SPECIAL REPORT 143, PART IV

MINERAL LAND CLASSIFICATION OF THE GREATER LOS ANGELES AREA, PART IV:

CLASSIFICATION OF SAND AND GRAVEL RESOURCE AREAS, SAN GABRIEL VALLEY PRODUCTION-CONSUMPTION REGION

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EXECUTIVE SUMMARY

Based upon the projected population increase and the predicted per capita consumption rates, approximately 780 million tons of aggregate will be required to satisfy demand in the San Gabriel Valley Production-Consumption Region to the year 2030.

Current *reserves* (aggregate materials believed to be acceptable for commercial use that exist within property owned or leased by an aggregate producing company and for which permission allowing extraction and processing has been granted by the proper authorities) total approximately 280 million tons, which is about one-third (18 year supply) of the requirements needed for the 50-year period.

Non-permitted resources (potentially usable aggregate materials that may be mined in the future but for which no use permit allowing extraction has been granted, or for which development has not been definitely established to be feasible based upon current technology or economic conditions) within the San Gabriel Valley Production-Consumption region total over 3 billion tons. Almost all of these resources are contained in the San Gabriel River alluvial fan. Over half of the 3 billion tons lies beneath the Santa Fe Dam Recreation Area. The remainder of the resources lies beneath other open-space land and under properties currently being mined.

The San Gabriel Valley P-C Region's 18-year reserve supply of aggregate could be prematurely depleted by exportation of sand and gravel to neighboring P-C regions, all three of which may experience a shortage of aggregate within the next 20 years.

CLASSIFICATION OF SAND AND GRAVEL RESOURCE AREAS SAN GABRIEL VALLEY PRODUCTION-CONSUMPTION REGION

INTRODUCTION

Land in the San Gabriel Valley Production-Consumption (P-C) Region of the greater Los Angeles metropolitan area (See Special Report 143, Part I, Plate 1.2) has been classified by the California Division of Mines and Geology (CDMG) according to the presence or absence of significant sand and gravel deposits (suitable for use in construction grade aggregate). The land classification is presented in the form of maps showing Mineral Resource Zones (MRZs) as described in Part I of SR 143. Twenty such maps on the U.S. Geological Survey topographic quadrangle bases accompany this report (Plates 4.5-4.24). Refer to Figure 4.1 for an index to quadrangle maps covering the San Gabriel Valley P-C Region. A list of lead agencies located within the San Gabriel Valley P-C Region is presented on Table 4.1

ESTABLISHMENT OF MINERAL RESOURCE ZONES

The boundaries of the San Gabriel Valley P-C Region circumscribe the primary marketing region for the San Gabriel fan sand and gravel production district, one of the major sand and gravel production districts in the greater Los Angeles metropolitan area (see SR 143, Part I, pages 6 and 8, Figures 1.2 and 1.3). Mineral Resource Zones (as defined by the "Guidelines for Classification and Designation of Mineral Lands," Special Report 143, Part I, Appendix A-3, p. 25) within the San Gabriel Valley P-C Region were delineated on the basis of a sand and gravel resource appraisal which included study of pertinent geologic reports and maps, field investigations, analysis of drill-hole data collected from the past 75 years, and inspection of aerial photographs.

Areas Classified MRZ-1

Plate 4.1 shows the general localities of the San Gabriel Valley P-C Region which are classified as MRZ-1. These are areas where adequate information indicates that no significant mineral deposits are present, or where it is judged that little likelihood exists for their presence (see "Guidelines for Classification and Designation of Mineral Lands," Appendix A-3 in SR 143, Part I, p. 32).

Many areas classified MRZ-1 occur within the interior parts of the Los Angeles basin where well-log data indicate the presence of sedimentary deposits that are composed predominantly of fine-grained material unsuitable for use as aggregate. In addition, several MRZ-1 areas are located in hilly or mountainous terrane. Classification of the latter areas was made mainly on the basis of available geologic mapping and field investigation. These

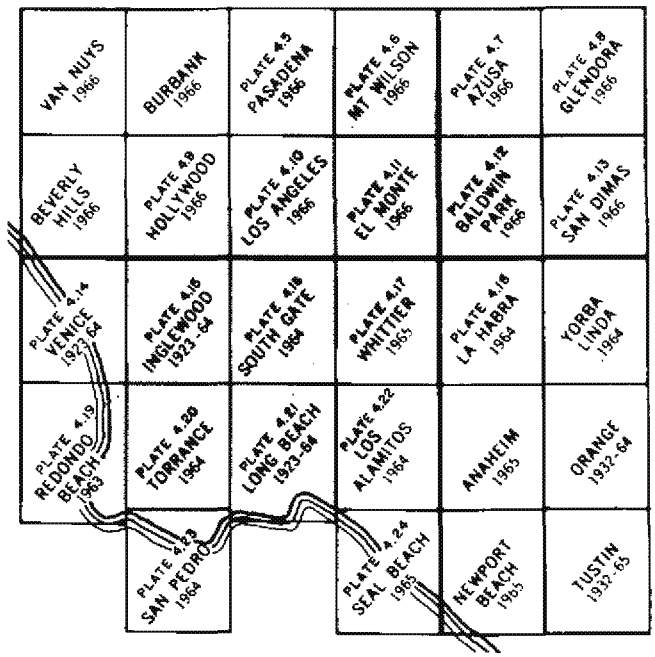


Figure 4.1 Index map of U.S. Geological Survey 7½ minute quadrangles (Plates 4.5-4.24) covering the San Gabriel Valley P-C Region.

areas include parts of the Palos Verdes, San Jose, Repetto, and Puente Hills. The sedimentary rocks that are unsuitable for use as aggregate include shale, siltstone, diatomite, and limestone of the Monterey Formation; platy siltstone, diatomaceous siltstone, shale, and dolomite of the Puente Formation; well-bedded siltstone and shale of the Topanga Formation; and massive siltstone of the Repetto Formation.

Areas Classified MRZ-2

Plate 4.1 shows the general localities of the San Gabriel Valley P-C Region which are classified as MRZ-2. These are areas where adequate information indicates that significant mineral deposits are present, or where it is judged that a high likelihood for their presence exists ("Guidelines for Classification and Designation of Mineral Lands," Appendix A-3 in SR 143, Part I, p. 32).

The geologic setting of the sand and gravel resources in the San Gabriel Valley P-C Region is a broad system of coalescing alluvial fans that have filled the San Gabriel Valley floor at the base of the San Gabriel Mountains. Alluvial fan deposits are formed when mountain streams carrying large volumes of sand and gravel enter into a valley or plain. The abrupt change in slope causes a sudden decrease in the transporting energy of the stream, thus resulting in deposition of coarse gravel material near the apex of the fan and finer material further downstream.

Table 4.1 List of lead agencies (county and incorporated city governments) located within the San Gabriel Valley P-C Region. Cities that have active aggregate operations within their jurisdictional boundaries are denoted by asterisks. Cities that have land within their jurisdiction classified MRZ-2 are denoted by Δ.

LOS ANGELES COUNTY

Alhambra	Inglewood	Rancho Palos Verdes
Δ Arcadia	* Δ Irwindale	Redondo Beach
* Δ Azusa	La Canada Flintridge	Rolling Hills
Δ Baldwin Park	Lakewood	* Δ Rolling Hills Estates
Bell	Δ La Puente	Δ Rosemead
Bellflower	Lawndale	Δ San Dimas
Bell Gardens	Lomita	Δ San Gabriel
Bradbury	Long Beach	San Marino
Carson	Δ Los Angeles	Δ Santa Fe Springs
Commerce	Lynwood	Δ Sierra Madre
Δ Covina	Manhattan Beach	Signal Hill
Cudahy	Maywood	Δ South El Monte
Δ Downey	Δ Monrovia	South Gate
Δ Duarte	Δ Montebello	Δ South Pasadena
Δ El Monte	Monterey Park	Δ Temple City
Gardena	Norwalk	Δ Torrance
Glendale	Palos Verdes Estates	Δ Vernon
Δ Glendora	Paramount	Walnut
Hawthorne	* Δ Pasadena	Δ West Covina
Δ Huntington Park	Δ Pico Rivera	Whittier
Δ Industry		

Alluvial fan deposits suitable as a source of aggregate are confined to the northern portion of the valley.

In order for a deposit of sand and gravel to be categorized as significant, it must satisfy the criteria given in the "Guidelines for Classification and Designation of Mineral Lands," (see Appendix A-3 in SR 143, Part I). In addition, the geologic factors that resulted in the formation of the deposit must be understood clearly enough so that reasonable interpretations can be made from surface exposure of the material and from drill-hole data.

Deposits within the San Gabriel Valley P-C Region that satisfy these criteria occur within the San Gabriel alluvial fan, Devils Gate Reservoir, Eaton Wash, and the Palos Verdes Hills (see Figure 4.2).

SAN GABRIEL ALLUVIAL FAN

One of the most significant sand and gravel deposits in the greater Los Angeles area occurs in the north-central San Gabriel Valley, in and near the City of Irwindale, California. The voluminous amount of aggregate material in the area is contained in the upper portion of the Holocene (recent geologic time period) San Gabriel alluvial fan (Figure 4.2).

The sedimentary material forming the San Gabriel alluvial fan was derived from rocks exposed in the San Gabriel Mountains to the north. The sediments are poorly sorted and range from boulders exceeding 8 feet in diameter to clay size particles. Coarse material within the fan consists of fresh durable rock clasts, the most common of which are composed of quartz diorite, granodiorite, granitic gneiss and schist. A mixture of gravel, sand, silt, and clay is found throughout all parts of the San Gabriel alluvial fan. Cobbles and boulders are predominantly deposited at the apex of the fan, and the average particle size decreases toward the sides and base of the fan.

The San Gabriel alluvial fan is underlain by older alluvial (Pleistocene) fan deposits which are exposed in parts of the eastern and western San Gabriel Valley. Unlike the Holocene San Gabriel alluvial fan, the older deposits contain large amounts of weathered material, which makes them unsuitable as sources of aggregate material. The geologic sections presented on Plate 4.2 show the general nature of sand, gravel, and clay distribution in portions of the San Gabriel alluvial fan.

The potential value of the San Gabriel alluvial fan as a source of quality sand and gravel for use as construction material was recognized long ago. Although no known records indicate when sand and gravel was first extracted from the fan, it probably was prior to 1900.

