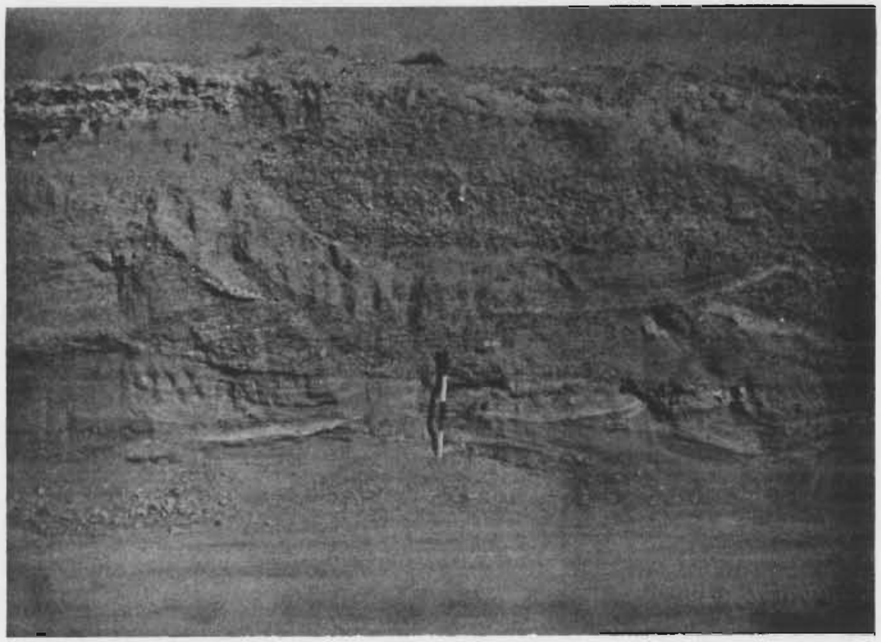

Figure No. 6 - Face of pit in the gravels of the Goose Creek Drainage.

indicate an extreme absorption value of 4.1, but generally, the values range from 1.6 to 1.2.

Thus, the Tuanas are suitable for crushed gravel surfacing aggregate. Where sorting and deposition have accumulated an excess of the low quality silicic extrusive material, use must be restricted to base or select borrow.

Crowsnest Gravels

The Crowsnest gravels occupy terraces which are about 250 feet above the Snake River and vary in thickness from 25 to 75 feet. The lithology of the Crowsnest gravels is extremely variable. Upstream from Hagerman the gravels are composed mainly of silicic volcanic pebbles, whereas, downstream they are predominantly quartzite and porphyry cobbles.

Glenns Ferry Formation

The Glenns Ferry Formation is a basin fill of undifferentiated, poorly-consolidated detrital material and minor lava flows of basalt. The lake and stream deposits are characterized by abrupt lateral changes in the facies. There are six facies, but only three contain gravel or sand; an evenly layered granitic sand facies, a fine pebble gravel facies, and a quartzitic cobble gravel facies.

The abrupt change in facies within the formation makes interpretation and mapping of any one facies almost impossible. This formation has not been developed as a source for aggregate because the formation in general lies away from present construction jobs.

West from Bliss the non-uniformity and apparent lack of continuity in the formation will necessitate a special investigation and a careful scrutiny, locally, to locate any suitable source. Geophysical methods can perhaps be employed to locate the gravel bearing areas within the formation having adequate quantities for use as an aggregate source.

Gooding County contains some alluvial material along the Big Wood and Malad Rivers. The material is of the same general composition as that along the northern reaches of the Big Wood River. Absorption test values are much lower for material in some sources, probably due to an addition of more quartzitic material. In general, the gravel is a hard, durable material of a surfacing quality.

The Cotton Wood Slough north from Marley contains small visible pockets of material and might warrant further investigation. This slough is apparently an overflow channel of the Big Wood River. The major part of the material deposited by this overflow is at the northern end of the slough. The gravel should compare to the Big Wood River alluvial material.

Little Wood River Quaternary Alluvium

The larger deposits of material along the Little Wood River are confined to the eastern reaches of the river. The material is composed of granite, chert, and quartzites and is generally in the form of a fine gravel and sand. There are many existing pits in the area and approximately 100,000 cubic yards of material may remain.

The material is of surfacing aggregate quality. Absorption is low for aggregates from some areas, and the remainder of the tests indicate a hard, durable gravel. The gravel exists in lenses which vary greatly in gradation. The maximum size of the material varies from 1 to 3 inches, depending on location within the depositional trough.

Camas Prairie Quaternary Alluvium

Camas Prairie and its border areas contain a large supply of alluvial material. All the sources to date have been located on the prairie floor. High L.A. wear values, a high clay content, and degradation of the finished product have been commonly reported test results for this material.

The reason for these poor results is the high feldspar content of the rock. The feldspar is in various stages of alteration with the end product of alteration being the clay kaolinite. The percent of alteration of the feldspar reflects the variation in engineering properties.

A few sources on the extreme east and west ends of the prairie produce surfacing quality aggregates. However, the majority of the pits located on the prairie floor are capable of producing only subbase material of questionable quality. Washing the aggregate to remove the clay fines might be beneficial; however, an attempt made to wash the material in Cm-67 proved unsuccessful because of the high cost and lack of water.

Quarry sites have been developed in the silicic extrusive rock bordering the south edge of the prairie. These quarries produce material with a low Los Angeles Wear and with no stripping when used with bituminous materials. Clay seams within the rock are reflected by high values of the plastic index and percentage passing the No. 200 sieve in the finished product. These quarries can produce acceptable cover coat material if it is economically feasible. Quality could be improved by selectively working the source and by rejection to reduce the amount of incorporated soil from clay seams.

Twin Falls County Quaternary Alluvium

The alluvial gravels of Twin Falls County exist in abundance east of the Salmon Falls Creek Drainage. These gravels do not conform to the present drainages as their genesis belongs to extinct depositional streams which have become somewhat obscured by more recent detrital material.

The composition of the alluvium reflects an origin from the nearby silicic volcanics. The andesites, welded tuffs, and minor quartzites included within these gravels do not produce a high quality aggregate.

Engineering tests from sources near the Hollister area illustrate the poor quality of these materials. Generally, tests show a high absorption and Los Angeles Abrasion values, a plastic index of approximately 2, an excessive amount passing the No. 200 sieve (13-15%) and a maximum size of about $1\frac{1}{2}$ inches.

Near Rogerson, the sources tested show high liquid limits and high Plasticity Index, high Bituminous Swell, and excessive stripping qualities. The alluvial material south of Hansen and Kimberly correlates in test properties with the above two areas.

The origin of this alluvium does not indicate that high quality aggregate can be produced. Low sand equivalents, and high degradation and absorption should be considered as general characteristics of the untreated aggregate obtained from the formation.

Cement or asphalt treatment might prove feasible for some of these sources. In some areas that contain material having a high degradation potential, petrographic studies should be made of the material to determine the type of degradation. If the material degrades due to a chemical breakdown when in the presence of water, it might prove unsuitable for use as a plantmix aggregate. Coating the aggregate with asphalt may provide a semi-impermeable shell around the particle minimizing chemical alteration and possibly make it acceptable for treated base.

Goose Creek Quaternary Alluvium

The Goose Creek Gravels include all the alluvial material deposited between Burley and the mountains to the south. Not all this material was deposited by Goose Creek, but since it lies adjacent to this drainage, were so named.

In the Goose Creek drainage, there is essentially an abundant supply of sand and gravel. The deposition of this material has been influenced by the Snake River, Goose Creek, Birch Creek and many other small tributaries that have eroded the present mountains to the south. Variations existing in the depositional characteristics, type and size of the material, are dependent upon the major streams with the parent rock being eroded by these streams, and the distance the material has been transported (See Figure 6).

These materials are predominantly andesites, quartzites, and metamorphics that range on the south from the 5 to 8 inch maximum sub-angular stone to 1 inch maximum well rounded gravels toward the north. The material varies in cleanliness, being slightly dirty on the east and cleaner toward the center of the valley. Well logs indicate a depth in the center of the valley of approximately 80 feet. Near Artesian City to the west the depth is about 70 feet.

Available tests show the Goose Creek Alluvial material from Oakley to Burley to be acceptable for all types of highway building aggregates (See Cs-128S and Cs-57S, App. C.). Commercial concrete aggregate is also produced from this material.

Raft River Quaternary Alluvium

The Raft River valley has gravel depths indicated to vary from 46 to 112 feet. The material near the center of the valley is composed of limestone, andesites, quartzites, and sandstone. It is fairly dirty and has some limestone coating. The tests indicate a stable material with a high percentage of natural sand, silt and clay. It may be suitable for base material, but may require cement or asphalt treatment to improve the quality.

The east edge of the valley is predominantly limestone fragments of approximately 6 inches maximum size. This material warrants further qualitative investigation as it appears to be a good quality material.

Snake River Quaternary Alluvium

Minidoka County is adjacent to, but separated from, Cassia County by the Snake River. The alluvial material in Minidoka County consists of fine gravel, sand and clay and correlates with the gravels on the south side of the river near Burley, but varies only in size.

Depth of the material near Paul is approximately 35 feet including 9 to 10 feet of a sand-clay overburden. The deposits in Minidoka County denote deposition in quiet water resulting in sand and fine alluvial material. The deposit extends to the north end and to the west from the Snake River until encountering the Snake River basalts which limited the size of the depositional basin.

The contribution of detrital material from the mountains south of Burley influences the position of the Snake River merely by the size of the material. The finer material is more easily eroded; hence, the river has moved northward. Also, there are no major drainages flowing from the northern area due to the porosity of the basalt. This water percolates into the ground and contributes to the regional water table. This is evident by the depth of the water table in the alluvial material which is generally within 3 feet of the surface.

This large alluvial plain terminates approximately 3 miles west of Burley. Here the Snake River basalts forming the higher local relief confine the river to a small channel.

Remnants of old terraces exist adjacent to and north of the Snake River and appear to be reworked Snake River sand and gravels. The supply of this material is limited, but approximately 30 to 40 acres of potential aggregates exist in this area if the material should prove suitable. Dredging and stockpiling of material from the river during low water would also be a possibility.

All the tests indicate a hard, durable material suitable for use as a plantmix aggregate or a concrete aggregate. An anti-stripping agent will be required for aggregates from some sources when used with asphalt.

The only other materials available in Minidoka County are the Snake River basalts, which are frequently covered by a thick loess soil deposit. The basalt has similar properties to other basalts throughout south central Idaho.

Fluvioglacial Deposits

Large quantities of high quality sand and gravel are available along the Big Wood River drainage above Stanton Crossing covering the Big Wood River Valley floor. These terraces owe their origin to deposition from streams fed from glaciers nestled in the higher mountains to the north. The material consists of granodiorites, quartz monzonites, weathered granites, quartzites, and quartz diorites and related rock types.

Well logs indicate the gravel depth in the center of the valley to be about 45 feet with 4 feet of a soil and clay overburden. The deposit is probably less thick to the north and becomes thicker toward the south. A high water table can be expected.

The majority of the test records are dated 1935 and 1936. At that time the material was used as a surfacing aggregate and Class "A" concrete aggregate. Los Angeles Abrasion values of the material indicate a hard, durable material which correlates with the type of rock comprising the deposits. Continuity of these deposits will be poor. There will be local lenses of silt, sand and of gravel, which is typical of stream-deposited material. The approximate maximum size is 6 inches and approximately six percent of the material is larger than 3 inches. The sand equivalent values vary between 57 and 78. Idaho Degradation tests are not available, but wear values are low indicating a good material.

