GENERAL GEOLOGIC DISCUSSION

ROCKY MOUNTAIN NATIONAL PARK - MATERIALS SURVEY

(Eastern Slope Area)

By

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(Revised August, 1966)

The Park-wide Materials Survey is to be performed in three increments. These will be: (1) the eastern slope area of the park, (2) the western slope area, and (3) the alpine or Trail Ridge Area.

This report covers the eastern slope area—flight strips 1 through 15. The elevations covered by the flight strips range from about 7500 to 9200 feet. The most prominent geologic features in this area are the glacial remnants—morraines, valley trains, and ground moraines—and the denuded batholithic structure which forms most of the country rock.

The average annual precipitation ranges from 18 inches to in excess of 24 inches in the southeastern portion of the park, and the climate is quite cool in summer to cold in the winter. No accurate frost depths were found; however, the area lies in the 30-inch frost depth zone.

The moranial materials are of three general ages, with a fourth stage representing recent age glacial activity in a few of the older cirques. The characteristics are different enough that they will probably be readily identifiable on air photographs and in the field.

The pre-"Bull Lake" (or Buffalo age) is represented only in Tahosa Valley, east of Long's Peak. The deposits are sheetlike and lack moranial topography. Weathering may extend as deeply as four feet and surface boulders tend to be broken or deeply exfoliated. Soils are quite acid, having a pH of 4.5 compared to 6.5 for the surface soils.

The oldest recognizable moraines are those which have been called "Old Moraine Remnants" by some workers, and have been correlated with the "Bull Lake" glaciation of the Wind River Range, Wyoming by Richardson, 1960.

The main identification characteristics of these moraines are:

(a) Low moraines which occur downstream from the high and conspicuous Park Border Moraines.

(b) These moraines do not form high ridges and have been deeply weathered.

(c) These are the oldest moraines that have a well-preserved moranial topography.

(d) Moraines are among the most extensive in the Park and have been axially bissected by streams and segmented by tributaries.

(e) Moraines represent two advances of the ice.

(f) Moraines have mature slopes and bear a scattering of boulders, many of which are cracked, spheroidally spalled, or split apart.

(g) In general, these moraines can be distinguished by a gray-brown podzolic soil, as much as 5 feet deep, which has formed on the deposits. The weathered material has a pH of 6 while deeper materials show a pH of 7.

(h) Soils show mature zonal profile which is less weathered than Buffalo age but more weathered than Pinedale. A large portion of the weathered rock may be crushed in the hands.

(i) The lateral moraines are perched as much as 1000 feet above the valley floors and as much as 500 feet above the Park Border (Pinedale) moraines.

(j) The cirques lack the steep headwalls of the Pinedale age, and their slopes are thickly mantled with talus and solifluction debris, which also bears a mature zonal soil.

(k) It is noted in some of the earlier literature, that in some valleys these moraines have been cut into terrace-like forms by streams.

The "Park Border" moraines (Correlated Pinedale by Richardson), show the following characteristics:

(a) The moraines form high and conspicuous ridges.

(b) The moraines represent three pulsations of ice. In the major valleys, the system is composed of three concentric lateral moraines which start, at the west, against rock valley walls.

(c) The outer ridge is more highly weathered than the inner two, but much less weathered than older moraines. In general, the material exhibits the gray soil horizon of unweathered till.

(d) The surfaces are irregular, hummocky, and littered with fresh boulders.

(e) The moraines of the earliest stage are quite large, and in places overlap those of the Bull Lake.

(f) Lateral moraines are but little dissected by streams and kettles contain water at least seasonally. Terminal moraines are only partly breached by axial streams.

(g) The till is sandier and much more bouldery than that of the Bull Lake and lacks any distinct evidence of clay accumulation.

(h) Moraines of the middle and late stages are relatively small, but are almost identical in nature with the earlier stage.

The "Upper Valley" moraines of earlier workers are correlated by Richardson as both "Pinedale" and "Neoglaciation" (of Recent Age).

(a) Neoglaciation included two small ice advances, confined to the cirque areas and extending no more than one mile from the headwalls, and commonly only about one-half mile.

(b) Deposits of the Temple Lake Stage are small and very bouldery, most of the boulders are blocky and angular, soil cover is developed but is sparse.

(c) The moraines are covered by scrub spruce or tundra vegatation.

(d) The moraines or rock glaciers of the younger, or historic stage, lie at the cirque heads above those of the Temple Lake stage, they appear very fresh, are blocky, and have no soil.

(e) In general, those moraines lie nearer to the valley floors than older moraines.

The eastern extension of the glaciers was to the west of Estes Park and no true till deposits are found east of Hondius Park on Fall River, or the YMCA camp on Thompson River. On St. Vrain drainage, moraines extend eastward to about Allens Park.

Valley trains extend eastward from below most of the moraines. These terraces are shown by ages in the literature, but will here be treated as an entry.

General features:

(a) Range in elevation from 6 feet to 45 feet to 50 feet above present stream beds.

(b) In general, they are imperfectly drained and exhibit a fairly lush vegetation.

(c) Most granular constituents are well water worn and are roughly stratified.

(d) In general, the materials are finer graded at greater distances from the terminal moraines. At distances of $\frac{1}{2}$ mile, boulders to 5 feet diameter are common while 3 to 4 miles away boulder size is nearer 2 feet diameter.

(e) These valley trains are generally missing in narrower parts of the canyon but almost wholely preserved at the wider points.

(f) These deposits are located primarily in Fall and Thompson River Canyons.

The bedrock of this area is mainly a result of the Longs Peak Batholith. This intrusion has been largely denuded by erosion, leaving the granite core exposed over a major portion of this area. Schist is found at Giant Track Mountain and the Twin Sisters Mountain area and also between Fall and Thompson Rivers west of Estes Park.

However, most of the glaciers have headed in granite rocks, and it is expected that a major portion of the till will be granitic.

The Longs Peak granite is described as moderately coarse grained, commonly porphyritic, flesh colored to gray granite. The microcline and orthoclase feldspars tend to lie in subparallel ranks oriented along that long axis. It weathers into fragmental separate crystals. Some orbicular structure has been noted at various locals with the dark minerals biotite and hornblende outlining the orbiculations. This structure is not common enough to identify this granite, however.

A deeper seated facies of the Longs Peak granite is a coarse, red granite, lacking parallel orientation of the feldspars. This material occurs in the St. Vrain area where erosion has cut deeper into the core. This granite is not shown inside the Park; however, it may well be found in moraine materials if the glacial cirques have cut deeply enough to expose it.

A granite chemically similar to the Longs Peak, but of a different age is the Mount Olympus granite. This granite is not shown as occuring in any single large area, but instead occurs as a great number of smaller intrusions. Several stock-like masses occur, but their outlines are not clear-cut. This granite is described as a massive, fine to medium grained, even textured, mostly light gray salt-and-pepper biotite granite. The weathering of this granite is less severe than the Longs Peak. The jointing is described as regular, rectangular and sheetlike. The orbicular

structure is absent in this granite.

The batholith did not extend under the continental divide from Mount Copeland southward, and 2000 feet to 3000 feet of schists are exposed in some of the cirques in this area. Therefore, it is expected that the southern tributaries to the North St. Vrain will contain primarily schist aggregates as moraines or terraces. The remainder of the schist occur mainly in combination with gneiss and due to the lit-par-lit injections of granites, should be reasonably sound in moraine and terrace deposits.

For aggregate purposes, the valley trains or stream terraces will probably afford the better materials. The moraines themselves will probably be considered only as secondary aggregate sources.

No mention is given in the literature of the eastern slope area of peat beds or landslides. However, the terrain and climatic conditions give strong indications that these may exist and they may be observed during the airphoto interpretation or field investigations.

BIBLIOGRAPHY

Boos, C. M. and M. F., 1934, Granities of the Front Range - The Longs Peak-St. Vrain Batholith: Geological Society of America Bulletin, Volume 45.

Ray, L. J., 1940, Glacial Chronology of the Southern Rocky Mountains: Geological Society of America Bulletin, Volume 51, Number 12, Part 1.

Jones and Quam, 1944, Glacial Landforms in Rocky Mountain National Park: Journal of Geology, Volume 52, Number 4.

Richardson, G. M., 1960, Glaciation of East Slope of Rocky Mountain National Park: Geological Society of America Bulletin, Volume 71.

Maps	Scale	
Trail Ridge	1:24000	7½' Quad.
Estes Park	1:24000	7½' Quad.
Longs Peak	1:24000	7½' Quad.

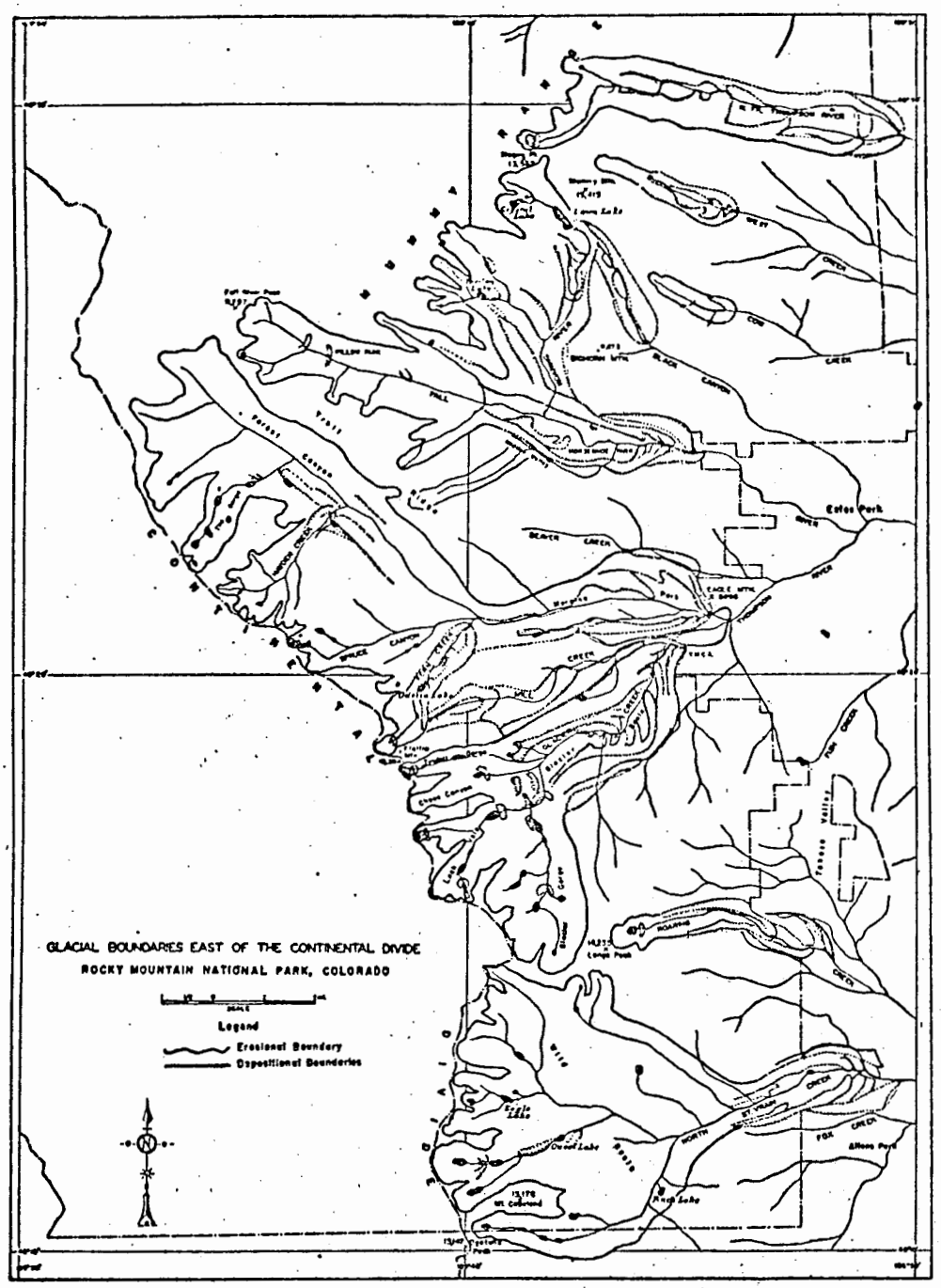

GLACIAL BOUNDARIES EAST OF THE CONTINENTAL DIVIDE
ROCKY MOUNTAIN NATIONAL PARK, COLORADO
Legend
Erosional Boundary
Depositional Boundaries

FIG. 2

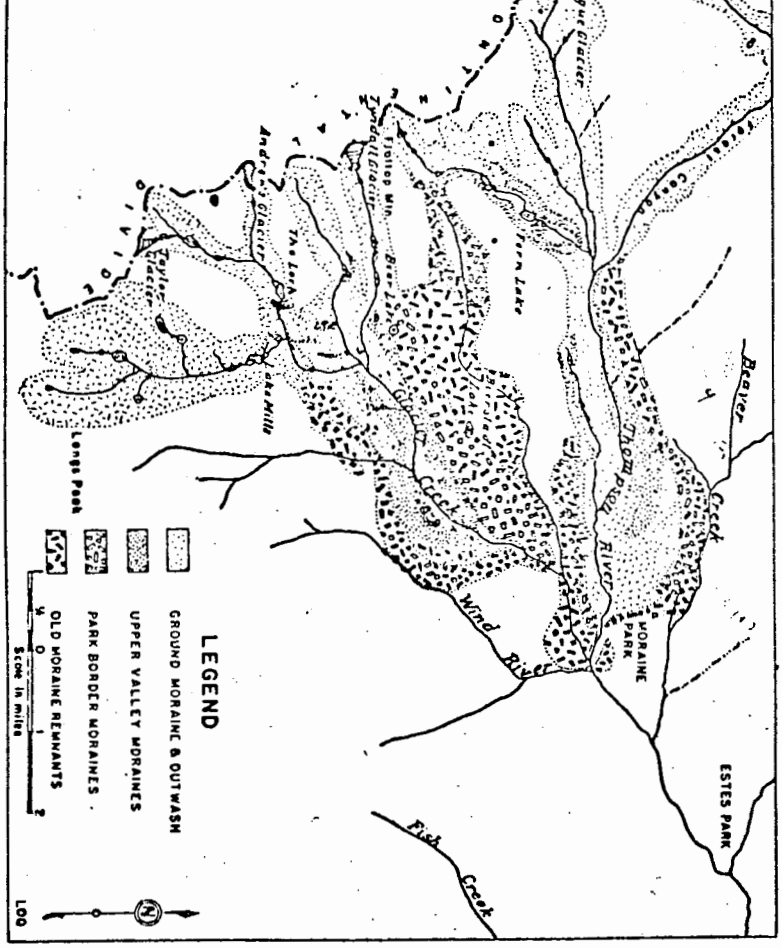
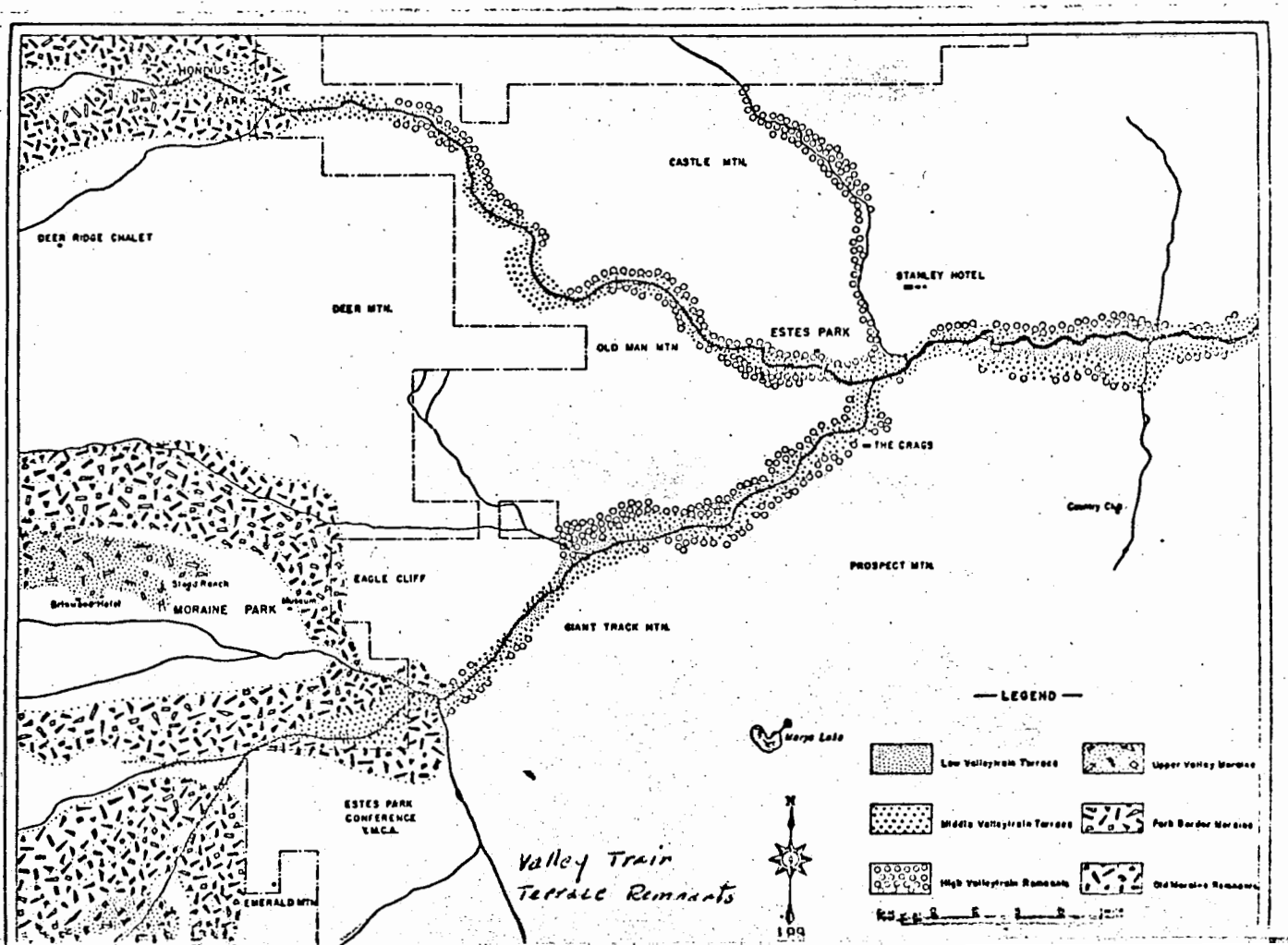


FIG. 3.—Glacial deposits in Glacier Creek and upper Thompson River valley systems



DISCUSSION OF PHOTOGRAPHS

ROCKY MOUNTAIN NATIONAL PARK - MATERIALS SURVEY

(Eastern Slope)

By

Robert L. Schuster

September 1966

PHOTOGRAPHIC INFORMATION

Flight Strip	1	Photographs 1-20 thru 1-28	(7/65 date flown)
Flight Strip	2	Photographs 4-24 thru 4-36	(9/65)
Flight Strip	3	Photographs 1-1 thru 1-6	(7/65)
Flight Strip	4	Photographs 1-2 thru 1-7	(10/64)
Flight Strip	5	Photographs 1-9 thru 1-22	(10/64)
Flight Strip	6	Photographs 1-45 thru 1-50	(7/65)
Flight Strip	7	Photographs 1-23 thru 1-27	(10/64)
Flight Strip	8	Photographs 1-30 thru 1-35	(10/64)
Flight Strip	9	Photographs 1-54 thru 1-58	(10/64)
Flight Strip	10	Photographs 1-36 thru 1-51	(10/64)
Flight Strip	11	Photographs 1-36 thru 1-40	(7/65)
		Photographs 1-59 thru 1-65	(10/64)
		Photographs 4-17 thru 4-23	(9/65)
Flight Strip	11A	Photographs 3-86 thru 3-94	(8/65)
Flight Strip	12	Photographs 1-54 thru 1-59	(7/65)
Flight Strip	13	Photographs 1-29 thru 1-33	(7/65)
Flight Strip	14	Photographs 4-9 thru 4-16	(9/65)
Flight Strip	15	Photographs 4-1 thru 4-8	(9/65)

Scale: 1:9600 (800 feet to one inch)

Width of flight strips: Approximately 7200 feet

Type of film: Agfa Color

GEOLOGIC REFERENCES

The following geologic references refer to the area in and adjacent to the eastern part of Rocky Mountain National Park. These references are listed in order of general importance to this section of the materials survey.

1. Richmond, G. M., "Glaciation of the East Slope of Rocky Mountain National Park, Colorado," Bulletin, Geological Society of America, Vol. 71, pp. 1371-1382, September 1960.

2. Boos, M. F., and Boos, C. M., "The Longs Peak - St. Vrain Batholith," Bulletin, Geological Society of America, Vol. 45 pp. 303-332, April 1934.

3. Jones, W. D., and Quam, L. O., "Glacial Land Forms in Rocky Mountain National Park, Colorado," Journal of Geology, Vol. 52, No. 4, pp. 217-234, 1944.

4. Ray, L.L., "Glacial Chronology of the Southern Rocky Mountains," Bulletin, Geological Society of America, Vol. 51, pp. 1851-1918, 1940.

MAPPING SYMBOLS

All	-	Alluvium. Generally too fine-grained and poorly graded to be classified as sand and gravel.
Bldrs	-	Concentration of large boulders.
Coll/Gr	-	Thin colluvium (generally less than 10 feet thick) over granite bedrock.
Fan	-	Alluvial fan. These deposits have been differentiated from sand and gravel (SG) deposits because they generally are more poorly graded. Occasionally these fans are composed partially of colluvial detritus in addition to alluvium.
Gn	-	Gneiss (metamorphosed granite).
Gr	-	Granite.
Mo	-	Glacial moraine. In most cases this can be classified as till, but locally it may contain deposits of waterworked material too small or indistinct to be differentiated.
Mo/Gr	-	Thin glacial moraine (generally less than 10 feet thick) over granite bedrock.
Muck	-	Tunnel muck, i.e., rock spoil from tunnel construction.

O	-	Organic materials (peat and muck). Where these deposits contain considerable soil, they are suitable for use as topsoil. Where the material is mostly peat and contains only a minor percentage of soil, it is suitable for mulch or as a soil conditioner.
O/SG	-	Organic material (generally about 1-3 feet thick) over sand and gravel.
SG	-	Sand and gravel.
Ta	-	Talus deposits.
TS	-	Areas with potential for topsoil borrow.

DESCRIPTION OF MATERIALS

Flight Strip 1, Photographs 1-20 thru 1-28
Flight Direction: Northeast to Southwest

Photograph 1-20

Since part of this photograph does not have stereoscopic coverage, its materials boundaries and descriptions are given under Photographs 1-22, Flight Strip 1, and 4-34, Flight Strip 2.

Photographs 1-22, 1-24, 1-26

The best sand and gravel deposit between Estes Park and Raymond occurs in Wild Basin as a sand and gravel (SG) terrace along the North Fork of the St. Vrain River. These terrace sands and gravels are fairly clean and well graded. The material exposed in the existing City of Longmont pit at the center of Photograph 1-22 is suitable for base course or surfacing aggregate.

The moraine (Mo) in this area is a coarse till which in some cases is so clean that it is difficult to distinguish from sand and gravel. This till is probably suitable for use as subbase and possibly as base course.

The organic (O) area on the north edge of Photograph 1-22 is a possible source of topsoil which occurs to a depth of one to two feet.

The granite (Gr) in the Wild Basin area is medium to coarse grained and is only moderately resistant to weathering. It would

probably not be worth quarrying since better materials are available in the area. The granite talus (Ta) on Photograph 1-24 could be used for riprap or barrier stone without the necessity of a quarrying operation.

Photograph 1-28

The materials on this photograph have not been mapped because the area covered is too far from any road and because no stereoscopic coverage is available.

Flight Strip 2, Photographs 4-24 thru 4-36
Flight Direction: North to South

Photograph 4-36

The moraine (Mo) on this photograph is a coarse till probably suitable for subbase and possibly for base course use.

The granite (Gr) has low resistance to weathering and in much of the area is covered by up to 10 feet of disintegrated granite (residual weathering product). The granite bedrock could be quarried for riprap or crushed stone if the quarry were pushed deep enough (generally greater than 10 feet) to obtain unweathered granite. The most satisfactory use of this material would probably be as base course protected from weathering by bituminous surfacing. The disintegrated granite is probably satisfactory for subbase use. However, the possibility of use of either of these materials is fairly small because of the existence of good sand and gravel deposits nearby in Wild Basin.

The organic material (O) in the northwestern quarter of the photograph is a possible source of topsoil which exists to a depth of about one foot.

Photograph 4-34

The materials on this photograph are described for Photograph 1-22, Flight Strip 1.

Photographs 4-32, 4-30, 4-28, 4-26

There are no worthwhile deposits of sand and gravel on these photographs.

The moraine (Mo) at the southern edge of Photograph 4-32 is a coarse till probably suitable for subbase and possible base course use. On Photographs 4-26 and 4-28 a thin layer (generally less than 10 feet thick) of this till overlies the granite bedrock. No definite boundary was found between the Mo/Gr and the Gr areas.

The granite (Gr) is a medium-grained granite which is fairly susceptible to deterioration due to weathering, and because of this in many places is covered by as much as several feet of residual disintegrated granite. The unweathered granite bedrock can be quarried for crushed stone, riprap, or barrier stone if it can be reached. The best use of this material would be as crushed stone base course protected from weathering by a bituminous surface.

The disintegrated granite probably would be suitable for subbase use.

Photograph 4-24

The materials on this photograph are mapped on Photographs 1-4 and 1-6, Flight Strip 3.

Flight Strip 3, Photographs 1-1 thru 1-6
Flight Direction: North to South

Photographs 1-6 and 1-4

The descriptions of these materials are the same as for Photographs 4-32, 4-30, 4-28 and 4-26, Flight Strip 2.

Photograph 1-2

The granite (Gr) in the center of this photograph apparently is more resistant to weathering than the more heavily timbered granites to the south. This greater resistance to weathering has resulted in less disintegrated granite in this area. If quarried, the granite bedrock could be used as crushed stone, riprap, or possibly barrier stone. The most satisfactory use would probably be as base course protected from weathering by a bituminous surface.

The colluvium which overlies granite (Coll/Gr) is an odd material. It is comprised of poorly graded angular fragments (mostly gneiss) up to two or three feet in size. This material probably would be suitable for use as subbase after crushing the larger sizes. Good exposures of this material can be seen in road cuts along the old highway (east central part of the picture).

Flight Strip 4, Photographs 1-2 thru 1-7
Flight Direction: North to South

Photograph 1-6

The granite (Gr) and colluvium over granite (Coll/Gr) in the southern one-third of the photograph have been described for Photograph 1-2, Flight Strip 3.

The alluvium (All) in this photograph is too silty (and in the darker patches, too organic) for use for anything but common borrow. The top foot or so of this material could be stripped for use as topsoil.

The granite (Gr) in the open areas in the northern part of this picture has low resistance to weathering, and thus is covered by as much as several feet of residual disintegrated granite. The disintegrated granite would be suitable for select borrow and possibly for subbase. The granite could be quarried, but the product obtained would not be of high enough quality to warrant the cost. If used it should be protected from weathering such as in base course covered by a bituminous mat surface.

The small area of SG consists of a silty sand and fine gravel in an old existing pit. The material should be satisfactory for subbase, but the volume remaining in the pit is probably too small to be bothered with.

Photograph 1-4

The best potential source of construction material in this

area is the tunnel muck (Muck) just southwest of Mary's Lake. This muck was obtained from the Ramshorn Tunnel which passes mainly through granite. The material is ungraded and ranges in size up to 6 to 8 inches. With proper grading it could be used for base course or surfacing. To obtain satisfactory gradation the larger sizes and some of the fines would have to be wasted (or the larger sizes could be crushed). The most promising role for this material would probably be as base course protected from weathering by a bituminous surface course.

In working a muck source of this type it should be remembered that waste metal components such as broken drill rod or trash are often encountered.

Most of the granite (Gr) on this photograph is badly weathered, and much of it is covered by up to several feet of disintegrated granite (some of which is not residual). This granite generally is of too low quality to warrant the cost of quarrying. The disintegrated granite should be suitable for use as select borrow or possibly subbase.

The alluvium (All) is too silty to be good for anything but common borrow. However, its surface is composed of about a foot of topsoil which could be obtained by stripping.

Photograph 1-2

The granite (Gr) and disintegrated granite on this photograph are essentially the same as that described for Photograph

1-4 except that the granite which makes up Prospect Peak is probably a little stronger and more resistant to weathering than that found on most of Photograph 1-4.

The alluvium (All) in the southeastern quarter of the photograph is described for Photograph 1-4.

Flight Strip 5, Photographs 1-9 thru 1-22
Flight Direction: North to South

Photograph 1-22

This photograph is extremely difficult to work with. It appears that this is almost entirely an area of granite bedrock with little non-rock material in evidence. There is a possibility that some of the rock in the southwest corner of the photograph is actually gneiss and not granite. This granite is similar to that described for Flight Strip 4.

Photograph 1-20

The SG on this photograph is a silty sand and fine gravel possibly suitable for use as select borrow or subbase. In part of the area designated as SG, the sand and gravel is interbedded with silty alluvium, and probably is good for little but common borrow.

The alluvium (All) is too silty for any use but common borrow. The top foot or so of the alluvium could serve as a source of topsoil.

The granite (Gr) on this photograph is similar to most of the granite in this area. It is badly weathered, and is covered with as much as several feet of disintegrated granite. The disintegrated granite is suitable for select borrow and possibly subbase. The bedrock is probably not of high enough quality to warrant the cost of quarrying. If crushed, it would be suitable for subbase and possibly base course but it should be protected from weathering by a bituminous wearing surface.

Photograph 1-18 and 1-16

The granite (Gr) on these two photographs is the same as that described for Photograph 1-20. Note that the large pit near the center of the photograph is in disintegrated granite.

The alluvium (All) on these photographs is too silty to be used for anything but common borrow. Most of this alluvium has about a foot of topsoil at the surface.

The sand and gravel (SG) at the northern edge of Photograph 1-16 is described for Photograph 1-14.

Photograph 1-14

The SG in the stream terraces adjacent to Lake Estes is composed of a fairly clean, well graded sand and gravel suitable for use as base course or surfacing aggregate. Good material could be obtained by dredging from Lake Estes as has been done in the past.

The granite (Gr) on this photograph is similar to that on Photographs 1-16, 1-18, and 1-20, and is described for Photograph 1-20.

The alluvium (All) on this photograph is the same as that described for Photographs 1-16 and 1-18.

Photographs 1-12 and 1-10

The lower elevations in this area consist of badly weathered granite covered by disintegrated granite up to several feet thick. The disintegrated granite is suitable for select borrow and possibly for subbase. The underlying weathered granite is generally not of good enough quality to warrant the cost of quarrying.

The higher elevations on these photographs are made up of a more resistant granite which is not covered by disintegrated granite as was the case at lower elevations. Satisfactory crushed stone, riprap, and possibly barrier stone could be produced by quarrying this material. Since this granite will be somewhat lacking in resistance to weathering, even though it is more resistant than the granite at lower elevation, it should be protected from weathering if possible. Thus, the optimum use probably would be as crushed stone subbase or base material under bituminous surfacing.

The alluvium (All) in these photographs is too silty to be used for anything but common borrow. There is a possibility of topsoil being obtained by stripping off the upper foot or so.

Flight Strip 6, Photographs 1-45 thru 1-50
Flight Direction: Northeast to Southwest

Photographs 1-46, 1-48, 1-50

The most promising source of material on this flight strip is the Common Point tunnel muck pile (Muck) on Photographs 1-46 and 1-48. This muck, which was obtained principally from granite bedrock, is ungraded and ranges in size up to 6 to 8 inches. With proper grading this material could be used for base course or surfacing. To obtain satisfactory gradation the larger sizes and some of the fines would have to be wasted (or the larger sizes could be crushed). The most promising role for this material would probably be as base course protected from weathering by a bituminous surface. In working a muck source of this type it should be remembered that waste metal or trash is often encountered.

Nearly all of the area on this flight strip is composed of medium-grained granite (Gr) similar to that found on other flight strips in this area. This material is rather badly weathered near the surface. It could be quarried for use as riprap, barrier stone, base course, or possibly surfacing material, but the zone of weathered material would have to be removed first. The most satisfactory use for this granite would be as subbase or base course protected from weathering by a bituminous surface.

The small source of SG on Photograph 1-46 is made up of silty sand and fine gravel. This deposit has been nearly worked out and very little usable material remains. What does remain is probably

suitable for use as select borrow and possibly as subbase but there is not enough to bother with.

The alluvium (All) on Photographs 1-48 and 1-50 is too silty to be used for anything but common borrow. The larger deposit near the southwestern edge of Photograph 1-50 is a possible source of topsoil about one foot thick.

Flight Strip 7, Photographs 1-23 thru 1-27
Flight Direction: Southeast to Northwest

Photographs 1-24 and 1-26

The SG in the valley of the Big Thompson River on Photograph 1-26 is a fairly clean, well graded sand and gravel suitable for base course or surfacing aggregate.

The small deposit of SG on the hillside in the center of Photograph 1-26 is a silty sand and fine gravel suitable for use as select borrow or possibly subbase material.

The granite (Gr) on these photographs is typical of the granite in this area. It is medium-grained and generally is badly weathered, the bedrock often being covered by as much as several feet of disintegrated granite.

The alluvium (All) on these photographs is too silty to be used for anything but common borrow. It possibly could serve as a source of topsoil which constitutes about the uppermost one foot of the deposit.

Flight Strip 8, Photographs 1-30 thru 1-35
Flight Direction: Southeast to Northwest

Photograph 1-30

The materials on this photograph are the same as those on Photograph 1-14, Flight Strip 5. The granite (Gr) on these photographs is similar to, and is described for, the granite on Photograph 1-20, Flight Strip 5. The alluvium (All) is the same as that described for Photographs 1-16 and 1-18, Flight Strip 5.

Photographs 1-32 and 1-34

The SG on these photographs is a slightly silty sand and fine gravel which might be suitable for subbase and possibly even for base course material.

The fan (Fan) in Photograph 1-32 is made up of poorly graded angular fragments of granite. This material is suitable for select borrow or subbase.

The granite (Gr) in these photographs is typical of that found in the Estes Park area. It generally is badly weathered at the surface except on some of the bare rock knobs from which the weathered material has been washed to the valley below. In places, especially on the lower valley walls, up to several feet of disintegrated granite, both residual and washed material, has accumulated on the bedrock. The fresh granite bedrock could be quarried for riprap, barrier stone, or crushed stone for base course of surfacing aggregate. The disintegrated granite would be suitable for select borrow and

and possibly for subbase. It should be protected from weathering by a bituminous surface.

The alluvium (All) in this valley is too silty to be used for anything but common borrow. The top foot of this material probably would be suitable for use as topsoil.

Flight Strip 9, Photographs 1-54 thru 1-58
Flight Direction: Southeast to Northwest

Photograph 1-54

The sand and gravel (SG) along the southwest edge of the photograph is part of a low terrace in Moraine Park. The material in this terrace is a fairly clean, well graded sand and gravel suitable for use as base course or surfacing material. If washed, this sand and gravel would probably be suitable for concrete aggregate. Since this terrace level rises to only a few feet above the water table, the material would have to be worked from a wet pit.

A very large area of organic material over sand and gravel (O/SG) is adjacent to the SG terrace mentioned above. This sand and gravel is similar to that in the terrace, but differs in that it has an organic layer one to three feet thick at the surface. Removal of this organic layer would slightly increase cost of production, but the finished product would be of as high quality as that in the terraces. The sand and gravel would be suitable

for base course or surfacing, and if washed could be used for concrete aggregate. Any pit in the O/SG area would of course be a wet one. The organic overburden in some places would be suitable for use as topsoil, in other places it is nearly all peat and would be an excellent mulch or soil conditioner.

The small area of sand and gravel (SG) adjacent to the highway in the southeast corner of Photograph 1-54 is a remnant of a high terrace composed of silty sand and gravel probably suitable for use as subbase and possibly as base course material. This material is not as good as that in the lower levels of Moraine Park, and probably would not be considered seriously as a source of sand and gravel with better sources so close.

The moraine (Mo) on this photograph is a coarse till suitable for use as subbase or possibly base course material.

The granite (Gr) is a medium-grained granite typical of that found in this area. It is fairly susceptible to weathering and on the flatter slopes may be covered by as much as several feet of disintegrated granite. The fresh granite bedrock could be used for riprap, barrier stone, or crushed stone. It could probably be used most satisfactorily as subbase or base course protected from weathering by a bituminous surface. The disintegrated granite could be used for select borrow or possibly for subbase.

Photographs 1-56 and 1-58

The moraine (Mo) on Photograph 1-56 is a coarse till suitable

for use as select borrow, subbase, or possibly base course material. There is a large existing pit in till near the southeast corner of Photograph 1-56. This pit could be extended to obtain more of this material.

The granite (Gr) is a medium-grained weathered granite. Quarried granite would be suitable for use as riprap, barrier stone, or crushed stone if the weathered material were first removed. This granite could best be used as subbase or base course to be covered with bituminous surfacing to prevent weathering.

The alluvium (All) is too silty (and in places too organic) to be suitable for anything but common borrow. Locally this deposit is covered by about a foot of topsoil which could be obtained by stripping.

Photograph 1-58 has not been fully mapped because of lack of stereoscopic coverage.

Flight Strip 10, Photographs 1-36 thru 1-50
Flight Direction: Northeast to Southwest

Photograph 1-36

See Photograph 1-14, Flight Strip 5.

Photograph 1-38

Sand and gravel (SG) on this photograph is found in terraces along the Big Thompson and Fall Rivers. This material is a fairly

clean, well graded sand and gravel suitable for use as base course or surfacing aggregate. If washed, it could be used for concrete aggregate. Unfortunately much of this material is located in downtown Estes Park and is unavailable for development as a materials source.

The fan (Fan) near the southwest edge of the photograph is composed of silty sand and fine gravel. This material would probably be suitable for use as select borrow and possibly subbase.

The granite (Gr) on this photograph is a medium-grained granite which has undergone considerable surface weathering. Most of the granite slopes in the valley are covered by as much as several feet of disintegrated granite. The higher knobs of granite in the area have relatively fresh (i.e., no weathered material) surfaces, and would be the best sites for quarries. Rock quarried from this material would be suitable for use as riprap, barrier stone, or crushed stone. Since this material is not particularly resistant to weathering, its most satisfactory use would probably be as subbase or base course covered by a bituminous surface to prevent weathering.

Photographs 1-40 and 1-42

The SG on these photographs is a fairly clean sand and gravel suitable for base course or surfacing aggregate. If washed, the better parts of this deposit would be suitable for concrete aggregate.

The area mapped as SG includes both terraces and floodplain deposits. Ordinarily the terraces contain the better material and

are the easier deposits to work.

The fan (Fan) on the east edge of Photograph 1-40 is described for Photograph 1-38.

The granite (Gr) on these photographs is the same as that described for Photograph 1-38 on this flight strip.

The moraine (Mo) at the east edge of Photograph 1-42 is described for Photograph 1-44.

Photographs 1-44 and 1-46

Moraine Park is composed of a very substantial amount of sand and gravel. Some of this occurs as a low terrace (SG) in the southwest quarter of Photograph 1-44. The material in this terrace is a fairly clean, well graded sand and gravel suitable for use as base course or surfacing material. If washed, this sand and gravel would probably be suitable for concrete aggregate. Since this terrace level rises to only a few feet above the water table, the material would have to be worked from a wet pit.

A very large area of organic material over sand and gravel (O/SG) is adjacent to the SG terrace mentioned above. This sand and gravel is similar to that in the terrace, but differs in that it has an organic layer one to three feet thick at the surface. Removal of this organic layer would slightly increase cost of production, but the finished product would be of as high quality as that in the terraces. The sand and gravel would be suitable for base course or surfacing, and if washed could be used for

concrete aggregate. Any pit in the O/SG area would of course be a wet one as can be noted at the existing pit on the west edge of Photograph 1-44 and the east edge of Photograph 1-46. The organic overburden in some places would be suitable for use as topsoil, in other places it is nearly all peat and would be an excellent source of mulch or soil conditioner.

Note that there is a large area of sand and gravel (SG) near the west edge of Photograph 1-46. This material is very similar to that found in the O/SG area except that the organic material is thinner (generally less than one foot thick). Also the depth to the base of the gravel is undoubtedly less than for the large deposit of O/SG further to the east on Photograph 1-46.

Under ordinary circumstances the slightly higher SG terrace on Photograph 1-44 would be preferred as a source of sand and gravel over the somewhat lower O/SG and SG floodplain deposits of Photograph 1-46. In this case, however, a pit in the floodplain deposits can be hidden from the road much more easily than one in the slightly higher terrace material. Also, upon completion of the operation it should be very easy to landscape the pit so it would soon look like a natural lake or pond. However, a pit on the higher ground would be dry and less costly to operate.

The small area of SG near the southeast corner of Photograph 1-44 is a remnant of a high terrace made up of silty sand and gravel probably suitable for use as subbase and possibly as base course material. This material is not as good as that in the

lower levels of Moraine Park and probably would not be considered seriously as a source of sand and gravel with better sources so close.

The moraine (Mo) on these photographs is a coarse till suitable for use as subbase or possibly base course. An existing pit in this till is located at the northwest edge of Photograph 1-44.

The granite (gr) on these photographs is a medium-grained granite typical of that found in this area. It is fairly susceptible to weathering and on the flatter slopes may be covered by as much as several feet of disintegrated granite. The fresh granite bedrock could be used for riprap, barrier stone, or crushed stone. It could probably be used most satisfactorily as subbase or base course protected from weathering by a bituminous surface. The disintegrated granite could be used for select borrow or possibly for subbase.

Photographs 1-48 and 1-50

The sand and gravel (SG) on these photographs is similar to that described for Photographs 1-44 and 1-46.

The moraine (Mo) is a coarse till suitable for use as subbase or possibly base course. Note that the material on the side of Steep Mountain (southern edge of Photograph 1-48) has been questionably identified as moraine (Mo?). The lack of certainty occurs because there is no clear boundary on these photographs between the till of South Lateral Moraine and the granite of the upper slopes of Steep Mountain.

The fan (Fan) on Photograph 1-48 is composed of poorly graded angular granitic fragments. This material would be satisfactory for subbase or possibly base course use.

The granite (Gr) on these photographs is similar to that described for Photographs 1-44 and 1-46.

The talus (Ta) on these photographs is derived from granite bedrock. It would be suitable for use as riprap, or if crushed, would be satisfactory for base course or possibly surfacing. Since it is fairly susceptible to weathering, this granitic material could probably best be used as base course protected by a bituminous surface.

Flight Strip 11, Photographs 1-36 thru 1-40, 4-17 thru 4-23, and 1-59 thru 1-65

Flight Directions:
Photographs 1-36 thru 1-40: Southwest to Northeast
Photographs 4-17 thru 4-23: Northeast to Southwest
Photographs 1-59 thru 1-65: Southwest to Northeast

Photographs 1-40 and 1-38

The sand and gravel (SG) along the Big Thompson River is a fairly clean, well graded sand and gravel suitable for base course or surfacing aggregate. If washed, the best of this material could be used for concrete aggregate. Generally the terrace sands and gravels are of a little better quality and are easier to work than the sands and gravels in the floodplain. Some of the floodplain deposits contain numerous boulders up to about three feet

in size.

The granite (Gr) on these photographs is a medium-grained rock typical of the granite in the Estes Park area. It has been subjected to considerable weathering, and on flatter slopes is covered by a layer of disintegrated granite up to several feet thick. The granite bedrock would be suitable for production of riprap, barrier stone, or crushed stone for base course or surfacing. Since this material is not particularly resistant to weathering, an optimum usage might be for base course protected from weathering by a bituminous surface.

Photograph 1-36

The sand and gravel (SG) in the eastern half of the photograph is a continuation of that described for Photographs 1-38 and 1-40, and has the same characteristics.

The sand and gravel (SG) and organic over sand and gravel (O/SG) in the northwestern corner of the photograph are described for Photograph 1-44, Flight Strip 10.

The moraine (Mo) in this area is a coarse till suitable for use as subbase and possibly base course material.

The granite (Gr) on this photograph is a medium-grained granite similar to that found elsewhere in this area. This granite is subject to weathering and is badly weathered on some of the flatter slopes. On these flatter slopes the bedrock is often covered by as much as several feet of disintegrated granite.

By quarrying into fresh granite, material suitable for riprap, barrier stone, or crushed stone could be obtained. Because this granite is subject to weathering its most satisfactory use might be as base course protected by a bituminous surface.

Photograph 1-64

The materials on this photograph are described for Photographs 1-36 and 1-38, Flight Strip 11.

Photograph 1-62 and 1-60

The sand and gravel (SG), organic over sand and gravel (O/SG), and till (Mo) along the northern edges of these photographs are described for Photographs 1-44 and 1-46, Flight Strip 10.

South Lateral Moraine (Mo) trending E-W through the center of these photographs is composed of coarse till suitable for subbase and possibly base course use. The same is true for the moraine (Mo) in the southern half of Photograph 1-60. The old C.C.C. pit on Photograph 1-60 is located in this till on the flank of South Lateral Moraine. If desired, this pit could be extended northward into the moraine.

The small area of boulders (Bldrs) near the center of Photograph 1-62 consists almost entirely of large granitic boulders, apparently torrentially deposited, with little finer material. These boulders range in size up to 8 to 10 feet in diameter.

The granite (Gr) and gneiss (Gn) on Photograph 1-60 have no clear-cut boundary between them. Both are medium-grained and are susceptible to weathering. On flatter slopes the granite and gneiss are covered by as much as several feet of disintegrated rock. Fresh, unweathered granite or gneiss could be obtained by quarrying to a depth of several feet into the bedrock. This material would be suitable for riprap, barrier stone, or crushed stone for base or possibly surfacing. If possible it should be used where not exposed to weathering. The granite forming Steep Mountain (western edge of Photograph 1-60) is similar to the above.

The organic material (O) near the center of the photograph is made up mainly of a few feet of peat and would be suitable for use as a mulch or soil conditioner.

Photograph 4-18

The materials on this photograph are described for Photograph 1-60, Flight Strip 11, and Photograph 1-46, Flight Strip 10.

Photograph 4-20

The moraine (Mo) on this photograph is a coarse till suitable for use as subbase and possibly base course material.

The granite (Gr) is similar to that described for Photographs 1-62 and 1-60, Flight Strip 11.

Photograph 4-22

This area was not mapped because it is inaccessible for any use of materials.