Aggregate production from the San Gabriel alluvial fan is taking place in the vicinity of the City of Irwindale, located 18 miles northeast of downtown Los Angeles (Figure 4.2). At the present time, a total of eight operations are active in this production district (Figure 4.3). One of the largest sand and gravel producing operations in the western United States, the Livingston-Graham, Inc., El Monte plant, is located here. Other major

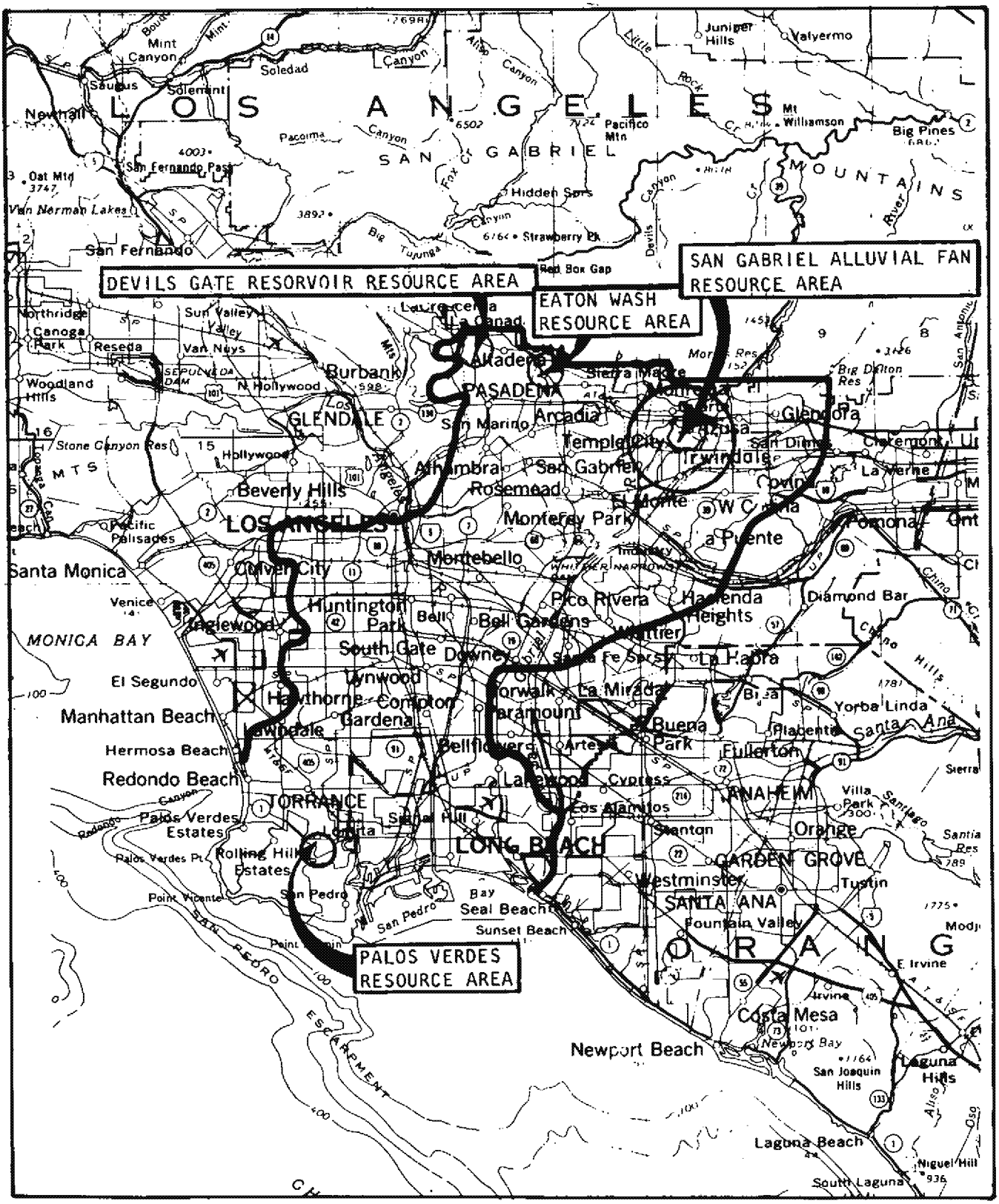


Figure 4.2 Map of the San Gabriel Valley P-C Region showing location of the San Gabriel alluvial fan, Eaton Wash, Devils Gate Reservoir, and Palos Verdes Resource Areas.

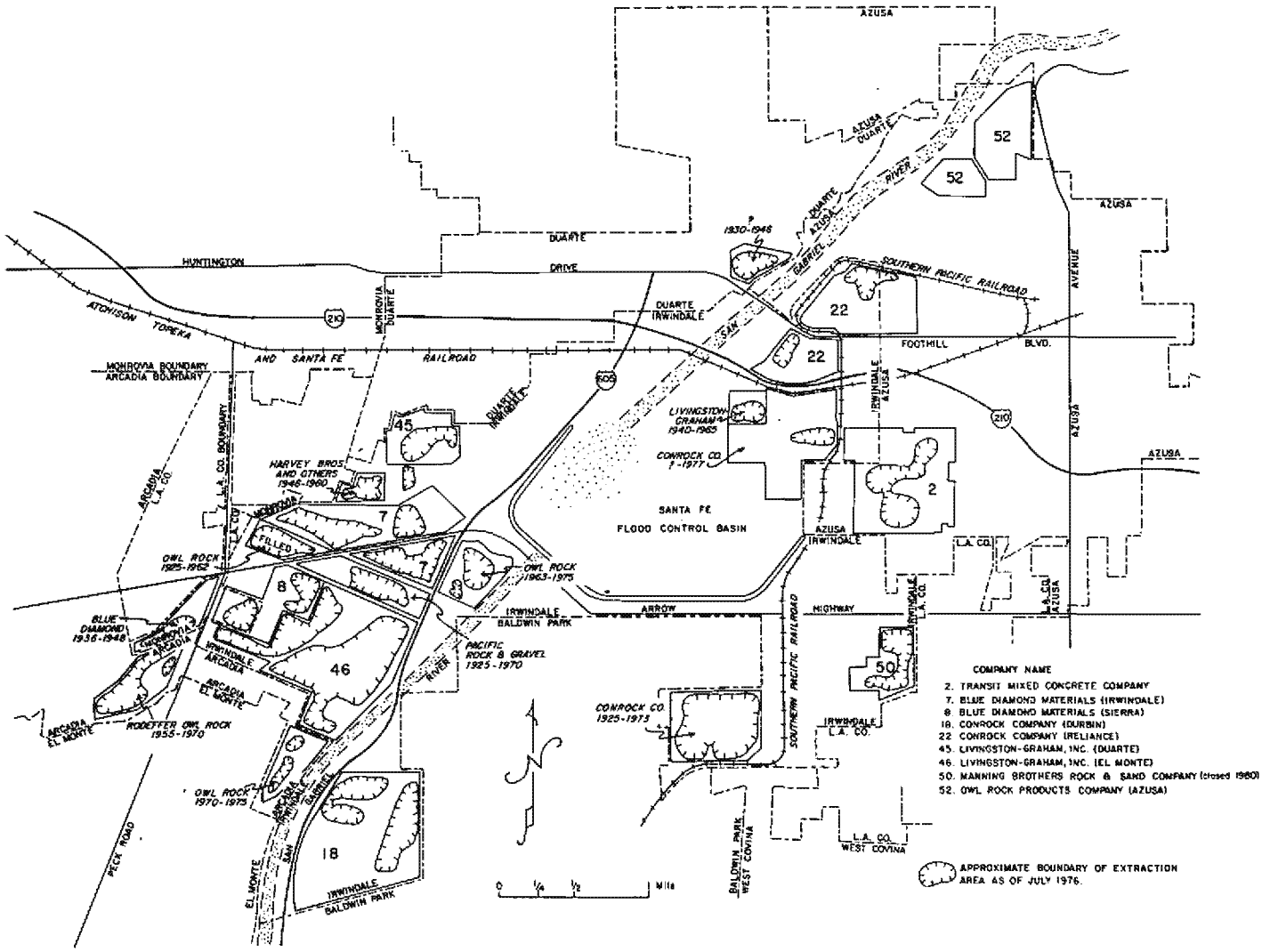


Figure 4.3 Sketch map of the San Gabriel Valley fan production district showing land owned or leased by aggregate companies as of January, 1981.

operations are the Owl Rock Products Co., Azusa plant, Blue Diamond Santa Fe plant, Transit Mixed Concrete plant, and Conrock's Durbin and Reliance plants. All of these plants have rated capacities of more than 1,000 tons per hour; the Livingston-Graham plant capacity is 3,000 tons per hour.

The annual production from the San Gabriel alluvial fan for the past 9 years has ranged from 9 million to 18.5 million short tons of processed aggregate. Over the 9-year period of 1970-78, average annual sales of aggregate from this district was over 14 million tons. Since 1960, the San Gabriel alluvial fan has yielded over 320 million tons of aggregate. This tonnage amounts to more than one-third of the total output of the entire greater Los Angeles classification project area. Refer to Evans and others (1979) for detailed discussions of the San Gabriel fan production district.

EATON WASH

Eaton Wash emanates from Eaton Canyon on the south slope of the San Gabriel Mountains (Plate 4.4). The deposit within Eaton Wash extends southward for a distance of approximately 5 miles and has an average width of 0.5 miles. Except for the northernmost portion, most of the wash has been urbanized.

The deposit is composed of fresh, durable detrital material. Grain sizes range from clay-size particles to boulders several feet in diameter. The sand-to-gravel ratio (based upon volume) is about 2:1. Clast types are predominantly granitic rocks similar to those found in the San Gabriel alluvial fan. Asphaltic sand and gravel and concrete sand has been produced from the Eaton Wash deposit, but there are no current operations.

DEVILS GATE RESERVOIR

The Devils Gate reservoir deposit is situated within the Arroyo Seco drainage about two miles east of the City of La Canada (see Plate 4.4). The deposit is in an alluvial channel of Holocene age which drains a large portion of the San Gabriel Mountains north of Pasadena. During periods of heavy rainfall, material is transported along the Arroyo Seco and is impounded due to the presence of Devils Gate Dam. Consequently, material must periodically be removed from the reservoir area to maintain the effectiveness of the dam.

Aggregate material within the Devils Gate deposit has an almost equal ratio (based upon volume) of sand to gravel. The coarsest material consist of boulders averaging about 3 feet in diameter, with some attaining dimensions of up to 6 feet. Common clast types identified include granite, granodiorite, quartz diorite, and quartz feldspathic gneisses and schists.

Mining at the Devils Gate reservoir area began in the early 1960s by Western Aggregate Co. In 1969, Pasadena Aggregate started mining and processing in the area; the operation has generally been continuous since then. The company operates under a lease issued by the City of Pasadena and administered by the Los Angeles County Flood Control District. Material from the mine is processed in a conventional crushing, washing, and screening operation.

SAN PEDRO SANDSTONE

The San Pedro Sandstone is a Pleistocene marine deposit which outcrops along the northern and northeastern fringes of the Palos Verdes Hills (Figures 4.4 and 4.5). This sandstone forms an almost continuous belt extending from the City of San Pedro northwestward to Malaga Cove. Historically, mining of the San Pedro Sandstone has taken place along a 2-mile strip in a northwesterly direction from the current mining site in the City of Rolling Hills Estates. This 2-mile stretch is classified as MRZ-2. The remaining areas underlain by San Pedro Sandstone are classified as MRZ-3 because of lack of adequate data concerning the quality of the material.

The depositional environment of the San Pedro Sandstone is believed to be cold-water marine probably corresponding to a period of maximum glaciation (Woodring, W.P., 1946). Regional tectonic uplift of the entire Palos Verdes Peninsula has left these marine deposits stranded hundreds of feet above the present sea level.