The compiled test information indicates this material is suitable for surfacing aggregate. A thorough investigation must be made prior to the selection of a source area because of the poor continuity of the deposit.

Terrace Gravels

The terrace gravels occupy the low land above the Big Wood River in Blaine County. The gravels are composed of granites, quartzites and quartz diorites with approximately a 5 inch maximum size. In the southern part of Blaine County the terrace deposits are thin and small. Continuing northward, the terraces become larger until, several miles above Ketchum, they reach a height of 70 to 80 feet above the river. Material here is nearly unlimited in quantity, but it would mean a haul of 90 to 100 miles to the Interstate highway near Jerome.

There are no known existing aggregate sources in this deposit and there have been no tests made on the material. This material can, however, be compared to the alluvial material along the Big Wood River in which there are sources having test results indicating a high quality sand and gravel. This comparison is justified because the terrace deposits are, to a large extent, the parent material of the alluvial deposits. The quality of the two materials should be about the same, but there will no doubt be a variation in gradation. The terrace deposits should contain a larger percentage of fine material than the alluvial deposits.

Snake River Basalt

Basalt Rock is the most abundant and widespread potential source of building material in District Two. During the fall of 1964, Interstate I-80N contractors employed core drilling in an attempt to locate basalt rock suitable for a quarry operation. Drill cores and samples from various parts of District Two were submitted for standard wear and degradation tests. The results of the tests revealed high Los Angeles Abrasion values (43-47) on the two samples taken from the top or vesicular part of the basaltic flows. A much lower Los Angeles Abrasion value (27) resulted from a sample taken from the more dense center of a flow. The drill cores, taken about a mile north from the Perrine Bridge, had Los Angeles Abrasion value for the top 15 feet of 47 and a value of 40 for 15 to 43 feet. Values above 40 are outside specification standards.

The petrographic study on the same material, believed to be representative of the basalt of the area, indicates a fresh basalt with minor alteration, indicating that chemical alteration of the basalt to deleterious secondary minerals is very unlikely. These tests would indicate that degradation testing should be separated into both a chemical and a mechanical degradation test to differentiate in the type of degradation possible.

Using this terminology, mechanical degradation can be expected using Snake River Basalt as aggregates. The amount of degradation should bear a definite relationship to the void ratio or vesicular characteristics of basalt. Vesicular basalt, when crushed, has sharp edges and thin walls between vesicules, both of which increase its susceptibility to mechanical degradation. The Los Angeles Abrasion test is indicative of mechanical degradation.

Mechanical degradation does not result in harmful secondary minerals, but is merely a smaller size of the parent rock. It seems safe to assume that mechanical degradation of the material derived from the Snake River basalts will not be nearly as detrimental as degradation resulting from chemical alteration.

Snake River basalt, if quarried properly, can be used as a roadway aggregate. Quarrying should require locating or developing at least one vertical open face to assure a complete cross-section of a flow to be worked. By selecting appropriate depths of quarrying, the top, less dense part of the flow, can either be used as base material or by going deeper, mixed with the middle more dense part of the flow, to be used as a surfacing material.

The petrographic study shows the basalt to be very stable. This is attributed to three facts:

1. Geologically speaking, the basalt of the area is young.
2. The basalt has very little glass.
3. There is little alteration present.

The tabulations below show the mineralogic composition. For percentage determinations, secondary minerals are included in the mineral from which they formed.

	TH-1	TH-2	TH-3	TH-4	TH-5
Plagioclase	20	30	35	40	35
Pyroxene (Augite)	20	25	35	35	35
Olivine	15	8	5	10	7
Magnetite	5	8	5	3	5
Voids	7	4	5	7	4
Glass	25	18	5	1	1
Accessory	6	15	10	4	13

The anorthite content of the plagioclase was not determined. Plagioclase in thin section shows as laths and as zoned crystals. The laths were distinct and had sharp borders with very little alteration, however white mica was noted.

The aluminum iron magnesian clinopyroxene, augite, makes up between 20 and 35% of the rocks. It occurs as wedges filling the interstices, as laths, and as irregular blebs.

Olivine crystals with iddingsite rims and olivine altered to magnetite is fairly common.

Magnetite makes up from 3 to 10 percent of the thin sections. It occurs in skeleton crystals, rough irregular blebs, and well formed crystals. Most of the magnetite is primary, but a minor amount has resulted from the breakdown of olivine.

Slag Material

The slag piles of the Westvaco Company of Pocatello, Idaho, are considered as a potential source for aggregate in District Two. Rail facilities, and the cost and quantities required for a given project will govern its use. Engineering properties are variable and control to obtain a uniform quality product will be necessary. The Westvaco Company will sell their slag material for two cents per ton. The Idaho Department of Highways Materials Laboratory has conducted tests on these slag materials and the following conclusions are taken from the report, RESULTS OF INVESTIGATIONAL TESTS ON WESTVACO SLAG FOR USE AS A PLANTMIX AGGREGATE:

> The results of these three types of tests (cohesion, immersion-compression, and aggregate bitumen stripping) would seem to indicate that Westvaco slag can be used for plantmix aggregate. The cohesion values are considerably higher than the values normally obtained using crushed gravel or rock aggregate. The samples undergoing immersion-compression tests gained strength after being immersed for four days. This gain was from 9% to 26%. The mixes showed good stability and were not susceptible to deterioration when immersed in water.

The aggregate-bitumen stripping tests indicated that an anti-stripping agent is definitely required for the Westvaco slag. The tests also indicated that considerable care should be used in picking a commercial anti-stripping agent. The agent should be heat-stable, which according to these tests, many are not, and it should be applied in the correct amount.

IV. AVAILABILITY OF AGGREGATES

Blaine County

The main source of gravel in Blaine County is the intermontane valley through which U.S. 93 passes. Three gravel formations are available: Fluvio-glacial deposits, terrace deposits, and river outwash. All of these formations are of suitable quality for all types of highway construction aggregates.

Blaine County can independently meet its aggregate requirements, and is also the nearest source of gravel to help meet the future needs of adjacent counties.

Camas County

The main source of material in Camas County lies within Camas Prairie and its borders. Camas Prairie is an eastward trending intermontane basin along the northern flank of the Snake River Plain. The basin is a structural depression about 45 miles long and 8 to 10 miles wide. Basalt flows at one time blocked the eastern outlet to the basin, behind which alluvial material and lake deposits accumulated. Intrusive and extrusive rocks of Cretaceous and Quaternary age surround the basin. Groundwater in the basin is generally within 10 feet of the surface.

The prairie is a gently undulating valley floor that slopes southward from the mountains north of the prairie onto low erosional terraces. The most noted example of this is Soldier Creek Valley. These terraces and fans appear to be the best prospect for future sources of aggregate. The rocks existing in the fans and terraces have the same mineral composition as found in present sources, but the material is larger and has not been affected by the valley water table. Thus, less alteration of the feldspars to kaolinite is to be expected and should result in sounder primary rock types.

Cassia County

Cassia County is geologically and topographically divided into a series of distinct units. In the northern part of the county there are two large areas covered with Snake River basalts. Tertiary silicious volcanics are exposed over most the southwestern portion of the County and in a north-south strip through the center. West of this central strip of volcanics is a parallel range of older hills. On the eastern border of the county is another north-south range of hills composed of Paleozoic marine limestones (not shown on the map).

The bulk of the present aggregate in Cassia County is taken from either the Snake River and its banks or from the widespread blanket of alluvial material. Deposits along Goose Creek and Raft River have produced a number of local sources. The Goose Creek drainage provides an abundant supply of good quality sand and gravel.

Because of the topography of the county, the traffic patterns have been confined primarily to the alluvial valleys. With the exception of those roads which traverse the basalt plain, aggregate sources are conveniently located.

Gooding County

Gooding County has a few select sources of material. The Melon gravels are available and are a dominant feature in Hagerman Valley. (See Appendix E).

Near Hagerman these gravels are composed of large well rounded boulders. Down river, near Bliss, the gravels grade into fine sand. There are several existing pits within this formation.

The Tuana gravels are exposed above the canyon near Bliss. There are several pits in these gravels, but the deposits in this area are nearly depleted.

North from Bliss there are two formations that include gravel: the Glenns Ferry Formation and the Banbury Basalt Formation. The Banbury Basalt Formation contains an upper and a lower unit of basalt and a middle part of sedimentary deposits. These sediments are made up of brown sand and gravel set in lenticular channel deposits, and light silt, clay and diatomite of lacustrine origin. There is a large deposit of quartzitic cobble gravel at Bray Lake, northwest of Gooding 15 miles. The gravel appears to be equal in engineering properties to the Tuana gravels.

There are alluvial stream deposits in the Gooding area on the Big Wood River and in Dry Creek Canyon. These deposits are thin and overlie basalt of the Snake River group. Large deposits of detritus are not present because the drainage onto the Snake River Plains was slight. A large quantity of the existing water enters the water table before it reaches the Plains and the remaining water is unable to carry very large quantities of material.

The aggregate needs of Gooding County cannot be met by the sources available within the county. Probably the nearest source of gravel to the Interstate alignment is the Tuana Gravels. Accessibility is limited, however, since the material is south and west of the Snake River and bridges crossing the Snake River are inadequate for large loads.

Jerome County

Jerome County, like many adjacent counties, is made up almost entirely of basalt rock which is mantled by eolian soils. Many fissure buttes and volcanic remnants dot the horizon and form the prominent area relief. No major drainages traverse the county which explains the lack of granular alluvial material.

The melon gravels form scattered bars and are widespread throughout the county. (See Appendix E.) Investigations of these gravels to date have been rather thorough due to the lack of other material for aggregate. The notable feature of these deposits is the variation in gradation, particularly in the larger material. Experience and use of these deposits has also been variable, but generally the results have been poor. High Los Angeles wear and high absorption are some of the characteristics that limit their use. The variation in gradation of the deposits insitu and the need for adequate material in this area, however, should warrant further qualitative investigation on these formations.

The basalt within the county could prove useful. The Los Angeles wear will be high on the vesicular flows and progressively less on the more dense basalts. Los Angeles values of between 40 and 60 can be expected from the flow tops. The structure and density of the basalt are controlled by the depth of flow. The depth of the flow is dependent upon the viscosity of the lava at the time of extrusion and the topography prior to deposition. An indication of the depth and properties of a flow can be obtained by inspecting the outcrops along the Snake River Canyon. For examples, visual inspection of the canyon walls south of Hazelton shows a fairly dense black basalt with dice structure. It is expected this particular flow will break into crushable size fragments with a minimum of powder.

Projection of the thickness and the properties of any individual flow cannot be made accurately over great distances. Core drilling is the best and most economical method of locating or tracing a flow suitable for use as aggregate.

Gravel suitable for surfacing aggregate will have to be hauled from other areas. At present, gravel is being hauled from source Ln-6 on the Big Wood River, 15 miles north from Shoshone. When this source is depleted, haul will necessarily increase since any remaining gravel will be found further north.

Other sources of gravel aggregates are the Goose Creek gravels in the Burley area and the Tuana gravels south from Bliss. The use of these two sources would also require long hauls. Another possibility is the Westvaco slag from Pocatello.

Lincoln County

Lincoln County is entirely covered with basalt flows, some of which are covered with alluvium or eolian soils. Volcanic remnants and cones are abundant and several are adjacent to the major highways. The use of these materials as aggregate is possible, but is deficient as discussed for basalt.