Flight Strip 11A, Photographs 3-86 thru 3-94
Flight Direction: Southwest to Northeast

Photographs 3-94 and 3-92

The moraine (Mo), granite (Gr), and boulders (Bldrs) comprising most of Photograph 3-94 are described for Photographs 1-62 and 1-60, Flight Strip 11.

The sand and gravel (SG) in the vicinity of Glacier Basin Campground (southwest corner of photograph) is a fairly clean sand and gravel suitable for use as base course or possibly surfacing material. If desired, the existing gravel pit in this deposit could be extended a short distance toward the west.

The sand and gravel (SG) in terraces between Glacier Basin Campground and Sprague Lake on Photograph 3-92 is fairly clean and is suitable for use as base course or possibly surfacing aggregate.

The sand (Sand) deposit just southwest of the Glacier Basin Campground consists of a fairly clean sand with a little fine gravel.

The alluvium (All) is too silty for any use but common borrow. It also has too many large boulders on the surface to provide a source of topsoil.

The organic material (O) would be suitable for mulching purposes or possibly for topsoil.

Note the large pit in moraine (Mo) near the center of Photograph 3-92. This pit could be extended along the slope if desired. The material is suitable for subbase and possibly as base course.

The large fan at the southwestern edge of Photograph 3-92 is described for Photograph 3-90.

Photograph 3-90

The most important deposit on this photograph is the sand and gravel (SG) in the large fan along the southeastern wall of the valley (southern edge of photograph). The material in this fan is a fairly clean sand and gravel suitable for use as subbase and base course material. This fan provides a very good possible site for a pit.

The large sand and gravel (SG) terrace at the southeastern corner of the photograph is described for Photograph 3-92.

The moraine (Mo) on this photograph is a coarse till suitable for use as subbase and possibly base course material. Note that in the southwestern part of this photograph this till is quite thin over granite (Mo/Gr).

The granite (Gr) in this photograph is medium-grained and not particularly resistant to weathering. It could be quarried for use as riprap, barrier stone, or crushed stone. It will give the best service if protected from weathering as when used in a subbase or base course protected by a bituminous surface.

The organic material (O) could be used as a mulching material and locally may possibly be suitable for use as topsoil.

Photograph 3-88

The moraine (Mo) and moraine over granite (Mo/Gr) on this photograph are similar to the same types of materials described

for Photograph 3-90.

The granite (Gr) and gneiss (Gn) are similar in character, both being medium-grained and not particularly resistant to weathering. These rocks could be quarried for riprap, barrier stone, or crushed stone. They will give the best service if protected from weathering as when used in a base course protected by a bituminous surface.

Photograph 3-86

This area was not mapped because most of it is too far from the road to be utilized as a source of materials. The area near Bear Lake has been mapped on Photograph 4-16, Flight Strip 14.

Flight Strip 12, Photographs 1-54 thru 1-59
Flight Direction: Northwest to Southeast

Photograph 1-54

The materials on this photograph are described for Photographs 1-36, 1-38 and 1-40, Flight Strip 11.

Photographs 1-56 and 1-58

The area shown on thse photographs is made up entirely of a medium-grained granite (Gr). On flatter slopes at lower elevations, and particularly in the vicinity of the YMCA Camp, the granite is badly weathered, generally being covered with a layer of disintegrated granite which may be as much as a few feet thick.

At higher elevations and on steeper slopes the granite is less weathered.

The unweathered granite could be used for riprap, barrier stone, or crushed stone for base course or surfacing. Since this rock is susceptible to weathering its most satisfactory use might be as base course protected from weathering by a bituminous surface. The disintegrated granite would be suitable for select roadway borrow or possibly for subbase.

Flight Strip 13, Photographs 1-29 thru 1-33
Flight Direction: Southwest to Northeast

Photograph 1-30

The materials on this photograph are described for Photographs 3-90 and 3-92, Flight Strip 11A.

Photograph 1-32

The materials shown on this photograph are described for Photographs 3-92 and 3-94, Flight Strip 11A, and Photographs 1-60 and 1-62, Flight Strip 11.

Flight Strip 14, Photographs 4-9 thru 4-16
Flight Direction: Northeast to Southwest

Photograph 4-10

The materials shown on this photograph are described for Photographs 3-92 and 3-94, Flight Strip 11A, and Photographs

1-60 and 1-62, Flight Strip 11.

Photograph 4-12

The materials shown on this photograph are described for Photographs 3-90 and 3-92, Flight Strip 11A.

Photograph 4-14

The granite (Gr) and gneiss (Gn) shown on this photograph are described for Photograph 3-88, Flight Strip 11A.

The moraine (Mo) and moraine over granite (Mo/Gr) areas contain coarse till suitable for subbase and possibly base course use.

Photograph 4-16

The moraine (Mo) on this photograph is a coarse till suitable for subbase or possibly base course material. This material is characterized by the till in the cut for the parking lot at Bear Lake. It should be noted that considerable yardage of this till could be obtained by flattening the slope of the cut or by opening a pit in the old lodge area just north of the parking lot.

The granite (Gr) which is exposed in most of this area is medium-grained and not badly weathered. This rock could be quarried for use as riprap, barrier stone, or crushed stone for use as base course or surfacing aggregate. Since this material is somewhat susceptible to weathering, it can best be used where protected from the weather as in a base course under a bituminous surface.

Flight Strip 15, Photographs 4-1 thru 4-8
Flight Direction: North to South

Except for the area around Bear Lake, which has already been described for Photograph 4-16, Flight Strip 14, the area covered by this flight strip is inaccessible, and thus has not been mapped for materials sources.

ROCKY MOUNTAIN NATIONAL PARK

PARKWIDE MATERIALS SURVEY

SOURCES OF MATERIALS SAMPLED AND TESTED

Western Slope ☐ Eastern Slope ☒

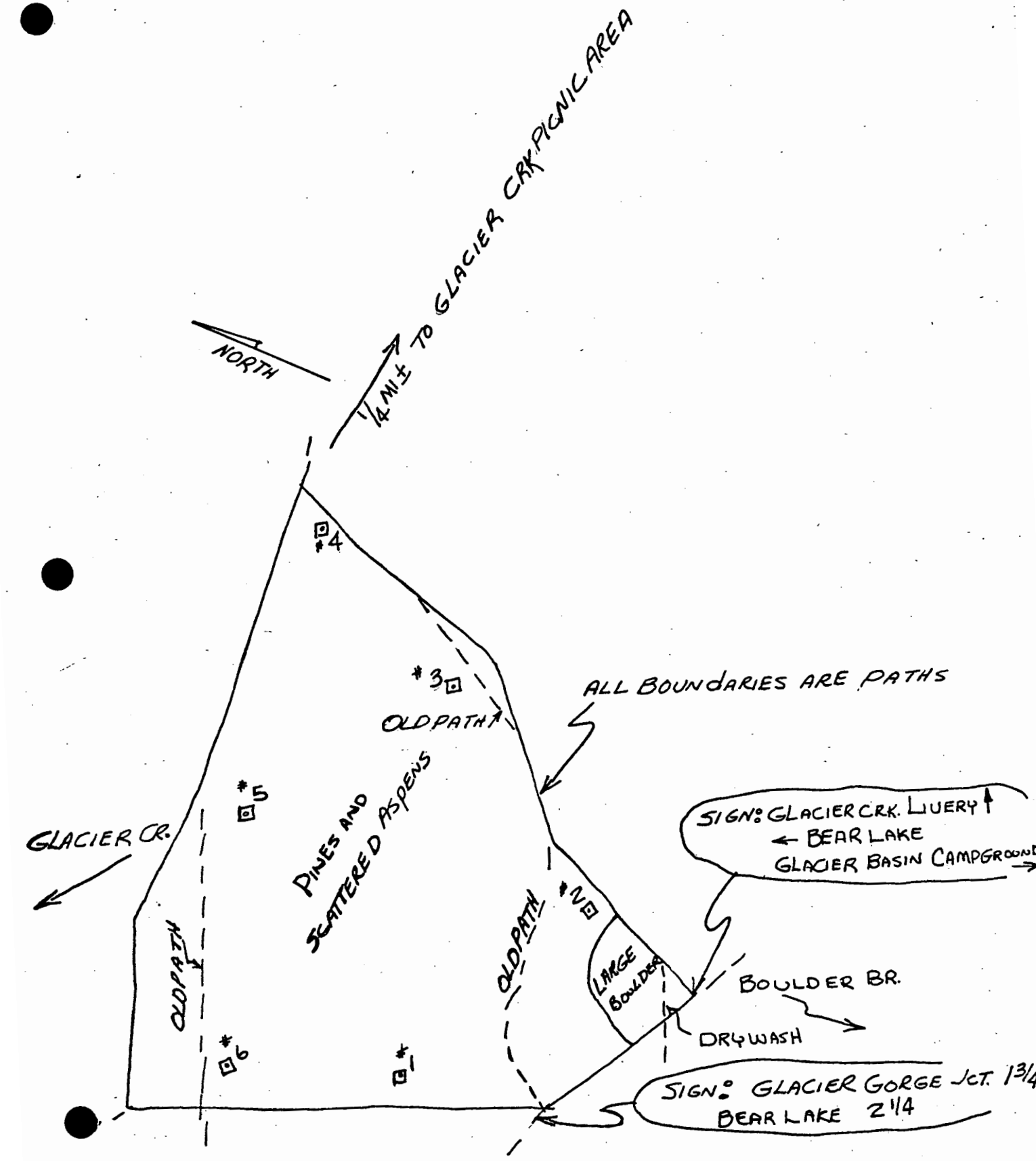
Pit Number 3-E BPR Lab. No. 67-418 through 67-423-P

Flight Strip 36 Photograph 5-20

LOCAL NAME, LOCATION AND GENERAL DESCRIPTION	Boulder Brook Pit One-fourth mile west of the Glacier Creek Picnic Area. Map Coordinates - Colorado Coordinate System, North Zone. 357 625 - 1968 500
QUANTITY	100,000 cubic yards
ANALYSIS OF LABORATORY TEST DATA, CONDITIONS OF USE AND RECOMMENDATIONS	This material is suitable for use as subbase, base, bituminous stabilized base and surfacing aggregates. However, fourteen percent of total pit was wasted in making base material. Stripping will be required, however, test holes indicate very little overburden. Five to ten percent of the material is in excess of ten inches in diameter with a maximum size of ½ cubic yard.

1" = 200'

BOULDER BROOK PIT



Eastern Slope
Boulder Brook Pit
3-E

Log of Holes

Hole No. 1:

0–6"	Dark brown clayey sand, roots (topsoil).
6"–5½'	Light brown, slightly clayey sand and coarse gravel. Cobbles moderately rounded.
	Up to 20% oversize. Maximum size about 1/3 cubic yard.

Hole No. 2:

0–6"	Dark brown clayey sand, roots (topsoil).
6"–9'	Light brown, medium-dense, slightly clayey sand and gravel. Cobbles sub-angular to sub-rounded.
	Two foot layer of boulders up to 18" at about 4'. Below 6', no oversize and few cobbles exceed 4".

Hole No. 3:

0–4"	Dark brown clayey sand, roots, (topsoil).
4"–1½'	Light brown clean, medium sand.
1½–4½'	Light brown, medium dense, slightly clayey sand and gravel. Cobbles sub-angular to sub-rounded.
	Less than 5% oversize. Maximum size ¼ cubic yard.
4½–10'	Red iron-oxidized layer and stringers underlain by gray, damp sand and gravel. Cobbles slightly more rounded.
	No oversize.

Hole No. 4:

0–6"	Dark brown, clayey sand, roots (topsoil).
6"–6½'	Light brown, slightly clayey, medium-dense sand and gravel. Cobbles are sub-angular to sub-rounded.
	At 6½' becomes grayer and damp. No oversize.
6½–7½'	Gray, varied, very fine sand. Similiar to Glacier Creek Pit.

Hole No. 5:

0–6"	Dark brown clayey sand, roots (topsoil).
6"–4'	Light brown slightly clayey sand and coarse gravel. Cobbles are sub-angular.
	10% oversize. 24" maximum size.
4–7'	Gray-brown, clean, damp sand and gravel. Cobbles are more rounded.
	No oversize. 5" maximum size.

Hole No. 6:

0–6"	Dark brown clayey sand, roots, (topsoil).
6"–6'	Light brown, slightly clayey, medium dense sand and gravel. Cobbles are sub-angular to sub-rounded.
	5–10% oversize. Maximum size 1/3 cubic yard.

Form PR-9-230
April 1965

U. S. DEPARTMENT OF COMMERCE
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Separate Test Hole Gradation, L. L., and P. I.)

Lab. No: 67-418-423-P Field Sample No: _____ Date: May 3, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: Runyan Quantity Rep. _____ Name of Material Gravel

Source: Boulder Brook Pit

Test for: Gradation, L.L. & P.L. Tested by: R.G., D.G., K.R., R.R.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	67-418 Hole #1	67-419 Hole #2	67-420A Hole #3	67-420B Hole #3	67-421 Hole #4	67-422A Hole #5	67-422B Hole #5	67-423 Hole #6	Comb.
3"						57	93	76	92
1½"	93	92	85	90	88	31	76	51	80
1"	90	87	80	85	77	27	71	46	75
¾"	88	83	73	80	71	26	66	42	70
½"									
3/8"	83	74	63	71	60	24	51	36	62
#4	78	66	56	63	49	22	40	32	55
#8									
#10	68	56	46	55	39	19	30	26	44
#40	34	27	21	35	17	10	11	12	20
#200	12	9	6	4	6	4	2	4	6
L.L.	—	—	—	—	—	—	—	—	—
P. I.	NP	NP	NP	NP	NP	NP	NP	NP	NP

REMARKS:

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

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Division Office	1
Project Eng.	1
Lab. File	2

REPORTED BY: ekt

Form PR-9-231
Rev. April 1965

U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Sub-base, Base Course, and Base Stabilization)

Lab. No: 67-418-423-P Field Sample No: _____ Date: May 3, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: D. R. Runyan Quantity Rep. _____ Name of Material: Gravel

Source: Boulder Brook Pit

Test for: Sec. 104, 200 Tested by: D. G., R. G., & K. R.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	Comb. Original	Sec. 104	Sec. 200*	Degr.	Specifications Sec. 104	Specifications Sec. 200
3"	92					
1½"	80	100			100	
1"	75	90				
¾"	70	80	100	100		100
½"						
3/8"	62	66	75	79		
#4	55	58	61	68	30–70	35–65
#8						
#10	44	48	49	57		
#40	20	23	24	32		
#200	6	6	5	12	0–15	0–10
L. L.	—	—	—	—		
P. I.	NP	NP	NP	NP		

STABILOMETER
"R" at 400 P. S. I. Ex. Pressure
R: 81
% Moisture: 6.8
Density: 132.1

Wt./Cu. Ft. Compacted
Base Course
T-180 Method D: 138.2 @ 7.0%
Subbase
T-180 Method D (Rev): 138.6 @ 7.3%
Asphalt Mix
T-167: _____

Soft Particles: 8 %
Fractured Faces: 98 %

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

CEMENTATION
P. S. I. Comp. Str. 23

HUBBARD FIELD
% Swell: _____
% Abs.: _____
Stab. Wet: _____
Stab. Dry: _____
% Retained: _____

L. A. ABRASION
Grading: _____

	100 R	500 R
% Loss	_____	48

Sand Eq. 61

OIL DESIGN
Additive used: See Sheet No. 3

% by C. K. E.	_____	_____	_____
% used	_____	_____	_____
% swell	_____	_____	_____
% absorption	_____	_____	_____
Stability P. S. I.			
Wet	_____	_____	_____
Dry	_____	_____	_____
% retained	_____	_____	_____

Remarks: * This gradation was obtained by wasting 24% of the original -#4 material

DISTRIBUTION:
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Division Office: 1
Project Eng.: 1
Lab. File: 2

REPORTED BY: e.t.

GPO 838-024

Form PR-9-232
April 1965

SHEET NO. 3 OF 3

U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Plant-mix and Chips)

Lab. No: 67-418-423-P Field Sample No: _____ Date: May 3, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted By: D. R. Runyan Quantity Rep. _____ Name of Material: Gravel

Source: Boulder Brook Pit

Test for: Sec. 217 & 313 Tested by: D. G., R. G., & K. R.

WASHED M.A. % PASSING

Sieve Size	Comb. Original	Sec. 200	Spec's. Sec. 200
3"	92		
1½"	80		
1"	75		
¾"	70	100	100
½"			
3/8"	62	75	
#4	55	61	35-65
#8			
#10	44	49	
#40	20	24	
#200	6	5	0-10
L. L.	—	—	
P. I.	NP	NP	

OIL DESIGN
120/150 AC

Additive Used	None	1%Acra	1%Lime
% by C. K. E.	5.3	5.3	6.3
% Used	7.3	7.3	8.3
% Swell	0.0	0.0	0.0
% Absorption	0.7	0.8	0.5
Stability P. S. I.			
Wet	353	348	448
Dry	336	249	317
% Retained	105	140	141
Specific Gravity			
Laboratory	2.31	2.31	2.33
Theo. Max.	2.38	2.38	2.38
% Theo.	97	97	98
wt./cu. ft. compacted	147	147	148

HUBBARD FIELD

% Swell	0.2
% Abs.	1.9
Stab. Wet	1450
Stab. Dry	1300
% Retained	112

L. A. ABRASION

Grading _____

	100R	500R
% Loss	_____	_____

STATIC IMMERSION

% Additive	Film Retained 0 Hours	24 Hours
~~None~~ RC-3	100	95+
5-A	100	95+
1-A	100	95+
1-PB	100	95+
RS-K	100	95+

SPECIFIC GRAVITY & ABS.

	+ #4	- #4	Comb.
Sp. Gr.	2.69	2.67	2.68
Abs.	1.2	0.8	0.9

Sand Equivalent	_____
Soft Particles	_____ %
Fractured Faces	_____ %
T-101 Swell	0.12 %
Sulfate Soundness	1.0 %

Remarks: _____

DISTRIBUTION:

Region Office	1
Division Office	1
Project Eng.	1
Lab. File	2
_____	_____

REPORTED BY: e. t.

Test data represented on this page is limited to the samples from the specific locations shown

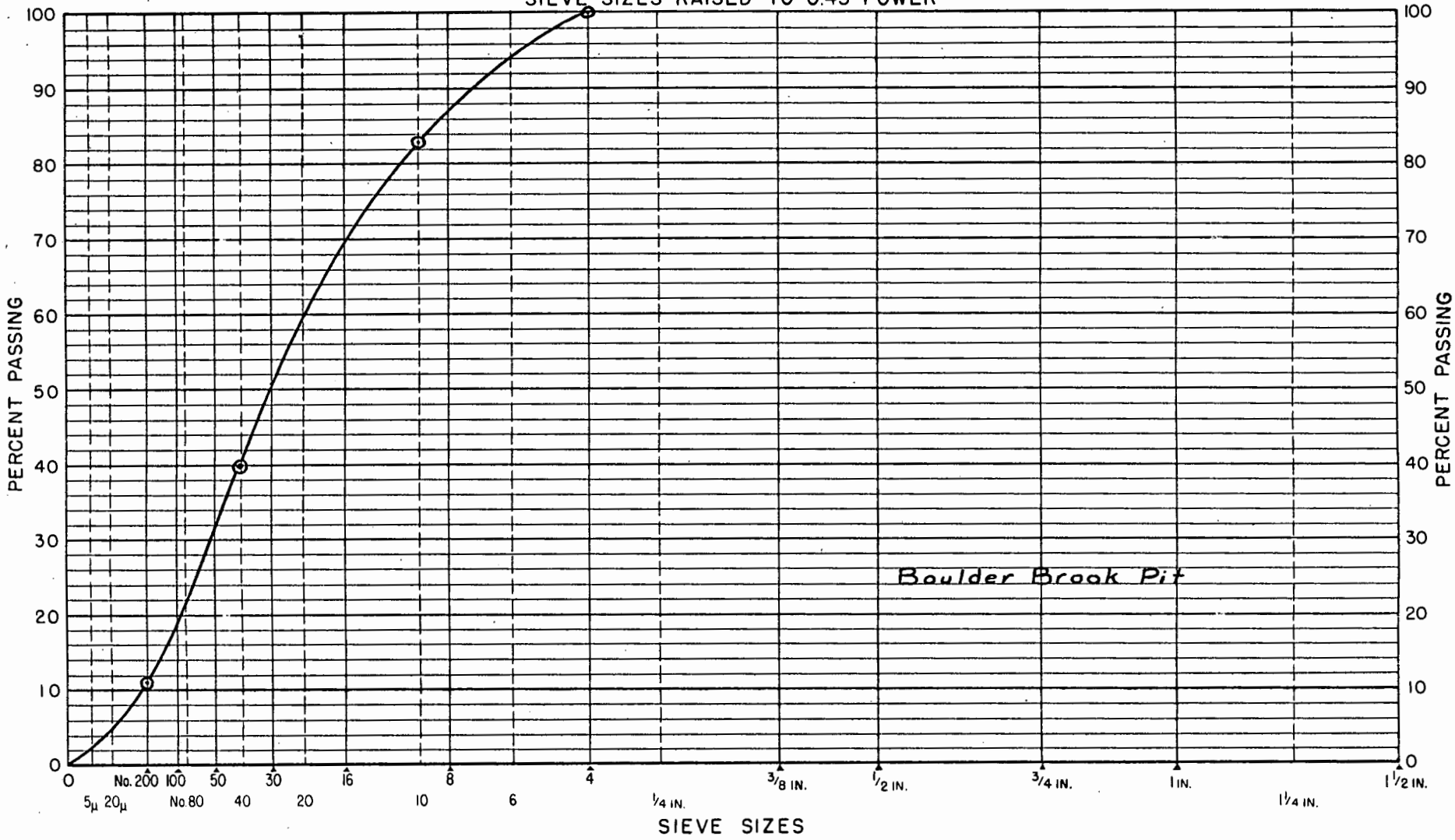
GPO 838-024

PR-1115

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS

GRADATION CHART

SIEVE SIZES RAISED TO 0.45 POWER



▲ THIS SYMBOL IDENTIFIES SIMPLIFIED PRACTICE AND COMPATIBLE SIEVE SIZES

Identification of gradations:

Sheet No.

Date

USCOMM-DC 40822-P62

FIGURE 1

Boulder Brook Pit. Looking northeast just off horse trail showing typical site of Hole 4.

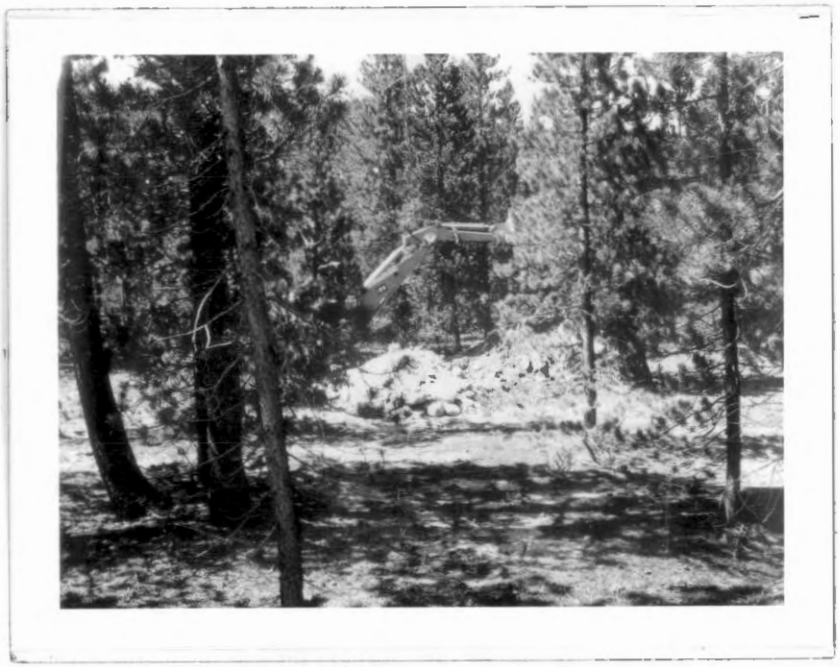


FIGURE 2

Boulder Brook Pit. Shows Hole 6 in a grove of aspen and pine (usually no more than 20' high) typical of the area.

ROCKY MOUNTAIN NATIONAL PARK

PARKWIDE MATERIALS SURVEY

SOURCES OF MATERIALS SAMPLED AND TESTED

Western Slope ☐ Eastern Slope ☒

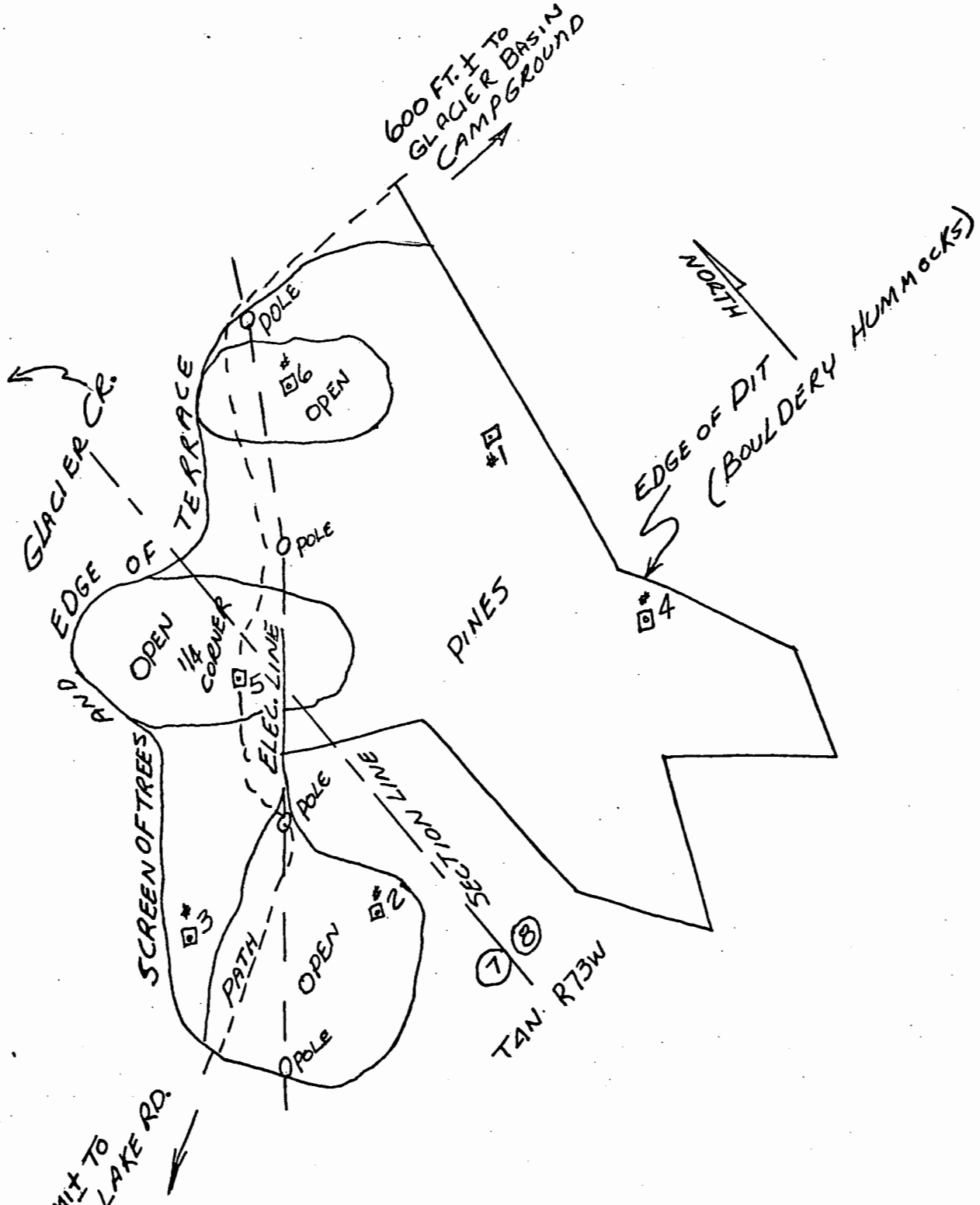
Pit Number 5-E BPR Lab. No. 67-428 through 67-433

Flight Strip 38 Photograph 5-45

LOCAL NAME, LOCATION AND GENERAL DESCRIPTION	Glacier Creek Pit, site between Glacier Basin Campground and Glacier Creek Picnic Area. Map Coordinates - Colorado Coordinate System, North Zone. 360 500 - 1972 250
QUANTITY	30,000 cubic yards.
ANALYSIS OF LABORATORY TEST DATA, CONDITIONS OF USE AND RECOMMENDATIONS	This material is suitable only for sub-base due to the high percentage of waste that would be necessary for base, and asphaltic stabilized base aggregates. There is little topsoil more than 4" deep and coarse material is confined to the top 3'±, but with a negligible amount in excess of 10". Selective work in pit area could result in better material if necessary.

1" = 100'

GLACIER CREEK PIT



Eastern Slope
Glacier Creek Pit
5-E

Log of Holes

Hole No. 1:

0–1'	Dark brown clayey sand and gravel, roots, (topsoil).
1–3½'	Light brown, damp, loose, clean sand and gravel. Cobbles are well rounded.
	4" maximum size.
3½–6'	Primarily sand, some gravel.
6–9'	Tan very fine sand and silt.

Hole No. 2:

0–2"	Dark brown very thin topsoil.
2"–3½'	Light brown, loose, medium-grained, damp, clean, sand.
3½–6½'	Tan compact silt to very fine sand.
6½–7'	Sand as before.

Hole No. 3:

0–2"	Dark brown very thin topsoil.
2"–2'	Light brown, loose, clean, damp sand and gravel. Cobbles are well-rounded.
	2–3" maximum size.
2–8'	Light brown, loose, clean sand with some fine gravel. Layers of very fine sand and gravel stringers.

Hole No. 4:

0–4"	Dark brown topsoil and roots.
4"–2½'	Light brown, slightly clayey sand and gravel. Cobbles are well-rounded.
	2–3" maximum size.
2½–5'	Light brown sand becoming finer with depth.
5–7½'	Tan silt to very fine sand.

Hole No. 5:

0–4"	Dark brown clayey sand, roots, (topsoil).
4"–10½'	Light brown, loose, coarse, damp, slightly clayey sand and gravel. Cobbles are well-rounded.
	Less than 5% oversize. 6" maximum size except for some ¼ cubic yard boulders.

Hole No. 6:

0–4"	Dark brown clayey sand and gravel, (topsoil).
4"–4'	Light brown, loose, damp, slightly clayey sand and gravel. Cobbles well-rounded.
	2–3" maximum size.
4–9'	Light brown clean sand and fine gravel. Contains 8–12" layer of silt underlain by coarse sand, fine gravel, and occasional oversize cobbles.

Form PR-9-230
April 1965

U. S. DEPARTMENT OF COMMERCE
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Separate Test Hole Gradation, L. L., and P. I.)

Lab. No: 67-428-433-P Field Sample No: _____ Date: May 6, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: Runyan Quantity Rep. _____ Name of Material: Gravel

Source: Glacier Creek Pit

Test for: Gradation, L.L. & P.L. Tested by: D.G., A.T., K.R.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	67-428 Hole #1	67-429 Hole #2	67-430 Hole #3	67-431 Hole #4	67-432 Hole #5	67-433 Hole #6	Hole #7	Hole #8	Comb.
3"	98				86	98			96
1½"	92		100		75				89
1"	89		99		69	94			87
¾"	86		97	99	63	90			83
½"									
3/8"	78	100	93	89	53	84			76
#4	71	99	89	76	44	78			69
#8									
#10	59	95	81	62	35	71			59
#40	21	43	60	30	17	45			32
#200	5	7	20	7	7	29			12
L.L.	—	—	—	—	—	—			—
P.I.	NP	NP	NP	NP	NP	NP			NP
	A-1-b	A-1-b	A-2-4	A-1-b	A-1-a	A-2-4			

REMARKS:

DISTRIBUTION:
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U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Sub-base, Base Course, and Base Stabilization)

Lab. No: 67-428-433-P Field Sample No: _____ Date: May 6, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: D.R. Runyan Quantity Rep. _____ Name of Material: Gravel

Source: Glacier Creek Pit

Test for: Gradation, L.A. Abras., Comp. Tested by: D. G., R.G., K.R., & A.T.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	Comb. Original	Sec. 104	Sec.	Degr.	Specifications Sec. 104	Specifications Sec.
3"	96					
1½"	89	100			100	
1"	87	91				
¾"	83	84				
½"						
3/8"	76	70				
#4	69	57			30–70	
#8						
#10	59	49				
#40	32	26				
#200	12	10			0–15	
L. L.	—	—				
P. I.	NP	NP				

STABILOMETER
"R" at P. S. I. Ex. Pressure
R _____
% Moisture _____
Density _____

Wt./Cu. Ft. Compacted
Base Course
T-180 Method D _____
Subbase
T-180 Method D (~~RXX~~) 140.9@4.6%
Asphalt Mix
T-167 _____

Soft Particles _____ %
Fractured Faces _____ %

CEMENTATION
P. S. I. Comp. Str. _____

HUBBARD FIELD
% Swell _____
% Abs. _____
Stab. Wet _____
Stab. Dry _____
% Retained _____

L. A. ABRASION
Grading _____

	100 R	500 R
% Loss	_____	40.6

Sand Eq. _____

OIL DESIGN

Additive used	_____	_____	_____
% by C. K. E.	_____	_____	_____
% used	_____	_____	_____
% swell	_____	_____	_____
% absorption	_____	_____	_____
Stability P. S. I.			
Wet	_____	_____	_____
Dry	_____	_____	_____
% retained	_____	_____	_____

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

Remarks:

NOTE: Sec. 200 was not designed for due to the large waste factor that would be required.

This gradation was obtained by wasting 53% of the original -#4 material.

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FIGURE 3

Glacier Creek Pit. Shows Hole 2 located in the largest clearing at the Pit site. The ridge just behind the hole is heavily bouldered.

FIGURE 4

Glacier Creek Pit. Hole 4 located in heavy stand of low timber typical of the area.

ROCKY MOUNTAIN NATIONAL PARK

PARKWIDE MATERIALS SURVEY

SOURCES OF MATERIALS SAMPLED AND TESTED

Western Slope ☐ Eastern Slope ☒

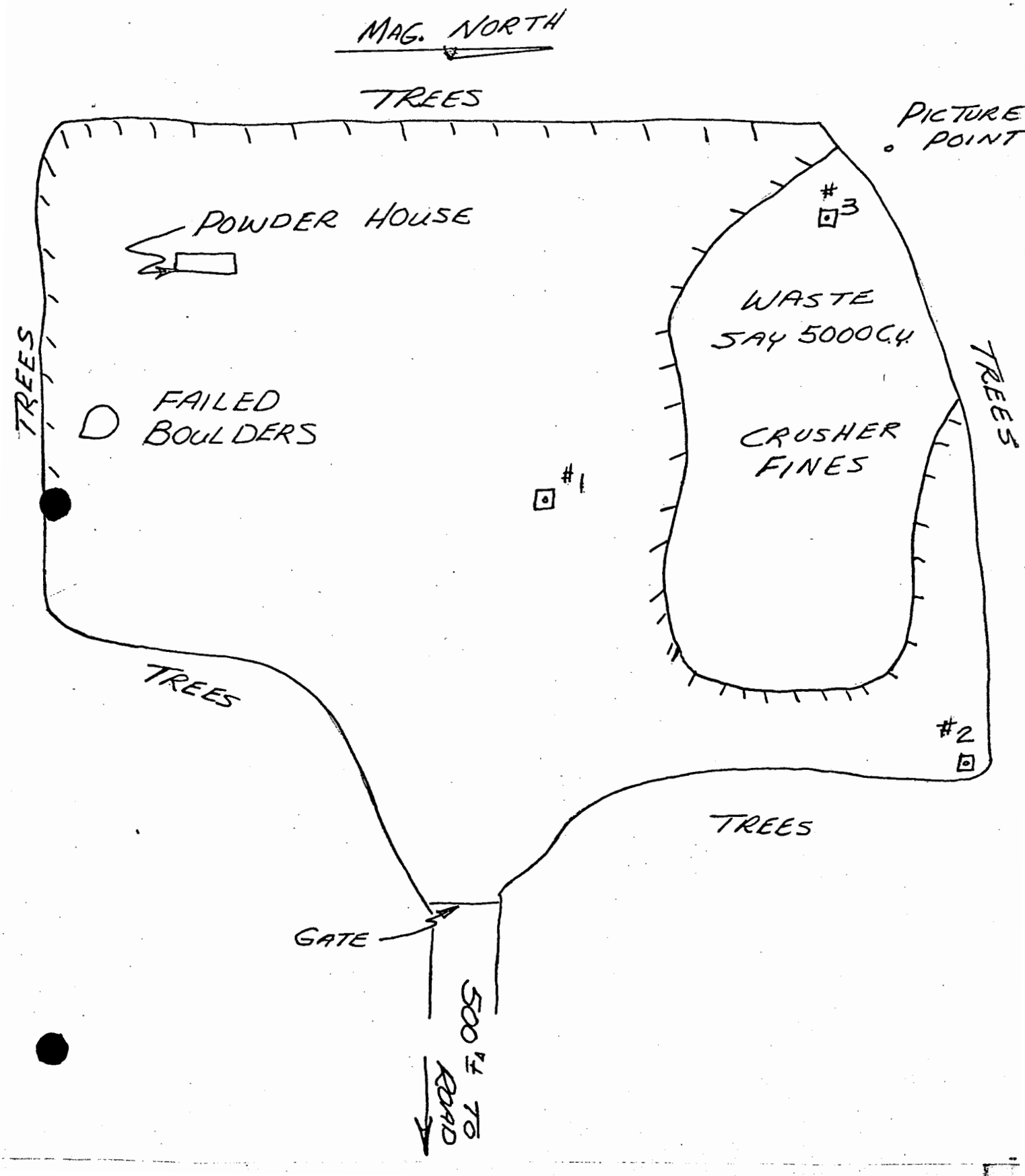
Pit Number 6-E BPR Lab. No. 66-874 through 66-876

Flight Strip 14 Photograph 4-11

LOCAL NAME, LOCATION AND GENERAL DESCRIPTION	Powder House Pit, across the road from Glacier Basin campground entrance. Map coordinates - Colorado Coordinate System, North Zone. 362 750 - 1971 750
QUANTITY	Limited by area within existing pit area: 17,000 cubic yards.
ANALYSIS OF LABORATORY TEST DATA, CONDITIONS OF USE AND RECOMMENDATIONS	Test results show that this material is suitable for subbase, base, and bituminous stabilized base aggregates. However, some wasting of fines could be required during production of base courses. 0-4' of overburden would have to be removed. There is approximately 10% in excess of 10", with maximum size of 1 cubic yard.

POWDER HOUSE PIT

1" = 50'



Eastern Slope
Powder House Pit
6-E

Log of Holes

Hole No. 1:

0-2'	Brown sand and boulders and a little trash.
2-7'	Sand, gravel, and boulders.
	10% oversize. 18" maximum size.

Hole No. 2:

0-4'	Brown fine sand, some silt, some gravel and cobbles.
	Overburden 0-4' deep.
4-8'	Brown sand, gravel and cobbles, some boulders.
	10% oversize. 24" maximum size.

Hole No. 3:

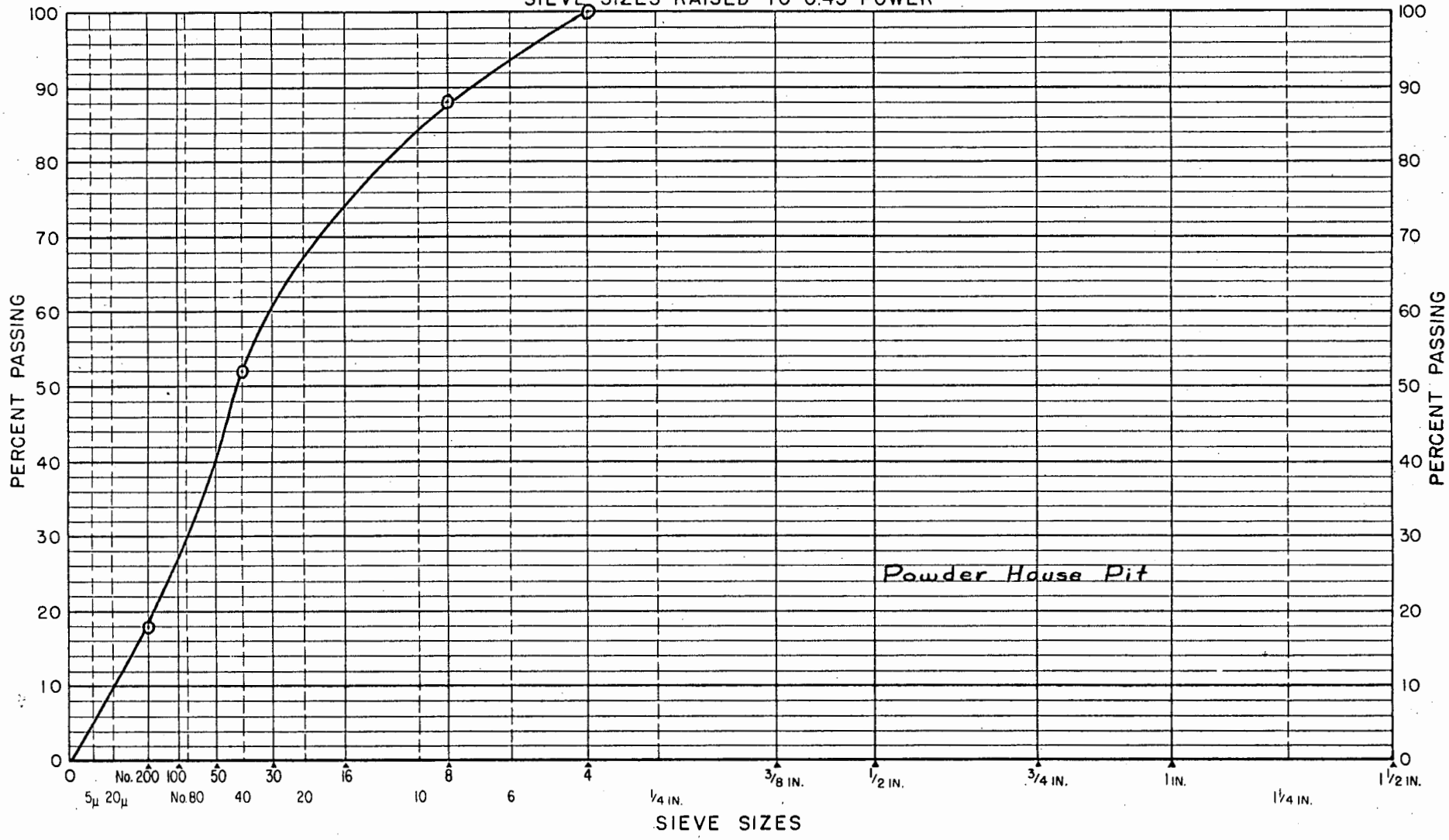
0-7'	Brown sand, gravel, and cobbles, with some boulders.

FORM PR-1115
(2-62)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS

GRADATION CHART

SIEVE SIZES RAISED TO 0.45 POWER



▲ THIS SYMBOL IDENTIFIES SIMPLIFIED PRACTICE AND COMPATIBLE SIEVE SIZES

Idenification of gradations:

Sheet No.

Date

USCOMM-DC 40822-P62

Form PR-9-230
April 1965

U. S. DEPARTMENT OF COMMERCE
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Separate Test Hole Gradation, L. L., and P. I.)

Lab. No: 66-874-P-~~66-876-P~~ Field Sample No: _____ Date: February 16, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: M.C. Everitt Quantity Rep. _____ Name of Material Gravel

Source: Powder House Pit

Test for: Gradation, L.L. & P.I. Tested by: R.R., R.G., D.G., T.G.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	66-874 Hole #1	66-875 Hole #2	66-875 * Hole #3	66-876 Hole #4	Hole #5	Hole #6	Hole #7	Hole #8	Comb.
3"	88	80	100	88					85
1½"	70	66	86	74					65
1"	64	57	83	69					62
¾"	58	54	82	65					58
½"									
3/8"	48	49	78	59					52
#4	42	45	74	53					47
#8									
#10	35	41	68	47					42
#40	20	25	48	30					25
#200	8	8	18	13					9
L.L.	--	--	--	--					--
P.I.	NP	NP	NP	NP					NP

REMARKS: *Overburden 0-4' deep

66-874 represents 35% of pit
66-875 represents 38% of pit
66-876 represents 27% of pit

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U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Sub-base, Base Course, and Base Stabilization)

Lab. No: 66-874-876-P Field Sample No: _____ Date: February 16, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: M.C. Everitt Quantity Rep. _____ Name of Material: Gravel

Source: Powder House Pit

Test for: Sec. 200, 104, L.A. Abrasion, Compaction Tested by: R.G., R.R., D.G., T.G.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	Comb. Original	Sec.* 104	Sec.** 200	200 Degr.	Specifications Sec. 104	Specifications Sec. 200
3"	85					
1½"	65	100			100	
1"	62	83				
¾"	58	71	100			100
½"						
3/8"	52	58	72	76		
#4	47	50	58	63	30–70	35–65
#8						
#10	42	44	49	53		
#40	25	26	28	32		
#200	9	9	10	12	0–15	0–10
L. L.	—	—	—	—		
P. I.	NP	NP	NP	NP		

STABILOMETER
"R" at 400 P. S. I. Ex. Pressure

R	87
% Moisture	5.6
Density	136.2

Wt./Cu. Ft. Compacted

Base Course T-180 Method D	138.2 @ 6.5%
Subbase T-180 Method D (Rev.)	140.9 @ 6.8%
Asphalt Mix T-167	
Soft Particles	1 %
Fractured Faces	99 %

CEMENTATION
P. S. I. Comp. Str. 30

HUBBARD FIELD
% Swell _____
% Abs. _____
Stab. Wet _____
Stab. Dry _____
% Retained _____

L. A. ABRASION
Grading _____

	100 R	500 R
% Loss	_____	42.96

Sand Eq. 45

OIL DESIGN
Additive used SEE SHEET NO. 3

% by C. K. E.	_____	_____	_____
% used	_____	_____	_____
% swell	_____	_____	_____
% absorption	_____	_____	_____
Stability P. S. I.			
Wet	_____	_____	_____
Dry	_____	_____	_____
% retained	_____	_____	_____

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

Remarks: * This gradation was obtained by crushing the +1½" material to -1½" material (no recrush or waste).

** This gradation was obtained by crushing the +3/4" material to -3/4" material (no recrush or waste).

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U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Plant-mix and Chips)

Lab. No: 66-874-876-P Field Sample No: _____ Date: February 16, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted By: M.C. Everitt Quantity Rep. _____ Name of Material: Gravel

Source: Powder House Pit

Test for: Oil design, Stat. Imm. Soundness Tested by: R.R., R.G., T.G., D.G.