The San Pedro Sandstone consists predominantly of quartz and feldspathic sands, most of which are poorly consolidated, relatively unaltered, coarse, and uncemented. The sandstone contains some minor (less than 2%) pebbly gravel, but the deposit is essentially a sand deposit. Much of the sandstone is

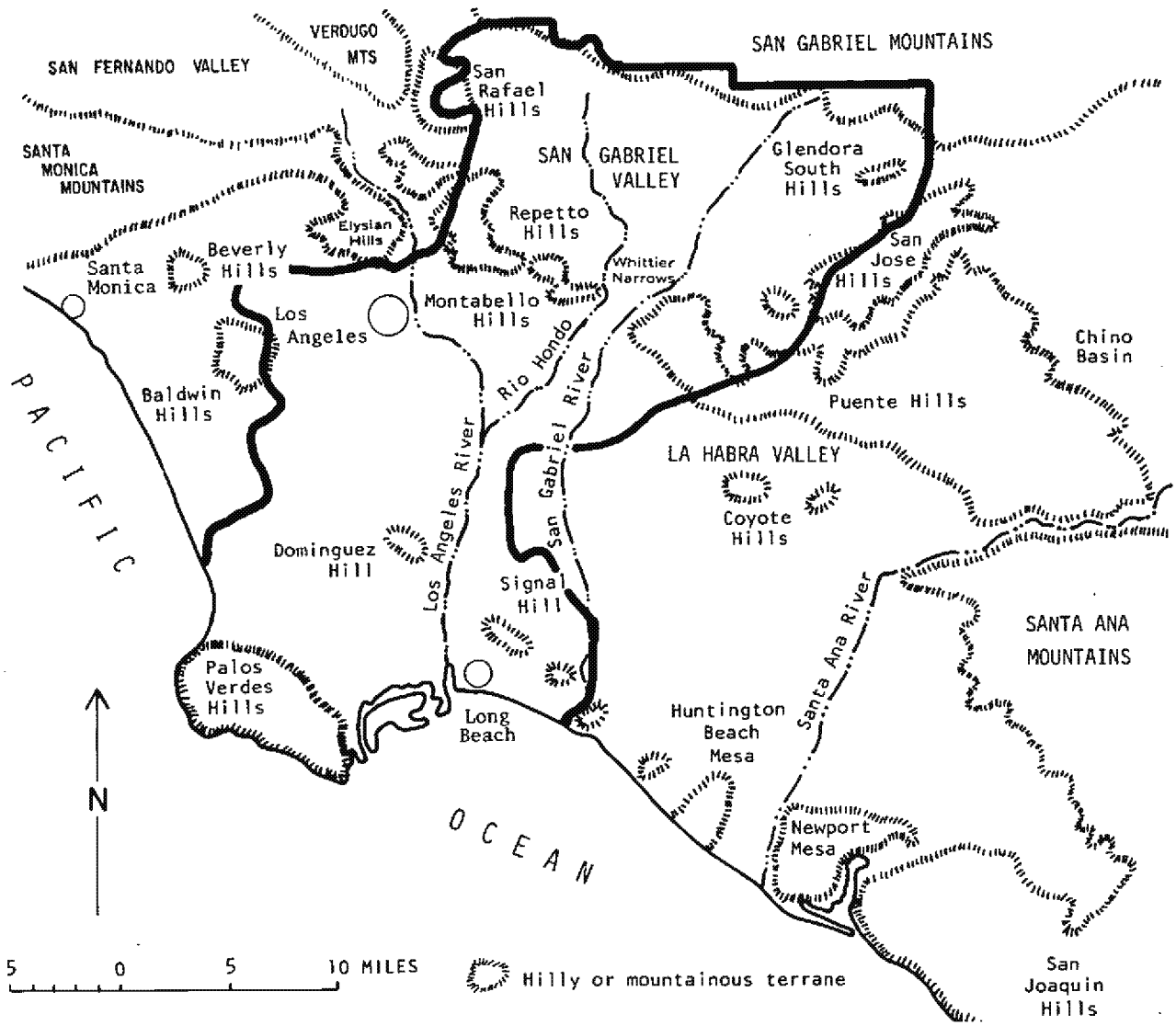
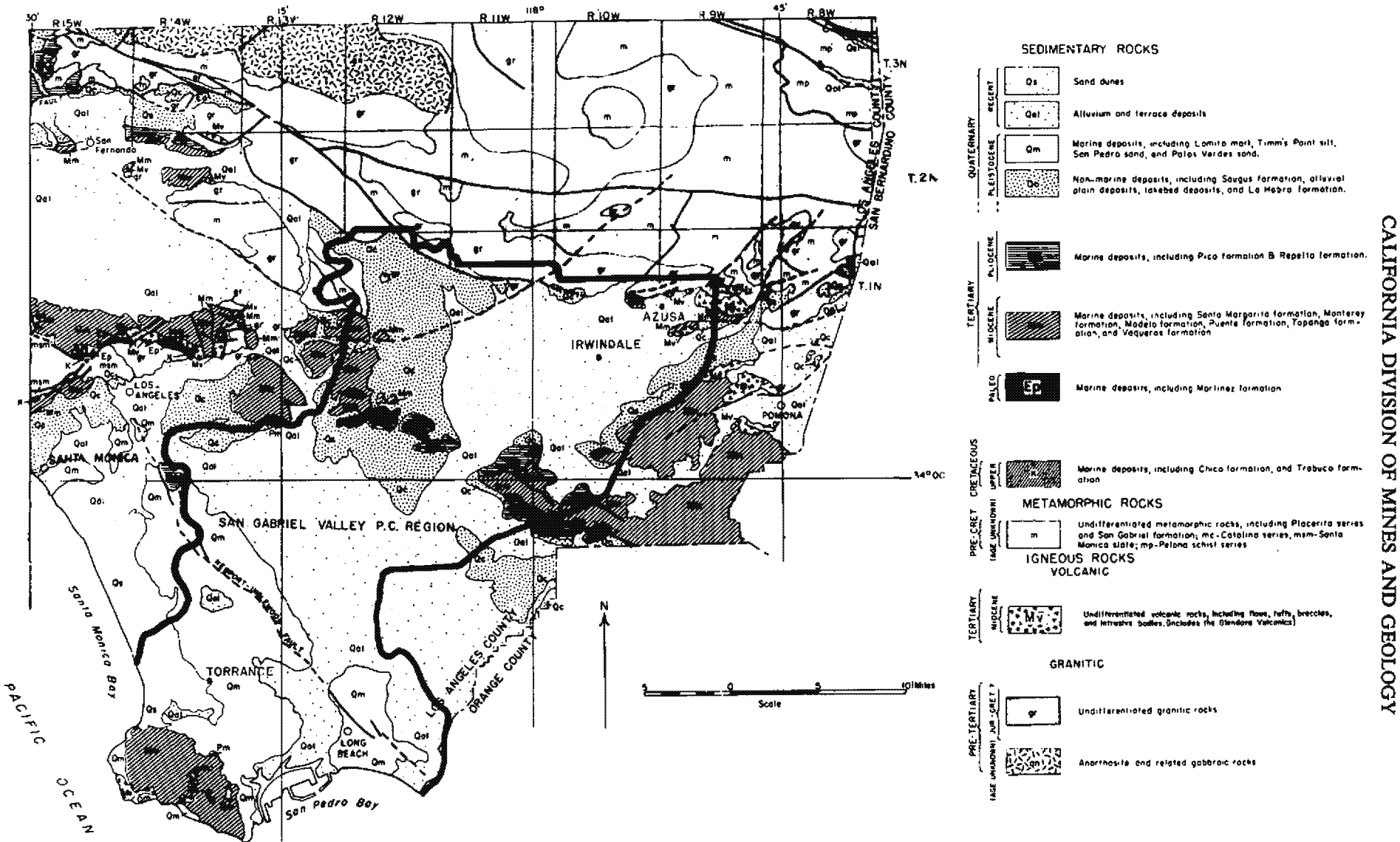


Figure 4.4 Major physiographic features of the San Gabriel Valley P-C Region and adjacent areas.



Modified from: Woodford, A.O., and others, 1954: Geology of the Los Angeles Basin, California Division of Mines and Geology, Bulletin 170, vol. 50, No. 3 and 4, Plate 4.

Figure 4.5 Geology of the San Gabriel Valley P-C Region and adjacent areas.

capped by late Pleistocene to Holocene, non-marine terrace cover ranging in thickness from a few feet to 100 feet (Woodring, W.P., 1946). Most of this terrace cover is less than 50 feet in thickness.

Operations at the currently operating Chandler's Palos Verdes mine began in 1921 and have been continuous since 1937. This is the only active operation in the Palos Verdes area. Because the deposit is composed almost solely of sand, coarse aggregate is imported from the San Gabriel fan production district in order to make Portland cement concrete at Chandler's batch plant.

Areas Classified MRZ-3

Plate 4.1 shows the general localities of the MRZ-3 areas within the San Gabriel Valley P-C Region. These areas incorporate land containing mineral deposits, the significance of which cannot be evaluated from available data (see Appendix A-3 in SR 143, Part I, p. 32). MRZ-3 areas in the San Gabriel Valley P-C Region include both valley regions and hilly or mountainous terrane. MRZ-3 areas located in valley or basin regions are generally underlain by alluvial deposits of Quaternary age. These deposits contain sand and gravel of which little is known because of inadequate subsurface data. MRZ-3 areas located in hilly or mountainous terrane are generally underlain by sedimentary deposits of Tertiary age, crystalline basement rock, or volcanic rocks (Plate 4.1 and Figure 4.5). Very little subsurface or surface data of the type needed to evaluate the suitability of these rocks for use in Portland cement concrete is available. Consequently, these areas were classified as MRZ-3.

Those MRZ-3 areas that are most promising as potential sources of aggregate material are discussed in the "Alternative Sources of Aggregate" section beginning on page 17.

GLENDORA SOUTH HILLS

The Glendora South Hills, a low ridge about a mile southeast of the City of Glendora, are classified as MRZ-3 (Figure 4.4). Rock units which comprise these hills belong to the Glendora Volcanics and the Topanga Formation (Figure 4.5). The Glendora Volcanics, which consist of andesites and undifferentiated volcanics, are exposed along the southern side of the hills. Crystalline volcanic rocks are often used as a source of crushed rock, especially where there is a shortage of naturally occurring coarse aggregate material. However, there is no known history of mining concrete aggregate material within the Glendora Volcanics. In order to classify these rocks as a crushed rock resource, physical and chemical properties of these rocks need to be evaluated. A discussion of Tertiary volcanic rocks, which includes the Glendora Volcanics, is given under the "Crushed Rock Sources as Alternatives" section of this report, page 17.

The Topanga Formation, consisting of coarse- to fine-grained, massive-bedded sandstone and conglomerate, are exposed along the northern side of the Glendora South Hills. These rocks have been assigned an MRZ-3 classification on the basis of lithologic descriptions and field observations. There is no history of mining these rocks.