Through the combined lava flows two small channels have been cut by the Big and Little Wood Rivers. The only possibility of locating gravel sources is along the reaches of these rivers. (See Appendix E).

The Cottonwood area, north and east from the Shoshone Ice Caves, is the largest source of gravel supply. Future needs can be filled from sources located in Blaine County when the Cottonwood area is depleted of sand and gravel.

Minidoka County

Minidoka County contains limited amounts of fine sand and gravel. Coarse, crushable material will have to be obtained from Cassia County or the few deposits adjacent to the Snake River. The material is of good quality if the clay can be rejected. The high water table will create additional expense when using the material. A dredging or pumping operation may be required.

Twin Falls County

Twin Falls County contains three sources of gravel: (1) Tuana gravels, (2) Melon gravels, and (3) Quaternary alluvium.

The Tuana gravels, on the western edge of the county may provide an abundant supply of gravel. Unfortunately, most of the source area is not immediately accessible for construction purposes. (See Appendix E).

The Melon gravels are located along the Snake River with an abundant supply. The largest deposit is a bar at the Clear Lakes Bridge. The basalt gravel here is fine and well rounded. This material lies at the bottom of the Snake River Canyon on the south side, making access difficult.

Quaternary alluvial deposits, near the center of the county, can provide a large quantity of subbase to base quality aggregate. Well logs show depths of the material up to 65 feet in all the alluvial valley fill deposits. This material is not of a sufficiently high quality for surfacing.

Material is scarce from Rogerson south. Alluvial fans at the edge of the Goose Creek Mountains may provide some material of base quality. There is also alluvial material in small quantities along Salmon Falls Creek (not shown on map).

Aggregates will have to be obtained from outlying areas to meet surfacing requirements in the populated areas. The Tuana gravels on the west may provide relief to the problem as can the Goose Creek gravels.

V. ECONOMIC CONSIDERATIONS

Table I lists approximate haul costs from and to various cities of aggregates available from areas having a surplus. Haul prices were derived from price lists obtained from Foster Slag Company in Pocatello and Clark Tank Lines in Salt Lake City. Both price lists noted consideration would be given to hauls with special merits.

Table II is a compilation of costs required to produce and haul aggregate for an assumed plantmix use. Such costs include loading, unloading, producing, shipping and any required treatments. The cost of asphalt is not included.

Aggregates produced from basalt quarries will cost between $2.00 and $2.50 per ton depending upon ease of rock fracture and the number of free working faces. Haul will be a minor item since basalt quarries could probably be located next to practically any project.

TABLE I

Approximate Cost of Shipping Aggregates

From:	Pocatello		Bellevue-Hailey		Burley Area	
To:	R.R.*	Truck	R.R.*	Truck	R.R.*	Truck
Paul	2.32	2.90	3.19	3.20	1.02	0.96
Hazelton	2.44	3.20	3.44	2.50	1.40	1.55
Eden	2.56	3.40	3.36	2.50	1.48	1.70
Jerome	2.82	3.85	2.96	2.30	1.89	2.10
Wendell	2.92	4.29	2.77	2.30	2.08	2.30
Tuttle	3.02	4.29	2.56	2.50	2.29	2.50
Bliss	2.92	4.74	2.39	2.50	2.45	2.90
Twin Falls	2.82	3.85	4.07	2.30	1.55	1.90
Shoshone	2.70	4.29	1.76	1.90	2.06	2.30

* These figures include additional truck haul from the Railroad siding to the project site.

TABLE II

Approximate Cost of Plant Mix Aggregate

From:	Pocatello		Bellevue-Hailey		Burley Area	
To:	R.R.*	Truck	R.R.	Truck	R.R.	Truck
Paul	3.85	4.23	4.31	4.02	2.25	1.89
Hazelton	3.97	4.53	4.56	3.32	2.63	2.48
Eden	4.09	4.73	4.48	3.32	2.71	2.63
Jerome	4.35	5.18	4.08	3.12	3.12	3.03
Wendell	4.45	5.62	3.89	3.12	3.31	3.23
Tuttle	4.55	5.62	3.68	3.32	3.52	3.43
Bliss	4.45	6.07	3.51	3.32	3.68	3.83
Twin Falls	4.35	5.18	5.19	3.12	2.78	2.83
Shoshone	4.23	5.62	2.88	2.72	3.29	3.23

VI. CONCLUSIONS

Gravel is abundant in some areas of District Two and absent in others. The Melon gravels, although widely distributed throughout the valley occur as scattered bars of varying gradation. The Melon gravels located above the Snake River Canyon are suitable for subbase only, while some of the bar deposits in the canyon are presently being used for plantmix aggregate. Cement or asphalt treatment might, in some cases, make the subbase material acceptable for use as a base material.

Jerome, Lincoln and Gooding Counties have a very limited supply of material. Lincoln County contains only one large source of material 16 miles north from Shoshone and a few small gravel deposits along the Big and Little Wood Rivers. This material is of good quality. It is generally acceptable for plantmix and for concrete aggregate. Gooding County contains a very limited amount of alluvial material around the townsite of Gooding and in the vicinity of Tuttle.

With some areas of these three counties, maintenance demands for aggregate can be met from local deposits. For larger projects shipping long distances will be necessary to bring in materials from outlying sources.

The southern part of Blaine County can supply good quality material to Jerome, Lincoln, and Gooding Counties. The Tuana gravels in northwestern Twin Falls County may also supply a good quality material. The economics of shipping will be the governing factor when selecting future sources of supply.

Twin Falls County contains an abundance of inferior base and subbase quality material. If necessary in any particular area, cement or asphalt treatment might bring some material up to base quality standards. Further tests will be required to prove this possibility.

The Camas County material degrades seriously and has a high clay content. These problems might be overcome by locating future sources to the north of Camas Prairie in the alluvial fan and terrace gravels.

Cassia County can adequately provide its own needs and supply material to other parts of District Two. The gravel in the Goose Creek Drainage is a hard, durable gravel suitable for any use.

The Raft River gravels are considered poor in quality because of a high percentage of natural sand, clay, and some calcite leaching. In most cases they are suitable for use as a base material. Rejection of a portion of these fines might make the material suitable as a surfacing aggregate.

The Snake River gravels are a hard, durable material suitable for any use, however, some of the material will require an anti-stripping agent when used as an asphalt surfacing aggregate.

Cassia County is an excellent supplier of aggregate for areas requiring material, particularly Minidoka, Twin Falls and Jerome Counties. The railroad might prove to be an economical means of transporting the material.

The Foster Slag material near Pocatello is another source of aggregate if economical to ship. The cost of the material is high at this time, however, because of the necessity of adding an anti-stripping agent and the extreme distance for shipping.

Hauling by railroad rather than by truck could prove to be less expensive if the costs of handling and transporting the materials from the railroad sidings to the projects can be reduced. Central stockpiling of the material might absorb some of the expense.

The inexhaustable supply of basalt could prove to be the solution to the materials availability problem. The high Los Angeles Abrasion values are the principal specification requirements that the material fails to meet. It is questionable if this criteria is applicable if the material does not chemically degrade. This is particularly true if it is considered that the material will have very little opportunity to abrade once it is emplaced and covered. It is also possible to obtain basalt quarry sites that will produce hard, durable material suitable for any use.

Remnants of volcanic cones are a good source for base material. The material does, however, require treatment to provide acceptable base.

VII. RECOMMENDATIONS

The geologic maps and report regarding quality and quantity of materials for highway purposes should not be considered final, but only the initial step to a coordinated study of materials availability in that portion of District Two. Similar studies should be prepared for the remainder of District Two and all the remainder of the State following the pattern of this study. Specific recommendations are as follows:

1. Continue correlation of geologic formations with engineering data regarding material tested. Refine mapping in areas where investigations are made and keep the maps current and accurate.
2. Compile information on the properties and performances of the material for each geologic formation. Definite performance characteristics should be developed for each use including information regarding treatments, etc.
3. Soil profiles should indentify the geologic formations encountered. Each survey should endeavor to further map and correlate the geologic formation.
4. Further testing of the Snake River basalts to determine acceptability for base and surfacing is warranted and should be expedited. Tests to determine the character of the basaltic glass and possible devitrification accompanying any mechanical degradation. Tests which can enlarge our knowledge in this regard are x-ray defraction and differential thermal analysis studies.

Mechanical degradation of excessive amounts of fine plastic material results is not in itself sufficiently detrimental to prohibit its use. Specifications should be developed for the use of the basalts including tests for degradation, etc.

5. Ask for alternate bids using crushed basalt with appropriate specifications versus crushed gravel with different, but appropriate specification if necessary. Most gravels would involve a longer haul distance and may offset cost of drilling, shooting and crushing basalt.

6. Continue similar studies for the remainder of the State and publish the compiled information of properties of the material as warranted for use by the Department and other agencies.

Conservation of the existing small sources of aggregate in Jerome, Gooding and Lincoln Counties for local use is warranted. Insufficient quantities exist for any large Interstate projects and would exhaust the supply completely.

GLOSSARY OF TERMS

AGGREGATE The mineral material, such as sand, gravel, shells, slag, or broken stone, or combinations thereof, with which cement or bituminous material is mixed to form a mortar or concrete.

ALLUVIUM Earth, sand, gravel and stones and other transported matter which has been washed away and thrown down by rivers, floods and other causes, upon land not permanently submerged beneath the waters of lakes and seas.

ANDESITE A volcanic rock composed essentially of andesine and one or more mafic constituents.

APHANITIC Pertaining to a texture of rocks in which the crystalline constituents are too small to be distinguished with the unaided eye.

BASALT An extrusive rock composed primarily of calcic plagioclase and pyroxene, with or without olivine.

BATHOLITH A stock-shaped mass of igneous rock intruded as the fusion of older formations.

CALICHE Gravel, sand, or desert debris cemented by porous calcium carbonate; also the calcium carbonate itself.

CROSS-BEDS The arrangement of laminations of strata transverse or ablique to the main planes of stratification of the strata concerned; inclined often lenticular, beds found between the main bedding planes, found only in granular desiments.

DETRITUS Matter worn from rocks by mechanical means.

DEVITRIFICATION The process by which glassy rocks break up into definite minerals.

DIATOMITE The silica secreted from a microscopic algar.

EOLIAN A term applied to the erosive action of the wind and to deposits which are due to the transporting action of the wind.

FACIES The "aspect" belonging to a geological unit of sedimentation, including mineral composition, type of bedding, fossil content, etc.

FELDSPAR A group of abundant rock-forming minerals.

FLUVIOGLACIAL Pertaining to streams flowing from glaciers or to the deposits made by such streams.

FORMATION In geology, any assemblage of rocks which have some character in common, whether of origin, age or composition.

INTERSTICE Pore

LACUSTRINE Produced by or belonging to lakes.

LAVA Fluid rock such as that which issues from a volcano or a fissure in the earth's surface.

LIMONITE A generic term for brown hydrous iron oxide not specifically identified.

LITHOLOGY The study of rocks based on the megascopic examination of samples.

LOESS A sediment, commonly nonstratified and commonly unconsolidated, composed dominantly of silt-size particles, ordinarily with accessory clay and sand, deposited primarily by the wind.

MAGMA Naturally occurring mobile rock material generated within the earth and capable of intrusion and extrusion from which igneous rocks are considered to have been derived by solidification.

MATRIX In a rock in which certain grains are much larger than the other grains of smaller size comprising the matrix.

