U.S. DEPARTMENT OF THE INTERIOR

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SAND AND GRAVEL RESOURCES OF THE SAN BERNARDINO NATIONAL FOREST, CALIFORNIA

SUMMARY PAMPHLET TO ACCOMPANY GEOLOGIC MAP

By

R.C. Greene and J.P. Calzia

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ABSTRACT

The San Bernardino National Forest is located in the San Gabriel, San Bernardino, and San Jacinto Mountains in southern California. Bedrock in these ranges consists principally of gneiss, schist, and granitic rocks with minor quartzite and limestone. Unconsolidated and semi-consolidated surficial deposits of Quaternary age overlie the bedrock and contain abundant sand and gravel resources. The principal types of sand and gravel resources include stream deposits, alluvial fans, glacial and glaciofluvial deposits, beach and dune deposits, and pre-Quaternary marine deposits that accumulated on continental shelves. Sand and gravel resources in stream, alluvial fan, and pre-Quaternary marine deposits are abundant in the San Bernardino National Forest and vicinity.

Field investigations suggest that the Lytle Creek area in the San Gabriel Mountains, the Cajon Canyon to Cajon Pass, upper Santa Ana River, Smarts Ranch, and Silverwood Lake areas in the San Bernardino Mountains, and the San Jacinto River area in the San Jacinto Mountains have high potential for sand and gravel resources in the San Bernardino National Forest. Additional testing and evaluation is required before these resources may be considered reserves.

INTRODUCTION

The San Bernardino National Forest is located in the San Gabriel, San Bernardino, and San Jacinto Mountains in southern California (see geologic map). Bedrock in each of these ranges is generally similar and consists mostly of gneiss, schist, and granitic rocks (Bortugno and Spittler, 1986; Rogers, 1965; and references therein). The age of the gneiss and schist is the subject of considerable controversey; some of these rocks are Precambrian and some may be Paleozoic and Mesozoic; the granitic rocks are mostly Jurassic and Cretaceous in age. Limestone and quartzite pendants are also common and may be Precambrian and Paleozoic in age.

Overlying these ancient rocks are unconsolidated sedimentary deposits of Quaternary age and semi-consolidated deposits of Pliocene and Miocene age. A reconnaissance investigation of these deposits was conducted in May, 1991 by Greene. Observations were mostly confined to natural stream cuts, road cuts, and the surfaces of alluviated areas; no sampling or testing of materials was done. This report describes the results of that investigation and, based on observations made in the field, provides preliminary estimates of the sand and gravel resources of the San Bernardino National Forest.

OVERVIEW OF THE SAND AND GRAVEL INDUSTRY

DEFINITION OF SAND AND GRAVEL RESOURCES

Geologists commonly divide sedimentary particles into size ranges based on the Wentworth Scale (Wentworth, 1922). Material ranging in size from 0.0625 to 2 mm is termed sand; coarser material is termed gravel. Each classification is subdivided and appropriate modifiers are applied to the subdivisions. Industrial terminology is less precise; the lower limit of sand may be 0.05 or 0.074 mm (standard seive sizes) and the upper limit varies from 2 mm to 6.35 mm (Bates, 1960); the upper limit of gravel is 7.5 to 8.8 cm. In commercial terms, material which is or has been crushed to <1/4 inch is called fine aggregate and material containing larger particles is called coarse aggregate.

TYPES OF DEPOSITS

Stream deposits--Stream-channel deposits consist of sand and gravel deposited in present or former stream courses. Many are accessible and easily mined. They are a desirable deposit for sand and gravel resources because relatively weak rocks have been ground to finer particles and carried downstream, leaving more resistant materials behind. In general, the grain size of gravel gradually decreases downstream; a desireable blend of particle sizes are often found far from the headwaters of the stream. The most desirable stream channel deposits are normally free of excessive silt and clay and may be renewed by seasonal influxes of new material (Goldman and Reining, 1975). Unit Qya on the geologic map that accompanies this report often includes sand and gravel resources.