SAN JOSE HILLS

Some of the Tertiary sedimentary formations exposed in the northwestern San Jose Hills contain deposits that are potential sources of aggregate and have been classified as MRZ-3. These are sandstone, pebbly sandstone, and conglomerates, most of which are assigned to the Soquel Member of the Puente Formation and the lower member of the Fernando Formation.

The Soquel Member of the Puente Formation consists of poorly cemented feldspathic sandstone and pebbly sandstone, interbedded siltstone, and local lenses of pebble conglomerate. In the past, aggregate was produced from a conglomerate lens of the Soquel Member in an area east of El Toro Marine Air Station (located in the adjacent Orange County-Temescal Valley P-C Region). It is not known whether conglomerate lenses of the Soquel Member within the San Jose Hills have similar physical and chemical properties to those mined in the east El Toro area.

The lower member of the Fernando Formation consists of alternating, massive silty sandstone and pebble conglomerate with local beds of intraformational breccia. There is no known history of mining of this lower member within the San Gabriel Valley P-C Region. These sediments were classified as MRZ-3 solely on the basis of lithologic descriptions and field observations.

In addition to these sedimentary units, areas underlain by rocks belonging to the Glendora Volcanics, which are exposed in the northeastern portion of the San Jose Hills, have been classified as MRZ-3.

WESTERN PUENTE HILLS

There are a few areas in the Western Puente Hills where Tertiary sedimentary formations that contain conglomerates and sandstones are exposed. These areas are potential sources of aggregate and have been classified as MRZ-3. These Tertiary sedimentary units are the Sycamore Canyon and the Soquel members of the Puente Formation, and the upper member of the Fernando Formation.

The Sycamore Canyon Member of the Puente Formation consists of fine- to coarse-grained sandstone, pebble conglomerate, and interbedded micaceous sandy siltstone. The conglomerate-sandstone-siltstone ratios vary considerably, depending on the specific locality. Consequently, each locality must be evaluated separately in order to determine its potential for aggregate use. Parts of the Sycamore Canyon Member are currently being mined in the adjacent Orange County-Temescal Valley P-C Region near Prado Dam.

The upper member of the Fernando Formation consists of massive sandstone, silty sandstone and pebble conglomerate, pebbly sandstone, and siltstone. Parts of this upper member are currently being mined in the Orange County-Temescal Valley P-C Region for base material in a quarry near Carbon Canyon.

Sediments belonging to the Soquel Member in the Western Puente Hills have similar lithologies to those sediments belonging to the same member in the San Jose Hills.

REPETTO HILLS

A few areas within the Repetto Hills believed to contain potential sources of aggregate are zoned MRZ-3. These are areas underlain by well-bedded, medium- to coarse-grained sandstones of the Puente Formation, conglomerates and sandstones of the Fernando Formation, and medium- to coarse-grained, well-bedded sandstones of the Topanga Formation.

MONTEBELLO HILLS

The Montebello Hills, situated on the southern flank of the Repetto Hills, are classified as MRZ-3. These hills are a geomorphic expression of an easterly-trending, elongated anticlinal fold. Pleistocene sands and conglomerates that overlap the upper member of the Pico Formation are exposed at the surface irregularly around the periphery of the hills. The upper member of the Pico Formation is exposed along the axis and the crest of the anticline. These rocks consist of massive buff siltstone containing several thin fossiliferous sandstone and conglomerate beds.

PALOS VERDES HILLS

The Palos Verdes Hills constitute an isolated upland peninsula along the southwest border of the Los Angeles Basin. These hills contain a number of formations which contain a variety of sedimentary rocks. Only a small portion of the hills are classified as having potential aggregate resources. Areas which are most likely to contain suitable material for aggregate use are those underlain by the San Pedro Sandstones (see page 5 for description). Outcrops of the San Pedro Sandstone indicate that most of the unit is homogeneous, yet the lack of test data, along with the lack of mining activities in much of the area underlain by the sandstone, prevents classifying the area as MRZ-2. Consequently, all areas underlain by the San Pedro Sandstone are classified as MRZ-3 except where mining has or is currently taking place.

In addition to the San Pedro Sandstone, several basalt bodies exposed in the Palos Verdes Hills may be potential crushed rock aggregate sources. Most of these igneous bodies are sills ranging in thickness from a foot to several hundred feet.

Areas Classified MRZ-4

Areas where available information is inadequate for any other classification have been assigned as MRZ-4 (Plate 4.1). Within the San Gabriel Valley P-C Region, the only areas so classified are limited to alluvial areas for which well-log data are lacking.

EVALUATION OF AGGREGATE RESOURCES IN THE SAN GABRIEL VALLEY P-C REGION

An analysis of aggregate supply in the San Gabriel Valley P-C Region is presented in this section of the report. The analysis was conducted on the basis of a quantitative evaluation of aggregate resources contained in urbanizing portions of the San Gabriel Valley P-C Region. Two similar evaluations have already been completed for the adjacent San Fernando Valley P-C Region (Anderson and others, 1979) and the Orange County-Temescal Valley P-C Region (Miller and others, 1981). A less detailed study has been made of the Claremont-Upland P-C Region, which borders the San Gabriel Valley P-C Region on the west (Plate 4.1). Evaluation of all adjacent P-C regions is necessary in order to determine what effects these regions might have on the availability of aggregate in the San Gabriel Valley P-C Region. These evaluations are presented in the "Alternative Sources of Aggregate" beginning on page 17.

A substantial amount of land in the San Gabriel Valley P-C Region has been classified MRZ-2 (Plate 4.1). By far, the bulk of the sand and gravel deposits contained within these classified areas occurs beneath urbanized land. Some of the remaining land is unoccupied, but is broken up into isolated properties by subdivisions, freeways, roads, power lines, and waterways. These unoccupied properties are, in many cases, too small to be considered for sand and gravel extraction.

Urbanized Versus Nonurbanized Land Uses

The State Geologist is responsible for calculating aggregate resources for those MRZ-2 areas that meet the State Mining and Geology Board's guidelines as candidates for designation by the Board. The Board has provided general criteria by which the State Geologist can make final decisions as to which portions or sectors of MRZ-2 areas would qualify as candidates for designation and has indicated its general intent by providing policy guidance to local governments concerning *compatible* and *incompatible* uses on lands adjacent to designated lands (California Division of Mines and Geology, 1979, p. 40). Because the Board does not designate areas presently dedicated to land uses that are incompatible with mining, the State Geologist has limited the calculation of aggregate resource tonnages to those MRZ-2 areas that have compatible land uses. Doing this has expedited the completion of the classification reports.

Because specific criteria to identify incompatible land uses are lacking, it is possible that more or less area than that identified by the State Geologist as *incompatible* will be judged by the Board to be *compatible*, based on further interpretations of these terms during their deliberations.

Because the Board's characterizations of *compatible* and *incompatible* provide only a general guidance rather than specific criteria for labeling particular MRZ-2 areas, the State Geologist has adopted the terms *nonurbanized* and *urbanized* for application to the particular MRZ-2 areas being considered, throughout this report.

Nonurbanized land includes very low density residential land (approximately one unit or less per ten acres), recreational land that does not have high cost improvements, agricultural land, silvicultural land, grazing land, and open space.

Urbanized land includes areas containing improvements of high cost, such as high density residential developments, intensive industrial developments, commercial developments, and major public facilities.

The determination of the above classifications for this report is based upon conditions of the land at the time of the study, in 1980. The use of the land was determined by the field geologists assigned to this project from information obtained through discussions with local agencies, examination of modern aerial photographs, and field reconnaissance observations.

Data Base

Much of the resource calculation that follows is based on an evaluation of drill-hole records of variable reliability collected over a time span extending back to the early part of this century. The drill-hole records describe the types of earth material (silt, sand, gravel, and bedrock types) encountered at various depths. The quality of drill-hole descriptions range from poor to very

good, but only drill-hole records that contain descriptions judged to be acceptable for analysis were used in the present study.

Terminology used to reflect the confidence level of resources has been adopted from U.S. Geological Survey Bulletin 1450-A (Appendix C in SR 143, Part I). For this study, permitted resources (reserves) fall under the category of indicated reserves. Non-permitted resources meet the criteria set forth for both indicated and inferred resources.

Reserves and Resources

A mineral commodity is recoverable only if local regulations permit mining activity. Therefore, sand and gravel resources herein placed in the category of *reserves* are limited to resources that underlie land where mining is permitted by lead agencies having jurisdiction over such land. The term *resources* includes both *reserves* and *non-permitted resources* (usable materials which could be mined in the future, but for which no use permit allowing extraction has been granted, or for which development has not been definitely established to be feasible based upon current technological or economic conditions).

Because almost all of the total reserves and resources for the San Gabriel Valley P-C Region lie within the San Gabriel alluvial fan, the following general discussion of evaluation parameters applies to aggregate deposits in the San Gabriel alluvial fan (Sectors A-E). The parameters used in evaluating the aggregate deposits in the other resource sectors in the P-C region (Sectors F-I) are explained in the individual sections dealing with those sectors.

PERMITTED RESOURCES (RESERVES)

Most reserve figures for the San Gabriel alluvial fan represent that portion of the resources underlying mining properties with a use permit to mine to a maximum depth of 150 feet. The 150-foot depth limit is a regulatory constraint set by the City of Irwindale (see "Regulatory Constraints," page 9). Three mining operations, two in the City of Irwindale and the other in the City of Azusa, are mining to depths in excess of 150 feet as authorized by the terms of their conditional use permits.

NON-PERMITTED RESOURCES

Figure 4.6 shows the generalized thickness of sand and gravel in the San Gabriel alluvial fan believed to be suitable for use as construction material. That portion of the suitable sand and gravel deposit whose extraction is not currently covered by a use permit and which lies at a technologically feasible mining depth (herein considered to be 400 feet maximum) is placed in the category of non-permitted resources. These resources may lie beneath land which is currently being mined or they may lie beneath unurbanized land which has no permit for extraction.

Mining Constraints

The quantity of reserves is highly dependent on both regulatory and economic constraints. Non-permitted resources have no regulatory or economic constraints because there is no way of knowing what regulatory or technological changes may take place before these resources become available. Consequently, current constraints should be used only as a starting point and it should be noted that the quantity of non-permitted resources may be drastically decreased or increased depending on future constraints.

REGULATORY CONSTRAINTS

The major regulatory restrictions that affect the total sand and gravel reserve pertain to slope angle, depth of extraction, and setback requirements. These regulatory constraints are largely imposed by the city or county that has jurisdiction over the mining property, but state and federal government agencies may impose their own special regulations.