OUTCROP The coming out of a stratum to the surface of the ground; that part of a stratum which appears at the surface.

PORPHYRY All porphyrite rocks; i.e., igneous rocks in which larger crystals are set in a finer groundmass.

PRESSURE RIDGE An elongated upbowing of the crust of a lava flow, apparently due to a compressive force imparted by the viscous drag of slowly moving subcrustal lava.

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APPENDIX A

SUMMARY OF QUANTITIES AVAILABLE AND REQUIRED

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SUMMARY OF QUANTITIES AVAILABLE AND REQUIRED

	Cubic Yards Material Available	Cubic Yards Material Required
Cassia	5,037,000	1,318,000
Minidoka	1,018,000	399,000
Jerome	1,958,000	1,730,000
Twin Falls	1,406,000	1,492,000
Gooding	1,231,000	1,825,000

The above figures reflect only the total quantity of available material in the present sources and not the quality. For instance, of the thirteen sources in Jerome County totaling 1,958,000 cubic yards, only one source can supply surfacing material. Cassia County is the only county that can adequately supply material of quality suitable for surfacing requirements.

Source of Information: District Two Materials Availability Study by Ron Schueffle, 1964.

APPENDIX B

INTERPRETATION OF PHYSICAL TESTS FOR QUALITY OF AGGREGATES

APPENDIX B

INTERPRETATION OF PHYSICAL TESTS FOR QUALITY OF AGGREGATES

Test	Interpretation
Los Angeles Abrasion	The test measures resistance to mechanical degradation of aggregates. It does not measure chemical degradation, or resistance to weathering. Values of less than 20 normally indicate good material, 20-35 fair, and above 35 weak materials. The higher the value the less durable the aggregate.
Degradation Potential	No definite standard test is presently available, although Idaho uses a tumbler to abrade the materials while wet. A reduction in Sand Equivalent Value and increase in percent passing the No. 200 Sieve is used to evaluate the material. Increases in No. 200 of 5% and drop in S.E. to less than 30 are usually considered a warning that serious degradation can occur in service. Petrographic analysis of thin sections can be equally useful, but judgment of the petrographer is the only reliable means for interpreting the seriousness of degradation.
Percent Passing No. 200	The percentage passing the No. 200 sieve must be limited to specification requirements. Should excessive amounts exist in a deposit, it must be removed before it can be used. An alternate to wasting is treatment of the material with Portland cement, lime or asphalt to nullify the excessive material passing the No. 200 sieve.
Sand Equivalent	The test measures the amount of material passing the No. 200 sieve and also the amount of active clay within the material. The lower the value the greater is the amount finer than the No. 200 sieve or it is a more active clay material. Values below 30 would indicate need for wasting fine aggregate or processing with Portland cement, lime or asphalt.
Liquid Limit and Plasticity Index	These tests measure properties similar to the Sand Equivalent. Normally values of S.E. above 30 are non-plastic and hence have no values for either. Specifications normally limit the LL to a maximum of 25 and P.I. to a maximum of 6.

Absorption

This test is a measure of the porosity of the stone particles. It is normally run in conjunction with specific gravity determinations using the absorption of water as a criteria. Absorptions less than 1½ percent are considered to indicate denser aggregates and values above 2½ percent, to be highly absorptive. Absorption tests made with asphalt are particularly important in predicting acceptable asphalt mixture service. Should the absorption of asphalt exceed 1 to 1½ percent, some difficulty may be experienced and should absorption exceed 3 percent, the aggregate should not be used.

Bituminous Swell

This test measures the affinity for water of the material passing the No. 200 sieve. If swelling occurs, it indicates the possible disintegration of the mixture due to infiltration of water.

Mortar Strength

This test measures the acceptable strength producing properties of a mortar for concrete. Specifications set forth the limits of the test requirements.

Gradation

Gradation of sand gravel deposits is important in considering the end product desired. Surfacing and base materials should have oversize material to be crushed with higher percentages desirable. Oversize, too large to be crushed, is undesirable if in amounts sufficient to affect production costs. Excessive amounts of sands, silts, etc., require these fractions be wasted and also affect production costs.

APPENDIX C

TYPICAL TEST RESULTS ON MATERIAL FROM EACH GEOLOGIC FORMATION

APPENDIX C

TYPICAL TEST RESULTS ON MATERIAL FROM EACH GEOLOGIC FORMATION

Pit	Location	Wear	% Absor.	Bit. Swell	LL	PI	SE	%Pass 200	Deg.Test SE	Deg.Test % 200
			Tuana Gravel Test Results							
TF-27	7 Miles NW Buhl	21	2.2	0.005	NV	NP	38-88	3	30	4-9
			Fluvioglacial Deposits							
Bl-51	1 Mile W. Gannett	16	1.6	0.008	NV	NP	-	2	-	-
Bl-91	3 Miles NW Gannett	19	-	-	NV	NP	57-78	2	-	-
			Melon Gravels							
Jr-2	2 Mi. N. Shoshone Falls	37	2.3	0.005	NV	NP	69	5	37	6-12
Jr-31	4 Miles N. Hansen Bridge	48	2.2	0.004	NV	NP	74	4	67	4-7
Jr-38	6 Miles S. Hazelton	43	2.4	0.009	NV	NP	34	7	59	8-13
TF-67	Clear Lakes	33	-	-	NV	2	26-62	8	18	11-20
Gd-45	2 Miles S. Hagerman	28	1.7	0.015	NV	NP	85	1	60	3-8
			Big Wood River Gravel							
Bl-94	3 Miles W. Stanton Crossing	21	1.5	0.007	NV	NP	72	2	52	3-9
Ln-6	2 Miles S. Ice Caves	19	1.2	0.004	NV	NP	82	1	60	2-7
Gd-43	1 Mile N. Tuttle	16	0.9	0.004	NV	NP	58	2	50	4-10
Gd-40	3 Miles NW Gooding	18	1.4	0.011	NV	NP	39	2	41	4-8
			Little Wood River Gravels							
Ln-67	8 Miles NW Shoshone	18	0.9	0.009	NV	NP	76	1	41	5-8
Ln-66A	11 Mi. NE Shoshone	22	1.6	0.005	NV	NP	80	2	54	2-5

(Continued)

Pit	Location	Wear	% Absorp.	Bit. Swell	LL	PE	SE	%Pass 200	Deg. Test SE	Deg. Test % 200
	Camas Prairie Gravels									
Cm-67	1 Mile N. Fairfield	35	2.5	0.014	NV	NP	55	4	41	4-10
Cm-45	4 Miles E. Fairfield	38	1.8	0.004	NV	NP	98	1	50	2-9
Cm-38	10 Miles SE Fairfield (Quarry)	17	3.7	-	39	13	-	5	-	-
	Twin Falls County Gravels									
TF-65	4 Miles SE Hollister	26	3.1	0.007	NV	NP	55	2	26	6-10
TF-7	8 Mi. S. Kimberly	30	2.8	0.024	NV	NP	84	4	49	7-10
TF-63	7 Miles S. Hansen	29	3.7	0.008	NV	NP	25-50	3	28	5-12
TF-35	1¼ Mile NE Rogerson	30	4.0	0.016	37	8	-	-	-	-
	Burley - Oakley Gravels									
Cs-128S	3 Miles SW Burley	24	2.0	0.013	NV	NP	81	1	48	2-6
Cs-57S	8 Miles N. Oakley	22	2.1	0.007	NV	NP	71	1	45	5-8
	Snake River Gravels									
Cs-85	Lake Wallcott	22	1.7	-	NV	NP	90	1	61	2-5
Cs-122	1 Mile E. Burley	24	-	-	NV	NP	89	1	55	1-9
Md-23	1 Mile E. Burley	24	-	-	NV	NP	89	1	66	2-6
	Westvaco Slag									
-	Pocatello	24	0.6	-	NV	NP	69	4	66	4-10
	Basalt									
Jr-38	Basalt Face	27	2.0	0.023	NV	NP	79	6	49	6-12
-	-	45	2.2	0.013	NV	NP	80	7	67	6-14

APPENDIX D

COST OF PRODUCTION AGGREGATES EXCLUDING HAUL

APPENDIX D

COST OF PRODUCTION AGGREGATES EXCLUDING HAUL

Slag Material

Truck Haul

Royalties	.02
Crushing	.70
Anti-stripping agent	.51
	$1.33/ton

Railroad Haul

Royalties	.02
Crushing	.70
Loading	.10
Unloading	.20
Anti-stripping agent	.51
	$1.53/ton

Bellevue - Hailey

Truck Haul

Royalties	.02
Crushing	.80
	$ .82/ton

Railroad Haul

Royalties	.02
Crushing	.80
Loading	.10
Unloading	.20
	$1.12/ton

Burley Area

Truck Haul

Royalties	.13
Crushing	.80
	$ .93/ton

Railroad Haul

Royalties	.13
Crushing	.80
Loading	.10
Unloading	.20
	$1.23/ton

APPENDIX E

MAPS OF COUNTIES SHOWING GEOLOGIC FORMATION

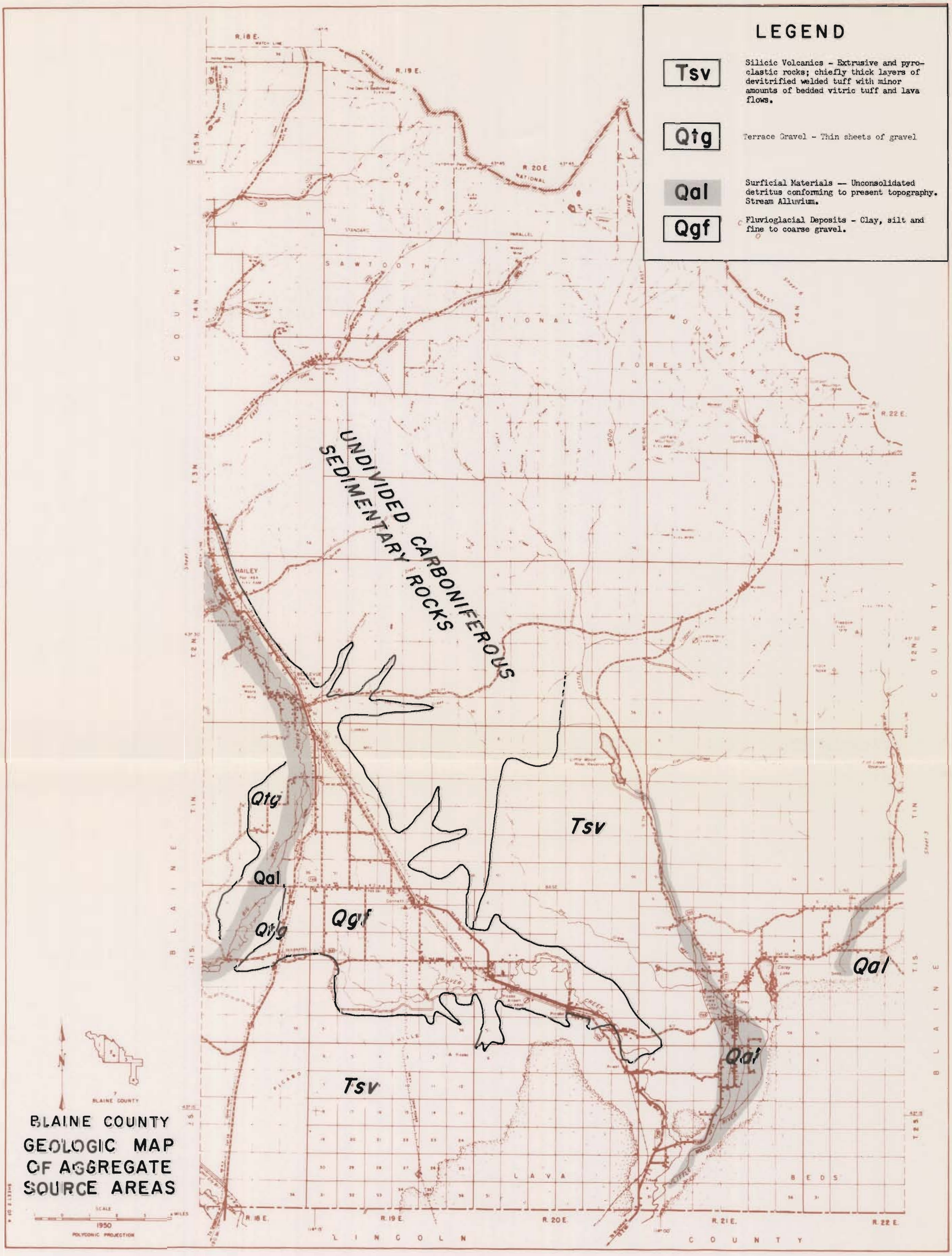
Counties Included:

Blaine - northwest quadrant
Camas - south half
Cassia
Gooding
Jerome
Lincoln
Minidoka - south half
Twin Falls

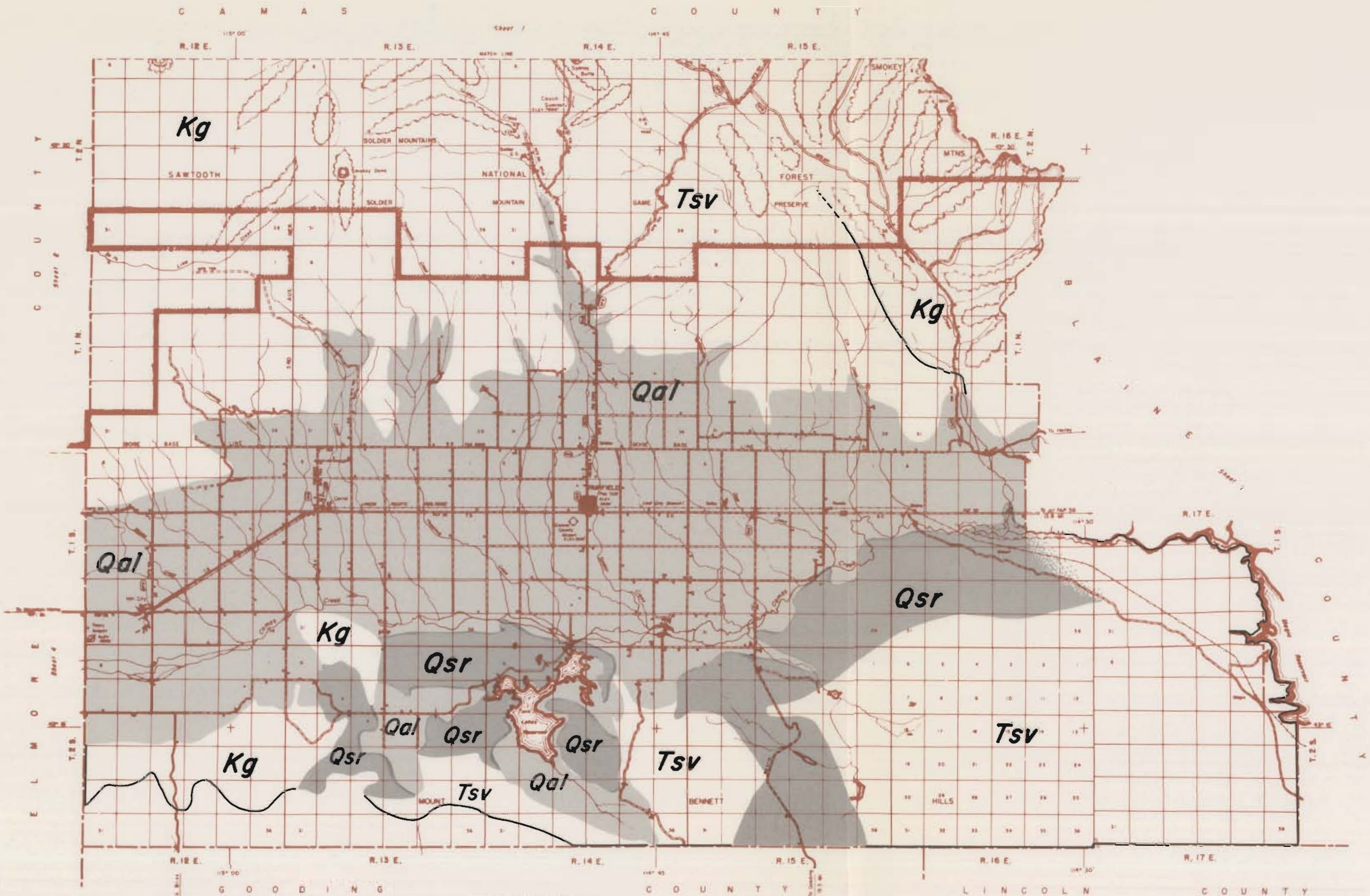
MAP KEY AND EXPLANATION

Quaternary

Recent	Qal / Qls	Surficial Materials - Unconsolidated detritus conforming to present topography. Qal, stream alluvium Qls, landslide debris
Recent	Qmk	McKinney Basalt - Lava flow of prophyritic plagioclase-olivine basalt from McKinney Butte, 8 miles northwest of Gooding.
Pleistocene	Qtg	Terrace Gravels - Thin sheets of gravel.
Pleistocene	Qm	Melon Gravels - Boulders, cobbles and pebbles of basalt in a matrix of basaltic sand, generally arranged in crossbeds.
Pleistocene	Qc	Crowsnest Gravel - Lithology variable - occupies terraces above the Snake River.
Pleistocene	Qbs	Bruneau Formation, Undivided - Detrital material dominated by massive lake beds of white, weathered fine silt, clay and dolomite in layers 50 feet or more thick. Some fangravels and basaltic lava flows.
Pleistocene	Qt	Tuana Gravels - Pebble and cobble gravel interbedded with layers of massive brown to gray sand and silt.
Pleistocene	Qgf	Fluvioglacial Deposits - Clay, silt and fine to coarse gravel.
	Qtg / Qtgb	Glenns Ferry Formation - Basin fill of poorly consolidated detrital material and minor lava flows. Qtg, lake and stream deposits characterized by abrupt lateral change in facies. Qtgb, lava flows of olivine basalt, most subaerial that form sheet-like bodies within detrital deposits.



BLAINE COUNTY
GEOLOGIC MAP
OF AGGREGATE
SOURCE AREAS



LEGEND

Qsr	Basalts of Snake River Group Undivided	Kg	Granitic Rocks of Idaho Batholith
Tsv	Silicic Volcanics - Extrusive and pyroclastic rocks; chiefly thick layers of devitrified welded tuff with minor amounts of bedded vitric tuff and lava flows.	Qal	Surficial Materials - Unconsolidated detritus conforming to present topography. Stream Alluvium.

N

CAMAS COUNTY

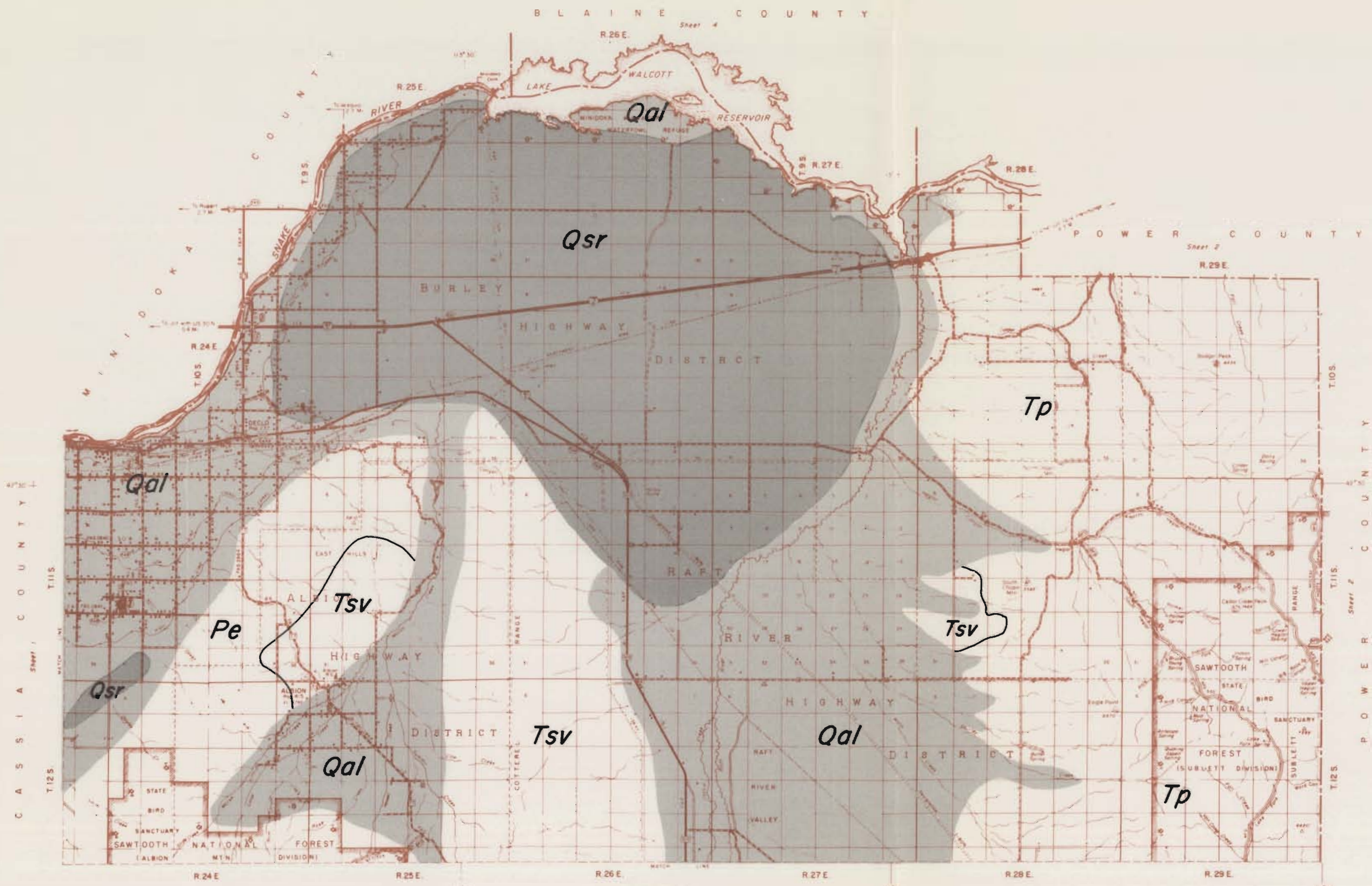
CAMAS COUNTY

GEOLOGIC MAP OF AGGREGATE SOURCE AREAS

SCALE

1950

POLYCONIC PROJECTION



LEGEND

Qal	Surficial Materials - Unconsolidated detritus conforming to present topography. Stream Alluvium.
Qsr	Basalts of Snake River Group Undivided
Tsv	Silicic Volcanics - Extrusive and pyroclastic rocks; chiefly thick layers of devitrified welded tuff with minor amounts of bedded vitric tuff and lava flows.
Pe	Precambrian Intrusive Rocks
Kg	Granitic Rocks of Idaho Batholith
Tp	Payette Formation - Moderately to poorly consolidated sand, silt and gravel of lacustrine and fluviatile origin.