Floodplain and terrace deposits may contain high quality materials similar to stream-channel deposits. These materials were deposited when stream erosion and deposition were more vigorous. They may contain surface layers of silt and clay but are desirable for mining because they are located away from surface or near-surface ground water. Unit Qoa often includes this type of deposit.

Alluvial fans--An alluvial fan is formed where a stream emerges from a mountain front onto an adjacent valley or plain. The decrease in slope causes the stream to spread out into a system of intermittently active channels and deposit suspended material. Coarser materials are deposited near the mountain front; finer materials are deposited near the margins of the valley. These deposits tend to be poorly sorted and may contain silty matrix or clay lenses. Many valuable sand and gravel deposits, such as those on the north side of the Los Angeles and San Bernardino Valleys, are of this type. Units Qf and Qwf on the geologic map consist of alluvial-fan deposits.

Glacial and glaciofluvial deposits--These materials are transported by continental or local mountain glaciers and consist of till and glacially transported materials reworked by meltwater streams. Till forms moraines of various types and consists of materials of diverse size and quality and is not considered a high-quality sand and gravel deposit. Outwash deposits, however, have characteristics in part similar to alluvial fans and in part similar to non-glacial stream deposits, depending on distance from the glacier terminus. These materials and unique types of glaciofluvial deposits, such as kames and eskers, may contain good quality sand and gravel resources that are easily mined. Unit Qg on the map consists of glacial till and outwash deposits.

Dune deposits--These deposits generally consist of well-sorted and well-rounded sand composed of resistant minerals from which silt and clay have been winnowed out. Dune deposits often contain high-quality sand for aggregate but lack accompanying gravel. Moreover, most are located in recreational areas and are not available as a resource. Unit Qs consists of dune sand.

Older geologic formations--Many pre-Quaternary semi-consolidated sand and conglomerate deposits in the San Bernardino National Forest locally include a valuable sand and gravel resource. To be valuable, the material must consistt of resistant and unweathered minerals that may be easily disaggregated and mined. The largest sand and gravel resources in the San Bernardino National Forest are this type of deposit and are included in units Qb, Tcr, Tsa, and Tcv on the map.

DESCRIPTION OF DEPOSITS

SAN GABRIEL AND SAN BERNARDINO MOUNTAINS

Deer Creek

Deer Creek is located in the San Gabriel Mountains directly north of Cucamonga (Map, no. 1). Construction of large new housing developments is now underway on the alluvial fan where Deer Creek enters the San Gabriel Valley. At the head of the fan near the national forest boundary are various channelization, gravel catchment, and water supply structures. Inside the national forest, the valley is floored with alluvium containing about 50 percent cobbles and boulders, mostly of gneiss and granitic rocks. These materials would be of value only if crushed.

Lytle Creek area

Lytle Creek is located in the San Gabriel Mountains southwest of and largely parallel to Cajon Canyon (Map, no. 2). In lower Lytle Creek, the valley is floored by active stream alluvium consisting mostly of coarse sand and gravel with a considerable proportion of cobbles and boulders. Virtually all clasts are gneiss and granitic rocks. Much of the stream bed below Turk Point is channelized with berms and appears to have been dredged for placer gold.

Bedded sand and gravel are exposed in a stream cut in the middle of the Lytle Creek drainage (Map, no. 3). The gravel consists of angular pebbles mostly <2 in. in maximum dimension and is interbedded with coarse sand containing minor silt. Similar materials underlie each of the two side canyons which extend about 0.5 mile northwest of this location, and may underlie much of the wide part of the main chnnel extending south to Turk Point. Assuming the bedded deposits cover a 0.5 mi^2 area and are 20 ft thick, the Lytle Creek area includes 17.5 million tons of sand and gravel resources at an average density of 0.065 $tons/ft^3$.