Most of the sand and gravel operations in the San Gabriel Valley P-C Region fall within the jurisdictional boundaries of the City of Irwindale. Any new sand and gravel extraction within Irwindale must be within a Q zone. Irwindale's Ordinance No. 245 addresses the permitted use for Q zones. The ordinance restricts the finished mining slopes to a maximum of one foot horizontally to one foot vertically (1:1) and permits mining to a maximum depth of 150 feet. Prior to Irwindale's adoption of the Q zones, mining was permitted on M-2 zoned properties under the regulations of a conditional use permit. These conditional use permits impose a 1:1 slope and a 150 foot depth limitation. Digging in excess of 150 feet in the Q zones and M-2 zones requires approval by the Irwindale City Council. The Livingston-Graham Company and the Conrock Company have recently been granted an exemption which permits both companies to mine to depths exceeding 150 feet.

Other cities that have jurisdiction over sand and gravel mining properties are Azusa, Pasadena, and Rolling Hills Estates. Rolling Hills Estates has also adopted a Q zone. Regulations for the Q zone are addressed in Ordinance Nos. 260 and 314 of the City of Rolling Hills Estates. Only one mining operation exists in the City of Rolling Hills Estates. Site-specific restrictions for this operation are stated in the Conditional Use Permit. Slope restrictions for this property are a maximum of 1:1 and minimum setbacks from property lines are 50 feet. There is no depth restriction stated in this permit. Mining depth is economically restricted by the depth of the water table which occurs at about 230 feet.

Azusa has not incorporated a Q zone into its city plans. Two active mining operations, Owl Rock and Transit Mixed Concrete, lie within the jurisdictional boundaries of Azusa. Regulations for these mines are set in Conditional Use Permits issued by the Azusa City Council. Slope restrictions are 1½:1 for the Owl Rock Mine and 1:1 for the Transit Mixed Concrete operation. Neither of these mines have any depth restrictions stated in their conditional use permits.

The only mining operation in the City of Pasadena is located in the Devils Gate Reservoir area, which is zoned R (residential). This land is owned by the City of Pasadena, which leases it to a private company for the purposes of mining. Because this land is owned by the City of Pasadena, it is exempt from any zoning regulations. The mine does not operate under any permit but instead is regulated by the Los Angeles County Flood Control District. The depth of excavation ranges from one foot to approximately 30 feet, depending upon the location in the wash. There are no setback regulations, but mining is restricted to the leased area.

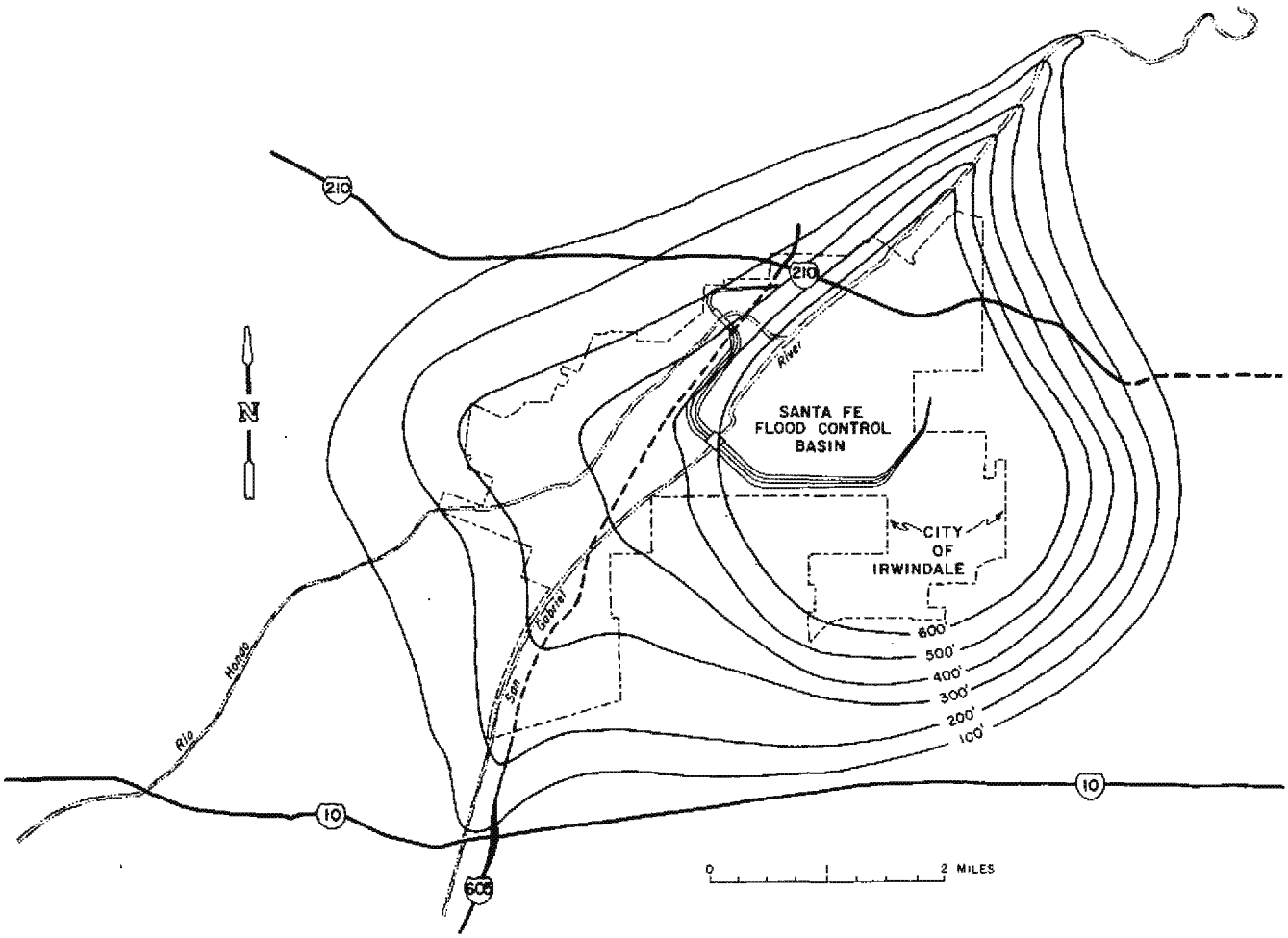


Figure 4.6 Contour map showing general thickness of sand and gravel within the San Gabriel Valley fan production district.

ECONOMIC CONSTRAINTS

In classifying sand and gravel deposits as significant and in calculating the available resources and reserves within those deposits, the following conditions involving economic factors must be satisfied:

1. Material meets the *mineability* and *threshold* criteria given in the "Guidelines for Classification of Mineral Lands" (Appendix A-3 in SR 143, Part I)
2. The deposit consists of sound durable material substantially free of chemically reactive substances that would preclude its use as a construction material.
3. Combined clay and silt fraction does not exceed 25 percent by volume.

Resource Sectors

To organize the volume calculations of the aggregate resources, and to inform the Board about the resources within specific land-use areas, the State Geologist has utilized the concept of "sectors" to identify those MRZ-2 areas that meet the Board's guidelines as eligible to be designated of regional or statewide significance. Each sector shown on Plates 4.3 and 4.4 is a part of the nonurbanized MRZ-2 land where the geometrical configuration of the deposit is fairly uniform, so that tonnages of the available mineral resource can be estimated with some degree of reliability. Thus, for example, sector boundaries would be established between that part of a natural deposit formed on a fan, and that part within the confines of an adjacent modern stream channel and its floodplain. The sector concept is used for the convenience of arraying resource information and is not intended to imply any recommendation for designation or for designation priority.

All sand and gravel deposits suitable for aggregate in the nonurbanized part of the San Gabriel Valley P-C Region have been divided into nine sectors for the purpose of making resource calculations. Sectors A-E contain alluvial areas within the San Gabriel fan production district (Plate 4.3). Sectors F through H are wash areas that are fed by watershed in the San Gabriel Mountains. The nonurbanized portion of Eaton Wash comprises Sector F. Sector H lies within the Devils Gate reservoir area. Sector I encompasses a unique bedrock deposit which is in the north central portion of the Palos Verdes peninsula (Plate 4.4).

SECTORS A AND B - NORTHERN SAN GABRIEL WASH

Sectors A and B, which cover the upper reaches of the San Gabriel alluvial fan, encompass a 1,450-acre portion of nonurbanized land extending from the mouth region of the San Gabriel Canyon southward along the San Gabriel River to the northern margin of the Santa Fe Flood Control Basin (Plate 4.3). For the purposes of this report, this area will be referred to as the Northern San Gabriel Wash. The area measures about 2 miles in length and 1,500 to 4,000 feet in width.

Sectors A and B are discussed jointly because they are both situated in the same physiographic area. Sector B includes all nonurbanized portions of the Northern San Gabriel Wash that are included as part of the Santa Fe Dam Recreation Area, while Sector A comprises the remaining portion of the Northern San Gabriel Wash. Sector A has no known current or proposed land uses that may be incompatible with sand and gravel mining. A further discussion of these sectors is presented below in the "Land Use Considerations" section beginning on page 13.

Well-log evaluation indicates that the depth of sand and gravel deposits in Sectors A and B believed to be of suitable quality for use in Portland cement concrete aggregate is 30 feet at the mouth of the San Gabriel Canyon and over 600 feet at the most southerly extent of the sectors. Technological constraints limit the depth for economic resource extraction to a maximum of 400 feet for Sectors A and B as well as for Sectors C, D, and E. Resource calculations reflect this depth. There is no overburden. None of the drill holes located between the mouth of the canyon and the southern extent of the sector penetrated bedrock. Well-logs within a few hundred feet of the outer canyon walls bottomed out in alluvium at a depth of about 150 feet. This indicates a sharp bedrock relief in the subsurface. The depth to bedrock and the surface bedrock configuration in Sectors A and B are not known. However, these factors do not appear to be critical in the present resource evaluation because well-log analysis shows that depth of resource is controlled by the presence of excessive silt and clay material in the substratum.

Based upon information provided by sand and gravel companies operating within the San Gabriel alluvial fan, the following assumptions were made for Sectors A and B, as well as C, D, and E.

1. The material is assumed to have an average waste of 10%.
2. The inplace density of the resource is assumed to be .065 short tons of sand and gravel per cubic foot (15.4 ft^3/ ton).
3. Pit-wall slopes will not exceed a 1:1 gradient. (This is the maximum final gradient which is authorized in the use permits issued to mining operations within the San Gabriel alluvial fan.)

There are 280 million tons of non-permitted resources included in Sector A. An additional 360 million tons of non-permitted resources are included in Sector B (Table 4.2). In order to protect proprietary information, reserve estimates for Sector A are not given in Table 4.2, but they are included in the total reserves for all sectors. There are no reserves in Sector B.

SECTOR C - SANTA FE FLOOD CONTROL BASIN AND SPILLWAY

Sector C encloses the area known as the Santa Fe Flood Control Basin and Spillway (Plate 4.3). As indicated on Figure

Table 4.2 Aggregate resources of the San Gabriel Valley P-C Region (all numbers in million short tons).

SECTOR	RESOURCES	
	PERMITTED RESOURCES (RESERVES) (Indicated Category)	NON-PERMITTED RESOURCES (Indicated and Inferred Category)
A	*	280
B	none	360
C	none	1320
D	150	600
E	50	440
F	none	5**
H	*	35**
I	*	15
TOTAL	280	3060

* Cannot be shown due to confidentiality of producer data
** 40% of this material is suitable for use in Portland cement concrete
NOTE: All figures over 50 million rounded down to nearest 10 million. Figures less than 50 million rounded down to nearest five million tons.