CASSIA COUNTY

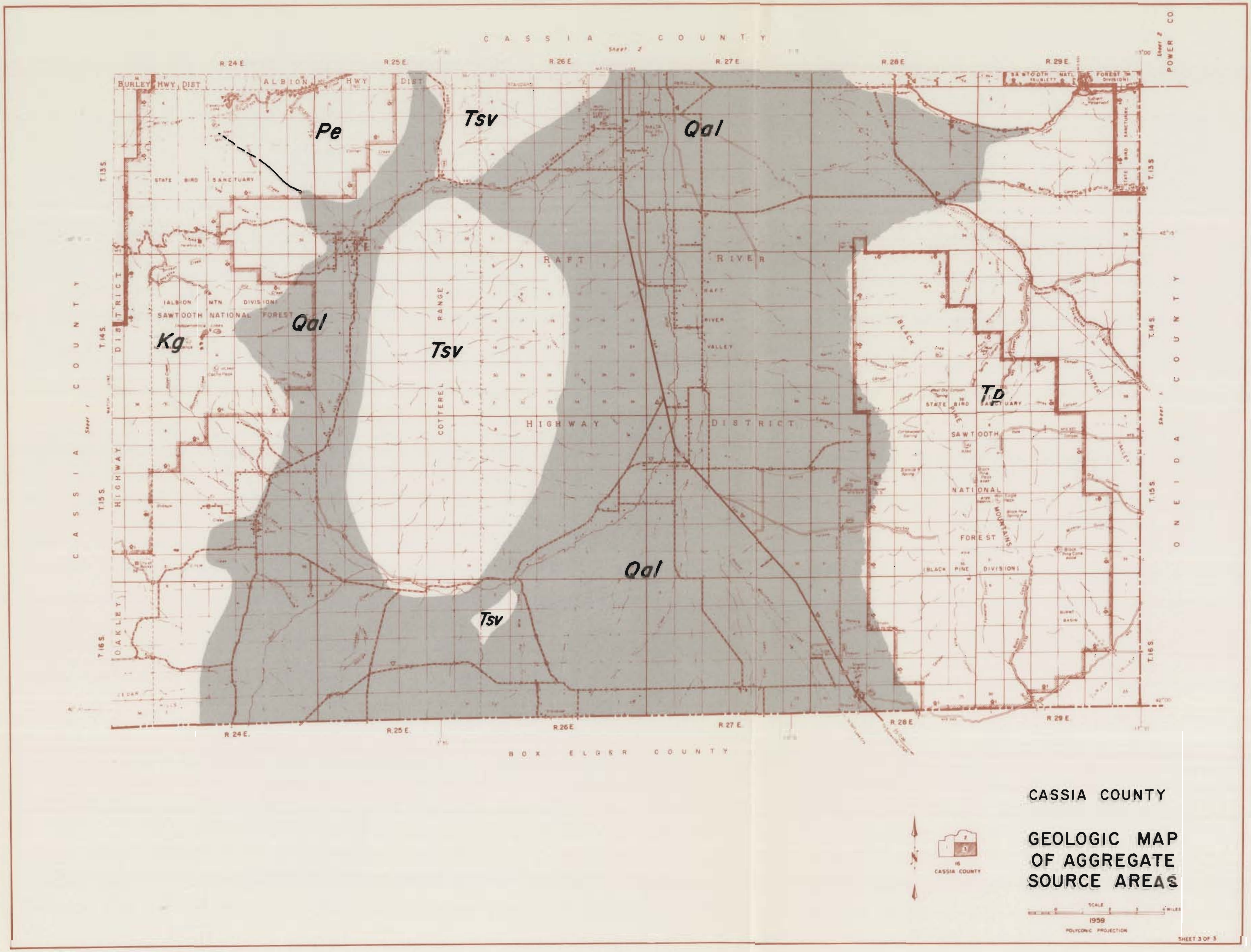
GEOLOGIC MAP OF AGGREGATE SOURCE AREAS

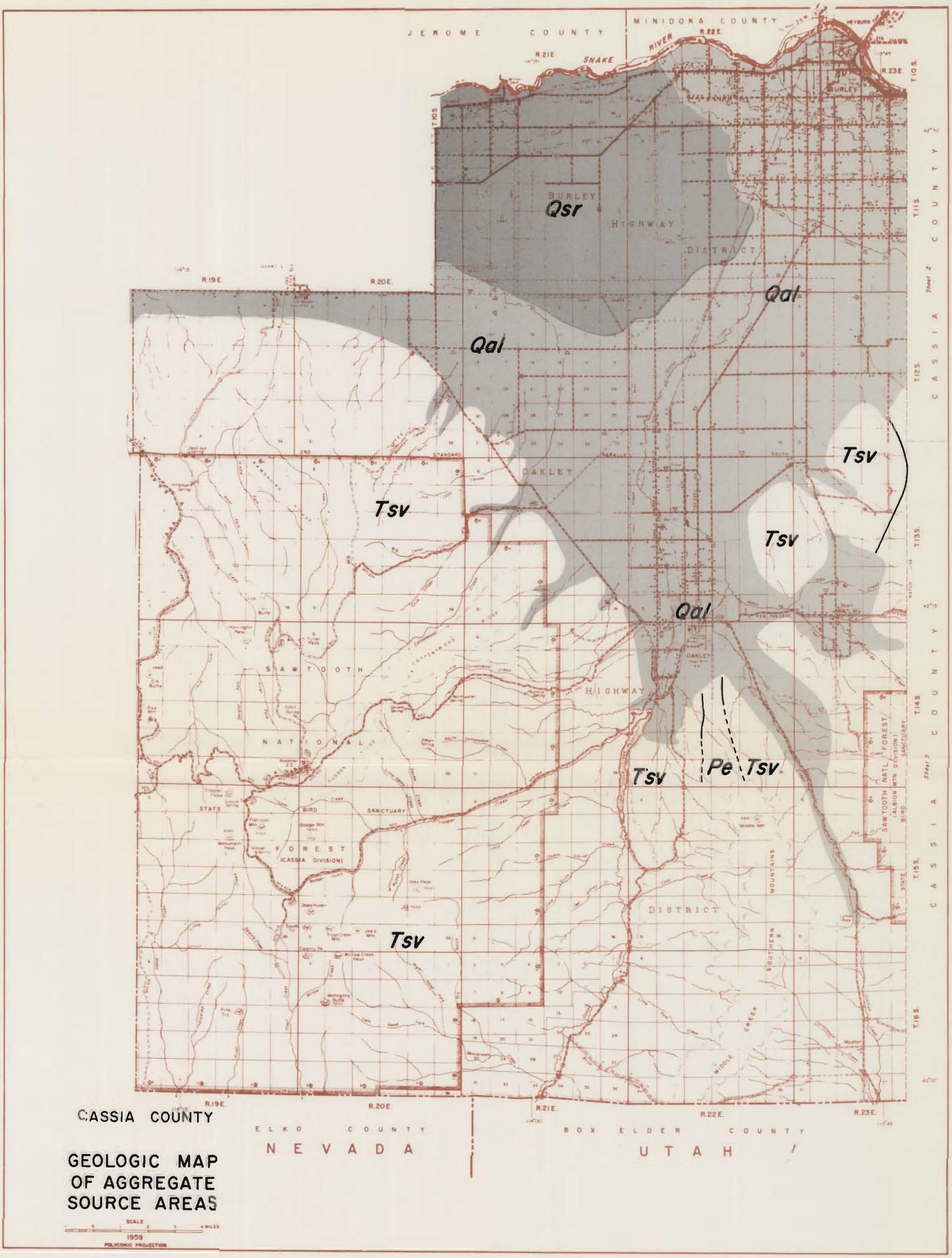
SCALE

1959

POLYCONIC PROJECTION

SHEET 2 OF 3

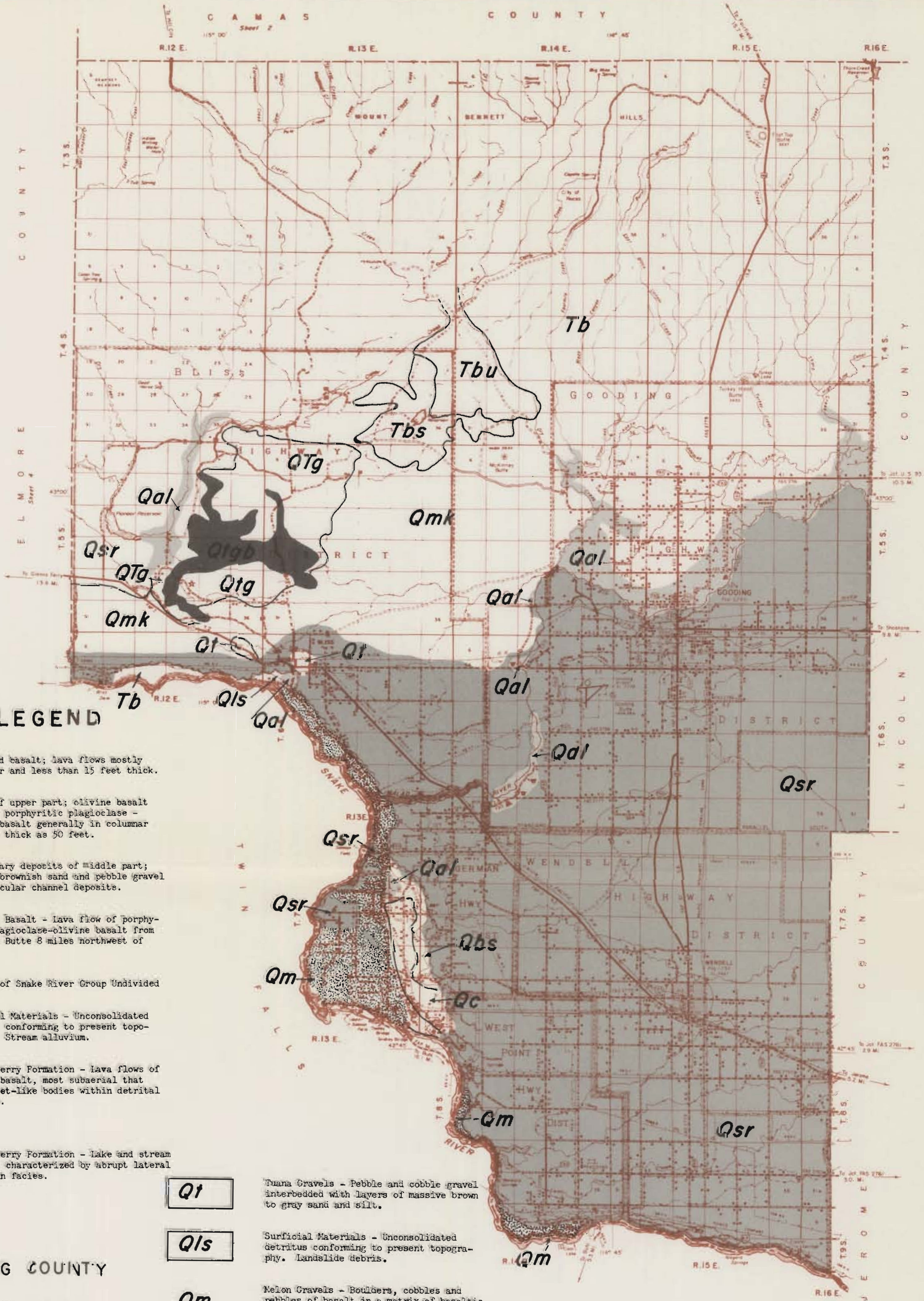

CASSIA COUNTY
Sheet 2
BOX ELDER COUNTY
CASSIA COUNTY
ONEIDA COUNTY
POWER CO
R. 24 E.
R. 25 E.
R. 26 E.
R. 27 E.
R. 28 E.
R. 29 E.
T. 13 S.
T. 14 S.
T. 15 S.
T. 16 S.
Pe
Tsv
Qal
Kg
Tp
RAFT RIVER HIGHWAY DISTRICT
BURLEY HWY DIST
ALBION HWY DIST
OAKLEY HIGHWAY DISTRICT
ALBION MTN DIVISION SAWTOOTH NATIONAL FOREST
STATE BIRD SANCTUARY
COTTEREL RANGE
RAFT RIVER VALLEY
BLACK PINE MOUNTAINS
SAWTOOTH NATIONAL FOREST (BLACK PINE DIVISION)
CASSIA COUNTY
GEOLOGIC MAP
OF AGGREGATE
SOURCE AREAS
SCALE
1959
POLYCONIC PROJECTION
SHEET 3 OF 3