WASHED M.A. % PASSING

Sieve Size	Comb. Original	Sec. 200	Spec's. Sec. 200
3"	85		
1½"	65		
1"	62		
¾"	58	100	100
½"			
3/8"	52	72	
#4	47	58	35-65
#8			
#10	42	49	
#40	25	28	
#200	9	10	0-10
L. L.	--	--	
P. I.	NP	NP	

OIL DESIGN
120/150 AC

Additive Used	None	1%Lime	1%Acra
% by C. K. E.	4.8	5.5	4.8
% Used	5.8	6.5	5.8
% Swell	0.1	0.1	0.1
% Absorption	1.3	1.1	1.3
Stability P. S. I.			
Wet	322	321	361
Dry	290	294	293
% Retained	111	109	123
Specific Gravity			
Laboratory	2.32	2.35	2.33
Theo. Max.	2.47	2.47	2.47
% Theo.	94	95	94
wt./cu.ft. compacted	146	148	147

HUBBARD FIELD

% Swell	0.3
% Abs.	0.7
Stab. Wet	1325
Stab. Dry	1150
% Retained	115

L. A. ABRASION

Grading _____

	100 R	500 R
% Loss		

STATIC IMMERSION

% Additive	Film Retained 0 Hours	24 Hours
None	100	95+
0.5-A	100	95+
1-A	100	95+
1-PB	100	95+
RSK	100	95+

SPECIFIC GRAVITY & ABS.

	+ #4	- #4	Comb.
Sp. Gr.	2.73	2.69	2.71
Abs.	1.0	1.1	1.1

Sand Equivalent _____

Soft Particles _____ %

Fractured Faces _____ %

T-101 Swell 0.3 %

Sulfate Soundness 1 %

DISTRIBUTION:

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Remarks: _____

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FIGURE 5

Powder House Pit. Looking southeast from Hole 3. Locations of Holes 1 and 3 are indicated. The site is of an old abondon pit used sometime ago.

ROCKY MOUNTAIN NATIONAL PARK

PARKWIDE MATERIALS SURVEY

SOURCES OF MATERIALS SAMPLED AND TESTED

Western Slope ☐ Eastern Slope ☒

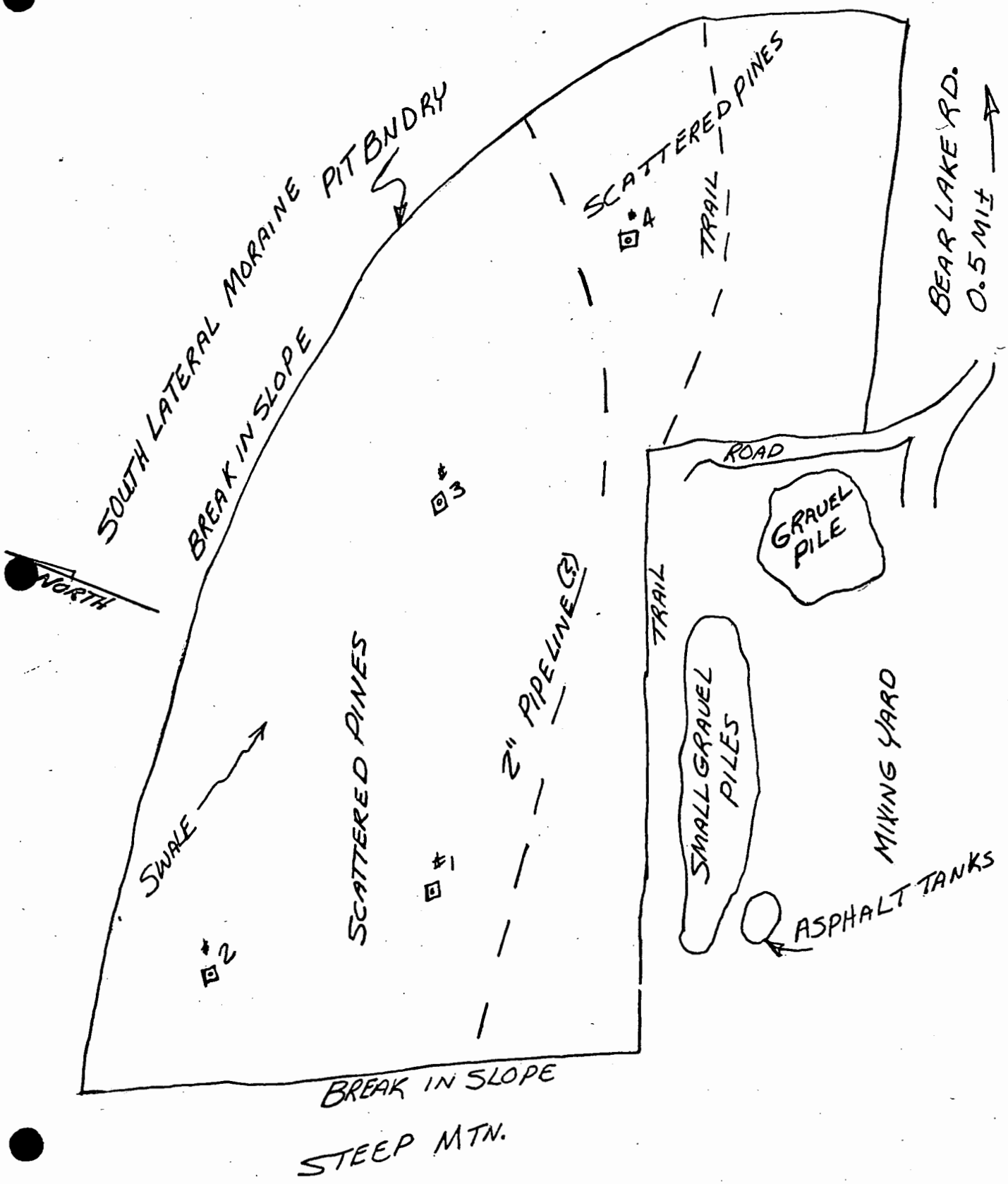
Pit Number 7-E BPR Lab. No. 67-424 through 67-427

Flight Strip 11 Photograph 1-60

LOCAL NAME, LOCATION AND GENERAL DESCRIPTION	CCC Camp Pit, Hollowell Park CCC Area. Map Coordinates - Colorado Coordinate System, North Zone 367 500 - 1969 375
QUANTITY	60,000± cubic yards
ANALYSIS OF LABORATORY TEST DATA, CONDITIONS OF USE AND RECOMMENDATIONS	This source is not recommended for use as any aggregate. All gradations are out of specifications on at least one sieve size. In addition, the material shows a high L.A. Abrasion loss, and low strength retained. Also, 23% of total pit was wasted in order to obtain the gradation for base. Up to 25% of the material exceeds 10 inches in diameter with a maximum size of ½ cubic yard. Logs of holes indicate an overburden of 1-2'.

1" = 100'

CCC CAMP PIT



Eastern Slope
CCC Camp Pit
7-E

Log of Holes

Hole No. 1:

0–1'	Dark brown clayey sand and roots, (topsoil).
1–2½'	Tan, very silty sand and gravel. Cobbles slightly rounded, few boulders to 12".
2½–6½'	Tan, silty sand and gravel. Cobbles slightly rounded. Many boulders to 12"+, with up to 25% greater than 10".

Hole No. 2:

0–6"	Dark brown topsoil, roots.
6"–3'	Light brown, slightly clayey sand and gravel. Less than 5% over 10".
	15" maximum size.

Hole No. 3:

0–2'	Dark brown, clayey sand and fine gravel, (topsoil).
2–7'	Light brown, loose, slightly clayey sand and gravel.
	Less than 5% over 10". ½ cubic yard maximum size.
7–8'	Same but denser and coarser.

Hole No. 4:

0–1'	Dark brown, clayey sand and fine gravel, (topsoil).
1–2½'	Light brown, slightly clayey sand and gravel.
	Less than 5% oversize. Few boulders to ¼ cubic yard.
2½–5'	Same but denser and coarser.
	Up to 25% oversize.

Form PR-9-230
April 1965

SHEET NO. ____ OF ____

U. S. DEPARTMENT OF COMMERCE
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Separate Test Hole Gradation, L. L., and P. I.)

Lab. No: 67-424-427-P Field Sample No: _____ Date: March 29, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: Runyan Quantity Rep. _____ Name of Material Gravel

Source: CCC Pit

Test for: Gradation, L.L. & P.I. Tested by: R.R., D.G., R.G.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	67-424 Hole #1	67-425 Hole #2	67-426 Hole #3	67-427 Hole #4	Hole #5	Hole #6	Hole #7	Hole #8	Comb.
3"	90	88	84						90
1½"	73	78	82	87					81
1"	69	73	79	83					76
¾"	65	70	77	80					72
½"									
3/8"	58	62	71	74					65
#4	50	52	64	65					58
#8									
#10	42	41	53	55					47
#40	21	20	24	25					21
#200	8	10	10	11					9
L.L.	22	21	—	—					19
P. I.	4	1	NP	NP					1

REMARKS:

DISTRIBUTION:
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U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Sub-base, Base Course, and Base Stabilization)

Lab. No: 67-424-427-P Field Sample No: ____ Date: March 29, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: Runyan Quantity Rep. ____ Name of Material: Gravel

Source: CCC Pit

Test for: Gradation, Degradation, Oil Design, Soundness, L.A. Abras., Spr. Gr. Tested by: R.R., D.G., R.G., A.T., T.G.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	Comb. Original	Sec. 104*	Sec. 200**	Degr.	Specifications Sec. 104	Specifications Sec 200***
3"	90					
1½"	81	100			100	
1"	76	95				
¾"	72	88	100			100
½"						
3/8"	65	75	85	92	30-70	
#4	58	65	66	84		45-80
#8						
#10	47	54	51	67		30-60
#40	21	24	24	33		25-35
#200	9	9	10	14	0-15	5-15
L.L.	19	19	—	—		
P.I.	1	NP	NP	NP		

STABILOMETER
"R" at P.S.I. Ex. Pressure
R 69
% Moisture 7.2
Density 133.6

Wt./Cu. Ft. Compacted
Base Course
T-180 Method D 137.7 @ 7.0%
Subbase
T-180 Method D (Rev.) 137.6 @ 6.7%
Asphalt Mix
T-167 141

Soft Particles 13 %
Fractured Faces 100 %

CEMENTATION
P.S.I. Comp. Str. 171

HUBBARD FIELD
% Swell ____
% Abs. ____
Stab. Wet ____
Stab. Dry ____
% Retained ____

L. A. ABRASION
Grading ____
	100 R	500 R
% Loss		70

Sand Eq. 32

OIL DESIGN
Additive used SEE SHEET NO. 3
% by C.K.E.
% used
% swell
% absorption
Stability P.S.I.
Wet . . . .
Dry . . . .
% retained

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

Remarks: * This gradation was obtained by crushing the +1½" material to -1½".
** This gradation was obtained by wasting 40% of the -#4 material (23% of total pit)
*** This is grading E(1) and not Grading E.

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Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Plant-mix and Chips)

Lab. No: 67-424-427-P Field Sample No: _____ Date: March 29, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted By: Runyan Quantity Rep. _____ Name of Material: Gravel

Source: CCC Pit

Test for: Oil Design, Stat. Imm. Tested by: A.T., R.R., D.G., R.G.

WASHED M. A. % PASSING

Sieve Size	Comb. Original	Sec. 200	Spec's. Sec. 200E (1)
3"	90		
1½"	81		
1"	76		
¾"	72	100	100
½"			
3/8"	65	85	
#4	58	66	45-80
#8			
#10	47	51	30-60
#40	21	24	25-35
#200	9	10	5-15
L. L.	19	—	
P. I.	1	NP	

OIL DESIGN
120/150 AC

Additive Used	None	1%Lime	1%Acra
% by C. K. E.	5.6	6.1	5.6
% Used *	7.1	7.6	7.1
% Swell	.7	1.2	.8
% Absorption	3.1	3.8	3.0
Stability P. S. I.			
Wet	158	116	180
Dry	268	313	271
% Retained	59	37	66
Specific Gravity			
Laboratory	2.22	2.25	2.23
Theo. Max.	2.41	2.41	2.41
% Theo.	92	93	93

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

HUBBARD FIELD

% Swell	1.6
% Abs.	3.0
Stab. Wet	1350
Stab. Dry	2170
% Retained	62

L. A. ABRASION

Grading _____

	100R	500R
% Loss		

STATIC IMMERSION

% Additive	Film Retained 0 Hours	24 Hours
None	100	95+
0.5-A	100	95+
1-A	100	95+
1-PB	100	95+
RSK	100	95+

SPECIFIC GRAVITY & ABS.

	+ #4	- #4	Comb.
Sp. Gr.	2.74	2.69	2.71
Abs.	4.5	4.5	4.5

Sand Equivalent	
Soft Particles	%
Fractured Faces	%
T-101 Swell	0.5%
Sulfate Soundness	%

Remarks: * Percent used by Rice Vacuum

DISTRIBUTION:

Region Office	1
Division Office	1
Project Eng.	1
Lab. File	2

REPORTED BY: ekt

GPO 838-024

FIGURE 6

CCC Camp Pit. Looking northerly into pit area which is the site of an old materials pit and asphalt mixing site. Holes 1, 3, & 4 are indicated. Hole No. 4 is located at the toe of a moraine.

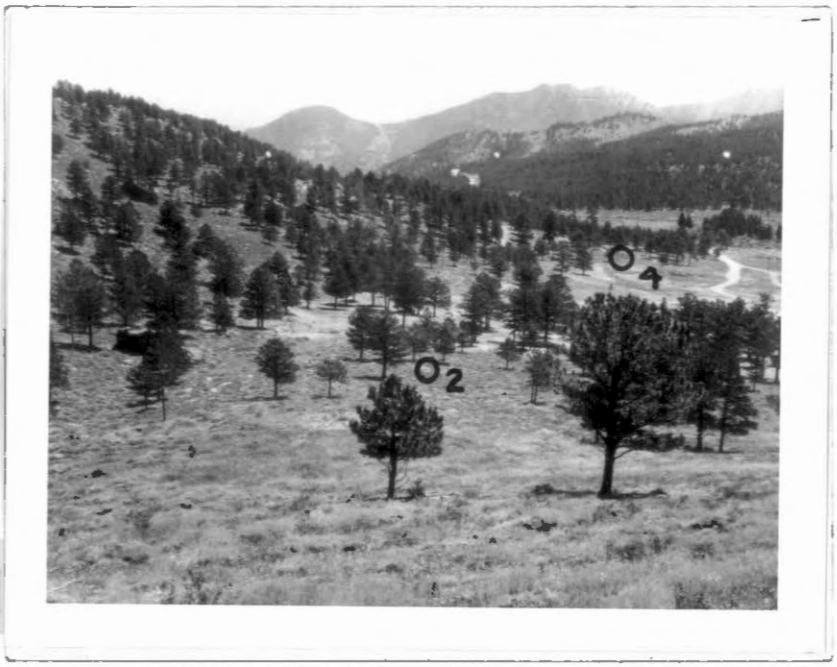


FIGURE 7

CCC Camp Pit. Looking easterly over the old pit site.
Holes 2 and 4 are indicated.

ROCKY MOUNTAIN NATIONAL PARK

PARKWIDE MATERIALS SURVEY

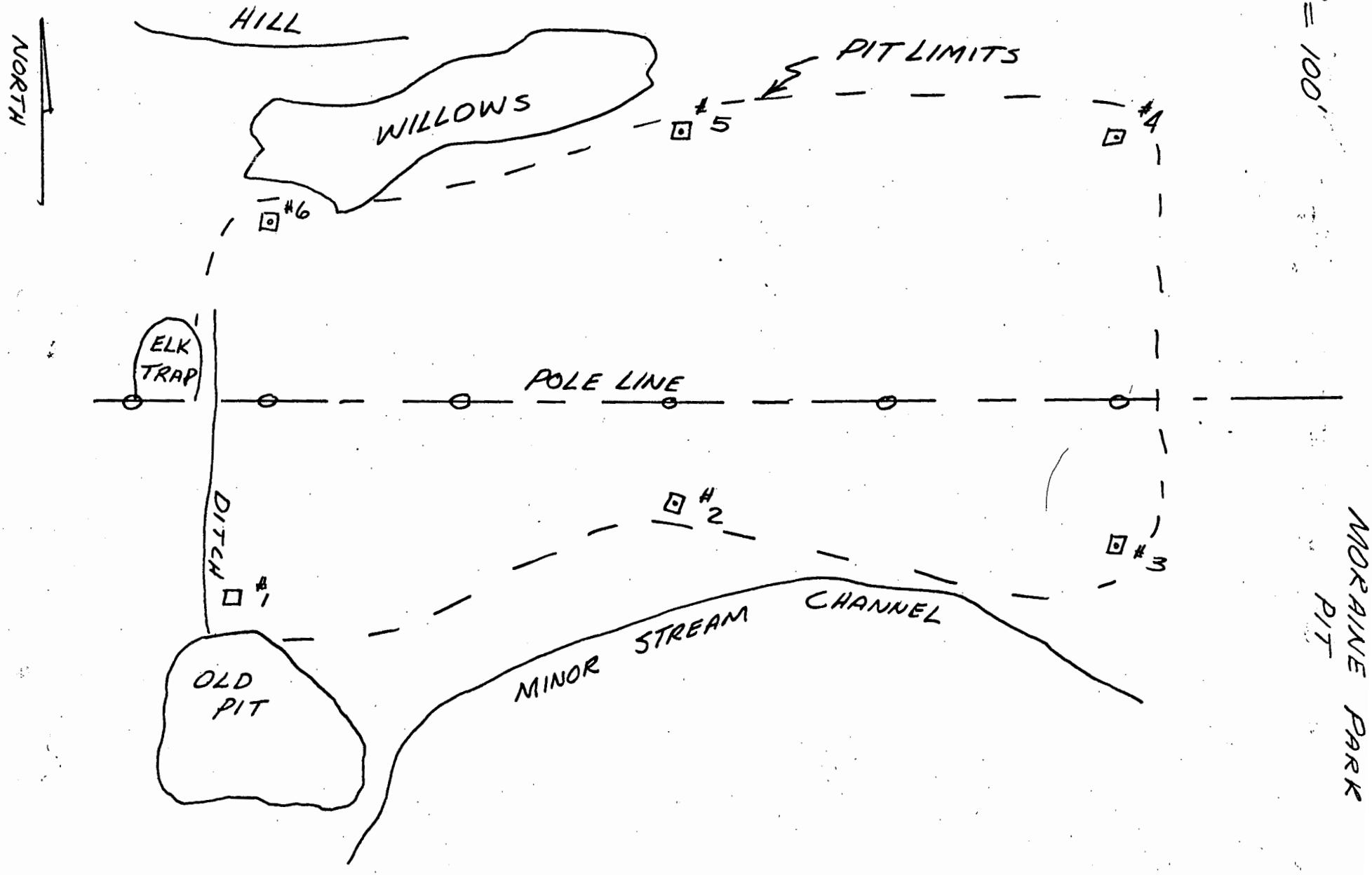
SOURCES OF MATERIALS SAMPLED AND TESTED

Western Slope ☐ Eastern Slope ☒

Pit Number 9-E BPR Lab. No. 66-882 through 66-887

Flight Strip 10 Photograph 1-44

LOCAL NAME, LOCATION AND GENERAL DESCRIPTION	Moraine Park Pit, in the vicinity of the elk trap. 0.9 miles west of Bear Lake Road in Moraine Park. Map Coordinates - Colorado Coordinate System, North Zone. 371 750 - 1972 875
QUANTITY	47,000 cubic yards.
ANALYSIS OF LABORATORY TEST DATA, CONDITIONS OF USE AND RECOMMENDATIONS	This material is suitable for subbase, base, bituminous stabilized base, surfacing, and concrete aggregate. Test holes indicate about 2' of overburden and stripping will be required. There is a negligible amount of material in excess of 10". Excavation deeper than 4-6' will result in a wet pit.


NORTH
HILL
WILLOWS
PIT LIMITS
#5
#4
#6
ELK TRAP
POLE LINE
DITCH
#2
#3
#1
OLD PIT
MINOR STREAM CHANNEL
1" = 100'
MORAINE PARK PIT

Eastern Slope
Moraine Park Pit
9-E

Log of Holes

Hole No. 1:

0–2'	Black gravelly organic topsoil.
2–8'	Sand and gravel. Water level at 4½'.
	6" maximum size.

Hole No. 2:

0–2½'	Black to brown organic topsoil.
2½–7'	Gray sand and gravel. Water level at 5'.
	6" maximum size.

Hole No. 3:

0–1½'	Organic topsoil.
1½–8'	Sand and gravel. Some silt and a trace of clay with some trash. Water level at 6'.

Hole No. 4:

0–1'	Organic topsoil.
1–7'	Brown and gray sand and gravel, little silt, stratified with fine sand pockets. Water level at 6'.
	6" maximum size.

Hole No. 5:

0–2'	Black organic topsoil.
2–8'	Brown and gray sand and gravel. Water level at 4'.
	6" maximum size.

Hole No. 6:

0–1½'	Organic topsoil.
1½–6'	Gray sand and gravel. Water level at 3½'. 6" maximum size.

Form PR-9-230
April 1965

U. S. DEPARTMENT OF COMMERCE
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Separate Test Hole Gradation, L. L., and P. I.)

Lab. No: 66-882-887-P Field Sample No: _____ Date: April 27, 1967

Project: R.M.N.P., Park Wide Survey, 1966

Submitted by: M.C. Everitt Quantity Rep. _____ Name of Materiol _____

Source: Morraine Park Pit

Test for: Original gradation, L.L. & P.I. Tested by: Lab School

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	882 Hole #1	883 Hole #2	884 Hole #3	885 Hole #4	886 Hole #5	887 Hole #6	Hole #7	Hole #8	Comb.
3"	92	97	98	93	89	96			94
1½"	63	73	75	70	65	70			77
1"	49	64	64	64	57	58			66
¾"	42	57	58	61	52	52			59
½"									
3/8"	29	44	49	52	42	41			48
#4	22	35	43	46	36	33			40
#8									
#10	15	24	36	41	29	24			32
#40	4	6	19	23	10	6			13
#200	1	1	10	3	2	1			2
L.L.	—	—	—	—	—	—			—
P. I.	NP	NP	NP	NP	NP	NP			NP

REMARKS:

DISTRIBUTION:
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Form PR-9-231
Rev. April 1965

U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Sub-base, Base Course, and Base Stabilization)

Lab. No: 66-882-887-P Field Sample No: _____ Date: April 27, 1967

Project: R.M.N.P., Park Wide Survey, 1966

Submitted by: M.C. Everitt Quantity Rep. _____ Name of Material: _____

Source: Morraine Park Pit

Test for: Sec. 104, & 200 Tested by: Lab School

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	Comb. Original	Sec. 104	Sec. 200	Degr.	Specifications Sec. 104	Specifications Sec. 200
3"	94					
1½"	77	100			100	
1"	66	80				
¾"	59	67	100	100		100
½"						
3/8"	48	49	62	70		
#4	40	40	45	55	30-70	35-65
#8						
#10	32	32	33	42		
#40	13	13	13	19		
#200	2	2	3	5	0-15	0-10
L. L.	—	—	—	—		0-25
P. I.	NP	NP	NP	NP	0-6	0-6

STABILOMETER
"R" at 400 P. S. I. Ex. Pressure
R: 80
% Moisture: 2.8
Density: 129.1

Wt./Cu. Ft. Compacted
Base Course
T-180 Method D: 135.8 @ 5.2%
Subbase
T-180 Method D (Rev.): 138.1 @ 3.5%
Asphalt Mix
T-167: _____

Soft Particles: 0 %
Fractured Faces: 88 %

CEMENTATION
P. S. I. Comp. Str. 2

HUBBARD FIELD
% Swell: _____
% Abs.: _____
Stab. Wet: _____
Stab. Dry: _____
% Retained: _____

L. A. ABRASION
Grading A

	100 R	500 R
% Loss	_____	42

Sand Eq. 79

OIL DESIGN

Additive used	_____	_____	_____
% by C. K. E.	_____	_____	_____
% used	_____	_____	_____
% swell	_____	_____	_____
% absorption	_____	_____	_____
Stability P. S. I.			
Wet	_____	_____	_____
Dry	_____	_____	_____
% retained	_____	_____	_____

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

Remarks: _____

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Lab. File 2

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Form PR-9-232
April 1965

U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Plant-mix and Chips)

Lab. No: 66-882-887-P Field Sample No: _____ Date: April 27, 1967

Project: R.M.N.P., Park Wide Survey, 1966

Submitted By: M.C. Everitt Quantity Rep. _____ Name of Material: _____

Source: Morraine Pit

Test for: Sec. 313 & 317 Tested by: Lab School

WASHED M.A. % PASSING

Sieve Size	Comb. Original	Sec. 317	Spec's. Sec. 317
3"	94		
1½"	77		
1"	66		
¾"	59	100	100
½"			
3/8"	48	62	
#4	40	45	45-65
#8		35	33-53
#10	32	33	
#40	13	13	10-25
#200	3-8	3	3-8
L. L.	—	—	
P. I.	NP	NP	0-6

OIL DESIGN
120/150 AC

Additive Used	None	1%Acra	1% Lime
% by C. K. E.	4.7	4.7	5.4
% Used *	6.0	*6.0	*6.7
% Swell	0.2	0.1	0.1
% Absorption	2.5	1.9	1.4
Stability P. S. I.			
Wet	176	211	213
Dry	189	175	194
% Retained	93	121	110
Specific Gravity			
Laboratory	2.28	2.29	2.30
Theo. Max.	2.43	2.43	2.40
% Theo.	94	94	96
Wt./cu. ft. compacted	142	142	145

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

HUBBARD FIELD

% Swell	0.5
% Abs.	1.4
Stab. Wet	1350
Stab. Dry	1380
% Retained	98

L. A. ABRASION

Grading _____

	100 R	500 R
% Loss		

STATIC IMMERSION

% Additive	Film Retained 0 Hours	24 Hours
None	100	95+
0.5A	100	95+
1-A	100	95+
1- PB	100	95+
RS-K	100	95+

SPECIFIC GRAVITY & ABS.

	+ #4	- #4	Comb.
Sp. Gr.	2.67	2.67	2.67
Abs.	1.0	1.4	1.2

Sand Equivalent _____

Soft Particles _____ %

Fractured Faces _____ %

T-101 Swell 0.2 %

Sulfate Soundness 1.0 %

Remarks: * Percent asphalt by Rice Vacuum method, 69% of the original voids filled and 94% of maximum specific gravity.

DISTRIBUTION:

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Project Eng.	1
Lab. File	2

REPORTED BY: ekt

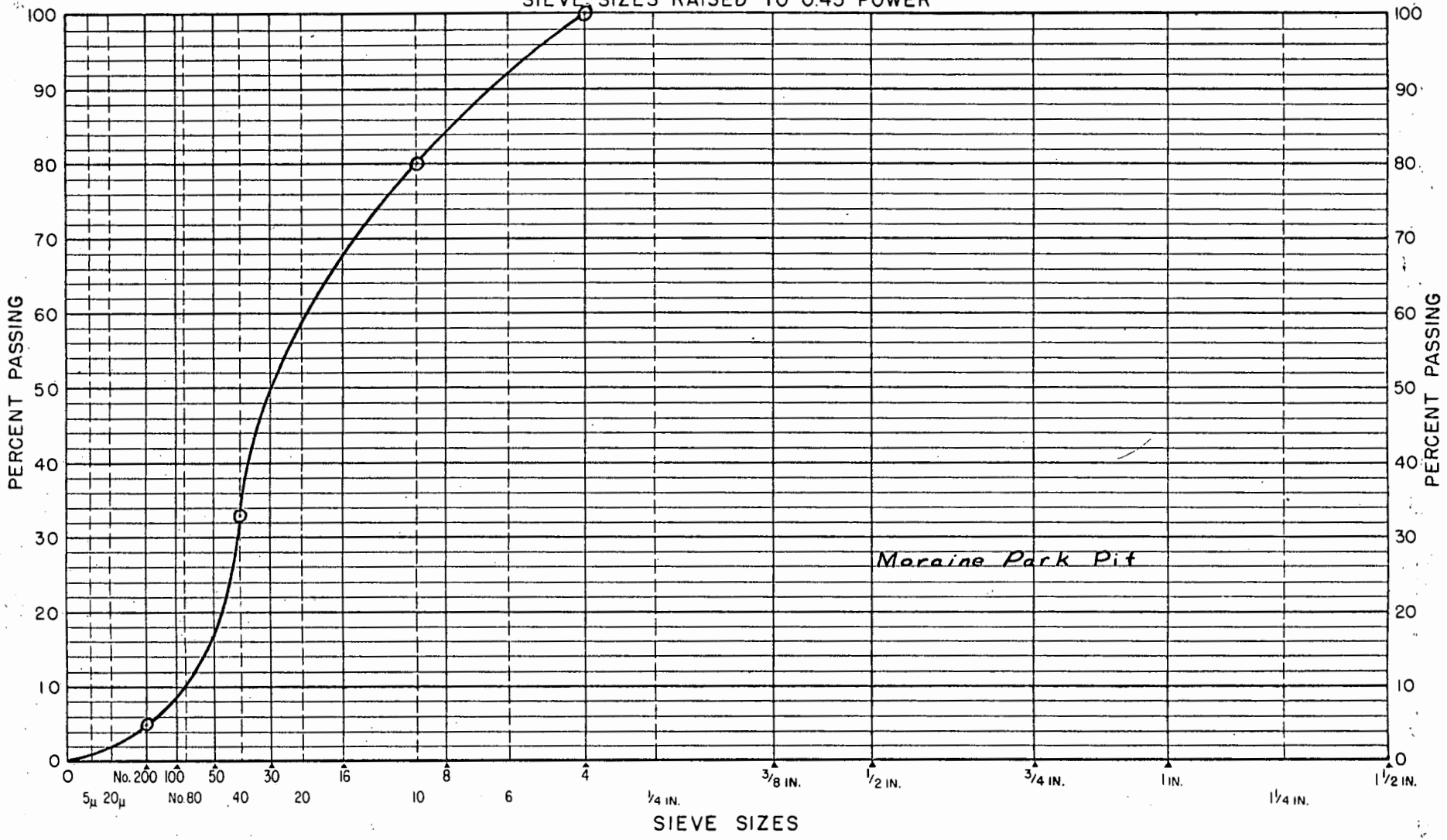
GPO 838-024

FO R-1115
(2-62)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS

GRADATION CHART

SIEVE SIZES RAISED TO 0.45 POWER



▲ THIS SYMBOL IDENTIFIES SIMPLIFIED PRACTICE AND COMPATIBLE SIEVE SIZES

Identification of gradations:

Sheet No.

Date

USCOMM-DC 40822-P62

FIGURE 8

Moraine Park Pit. Looking south over the pit area. Holes 1, 2, 3, 5, and 6 are indicated. Back of Hole 1 is the old pit, which is now ponded. The area is quite flat as indicated by the photograph.

ROCKY MOUNTAIN NATIONAL PARK

PARKWIDE MATERIALS SURVEY

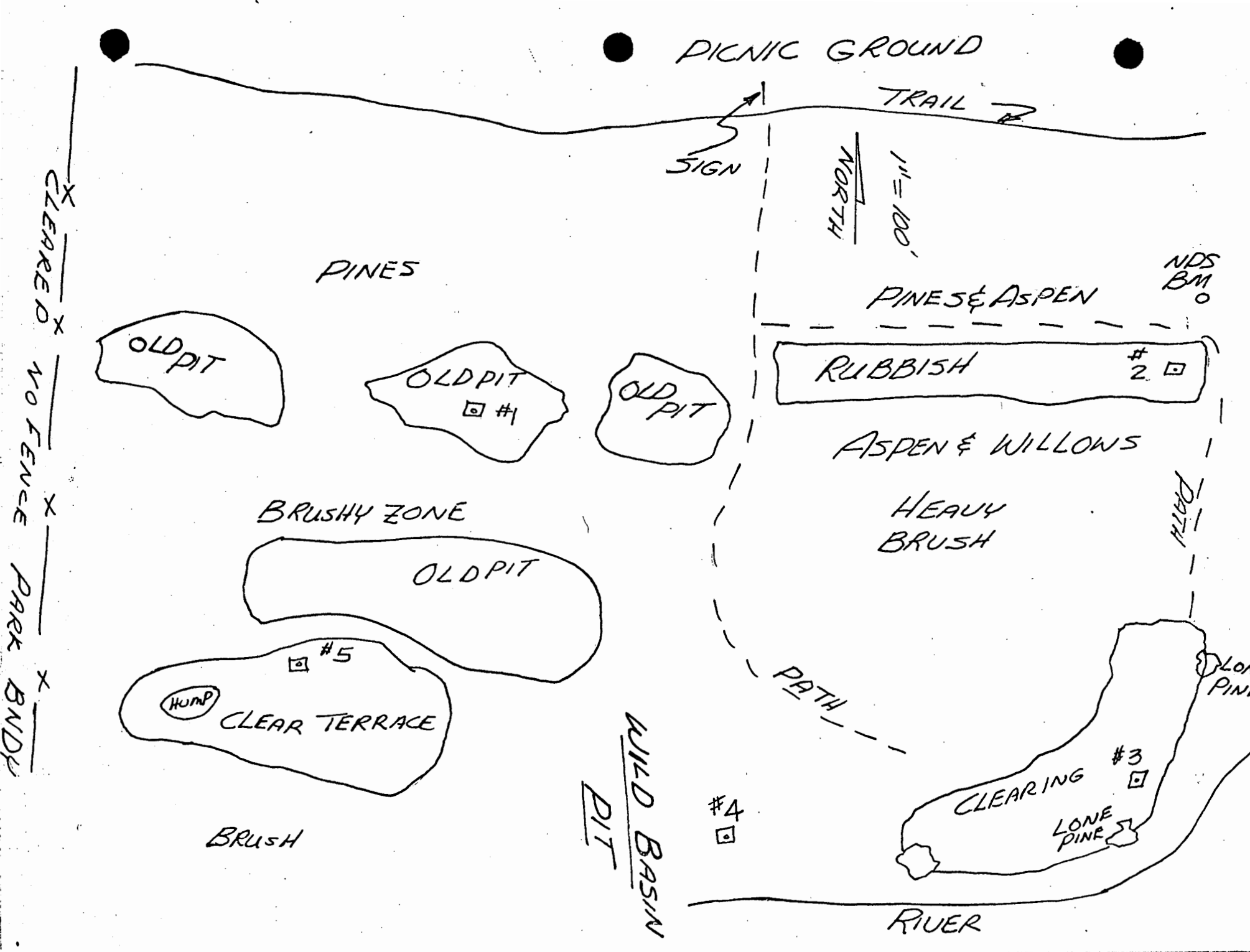
SOURCES OF MATERIALS SAMPLED AND TESTED

Western Slope ☐ Eastern Slope ☒

Pit Number 12-E BPR Lab. No. 65-1162-P through 65-1166

Flight Strip 1 Photograph 1-23

LOCAL NAME, LOCATION AND GENERAL DESCRIPTION	Wild Basin, site of an existing pit west of Copeland Lake. Map Coordinates - Colorado Coordinate System, North Zone. 321 750 - 1989 000
QUANTITY	Unlimited
ANALYSIS OF LABORATORY TEST DATA, CONDITIONS OF USE AND RECOMMENDATIONS	This material is suitable for use as subbase, base, bituminous stabilized base, surfacing, seal coat chips, and concrete aggregate. If used with asphalt grade MC-800, an antistripping agent will be needed. Tests indicate that no additive will be needed for 120-150 AC asphalt. The quantity of material that is available is unlimited but sections will be wet at least seasonally. Stripping of approximately 1½' will be necessary. There is a negligible amount of material in excess of 10". The source is on private land; apparently owned by the City of Longmont.


PICNIC GROUND
TRAIL
SIGN
NORTH
1" = 100'
NDS BM
PINES
PINES & ASPEN
OLD PIT
OLD PIT
#1
OLD PIT
RUBBISH
#2
ASPEN & WILLOWS
HEAVY BRUSH
BRUSHY ZONE
PATH
OLD PIT
#5
HUMP
CLEAR TERRACE
PATH
WILD BASIN PIT
#4
#3
CLEARING
LONE PINE
BRUSH
RIVER
CLEARED
NO FENCE
PARK BNDY

Eastern Slope
Wild Basin Pit
12-E

Log of Holes

Hole No. 1:

0-8'	Well-graded sand and gravel with cobbles. Negligible amount of cobbles larger than 10".
	12" maximum size.

Hole No. 2:

0-½'	Rubbish and topsoil.
½-10'	Sand and gravel with cobbles, similar to Hole No. 1. Moisture appearing at the bottom of hole.

Hole No. 3:

0-10'	Sand and gravel with cobbles, slightly finer than Holes 1 and 2. Water level at 10' in gray sand and gravel.

Hole No. 4:

0-1½'	Dark brown silty sand and gravel topsoil.
1½-5'	Brown sand and gravel with cobbles similar to Holes 1 and 2.
5-8'	Gray silty fine sand under water.

Hole No. 5:

0-1½'	Dark brown silty sand and gravel topsoil.
1½-9'	Brown sand and gravel, water level at 9'.
9-11'	Gray sand and gravel.

Form PR-9-230
April 1965

U. S. DEPARTMENT OF COMMERCE
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Separate Test Hole Gradation, L. L., and P. I.)

Lab. No: 65-1162P-1166P Field Sample No: _____ Date: April 15, 1966

Project: Nederland - Raymond 1965 Survey

Submitted by: M.C. Everitt Quantity Rep. 100,000 Tons Name of Material Alluvial Gravel

Source: Wild Basin Pit

Test for: Gradation, L.L.& P.I. Tested by: K.W., B.R.P., KKR

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	65-1162 Hole #1	65-1163 Hole #2	65-1164 Hole #3	65-1165 Hole #4	65-1166 Hole #5	Hole #6	Hole #7	Hole #8	Comb.
3"	76	65	83	82	79				77
1½"	56	52	73	66	71				55
1"	51	44	66	56	64				49
¾"	45	40	62	50	59				45
½"									
3/8"	36	32	53	42	49				37
#4	30	26	45	37	41				31
#8									
#10	23	19	36	30	32				24
#40	7	7	18	11	9				9
#200	2	2	6	2	2				2
L.L.	--	--	--	--	--				--
P.I.	NP	NP	NP	NP	NP				NP

REMARKS:

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

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Project Eng.	1
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Rev. April 1965

U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Sub-base, Base Course, and Base Stabilization)

Lab. No: 65-1162-1166 Inc. Field Sample No: _____ Date: April 18, 1966

Project: Nederland - Raymond, 1965 Survey

Submitted by: M.C. Everitt Quantity Rep. 100,000 Tons Name of Material: Alluvial Gravel

Source: Wild Basin Pit

Test for: Sec. 102, 104, 200 Tested by: K.W., P.W.B., K.K.R., B.R.P.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	Comb. Original	Sec. 104	Sec.* 200	Sec. 200 Degr.	Specifications Sec. 104	Specifications Sec. 200
3"	77					
1½"	55	100			100	
1"	49	86				
¾"	45	71	100	100		100
½"						
3/8"	37	52	68	81		
#4	31	42	51	62	30-70	35-65
#8			40			
#10	24	32	37	49		
#40	9	12	13	23		
#200	2	3	3	7	0-15	0-10
L.L.	—	—	—	—		< 25
P.I.	NP	NP	NP	NP	0-6	0-6

STABILOMETER
"R" at 400 P.S.I. Ex. Pressure

R	80
% Moisture	4.8
Density	126.9#/ft.³ with baskets

Wt./Cu. Ft. Compacted

Base Course
T-180 Method D: 135.8 @ 6.1%

Subbase
T-180 Method D (Rev.): 139.2 @ 5.2%

Asphalt Mix
T-167: 151

Soft Particles	0 %
Fractured Faces	93 %

CEMENTATION
P.S.I. Comp. Str. 12

HUBBARD FIELD
% Swell _____
% Abs. _____
Stab. Wet _____
Stab. Dry _____
% Retained _____

L. A. ABRASION
Grading A

	100 R	500 R
% Loss	10	39

Sand Eq. 83

OIL DESIGN
M.C. 800

Additive used	None	1% Acra	1% Lime
% by C.K.E.	3.8	3.8	4.7
% used	3.8	3.8	4.7
% swell	0	0	.03
% absorption	4.5	3.8	3.4
Stability P.S.I.			
Wet	47	76	76
Dry	77	69	103
% retained	61	110	74

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

Remarks:
* This grading also meets spec. for Sec. 317

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Project Eng.	1
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Form PR-9-232
April 1965

U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Plant-mix and Chips)

Lab. No: 65-1162-1166 Inc. Field Sample No: _____ Date: April 18, 1966

Project: Nederland - Raymond, 1966 Survey

Submitted By: M.C. Everitt Quantity Rep. 100,000 Tons Name of Material: Alluvial Gravel

Source: Wild Basin Pit

Test for: Sec. 317 Tested by: K.W., P.W.B., B.R.P., K.K.R.

WASHED M.A. % PASSING

Sieve Size	Comb. Original	Sec. 317	Spec's. Sec.
3"	77		
1½"	55		
1"	49		
¾"	45	100	100
½"			
3/8"	37	68	
#4	31	51	45-65
#8		40	33-53
#10	24	37	
#40	9	13	10-25
#200	2	3	3-8
L.L.	--	--	
P.I.	NP	NP	

OIL DESIGN
120/150 AC

Additive Used	None	1%Acra	1%Lime
% by C.K.E.	5.2	5.2	6.0
% Used	5.2	5.2	6.0
% Swell	0	0	0
% Absorption	2.8	2.6	2.0
Stability P.S.I.			
Wet	244	230	269
Dry	175	192	204
% Retained	139	120	132
Specific Gravity			
Laboratory	2.23	2.24	2.27
Theo. Max.	2.38	2.38	2.36
% Theo.	94	94	132
Comp. #/Ft.^{3}	150	152	152

HUBBARD FIELD

% Swell	0.55
% Abs.	1.0
Stab. Wet	2400
Stab. Dry	1780
% Retained	135

STATIC IMMERSION

% Additive	Film Retained 0 Hours	24 Hours
None	100	95-
A	100	95+
PB	100	95+
RSK	100	95+

L. A. ABRASION
Grading _____

	100R	500R
% Loss		

SPECIFIC GRAVITY & ABS.

	+#4	-#4	Comb.
Sp. Gr.	2.59	2.58	2.58
Abs.	1.0	1.2	1.1

Sand Equivalent	
Soft Particles	%
Fractured Faces	%
T-101 Swell	0.4 %
Sulfate Soundness	0 %

Remarks: _____

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

DISTRIBUTION:

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Lab. File	2

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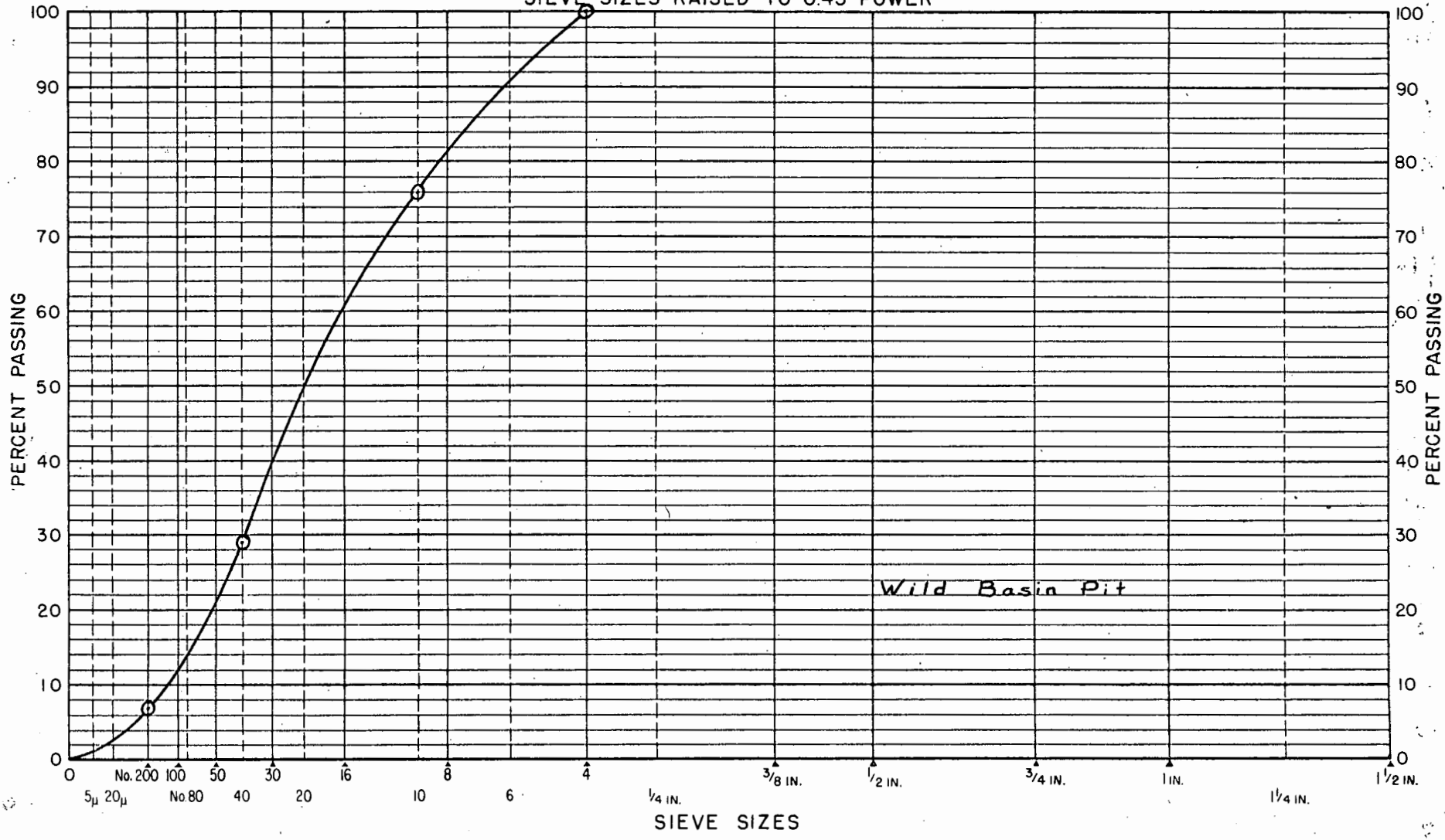
FORM PR-1115
(2-62)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS

GRADATION CHART

SIEVE SIZES RAISED TO 0.45 POWER



▲ THIS SYMBOL IDENTIFIES SIMPLIFIED PRACTICE AND COMPATIBLE SIEVE SIZES

Identification of gradations:

Sheet No.