4.6, sand and gravel believed to be of suitable quality for Portland cement concrete aggregate extends to a depth of about 600 feet over most of the area contained in Sector C.

A total of 1,320 million tons of non-permitted resources (0-400 foot depth) are contained in areas enclosed in Sector C. There are no reserves within Sector C.

SECTOR D - SAN GABRIEL ALLUVIAL FAN, WEST

Sector D consists of numerous isolated nonurbanized areas to the west and southwest of the Santa Fe Dam (Plate 4.3). Most of these areas are controlled by aggregate producers and are sites of present day or past mining activity. The depth of sand and gravel suitable for Portland cement concrete aggregate is less than 200 feet in the far western and southern portions of the sector and more than 600 feet in the northeastern areas (Figure 4.6).

Approximately 150 million tons of reserves remain in Sector D. An estimated 600 million tons of non-permitted resources are believed to lie beneath Sector D.

SECTOR E - SAN GABRIEL ALLUVIAL FAN, EAST

Sector E encloses several properties which lie to the east and southeast of the Santa Fe Flood Control Basin (Plate 4.3). Much of the resources underlying Sector E are controlled by aggregate producers. Subsurface data indicates that sand and gravel suitable for use in Portland cement concrete exceeds depths of 600 feet in all portions of Sector E.

An estimated 50 million tons of reserves remain in Sector E. Approximately 440 million tons of non-permitted resources lie beneath Sector E.

SECTOR F - EATON WASH

All resources underlying Sector F are located within the alluvial channel beneath Eaton Wash (Plate 4.4). Resource estimates for material underlying this sector were determined for the major nonurbanized portion of the wash which is north of Sierra Madre Boulevard. Approximately 35% of the material within the wash consists of coarse material. The remaining 65% is fine sands, silts, and clays. Well-logs indicate that the material has less silts and clays at the northern end of the wash than at the southern end. Consequently, the waste percentage increases to the south. Asphaltic sand and gravel and concrete sand have been produced from Eaton Wash deposit, but there is currently no mining taking place within the wash. Excavation of material within the wash for channel maintenance does take place after heavy rainfall periods.

Sector F includes all of the nonurbanized land within the wash north of Eaton Wash Dam. An average of 50 feet of sand and gravel lies beneath Sector F. Overburden averages approximately 3 feet.

Based upon field observations and information provided by a sand and gravel company which previously mined material from Eaton Wash, the following assumptions were made for determining the resource for Sector F.

1. The material is assumed to have an average waste of 30%.
2. Approximately 40% of the resource is suitable for use as Portland cement concrete aggregate.
3. The inplace density of the resource is assumed to be .065 short tons of sand and gravel per cubic foot (15.4 ft.^{3}/ton).
4. The pit wall slopes will not exceed a 1:1 finished gradient.

Based on the above assumptions, approximately 5 million tons of non-permitted resources are believed to underlie Sector F. Of this total resource, approximately 2 million tons of aggregate (40% of the resource) is believed to be suitable for Portland cement concrete aggregate.

The portion of Eaton Wash identified as Sector G in preliminary drafts of this report has been deleted.

SECTOR H - DEVILS GATE RESERVOIR

Sector H is a 200-acre wash area within Arroyo Seco to the north of Devils Gate Dam. This area is referred to as the Devils Gate Reservoir Area (Plate 4.4). One aggregate company is currently mining Portland cement concrete aggregate within this sector. A major function of this operation is to provide channel maintenance for the Los Angeles County Flood Control District.

Drill holes in this sector indicate a depth of sand and gravel to 100 feet below the present day channel surface. There is no overburden. The overall mining depth for the current operation is controlled by the Los Angeles County Flood Control District under the current excavation plan. In most areas, the excavation depth does not exceed 30 feet. Since there is little information regarding the quality of material below 30 feet, this depth was used for resource calculations.

Based upon both field observations and information provided by the sand and gravel company operating within the Devils Gate Reservoir Area, the following assumptions were made for determining a resource for Sector H.

1. The material is assumed to have an average waste of 30%.
2. Approximately 40% of the resource is suitable for Portland cement concrete aggregate.
3. The inplace density of the resource is assumed to be .065 short tons of sand and gravel per cubic foot (15.4 ft.^{3}/ton).
4. The pit-wall slopes will not exceed a 1:1 gradient (although this slope may be regulated by the L.A. County Flood Control District).

Based upon the above assumptions, approximately 35 million tons of non-permitted resources are believed to lie beneath Sector H. Of this 35 million tons, approximately 14 million tons of material (40% of the total resource) is believed to be suitable for use as Portland cement concrete aggregate. The reserves for Sector H are proprietary, but are included in the total reserves for all sectors in Table 4.2

SECTOR I - PALOS VERDES HILLS

Sector I covers approximately 120 acres located in the northeastern flank of the Palos Verdes Hills (Plate 4.4). Aggregate in Sector I is produced from the San Pedro Sandstone. This deposit is the only bedrock deposit that is being mined for aggre-

gate use in the San Gabriel Valley P-C Region. Because the deposit consists almost solely of sandstone, and because Portland cement concrete requires an almost equal mixture of sand and gravel, this deposit cannot be classified as an independent source of aggregate for making Portland cement concrete. Nevertheless, it provides the only local source of Portland cement concrete sand in the Palos Verdes area. Other aggregate products produced from this deposit include plaster sand, masonary sand, and gunite sand.

Drill-hole data in Sector I shows that the sandstone extends to depths of nearly 600 feet. Presently, no depth regulations are in force for the operation. The main economic depth constraint is the depth to the water table, which is approximately 230 feet above mean sea level. Also, mining depth is restricted to the depth at which the pit walls nearly converge.

Based upon both field observations and information provided by the sand and gravel company operating within Sector I, the following assumptions were made for determining a resource for Sector I.

1. There is an overall uniformity and continuity of the San Pedro Sandstone in the area shown as Sector I (Plate 4.4).
2. The material has an average waste of 7%.
3. The inplace density of the resource is assumed to be 0.57 tons per cubic foot (or 17.5 ft. ^{3}/ton).
4. The maximum extent of mining is the depth at which the pit walls nearly converge.
5. The pit walls will not exceed a 1:1 final gradient.

Based upon the above assumptions, approximately 15 million tons of non-permitted resources underlie Sector I. Reserve estimates are confidential.

Land Use Considerations

The resource estimates that have been made for Sectors A-I indicate the total quantity of aggregate material that is geologically available for mining. As previously explained, areas already urbanized were excluded from resource calculations. Otherwise, the resource estimates for Sectors A-I do not reflect land-use considerations. The estimates include resources in areas currently committed to a particular land use. A prime example is the Santa Fe Dam Recreational Area, a federally owned regional park developed by the Los Angeles County Department of Parks and Recreation. The park area includes more than 1,100 acres of land located in the Santa Fe Dam reservoir and spillway area, and the upper reaches of the San Gabriel River. Land belonging to this recreation area that contains sand and gravel resources has been grouped into Sectors B and C (Plate 4.3). It is estimated that these two sectors alone contain approximately 1,680 million tons of resources, which is more than half of the total 3,060 million tons of resources present in the San Gabriel Valley P-C Region.

Other areas which are known to have a specified use other than sand and gravel extraction, are parcels of land currently owned by the Miller Brewing Company and the Conrock Company. These parcels are located within Sector E, adjacent to the eastern boundary of the Santa Fe Dam Recreation area. An estimated 100 million tons of resources (or about ¼ of the total resources in Sector E) are contained beneath these areas.

ESTIMATED 50-YEAR CONSUMPTION OF AGGREGATE

The total projected consumption of aggregate in the San Gabriel Valley P-C Region for the next 50 years is estimated to be 780 million tons (Table 4.3). This estimate is based on past consumption-rate patterns as described in SR 143, Part I, "Description of the Mineral Land Classification Project of the Greater Los Angeles Area."

Aggregate Production Records

Aggregate production records were compiled for the years 1961 through 1977 for the San Gabriel Valley and its adjacent P-C regions (Figures 4.7- 4.10). Records for the greater Los Angeles Basin for the years prior to 1961 are, in most cases, incomplete. Aggregate production data were obtained from the United States Bureau of Mines (USBM) statistics. These records are compiled from responses to a voluntary questionnaire that is sent out on an annual basis to all known mining operations. Each producer is requested to divulge their annual production for the preceeding year. It is important to note that the degree of accuracy of these statistics depends strictly on the producer's response. The CDMG staff had no way of checking incorrect information or getting production data from companies who did not respond to the U.S. Bureau of Mines inquiries.

Population Records

Population data for the San Gabriel Valley and its adjacent P-C regions were also compiled for the years 1961-1977 (Figures 4.7- 4.10). The historical population data for this period was obtained from statistical bulletins that have been published by Los Angeles and Orange counties on a quarterly or annual basis.

Population projections for the years between 1978 and 2020 were made for the P-C region using area projections furnished by county governments, the State Department of Finance (1977), and the Southern California Association of Governments (1978). Population projections for the 10-year period between 2020 and 2030 were extrapolated by CDMG staff from the above mentioned data. The resulting population projections to the year 2030 are presented on Figure 4.11.

Per Capita Consumption Rates and Population Densities

Per capita consumption rates of aggregate have varied through time and are different in each P-C region. Several factors, such as changes in urban growth with time, relative degrees of urban maturity, and proximity to major construction projects (for example, freeways), account for some of the variations and differences.

Historical per capita consumption rates from the years 1961 through 1977 for the San Gabriel Valley and its adjacent P-C regions are shown on Figure 4.12. The San Gabriel Valley P-C Region had an average consumption rate of about 4.5 tons of

Table 4.3 Projected aggregate consumption(to the year 2030)for the San Gabriel Valley, San Fernando Valley, Orange County-Temescal Valley and Claremont -Upland P-C regions

YEARS	SAN GABRIEL VALLEY P-C REGION			SAN FERNANDO VALLEY P-C REGION			ORANGE CO-TEMESCAL VALLEY P-C REGION			CLAREMONT-UPLAND P-C REGION		
	Average Population (millions)	5 year Per Capita Consumption (tons)	Aggregate Consumption (million tons)	Average Population (millions)	5 year Per Capita Consumption (tons)	Aggregate Consumption (million tons)	Average Population (millions)	5 year Per Capita Consumption (tons)	Aggregate Consumption (million tons)	Average Population (millions)	5 year Per Capita Consumption (tons)	Aggregate Consumption (million tons)
1980-1985	3.68	X 21.4	= 79	2.74	X 8.0	= 22	2.46	X 28.9	= 71	.54	X 43.7	= 24
1985-1990	3.74	X 21.1	= 79	2.80	X 8.0	= 22	2.73	X 27.8	= 76	.57	X 43.7	= 25
1990-1995	3.82	X 20.8	= 79	2.86	X 8.0	= 23	2.97	X 26.9	= 80	.59	X 43.7	= 26
1995-2000	3.87	X 20.3	= 79	2.91	X 8.0	= 23	3.17	X 26.2	= 83	.61	X 43.7	= 27
2000-2005	3.92	X 20.0	= 78	2.95	X 8.0	= 24	3.34	X 25.5	= 85	.63	X 43.7	= 28
2005-2010	3.96	X 19.8	= 78	2.97	X 8.0	= 24	3.51	X 24.8	= 87	.64	X 43.7	= 28
2010-2015	4.01	X 19.5	= 78	2.99	X 8.0	= 24	3.67	X 24.3	= 89	.66	X 43.7	= 29
2015-2020	4.05	X 19.3	= 78	3.01	X 8.0	= 24	3.82	X 23.6	= 90	.67	X 43.7	= 29
2025-2025	4.09	X 19.0	= 78	3.03	X 8.0	= 24	3.95	X 23.3	= 92	.68	X 43.7	= 30
2025-2030	4.13	X 18.7	= 77	3.05	X 8.0	= 24	4.07	X 22.8	= 93	.69	X 43.7	= 30
TOTAL			780*			230*			850*			280*

* Figure rounded off to the nearest ten million tons.