CASSIA COUNTY

GEOLOGIC MAP OF AGGREGATE SOURCE AREAS

SCALE
0 1 2 3 4 MILES
1959
POLYCONIC PROJECTION



LEGEND

Tb	Undivided basalt; lava flows mostly vesicular and less than 15 feet thick.
Tbu	Basalt of upper part; olivine basalt and some porphyritic plagioclase - olivine basalt generally in columnar flows as thick as 50 feet.
Tbs	Sedimentary deposits of middle part; largely brownish sand and pebble gravel in lenticular channel deposits.
Qmk	McKinney Basalt - Lava flow of porphyritic plagioclase-olivine basalt from McKinney Butte 8 miles northwest of Gooding.
Qsr	Basalts of Snake River Group Undivided
Qal	Surficial Materials - Unconsolidated detritus conforming to present topography. Stream alluvium.
Qtgb	Glenns Ferry Formation - Lava flows of olivine basalt, most subaerial that form sheet-like bodies within detrital deposits.
QTg	Glenns Ferry Formation - Lake and stream deposits characterized by abrupt lateral change in facies.
Qt	Tuana Gravels - Pebble and cobble gravel interbedded with layers of massive brown to gray sand and silt.
Qls	Surficial Materials - Unconsolidated detritus conforming to present topography. Landslide debris.
Qm	Melon Gravels - Boulders, cobbles and pebbles of basalt in a matrix of basaltic sand, generally arranged in crossbeds.
Qbs	Bruneau Formation - Undivided - Detrital material dominated by massive lake beds of white-weathered fine silt, clay and dolomite in layers 50 feet or more thick. Some fangravels and basaltic lava flows.
Qc	Crowsnest Gravel - Lithology variable - occupies terraces above Snake River.