Date

USCOMM-DC 40822-P62

ROCKY MOUNTAIN NATIONAL PARK

PARKWIDE MATERIALS SURVEY

SOURCES OF MATERIALS SAMPLED AND TESTED

Western Slope ☐ Eastern Slope ☒

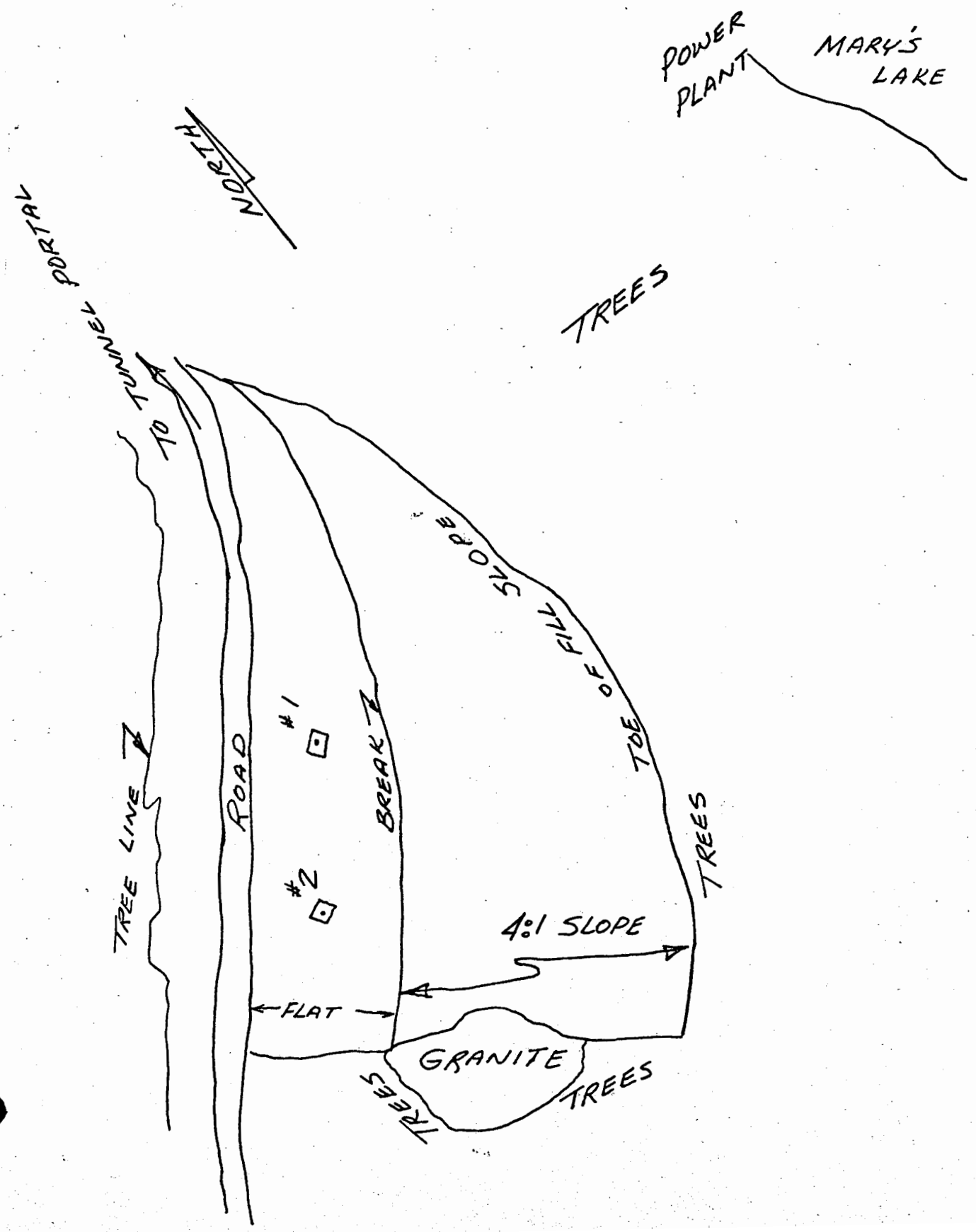
Pit Number 13-E BPR Lab. No. 66-880 and 66-881

Flight Strip 4 Photograph 1-5

LOCAL NAME, LOCATION AND GENERAL DESCRIPTION	Mary's Lake Tunnel Spoil. This material is located above Mary's Lake adjacent to Ram's Horn Tunnel Portal. Map Coordinates - Colorado Coordinate System, North Zone. 366 875 - 1990 875
QUANTITY	Not available for use.
ANALYSIS OF LABORATORY TEST DATA, CONDITIONS OF USE AND RECOMMENDATIONS	This material is quite suitable for subbase, base, bituminous stabilized base, seal coat chips, and bituminous surfacing aggregates. There is a negligible amount larger than 10". This pit is no longer available for use, as ordered by the Bureau of Reclamation in their August 22, 1967 letter.

MARY'S LAKE TUNNEL SPOIL

1" = 100'



Eastern Slope
Mary's Lake Tunnel Spoil
13-E

Log of Holes

Hole No. 1:

0-6"	Topsoil.
6"-10'	Gray sand and rock fragments.

Hole No. 2:

0-6"	Topsoil.
6"-10'	Brown and gray sand and rock fragments.

Form PR-9-231
Rev. April 1965

U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Sub-base, Base Course, and Base Stabilization)

Lab. No: 66-880-1-P Field Sample No: _____ Date: July 7, 1967

Project: Rocky Mountain National Park, 1966 Survey

Submitted by: M. C. Everitt Quantity Rep. _____ Name of Material: Granite Tunnel Spoil

Source: Mary's Lake Tunnel Spoil

Test for: Sec. 102, 104, 200 and 217 Tested by: J.D., J.R., A.T., and D.B.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	Comb. Original	Sec. 104	Sec. 200	Degr.	Specifications Sec. 104	Specifications Sec. 200
3"	88					
1½"	69	100			100	
1"	61	85				
¾"	54	68	100	100		100
½"		54				
3/8"	42	47	66	73		
#4	34	36	48	55	30-70	35-65
#8			39			
#10	26	27	37	41		
#40	14	15	21	21		
#200	5	6	8	8	0-15	0-10
L. L.	NV	NV	NV	NV		0-25
P. I.	NP	NP	NP	NP	0-6	0-6

STABILOMETER
"R" at 400 P. S. I. Ex. Pressure

R: 82
% Moisture: 3.7%
Density: 130.3

Wt./Cu. Ft. Compacted
Base Course
T-180 Method D: 137.3 @ 5.8%
Subbase
T-180 Method D (Rev.): 140.6 @ 4.6%
Asphalt Mix
T-167: 147

Soft Particles: 0.0 %
Fractured Faces: 100 %

CEMENTATION
P. S. I. Comp. Str.: 4

HUBBARD FIELD
% Swell: _____
% Abs.: _____
Stab. Wet: _____
Stab. Dry: _____
% Retained: _____

L. A. ABRASION
Grading: A

	100 R	500 R
% Loss	_____	33

Sand Eq.: 67

OIL DESIGN
Additive used: SEE SHEET NO. 2

% by C. K. E.	_____	_____	_____
% used	_____	_____	_____
% swell	_____	_____	_____
% absorption	_____	_____	_____
Stability P. S. I.			
Wet	_____	_____	_____
Dry	_____	_____	_____
% retained	_____	_____	_____

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

Remarks: _____

DISTRIBUTION:
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Division Office: 1
Project Eng.: 1
Lab. File: 2

REPORTED BY: ekt

GPO 838-024

Form PR-9-232
April 1965

U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Plant-mix and Chips)

Lab. No: 66-880-1-P Field Sample No: Date: July 7, 1967

Project: Rocky Mountain National Park, 1966 Survey

Submitted By: M.C. Everitt Quantity Rep. Name of Material: Granite Tunnel Spoil

Source: Mary's Lake Tunnel Spoil

Test for: Sec. 313 and 317 Tested by: J.D., J.R., A.T., and D.B.

WASHED M.A. % PASSING

Sieve Size	Comb. Original	Sec. 317	Spec's. Sec. 317*
3"	88		
1½"	69		
1"	61		
¾"	54	100	100
½"			
3/8"	42	66	
#4	34	48	45-65
#8		39	33-53
#10	26	37	
#40	14	21	10-25
#200	5	8	3-8
L.L.	NV	NV	
P.I.	NP	NP	0-6

OIL DESIGN
120/150 AC

Additive Used	None	1%Lime	1%Acra
% by C.K.E.	4.5	5.3	4.5
% Used	5.5	6.3	5.5
% Swell	0.0	0.0	0.0
% Absorption	1.8	1.0	0.7
Stability P.S.I.			
Wet	194	318	338
Dry	267	306	324
% Retained	73	104	104
Specific Gravity			
Laboratory	231	234	235
Theo. Max.	2.45	2.45	2.45
% Theo.	94	96	96
lb/cu.ft. compacted	145	147	148

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

HUBBARD FIELD

% Swell	0.2
% Abs.	2.1
Stab. Wet	1750
Stab. Dry	1980
% Retained	88

STATIC IMMERSION

% Additive	% Film Retained 0 Hours	24 Hours
None	100	95+
0.5A	100	95+
1-A	100	95+
1-PB	100	95+
RS-K	100	95+

Sand Equivalent

Soft Particles %

Fractured Faces %

T-101 Swell 0.0 %

Sulfate Soundness 0.0 %

L. A. ABRASION

Grading

	100R	500R
% Loss		

SPECIFIC GRAVITY & ABS.

	+ #4	- #4	Comb.
Sp. Gr.	2.67	2.66	2.67
Abs.	0.7	1.0	0.9

DISTRIBUTION:

Region Office	1
Division Office	1
Project Eng.	1
Lab. File	2

Remarks:

* Section 317 meets the same specs. as Section 200

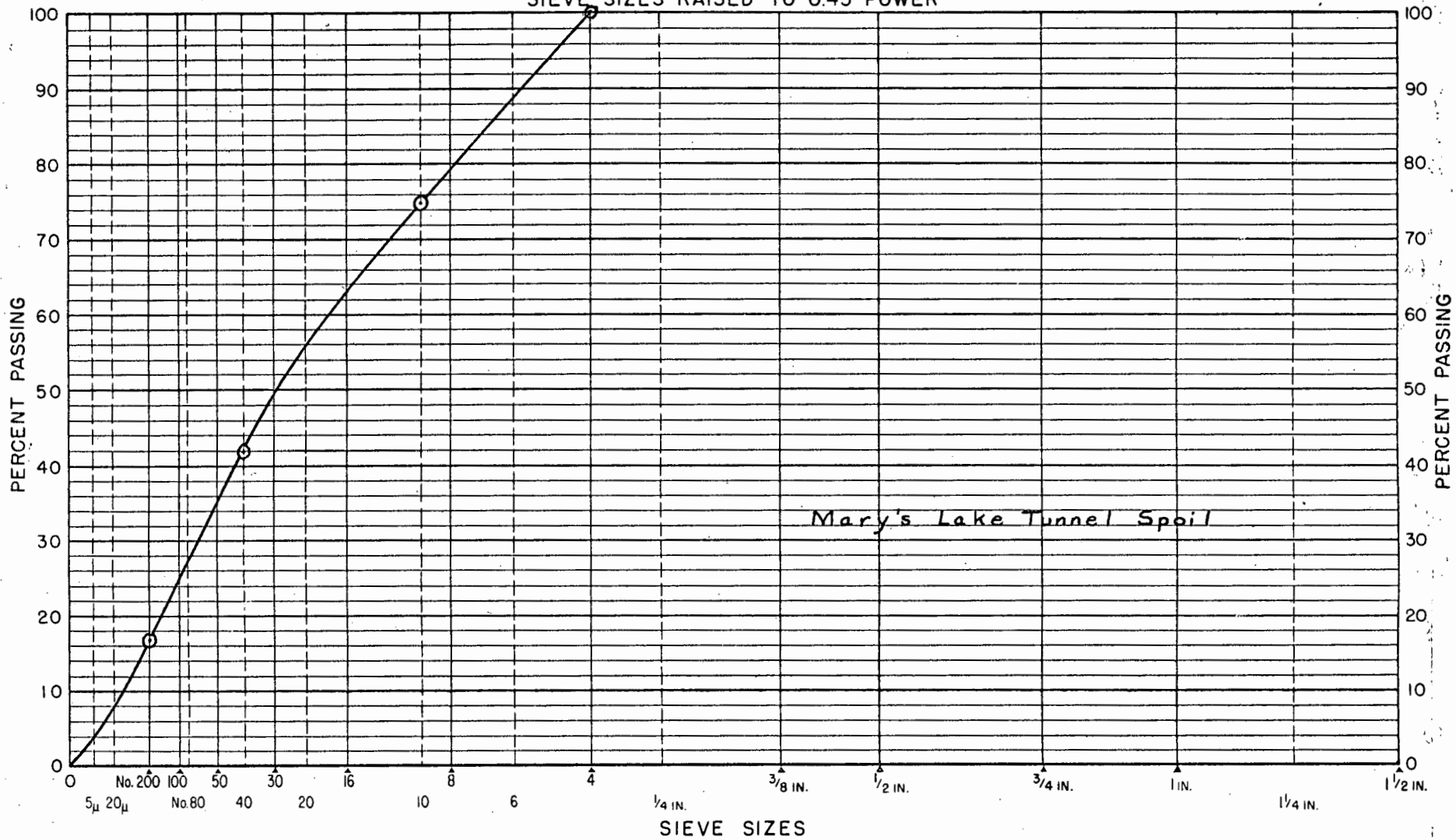
REPORTED BY: ekt

FORM PR-1115
(2-62)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS

GRADATION CHART

SIEVE SIZES RAISED TO 0.45 POWER



▲ THIS SYMBOL IDENTIFIES SIMPLIFIED PRACTICE AND COMPATIBLE SIEVE SIZES

Idenification of gradations:

Sheet No.

Date

USCOMM-DC 40822-P62

ROCKY MOUNTAIN NATIONAL PARK

PARKWIDE MATERIALS SURVEY

SOURCES OF MATERIALS SAMPLED AND TESTED

Western Slope ☐ Eastern Slope ☒

Pit Number 14-E BPR Lab. No. 66-877-879-P

Flight Strip 6 Photograph 1-46

LOCAL NAME, LOCATION AND GENERAL DESCRIPTION	Common point tunnel spoil, 7 miles east of Estes Park. Map Coordinates - Colorado Coordinate System, North Zone.
QUANTITY	80,000 cubic yards
ANALYSIS OF LABORATORY TEST DATA, CONDITIONS OF USE AND RECOMMENDATIONS	This material is suitable for subbase, base, bituminous stabilized base and surfacing aggregates. It is borderline material for seal coat chips, and it is not recommended for concrete aggregate because of the heavy washing that would be required. In making the gradation for surfacing 19% of the total pit was washed. This pit is on private land, refer to Bureau of Reclamation August 22, 1967 letter.

Form PR-9-231
Rev. April 1965

SHEET NO. 1 OF 2

U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Sub-base, Base Course, and Base Stabilization)

Lab. No: 66-877-9-P Field Sample No: Date: July 21, 1967

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: M.C. Everitt Quantity Rep. Name of Material: Tunnel Spoils

Source: Common Point Tunnel Spoils

Test for: Sec. 104-200-217 Tested by: J.D., J.R., A.T. and D.B.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	Comb. Original	Sec. 104	Sec. 200	Degr.	Specifications Sec. 104	Specifications Sec. 200
3"	86					
1½"	70	100			100	
1"	61	82				
¾"	57	67	100	100		100
½"		56				
3/8"	45	50	61	69		
#4	36	40	44	55	30–70	35–65
#8						
#10	28	33	34	41		
#40	16	20	19	22		
#200	6	8	8	9	0–15	0–10
L. L.	NV	NV	NV	NV		0–25
P. I.	NP	NP	NP	NP	0–6	0–6

STABILOMETER
"R" at 400 P. S. I. Ex. Pressure

R	83
% Moisture	5.2
Density	134.6

Wt./Cu. Ft. Compacted

Base Course
T-180 Method D 138.7 @ 5.8%

Subbase
T-180 Method D (Rev.) 139.1 @ 5.4%

Asphalt Mix
T-167 147

Soft Particles %
Fractured Faces 100 %

CEMENTATION
P. S. I. Comp. Str. 4

HUBBARD FIELD
% Swell
% Abs.
Stab. Wet
Stab. Dry
% Retained

L. A. ABRASION
Grading A

	100 R	500 R
% Loss		40

Sand Eq.

OIL DESIGN 200
120/150 AC

Additive used	None	Lime	Acra
% by C. K. E.	4.5	5.3	4.5
% used	5.5	6.3	5.5
% swell	.01	0	0.0
% absorption	1.5	0.5	0
Stability P. S. I.			
Wet	249	329	315
Dry	251	302	281
% retained	99	109	112
lbs/cu.ft. compacted	146	---	---

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

Remarks:

DISTRIBUTION:

Region Office	1
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Lab. File	2

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Form PR-9-232
April 1965

SHEET NO. 2 OF 2

U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Plant-mix and Chips)

Lab. No: 66-877-9-P Field Sample No: Date: July 21, 1967

Project: Rocky Mountain National Park, 1967 Survey

Submitted By: M.C. Everitt Quantity Rep. Name of Material: Tunnel Spoils

Source: Common Point Tunnel Spoils

Test for: Sec. 317 Tested by: J.D., J.R., A.T., and D.B.

WASHED M.A. % PASSING

Sieve Size	Comb. Original	**Sec. 317	Spec's. Sec.317
3"	86		
1½"	70		
1"	61		
¾"	57	100	100
½"			
3/8"	45	68	
#4	36	47	45-65
#8			33-53
#10	28	33	
#40	16	18	10-25
#200	6	7	3-8
L. L.	NV	NV	
P. I.	NP	NP	0-6

OIL DESIGN
120/150 AC

Additive Used	None	1%Lime	1%Acra
% by C. K. E.	4.4	5.0	4.4
% Used ***	5.4	6.0	5.4
% Swell	.03	.01	.005
% Absorption	2.0	1.0	1.5
Stability P. S. I.			
Wet	237	325	302
Dry	325	307	285
% Retained	73	106	106
Specific Gravity			
Laboratory	2.32	2.35	2.34
Theo. Max.	2.45	2.42	2.45
% Theo.	96	97	96
lbs./cu.ft. compacted	145	148	148

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

HUBBARD FIELD

% Swell	0.2
% Abs.	2.1
Stab. Wet	1680
Stab. Dry	2130
% Retained	79

L. A. ABRASION

Grading

	100 R	500 R
% Loss		

STATIC IMMERSION

% Additive	Film Retained 0 Hours	24 Hours
None	100	95-
0.5-A	100	95+
1-A	100	95+
1-PB	100	95+
RSK	100	95+

SPECIFIC GRAVITY & ABS.

	+ #4	- #4	Comb.
Sp. Gr.	2.68	2.66	2.67
Abs.	0.8	1.3	1.1

Sand Equivalent	69
Soft Particles	17.0 %
Fractured Faces	99.5 %
T-101 Swell	0.0 %
Sulfate Saundness	---- %

DISTRIBUTION:

Region Office	1
Division Office	1
Project Eng.	1
Lab. File	2

Remarks:

** Wasted 40% of -4 and recrushed 10% +4 to obtain this gradation.

*** Percent oil by Rice Vacuum

REPORTED BY: ekt

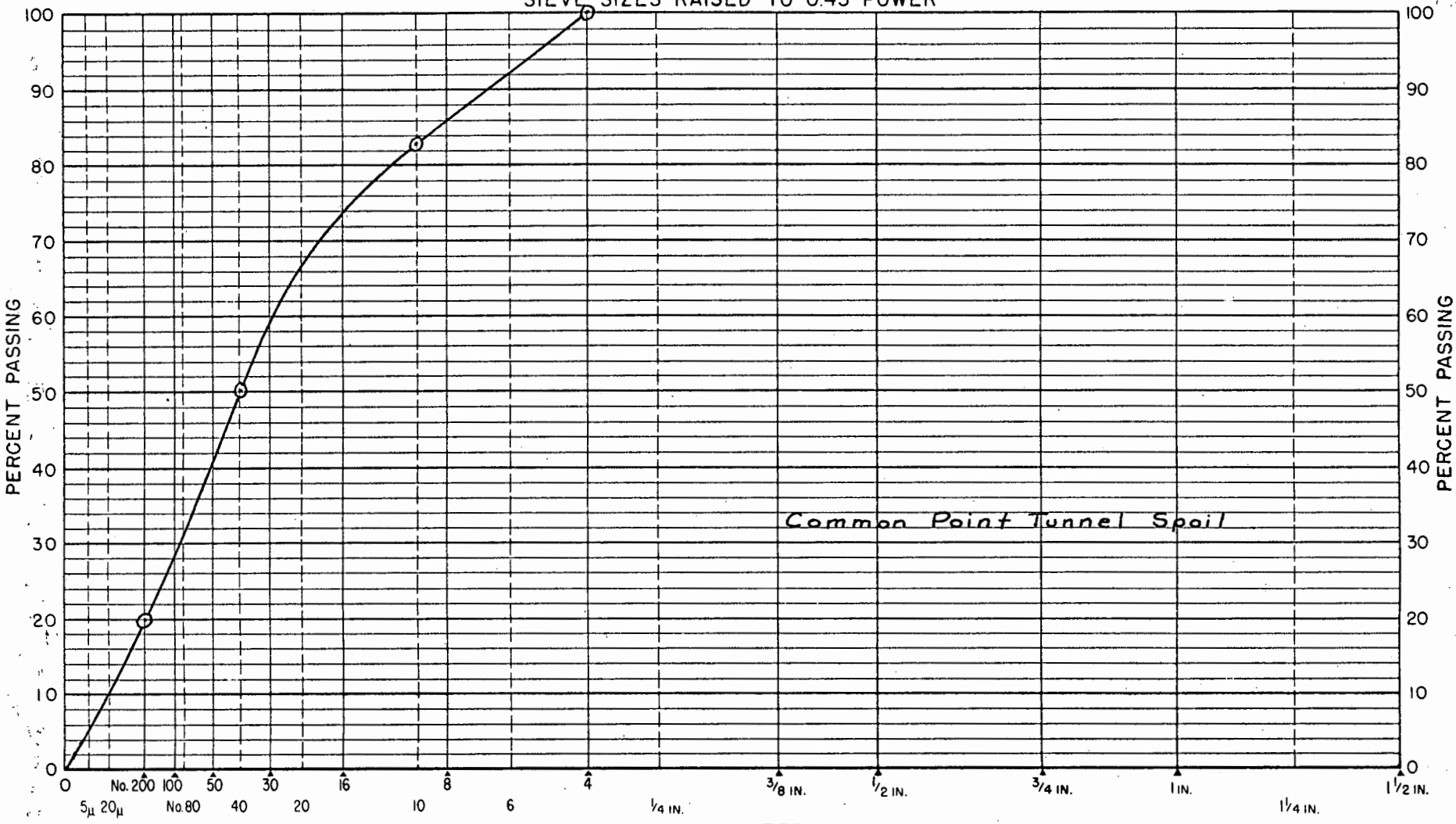
GPO 838 - 024

FORM PR-1115
(2-62)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS

GRADATION CHART

SIEVE SIZES RAISED TO 0.45 POWER



▲ THIS SYMBOL IDENTIFIES SIMPLIFIED PRACTICE AND COMPATIBLE SIEVE SIZES

Identification of gradations:

Sheet No.

Date

USCOMM-DC 40822-P62

GENERAL GEOLOGIC DISCUSSION

ROCKY MOUNTAIN NATIONAL PARK - MATERIALS SURVEY

(Western Slope Area)

By

R. G. Burdick

January 1965

This report covers the area west and south of the Trail Ridge Area. In general this is the Colorado River - Granby Lake Area covered by flight strips 28 through 39. The elevations through this area range from 8,000 ft. to 10,500 ft. Average annual precipitation is 18" - 24".

This western slope area will be characterized mainly by volcanic features, glacial deposits, and large areas of metasediment rocks rather than the igneous rock to the east. In recent years, several dam-building projects have changed the economic characteristics of the Colorado River Valley to those dealing with tourism. For this reason, although aggregate potential is fairly high, the acquisition of pit areas may require considerable reconnaissance, particularly in those areas near the Park Boundary, to develop sites acceptable to all concerned.

The northern portion of this area is flanked by the volcanic areas at the summit of the Never Summer Range, and Specimen Mountain. These volcanic materials as described for Specimen Mountain are of two main types:

(a) The lower portions are of quartz latite and its associated ash.

(b) The upper portions are of rhyolite and its ash deposits.

The upper flows have considerable amounts of bentonite associated with them, and this material may be encountered in either moraines or terraces through the Colorado River Valley. It is expected that the latites will furnish good aggregates while the rhyolites or breccias will be of lower quality.

The Central portions of this area lie primarily in schists and, except for tributary streams rising high to the east, such as Tonahutu Creek or North Inlet Creek, the aggregate potential is rather low. The two creeks mentioned head in granite areas and may afford good aggregate. It has been noted that the area to the West of Grand Lake is of tertiary age rock composed of 900'± interbedded sandstones and shales with basalt layers. Also there is a large area of poorly cemented conglomerate of pliestocene age in Stillwater Creek Valley that is up to 100 ft. deep and about 1 mile wide. These formations, the Table Mountain and Porphyry Peaks respectively, will probably not be of much value from a materials standpoint.

The southern portion of the area will be characterized by moraine and outwash materials from the Continental Divide area to the east, and bedrock formations which range from pre-Cambrian to quaternary in age. The morainal materials occur mostly along Arapaho Creek and are composed primarily of metamorphic rocks (the batholith intrusion is missing from Copeland Mountain South through the Arapaho Peaks, and schists 2,000 ft. - 3000 ft. thick are shown in this area) and their quality or that of the outwash materials will probably be low.

The bedrocks shown are described as follows:

(a) Pre-cambrian gneiss and schist, Idaho Springs fm., form most of the surface east of the Colorado River.

(b) Pre-cambrian pegmatite, granite and schist, Green Ridge Pegmatite, forms a ridge 7 miles long and more than 1 mile wide west of the Colorado River between Shadow Mountain and Granby Lakes. It is composed largely of

pegmatite, but contains inclusions of granite and schist. Mica and beryl are present in noticeable amounts.

(c) Tertiary sandstone, shale, and basalt flows, Table Mtn. fm., sediments of lacustrine origin with interbedded basalts. These deposits occur mainly west of the Colorado River.

(d) Quaternary conglomerate, Porphyry Peaks, occurs in the Stillwater Valley west of the Colorado River. This poorly consolidated material occurs in two layers separated in places by cross-bedded sand. Most of the large boulders are gray prophyry from a dike near Pory Park. The top of the conglomerate is veneered with injection gneiss fragments from nearby moraines.

The literature shows five glacial ages in this area. These glacial ages seem to correlate with the ones on the eastern slope.

Moraine one, from Monarch to Colorado River along Arapaho Creek. Forms a prominent lateral ridge 900 ft. above the present valley. The material is highly weathered and probably of no value as aggregate. (Material may be similar to Old Moraine Remnants on Eastern Slope.)

Moraine two, lies inside of moraine one. Material less severely weathered, schists decomposed but other materials sound.

Moraine three and four, show individual terminal moraines but laterals merge upstream. (Moraines two, three and four may be similar to Park Boundary moraines on east slope).

Moraine five, fairly recent origins, however, some of the schists and granites are badly weathered due to locally humid climate (may be similar to upper valley moraines.)

The literature cites the presence of landslides in the area and also the presence of extensive peat beds in the higher basins. Lower Arapaho Creek Valley contains several wet meadows of organic deposits mixed with fine alluvium.

BIBLIOGRAPHY

Boos, C. M. and F. M., 1934, Granites of the Front Range - The Longs Peak - St. Vrain Batholith; Geological Society American Bulletin, Volume 45.

Ives, R. L. , 1938, Glacial Geology of the Monarch Valley, Grand County Colorado; Geological Society America Bulletin, Volume 49.

Wahlstrom, E.E., 1944, Structure and Petrology of Specimen Mountain, Colorado; Geological Society America Bulletin, Volume 49.

Maps	Scale		
Trail Mountain	1:24,000	7½ ft.	Quad.
Granby	"	"	"
Fall River Pass	"	"	"
Grand Lake	"	"	"
Shadow Mountain	"	"	"
Strawberry Lake	"	"	"
Isolation Peak	"	"	"
Monarch Lake	"	"	"

DISCUSSION OF PHOTOGRAPHS

ROCKY MOUNTAIN NATIONAL PARK - MATERIALS SURVEY

(Western Slope)

By

Robert L. Schuster

September 1966

PHOTOGRAPHIC INFORMATION

Flight Strip	27	Photographs 3-48 thru 3-56	(8/65 date flown)
Flight Strip	28	Photographs 2-2 thru 2-15	(8/65)
Flight Strip	29	Photographs 2-19 thru 2-31	(8/65)
Flight Strip	30	Photographs 2-32 thru 2-52	(8/65)
Flight Strip	31	Photographs 2-61 thru 2-74	(8/65)
Flight Strip	32	Photographs 2-54 thru 2-60	(8/65)
Flight Strip	33	Photographs 2-77 thru 2-95	(8/65)
Flight Strip	34	Photographs 5-2 thru 5-7	(9/65)
Flight Strip	35	Photographs 5-10 thru 5-16	(9/65)
Flight Strip	36	Photographs 5-17 thru 5-25	(9/65)
Flight Strip	37	Photographs 5-27 thru 5-34	(9/65)
Flight Strip	38	Photographs 5-36 thru 5-47	(9/65)
Flight Strip	39	Photographs 5-50 thru 5-57	(9/65)

Scale: 1:9600 (800 feet to one inch)

Width of flight strips: Approximately 7200 feet

Type of film: Agfa Color

GEOLOGIC REFERENCES

Little detailed geologic mapping of the western portion of Rocky Mountain National Park has been accomplished. The following few references represent mapping that has been done in portions of the area represented by this report. They are listed in order of general importance to this section of the materials survey.

1. Ives, R. L., "Glacial Geology of the Monarch Valley, Grand County, Colorado", Bulletin, Geological Society of America, Vol. 49, pp. 1045-1066, July 1938.

2. Spock, L. E., Jr., "Geological Reconnaissance of Parts of Grand, Jackson, and Larimer Counties, Colorado", Annals, New York Academy of Science, Vol. XXX, pp. 177-261, 1928.

3. Wahlstrom, E. E., "Structure and Petrology of Specimen Mountain, Colorado", Bulletin, Geological Society of America, Vol. 55, pp. 77-90, January, 1944.

4. Gorton, K. A., "Geology of the Cameron Pass Area, Grand, Jackson, and Larimer Counties, Colorado," Guidebook, Eighth Annual Field Conference, Wyoming Geological Association, pp. 87-98, 1953.

MAPPING SYMBOLS

All - Alluvium. Generally too fine-grained and poorly graded to be classified as sand and gravel.

Bas - Basalt.

BR - Undifferentiated bedrock.

Coll - Colluvium, generally poorly graded from clay size through angular boulders.

Fan - Alluvial fan. These deposits have been differentiated from sand and gravel (SG) because they generally are more poorly graded. Occasionally these fans are composed partially of colluvial detritus in addition to alluvium.

Gn - Gneiss. The gneisses in this area often locally grade into schists, and it is not possible to differentiate between them in mapping on this scale. Where both rock types are present, the symbol for gneiss is used where gneiss predominates.

Gr - Granite.

Mo - Glacial moraine. In most cases this can be classified as till, but locally it may contain deposits of water-worked material too small or indistinct to be differentiated in mapping.

Mo/Gn - Thin glacial moraine (generally less than 10 feet thick) over gneiss bedrock.

Mo/Sed - Thin glacial moraine (generally less than 10 feet thick) over sedimentary rocks.

O - Organic material (peat and muck). Where these deposits contain considerable soil, they are suitable for use as topsoil. Where the material is mostly peat and contains only a minor percentage of soil, it is suitable for mulch or as a soil conditioner.

Sand - Waterworked material containing practically no gravel.

Sch - Schist. When schists and gneisses are both present locally, the symbol for schist is used where schist predominates.

Sed - Sedimentary rocks. Generally soft shales, siltstones, sandstones, and conglomerates, undifferentiated.

SG - Sand and gravel.

Ta - Talus deposits.

TS - Areas with potential for topsoil borrow.

Vol - Undifferentiated volcanic rocks. May be either flows or pyroclastics.

DESCRIPTION OF MATERIALS

Flight Strip 27, Photographs 3-48 thru 3-56
Flight Direction: North to South

Photographs 3-48 and 3-50

Sand and gravel (SG) in terrace remnants between Long Draw Reservoir and La Poudre Pass is generally clean and of good quality. However, this material is short on gravel sizes, i.e., most of it will pass the #4 sieve. The two large terrace remnants on the southern edge of Photograph 3-48 and the northern one-half of Photograph 3-50 rise to 20 to 30 feet above the creek level and would make good sources of base course material. This material, which lies in Roosevelt National Forest, was not sampled because its location on the north side of La Poudre Pass precludes its use on existing roads in Rocky Mountain National Park.

The bedrock in this area is predominantly gneiss (Gn), with some schist (Sch), and generally is of too low quality for use in construction. It is lacking in strength, abrasion resistance, and resistance to weathering.

The organic (O) areas on these photographs show as much as 8 feet of peat in stream cuts. Some of these organic areas are possible sources of an organic topsoil.

Photographs 3-52, 3-54, and 3-56

The sand and gravel (SG) in the valley bottom of the Colorado River on Photographs 3-54 and 3-56 is a clean well graded rhyolitic aggregate derived from the volcanic bedrock comprising the valley

wall. Since this is a quality material and is rather limited in quantity, it probably should be considered only as a source of surfacing material or concrete aggregate. Before being used as a surfacing material it should be checked for stripping characteristics, and the possibility of alkali-aggregate reaction should be considered if it is to be used as concrete aggregate.

The fans (Fan) on Photograph 3-56 (site of Lulu City) are composed of dirty, angular, gneissic material. They contain an abundance of angular gneissic cobbles and boulders. This material would be suitable for common borrow or possibly for subbase.

The bedrock in the area covered by these photographs consists of volcanics (Vol) and gneiss (Gn). The volcanics are comprised mainly of rhyolite which in general is not of high enough quality to warrant quarrying. However, some of the rhyolite on the east valley wall consists of talus (Ta) which could be used as borrow. Schist is locally associated with the gneiss; neither material is of high enough quality to warrant quarrying. Both are lacking in strength, abrasion resistance, and resistance to weathering.

Flight Strip 28, Photographs 2-2 thru 2-15
Flight Direction: North to South

Photograph 2-2

See description for Photographs 3-54 and 3-56, Flight Strip 27.

Photographs 2-4 and 2-6

The sand and gravel (SG) and the fans in the northern portion

of Photograph 2-4 are described for Photographs 3-54 and 3-56, Flight Strip 27.

The very large heavily wooded fan (Fan) on these photographs is composed of dirty, angular, gneissic material. It contains an abundance of cobbles and boulders. This material would be suitable for common borrow or possibly subbase.

The alluvium (All) on Photograph 2-4 is a possible source of topsoil.

The bedrock on these photographs is gneiss (Gn) with some schist. It generally is not of high enough quality to warrant quarrying for use as a construction material. However, the gneissic talus (Ta) at the south edge of Photograph 2-6 could be worked more cheaply and might make suitable base material, especially if protected by a bituminous surface to prevent weathering.

Photograph 2-8

The fans (Fan) in this photograph are comprised of dirty, angular, gneissic material. There is an abundance of cobbles and boulders. This material would be suitable for common borrow or possibly subbase.

The small terrace remnant (SG) in the southern half of the photograph is made up of a somewhat dirty fine sand and gravel. This material would be suitable for subbase or possibly base course use.

The alluvium (All) on the photograph is a possible source of topsoil. It is too fine-grained for any other use but common borrow.

The bedrock consists primarily of gneiss (Gn) on the lower valley walls. This gneiss grades into schist (Sch) on the upper east valley wall. Neither of these is suitable for quarrying for constructinn purposes since both are generally lacking in strength, abrasion resistance, and resistance to weathering.

The organic matter (O) in this area would be suitable for mulch or soil conditioner, and in some places may contain enough soil material to be used as topsoil.

Photograph 2-10

The sand and gravel (SG) near the south edge of the photograph is a fairly clean sand and gravel suitable for base course or possibly surfacing material. The alluvial fans (Fan) are comprised of dirty angular sand and gravel with large numbers of gneissic cobbles and boulders. The fan material might be suitable for subbase.

The morainic material (Mo) near the south edge of the photograph is primarily a coarse till. This material would be suitable for use as subbase or possibly base course.

The alluvium (All) in the stream bottom is generally too fine-grained to be suitable for anything but common borrow, but it is a possible source of topsoil.

The bedrock in this area consists of gneiss (Gn) which locally grades into schist. Neither of these materials is of high enough quality to warrant quarrying as both are lacking in strength, abrasion

resistance, and resistance to weathering.

Photograph 2-12

The terrace remnants (SG) on both sides of the valley are comprised of fairly clean sand and gravel suitable for use as base course and possibly for surfacing aggregate.

The moraine (Mo and Mo/Gn) is coarse-grained till of varying depth. This material would be suitable for use as subbase or possibly base course material.

Photograph 2-14

See Photographs 2-20 and 2-22, Flight Strip 29.

Flight Strip 29, Photographs 2-19 thru 2-31
Flight Direction: North to South

Photograph 2-20

The sand and gravel terrace remnants (SG) on both sides of the valley are comprised of fairly clean sand and gravel suitable for subbase or base course, and possibly for surfacing material.

The sand and gravel (SG) on the floodplain of the Colorado River (southern edge of photograph) is not generally as good a material as the higher terrace gravels. It often is interbedded with silty alluvium. In addition, most of this material lies below the ground water table which would necessitate a wet operation if the material were to be used. Locally, topsoil could be obtained from the surface of these deposits. The topsoil is about one foot thick.

The moraine (Mo and Mo/Gn) is primarily coarse til suitable for subbase and possibly base course use.

Photograph 2-22

The sand and gravel (SG) in terrace remnants at the north and south edges of this photograph is fairly clean sand and gravel which generally should be suitable for base course and possibly for surfacing material.

The sand and gravel (SG) on the river floodplain is fairly fine-grained and often is interbedded with finer-grained silty alluvium. The sand and gravel probably varies in gradation locally from material suitable only for subbase to material suitable for base and possibly surfacing. Since most of the material lies beneath the water table, dredging would be necessary to obtain the material. Locally about one foot of topsoil could be stripped from these deposits.

The sand and gravel (SG) in the large fan near the center of the photograph is poorly graded, angular, and gneissic. It contains an abundance of cobbles and boulders. This material would be suitable for common borrow or subbase.

The moraine (Mo) is a coarse till suitable for use as subbase or possibly base course material.

The bedrock in this area is mainly gneiss (Gn) and is not generally of high enough quality to warrant quarrying.

Photographs 2-24, 2-26 and 2-28

The best material on these photographs is to be found in the sand and gravel terrace remnants (SG) along the sides of the valley. This material is a fairly clean to somewhat dirty sand

and gravel which is generally suitable for subbase and base course, and possibly for surfacing material.

There are large amounts of sand and gravel (SG) in the floodplain of the Colorado River here. This material varies in quality locally. Near the surface this sand and gravel is locally interbedded with silty alluvium. At depth this interbedding is probably less likely to occur. Where the sand and gravel is free of this alluvium, it probably is suitable for use as base course and possibly surfacing. Since most of this material lies below the water table, the pit operation would be a wet one. If this material were used, the pit could be made to look natural after the operation ended by leaving it as a small lake. Approximately one foot of topsoil could be obtained by stripping the surface of this deposit.

Undoubtedly, sand and gravel can be found under the low-lying areas noted as being organic (O). Most of the organic material is from 2 to 5 feet thick. However, these deposits would be more difficult to operate than those in areas without so much organic cover. The organic material would be useful as a mulch or soil conditioner.

The fan (SG) on Photograph 2-26 is comprised of poorly graded, angular, gneissic material. This material would be suitable for common borrow or subbase.

The moraine (Mo) on these photographs is a coarse-grained till. It is suitable for subbase and possibly base course material.

In places gneiss (Gn) can be found at the surface in the Mo/Gn area. This gneiss is not of high enough quality to be quarried.

Photograph 2-30

See Photograph 2-34, Flight Strip 30.

Flight Strip 30, Photographs 2-32 thru 2-52
Flight Direction: North to South

Photograph 2-32

See Photograph 2-38, Flight Strip 29.

Photograph 2-34

Basalt bedrock (Bas) adjacent to the existing gravel pit at the east edge of the photograph is a high quality material suitable for crushing, for use as base course or surfacing material. It probably also could provide barrier stone. A quarry could be set up here and not be within sight of the highway.

The sand and gravel (SG) in terraces along the edges of the valley is a fairly clean to somewhat dirty fine sand and gravel suitable for subbase or base course. The existing pit on the east edge of the photograph has been extended about as far as is possible without being visible from the highway.

The sand and gravel (SG) in the floodplain of the Colorado River is locally interbedded with alluvium. Where such interbedding does not occur, this material would be suitable for base course and possibly surfacing. Operation in this material would necessitate dredging. The pit could be made to look natural after such an

operation by landscaping it as a small lake. Topsoil could possibly be obtained by stripping a thin layer, about one foot thick, from the surface of this floodplain gravel.

At the little bridge over the Colorado River in the southeast quarter of this photograph the floodplain profile shows one foot of topsoil over three to four feet of dirty gravel above the water table. Probably the sand and gravel are cleaner at depth, but as noted previously, it would be a wet pit.

The moraine (Mo) in this area is a coarse till suitable for subbase or possibly base course use.

Photograph 2-36

The best possibility for material on this photograph is probably the timbered sand and gravel terrace (SG) on the west side of the valley in the northern half of the photograph. This sand and gravel is fairly clean to somewhat dirty and should be suitable for subbase or base course material, and possibly for surfacing material.

The other materials on this photograph are the same as those described for Photographs 2-38 and 2-40.

Photographs 2-38 and 2-40

The main source of material on these photographs is the sand and gravel (SG) in the floodplain. This appears to be interbedded locally near the surface with silty alluvium. Where this alluvium is not present the sand and gravel should be suitable for base course and possibly for surfacing. Since most of this material is to be worked. Such a pit could be made to look natural after

such an operation by landscaping it as a small lake. Thin topsoil, about one foot thick, could be obtained by stripping the surface of these floodplain deposits.

The organic areas (O) on these photographs lie in the lower portions of the sand and gravel floodplain. Sand and gravel could undoubtedly be obtained by stripping away the organic matter, but this would generally be economically unfeasible since there is so much sand and gravel available nearby which has little, if any, organic cover. The organic matter itself is comprised mainly of peat and muck; where its soil content is high it may be suitable for use as topsoil, otherwise it could serve as a mulch or soil conditioner.

The moraine (Mo) in this area is a coarse till suitable for subbase or possibly base course use.

The bedrock is gneiss (Gn) which probably is not of high enough quality in this area to warrant quarrying.

Photographs 2-42, 2-44 and 2-46

The best sand and gravel (SG) deposit along the Colorado River in Rocky Mountain National Park is the high terrace which begins in the southern one-half of Photograph 2-42 and extends south through Harbison Meadow nearly to the south edge of Photograph 2-46. The existing pit on Photograph 2-44 shows 30 feet of fairly clean, well-graded sand and gravel suitable for base course or surfacing. If washed, the material could be used for concrete aggregate. At the time of field study (July 1966), no water was

present in the bottom of the pit.

This pit could be extended to the south or southwest without being brought into view from either the highway or the river. Pits in other parts of this terrace would also yield a high quality sand and gravel, but there is probably little reason to open such pits since extension of the existing pit would yield all the gravel needed for a reasonable period of time.

This same terrace level extends across to the west side of the Colorado River in the vicinity of Sun Valley Ranch. This deposit on the west side of the river is discussed in conjunction with Photograph 2-66, Flight Strip 31.

The areas delineated as sand and gravel (SG) grade into those mapped as organic material (O) which lie at slightly lower elevation. Sand and gravel could be obtained from these organic areas by stripping away the organic matter, but this would generally be economically unfeasible since there is so much sand and gravel in the area with no substantial organic cover. The organic matter itself is comprised mainly of peat and muck; where its soil content is high it may be suitable for use as topsoil, otherwise it could serve as a mulch or soil condtioner.

The moraine (Mo) shown on these photographs is a coarse till suitable for subbase and possibly base course.

The bedrock is gneiss (Gn) which is probably not of high enough quality to warrant a quarry in this area.

Photograph 2-48

The sand and gravel (SG) on this photograph, except for the small area of Harbison Meadow at the northern end of the photograph, is an area of sand and gravel higher in elevation than the terrace gravels shown on Photographs 2-42, 2-44 and 2-46. This higher material is not as good quality as that found in the aforementioned terrace. As shown in the existing pit some 2,000 feet northwest of the Park Service maintenance building, this material is a fairly clean to somewhat dirty sand and fine gravel with a low percentage of gravel. Some of the best looking material in this deposit was noted in the Grand Lake Cemetery; this material also consisted of sand and fine gravel with a low percentage of gravel. The material in this deposit would be suitable for subbase and possibly base course use.

The boundary between sand and gravel (SG) and moraine (Mo) is very hard to delineate here since there seem to be local discontinuities and because it sometimes is difficult even in the field to distinguish between the two materials in this area. The till is slightly more plastic than the sand and gravel; it should be satisfactory for subbase and possibly for base course.

The alluvium (All) just south of the N.P.S. shop area is a possible source of topsoil, although boulders would have to be removed from the soil before it could be used. The organic material (O) in the photograph also could be used as topsoil where its soil content is high; where it consists of highly organic peat, it would

serve better as a mulch or soil conditioner.

Photographs 2-50 and 2-52

The sand and gravel (SG) in these photographs consists of material deposited between morainal (Mo) ridges along the north shores of Grand Lake and Shadow Mountain Reservoir. These sands and gravels are not of particularly high quality and sometimes are hard to distinguish from the coarse till in the moraines. The sand and gravel would be suitable for subbase or possibly base course, but because of the location of these deposits in the town of Grand Lake, this material will probably never be used.

The moraine (Mo) on these photographs is a coarse till which makes up morainal ridges along the shores of Grand Lake and Shadow Mountain Reservoir. This material would be suitable for subbase or possibly base course use.