The north fork of Lytle Creek above Scotland and Lytle Creek village (Map, no. 4) is floored by bouldery alluvium similar to alluvial deposits in the lower part of the creek. The lower part of Coldwater Canyon (Map, no. 5) contains gravel with a minimum of boulders; sand and gravel materials at Stockton Flat (Map, no. 6) are very bouldery.

Lone Pine Canyon

Lone Pine Canyon (Map, no. 7) lies north of the North Fork of Lytle Creek and follows the San Andreas Fault. It is floored by boulder-rich alluvium. Side canyons above Clyde Ranch (Map, no. 8) and Slover Canyon (Map, no. 8A) contain finer materials, as well as large slabs and fragments of schist. The valley of Sheep Creek (Map, no. 9) at the Angels Crest Highway north of Wrightwood likewise contains schist-rich gravel.

Cajon Canyon, Northwest Part

Roadcuts on State Highway 138 between State Highway 2 and Nuss Ranch (Map,no. 10) show several tens of feet of well-bedded very coarse-grained sand and about 5 percent gravel with clasts <4 in. in diameter . These exposures are mostly within the San Bernardino National Forest but extend outside the forest boundary and have been mapped as the Crowder Formation of Pliocene age (see Bortugno and Spittler, 1986; Dibblee, 1965a, 1965b; Woodburne and Golz, 1972). Similar materials are exposed in a scarp east of Nuss Ranch and extending eastward for several miles toward Cajon Summit (Map, no. 11). However, these materials are mapped as the undivided Harold Formation and Shoemaker Gravel of Pleistocene age by Bortugno and Spittler (1986). Semi-consolidated sand and gravel south of Nuss Ranch are exposed on several irregular ridges that reach into the valley from the south (Map, no. 12). These material are mapped as the Pliocene Crowder Formation and the Miocene Punchbowl(?) Formation of Cajon Valley by Bortugno and Spittler (1986). Rocks mapped as the Punchbowl(?) Formation near Cajon Junction (Map, no. 13) form bold outcrops locally known as the Mormon Rocks. These rocks are probably too consolidated and of too much scenic value to constitute a valuable sand and gravel resource.

Cajon Junction, Cajon Summit, and Cajon Pass

Semi-consolidated sand and gravel, similar to that found along State Highway 138, is exposed in several road and freeway cuts between Cajon Junction and Cajon Summit (Map, no. 14). These materials were mapped as the Punchbowl and Crowder Formations by Dibblee (1965a, 1965b) and Woodburne and Golz (1972) and may be a viable sand and gravel resource.

A 200-ft thick section of semi-consolidated sand and gravel is exposed in a road cut about 0.5 mi north of Cajon Pass (Map, no. 15) just outside the national forest boundary. The gravel content in this section is about 5 percent near the top of the road cut and increases to 20 percent near the base. Similar materials, mostly containing about 5 percent gravel, are exposed in numerous road and stream cuts from Cajon Pass to Cajon Junction (Map, no. 16); these deposits were mapped as the Crowder Formation by Dibblee (1965a, 1965b). These data suggest that the Punchbowl and Crowder Formations underlie a 20.3 mi^2 area from Cajon Canyon to Cajon Pass; assuming an average thickness of 100 ft, these rocks contain approximately 3.5 billion tons of sand and gravel resources.

Cajon Junction to Devore

The lower part of Cajon Canyon (Map, no. 17) is floored with bouldery alluvium. Local terraces may form a significant sand and gravel resource but are not within the national forest. A sand pit at Cozy Dell (Map, no. 18) is currently producing coarse sand; cobbles and boulders are also being crushed to produce limited quantities of gravel.

Silverwood Lake Area

Semi-consolidated bedded sand with minor gravel occurs north and west of Miller Canyon (Map, nos. 19 and 20, respectively) near Silverwood Lake. These deposits are mapped as part of the Crowder Formation by Dibblee (1965b) and represent an eastward extension of similar deposits in Cajon Pass. Assuming an average thickness of 50 ft over the 0.25-mi^2 outcrop area yields 22.0 million tons of sand and gravel resources in this area.