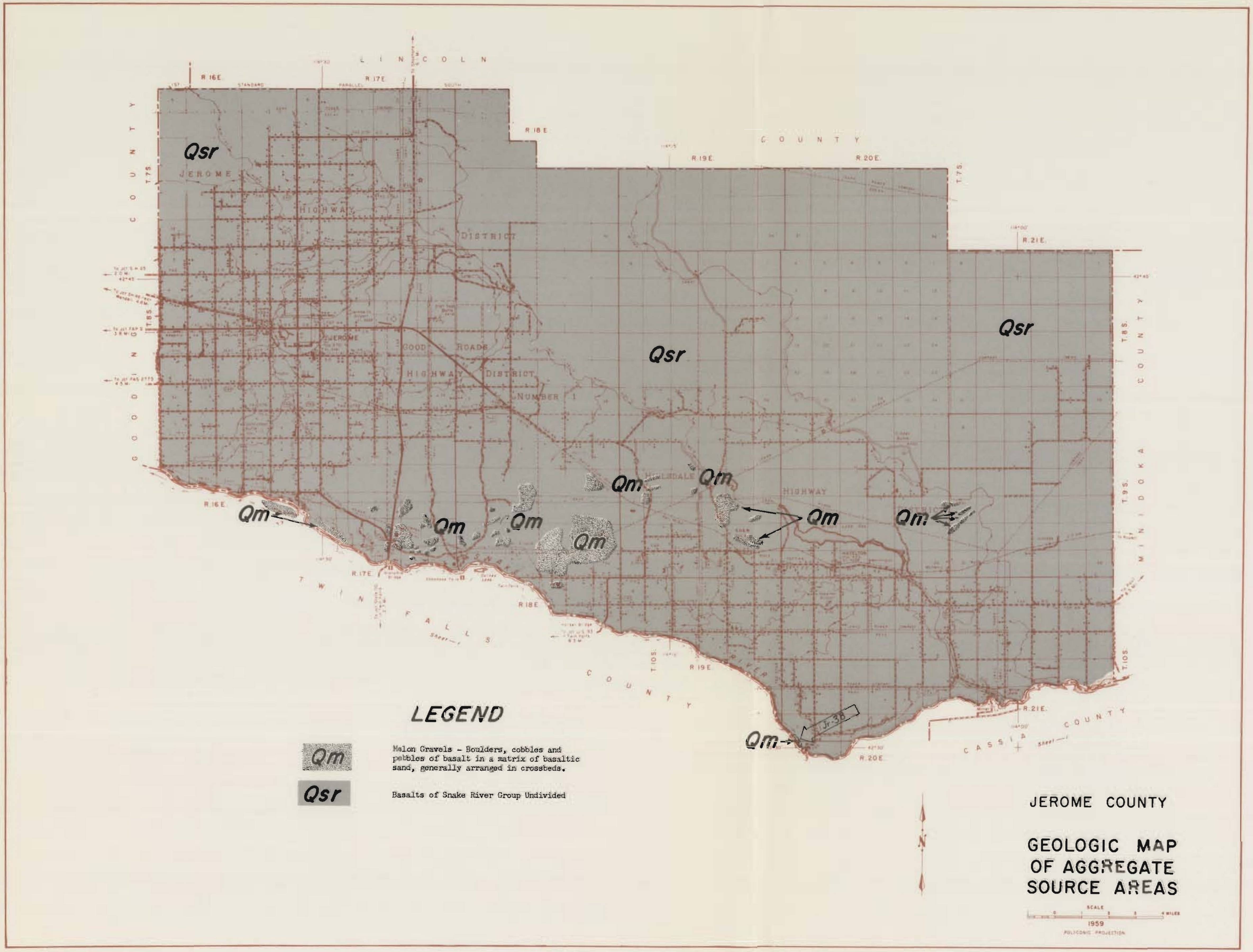
GOODING COUNTY

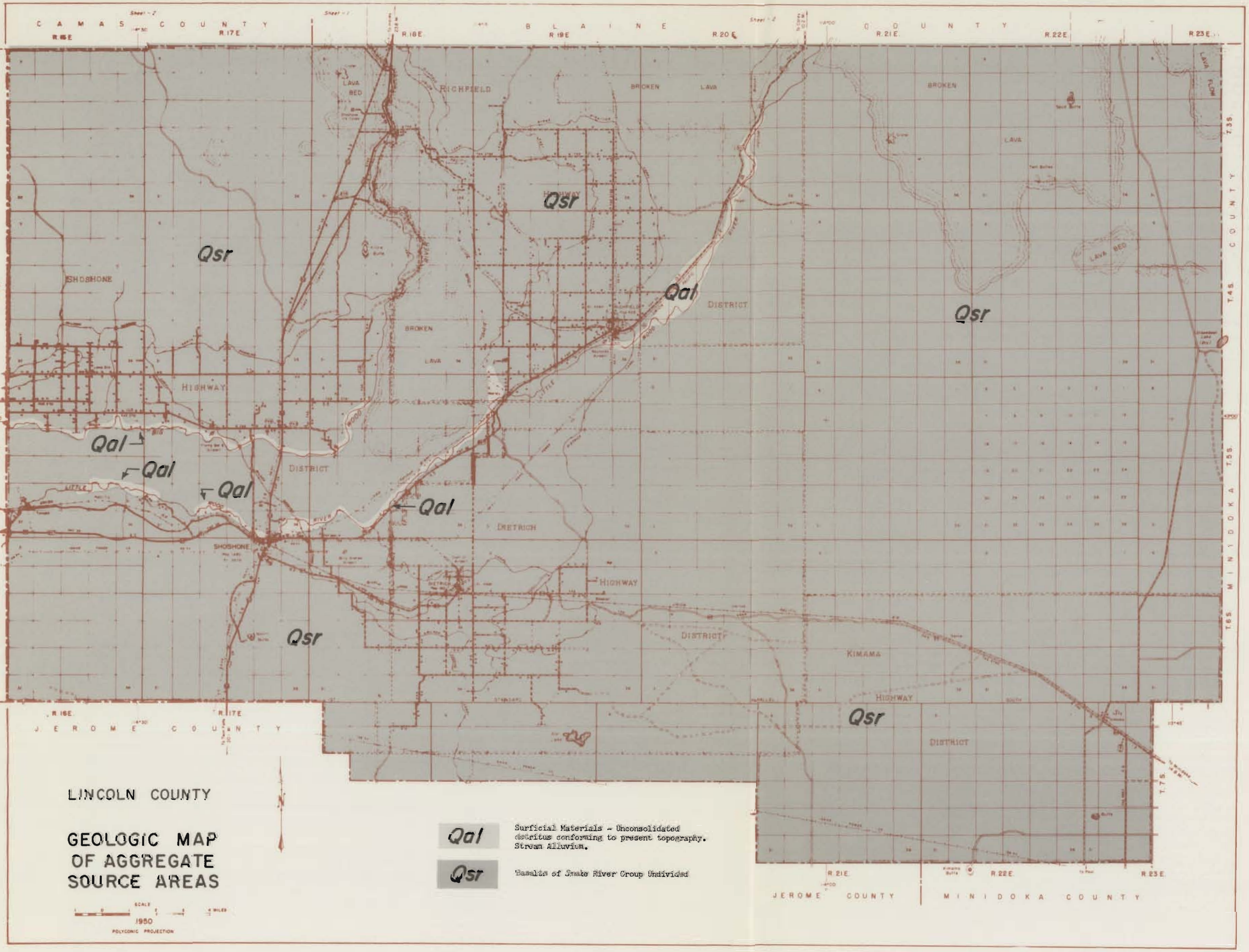
GEOLOGIC MAP OF AGGREGATE SOURCE AREAS

SCALE

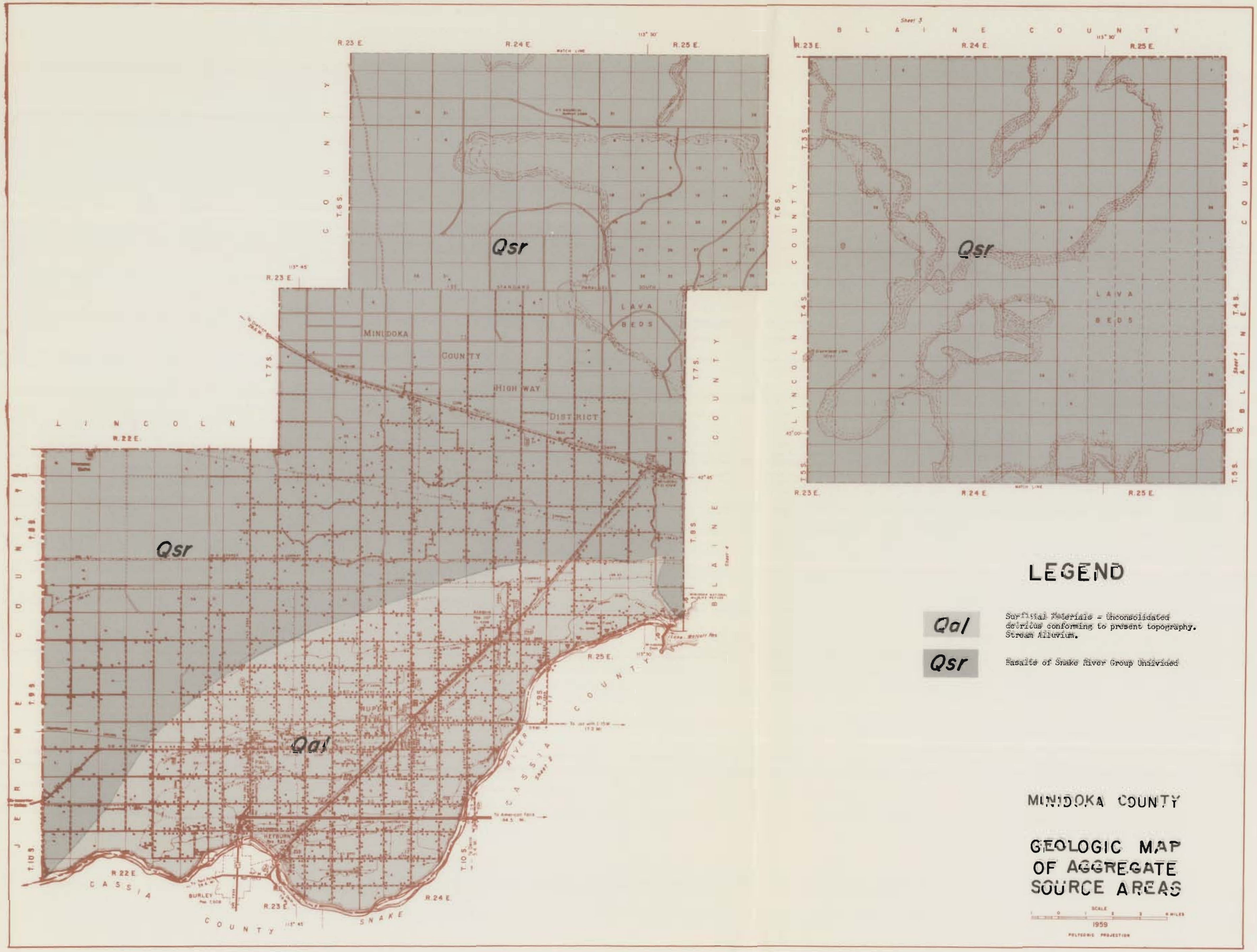
1960

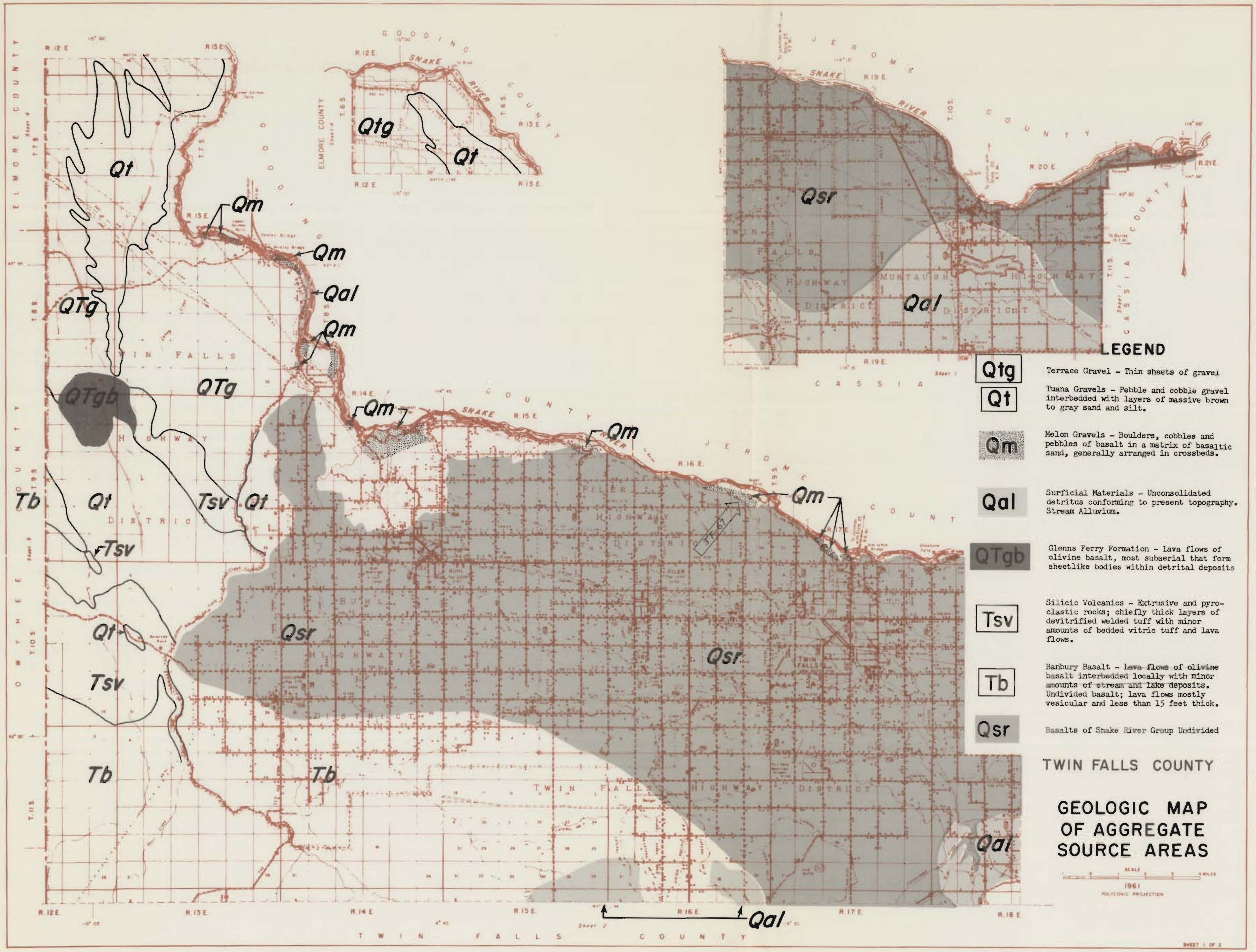
POLYCONIC PROJECTION


LINCOLN
R.16E.
R.17E.
R.18E.
R.19E.
R.20E.
R.21E.
COUNTY
T.7S.
T.8S.
T.9S.
T.10S.
GOODING COUNTY
MINIDOKA COUNTY
TWIN FALLS COUNTY
CASSIA COUNTY
JEROME
HIGHWAY
DISTRICT
GOOD ROADS
HIGHWAY DISTRICT
NUMBER 1
HIGHWAY
RIVER
Qsr
Qm
Jr.36
LEGEND
Qm
Melon Gravels - Boulders, cobbles and pebbles of basalt in a matrix of basaltic sand, generally arranged in crossbeds.
Qsr
Basalts of Snake River Group Undivided
N
JEROME COUNTY
GEOLOGIC MAP
OF AGGREGATE
SOURCE AREAS
SCALE
1959
POLYCONIC PROJECTION



CAMAS COUNTY
BLAINE COUNTY
GOODING COUNTY
JEROME COUNTY
MINIDOKA COUNTY
R.16E.
R.17E.
R.18E.
R.19E.
R.20E.
R.21E.
R.22E.
R.23E.
T.3S.
T.4S.
T.5S.
T.6S.
T.7S.
RICHFIELD
SHOSHONE
DIETRICH
KIMAMA
BROKEN LAVA
LAVA BED
HIGHWAY
DISTRICT
LITTLE WOOD RIVER
Qsr
Qal
LINCOLN COUNTY
GEOLOGIC MAP
OF AGGREGATE
SOURCE AREAS
SCALE
1950
POLYCONIC PROJECTION
Qal
Surficial Materials - Unconsolidated detritus conforming to present topography. Stream Alluvium.
Qsr
Basalts of Snake River Group Undivided


BLAINE COUNTY
LINCOLN COUNTY
JEROME COUNTY
CASSIA COUNTY
MINIDOKA COUNTY HIGHWAY DISTRICT
LAVA BEDS
Qsr
Qal
R. 22 E.
R. 23 E.
R. 24 E.
R. 25 E.
T. 3 S.
T. 4 S.
T. 5 S.
T. 6 S.
T. 7 S.
T. 8 S.
T. 9 S.
T. 10 S.
SNAKE RIVER
HEYBURN
BURLEY
RUPERT
LEGEND
Qal
Surficial Materials = Unconsolidated detritus conforming to present topography. Stream Alluvium.
Qsr
Basalts of Snake River Group Undivided
MINIDOKA COUNTY
GEOLOGIC MAP OF AGGREGATE SOURCE AREAS
SCALE
1959
POLYCONIC PROJECTION


LEGEND
Qtg Terrace Gravel - Thin sheets of gravel
Qt Tuana Gravels - Pebble and cobble gravel interbedded with layers of massive brown to gray sand and silt.
Qm Melon Gravels - Boulders, cobbles and pebbles of basalt in a matrix of basaltic sand, generally arranged in crossbeds.
Qal Surficial Materials - Unconsolidated detritus conforming to present topography. Stream Alluvium.
QTgb Glenns Ferry Formation - Lava flows of olivine basalt, most subaerial that form sheetlike bodies within detrital deposits
Tsv Silicic Volcanics - Extrusive and pyroclastic rocks; chiefly thick layers of devitrified welded tuff with minor amounts of bedded vitric tuff and lava flows.
Tb Banbury Basalt - Lava flows of olivine basalt interbedded locally with minor amounts of stream and lake deposits. Undivided basalt; lava flows mostly vesicular and less than 15 feet thick.
Qsr Basalts of Snake River Group Undivided
TWIN FALLS COUNTY
GEOLOGIC MAP OF AGGREGATE SOURCE AREAS
SCALE
1961
POLYCONIC PROJECTION
SHEET 1 OF 2
ELMORE COUNTY
OWYHEE COUNTY
GOODING COUNTY
JEROME COUNTY
CASSIA COUNTY
TWIN FALLS COUNTY
SNAKE RIVER
TWIN FALLS HIGHWAY DISTRICT
FILER HIGHWAY DISTRICT
BUHL HIGHWAY DISTRICT
MURTAUGH HIGHWAY DISTRICT
R.12 E.
R.13 E.
R.14 E.
R.15 E.
R.16 E.
R.17 E.
R.18 E.
R.19 E.
R.20 E.
R.21 E.
Qt
Qtg
QTg
QTgb
Qm
Qal
Tsv
Tb
Qsr