The bedrock in this area is a medium- to coarse-grained granite (Gr) which would be a better source of crushed material, riprap, or barrier stone than the gneisses which make up the bedrock to the north. This rock is susceptible to weathering damage, but apparently is resistant enough to give fairly good performance especially when protected from the elements by a relatively impermeable surface.

Flight Strip 31, Photographs 2-61 thru 2-74
Flight Direction: North to South

Photographs 2-62 and 2-64

The sand and gravel (SG) on these photographs occurs in the floodplain of the Colorado River and as a terrace plastered along the valley wall adjacent to the floodplain. All this material is on private land.

The long narrow terrace probably provides the best source of sand and gravel on these photographs. The material is a slightly dirty sand and gravel which would be suitable for subbase and probably for base course material.

The sand and gravel (SG) in the floodplain is typical of the floodplain deposits noted on Flight Strip 31. It generally is overlain by a foot or so of topsoil and often is interbedded or mixed with fine alluvium. The quality of the sand and gravel probably improves with depth, but a wet pit would be necessary to get at this material. The topsoil could be obtained by stripping the surface.

The areas delineated as sand and gravel (SG) grade into those mapped as organic material (O) which lie at slightly lower elevation. Sand and gravel could be obtained from these organic areas by stripping away the organic matter, but this would generally be economically unfeasible since there is so much sand and gravel in the area with no substantial organic cover. The organic material itself is comprised mainly of peat and muck; where the soil content is high, it may be suitable for use as topsoil, otherwise it could

serve as a mulch or soil conditioner.

The surfaces of the hills to the west of the valley floor have been mapped as moraine (Mo). This involves some guess-work since the area is under a fairly heavy timber cover. Field checking showed till all along the hillside above the existing road, and this information was extrapolated further up the hillside. This till is coarse-grained and would be suitable for subbase and possibly base course material.

Photographs 2-66 and 2-68

The sand and gravel deposits (SG) on these photographs include both terrace and floodplain deposits. The two types of deposits have not been separated by boundaries on the photographs because the physical separation is not too distinct. Generally, however, the higher deposits with surfaces 10 to 30 feet above river level can be considered to be terrace gravels and the lower deposits to be floodplain gravels.

In general the terrace sands and gravels are clean and well graded and are suitable for use as base course or surfacing materials. These sands and gravels are best shown in the Weber Sand and Gravel Company pit at the east edge of Photograph 2-66. This pit is in 15 to 20 feet of very good sand and gravel and looks as though it could be extended considerably deeper without encountering water.

The floodplain sands and gravels on these photographs also appear to be of good quality, but probably have some silty alluvium

in the upper few feet. If these deposits are to be utilized, dredging will be necessary. Most of these floodplain gravels are covered by about a foot of topsoil which could be obtained by stripping.

The sand and gravel (SG) in the timbered terrace in the southeast corner of Photograph 2-68 does not appear to be of as high quality as that in the terraces around Sun Valley Ranch to the north (on Photograph 2-66). These sands and gravels will be more fully described on Photograph 2-70.

The organic material (O) on these photographs is very similar to that described for Photographs 2-62 and 2-64.

The moraine (Mo) in this area is a coarse till suitable for subbase or possibly base course use. Because of timber cover and lack of access, it was impossible to ascertain how far west the moraine on Photograph 2-66 extends.

Photograph 2-70

The northern one-third of this photograph consists of floodplain sands and gravels (SG) which are part of the same floodplain deposits described for Photograph 2-68.

The sand deposits (Sand) to the north and northwest of Columbine Lake contain very little material larger than the #10 sieve. This fairly clean, water-deposited sand probably could not be used either as subbase or base without some sort of stabilization treatment. It would be suitable for any specialized use requiring sand such as soil cement, filter beds, or blending purposes.

To the east and northeast this sand grades into a somewhat coarser material which has been designated SG on the photograph. This is a deposit of sand and fine gravel which is suitable for use as subbase and possibly base course material.

It is difficult to establish a boundary between the aforementioned sand and gravel (SG) and the moraine (Mo) at the southern edge of the photograph. For this reason a question mark has been added to the SG symbol near the boundary and a similar mark has been used with the sand notation. The moraine (Mo) is a coarse till suitable for use as subbase and possibly as base material.

Photographs 2-72 and 2-74

The sand and gravel (Sand and SG) deposits on Photographs 2-72 and 2-74 are described for Photograph 2-70.

The moraine (Mo) which covers most of the area of these photographs is a coarse till suitable for use as subbase and possibly as base course material. Close to the shoreline of Shadow Mountain Reservoir the cover of moraine over sedimentary rocks is only a few feet thick and has thus been designated as Mo/Sed. No distinct boundary is present. The underlying sedimentary rocks are soft shales, siltstones, and conglomerates and are of little use as construction materials. They are generally soft enough to be excavated with power equipment.

Flight Strip 32, Photographs 2-54 thru 2-60
Flight Direction: Northeast to Southwest

Photographs 2-54 and 2-56

The fans noted along North Inlet Creek are comprised of poorly graded, angular, granitic sand and gravel (SG) with an abundance of cobbles and boulders. This material is suitable for use as subbase.

The sand and gravel (SG) near the downstream (southwestern) edge of Photograph 2-56 is a terrace composed of a somewhat dirty sand and fine gravel. This material would be suitable for use as subbase, but probably not base course.

The organic material (O) in this valley consists mainly of peat and muck suitable for use only as a mulch or soil conditioner. Locally, however, the soil content of this material is high enough so that it could be cnnsidered for use as topsoil.

The bedrock in this area is a medium- to coarse-grained granite (Gr) with only moderate resistance to weathering. In spite of its lack of weathering resistance, this granite could be successfully used for highway purposes, particularly in situations where it is protected from the weather by a bituminous surface course. Granite for use as crushed stone, riprap, or barrier stone could be quarried from the valley wall on the northwest side of the valley. The talus (Ta) in these photographs is of the same quality as the granite bedrock.

The break between granite (Gr) and moraine (Mo) along the southeast valley wall on Photograph 2-56 is poorly defined in the

field. This accounts for the question marks and lack of boundary between moraine and granite on this photograph.

Photograph 2-58

The sand and gravel (SG) along North Inlet Creek is a somewhat dirty sand and fine gravel which in places is interbedded with silty alluvium. This sand and gravel would probably be suitable for use as subbase but not base course.

The alluvium (All) in this valley is very silty and probably good for nothing but common borrow. This alluvium is capped by about a foot of topsoil.

The organic material (O) in this valley consists mainly of peat and muck suitable for use only as a mulch or soil conditioner. Locally, however, the soil content of this material is high enough so that it could be considered for use as topsoil.

The granite (Gr) is the same as that described for Photographs 2-54 and 2-56.

Photograph 2-60

Sand and gravel (SG) occurs on this photograph as (1) a terrace along North Inlet Creek, (2) a fan at the mouth of North Inlet Creek, and (3) a band of glacial gravel located between two morainal ridges in downtown Grand Lake. Of these, only the terrace on North Inlet Creek has any possibility of actual use as a source because the other two deposits are located in town. This terrace is made up of slightly dirty sand and fine gravel suitable for subbase and possibly for base course use.

The organic material (O) on this photograph is the same as

that on Photograph 2-58.

The moraine (Mo) on this photograph is a coarse till suitable for subbase and possibly base course use. Locally this moraine provides only a few feet of cover over the underlying granite.

The granite (Gr) here is of the same quality as that described for Photographs 2-54 and 2-56.

Flight Strip 33, Photographs 2-77 thru 2-95
Flight Direction: Northeast to Southwest

Photograph 2-78

The only construction material on this photograph is moraine (Mo). This material is a coarse till suitable for use as subbase or possibly as base course. In some places along U.S. Highway 34 there is less than 10 feet of till over the underlying soft shales, siltstones, and conglomerates (Mo/Sed) but no clear boundary between this and deeper till is mappable.

Photographs 2-80 and 2-82

The best construction material on these photographs is the sand and gravel (SG) to be found in the terrace along the east side of the Colorado River. Existing pits in this terrace show 10 to 15 feet of fairly clean sand and gravel which should be satisfactory for use as subbase or base material.

Probable sand and gravel terraces on the west side of the river on Photograph 2-82 were not field checked and may be misidentified. If these areas (marked with SG?) are terraces as

thought, the quality of the material should be similar to that found in the terrace on the east side of the river.

There also are small patches of sand and gravel (SG) in the floodplain of the river. The sand and gravel in these deposits is interbedded with silty alluvium and probably is good only for common borrow or possibly for subbase material.

The alluvium (All) in the floodplain is of little value as a construction material, but it is covered by about one foot of topsoil which could be utilized by stripping.

The areas mapped as organic (O) on Photograph 2-80 are made up of peat and muck which is encroaching on shallow vegetation -- choked ponds. This peat and muck would be suitable for use as a mulch or soil conditioner.

The moraine (Mo) on these photographs is a coarse till suitable for use as subbase or possibly base course material. This till is underlain by soft sedimentary rocks. Although it was not possible to field check, it is probable that the area mapped as undifferentiated bedrock (BR) is an area where this sedimentary rock is at the surface.

Photographs 2-84, 2-86 and 2-88

The alluvium (All) shown on these photographs is probably too silty to be good for anything other than common borrow. However, the approximate one foot of soil cover on top of the alluvium could serve as a source of topsoil.

The sand and gravel (SG) in the southeastern corner of Photograph 2-88 is part of a larger deposit described for Photograph 5-6,

Flight Strip 34. This material would be suitable for use as subbase and possibly base course.

The moraine (Mo) is a coarse till and is probably the best potential source of construction materials on these photographs. This till would be suitable for subbase and possibly base course use.

In the area shown in Photograph 2-88 no clear break was noted in the field between moraine (Mo) and soft sedimentary rocks (Sed) in the northwest quarter of the photograph. For this reason one boundary between these two has been omitted and a few question marks have been used.

The granite (Gr) is medium- to coarse-grained and is susceptible to weathering. If quarried, this material could be used as crushed stone, riprap, or barrier stone. However, it would perform most satisfactorily as subbase or base material protected from weathering by a bituminous surface.

Photographs 2-90, 2-92 and 2-94

There are no good construction materials in the area covered by these photographs. The best is a deposit of fairly clean sand and fine gravel (SG) in the north-central part of Photograph 2-90. This material is suitable for subbase and possibly base course use. There is also a small area of sand and gravel (SG) in the northeastern corner of Photograph 2-90. This deposit has been described for Photograph 2-88.

Two smaller deposits of sand and gravel (SG) on U. S. Highway 34 on Photographs 2-92 and 2-94 have already been worked for local use. Both of these deposits consist of silty sands and fine gravels. The best material has already been removed from both deposits, and neither should be considered a potential source of sand and gravel.

The alluvium (All) on these photographs is too silty to be used for anything but common borrow. It could serve as a source of topsoil (depth of about one foot), however.

A large mass of medium- to coarse-grained granite (Gr) in Photographs 2-90 and 2-92 could be quarried for riprap, barrier stone, or crushed stone. The weathering resistance of the finished product would be fairly low, but probably not low enough to preclude its use, especially as base or subbase material which could be protected by a bituminous surface.

The colluvium (Coll) on Photographs 2-90 and 2-92 is a poorly graded detritus derived from the granite bedrock. It is too dirty for any construction use except common borrow.

The sedimentary rocks (Sed) shown consist of soft shale, siltstone, and fine-grained conglomerate. This rock has little value as construction material.

Flight Strip 34, Photographs 5-2 to 5-7
Flight Direction: Northeast to Southwest

Photographs 5-2 and 5-4

The only sand and gravel (SG) on these photographs is a smear of material adjacent to morainal ridges along the south shore of Shadow Mountain Reservoir. Most of this sand and gravel appears to be waterworked till and in some places is difficult to differentiate from the adjacent morainal material. The sand and gravel is fairly clean and well graded and is suitable for use as subbase and base course material, and possibly for surfacing material.

The morainal material (Mo) is a coarse till which is suitable for subbase and possibly for base course use.

The alluvium (All) on these photographs is too silty for any use but common borrow. Topsoil, depth about one foot, could be obtained by stripping the surface of the alluvium.

The gneiss (Gn) in the southeast corner of Photograph 5-4 is described in conjunction with Photograph 5-6.

Photograph 5-6

The sand and gravel (SG) on this photograph varies from a fairly clean well graded sand and gravel to a somewhat silty sand and gravel. The boundary between sand and gravel (SG) and moraine (Mo) is difficult to establish because of similarity between the sand and gravel and the till. The best sand and gravel is located close to the shore of the reservoir; this material would be satisfactory for base course and possibly surfacing use. The poorer

sand and gravel which is closer to the boundaries with morainal material and sedimentary rocks would be satisfactory for subbase and possibly base course.

The moraine (Mo) is primarily a coarse till suitable for use as subbase and possibly base course material.

The alluvium (All) is too silty for any use but common borrow.

Although the gneiss (Gn) on the west side of Rocky Mountain National Park to the north of here (from about Holzwarth's Ranch north) was generally found to be of too low quality to be used as a construction material (it generally is lacking in strength, abrasion resistance, and resistance to weathering), the gneiss in this area is of higher quality, and could possibly be used as crushed stone, riprap, or barrier stone. It would perform most satisfactorily as subbase or base material protected by a bituminous surface. An existing quarry in fairly fresh gneiss with a coarse jointing pattern lies just off the northeast edge of this photograph and is indicated by an arrow on the photograph.

The sedimentary rocks (Sed) in this area are too soft to be used as construction material.

Flight Strip 35, Photographs 5-10 thru 5-16
Flight Direction: Northwest to Southwest

Photographs 5-10, 5-12 and 5-14

The best source of quality construction material on these photographs is the large basalt (Bas) flow forming the top of Table Mountain. In spite of the height of this deposit, access would not be too difficult from the west side. This material would be suitable for riprap or barrier stone, and if crushed, would make excellent surfacing aggregate.

The basalt (Bas) in the southeastern corner of Photograph 5-14 is part of a larger flow of excellent material which if fully described for Photograph 5-18, Flight Strip 36.

The sand and gravel (SG) in the small pocket on Photograph 5-10 is a silty sand and fine gravel. Much of the best material in this deposit has already been removed for local use. The remaining yardage is not sufficient for this to be considered a worthwhile source. If the material were to be used, it would be satisfactory for subbase or possibly base course.

The sand and gravel (SG) in the southeastern corner of Photograph 5-14 is part of a large deposit of very good material which is fully described for Photograph 5-18, Flight Strip 36.

The alluvium (All) on Photographs 5-10 and 5-14 is too silty to be used for anything but common borrow. However, these deposits could possibly be stripped to a depth of about one foot to obtain topsoil.

The gneiss (Gn) at the south edge of Photograph 5-14 is fully described for Photograph 5-20, Flight Strip 36.

The sedimentary rocks (Sed) on these photographs are shales, siltstones and fine-grained conglomerates, all of which are too soft to be of use as construction materials.

Photograph 5-16

The materials on this photograph are described for Photograph 5-20, Flight Strip 36.

Flight Strip 36, Photographs 5-17 thru 5-25
Flight Direction: Northeast to Southwest

Photographs 5-18, 5-20

The large sand and gravel (SG) deposit which comprises Sunset Point and vicinity is one of the best deposits in the Rocky Mountain National Park area. It has already been worked extensively for use in construction of Granby Reservoir, and much of the excavation scar has healed enough so that it is barely recognizable from the road. However, considerable further yardage could be removed along the eastern edge of the deposit in a position which is hidden from the road. The best approach would be to extend the existing pit which is located just south of Granby Dam. The material is suitable for base course or surfacing, and, if washed, could be used for concrete aggregate.

The basalt (Bas) adjacent to this sand and gravel deposit

would be an excellent source of crushed stone, riprap, or barrier stone. Existing quarries, on the government road along the river, show a very hard, excellent rock with a joint pattern suitable for the production of riprap or barrier stone.

There is also some sand and gravel (SG) shown in terraces along the Colorado River and in a small tributary valley in the southeastern part of Photograph 5-18. The Colorado River terraces are composed of fairly clean sand and gravel suitable for subbase, base, and possibly surfacing. The tributary gravels appear to be somewhat more silty and would be suitable for subbase and possibly base course use.

Near the southern edge of Photograph 5-20 there is a small deposit of sand and gravel (SG) on the west side of the road which could provide some good aggregate if the road were straightened or the slope laid back. This deposit consists of a fairly clean sand and gravel suitable for use as subbase or base.

The silty alluvium (All) on these photographs is overlain by about one foot of topsoil which could be obtained by stripping. The alluvium is suitable only for common borrow.

The gneiss (Gn) in this area could possibly be used for purposes such as riprap or crushed stone, but it has a fairly low resistance to weathering. There probably would be little reason to quarry it with the excellent deposits of basalt and gravel being so near. The same probably also holds true for the small deposit of gneissic talus (Ta) next to the road in the southeastern portion of Photograph 5-20.

The colluvium (Coll) at the southern edge of Photograph 5-20 is a poorly graded detritus derived from the gneiss bedrock. This material is too dirty for use for anything but common borrow.

The sedimentary rocks (Sed) on these photographs consist of shales, siltstones, and fine-grained conglomerates which are too soft to be used as construction materials.

Photographs 5-22 and 5-24

This area has large excellent deposits of sand and gravel (SG). The most readily accessible deposit is in the low terraces which make up the valley floor of the Colorado River. The top of this terrace level generally lies about 15 feet above the level of the stream. The existing pit at the center of Photograph 5-24 shows about 15 feet of fairly clean well graded sand and gravel suitable for base or surfacing aggregate. If washed, this material would probably be suitable for use as concrete aggregate.

The terrace remnant in the southwest corner of Photograph 5-24 (continues on to 5-22) rises to a height of nearly 200 feet above the river. This is a tremendous source of sand and gravel which appears to be of good quality. Exposures at the edge of the timber near the top of this deposit at the southern edge of Photograph 5-24 show a fairly clean sand and gravel up to six inches in size. This material would be suitable for subbase or base course and probably for surfacing.

There is a small deposit of volcanic rock (Vol) on Photograph 5-24 which would be suitable for quarrying. This rock is

similar to basalt, and could be suitable for crushed stone or riprap and possibly for barrier stone.

The colluvium (Coll) and alluvium (All) on Photograph 5-22 are both poorly graded and are good for little else but common borrow.

The gneiss (Gn) on Photograph 5-22 has been described for Photograph 5-20.

The sedimentary rock (Sed) on these photographs consists of shale, siltstone, and fine-grained conglomerate which are too soft to be used as construction materials.

Flight Strip 37, Photographs 5-27 thru 5-34
Flight Direction: Northwest to Southeast

Photograph 5-28

The materials in the northern half of this photograph are described for Photograph 5-20, Flight Strip 36.

The sand and gravel (SG) extending across the photograph to the base of Dike No. 3 (Kamloop Cove) appears to be till that has been reworked by water. It consists of a poorly graded sand and gravel with large boulders on the surface. It does not appear to be a very good source of construction material.

The potential volume of basalt (Bas) on the hillside adjacent to the above sand and gravel (SG) deposit is difficult to evaluate since bedrock only peeks through a thin colluvial cover.

This basalt would be satisfactory for crushed stone, riprap, and possibly barrier stone. There would be little reason to open a quarry here, however, when excellent material can be taken from existing quarries just across the Colorado River to the northwest (see Photograph 5-20, Flight Strip 36).

The moraine (Mo) on this photograph seems to be a little more plastic than that found to the north in Rocky Mountain National Park. However, this till still is suitable for use as subbase or possibly base course material.

The gneiss (Gn) is similar to the other gneiss in this area. It is medium-grained and not highly foliated, but has only moderate resistance to weathering. While it possibly would be suitable for use as crushed stone, riprap, or barrier stone, such use is probably not feasible because of the existence of much better material in the area.

Photograph 5-30 and 5-32

There are no materials of particular interest on these photographs. The alluvium (All) is too silty for any use but common borrow, or as a possible source of topsoil which comprises the top foot or so of the alluvium. The other materials are essentially the same as described for Photograph 5-28.

Photograph 5-34

This area has not been mapped because of its relative inaccessibility and because it is on private land.

Flight Strip 38, Photographs 5-36 thru 5-47
Flight Direction: East to West

Photographs 5-46 and 5-44

The main potential source of material on these photographs is the deposit of sand and gravel (SG) lying along the road and lakeshore. This material appears to be lateral moraine which has been reworked by water. It varies in quality from a fairly clean well graded sand and gravel to a more silty, poorly graded sand and gravel which cannot easily be distinguished from the adjacent till (Mo). Many large gneiss boulders are scattered over the surface. This sand and gravel generally is suitable for subbase and base course use.

A small area of good topsoil (TS) is noted near the eastern edge of Photograph 5-46. This area has one to two feet of very good topsoil. It is well hidden in the trees where it could be stripped off without being exposed to the public.

The moraine (Mo) which comprises much of the area shown in the photograph is a slightly plastic coarse till which would be suitable for subbase and possibly for base course.

The materials in the western portion of Photograph 5-46 are described for Photograph 5-28, Flight Strip 37.

Photographs 5-42 and 5-40

The fan (SG) in the center of Photograph 5-40 is the best potential sand and gravel source on the flight strip. This large fan is composed of fairly clean sand, gravel, cobbles and boulders up to about two to three feet in diameter. The material is suitable

for use as subbase or base course and possibly as surfacing aggregate. A pit could probably be hidden in the trees above the road. Some material could also be obtained by laying back the large road out to a flatter slope. Also, this fan continues out under the water in the reservoir, and this same material could be obtained by dredging below the waterline or by working an open pit during periods of extreme low water level.

In spite of being only moderately resistant to weathering, the gneiss (Gn) in this area probably would be satisfactory for crushed stone, riprap, or barrier stone. It would perform best as base course under a bituminous surface which would protect it from the elements. The material could be quarried at several sites along the existing road by widening the roadway, flattening the side slopes, or putting in a parking area.

The SG and Mo at the west end of Photograph 5-42 are described under Photograph 5-44.

Photograph 5-38 and 5-36

There is considerable sand and gravel (SG) along Arapahoe Creek. This material is a fairly clean to silty sand and fine gravel which would be suitable for subbase or possibly base course use. Unfortunately all this material is located in a prime recreational area.

The small fan (Fan) is comprised of poorly graded angular gneissic fragments up to boulder size. This material would be suitable for subbase.

The gneiss (Gn) on these photographs is similar to that on Photographs 5-40 and 5-42. It could be most easily quarried along the north wall of the valley. The gneissic talus (Ta) along the north valley wall is the same rock; it exists in blocks up to about six feet in size. This talus could be worked at lower cost than the gneiss bedrock if it is clean enough.

Flight Strip 39, Photographs 5-50 thru 5-57
Flight Direction: Northwest to Southeast

Photographs 5-50 and 5-52

The materials on these photographs are described for Photograph 5-36, Flight Strip 38.

Photographs 5-54 and 5-56

The sand and gravel (SG) and talus (Ta) on Photograph 5-54 are described for Photograph 5-36, Flight Strip 38.

The moraine (Mo) on these photographs is a fairly thin coarse till. In parts of the area it is very difficult to sketch a boundary between the till and the adjacent gneiss (Gn). This accounts for the question marks on Photograph 5-56. This coarse till could be used for subbase and possibly base course.

The gneiss (Gn) on these photographs is similar in quality to that described for Photographs 5-49 and 5-42, Flight Strip 38. It could be effectively quarried in several places along the north side of the valley.

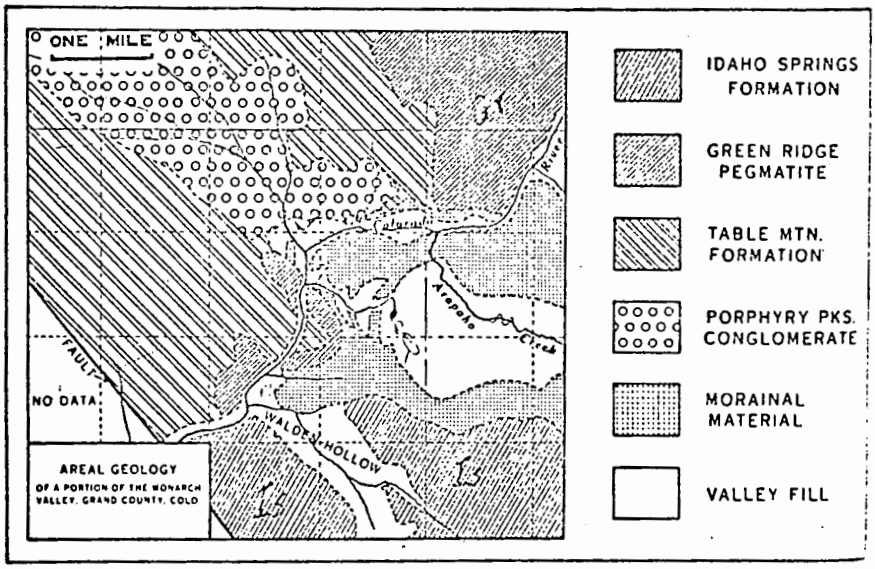
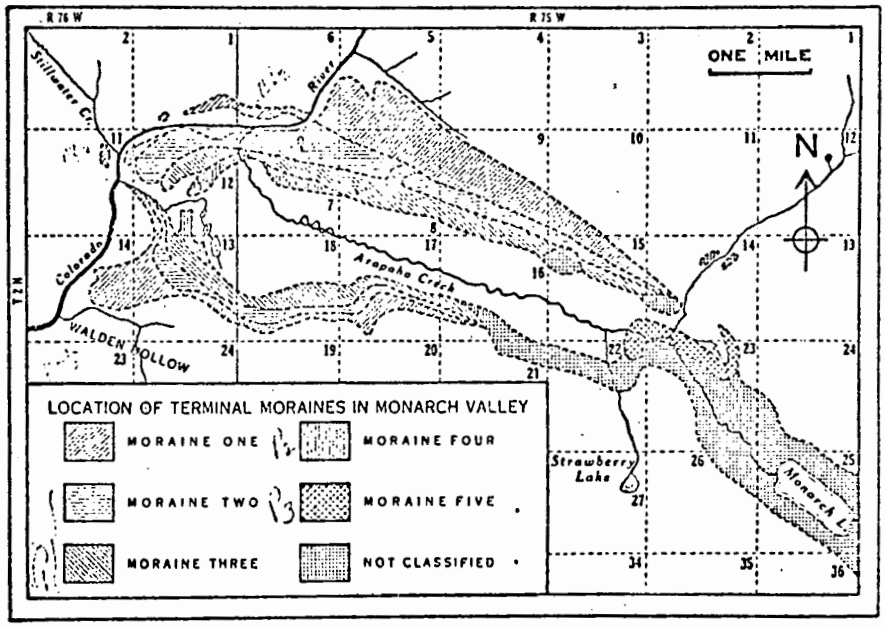


FIGURE 2.—*Areal geology*

East of this area, only pre-Cambrian and post-Pliocene materials are present.


R 76 W
R 75 W
T 2 N
ONE MILE
N
Stillwater Cr.
Colorado River
Arapaho Creek
WALDEN
FOLLOW
Strawberry Lake
Monarch L.
LOCATION OF TERMINAL MORAINES IN MONARCH VALLEY
MORAINE ONE
MORAINE TWO
MORAINE THREE
MORAINE FOUR
MORAINE FIVE
NOT CLASSIFIED

ROCKY MOUNTAIN NATIONAL PARK

PARKWIDE MATERIALS SURVEY

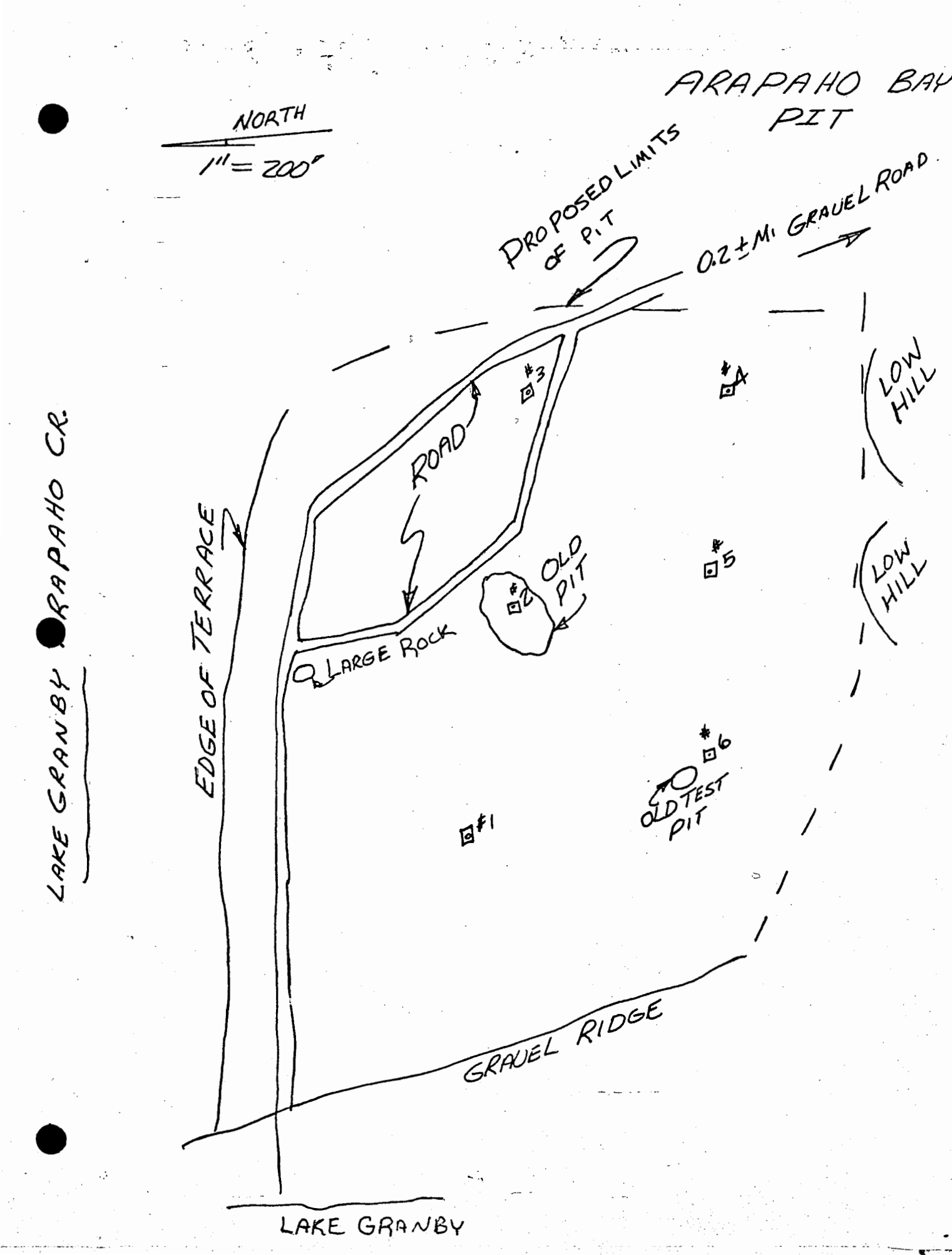
SOURCES OF MATERIALS SAMPLED AND TESTED

Western Slope [X] Eastern Slope [ ]

Pit Number 7-W BPR Lab. No. 67-504 through 67-508 and 67-518

Flight Strip 39 Photograph 5-52

LOCAL NAME, LOCATION AND GENERAL DESCRIPTION	Arapaho Bay Pit, the area below high water on Lake Granby west (downstream) of the proposed Arapaho Bay Dam. Map Coordinates - Colorado Coordinate System, North Zone. 290 000 - 1923 625
QUANTITY	245,000+ cubic yards.
ANALYSIS OF LABORATORY TEST DATA, CONDITIONS OF USE AND RECOMMENDATIONS	This material is suitable for subbase, base, bituminous stabilized base, surfacing, seal coat chips, and concrete aggregate. The depth of the overburden is up to 3' of silt and silty sand. The material that is available in the dry is dependent upon the level of the lake. Less than 5% of material is in excess of 10" diameter with a maximum size of 24". Removal of material will be governed by Bureau of Reclamation's letter of August 22, 1967.


ARAPAHO BAY
PIT
NORTH
1" = 200'
PROPOSED LIMITS OF PIT
0.2 ± MI GRAVEL ROAD
ROAD
#3
#4
LOW HILL
#5
LOW HILL
#2
OLD PIT
LARGE ROCK
EDGE OF TERRACE
#6
OLD TEST PIT
#1
GRAVEL RIDGE
LAKE GRANBY
ARAPAHO CR.
LAKE GRANBY

Western Slope
Arapaho Bay Pit
7-W

Log of Holes

Hole No. 1:

0–6"	Light brown sandy silt, few roots.
6"–3'	Light brown, slightly clayey sand.
3–11½'	Gray-brown, slightly clayey sand and gravel. Cobbles are sub-rounded to rounded. Gray, silty fine sand from 6–7'.
	No oversize, 3–4" maximum size.
	Coarser gravel and sand below 7'. Cobbles are sub-rounded to sub-angular.
	No oversize but maximum is 8–10".

Hole No. 2:

0–4"	Dark brown silty clay, few roots, (topsoil).
4–8"	Buff sand.
8"–8'	Gray-brown, slightly clayey sand and coarse gravel. Cobbles are sub-angular to sub-rounded. Water at 7'.
	5% oversize to 24", and 5% to 8–10".

Hole No. 3:

0–6"	Light brown clayey sand, few roots in top.
6"–11'	Gray-brown, slightly clayey sand and gravel. Cobbles are sub-rounded to sub-angular. Water with depth.
	Less than 5% oversize to 12".

Hole No. 4:

0-1'	Light brown clayey sand, roots in top few inches.
1-10½'	Light brown, slightly clayey sand and coarse gravel. Lens of silty sand from 2½-3½'. Cobbles are sub-rounded to sub-angular. Sandier from 8-9'.
	5% oversize to 18", and 5% 8-10".

Hole No. 5:

0-1'	Light brown silty sand, few roots at top.
1-11'	Gray-brown slightly clayey sand and coarse gravel. Cobbles are sub-rounded to sub-angular,
	5% oversize to 18", and 5% 8-10".

Hole No. 6:

0-4"	Gray silt, roots, (topsoil).
4"-11'	Orange-brown silty sand.
1-10½'	Gray-brown clean sand and coarse gravel. Cobbles are sub-rounded to sub-angular.
	Less than 5% oversize, but 5-10% 8-10".

Form PR-9-230
April 1965

U. S. DEPARTMENT OF COMMERCE
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Separate Test Hole Gradation, L. L., and P. I.)

Lab. No: 67-504-508&518- P Field Sample No: _____ Date: May 7, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: Runyan Quantity Rep. _____ Name of Material: Gravel

Source: Arapahoe Bay Pit

Test for: Gradation, L.L. & P.I. Tested by: D.G., K.R., R.G., P.B., A.T.,

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	67-504 Hole #1	67-505 Hole #2	67-506 Hole #3	67-507 Hole #4	67-508 Hole #5	67-518 Hole #6	Hole #7	Hole #8	Comb.
3"	90	80	89	82	84	75			83
1½"	73	72	84	66	63	62			69
1"	67	65	75	56	59	57			62
¾"	65	59	66	51	54	52			57
½"									
3/8"	57	49	52	41	43	44			46
#4	51	40	40	32	34	37			37
#8									
#10	38	26	28	25	26	27			28
#40	13	6	8	8	9	5			9
#200	4	2	2	1	2	1			2
L.L.	—	—	—	—	—	—			—
P.I.	NP	NP	NP	NP	NP	NP			NP

REMARKS:

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

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U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Sub-base, Base Course, and Base Stabilization)

Lab. No: 67-504-508 &518-P Field Sample No: _____ Date: May 7, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: Runyan Quantity Rep. _____ Name of Material: Gravel

Source: Arapahoe Bay Pit

Test for: Sec. 104, 200 Tested by: D.G., K.R., R.G., P.B., A.T.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	Comb. Original	Sec. 104	Sec. 200	Degr.	Specifications Sec. 104	Specifications Sec. 200
3"	83					
1½"	69	100			100	
1"	62	83				
¾"	57	68	100	100		100
½"						
3/8"	46	49	70	76		
#4	37	38	51	60	30-70	35-65
#8						
#10	28	28	40	42		
#40	9	9	13	18		
#200	2	2	4	6	0-15	1-10
L. L.	—	—		—		
P. I.	NP	NP		NP		

STABILOMETER
"R" at 240 P. S. I. Ex. Pressure

R	80
% Moisture	5.8
Density	129.0

Wt./Cu. Ft. Compacted

Base Course T-180 Method D	138.3@5.9%
Subbase T-180 Method D (~~Rex~~)	140.5 @ 7.2%
Asphalt Mix T-167	
Soft Particles	0 %
Fractured Faces	100 %

CEMENTATION
P. S. I. Comp. Str. 16

HUBBARD FIELD

% Swell	
% Abs.	
Stab. Wet	
Stab. Dry	
% Retained	

L. A. ABRASION
Grading _____

	100 R	500 R
% Loss		37

Sand Eq. 84

OIL DESIGN

SEE SHEET NO. 3

Additive used			
% by C. K. E.			
% used			
% swell			
% absorption			
Stability P. S. I.			
Wet			
Dry			
% retained			

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

Remarks: _____

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Form PR-9-232
April 1965

SHEET NO. 3 OF 3

U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Plant-mix and Chips)

Lab. No: 67-504-508, 518-P Field Sample No: _____ Date: May 7, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted By: Runyan Quantity Rep. _____ Name of Material: Gravel

Source: Arapahoe Bay Pit

Test for: Oil Design, etc. Tested by: D.G., K.R., R.G, P.B., A.T.

WASHED M. A. % PASSING

Sieve Size	Comb. Original	Sec. 200	Spec's. Sec. 200
3"	83		
1½"	69		
1"	62		
¾"	57	100	100
½"			
3/8"	46	70	
#4	37	51	35-65
#8			
#10	28	40	
#40	9	13	
#200	2	4	0-10
L. L.	--		
P. I.	NP		

OIL DESIGN
120/150 AC

Additive Used	None	1%Acra	1%Lime
% by C. K. E.	4.4	4.4	4.9
% Used *	6.4	6.4	6.9
% Swell	0.0	0.0	0.1
% Absorption	2.4	1.6	1.2
Stability P. S. I.			
Wet	187	251	243
Dry	239	270	231
% Retained	78	93	105
Specific Gravity			
Laboratory	2.26	2.27	2.31
Theo. Max.	2.44	2.44	2.44
% Theo.	93	93	95
wt./cu.ft. compacted	143	144	146

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

HUBBARD FIELD

% Swell	1.1
% Abs.	1.5
Stab. Wet	900
Stab. Dry	740
% Retained	122

L. A. ABRASION

Grading _____

	100 R	500 R
% Loss	_____	_____

STATIC IMMERSION

% Additive	Film Retained 0 Hours	24 Hours
None	100	95+
0.5-A	100	95+
1-A	100	95+
1-PB	100	95+
RS-K	100	95+

SPECIFIC GRAVITY & ABS.

	+ #4	- #4	Comb.
Sp. Gr.	2.69	2.70	2.70
Abs.	1.1	1.5	1.3

Sand Equivalent	_____
Soft Particles	_____ %
Fractured Faces	_____ %
T-101 Swell	0.3 %
Sulfate Soundness	1.0 %

Remarks: *Percent used by Rice Vacuum

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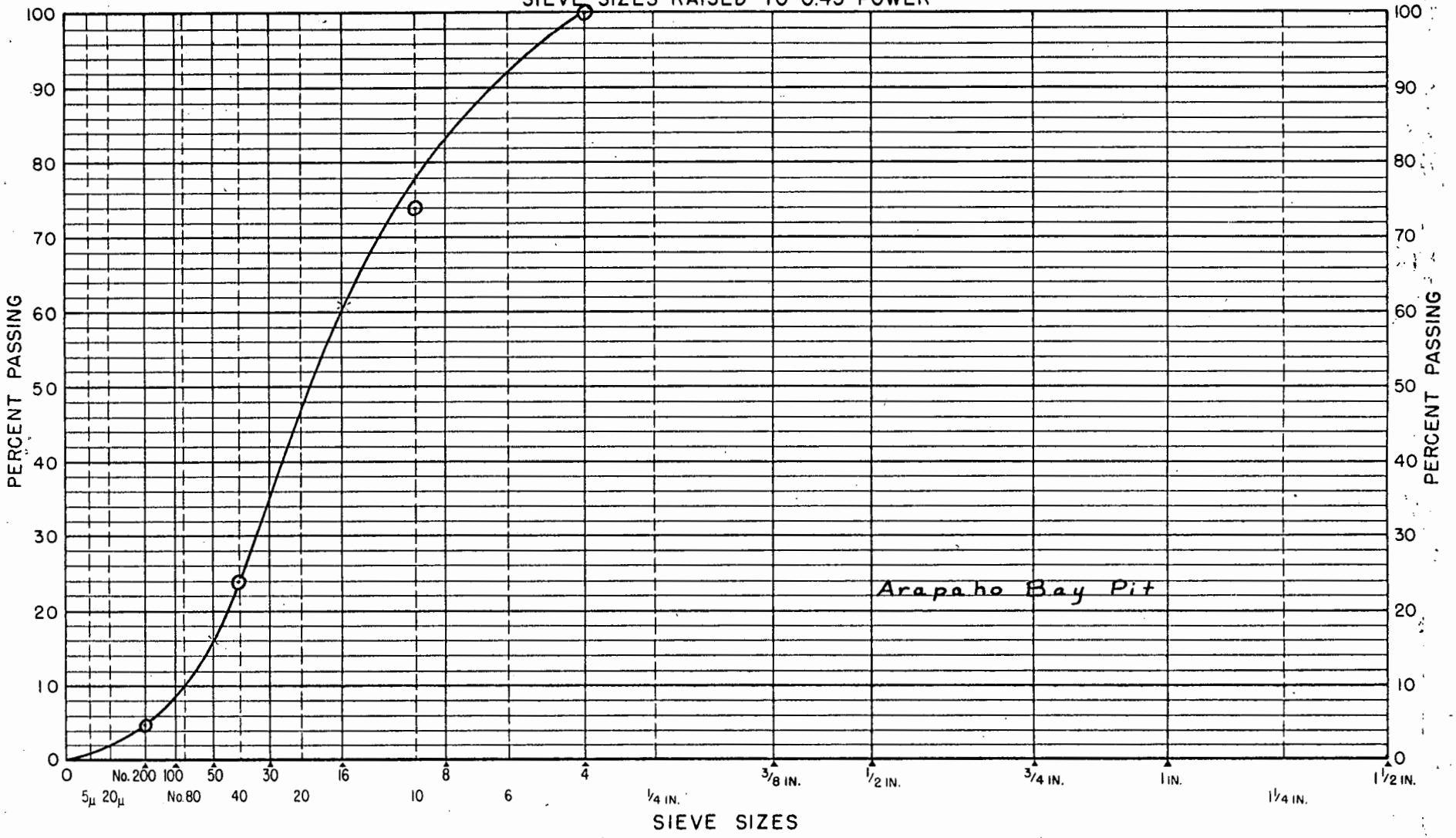
GPO 838 - 024

FORM PR-1115
(2-62)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS

GRADATION CHART

SIEVE SIZES RAISED TO 0.45 POWER



▲ THIS SYMBOL IDENTIFIES SIMPLIFIED PRACTICE AND COMPATIBLE SIEVE SIZES

Identification of gradations:

Sheet No.

Date

USCOMM-DC 40822-P62

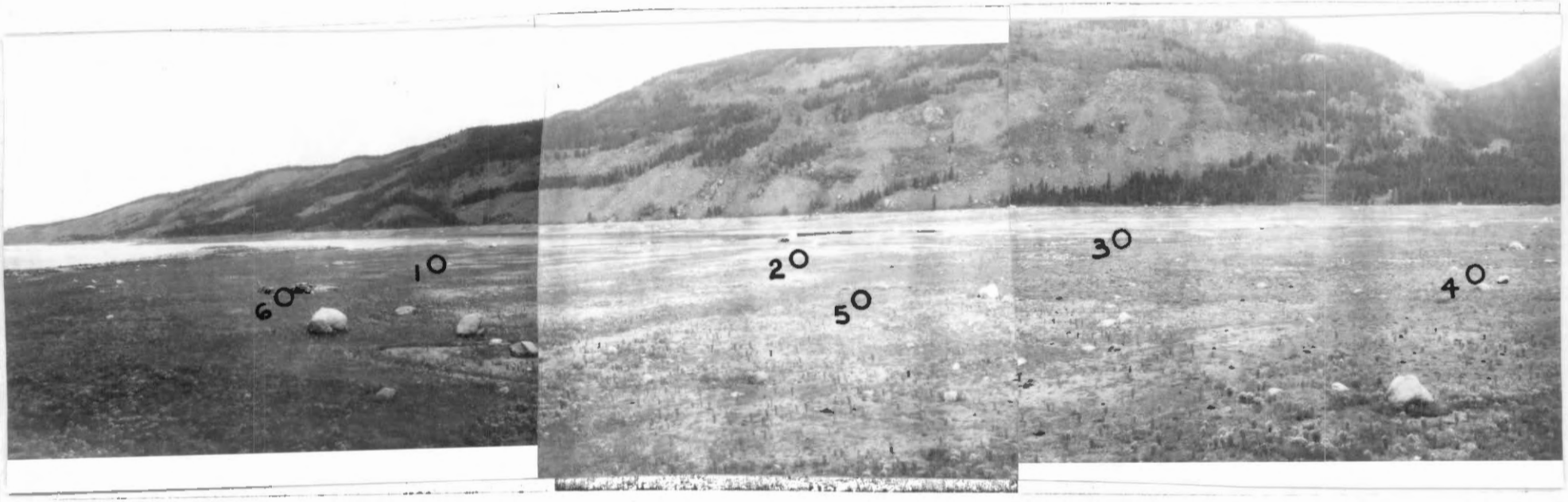


FIGURE 16

Arapahoe Bay Pit. Looking northeasterly over Arapaho Bay portion of Lake Granby. Holes 1, 2, 3, 4, 5, and 6 are indicated.