Lake Arrowhead Area

No bedded sand and gravel was discovered in the Lake Arrowhead area (Map, no. 21). The area is mostly underlain by coarse-grained granitic rocks (Bortugno and Spittler, 1986; Dibblee, 1973, 1974); weathered granite residium or grus is abundant and is locally many feet thick. This weathered rock is suitable for sub-base and fill material.

Harrison Mountain Area

Three areas with sand and gravel potential are present in the Harrison Mountain area between Highland and Redlands just north of the crest of the San Bernardino Mountains. One area is at the foot of Mud Flat (Map, no. 22) and consists of a heterogeneous mixture of angular weathered rock fragments. Despite this name and its peculiar appearance on the topographic map, this area appears to be a talus apron and not a landslide deposit; the rock fragments would be of value only as fill material.

More accessible areas are located near City Creek Ranger Station (Map, no. 23) and near Little Mill Creek (Map, no. 24). Crudely-bedded granule sand and cobble deposits at these localities may have potential for sand and gravel resources after crushing.

Santa Ana River

The Santa Ana River emerges from the San Bernardino Mountains north of Redlands. In the mountains, the river occupies a scenic canyon and is floored by bouldery aluvium (Map, no. 25). However, the valley is now closed for the construction of a flood control dam; the dam precludes the development of the sand and gravel resources in this area.

Mill Creek

Mill Creek is located a few miles east of the Santa Ana River. It forms a canyon extending about 9 mi east to Forest Falls and beyond (Map, no. 26). The canyon is floored with very bouldery alluvium which is of little aparant value without crushing a large proportion of the material. Minor terraces along the side of Mill Creek may contain better sand and gravel but are covered by the highway.

Barton Flats-Upper Santa Ana River

A large deposit of fine-grained sand underlies a terrace on the north side of the Santa Ana River directly east of Seven Oaks Resort (Map, no. 27). Roadcut exposures show the sand to be bedded, well sorted, and poorly consolidated. This deposit may continue northeast as far as Converse Flats (Map, no. 28) and was mapped as the Santa

Ana Sandstone of Vaughan (1922) by Dibblee (1964a); Bortugno and Spittler (1986) have assigned a Miocene age to these rocks.

The upper reaches of the Santa Ana River include several sand and gravel resource areas. Hathaway Flat and the upper part of Barton Flats along Jenks Lake road (Map, nos. 29-30) are underlain by coarse talus and alluvial-fan deposits. Stream cut and roadcut exposures in the upper parts of the Santa Ana River (Map, no. 31) contain well-bedded coarse sand with local angular pebbles and cobble-boulder beds; the gravel beds constitute <5 percent of the section. These exposures, and others in the Barton Flats area, were mapped as part of the Santa Ana Sandstone by Dibblee (1964a). These areas contain approximately 1.8 billion tons of sand and gravel resources, assuming an average thickness of 100 ft of the Santa Ana Sandstone over a 10.2 mi^2 area adjacent to the Santa Ana River.

Big Bear Lake Area

Quartzite talus south of Sugarloaf Peak (Map, no. 32) has possible value if crushed. Although no exposures of sand and gravel were found in either Fawnskin Valley or Holcomb Valley (Map, nos. 33 and 34, respectively), marble outcrops in Van Duesen Canyon (Map, no. 35) have potential for crushed stone. This marble was mapped as the Bonanza King Formation of Cambrian age by Sadler (1981).

Talus consisting largely of quartzite has been quarried at a site near Big Bear City (Map, no. 36) and could be quarried at additional sites surrounding Gold Mountain. Gold Mountain is underlain by quartzite mapped as the Proterozoic Wildhorse Formation by Sadler (1981).

A gravel pit near Smart's Ranch (Map, no. 37) contains poorly bedded very coarse sand with a few pebbles and cobbles intervals up to 6 in. thick. These sediments are floodplain deposits that were derived from parent granitic rocks along Arrastre Creek. Assuming the deposits are 20 ft thick over an area of 1 mi^2, the floodplain deposits would contain 35.1 million tons of sand and gravel resources.