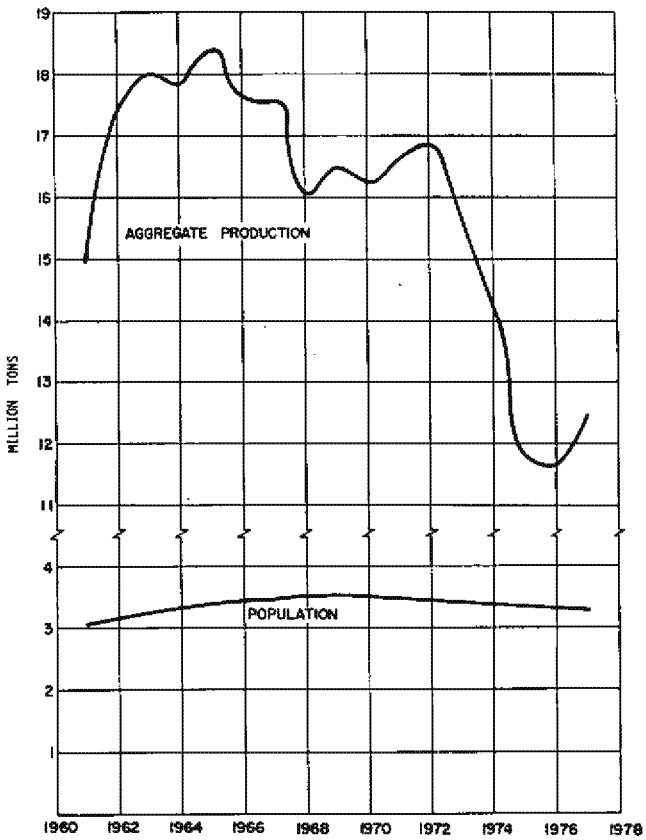


Figure 4.7 San Gabriel Valley P-C Region: population and aggregate production record for years 1961-1977.

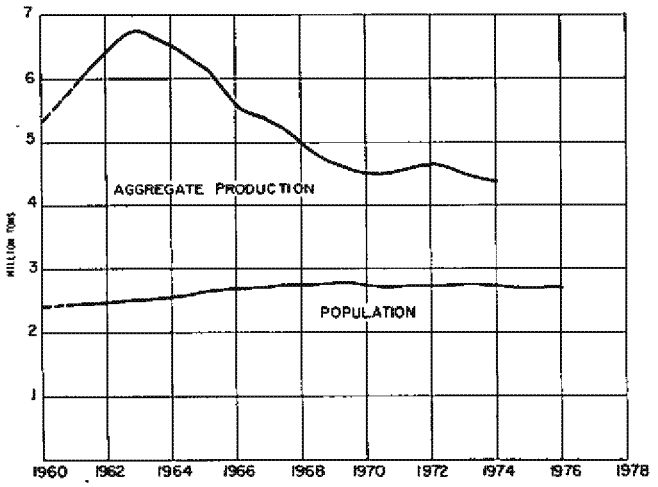


Figure 4.8 San Fernando Valley P-C Region: population and aggregate production record for years 1961-1976.

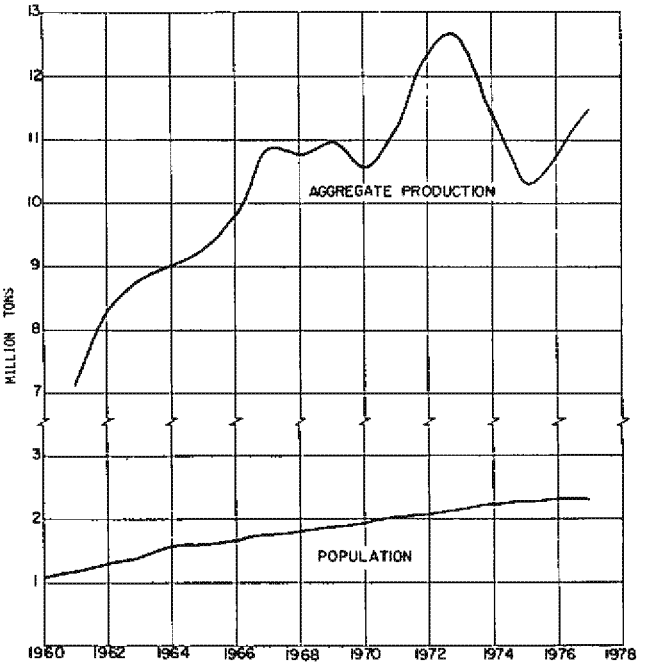


Figure 4.9 Orange County-Temescal Valley P-C Region: population and aggregate production record for years 1960-1977.

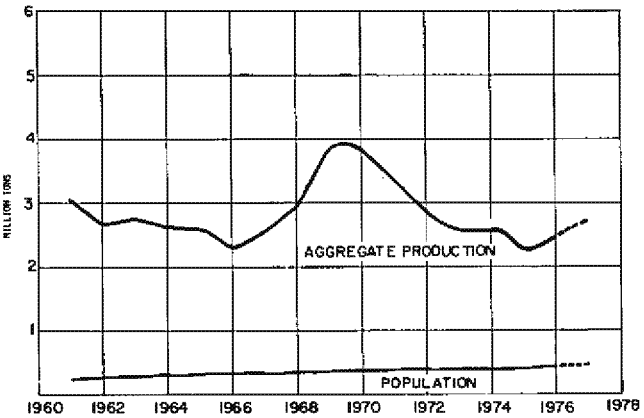


Figure 4.10 Claremont-Upland P-C Region: population and aggregate production record for years 1961-1977.

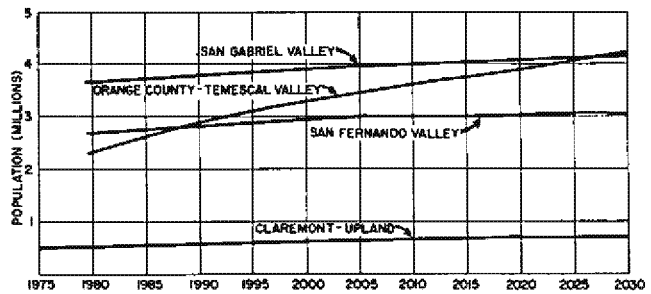


Figure 4.11 Projected population of the San Gabriel Valley, San Fernando Valley, Orange County-Temescal Valley, and Claremont-Upland P-C regions to the year 2030.

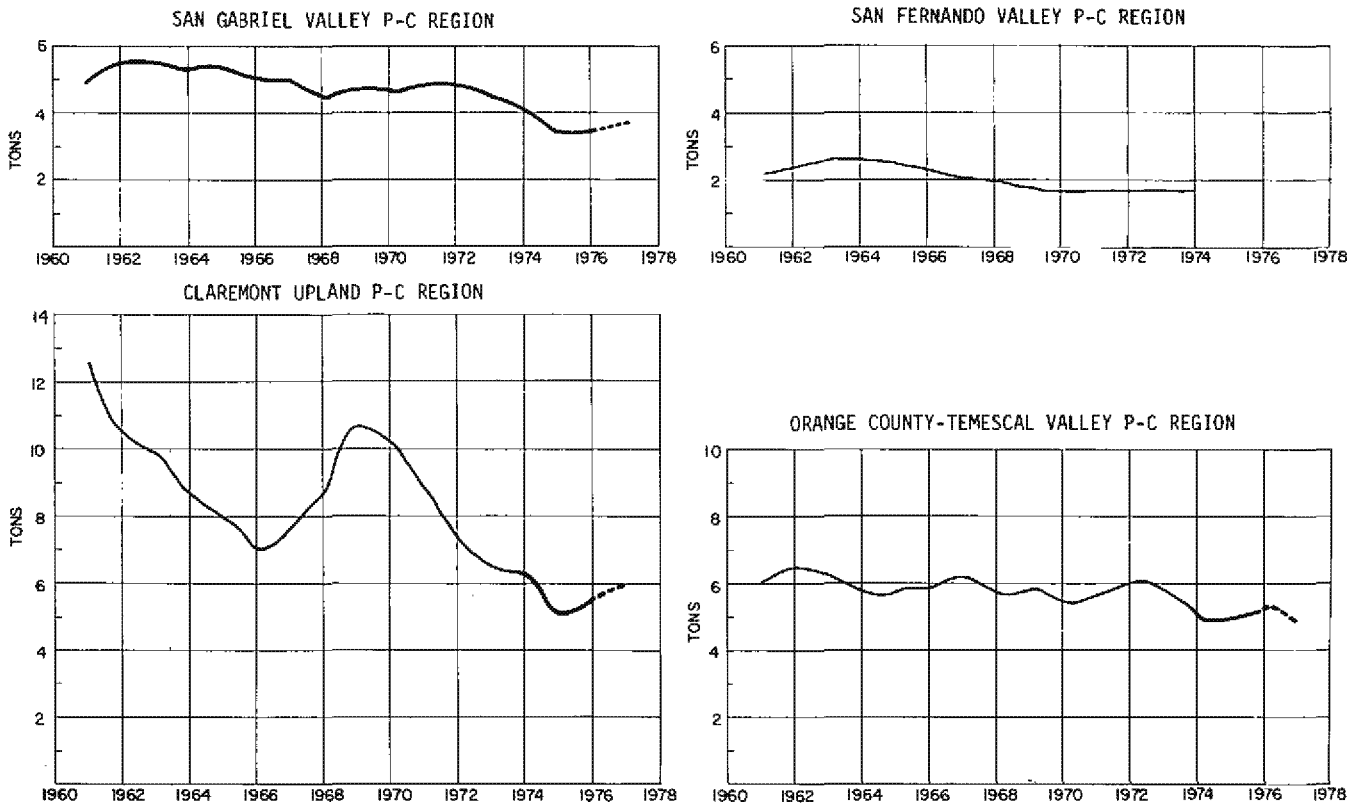


Figure 4.12 Annual per capita consumption of aggregate in the San Gabriel Valley, San Fernando Valley, Orange County-Temescal Valley, and Claremont -Upland P-C regions for years 1961-1977 (San Fernando Valley P-C Region data to 1974 only).

aggregate per person per year between 1960 and 1977 (Figure 4.12). In order to project the per capita consumption rate to the year 2030, per capita consumption data was plotted against population figures for the four large-population P-C regions in the greater Los Angeles area: San Fernando Valley, San Gabriel Valley, Orange County-Temescal Valley, and San Bernardino. Together these four regions total more than 90% of the population within the greater Los Angeles area. The resulting line indicated a gradual decline in the per capita consumption rate with increased population density. This consumption-rate trend was adjusted for in calculating the estimated aggregate consumption needs for the San Gabriel P-C Region to the year 2030 (Figure 4.13), based upon projected population increases for the period. The estimate for Orange County-Temescal Valley P-C Region is taken from Special Report 143, Part III. Similar estimates, without the calculated rate of per capita consumption decline, were made for the San Fernando Valley and Claremont-Upland P-C regions.