ROCKY MOUNTAIN NATIONAL PARK

PARKWIDE MATERIALS SURVEY

SOURCES OF MATERIALS SAMPLED AND TESTED

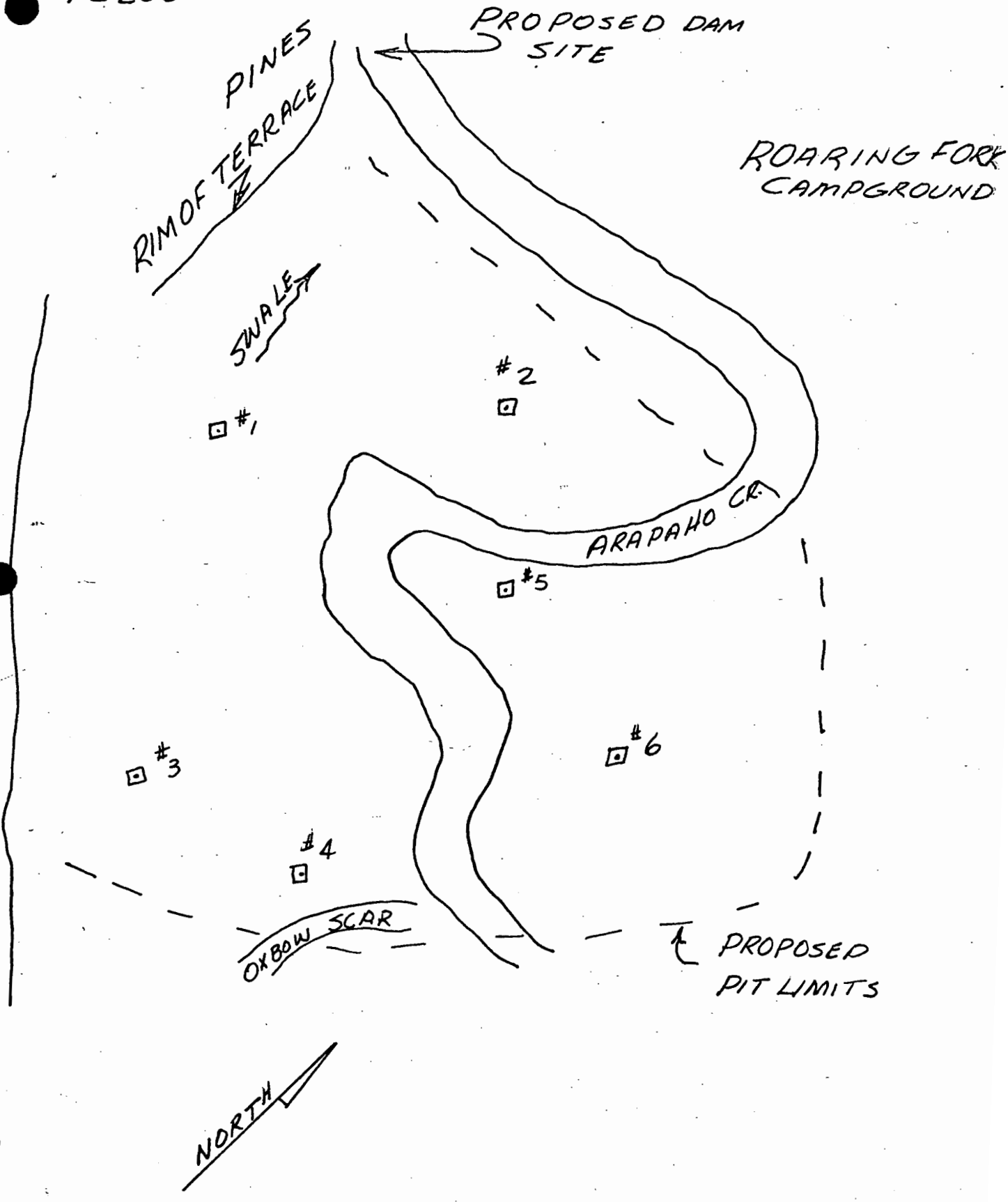
Western Slope [X] Eastern Slope [ ]

Pit Number 8-W BPR Lab. No. 67-509 through 67-517

Flight Strip 39 Photograph 5-52

LOCAL NAME, LOCATION AND GENERAL DESCRIPTION	Arapaho Creek Pit. The area below Lake Granby high water, upstream from the proposed Arapaho Bay Dam. Map Coordinates - Colorado Coordinate System, North Zone. 288 500 - 1925 875
QUANTITY	222,000 cubic yards.
ANALYSIS OF LABORATORY TEST DATA, CONDITIONS OF USE AND RECOMMENDATIONS	Material is suitable for subbase, base, bituminous stabilized base, surfacing and seal coat, aggregates. However, overburden stripping consists of up to 5' of gray silty clay on south-side and 1½' on the north side. There is less than 5% greater than 10" diameter with a maximum size of 15". Removal of material will be subject to the terms of the Bureau of Reclamation letter dated August 22, 1967.

ARAPAHO CREEK PIT



Western Slope
Arapaho Creek Pit
8-W

Log of Holes

Hole No. 1:

0–1½'	Tan clayey sand and fine gravel, few angular oversize cobbles. Roots in top few inches.
1½–5'	Gray, very silty clay.
5–8'	Yellow-brown slightly clayey sand.
8–10'	Yellow-brown, damp, clayey sand and gravel. Nothing over 2" until two oversize boulders at 10'.

Hole No. 2:

0–4'	Gray silt, roots.
4–7'	Gray-brown, slightly clayey sand and gravel. Cobbles are sub-rounded to sub-angular. Water at 4'. Very silty fine sand at 6'.
	Less than 5% oversize to 15".

Hole No. 3:

0–1½'	Tan silt, roots in top few inches.
1½–3'	Gray very silty clay.
3–11½'	Yellow-brown, slightly clayey sand and fine gravel. Nothing over 2" in size to 7'. Below 8' lenses of fine sandy clay to clayey fine sand occur. Water at bottom.
	Less than 5% oversize to 15" below 7'.

Hole No. 4:

0–1½'	Light brown slightly clayey sand, few roots at top.
1½–7'	Gray-brown with rust streaks, slightly clayey sand and gravel. Cobbles are sub-rounded to sub-angular. Water at 6'.
	Less than 5% oversize to 15", few over 6".

Hole No. 5:

0–1½'	Grayish-tan silt to very silty clay, few roots in top.
1½–7'	Gray-brown slightly clayey sand and fine gravel.
	Nothing over 2".
7–11'	Yellow-brown slightly clayey sand and gravel. Cobbles are sub-rounded to sub-angular. Water at bottom.
	No oversize, 6–8" maximum.

Hole No. 6:

0–1½'	Tan silty clay, roots at top.
1½–4'	Light brown clayey sand and gravel.
	No oversize, few cobbles to 3–4".
4–9'	Gray, slightly clayey, wet sand and gravel, cobbles are sub-rounded. Water seeping in at 6½'.
	No oversize, 5–6" maximum.
9–10½'	Yellow-brown clayey sand.

Form PR-9-230
April 1965

U. S. DEPARTMENT OF COMMERCE
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Separate Test Hole Gradation, L. L., and P. I.)

Lab. No: 67-509-517-P Field Sample No: _____ Date: May 3, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: Runyan Quantity Rep. _____ Name of Material Gravel

Source: Arapahoe Creek Pit

Test for: Gradation, L.L. & P.I. Tested by: K.R., R.G., D.G.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	67-509 Hole #1	67-510 Hole #2	67-511 Hole #3	67-512 Hole #4	67-513 Hole #5	67-514 Hole #5	67-515 Hole #6	67-516 Hole #6	67-517 *
3"		86	93	82		84	91	95	
1½"		74	78	69		82	83	77	
1"	97	66	73	65		79	76	64	
¾"	92	59	68	60	100	76	66	56	
½"									
3/8"	66	44	54	47	94	65	46	44	
#4	52	33	44	37	69	52	36	34	100
#8									
#10	45	24	37	29	43	40	30	26	100
#40	24	11	18	15	18	15	14	12	100
#200	9	1	5	6	6	4	5	6	98
L.L.	--	--	--	--	--	--	--	23	43
P.I.	NP	NP	NP	NP	NP	NP	NP	5	14

REMARKS: * Soils Classification = A-7-6 (14)

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Rev. April 1965

SHEET NO. 2 OF 3

U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Sub-base, Base Course, and Base Stabilization)

Lab. No: 67-509-516-P Field Sample No: _____ Date: May 3, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: D.R. Runyan Quantity Rep. _____ Name of Material: Gravel

Source: Arapaho Creek Pit

Test for: Sec. 104, 200 Tested by: R.G., D.G., K.R., & P.B.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	Comb. Original	Sec. 104	Sec. 200	Degr.	Specifications Sec. 104	Specifications Sec. 200
3"	90					
1½"	86	100			100	
1"	76	90				
¾"	70	77	100	100		100
½"						
3/8"	55	59	69	75		
#4	43	46	52	62	30–70	35–65
#8			43			
#10	34	35	41	48		
#40	16	16	19	27		
#200	5	5	7	11	0–15	0–10
L. L.	—	—	—	—		
P. I.	NP	NP	NP	NP		

STABILOMETER
"R" at 400 P. S. I. Ex. Pressure

R: 80
% Moisture: 6.1
Density: 136.0

Wt./Cu. Ft. Compacted
Base Course
T-180 Method D: 140.9 @ 6.7%
Subbase
T-180 Method D (~~RxX~~): 143.1 @ 5.5%
Asphalt Mix
T-167: _____

Soft Particles: 1 %
Fractured Faces: 92 %

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

CEMENTATION
P. S. I. Comp. Str. 95

HUBBARD FIELD
% Swell: _____
% Abs.: _____
Stab. Wet: _____
Stab. Dry: _____
% Retained: _____

L. A. ABRASION
Grading _____

	100 R	500 R
% Loss	_____	36

Sand Eq. 38

OIL DESIGN
Additive used: See Sheet No. 3

% by C. K. E.			
% used			
% swell			
% absorption			
Stability P. S. I.			
Wet			
Dry			
% retained			

Remarks: _____

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Form PR-9-232
April 1965

SHEET NO. 3 OF 3

U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Plant-mix and Chips)

Lab. No: 67-509-516-P Field Sample No: _____ Date: May 3, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted By: D.R. Runyan Quantity Rep. _____ Name of Material: Gravel

Source: Arapaho Creek Pit

Test for: Sec. 217 & 313 Tested by: A.T., K.R., D.G., R.G., & P.B.

WASHED M.A. % PASSING

Sieve Size	Comb. Original	Sec. 200	Spec's. Sec.
3"	90		
1½"	86		
1"	76		
¾"	70	100	100
½"			
3/8"	55	69	
#4	43	52	35-65
#8		43	
#10	34	41	
#40	16	19	
#200	5	7	0-10
L.L.	—	—	
P.I.	NP	NP	

OIL DESIGN
120/150 AC

Additive Used	None	1%Acra	1%Lime
% by C. K. E.	5.3	5.3	5.4
% Used	6.3	6.3	6.4
% Swell	0.2	0.2	0.2
% Absorption	1.8	1.6	1.9
Stability P. S. I.			
Wet	266	345	235
Dry	212	262	245
% Retained	125	132	96
Specific Gravity			
Laboratory	2.29	2.29	2.30
Theo. Max.	2.43	2.43	2.43
% Theo.	94	94	95
wt./cu.ft. compacted	146	147	146

HUBBARD FIELD

% Swell	0.6
% Abs.	2.9
Stab. Wet	940
Stab. Dry	1965
% Retained	48

L. A. ABRASION

Grading _____

	100 R	500 R
% Loss		

STATIC IMMERSION

% Additive	Film Retained 0 Hours	24 Hours
None	100	95+
0.5-A	100	95+
1-A	100	95+
1-PB	100	95+
RS-K	100	95+

SPECIFIC GRAVITY & ABS.

	+ #4	- #4	Comb.
Sp. Gr.	2.73	2.73	2.73
Abs.	1.2	1.3	1.3

Sand Equivalent _____

Soft Particles _____ %

Fractured Faces _____ %

T-101 Swell None %

Sulfate Soundness 2 %

DISTRIBUTION:

Region Office	1
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Remarks: Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

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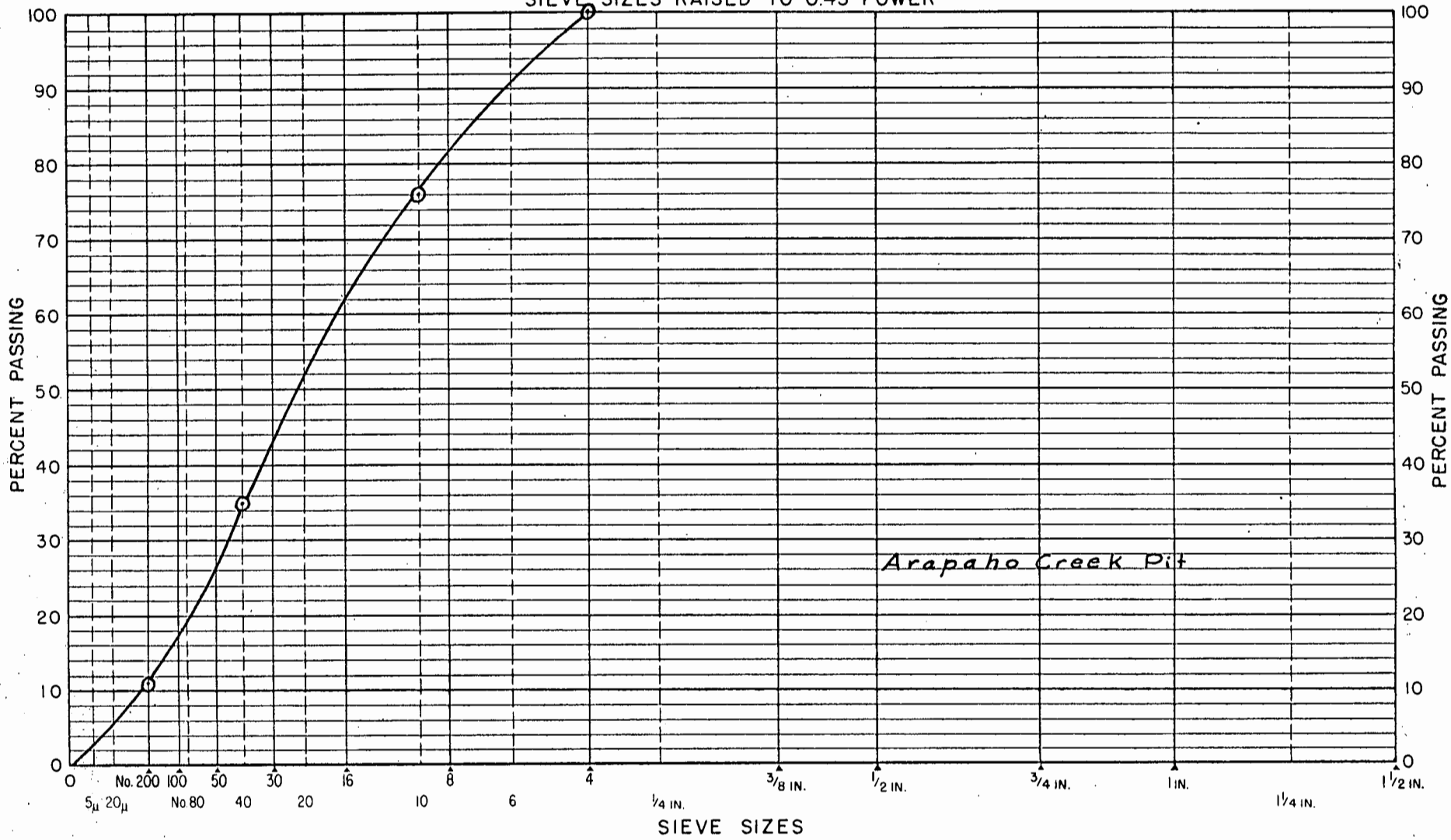
GPO 838-024

FO PR-1115
(2-62)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS

GRADATION CHART

SIEVE SIZES RAISED TO 0.45 POWER



▲ THIS SYMBOL IDENTIFIES SIMPLIFIED PRACTICE AND COMPATIBLE SIEVE SIZES

Idenification of gradations:

Sheet No.

Date

USCOMM-DC 40822-P62

FIGURE 17

Arapaho Creek Pit. Looking southeasterly over the pit area which lies primarily within high water of Granby Lake and on both sides of Arapaho Creek. Holes 1, 2, 3, 4, 5, and 6 are indicated.

ROCKY MOUNTAIN NATIONAL PARK

PARKWIDE MATERIALS SURVEY

SOURCES OF MATERIALS SAMPLED AND TESTED

Western Slope [X] Eastern Slope [ ]

Pit Number 9-W BPR Lab. No. 67-497 through 67-503

Flight Strip 34 Photograph 5-6

LOCAL NAME, LOCATION AND GENERAL DESCRIPTION	Cutthroat Bay Pit, a point below Lake Granby high water forming the west side of Cutthroat Bay, west of the Granby pumping plant. Map Coordinates - Colorado Coordinate System, North Zone. 311 000 - 1894 000
QUANTITY	145,000 cubic yards "indicated".
ANALYSIS OF LABORATORY TEST DATA, CONDITIONS OF USE AND RECOMMENDATIONS	As indicated by test results, Holes 4 & 5are of poor material. This material is located at west edge of pit limits could be excluded in excavation, thereby raising the quality of the material in the rest of the pit. However, this would decrease the quantity of material available. The tests indicate that 52% of -#4 material was wasted in order to meet the specification for base material. If the material surrounding Holes 4 and 5 were excluded, the amount of -#4 material that has to be wasted would be lowered considerably. Excluding Holes 4 and 5, this material probably is suitable for subbase, base, and bituminous stabilized base aggregate. This material could probably be used for concrete aggregate if the material from Holes 4 and 5 were excluded and some of the -#4 material wasted.

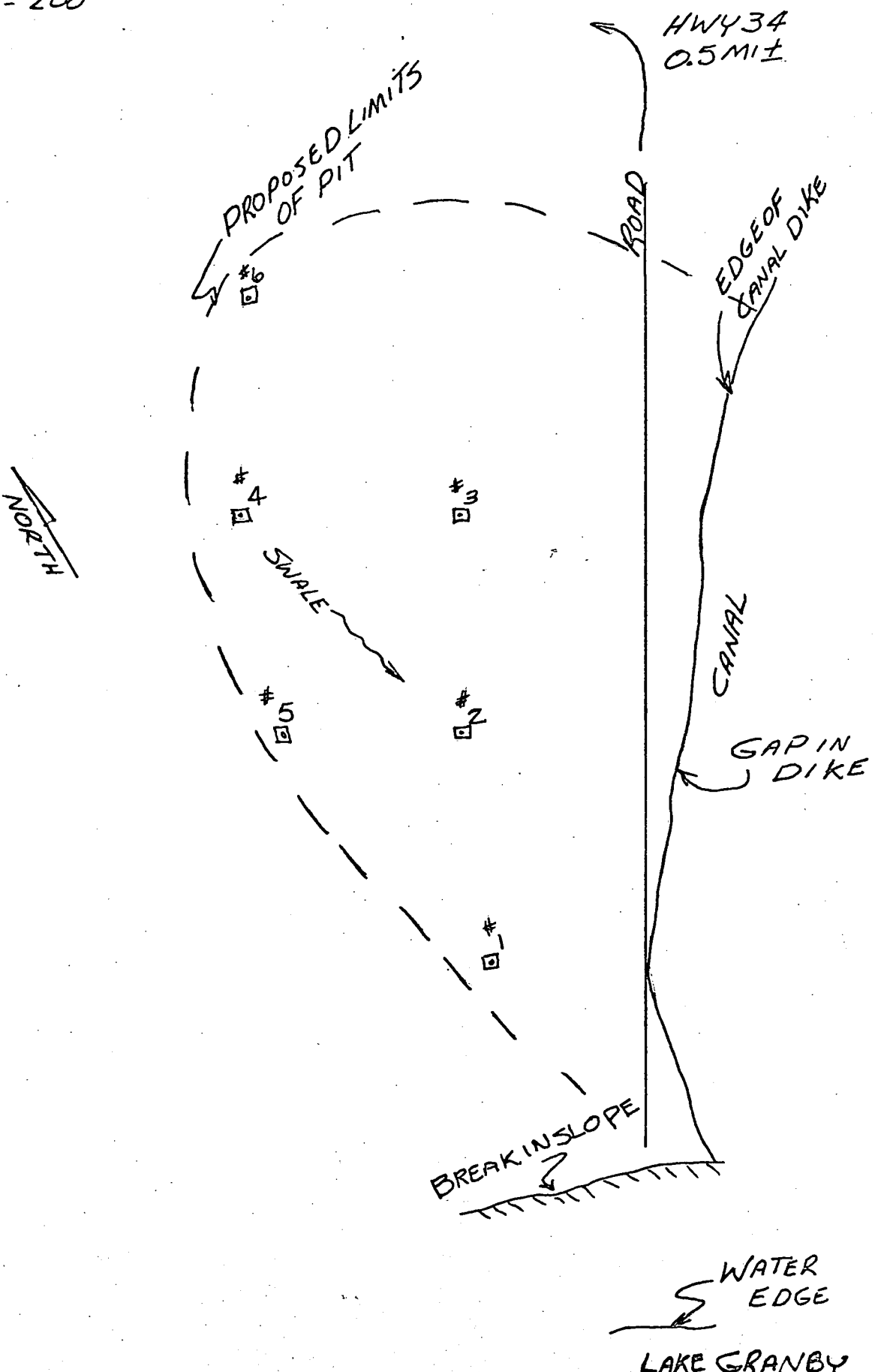
(continued)

(Continued)

The use of this aggregate with asphaltic material might require an anti-stripping agent such as hydrated lime or acra. A clayey overburden up to 6' would have to be removed; and 10-15% of the material is in excess of 10" with a maximum size of 1/3 cubic yard. Material removed will be subject to terms set in Bureau of Reclamation's August 22, 1967, letter.
Amount of material available will depend on the lake level.

CUTTHROAT BAY PIT

1" = 200'



Western Slope
Cutthroat Bay Pit
9-W

Log of Holes

Hole No. 1:

0–4"	Dark brown silty clay, roots (topsoil).
4"–6'	Brown, silty plastic clay.
6–11½'	Gray-brown clayey sand and gravel. Cobbles rounded to sub-rounded.
	5–10% oversize to 15".

Hole No. 2:

0–1½'	Brown silty clay, roots in top few inches.
1½–4'	Light brown very sandy clay grading downward into clayey sand and gravel.
4–11'	Gray-brown clayey sand grading downward into damp, slightly clayey sand and gravel. Cobbles are sub-rounded. Water in very bottom.
	5% oversize to 18". 10–15% of the oversize between 4–8".

Hole No. 3:

0–1½'	Brown silty and sandy clay with roots at top.
1½–9½'	Light brown clayey sand and coarse gravel. Cobbles are sub-rounded to sub-angular.
	Up to 25% oversize to 1/3 cubic yard.

Hole No. 4:

0–1'.	Brown silty clay, roots in top few inches.
1–4'	Light brown clayey sand to very sandy clay.

Hole No. 4: (continued)

4-11½'	Gray-brown very sandy clay to clayey sand and gravel. Clay is gray and very plastic. Very clayey from 6-8'. Slightly cleaner below 8'. Water at 11'.
	5% oversize to 18".

Hole No. 5:

0-6"	Dark brown silty clay, roots, (topsoil).
6"-5'	Brown silty clay. Caliche at base.
5-6½'	Light brown, very sandy and gravelly clay. Cobbles are sub-rounded.
	No oversize.
6½-10'	Gray-brown slightly clayey sand and gravel. Cobbles are sub-rounded.
	Less than 5% oversize to 18", but up to 15% oversize between 9-10'.

Hole No. 6:

0-1'	Brown silty and sandy clay, roots at top.
1-9½'	Light brown clayey sand and coarse gravel. Becomes slightly cleaner with depth. Cobbles are sub-rounded.
	10-15% oversize to 24".

Form PR-9-230
April 1965

U. S. DEPARTMENT OF COMMERCE
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Separate Test Hole Gradation, L. L., and P. I.)

Lab. No: 67-497-502-P Field Sample No: Date: April 11, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: Runyan Quantity Rep. Name of Material Gravel

Source: Cutthroat Bay Pit

Test for: Gradation, L.L., P.L. Tested by: R.G., D.G., V.M.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	67-497 Hole #1	67-498 Hole #2	67-499 Hole #3	67-500 Hole #4	67-501 Hole #5	67-502 Hole #6	Hole #7	Hole #8	Comb.
3"	68	82	88	86	80	86			81
1½"	61	72	73	85	63	68			73
1"	56	66	68	82	56	62			70
¾"	52	64	65	79	54	58			67
½"									
3/8"	46	57	58	69	48	51			59
#4	40	50	51	57	41	44			50
#8									
#10	34	39	39	49	34	33			40
#40	14	13	14	35	18	14			19
#200	7	5	6	25	11	5			10
L.L.	23	23	24	37	31	24			28
P. I.	2	2	3	20	11	3			10

REMARKS:

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Form PR-9-230
April 1965

U. S. DEPARTMENT OF COMMERCE
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Separate Test Hole Gradation, L. L., and P. I.)

Lab. No: 67-503-P Field Sample No: _____ Date: April 11, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: Runyan Quantity Rep. _____ Name of Material Overburden

Source: Cutthroat Bay Pit

Test for: Gradation, L.L. & P.I. Tested by: _____

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	67-503 Hole #1	Hole #2	Hole #3	Hole #4	Hole #5	Hole #6	Hole #7	Hole #8	Comb.
3"									
1½"									
1"									
¾"									
½"									
3/8"									
#4	100								
#8									
#10	99								
#40	96								
#200	82								
L.L.	37								
P.I.	16								

REMARKS:

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Form PR-9-231
Rev. April 1965

U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Sub-base, Base Course, and Base Stabilization)

Lab. No: 67-497-502-P Field Sample No: _____ Date: April 11, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: Runyan Quantity Rep. _____ Name of Material: Gravel

Source: Cutthroat Bay Pit

Test for: Sec. 104, 200, Degradation, Compaction, L.A. Abrasion Tested by: R.G., D.G., V.M., K.R.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	Comb. Original	Sec. 104	Sec. 200	Degr.	Specifications Sec. 104	Specifications Sec. 200
3"	81					
1½"	73	100*			100	
1"	70	93				
¾"	67	84	100**			100
½"						
3/8"	59	66	70	77		
#4	50	55	50	62	30-70	35-65
#8						
#10	40	43	37	48		
#40	19	21	18	25		
#200	10	11	9	12	0-15	0-10
L. L.	28	25	--	24		0-25
P. I.	10	7	NP	6		0-6

STABILOMETER
"R" at 250 P.S.I. Ex. Pressure

	Sec. 104	Sec. 200
R	73	76
% Moisture	7.3	7.2
Density	134.0	132.6

Wt./Cu. Ft. Compacted
Base Course
T-180 Method D 140.7 @ 6.5%
Subbase
T-180 Method D (Rev.) 137.6 @ 7.1%
Asphalt Mix
T-167 _____

Soft Particles 2 %
Fractured Faces 80 %

CEMENTATION
P. S. I. Comp. Str. 79

HUBBARD FIELD
% Swell _____
% Abs. _____
Stab. Wet _____
Stab. Dry _____
% Retained _____

L. A. ABRASION
Grading _____

	100 R	500 R
% Loss	_____	42

Sand Eq. _____

OIL DESIGN
Additive used SEE SHEET NO. 4

% by C. K. E.	_____	_____	_____
% used	_____	_____	_____
% swell	_____	_____	_____
% absorption	_____	_____	_____
Stability P. S. I.			
Wet	_____	_____	_____
Dry	_____	_____	_____
% retained	_____	_____	_____

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

Remarks: * This gradation was obtained by crushing all of the +1½" material to -1½" material.
** This gradation was obtained by wasting 52% of the -#4 material.

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Form PR-9-232
April 1965

U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Plant-mix and Chips)

Lab. No: 67-497-502-P Field Sample No: _____ Date: April 11, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted By: Runyan Quantity Rep. _____ Name of Material: Gravel

Source: Cutthroat Bay Pit

Test for: Oil Design, Stat. Immersion, Specific Gravity Tested by: D.G., R.R., A.T., R.G., K.R.

WASHED M.A. % PASSING

Sieve Size	Comb. Original	Sec. 200	Spec's. Sec.
3"	81		
1½"	73		
1"	70		
¾"	67	100 100	
½"			
3/8"	59	70	35-65
#4	50	50	
#8			
#10	40	37	
#40	19	18	
#200	10	9	0-10
L. L.	28	—	
P. I.	10	NP	

OIL DESIGN
120/150 AC

Additive Used	None	1%Lime	1%Acra
% by C. K. E.	4.3	5.2	4.3
% Used *	8.3	9.2	8.3
% Swell	1.0	0.8	0.7
% Absorption	3.8	2.8	2.3
Stability P. S. I.			
Wet	102	167	165
Dry	195	207	225
% Retained	52	81	73
Specific Gravity			
Laboratory	2.23	2.26	2.26
Theo. Max.	2.33	2.33	2.33
% Theo.	96	97	97
wt./cu. ft. compacted	141	143	142

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

HUBBARD FIELD

% Swell	3.4
% Abs.	7.6
Stab. Wet	400
Stab. Dry	2210
% Retained	18

STATIC IMMERSION

% Additive	Film Retained 0 Hours	24 Hours
None	100	95+
0.5-A	100	95+
1-A	100	95+
1-PB	100	95+
RSK	100	95+

Sand Equivalent: 34

Soft Particles: _____ %

Fractured Faces: _____ %

T-101 Swell: 0.7 %

Sulfate Soundness: 3 %

L. A. ABRASION
Grading _____

	100 R	500 R
% Loss	_____	_____

SPECIFIC GRAVITY & ABS.

	+ #4	- #4	Comb.
Sp. Gr.	2.69	2.69	2.69
Abs.	1.3	2.0	1.7

Remarks: * Percent used by Rice Vacuum

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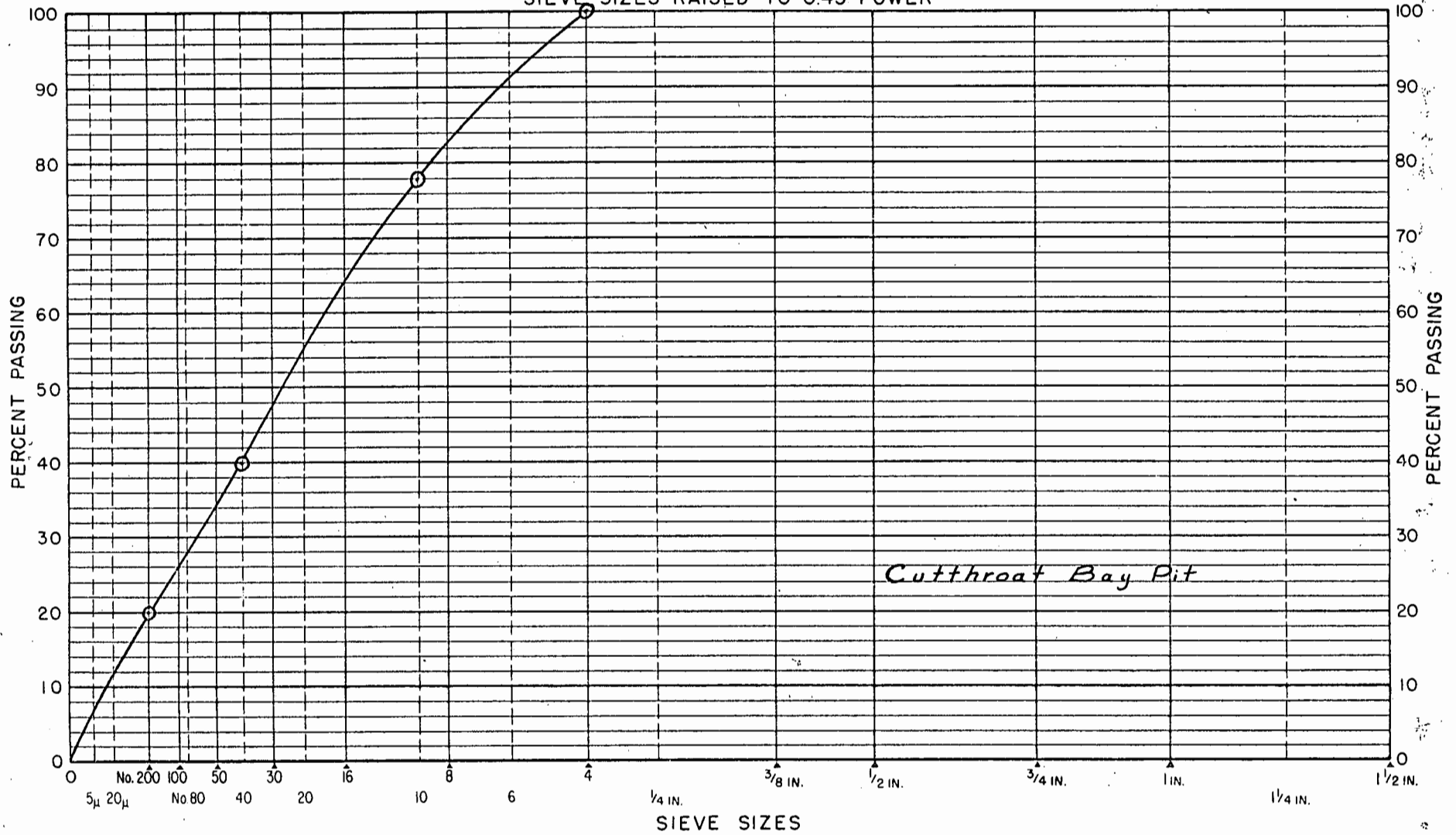
FORM [illegible]-1115
(2-62)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS

GRADATION CHART

SIEVE SIZES RAISED TO 0.45 POWER



▲ THIS SYMBOL IDENTIFIES SIMPLIFIED PRACTICE AND COMPATIBLE SIEVE SIZES

Identification of gradations:

Sheet No.

Date

USCOMM-DC 40822-P62

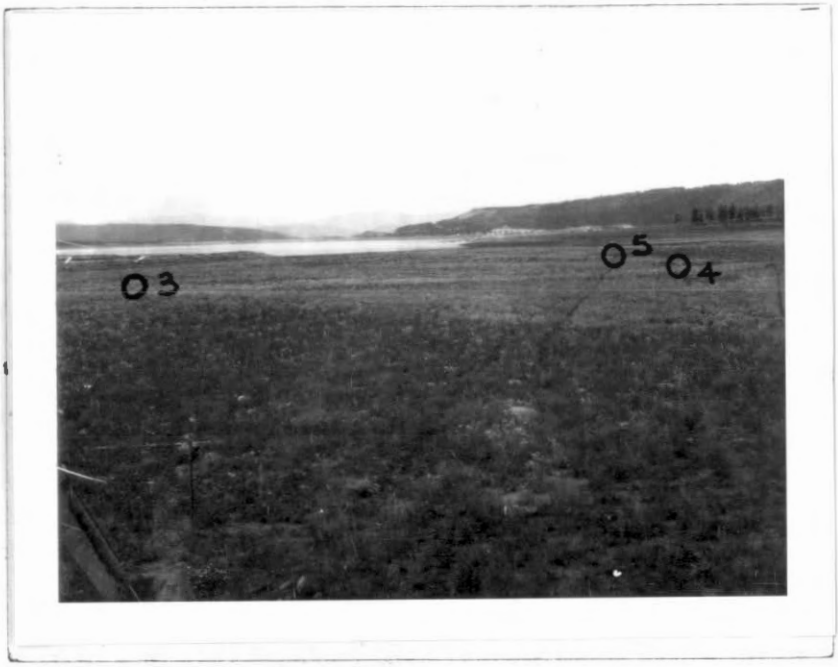


FIGURE 9

Cutthroat Bay Pit. Looking south from Hole 6. Holes 3, 4, and 5 are indicated. Pit area is below Lake Granby's high water level on the west side Cutthroat Bay. Lake Granby is in the background.

ROCKY MOUNTAIN NATIONAL PARK

PARKWIDE MATERIALS SURVEY

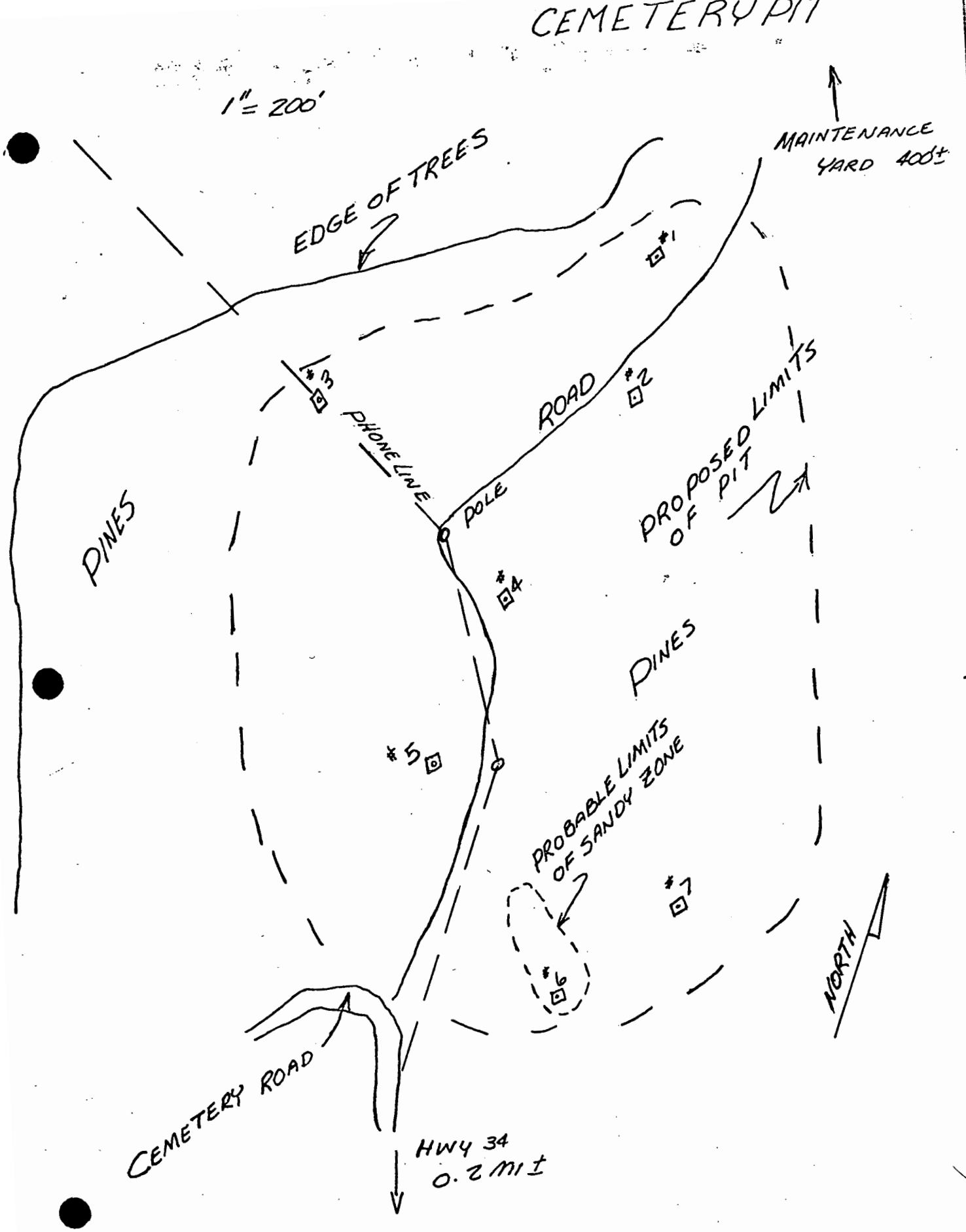
SOURCES OF MATERIALS SAMPLED AND TESTED

Western Slope [X] Eastern Slope [ ]

Pit Number 13-W BPR Lab. No. 67-489 through 67-496

Flight Strip 30 Photograph 2-48

LOCAL NAME, LOCATION AND GENERAL DESCRIPTION	Cemetery Pit, 400'± south of RMNP Westside Maintenance yard and north of Grand Lake Cemetery. Map-Coordinates - Colorado Coordinate System, North Zone. 338 625 - 1905 750
QUANTITY	201,000 cubic yards.
ANALYSIS OF LABORATORY TEST DATA, CONDITIONS OF USE AND RECOMMENDATIONS	This material is suitable for subbase, as too much material would be wasted for base, or asphaltic surfacing aggregates. The gradation for subbase was obtained by wasting 29% of the total pit. Test holes indicate up to 2' of sandy clay or silt overburden. 5-10% of material is in excess of 10", with maximum size of ½ cubic yard.


CEMETERY PIT
1" = 200'
MAINTENANCE YARD 400±
EDGE OF TREES
#1
#2
#3
PHONE LINE
ROAD
POLE
PROPOSED LIMITS OF PIT
PINES
#4
PINES
#5
PROBABLE LIMITS OF SANDY ZONE
#7
#6
NORTH
CEMETERY ROAD
HWY 34
0.2 mi ±

Western Slope
Cemetery Pit
13-W

Log of Holes

Hole No. 1:

0-2'	Light brown, very clayey sand and gravel. Roots in top 6".
2-3'	Gray-brown, clean sand and gravel. Cobbles are sub-rounded.
	No oversize, 6" maximum size.
3-9'	Gray-brown, clayey sand and coarser gravel. Cobbles are mainly sub-rounded. Becomes damper and less coarse toward bottom.
	Less than 5% oversize to 15-18".

Hole No. 2:

0-2'	Light brown, sandy clay, roots in top 6".
2-9'	Gray-brown, clayey sand and gravel. Cobbles are sub-angular to sub-rounded.
	Less than 5% oversize to 15-18".

Hole No. 3:

0-6"	Dark brown sandy clay, roots, (topsoil).
6"-1½'	Light brown clayey silt.
1½-10'	Gray-brown, clayey sand and gravel. Clear in top few inches. Cobbles are sub-angular to sub-rounded. Material very spotty; becomes cleaner below 6'. Clayey silt at very bottom.
	5-10% oversize to ¼-½ cubic yard.

Hole No. 4:

0–1½'	Light brown clayey silt, roots in top 6".
1½–2½'	Gray sandy silt with some gravel to 6".
2½–10'	Gray-brown clayey sand and gravel. Cobbles are sub-rounded to sub-angular. Material is spotty, but in general quite dirty; coarser and cleaner toward bottom.
	Less than 5% oversize to 18".

Hole No. 5:

0–6"	Light brown sandy clay, roots, (topsoil).
6"–10½'	Gray-brown, clayey sand and gravel to sandy silt. Cobbles are sub-rounded to sub-angular. Clean layer at 7'.
	Less than 5% oversize to 1/3 cubic yard.

Hole No. 6:

0–6"	Brown sandy clay, roots, (topsoil).
6"–3'	Light brown silty sand, no gravel.
3'–8½'	Light gray-brown, slightly clayey sand and fine gravel. Nothing over 1".

Hole No. 7:

0–6"	Brown sandy clay roots, (topsoil).
6"–3'	Light brown clayey sand.
3–7'	Gray-brown clayey sand and gravel. Cobbles are sub-rounded to sub-angular.
	5% oversize to 15".
7–10½'	Gray-brown, clean sand and fine gravel. Little over 1". Water seepage at bottom of hole.

Form PR-9-230
April 1965

U.S. DEPARTMENT OF COMMERCE
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Separate Test Hole Gradation, L. L., and P. I.)

Lab. No: 67-489-496-P Field Sample No: _____ Date: May 3, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: Runyan Quantity Rep. _____ Name of Material: Gravel

Source: Cemetery Pit

Test for: Gradation, L.L. & P.I. Tested by: D.G., A.T., R.G., K.R.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	67-489 Hole #1	67-490 Hole #2	67-491 Hole #3	67-492 Hole #4	67-493 Hole #5	67-496 Hole #6	67-494 Hole #7	67-495 Hole #8	Comb.
3"		95	92	93	95		84		94
1½"	95	92	81	91	90				86
1"	92	88	78	87	87		80		80
¾"	89	85	74	84	86	100	79		78
½"									
3/8"	84	79	69	78	82	98	74	93	73
#4	79	74	64	74	78	95	68	88	68
#8									
#10	72	66	59	70	72	87	58	77	61
#40	47	41	36	48	48	55	24	38	39
#200	21	18	15	23	13	5	5	4	14
L.L.	--	--	--	--	--	--	--	--	--
P. I.	NP	NP	NP	NP	NP	NP	NP	NP	NP

REMARKS:

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

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U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine.

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Sub-base, Base Course, and Base Stabilization)

Lab. No: 67-489-496-P Field Sample No: _____ Date: May 3, 1968

Project: Rocky Mountain Nat'l. Park, 1967 Survey

Submitted by: Runyan Quantity Rep. _____ Name of Material: Gravel

Source: Cemetery Pit

Test for: Sec. 104 Tested by: D.G., A.T., R.G., K.R.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	Comb. Original	Sec. 104 *	Sec.	Degr.	Specifications Sec. 104	Specifications Sec.
3"	94					
1½"	86				100	
1"	80	90				
¾"	78	82				
½"						
3/8"	73	72				
#4	68	63			30-70	
#8						
#10	61	55				
#40	39	34				
#200	14	13			0-15	
L. L.	--	--				
P. I.	NP	NP				

STABILOMETER
"R" at P. S. I. Ex. Pressure
R _____
% Moisture _____
Density _____

Wt./Cu. Ft. Compacted
Base Course
T-180 Method D _____
Subbase
T-180 Method D (Rex.) 139.4 @ 6.0%
Asphalt Mix
T-167 _____

Soft Particles _____ %
Fractured Faces _____ %

CEMENTATION
P. S. I. Comp. Str. _____

HUBBARD FIELD
% Swell _____
% Abs. _____
Stab. Wet _____
Stab. Dry _____
% Retained _____

L. A. ABRASION
Grading _____

	100 R	500 R
% Loss		

Sand Eq. _____

OIL DESIGN
_____

Additive used			
% by C. K. E.			
% used			
% swell			
% absorption			
Stability P. S. I.			
Wet			
Dry			
% retained			

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

Remarks: * This gradation was obtained by wasting 43% of the original -#4 material

NOTE: Did not design for Sec. 200 due to the large amount of waste that would have been required.

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GPO 838-024

FIGURE 10

Cemetery Pit. Photograph shows Hole 1 across the graveled road. The area is heavily wooded with lodgepole pit and a few aspen. As small clearing is noted in the background.

FIGURE 11

Cemetery Pit. Looking north showing Hole 6 with erratocs in foreground and possible sand-filled shallow swale in background. The area is heavily timbered with lodgepole pine.