Banning Canyon

Banning Canyon (Map, no. 39) is drained by the San Gorgonio River. The canyon is covered by bouldery alluvium that would require crushing to be of value as a sand and gravel resource.

SAN JACINTO MOUNTAINS

Snow Canyon

Snow Canyon (Map, no. 40) located along the northern front of the San Jacinto Mountains near San Gorgonio Pass is floored by an alluvial fan. The fan materials are very coarse, containing boulders as much as 5 ft in diameter. Abundant flowering plants and a trailhead are located here. The preservation value of this area may outweigh its value as a gravel source, despite its proximity to major highways.

San Jacinto River-Rouse Ridge

Several sand and gravel resource areas are located along the San Jacinto River on the west side of the San Jacinto Mountains. Bedded sand, mostly very fine- and fine-grained but grading to very coarse in some beds, is exposed in several roadcuts near the Cranston Ranger Station (Map, no. 41); similar material is exposed in roadcuts east of this locality as far as the junction of Dry and Strawberry Creeks (Map, no. 42). Although gravel beds are rare, cobble and boulder beds become more common to the east. These materials were mapped as the Pleistocene Bautista Beds by Rogers (1965) and underlie a large area extending from Blackburn Canyon to north of the San Jacinto River (Map, no. 43). Assuming 12.4 mi^2 of the San Bernardino National Forest are underlain by these materials with an average thickness of 200 ft, this area contains approximately 4.4 billion tons of sand and gravel resources.

In addition to the Bautista Beds, alluvial deposits of Holocene age are currently being quarried in a gravel pit 0.5 mi east of Cranston Station (Map, no. 44). Similar gravel deposits are abundant in the San Jacinto River from Cranston Ranger Station to Dry Creek (Map, no. 45).

Mountain Center to Garner Valley and Santa Rosa Summit

Fanglomerate deposits, consisting mostly of granitic cobbles and boulders, are exposed in roadcuts between Keen Camp Summit and Herkey Creek Park (Map, no. 46).

These deposits, as well as that on Keen Ridge to the north, were mapped as the Bautista Beds by Rogers (1965). Similar deposits are also exposed along the Apple Canyon road (Map, no. 47) and the Forbes Ranch road (Map, no. 48). Clayey, organic-rich sediments containing minor amounts of coarse sand are exposed in a small stream cut in Garner Valley.

Roadcuts on Morris Ranch road (Map, no. 49) reveal poorly-sorted silty sand and gravel between 4,600- to about 4,920-ft elevation. Above 4,920 ft elevation (Map, no. 50), poorly-bedded sediments are overlain by boulder fanglomerate similar to that described above. These deposits were mapped as the Bautista Beds by Rogers (1965).

Roadcuts exposing bedded sand with minor gravel are present along Highway 74 immediately east of Santa Rosa Summit (Map, no. 51). This area is part of the Santa Rosa Indian Reservation but is adjacent to the national forest boundary. These materials are mapped as the Bautista Beds by Rodgers (1965).

Pinyon Flat

Pinyon Flat (Map, no. 52) appears to be underlain entirely by coarse- grained plutonic rocks and weathered granite grus.

Bautista Canyon

Bautista Canyon drains the northwest corner of Anza Valley. Fanglomerate deposits similar to deposits along Forbes Ranch road are present in roadcuts along Bautista Canyon (Map, no. 53). The fanglomerate deposits in these roadcuts were mapped as the Bautista Beds by Rogers (1965).

SAND AND GRAVEL RESOURCE POTENTIAL

USES AND GRADES

The construction industry consumes 96 percent of the sand and gravel resources produced in the United States; the remainder goes to specialty uses such as glass manufacture or casting sands (Goldman and Reining, 1975). Highway construction consumes the most material; it is utilized for concrete or asphalt aggregate, for base directly under pavement, and for fill where good drainage is required. Building construction is the other important use. Most goes into concrete aggregate for foundations and pillars; much sand also goes into mortar, plaster, plaster board, brick, and tile.