ROCKY MOUNTAIN NATIONAL PARK

PARKWIDE MATERIALS SURVEY

SOURCES OF MATERIALS SAMPLED AND TESTED

Western Slope ☒ Eastern Slope ☐

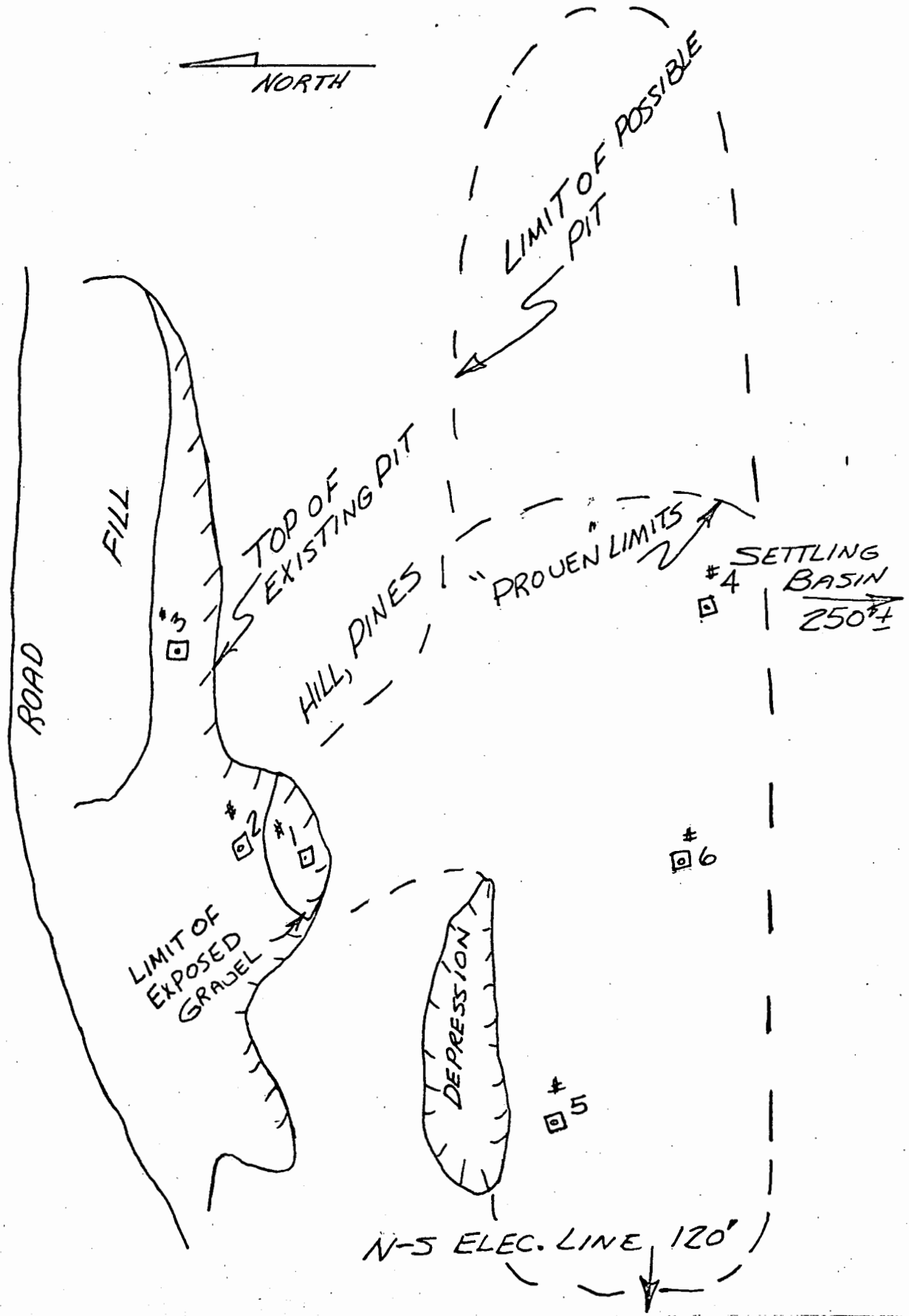
Pit Number 14-W BPR Lab. No. 67-463 through 67-467

Flight Strip 30 Photograph 2-48

LOCAL NAME, LOCATION AND GENERAL DESCRIPTION	Harbison Pit, an existing pit south of Harbison Meadows, located 4 miles west of U.S. Highway 34. Map Coordinates - Colorado Coordinate System, North Zone. 340 500 - 1905 000
QUANTITY	75,000± cubic yards.
ANALYSIS OF LABORATORY TEST DATA, CONDITIONS OF USE AND RECOMMENDATIONS	This material is suitable for only subbase, and wasting 16% of the total pit would be required to make subbase. Stripping of approximately 1' would be required and 5% of the material is in excess of 10", with a maximum size of ¼ cubic yard.

HARRISON PIT

1" = 100'



Western Slope
Harbison Pit
14-W

Log of Holes

Hole No. 1:

0-(+)5' Tan clayey sand and gravel. Cobbles are sub-angular to sub-rounded.

5% oversize to 18".

Represents 17' high pit face.

Hole No. 2:

0-4'+ Brown clayey sand and gravel. Very spotty with a few lumps of sandy clay. Cobbles are sub-angular (larger sizes) to sub-rounded (smaller sizes).

5-10% oversize decreasing with depth. 24" maximum size.

4+-9' Gray clean sand with some rounded gravel.

Hole No. 3:

0-4' Brown to dark gray, clayey sand and gravel to sandy clay. Wood fragments (fill).

4-9' Gray-brown, clean sand and fine gravel. Free water at $8\frac{1}{2}$' but not particularly damp above.

Hole No. 4:

0-6" Dark brown sandy clay, roots (topsoil).

6"-$3\frac{1}{2}$' Light brown clean sand and gravel. Cobbles are sub-rounded.

No oversize, maximum 3-4".

$3\frac{1}{2}$-11' Same but gray-brown. Half inch layers of fine gravel in clayey matrix at bottom.

Hole No. 5:

0-6"	Dark brown sandy, clay, roots, (topsoil).
6"-9'	Light brown clayey sand and gravel. Cobbles are sub-angular.
	5-10% oversize to $\frac{1}{4}$ cubic yard.

Hole No. 6:

0-2½'	Light brown clayey silt. Roots appear in upper 6".
2½-10'	Gray-brown clayey sand and gravel. Cobbles are sub-angular (larger sizes) to sub-rounded (smaller sizes). Becomes damper with depth. Small amount of seepage 1-2' above bottom.
	5% oversize to 24".

Form PR-9-230
April 1965

U. S. DEPARTMENT OF COMMERCE
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Separate Test Hole Gradation, L. L., and P. I.)

Lab. No: 67-463-467-P Field Sample No: _____ Date: May 8, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: Runyan Quantity Rep. _____ Name of Material Gravel

Source: Harbinson Pit

Test for: Gradation, L.L. & P.I. Tested by: R.G., A.T., R.R., K.R., D.G.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	67-463 Hole #1	67-464 Hole #2	67-468 Hole #3	67-465 Hole #4	67-466 Hole #5	67-467 Hole #6	Hole #7	Hole #8	Comb.
3"	92	100		97	91	90			96
1½"	85	96		92	83	82			89
1"	83	93		89	81	77			84
¾"	79	90		85	78	75			81
½"									
3/8"	71	84	100	78	72	67			75
#4	65	78	94	71	66	60			68
#8									
#10	57	69	86	58	58	52			59
#40	37	36	38	15	34	31			32
#200	17	9	1	1	16	15			12
L.L.	--	--	--	--	--	--			-6
P.I.	NP	NP	NP	NP	NP	NP			NP

REMARKS:

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Rev. April 1965

U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Sub-base, Base Course, and Base Stabilization)

Lab. No: 67-463-467-P Field Sample No: _____ Date: May 8, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: Runyan Quantity Rep. _____ Name of Material: Gravel

Source: Harbinson Pit

Test for: Sec. 104, 200 Tested by: D.G., K.R., A.T., R.G.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	Comb. Original	Sec. 104	Sec. 200	Degr.	Specifications Sec. 104	Specifications Sec. 200
3"	96					
1½"	89	100*			100	
1"	84	90				
¾"	81	82	100**	100		100
½"						
3/8"	75	71	68	72		
#4	68	62	51	59	30-70	35-65
#8						
#10	59	53	42	45		
#40	32	27	22	26		
#200	12	10	9	11	0-15	0-10
L. L.	--	--	--			
P. I.	NP	NP	NP			

STABILOMETER
"R" at P. S. I. Ex. Pressure
R 78
% Moisture 6.3
Density 134.7

Wt./Cu. Ft. Compacted
Base Course
T-180 Method D 141.0 @ 6.6%
Subbase
T-180 Method D (Rev) 139.7 @ 6.0%
Asphalt Mix
T-167 _____

Soft Particles 1 %
Fractured Faces 99 %

CEMENTATION
P. S. I. Comp. Str. 97

HUBBARD FIELD
% Swell _____
% Abs. _____
Stab. Wet _____
Stab. Dry _____
% Retained _____

L. A. ABRASION
Grading _____

	100 R	500 R
% Loss	_____	35.7

Sand Eq. _____

OIL DESIGN
Additive used SEE SHEET NO. 3
% by C. K. E. _____
% used _____
% swell _____
% absorption _____
Stability P. S. I.
Wet _____
Dry _____
% retained _____

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

Remarks: *This gradation was obtained by wasting 23% of the original -#4 material

** This gradation was obtained by wasting 60% of the original -#4 material

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Form PR-9-232
April 1965

U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Plant-mix and Chips)

Lab. No: 67-463-467-P Field Sample No: _____ Date: May 8, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted By: Runyan Quantity Rep. _____ Name of Material: Gravel

Source: Harbison Pit

Test for: Sec. 200 Tested by: D.G., R.G., A.T., K.R.

WASHED M. A. % PASSING

Sieve Size	Comb. Original	Sec. 200	Spec's. Sec. 200
3"	96		
1½"	89		
1"	84		
¾"	81	100	100
½"			
3/8"	75	68	
#4	68	51	35-65
#8			
#10	59	42	
#40	32	22	
#200	12	9	0-10
L. L.	--	--	
P. I.	NP	NP	

OIL DESIGN
120/150 AC

Additive Used	None	1%Acra	1%Lime
% by C. K. E.	4.8	4.8	5.3
% Used	5.8	5.8	6.3
% Swell	.06	.05	.05
% Absorption	1.1	0.9	0.8
Stability P. S. I.			
Wet . . . . . :	321	321	279
Dry	365	287	293
% Retained	88	112	95
Specific Gravity			
Laboratory	2.31	2.33	2.33
Theo. Max.	2.44	2.44	2.44
% Theo.	95	95	95
wt./cu.ft. compacted	147	148	148

HUBBARD FIELD

% Swell	0.0
% Abs.	1.4
Stab. Wet	900
Stab. Dry	1080
% Retained	83

L. A. ABRASION

Grading _____

	100 R	500 R
% Loss		

STATIC IMMERSION

% Additive	Film Retained 0 Hours	24 Hours
None	100	95+
0.5-A	100	95+
1-A	100	95+
1-PB	100	95+
RS-K	100	95+

SPECIFIC GRAVITY & ABS.

	+ #4	- #4	Comb.
Sp. Gr.	2.66	2.65	2.66
Abs.	1.1	2.1	1.6

Sand Equivalent	54
Soft Particles	%
Fractured Faces	%
T-101 Swell	0.39%
Sulfate Soundness	1 %

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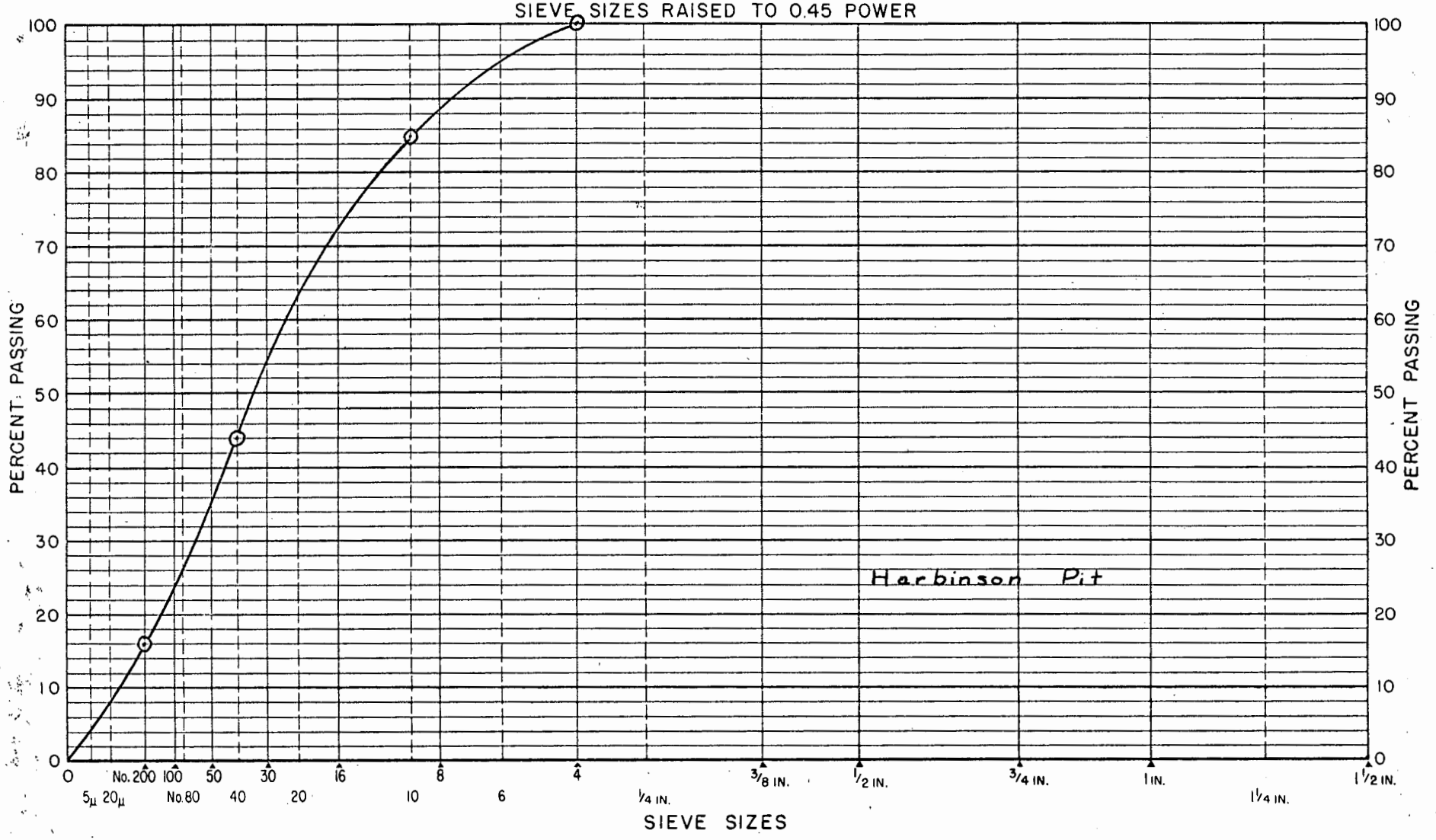
FORM PR-1115
(2-62)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS

GRADATION CHART

SIEVE SIZES RAISED TO 0.45 POWER



▲ THIS SYMBOL IDENTIFIES SIMPLIFIED PRACTICE AND COMPATIBLE SIEVE SIZES

Identification of gradations:

Sheet No.

Date

USCOMM-DC 40822-P62

FIGURE 12

Harbison Pit. Looking west, shows Holes 1, 2, and 3 along wall of existing pit.

FIGURE 13

Harbison Pit. Shows Hole 6 with morainal hill behind. Quite heavily timbered in this area.

ROCKY MOUNTAIN NATIONAL PARK

PARKWIDE MATERIALS SURVEY

SOURCES OF MATERIALS SAMPLED AND TESTED

Western Slope [X] Eastern Slope [ ]

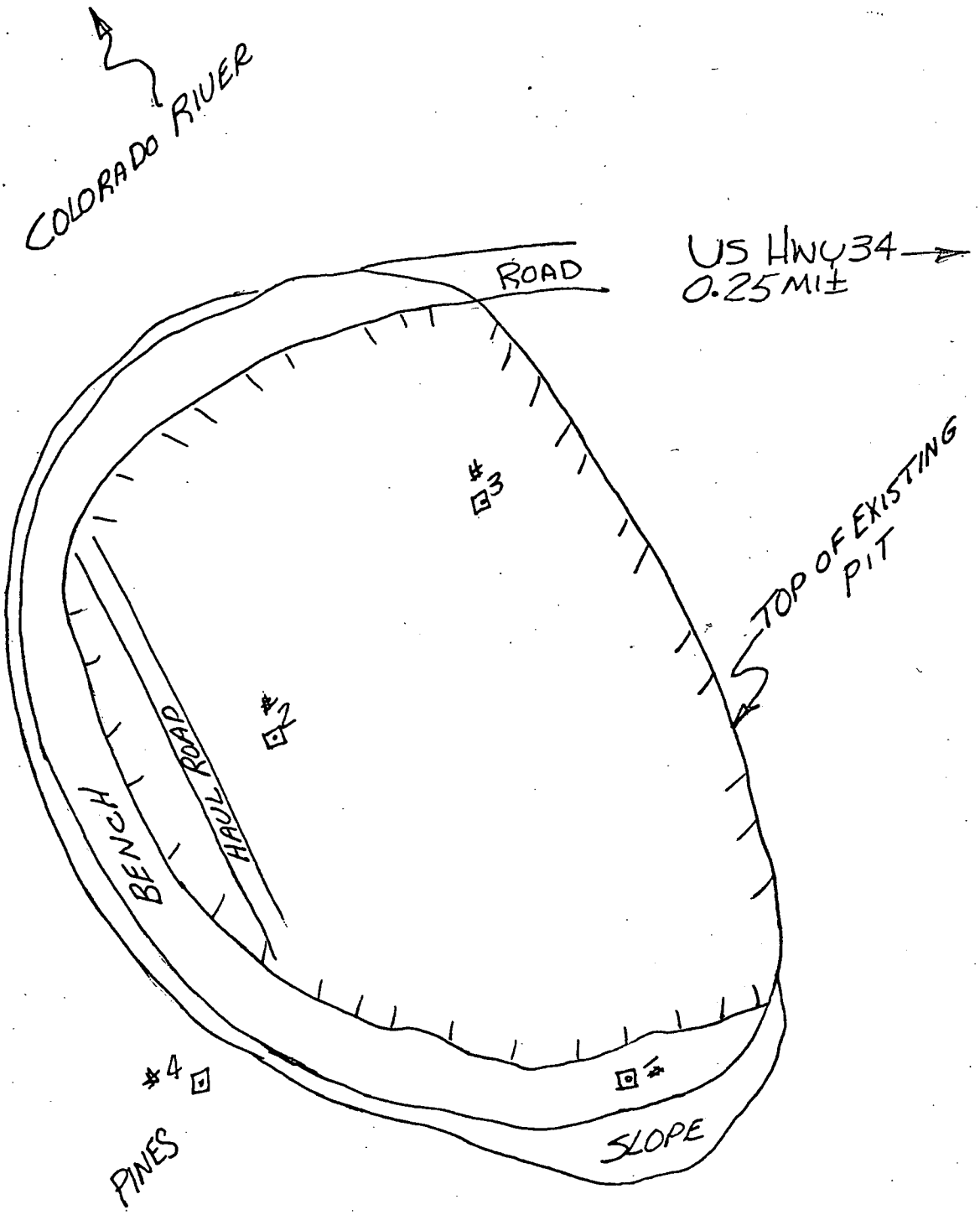
Pit Number 16-W BPR Lab. No. 67-455 through 67-458

Flight Strip 30 Photograph 2-44

LOCAL NAME, LOCATION AND GENERAL DESCRIPTION	"Round Pit", west of the proposed Harbison Meadows campground. This is an existing pit and about ¼ mile west of U.S. Hwy. 34. Map Coordinates - Colorado Coordinate System, North Zone. 347 500 - 1903 750
QUANTITY	37,000± cubic yards.
ANALYSIS OF LABORATORY TEST DATA, CONDITIONS OF USE AND RECOMMENDATIONS	This material is suitable for subbase, base, bituminous stabilized base, surfacing, and concrete aggregate. However, an antistripping agent such as hydrate lime or Acra, will be needed when used with asphalt. In July, 1967, during sampling 75% of pit was covered by 2' of water. There is negligible material in excess of 10". Developing pit in the SE direction will produce much more material of similar quality with approximately 1' of stripping.

1" = 100'

"ROUND" PIT



Western Slope
"Round" Pit
16-W

Log of Holes

Hole No. 1:

0-6"	Light brown, dry, sandy clay.
6"-11'	Brown, slightly clayey sand and coarse gravel. Cobbles are sub-rounded. Becomes damp at 4'. Becomes grayer and sandier at 8½'.
	Minor amount of oversize to 10-12".

Hole No. 2:

0-6'	Brown damp to wet sand and gravel. Cobbles are sub-rounded. Water running in at 2½'.
	No oversize. 6" maximum size.

Hole No. 3:

0-6"	Light brown sandy clay.
6"-8'	Brown, slightly clayey sand and gravel. Cobbles are sub-rounded. Water at 7'. Minor amount of oversize with maximum size of 10-12".

Hole No. 4:

0-1'	Brown sandy clay, roots, (poor topsoil).
1-3'	Light brown, slightly clayey sand and gravel. Cobbles are sub-rounded.
	No oversize, 6" maximum size.
3-10'	Gray-brown, clean, damp, sand and coarse gravel. Cobbles are sub-rounded.
	Less than 5% oversize to 15".

Form PR-9-230
April 1965

U.S. DEPARTMENT OF COMMERCE
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Separate Test Hole Gradation, L. L., and P. I.)

Lab. No: 67-455-458-P Field Sample No: _____ Date: May 7, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: Runyan Quantity Rep. _____ Name of Material Gravel

Source: Round Pit

Test for: Gradation, L.L. & P.I. Tested by: D.G., K.R., A.T., R.G., P.B.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	67-455 Hole #1	67-456 Hole #2	67-457 Hole #3	67-458A Hole #4	67-458B Hole #5	Hole #6	Hole #7	Hole #8	Comb.
3"	97	96	99	76	84				93
1½"	87	85	74	62	65				80
1"	81	70	65	54	56				75
¾"	76	66	60	49	50				70
½"									
3/8"	64	53	50	40	41				59
#4	53	42	52	31	33				49
#8									
#10	39	29	33	21	24				38
#40	12	10	11	5	5				12
#200	1	1	3	1	1				2
L.L.	--	--	--	--	--				--
P.I.	NP	NP	NP	NP	NP				NP

REMARKS:

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U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Sub-base, Base Course, and Base Stabilization)

Lab. No: 67-455-458-P Field Sample No: _____ Date: May 7, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: Runyan Quantity Rep. _____ Name of Material: Gravel

Source: Round Pit

Test for: Sec. 104, 200 Tested by: D.G., K.R., A.T., R.G., P.B.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	Comb. Original	Sec. 104	Sec. 200	Degr.	Specifications Sec. 104	Specifications Sec. 200
3"	93					
1½"	80	100			100	
1"	75	87				
¾"	70	75	100	100		100
½"						
3/8"	59	59	73	75		
#4	49	47	58	64	30-70	35-65
#8						
#10	38	35	42	47		
#40	12	10	16	20		
#200	2	2	3	6	0-15	0-10
L. L.	--	--	--	--		
P. I.	NP	NP	NP	NP		

STABILOMETER
"R" at 240 P. S. I. Ex. Pressure

R	70
% Moisture	6.8
Density	127.9

Wt./Cu. Ft. Compacted

Base Course	
T-180 Method D	139.2 @6.4%
Subbase	
T-180 Method D (Rev.)	137.8 @ 7.5%
Asphalt Mix	
T-167	
Soft Particles	0 %
Fractured Faces	100 %

CEMENTATION
P. S. I. Comp. Str. 12

HUBBARD FIELD
% Swell _____
% Abs. _____
Stab. Wet _____
Stab. Dry _____
% Retained _____

L. A. ABRASION
Grading _____

	100 R	500 R
% Loss	_____	32

Sand Eq. 89

OIL DESIGN
Additive used SEE SHEET NO. 3
% by C. K. E. _____ _____ _____
% used _____ _____ _____
% swell _____ _____ _____
% absorption _____ _____ _____
Stability P. S. I.
Wet . . . . . _____ _____ _____
Dry . . . . . _____ _____ _____
% retained _____ _____ _____

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

Remarks: _____

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April 1965

U. S. DEPARTMENT OF TRANSPORTATION
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Plant-mix and Chips)

Lab. No: 67-455-458-P Field Sample No: _____ Date: May 7, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted By: Runyan Quantity Rep. _____ Name of Material: Gravel

Source: Round Pit

Test for: Oil Design, Soundness, Stat. Imm., Hub. Field Tested by: D.G., K.R., A.T., R.G., P.B.

WASHED M. A. % PASSING

Sieve Size	Comb. Original	Sec. 200	Spec's. Sec.
3"	93		
1½"	80		
1"	75		
¾"	70		
½"			
3/8"	59		
#4	49		
#8			
#10	38		
#40	12		
#200	2		
L. L.	--		
P. I.	NP		

OIL DESIGN
120/150 AC

Additive Used	None	1%Acra	1%Lime
% by C. K. E.	4.5	4.5	5.1
% Used *	6.5	6.5	7.1
% Swell	0.3	0.2	0.2
% Absorption	3.3	2.4	2.2
Stability P. S. I.			
Wet	99	165	146
Dry	153	160	174
% Retained	65	103	84
Specific Gravity			
Laboratory	2.23	2.24	2.27
Theo. Max.	2.44	2.44	2.44
% Theo.	91	92	93
wt./cu.ft. compacted	143	143	145

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

HUBBARD FIELD

% Swell	0.75
% Abs.	1.6
Stab. Wet	740
Stab. Dry	1540
% Retained	48

STATIC IMMERSION

% Additive	Film Retained 0 Hours	24 Hours
None	100	95+
0.5-A	100	95+
1-A	100	95+
1-PB	100	95+
RS-K	100	95+

Sand Equivalent	
Soft Particles	%
Fractured Faces	%
T-101 Swell	0.16 %
Sulfate Soundness	1 %

L. A. ABRASION
Grading _____

% Loss	100R	500R

SPECIFIC GRAVITY & ABS.

	+ #4	- #4	Comb.
Sp. Gr.	2.71	2.72	2.71
Abs.	0.9	1.5	1.2

Remarks: *Percent used by Rice Vacuum

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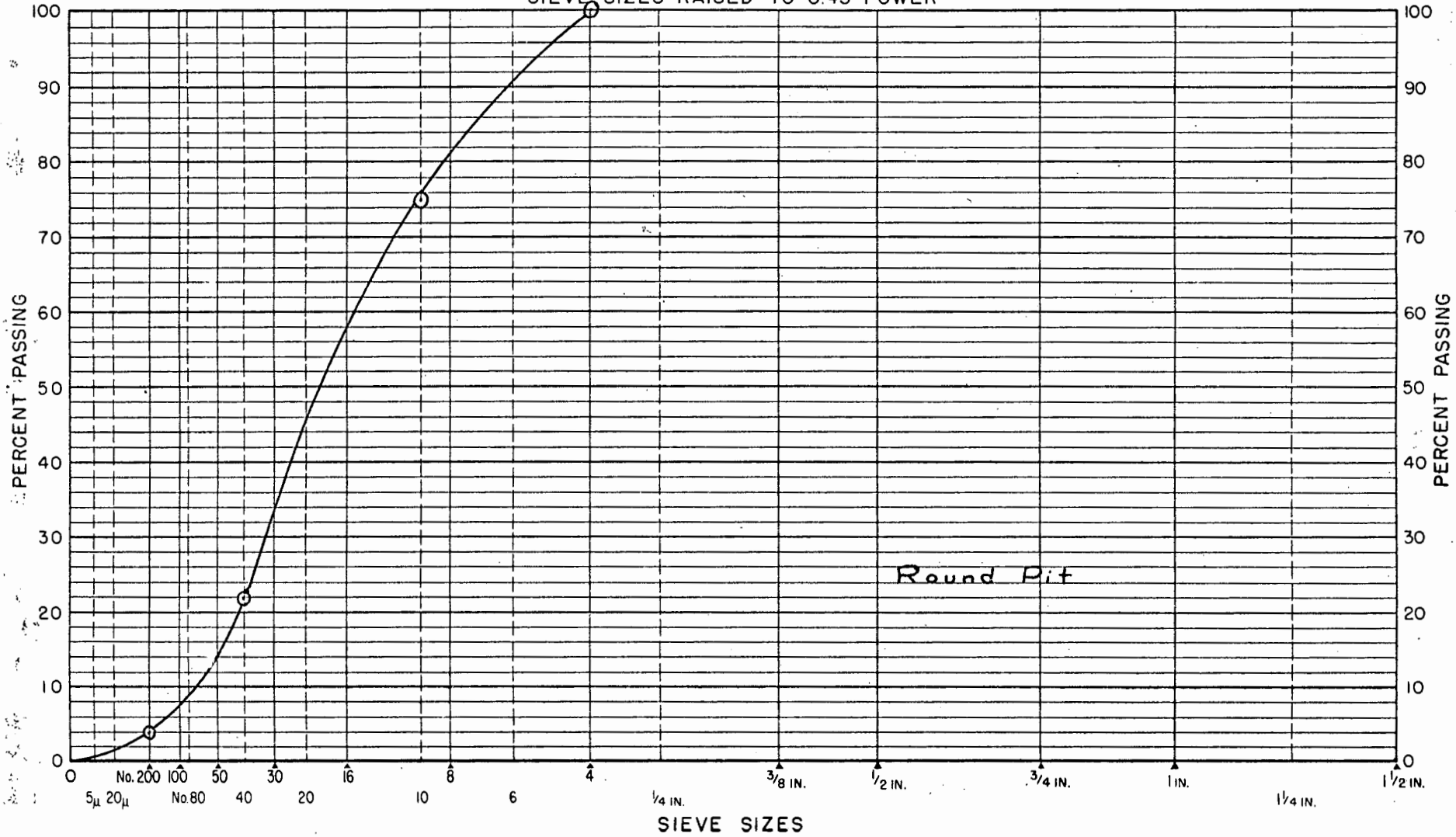
FORM PR-1115
(2-62)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS

GRADATION CHART

SIEVE SIZES RAISED TO 0.45 POWER



▲ THIS SYMBOL IDENTIFIES SIMPLIFIED PRACTICE AND COMPATIBLE SIEVE SIZES	Idenification of gradations:	Sheet No.
		Date

USCOMM-DC 40822-P62

FIGURE 14

Round Pit. Looking southwest over old existing pit area. Holes 1, 2, and 3 are indicated. Hole 4 is in trees behind power shovel.

ROCKY MOUNTAIN NATIONAL PARK

PARKWIDE MATERIALS SURVEY

SOURCES OF MATERIALS SAMPLED AND TESTED

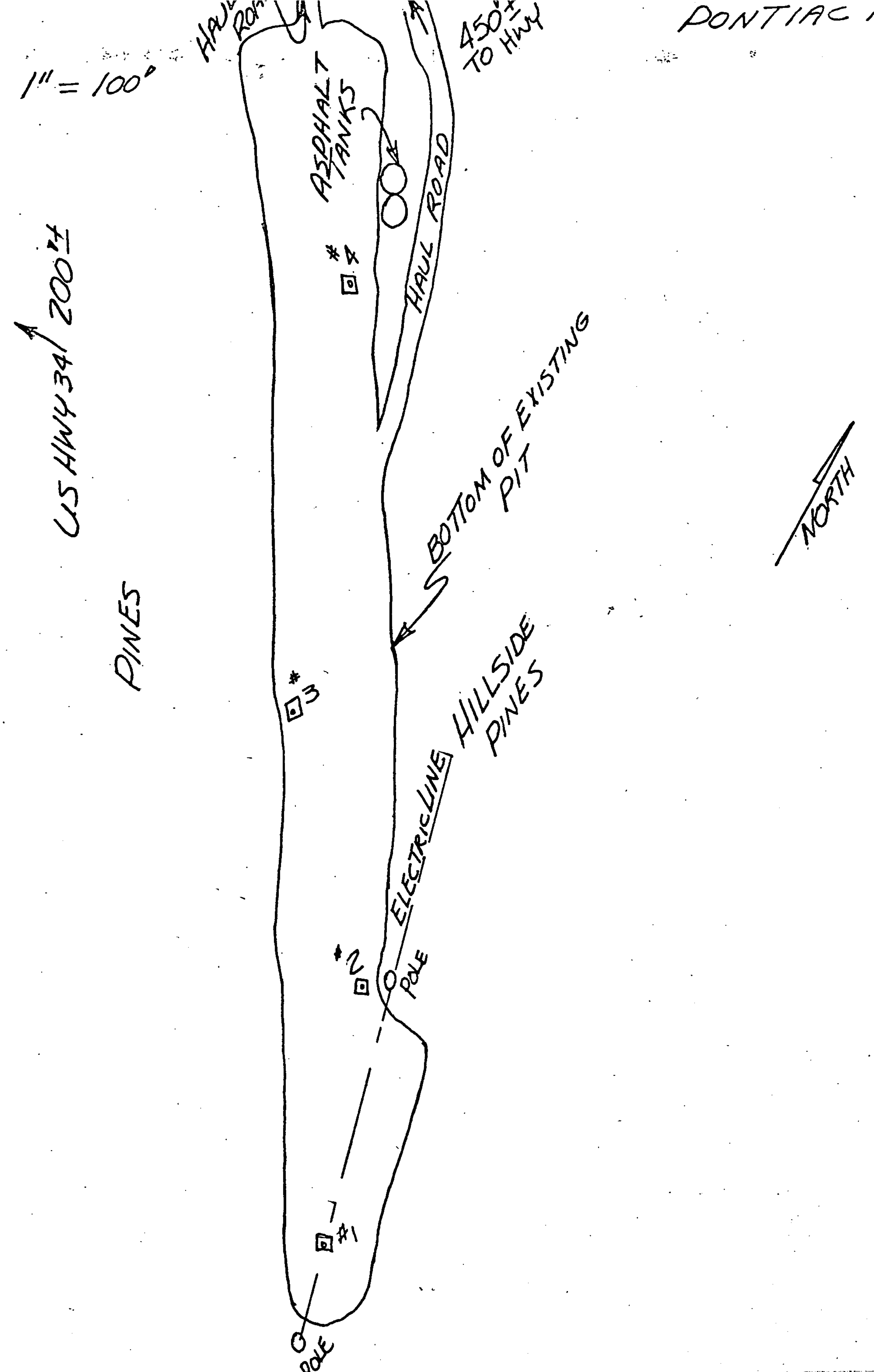
Western Slope [X] Eastern Slope [ ]

Pit Number 17-W BPR Lab. No. 67-459 through 67-462

Flight Strip 30 Photograph 2-37

LOCAL NAME, LOCATION AND GENERAL DESCRIPTION	Pontiac Pit, an existing pit east of Trail Ridge Road, approximately 5½ miles north of Grand Lake. Map Coordinates - Colorado Coordinate System, North Zone. 362 125 - 1901 875
QUANTITY	23,000 cubic yards
ANALYSIS OF LABORATORY TEST DATA, CONDITIONS OF USE AND RECOMMENDATIONS	This material is suitable for subbase, base, bituminous base, seal coat chips, and bituminous surfacing. It could be used for concrete aggregate with a small amount of washing. The pit can not be extended horizontally but it may be deepened. This will be a wet pit during spring time. A minimum amount of stripping will be required, and there is a negligible amount of material in excess of 10".

PONTIAC PIT



1" = 100'
450'± TO HWY
ASPHALT TANKS
HAUL ROAD
#4
US HWY 34/200 ±
BOTTOM OF EXISTING PIT
NORTH
PINES
#3
HILLSIDE PINES
ELECTRIC LINE
#2
POLE
#1
POLE

Western Slope
Pontiac Pit
7-W

Log of Holes

Hole No. 1:

0-1'	Gray-brown, clayey sand and gravel. Few cobbles to 6" and sub-rounded.
1-9'	Same material, but slightly clayey. Becomes damper with depth but no free water.

Hole No. 2:

0-10½'	Gray-brown, slightly clayey sand and gravel. Cobbles are sub-rounded with maximum size 3-4". Very damp toward bottom.

Hole No. 3:

0-4"	Asphalt mixed with sand and gravel due to mixing operations.
4"-9½'	Brown, slightly clayey sand and gravel. Few cobbles are sub-rounded, 6" maximum diameter.

Hole No. 4:

0-10½'	Brown, clayey to slightly clayey sand and coarse gravel. Cobbles are sub-rounded, maximum diameter of 6". Becomes wet at 4'.

Form PR-9-230
April 1965

U. S. DEPARTMENT OF COMMERCE
Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Separate Test Hole Gradation, L. L., and P. I.)

Lab. No: 67-459-462-P Field Sample No: _____ Date: February 7, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: Runyan Quantity Rep. _____ Name of Material Gravel

Source: Pontiac Pit

Test for: Gradation, L.L. & P.I. Tested by: R.R., & R.G.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	67-459 Hole #1	67-460 Hole #2	67-461 Hole #3	67-462 Hole #4	Hole #5	Hole #6	Hole #7	Hole #8	Comb.
3"			92	98					100
1½"	96	95	75	85					86
1"	93	91	69	78					81
¾"	87	83	65	73					73
½"									
3/8"	72	67	53	58					59
#4	54	50	41	42					43
#8									
#10	37	35	30	24					31
#40	13	13	10	9					10
#200	3	3	3	3					3
L.L.	--	--	--	24					--
P. I.	NP	NP	NP	2					NP

REMARKS: 67-459 represents 25% of total pit
67-460 represents 26% of total pit
67-461 represents 24% of total pit
67-462 represents 25% of total pit

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

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Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Sub-base, Base Course, and Base Stabilization)

Lab. No: 67-459-462-P Field Sample No: _____ Date: February 7, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted by: Runyan Quantity Rep. _____ Name of Material: Gravel

Source: Pontiac Pit

Test for: Sec. 104, 200, Degradation, Compaction, L.A. Abrasion Tested by: R. R., & R.G.

WASHED MECHANICAL ANALYSIS, % PASSING

Sieve Size	Comb. Original	Sec. 104	Sec. 200	Degr.	Specifications Sec. 104	Specifications Sec.200
3"	100					
1½"	86	100*			100	
1"	81	97				
¾"	73	83	100**			100
½"						
3/8"	59	63	72	76		
#4	43	47	51	59	30-70	35-65
#8						
#10	31	32	34	42		
#40	10	11	13	19		
#200	3	3	4	6	0-15	0-10
L.L.	--	--	--	--		
P.I.	NP	NP	NP	NP		

STABILOMETER
"R" at P. S. I. Ex. Pressure: 81
% Moisture: 7.6
Density: 133.2

Wt./Cu. Ft. Compacted
Base Course
T-180 Method D: 139.1 @ 6.0%
Subbase
T-180 Method D (Rev): 138.4 @ 7.7%
Asphalt Mix
T-167: _____

Soft Particles: 0.0 %
Fractured Faces: 96 %

CEMENTATION
P. S. I. Comp. Str. 60

HUBBARD FIELD
% Swell: _____
% Abs.: _____
Stab. Wet: _____
Stab. Dry: _____
% Retained: _____

L. A. ABRASION
Grading _____

	100 R	500 R
% Loss	7.78	31.08

Sand Eq. 59

OIL DESIGN
Additive used: SEE SHEET NO. 3
% by C. K. E.: _____
% used: _____
% swell: _____
% absorption: _____
Stability P. S. I.
Wet . . . . . : _____
Dry . . . . . : _____
% retained: _____

Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

Remarks: * This gradation was obtained by crushing the +1½" material to -1½".
** This gradation was obtained by crushing the +3/4" to - 3/4".

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Bureau of Public Roads
Region Nine

REPORT OF TESTS ON SURFACING AND OIL-MAT MATERIALS
(Plant-mix and Chips)

Lab. No: 67-459, 462-P Field Sample No: _____ Date: February 7, 1968

Project: Rocky Mountain National Park, 1967 Survey

Submitted By: Runyan Quantity Rep. _____ Name of Material: Gravel

Source: Pontiac Pit

Test for: Oil Design Tested by: R. R. & R.G.

WASHED M.A. % PASSING

Sieve Size	Comb. Original	Sec.	Spec's. Sec.
3"	100		
1½"	86		
1"	81		
¾"	73	100	100
½"			
3/8"	59	72	
#4	43	51	35-65
#8			
#10	31	34	
#40	10	13	
#200	3	4	0-10
L. L.	--	--	
P. I.	NP	NP	

OIL DESIGN
120/150 AC

Additive Used	None	1%Lime	1% Acra
% by C. K. E.	4.8	5.5	4.8
% Used	6.8	7.5	6.8
% Swell	0.2	0.1	0.2
% Absorption	2.5	1.6	2.2
Stability P. S. I.			
Wet	149	178	167
Dry	179	187	205
% Retained	85	95	81
Specific Gravity			
Laboratory	2.24	2.27	2.25
Theo. Max.	2.41	2.41	2.41
% Theo.	93	94	93
wt/cu.ft. compacted	140	143	142

HUBBARD FIELD

% Swell	1.0
% Abs.	2.3
Stab. Wet	950
Stab. Dry	1640
% Retained	58

L. A. ABRASION
Grading _____

	100R	500R
% Loss		

STATIC IMMERSION

% Additive	Film Retained 0 Hours	24 Hours
None	100	95+
0.5-A	100	95+
1-A	100	95+
1-PB	100	95+
RSK	100	95+

SPECIFIC GRAVITY & ABS.

	+ #4	- #4	Comb.
Sp. Gr.	2.69	2.70	2.69
Abs.	1.5	2.5	2.0

Sand Equivalent _____

Soft Particles _____ %

Fractured Faces _____ %

T-101 Swell 0.8 %

Sulfate Soundness 0 %

DISTRIBUTION:

Region Office	1
Division Office	1
Project Eng.	1
Lab. File	2

Remarks: Test data represented on this page is limited to the samples from the specific locations shown and to those locations alone.

REPORTED BY: ekt

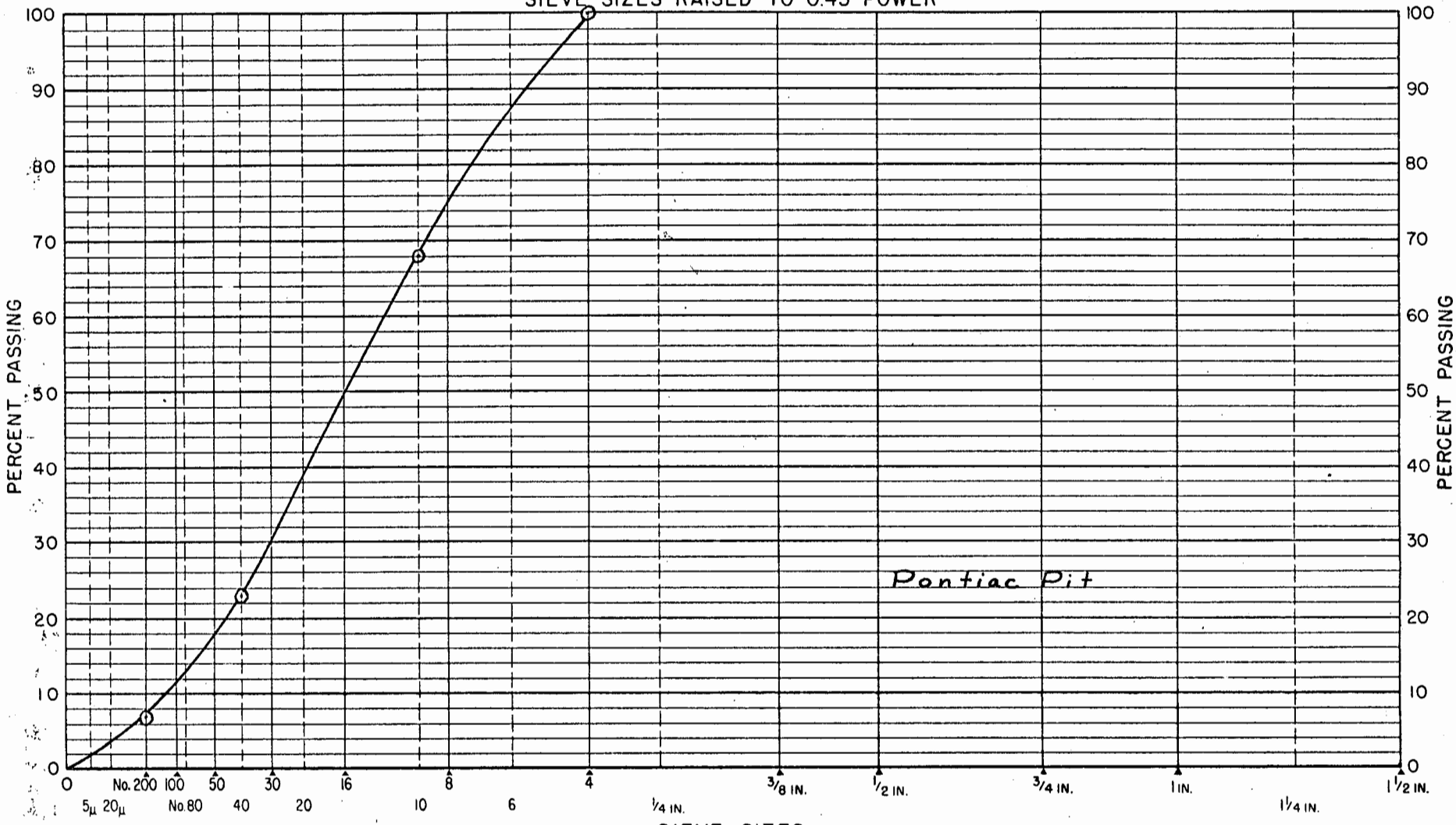
GPO 838-024

FORM PR-1115
(2-62)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS

GRADATION CHART

SIEVE SIZES RAISED TO 0.45 POWER



▲ THIS SYMBOL IDENTIFIES SIMPLIFIED PRACTICE AND COMPATIBLE SIEVE SIZES	Idenification of gradations:	Sheet No.
		Date

USCOMM-DC 40822-P62

FIGURE 15

Pontiac Pit. Looking south from asphalt tanks. Holes 1, 2, 3, and 4 are indicated. Pit site is in old existing pit site used for asphalt storage and mixing.

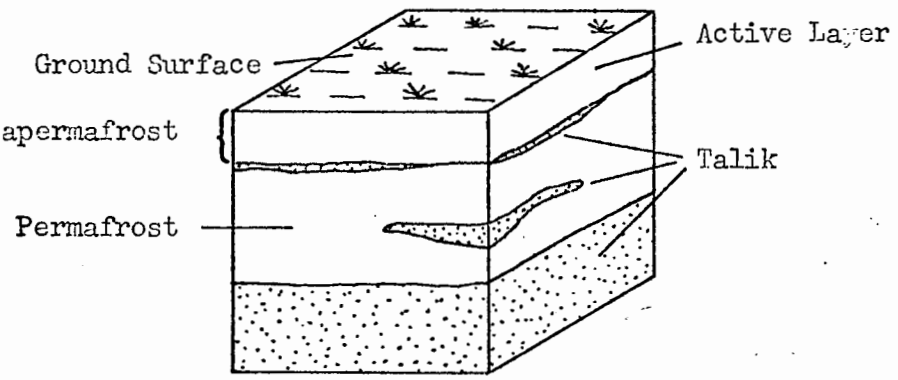
ALPINE SECTION

Ecological Effects

Experience shows that permafrost tundra exists in a delicate limbo with its enviorns. We know that such areas heave and subside as a direct function of temperature and soil conditions, where silts and clays are the most susceptible. Such sensitivity has been exhibited on several occasions on the Alaskan wilderness where slopes of less than one percent have flowed upon thawing. After thawing the bearing capacity and stability of a soil is reduced substantially for a certain period of time. These phenomena are a direct function of soil porosity, moisture content, and the amount and magnitude of ice lenses and wedges.

Permafrost is defined exclusively on the basis of temperature. It is rock or soil material, with or without included moisture or organic matter, that has remained below 0° C (32° F.) continuously for two or more years. In most areas it has remained frozen for many thousands of years; however, permafrost can be quite young in areas where very recent sediments have been laid down, where very recent changes in the location of water bodies have taken place, and where man has disturbed the terrain.

The permafrost table is the upper surface of the permafrost, and the ground above the permafrost table is called the suprapermafrost layer. The active layer is that part of the suprapermafrost zone that freezes in the winter and thaws in the summer, or simply, seasonally frozen ground. Because water in the soil tends to reduce temperature fluctuations from summer to winter, the summer thawing - and hence the active layer - is deeper in drier materials. Seasonal frost penetrates down to the permafrost table in most places; however, if it does not, an unfrozen zone called a talik remains between the bottom of the seasonal frost and the permafrost table. Unfrozen zones within and below the permafrost also are called taliks.



As can be seen from the foregoing discussion and illustration, the system is directed by a very fragile thermal condition. Any disturbance, such as that created man, that jeopardizes this equilibrium may result in an irreversible condition related to thawing that is irrepairable. Roads in permafrost areas that are built on the vegetation without fill, quickly becomes useless. Such damage would leave an unsightly scar upon the tundra landscape.

Construction and maintenance in regions underlain by permafrost are characterized by a wide range of problems in addition to those experienced elsewhere. Basically, there are two methods of constructing on permafrost: (1) the active method, and (2) the passive method.

The active method is used in areas where permafrost is thin and generally discontinuous or where it contains relatively small amount of ice. The object of this method is to thaw the permafrost, and if the thawed material has a satisfactory bearing strength, then construct in a normal manner. Generally, the thawing of the permafrost is accomplished simply by clearing the vegetation, which normally insulates the permafrost from the heat in the air and from solar radiation. Naturally, the active method of construction has limited application because it is a function of permafrost thickness and thawing time required.

The passive method, which has broad application throughout most of the permafrost region, where it is impractical to thaw the permafrost. The object of this method is to minimize disturbance of the permafrost and of the thermal regime. The thermal regime in an area in a natural undisturbed state is normally in quasi-equilibrium with all the environmental factors, but in many areas this state of equilibrium is very sensitive. The simmple passage of a tracked vehicle that destroys the vegetation mat is enough to upset the delicate balance and to cause the top of the permafrost layer to thaw. This thawing can cause differential settlement of the surface of the ground, drainage problems, and severe frost action. Once the equilibrium is upset, the whole process can feed on itself and be practically impossible to reverse.

Engineering problems in permafrost nearly always are associated with the active layer (the layer that freezes and thaws annually) and the active layer-permafrost interface (permafrost table). Changes in the surface environment, either natural or man made, produce thermal changes in this zone that can have serious effects upon engineering works.

Ultimately, the problem of building in or on permafrost, or traversing the same, is to not upset the thermal regime. Pit and quarry access roads should be constructed as a low fill consisting of coarse free drainage material upon the local vegetation. All construction should be undertaken when the active layer is frozen and possesses bearing capacity.

GENERAL GEOLOGIC DISCUSSION

ROCKY MOUNTAIN NATIONAL PARK - MATERIALS SURVEY

(Alpine Area)

By

R. G. Burdick

January 1965

This report covers the survey increment through the high alpine area, flight strips 16 through 26 and 27. The elevations covered by these strips range from 9,000 feet to 12,000 feet. This area includes that portion of road known as the Trail Ridge Road.

The geologic features through this area include the granites and schists of the Longs Peak batholith; the pyroclastics and flow rocks of the Specimen Mountain volcano; and the glacially cut areas and a portion of their moraines. A large portion of this section is in the above-timberline area of the Continental Divide. Precipitation for this area is shown as 18 - 24 inches per year.

The Longs Peak batholith is composed mainly of a moderately coarse grained, commonly porphyritic, flesh colored to gray granite in which the feldspar crystals are usually oriented along their long axis. This granite commonly shows an orbicular structure and weathers into fragmental crystals. A different granite may be encountered at or south of Fall River Pass. This granite, the Mt. Olympus, is a fine to medium grained, even textured, mostly light gray salt-and-pepper biotite granite which weathers more uniformly than the Longs Peak granite noted previously.

The batholith is still covered extensively with a roof of schist through this area. Many of the glacial cirques in this area show, in addition to this roof, many schist roof pendants and xenoliths in the granite rock. The schist is derived mainly from

shales and sandstones which have been injected with granite magma. In general, the schistocity parallels the original bedding planes of the sediments. The schist is lying nearly horizontal at the continental divide, but to the west, the dip ranges from 15° - 40° NW. The schist near Fall River Pass has been intruded by a graphic granite. It is noted in the literature that there is a great diversity in types of schist which may be encountered in this general area.

From about Iceberg Lake to Poudre Lake, pyroclastics and flow rocks may be encountered. The source of these volcanics was Specimen Mountain, a late tertiary volcano. Specimen Mountain has an elevation of 12,482 feet and has been subjected to intense alpine glaciation and considerable faulting. The northwest and south slopes drop steeply into valleys 2500' - 3000' below.

The volcano shows two distinct types of extrusives:

1. The basal flows are quartz latite ash, resting on eroded pre-Cambrian gneiss and schist, overlain by quartz latite flows. (The basal ashes are described as brown glass with rare phenocrysts of labradorite alternation with quartz latite flows.) The basal flow rock is dark gray to greenish gray in fresh exposures, while surface alteration intensifies the green color or produces purple, brown and orange colors. Hand specimens show phenocrysts of plagioclase, needles of black amphibole (hornblende, augite), and plates of biotite, all embedded in a fine-grained holocrystalline groundmass.

2. The upper flows consist of thick beds of rhyolitic pyroclastics overlain by rhyolite flow rock. The pyroclastics are described as beds of rhyolite ash, agglomerates containing large portions of the basal and underlying pre-Cambrian rock, and breccias with thin beds of tuff. The literature notes the presence of mud flows in the pyroclastic beds. Overlying the pyroclastic beds are several hundred feet of rhyolite flows interbedded with ash and breccia lenses and containing some pitchstone layers. The rhyolite is described as light gray to pinkish gray and showing conspicuous flow banding. Topaz crystals are locally abundant in gas cavities in the porous rhyolite. The literature notes extensive bentonite beds near the saddle of Specimen Mountain (vicinity Poudre Lake.) These beds may also influence the character of the soils and aggregates southward in the Colorado River Valley.

It is anticipated that gravel aggregate sources will be scarce through this area. However, quarry sources are distinctly possible. Some of the potential areas are:

(a) The quartz latite flows near the north end of Poudre Lake.

(b) The rhyolite or welded tuff exposed near Iceberg Lake.

(c) The Mt. Olympus granites in vicinity of Iceberg Pass - rock cut.

(d) Granite outcrops near upper end of old Fall River Road.

It may be necessary to also investigate some of the glacial materials near the upper end of Horseshoe Park or near Deer Ridge.

The literature notes the presence of ancient mudflows near Specimen Mountain; however, whether these or other types of slides are presently active will have to be field checked. The presence of landslides in the bentonite beds near Poudre Lake are a distinct possibility; although they have not been noted in the literature.

BIBLIOGRAPHY

Boos, C. M. and F. M., 1934, Granites of the Front Range - The Longs Peak - St. Vrain Batholith. Geological Society American Bulletin, Volume 45.

Jones & Quam, 1944, Glacial Landforms in Rocky Mountain National Park. Journal of Geology, Volume 52.

Wahlstrom, E. E., 1944, Structure and Petrology of Specimen Mountain, Colorado. Geological Society American Bulletin, Volume 55.

Maps

McHenrys Peak

Trail Ridge

Grand Lake

Fall River Pass

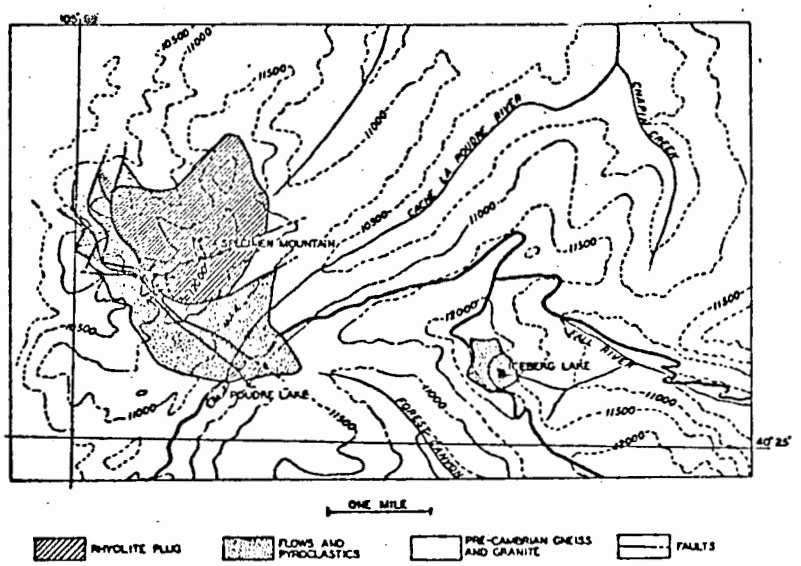


FIGURE 5. *Geologic map showing relationship of flow at Iceberg Lake to Specimen Mountain*

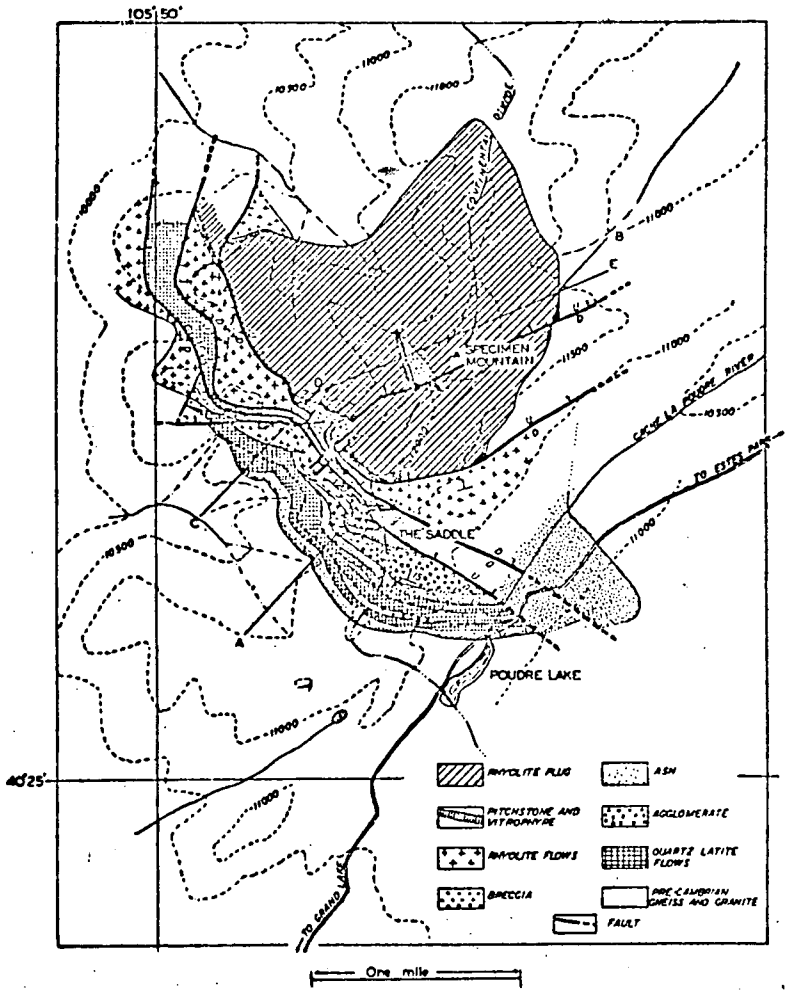


FIGURE 2. *Geologic map of Specimen Mountain area*

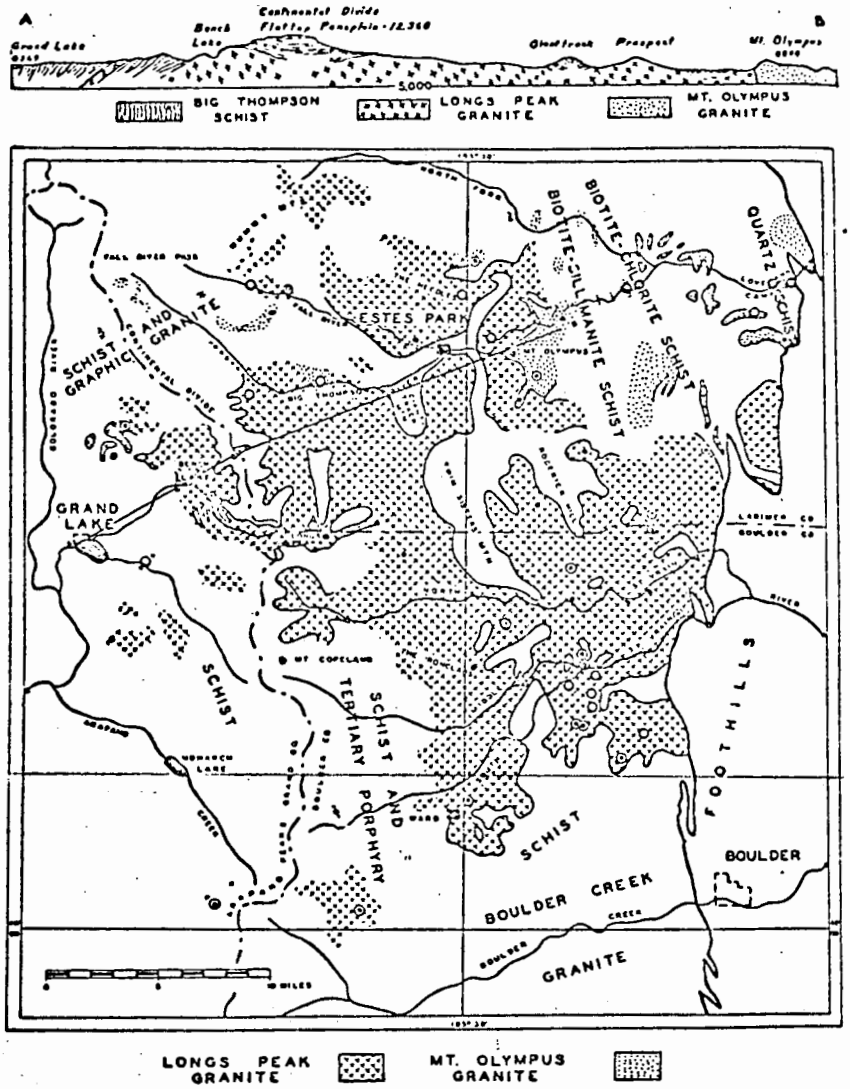


FIGURE 2.—*Longs Peak-St. Vrain batholith*

DISCUSSION OF PHOTOGRAPHS

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ROCKY MOUNTAIN NATIONAL PARK - MATERIALS SURVEY

(Alpine Section)

By

Robert L. Schuster

September 1966

PHOTOGRAPHIC INFORMATION

Flight Strip	16	Photographs 3-73 thru 3-80	(8/65 date flown)
Flight Strip	17	Photographs 3-67 thru 3-72	(8/65)
Flight Strip	18	Photographs 3-61 thru 3-66	(8/65)
Flight Strip	19	Photographs 3-57 thru 3-60	(8/65)
Flight Strip	20	Photographs 3-81 thru 3-85	(8/65)
Flight Strip	21	Photographs 3-1 thru 3-11	(8/65)
Flight Strip	22	Photographs 3-12 thru 3-18	(8/65)
Flight Strip	23	Photographs 3-19 thru 3-32	(8/65)
Flight Strip	24	Photographs 3-33 thru 3-41	(8/65)
Flight Strip	25	Photographs 3-42 thru 3-47	(8/65)

Scale: 1:9600 (800 feet to one inch)

Width of flight strips: Approximately 7200 feet

Type of film: Agfa Color

GEOLOGIC REFERENCES

The following geologic references refer to the Trail Ridge area which for this report is taken to extend from the vicinity of Rainbow Curve and Sheep Lakes on the east to the area where the highway climbs out of the valley of the North Fork of the Colorado River on the west.

1. Boos, M. F., and Boos, C. M., "The Longs Peak-St. Vrain Batholith," Bulletin, Geological Society of America, Vol. 45, pp. 303-332, April 1934.

2. Wahlstrom, E. E., "Structure and Petrology of Specimen Mountain, Colorado," Bulletin, Geological Society of America, Vol. 55, No. 1, pp. 77-90, January 1944.

3. Richmond, G. M., "Glaciation of the East Slope of Rocky Mountain National Park, Colorado," Bulletin, Geological Society of America, Vol. 71, pp. 1371-1382, September 1960.

MAPPING SYMBOLS

All - Alluvium. Generally too fine-grained and poorly graded to be designated as sand and gravel.

Coll/Gr - Thin colluvium (generally less than 10 feet thick) over granite bedrock.

Fan - Alluvial fan. These deposits have been differentiated from sand and gravel (SG) deposits because they generally are more poorly graded. Occasionally these fans are composed partially of colluvial detritus in addition to alluvium.

Gn - Gneiss. The gneisses in this area often locally grade into schists, and it is not possible to differentiate between them in mapping on this scale. Where both rock types are present, the symbol for gneiss is used where gneiss predominates.

Gr - Granite.

Mo - Glacial moraine. In most cases this can be classified as till, but locally it may contain deposits of waterworked material too small or indistinct to be differentiated in mapping.

Mo/Gn - Thin glacial moraine (generally less than 10 feet thick) over gneiss bedrock.

Mo/Sch - Thin glacial moraine (generally less than 10 feet thick) over schist bedrock.

O - Organic material (peat and muck). Where these deposits contain considerable soil, they are suitable for use as topsoil. Where the material is mostly peat and contains only a minor percentage of soil, it is suitable for mulch or as a soil conditioner.

Sch - Schist. When schists and gneisses are both present locally, the symbol for schist is used where schist predominates.

SG - Sand and gravel.

Ta - Talus deposits.

Vol - Undifferentiated volcanic rocks. May be either flows or pyroclastics.

DESCRIPTION OF MATERIALS

Flight Strip 16, Photographs 3-73 thru 3-80
Flight Direction: West to East

Photograph 3-80

The sand and gravel (SG) along the Fall River is fairly clean. This material is suitable for use as subbase or possibly base course material. Note that the eastern one-third of this photograph has not been mapped due to lack of stereoscopic coverage; this explains the abrupt termination of the boundary between sand and gravel (SG) and granite (Gr) near the Fall River Entrance to the Park.

The sand and gravel (SG) in the southwest corner of the photograph appears to be a fairly thin deposit of rather dirty sand and fine gravel. It would be suitable for common borrow or subbase.

The organic material (O/SG) on the floodplain of the Fall River is on the order of 1 to 3 feet thick. The gravel underlying this peat and muck is probably of good quality and could be worked in a wet operation. The ensuing lake could be landscaped to look natural.

The morainic material (Mo) is a fairly coarse till. It would be suitable for use as subbase.

The granite (Gr) is a medium- to coarse-grained granite and weathers fairly easily. If weathered, it would probably

be suitable for crushed stone or riprap. It would perform best as a base course protected from weathering by a bituminous surface.

Photographs 3-78 and 3-76

The SG on these photographs is a fairly clean sand and gravel suitable for use as subbase and probably as base course material. Material has been taken from an old pit at the western edge of Photograph 3-78, and it appears as if Sheep Lakes may be old gravel pits. Although these gravel terraces are all in open view of the highway, the possibility of removing material and leaving behind a well-landscaped lake similar to Sheep Lakes should be explored. Such a pit, and ensuing lake, would be well suited for the large, low sand and gravel (SG) just south of the center of Photograph 3-78. Sand and gravel of good quality could be obtained in the same way from beneath the organic (O/SG) material in the floodplain of the Fall River on either of these photographs. On the floodplain, the lake remaining after the operation could be landscaped, and, in addition, would be hidden from the road by willow brush.

The large fans (Fan) on Photograph 3-76 consist of poorly graded granitic detritus suitable for use as subbase and possibly base material. The granite weathers readily and should be protected by a pavement.

The glacial moraine (Mo) and granite (Gr) are very similar to those described for Photograph 3-80.

Photograph 3-74

The materials on this photograph are mapped and described for Photograph 3-76 of this flight strip and Photograph 3-72, Flight Strip 17.

Flight Strip 17, Photographs 3-67 thru 3-72
Flight Direction: West to East

Photograph 3-72

The SG at Endovalley Campground is a fairly clean sand and gravel suitable for subbase, base course, or surfacing use, but the position of this deposit is such that it is probably not available for development for aesthetic reasons. There is a better possibility of use of the sands and gravels under the organic material (O/SG) on the floodplain of the Fall River as described for Photographs 3-76, 3-78 and 3-80, Flight Strip 16. After removal of the organic overburden, these sands and gravels could be dredged and used for base course or surfacing, and, if washed, they might be suitable for concrete aggregate.

The small deposit of sand and gravel (SG) in the east-central part of the photograph is a small terrace. The sand and gravel is of high enough quality for base course or possibly surfacing, but is very limited in volume.

The material in the fans (Fan) on this photograph has been described for Photograph 3-76, Flight Strip 16.

The glacial moraine (Mo) and granite (Gr) are similar to those described for Photograph 3-80, Flight Strip 16. The surface contact between moraine and granite is not well-marked in the field, and thus the boundary between these materials shown on the photograph is only approximate.

The talus (Ta) on this photograph is derived from granite. It would be easier to work than granite bedrock but is relatively inaccessible from existing roads, and a talus operation would be in full view from the existing road.

Photograph 3-70

The only material of consequence in this area is granite (Gr) bedrock. This granite, which locally grades into gneiss, is fairly coarse and weathers fairly easily. If quarried, it could be used as crushed stone, riprap, or barrier stone, but it would probably perform best as crushed stone base protected from weathering by a bituminous surface.

Photograph 3-68

The boundary between granite (Gr) and gneiss (Gn) is very indistinct in this area since there is a gradual change from one to the other. Both rocks are coarse grained and are fairly susceptible to weathering. If quarried, both could probably be used for crushed stone, riprap, and possibly barrier stone, but the granite should perform somewhat better than the gneiss. Both would be at their best used as crushed stone base protected from weathering by a bituminous surface.

The fan (Fan) on this photograph consists of coarse, angular detritus derived from the gneiss. It would be suitable for common borrow, subbase, and possibly base course use.

The isolated body of glacial moraine (Mo) in the center of the photograph is a coarse till suitable for common borrow and subbase use.

Flight Strip 18, Photographs 3-61 thru 3-66
Flight Direction: West to East

Photograph 3-66

The materials on this photograph are described for Photographs 3-68 and 3-70, Flight Strip 17.

Photographs 3-64 and 3-62

The materials on the eastern one-half of Photograph 3-64 have been described for Photograph 3-68, Flight Strip 17.

The gneiss (Gn) on these photographs becomes somewhat poorer in quality (i.e., more schistose) in going up the valley from the indistinct contact with the granite (Gr) on Photograph 3-64. At its best this material may be suitable for crushed stone, riprap, and possibly barrier stone, although it is fairly susceptible to weathering. Where it becomes schistose, it is of no value as a construction material.

The small deposit of sand and gravel (SG) at the western edge of Photograph 3-62 is too small and too shallow to be considered as a source of construction material.

What appears to be a landslide area in switchbacks on the old Fall River Road at the western edge of Photograph 3-64 and the eastern edge of Photograph 3-62 is not as bad as it appears. The only material that has moved in this "slide" area consists of old hand-placed rock retaining walls and their fills which have slid out of place on the steep mountainside. There has been little, if any, movement of material in the natural or cut slopes.

Flight Strip 19, Photographs 3-57 thru 3-60
Flight Direction: West to East

Photograph 3-60

The gneiss (Gn) on this photograph grades into schist (Sch) near the western edge of the photograph. There is no identifiable boundary between the two, and thus no boundary is shown on the photograph. These rocks are not generally of high enough quality to warrant quarrying for use as construction materials.

The small deposit of sand and gravel (SG) in the west-central part of Photograph 3-60 is too small and too shallow to be considered as a source of construction material.

The area mapped as moraine over schist (Mo/Sch) is somewhat in question. It appears to be a shallow deposit of coarse till (including large boulders) which has been deposited in the valley bottom (even though there are no other obvious glacial deposits in the vicinity). The till would probably be suitable for select

borrow and possibly for subbase if the boulders were crushed.

Photograph 3-58

The schist (Sch) which comprises much of this photograph is of too low quality to warrant quarrying for construction materials.

The gneiss (Gn) is of better quality than the schist (Sch), but it has a degree of foliation which generally precludes its use as a construction material. Locally the gneiss may be of better quality and possibly might be quarried for use as crushed stone or riprap.

The volcanic rocks (Vol) are described for Photograph 3-2, Flight Strip 21, and are located in the northeast corner of Photograph 3-2.

The moraine over schist (Mo/Sch) has been described for Photograph 3-60.

Flight Strip 20, Photographs 3-81 thru 3-85
Flight Direction: Southwest to Northeast

Photograph 3-84

Most of the area of this photograph is comprised of a strong, medium-grained granite (Gr) which does not appear to be as susceptible to weathering as the granites noted at lower elevation in Rocky Mountain National Park. This material would be suitable for use as crushed stone, riprap or barrier stone. It is suggested that considerable yardage of this material might be obtained by widening the highway from Rainbow Curve to the west. The best

granite was noted about 1000 feet west of Rainbow Curve, but the granite right at the Curve is also of good quality, and all the granite in the photograph is better than has been noted at lower elevations in the Park.

A rib of gneiss (Gn) crosses the ridge near the center of the photograph. This material is not as high in quality as the aforementioned granite, and probably would not be worth quarrying. However, if the highway were to be widened across the band of gneiss, the rock could be crushed and would probably be suitable for subbase use. Note that the boundary between the gneiss (Gn) and granite (Gr) is poorly defined. Because of this lack of definition and the great amount of relief involved, this boundary has not been extended into the valley to the north of the highway.

The area designated as colluvium over granite (Coll/Gr) is poorly defined because of the heavy timber cover in the southeastern portion of the photograph. For this reason no boundaries have been drawn between the colluvium and non-colluvium areas. The colluvium is poorly graded detritus derived from the granite and gneiss. Because it is fairly dirty it probably could serve only as common borrow.

Photograph 3-82

This area is comprised almost entirely of medium-grained granite (Gr). Although this granite is not quite as high in quality as that in the vicinity of Rainbow Curve to the east (see Photograph 3-84), it is generally of better quality than that

found in the lower elevations of Rocky Mountain National Park. It has good strength and is moderately resistant to weathering. It would be suitable for use as crushed stone, riprap, or barrier stone, but optimum usage would be as crushed stone subbase or base protected from weathering by a bituminous surface.

The gneiss (Gn) in the two small bodies in the northwest corner of the photograph is strongly foliated and thus is not of high enough quality to be considered for any purpose but common borrow.

Flight Strip 21, Photographs 3-1 thru 3-11
Flight Direction: Northwest to Southeast

Photograph 3-10

The materials on this photograph are the same as those described for Photograph 3-82, Flight Strip 20.

Photograph 3-8

The granite (Gr) in this photograph is of the same character as that described for Photograph 3-82, Flight Strip 20. In general, this granite is medium-grained and moderately resistant to weathering. It would probably be suitable for crushed stone, riprap, or barrier stone.

The gneiss (Gn) varies in quality considerably, but generally is too coarse-grained and lacking in resistance to weathering to be considered for any use but crushed stone for subbase and

possibly base course protected by bituminous surfacing.

The schist (Sch) is soft and highly foliated. It is too poor in quality to be used for anything but common borrow.

Photograph 3-6

The best possible source of construction material on this photograph is the granite (Gr) and granite talus (Ta) near Toll Memorial northeast of the center of the photograph. This granite is fine- to medium-grained, and is strong and resistant to weathering. It would be suitable for use as building stone, barrier stone, riprap, and crushed stone for subbase, base, or surfacing courses. This material is the site of an old quarry which has served as a source of high-quality granite in the past.

The gneiss (Gn) on this photograph varies from medium- to coarse-grained and from slightly to highly foliated. It is much stronger and more resistant to weathering than the surrounding schist (Sch), and therefore forms a prominent ridge across the center of the photograph. However, it is not as good as the granite. This gneiss would be suitable for use as riprap and probably as crushed stone for subbase or base course use.

The schist (Sch) is soft and highly foliated; it is not suitable for any construction use except common borrow. Much of this schist is covered by a thin layer of soil and vegetation comparable to arctic tundra. However, this layer of "tundra" is generally less than a foot thick and should have little effect

on construction in the area.

The organic material (O) on these photographs does not appear to be more than 1 to 2 feet thick over the schist bedrock. It is not thick enough to present problems in construction. It could provide topsoil or mulching material.

Photographs 3-4 and 3-2

The volcanic rocks (Vol) on these photographs vary from soft, weak material to rock which is hard and resistant to weathering. The best rock in the vicinity of the highway is in the western portion of the deposit. Most of the surface of the deposit is covered with talus from the volcanic bedrock. Both the bedrock and talus could be crushed and used for base or surfacing. Considerable yardage of this volcanic rock could be obtained by widening the existing highway where it cuts through this deposit.

The schist (Sch) on these photographs is too soft and foliated to be used for anything but common borrow. This schist grades into a small amount of gneiss (Gn) near the eastern edge of the volcanics. This gneiss is stronger and more resistant to weathering than the schist, but it is not as good as the volcanics, and is in plain view of the highway. Therefore, the gneiss should not be considered as a material source.

Flight Strip 22, Photographs 3-12 thru 3-18
Flight Direction: Southwest to Northeast

Photograph 3-12

The materials in this photograph have not been mapped due to lack of stereoscopic coverage. An exception is the area in the southwest quarter of this photograph which is mapped on Photograph 3-58, Flight Strip 19.

Photograph 3-14

The best material on this photograph is the gneiss (Gn) which forms the ridges north and northeast of Fall River Pass. This gneiss is medium- to coarse-grained and medium to highly foliated. It shows moderate resistance to weathering, and would be suitable for riprap or for use as crushed stone for subbase or base course protected by bituminous surfacing. The gneiss in the northwestern corner of the photograph (in the valley of the Cache la Poudre River) has not been separated by a boundary from the schist because no boundary was evident on the photographs and the area was too inaccessible for field checking. The presence of the gneiss along the Cache la Poudre River was confirmed by field checking.

The schist (Sch) is too soft and highly foliated to be used for anything but common borrow.

Photograph 3-16

The gneiss (Gn) on this photograph is medium- to coarse-grained. It is moderately resistant to weathering and would be

suitable for use as crushed stone for subbase or base course protected by bituminous surfacing.

The schist (Sch) is too soft and highly foliated to be used for anything but common borrow. No boundary is evident between the gneiss and schist; they seem to grade into each other.

The small deposit of sand and gravel (SG) along the Cache la Poudre River is described for Photograph 3-28, Flight Strip 23. This deposit is also similar to those described for Photograph 3-18, but it is probably too small to be worked.

Photograph 3-18

The sand and gravel (SG) consists of small terraces along the Cache la Poudre River. The largest of these terraces (at the contact between Vol and Gn) is about 30 feet thick in places and would be a source of clean but fine-grained gravel. The pebbles in this gravel are gneiss, schist, and soft volcanics, and are not very strong. This material, which is obviously limited in volume, would be suitable for subbase and probably for base course. The two smaller deposits of sand and gravel (SG) are not as clean and probably are too small to be considered as materials sources.

Some of the alluvium (All) along the Cache la Poudre River would be suitable for use as topsoil. If a highway were to be built on this alluvium, the topsoil should first be stripped.

The volcanics (Vol) and talus (Ta) on this photograph are soft pyroclastics unsuitable for use as construction materials.

The gneiss (Gn) in the valley of the Cache la Poudre River is medium-grained and moderately resistant to weathering. If quarried, this material would be suitable for riprap, barrier stone, or crushed stone for subbase or base course protected by bituminous surfacing.

The schist (Sch) is too soft and foliated to be used for anything but common borrow.

Flight Strip 23, Photographs 3-19 thru 3-32
Flight Direction: Northeast to Southwest

Photographs 3-20 and 3-22

These areas were not mapped because of inaccessibility for field checking. However, the photographs show several low terrace remnants along the Cache la Poudre River. If a highway were to be constructed down this valley, these terraces should be checked as possible sources of sand and gravel.

Photograph 3-24

The material mapped as Fan in this photograph consists mainly of dirty sand and gravel with boulders up to 4 feet in diameter. The stream cuts expose considerable silt and clay interbedded with the sand and gravel. Thus, the material in these fans might be suitable for subbase, but nothing better.

The sand and gravel (SG) near the center of the photograph is of higher quality than that in the fans. It is of high enough quality for subbase or possibly base course, but is of very limited volume.

The gneiss (Gn) which comprises most of the area of the photograph is a medium-grained rock with moderate resistance to weathering. If quarried, this gneiss would be suitable for rip-rap, barrier stone, and crushed stone for subbase or base course use protected by bituminous pavement.

The organic material (O) on this photograph is found in marshy areas where side seepage flows down to the river. These organic deposits do not appear to be very thick, but they should be explored further if a highway is to be located through them. They would provide topsoil or mulching materials.

Photograph 3-26

The terrace remnant (SG) near the center of the photograph consists of up to 12 feet of slightly dirty fine sand and gravel. This material would be suitable for use as subbase or possibly base course.

The fan (Fan) is similar to those on Photograph 3-24. It consists of dirty sand and gravel possibly suitable for subbase.

The gneiss (Gn) and organic material (O) are described for Photograph 3-24.

Photograph 3-28

The long, narrow deposit of sand and gravel (SG) at the southwest edge of the photograph consists of up to 30 feet of fairly clean fine sand and gravel ranging in size up to about 2 inches. Sand predominates over gravel in this deposit. The gravel consists of weak gneiss, schist, and volcanic pebbles. This material would be suitable for subbase or base course use (some of the fines might have to be wasted if the material were used for base course). Note that although this deposit is as much as 30 feet thick in the stream cut, it is very narrow and probably is resting on a fairly steep rock surface. Thus it probably is not very thick on the side away from the creek.

The two smaller deposits of sand and gravel (SG) consist of dirty sand and gravel suitable for subbase. However, the volume of these deposits is very small.

The gneiss (Gn) which comprises most of the area of the photograph is a medium-grained rock with moderate resistance to weathering. If quarried, this gneiss would be suitable for rip-rap, barrier stone, and crushed stone for subbase or base course use. This gneiss grades into schist (Sch) near the highway southeast of the Cache la Poudre River. This schist is of too low quality to be used for anything but common borrow.

The volcanics (Vol) at the southwestern edge of the photograph are described for Photograph 3-30.

Photograph 3-30

The long, narrow deposit of sand and gravel (SG) near the northeastern edge of the photograph is described for Photograph 3-28. The small deposit of sand and gravel (SG) near the center of the photograph is too shallow and small to be a suitable source of construction material.

The fan (Fan) at the southwestern edge of the photograph consists of dirty, angular sand, gravel and cobbles. It would be suitable for common borrow and possibly for select borrow.

The alluvium (All) along the Cache la Poudre River is a possible source of thin somewhat rocky topsoil.

The volcanic rocks (Vol) consist mainly of ash and soft pyroclastics. These rocks are generally weak and have no use as construction materials.

The talus (Ta) is derived from some of the better volcanics. It might be suitable for riprap, and if crushed, could possibly be used for subbase.

The gneiss (Gn) and schist (Sch) are similar to those units described for Photograph 3-28.

Photograph 3-32

The volcanics (Vol) and fan (Fan) on this photograph have been described for Photograph 3-30.

The schist (Sch) is generally soft and highly foliated. It would be suitable only for common borrow.

The best aggregate material on this photograph is the

gneiss (Gn) and its associated talus (Ta) just southeast of the highway. This is a rather strong, weather-resistant gneiss suitable for riprap, barrier stone or crushed stone for subbase, base course, or possibly surfacing. Unfortunately, the gneiss and talus are in open view of the public.

The organic material (O) is located around the margins of small ponds. It is of very limited quantity.

Flight Strip 24, Photographs 3-33 thru 3-41
Flight Direction: Northeast to Southwest

Photograph 3-34

The materials on this photograph are described for Photograph 3-28 and 3-30, Flight Strip 23.

Photograph 3-36

The materials on this photograph are described for Photograph 3-30 and 3-32, Flight Strip 23.

Photograph 3-38 and 3-40

This area is composed almost entirely of gneiss (Gn) and schist (Sch) which grade into each other. The gneiss is medium-grained and moderately resistant to weathering. It generally shows on the photographs as a darker color than the schist. The gneiss is suitable for use as riprap, barrier stone, or crushed stone for subbase, base course, or possibly surfacing. The best of the gneiss is located in the small outlier of gneiss and talus near the northeast edge of Photograph 3-40, but this outlier is

in full view of the highway.

The schist (Sch) is soft and highly foliated. It could be suitable for use only as common borrow.

The fan (Fan) in the extreme southwest corner of Photograph 3-40 is composed of dirty angular sand and gravel with large numbers of gneissic cobbles and boulders. This material might be suitable for subbase.

Flight Strip 25, Photographs 3-42 thru 3-47
Flight Direction: Southeast to Northwest

Photograph 3-42

This photograph was not mapped because of extremely rough terrain and lack of stereoscopic coverage.

Photograph 3-44

The gneiss (Gn) and schist (Sch) on this photograph grade into each other. In general, the gneiss shows in darker color on the photograph than the schist. The gneiss is medium-grained and moderately resistant to weathering. It would be suitable for riprap, barrier stone, or crushed stone for subbase or base course use.

The schist (Sch) is soft and highly foliated. It is suitable only for common borrow.

This area at the northwest edge of the photograph which is mapped as Mo appears to be glacial till. This material is poorly

graded from clay to boulder size. It would be suitable for common borrow and possibly select borrow.

The fan (SG) and moraine over gneiss (Mo/Gn) areas along the southwest edge of the photograph are in the vicinity of the Colorado River. The fan material is a dirty angular sand and gravel with large numbers of gneissic cobbles and boulders. This material might be suitable for subbase. The moraine over gneiss is a coarse till only a few feet thick. It is suitable for subbase or possibly base course use.

Photograph 3-46

The gneiss (Gn), schist (Sch), and moraine (Mo) in the area southwest of the Colorado River are as described for Photograph 3-44.

The sand and gravel (SG) on the photograph consists of a small terrace along the Colorado River and fans (Fan) along the edges of the valley. The sand and gravel in the small terrace is somewhat dirty. It would be suitable for subbase or possibly base course use.

The sand and gravel in the fans is made up of dirty, angular gneissic material with an abundance of cobbles and boulders. This material would be suitable for common borrow or possibly subbase.

The alluvium (All) is a possible source of topsoil. It is too fine-grained for any other use but common borrow.

The bedrock in this area consists of gneiss (Gn) which locally grades into schist. Neither of these materials is of

high enough quality to warrant quarrying as both are lacking in strength, abrasion resistance, and resistance to weathering.

The organic matter (O) would be suitable for mulch or a soil conditioner, and in some places may contain enough soil material to be used as topsoil.

GLOSSARY

ALLUVIUM	A general term for all fragmental material deposited by streams. It includes unconsolidated gravel, sand, silt, and clay, and all variations and mixtures of these.
ALLUVIAL FAN	A sloping, fan-shaped mass of loose rock material deposited by a stream at the place where it emerges from an upland into a broad valley or a plain. Often a good source of granular construction material.
ALTERATION	Strictly, any physical or chemical change in a rock or mineral subsequent to its formation. As used here, the term applies to chemical and mineralogical changes in rock caused by thermal activity or weathering.
BASALT	A fine-grained, dark, heavy volcanic rock. Commonly used as crushed aggregate, riprap, and rough building stone because of its toughness, hardness, and relatively high specific gravity.
BEDROCK	More or less solid undisturbed rock in place either at the surface or beneath unconsolidated deposits of gravel, sand, soil, etc. Often referred to as "ledge".
BOULDER	A large detached rock fragment somewhat rounded or otherwise modified in shape by transport. A boulder is larger than a cobble, ten inches having been suggested as a convenient lower limit for the diameter. The notion of transportation is usually involved but large rock masses rounded in place by weathering of bedrock are sometimes called boulders.
CLAY	As a particle-size term denotes all mineral particles less than 5 microns (0.005 mm.) diameter. Represented by AASHO soil groups A-6 and A-7.
COBBLE	A rock fragment between 2.5 and 10 inches in diameter, thus larger than a pebble and smaller than a boulder. Commonly somewhat rounded in the course of transport by water, wind, or ice.

"DIRTY GRAVEL" Coarse granular material (sand size or larger) mixed with considerable finer material (silt and/or clay). The fines show moderate to considerable plasticity.

ERRATIC A rock fragment, usually of boulder size, that has been transported from a distant source, especially by the action of glacial ice.

FAULT A break in materials of the earth's crust along which movement has occurred. A fault occurs when rocks are strained past the breaking point and yield along a crack or series of cracks so that corresponding points on the two sides are distinctly offset.

FINES Fine-grained materials passing the 200 mesh sieve (less than 0.075 mm.).

FLOODPLAIN A strip of relatively smooth land bordering a stream, built of sediment carried by the stream and deposited fairly close to the level of the stream. As used here, a floodplain can be differentiated from a terrace in that a floodplain is overflowed in times of high water.

FRACTURE A crack in a rock large enough to be visible to the unaided eye. May be either a joint or a fault.

GLACIAL LAKE DEPOSITS Sediments deposited in lakes formed by glacial damming. Generally comprised mainly of silt and clay with some sand.

GLACIAL TILL Material deposited directly by glacial ice. Generally a heterogeneous mixture of particles of all sizes from clay through boulders. May be locally interbedded with water-deposited granular materials.

GRANITE A visibly granular igneous rock composed mainly of quartz and orthodase feldspar.

GRANULAR MATERIAL Soil containing 35 percent or less of particles passing No. 200 sieve. Represented by AASHO Soil Groups A-1, A-2, and A-3.

GRAVEL Loose or unconsolidated coarse granular material, larger than sand grains. The lower size limit is usually 2 mm. and the upper size limit generally 2 to 3 inches diameter. Gravel is seldom clean, the spaces between the larger fragments being usually filled with silt and sand.

JOINT	A fracture in rock along which there has been little, if any, movement between the two sides.
OUTCROP	A part of a body of rock that appears bare and exposed at the surface of the ground.
OVERBURDEN	Unconsolidated material that overlies gravel or other useful material.
RHYOLITE	A light-colored fine-grained volcanic rock. Hard and durable when unaltered, but rhyolite in Yellowstone is often soft and non-durable due to thermal alteration.
SAND	Rock material passing the #4 sieve (4.7 mm.) retained on the #200 sieve (0.074 mm.). Commonly represented by AASHO Soil Group A-3.
SILT	Material passing the No. 200 sieve (0.074 mm.) and larger than 0.005 mm. diameter. Most often represented by AASHO Soil Groups A-4 and A-5.
TALUS	An accumulated heap of rock fragments derived from and lying at the base of a cliff or very steep slope.
TERRACE	A bench along a valley or lake wall. Usually composed of alluvial material, but bedrock may be present at shallow depth. May be differentiated from floodplain in that terraces are not commonly overflowed in times of high water.
TERRACE REMNANT	Portion of a terrace remaining after much of the original terrace has been eroded away.
VOLCANIC BRECCIA	Fragmental volcanic rock. The fragments, which are usually angular and greater than 32 mm. in size, are held together by a finer-grained matrix.
VOLCANICS	Rocks that have issued from vents in the earth's surface, either ejected explosively or extruded as lava. These rocks generally are fine-grained or glassy.

ADDENDUM

IGNEOUS ROCKS	Rocks formed by solidification of hot mobile rock material (magma) either deep-seated or on the earth's surface.
SILICEOUS SINTER	The white or light-colored porous siliceous material deposited by the hot waters of geysers and hot springs. Also called geyserite.
DECOMPOSITION	The breaking down of minerals and rocks of the earth's crust by chemical activity.
TUFF	A soft volcanic rock consisting wholly or predominantly of compacted fine-grained volcanic ash and volcanic dust.
WELDED TUFF	A hard volcanic rock formed by the cementing together of volcanic ash fragments apparently while still hot and plastic after deposition.
TOPSOIL	Surface portion of the soil or so-called "A" horizon (pedologic). It varies in depth and productivity. Presumably fertile soil material used to topdress roadbanks and backslopes for growing grass.
CONTACT	The surface, often irregular, which constitutes the junction of two bodies of rock of different types.
COLLUVIUM	A term applied to heterogeneous masses of rock material transported by gravity.
COMMON BORROW	Material approved by the engineer as meeting the requirements for the particular embankment, backfill, or other use for which the material is intended.
SELECT BORROW	Earth material used for top portions of the roadbed in both cuts and embankments. Normally it will be of such gradation that all particles will pass a sieve with 3-inch square openings and not more than 15 percent will pass a No. 200 sieve. The portion of the material passing a No. 40 sieve shall have a plasticity index of not more than 6.

BAR (RIVER)	Accumulation of sand, gravel, or other unconsolidated material in a river channel.
PERLITE	A siliceous glassy volcanic rock showing spherical fracture in which the size of the resulting spheroids usually ranges from small shot to peas.
QUARTZ	A very common hard crystalline mineral composed of SiO_2.
FELDSPAR	A member of an important group of rock-forming minerals composed of silicates of alumina and some other base; potash, soda, or lime. Feldspars are hard minerals, but they are subject to chemical decomposition.
VESICULAR	A texture of rocks which are full of air bubbles occurring in many shapes.
DISINTEGRATION	The reduction of rock to smaller pieces mainly by mechanical means.