Since concrete aggregate is the principal use for sand and gravel resources, most deposits must be evaluated for suitability for this use. General characteristics which can be determined by hand or microscopic examination include particle shape, surface character, grain size, texture, color, mineral composition, degree of weathering, and prescence of potentially harmful substances such as unstable volcanic rock fragments.

Various standards are established by government agencies and engineering societies which conform to standards established by the American Society for Testing and Materials (Goldman and Reining, 1975). Tests have been devised to determine abrasion resistance, soundness (absence of cracks in grains), specific gravity, size and grading (gradation of grain sizes with a low proportion of very-fine grained material), reactivity (low expansion by reaction with alkali cement), absorption, and durability when subjected to alternate freezeing and thawing.

Sand and gravel deposits are mined with power shovels, draglines, bulldozers, and dreges. The choice of equipment depends on whether the deposit is mined dry or wet (Goldman and Reining, 1975). In dry-pit operations, shovels, loaders, or draglines load the material into trucks or onto conveyor belts for transfer to the processing plant. In wet-pit operations, material is mined with a land-based dragline or by a floating dredge, commonly in a pond created for the purpose. Dredging for sand and gravel is also done in natural lakes, rivers, and bays.

Processing of sand and gravel deposits depends on the end use. Material used for base and fill in highway construction may require little to no processing. Material to be used for concrete aggregate will require washing, sorting by screening, and blending. Commonly, some crushing of coarser particles will be part of the process. A modern plant designed to produce aggregate to various specifications is located in Irwindale, CA and utilizes material from the alluvial fan of the San Gabriel River.

SUPPLY AND DEMAND

The California Division of Mines and Geology's series of reports *Mineral land classification of the greater Los Angeles area* (Anderson and others, 1979; Cole, 1987; Miller, 1987; Miller and Corbaly, 1980) provides figures for the resources, reserves, and anticipated consumption of sand and gravel in and adjacent to the Los Angeles metropolitan area. Resources are sand and gravel deposits that are known or believed to exist but are not permitted for mining and are subject to competition for other types of land use; reserves are defined as sand and gravel deposits that are owned by producing companies and permitted for mining. The anticipated consumption is a projection for the next 50 years and takes into account anticipated population growth and per capita consumption as determined from the degree of urban maturity.

The Division of Mines and Geology divided the greater Los Angeles area into six production-consumption regions; three of these are near the San Bernardino National Forest. Although the national forest is not included in the resource and reserve estimates, potential production of sand and gravel resources within the national forest would most likely be consumed within one or more of these regions. The Division's projections suggest that only the San Bernardino region has reserves nearly equaling the anticipated consumption while the others fall far short (Table). While some resources in these regions will eventually become reserves, potential resources within the San Bernardino National Forest are also of importance and could become additional reserves.

Projected supply and demand for sand and gravel resources in the Los Angeles metropolation area (in millions of tons)

Subregion	Resources	Reserves	Consumption
San Bernardino	10, 450	430	476
Claremont-Upland	1,300	60	245
Orange County	1,200	260	844

ASSESSMENT OF SAND AND GRAVEL RESOURCES

Areas with high potential for sand and gravel resources in the San Bernardino National Forest are: 1) Cajon Canyon to Cajon Pass [3.5 billion tons]; 2) Barton Flats and upper Santa Ana River [1.8 billion tons]; 3) San Jacinto River and vicinity [4.4 billion tons]; 4) Lytle Creek fish hatchery [17.5 million tons]; 5) Silverwood Lake area [2.0 million tons]; and 6) Smarts Ranch [35.1 million tons]. Testing and economic evaluation is necessary to determine the quality of sand and gravel resources in each of these areas.. Factors such as distance to market, suitablity of roads, environmental concerns, zoning, and permits will determine the commercial status of each deposit. Traditionally, only a small fraction of identified sand and gravel resources become reserves.

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