The population density of the San Gabriel Valley P-C Region appears to be moderately high in comparison to the less mature urban areas in the Claremont-Upland and Orange County-Temescal Valley P-C regions, yet it is somewhat lower than the more mature[1] San Fernando Valley P-C Region (Figure 4.14). This is reflected somewhat in the average per capita consumption rates established for these areas from 1960 to 1977. The San Gabriel Valley P-C Region's per capita consumption rate of 4.5 tons is lower than the Orange County-Temescal Valley rate of 5.9 and is substantially lower than the Claremont-Upland rate of 8.75. These higher rates may reflect the lower population densities[2] in the two P-C regions. The San Fernando Valley per capita consumption rate of 1.6 tons per year is substantially lower than the San Gabriel Valley's rate of 4.5. Again, this difference in rates is reflected in the population densities.

The San Gabriel Valley P-C Region's per capita consumption is not projected to change significantly in future years. This can be seen on Table 4.3, which shows less than a 10 percent decline in per capita rate in the next 50 years. Events such as massive urban renewal or disaster reconstruction would result in a sharp increase in per capita consumption of aggregate during the period of active reconstruction. The amount of aggregate needed in addition to the projected consumptions would depend upon the extent and duration of reconstruction. Per capita consumption would probably then gradually return to a maintenance level equivalent to that which existed before reconstruction began.

1. Full "urban maturity" is the point in the development of an area at which construction materials are used primarily to maintain what has already been developed rather than to supply further development.
2. In P-C regions with relatively low population densities, a special project such as the construction of a freeway could cause a large per capita increase.

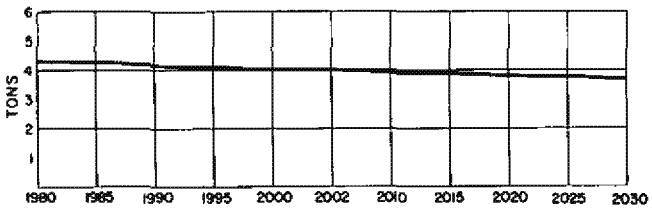


Figure 4.13 Projected 50-year per capita consumption for the San Gabriel Valley P-C Region.

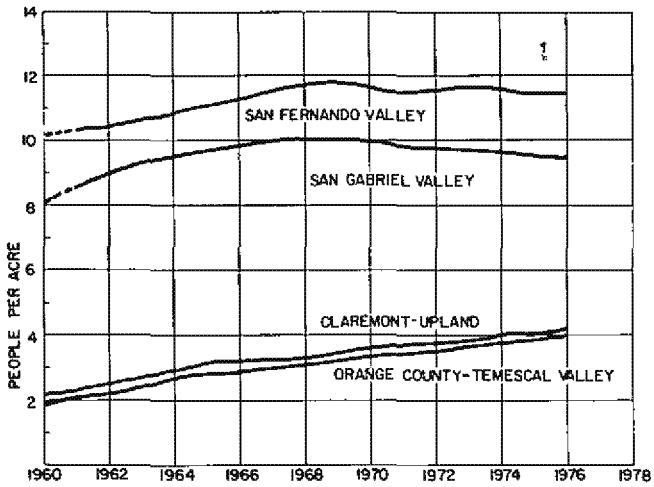


Figure 4.14 Comparison of population densities for San Gabriel Valley, San Fernando Valley, Orange County-Temescal Valley, and Claremont-Upland P-C regions for years 1960-1976.

ALTERNATIVE SOURCES OF AGGREGATE

Potential alternatives to those sources of aggregate described in Sectors A-I (Plates 4.3 and 4.4) occur in areas within and near the San Gabriel Valley P-C Region. These sources include resources in adjacent P-C regions, areas underlain by crystalline rock, older Tertiary sedimentary deposits, other Holocene alluvial deposits, and offshore sediments.

Except for the resources in adjacent P-C regions, too little is known about the physical and chemical characteristics (see "Overview of Aggregate," SR 143, Part I) of alternative sources of aggregate to permit resources estimates. However, a general discussion about the potential resources, their occurrence, and factors controlling their utilization is presented in the following section.

Sand and Gravel Resources of Adjacent P-C Regions

RESOURCE ESTIMATES

Resource estimates for two of the adjacent P-C regions, San Fernando Valley and Orange County-Temescal Valley, have already been completed (Anderson and others, 1979; Miller and others, 1981). Resource calculations for the remaining adjacent P-C region, Claremont-Upland, represents modifications of data taken from California Division of Mines and Geology Special Report 139 (Evans, 1979) and are preliminary. Mineral Resource classification is also preliminary in this P-C region. The *reserve* estimates are current to January 1979. The *resource* estimates were made relying upon published geologic maps with additional reconnaissance field checking, including visits to sand and gravel plants operating in 1978. The following values and conditions were assumed in estimating the largest part of the Claremont-Upland resources:

(1) Material density ranges from .060 to .065 short tons per cubic foot.

(2) Waste material does not exceed 25 percent.

(3) Present technology allows economic extraction to the depths calculated.

(4) Estimates were limited to areas which are not urbanized and for which mining is still a possible land use.

The estimated resources of the adjacent P-C regions are summarized in Table 4.4.

ESTIMATED 50-YEAR CONSUMPTION OF AGGREGATE IN ADJACENT P-C REGIONS

The estimated 50-year aggregate needs for adjacent P-C regions are presented on Table 4.3. Comparison of Table 4.3 and 4.4 shows that the projected 50-year total consumption of aggregate for each of the three adjacent P-C regions is less than their respective total *resource* estimates. However, the *reserves* in the San Fernando Valley, the Orange County-Temescal Valley, and the Claremont-Upland P-C regions are not sufficient to supply their respective 50-year projected needs. This could mean a total shortfall of over one billion tons for these P-C regions. It should be noted then, if *non-permitted resources* within these three P-C regions are not utilized to fill the shortfall, they will have to be filled from other areas. In such an event, it is likely that a major source of supply would be reserves of the San Gabriel Valley P-C Region.

Crushed Rock Sources as Alternative

Metamorphic, granitic, and volcanic rocks may provide an alternative source of crushed aggregate for the San Gabriel Valley P-C Region (Figure 4.5). Most of these rocks lie within the unclassified area of the San Gabriel Mountains to the north of the P-C region. The prospective crushed rock resource areas that are located within the San Gabriel Valley P-C Region are zoned MRZ-3.

METAMORPHIC AND GRANITIC ROCKS

Metamorphic and granitic basement rocks of the San Gabriel and Verdugo Mountains, the San Rafael Hills, and eastern Santa Monica Mountains may provide an alternative source of construction-grade sand and gravel (Figure 4.5). Most of this exposed basement rock occurs outside of the San Gabriel Valley P-C Region, but is within close enough proximity to be considered as an alternative source of aggregate. Almost all of the sand and gravel within MRZ-2 areas of the San Gabriel alluvial fan, Eaton Wash, and Arroyo Seco was derived from this basement

Table 4.4 Aggregate resources of the San Fernando Valley, Claremont Upland, and Orange County-Temescal Valley P-C Regions.

PRODUCTION-CONSUMPTION REGION	INFERRED RESERVES (Million Tons)	INFERRED RESOURCES (Million Tons)	TOTAL (Million Tons)
SAN FERNANDO VALLEY	40	720	760
CLAREMONT-UPLAND	40	1300	1350
ORANGE COUNTY-TEMESCAL VALLEY	260	1200	1460
CATEGORY TOTAL	340	3200*	3500*
TOTAL RESERVES-RESOURCES, San Fernando Valley, Claremont-Upland and Orange County-Temescal Valley:			

* Figures rounded down to nearest 100 million.

terrain. Therefore, it is likely that a large portion of these basement rocks are suitable for Portland cement concrete aggregate. Nevertheless, exploration, including detailed field mapping and testing, is necessary to delineate areas where basement rocks of suitable quality occur. Quality specifications of these rocks are discussed by Anderson and others, 1979, (p. 28).

TERTIARY VOLCANIC ROCKS

Tertiary volcanic rocks are exposed along several areas adjacent to and within the San Gabriel Valley P-C Region. These areas include the eastern Santa Monica Mountains, the northeastern San Jose Hills, the Glendora South Hills, and the southern front of the San Gabriel Mountains foothills near the City of Glendora (Figure 4.5). Some of these volcanic rocks are crystalline lava basalts which may prove to be processable into aggregate material, but these have not yet been tested for aggregate suitability. An additional discussion of Tertiary volcanic rocks is contained in a report by Anderson and others (1979, p. 29).

Tertiary Sedimentary Rocks as Alternative

Tertiary sedimentary rocks that may have potential for aggregate use include sandstones and conglomerates from the Topanga Formation, the Soquel and Sycamore Canyon Members of the Puente Formation, the lower member of the Fernando Formation (Repetto Formation), and the upper member of the Fernando Formation (Pico Formation) (Figure 4.5). A discussion of all of these formations is given in the "Areas Classified MRZ-3" section (p. 7) of this report. Mining in the Sycamore Canyon Member of the Puente Formation and the upper member of the Fernando Formation is currently taking place within the adjacent Orange County-Temescal Valley P-C Region (Miller and others, 1981). Mining of the Soquel Member of the Puente Formation has formerly taken place within the Orange County-Temescal Valley P-C Region. Although the quality of these Tertiary rocks has not been thoroughly evaluated, production from these deposits often is of lower quality aggregate, which is predominately used for base, fill, and asphaltic concrete.

Holocene Alluvial Deposits as Alternative

Approximately 1,400 acres of nonurbanized land lying behind the Whittier Narrows Dam may be a potential alternative resource (Plate 4.11, El Monte quadrangle). Extensive well-log data in the area shows sand and gravel exceeding depths of over 500 feet, yet the quality of the material is unknown. Consequently, the Whittier Narrows area is classified MRZ-3. If the material is found to be of suitable quality, the most limiting geologic factor will undoubtedly be the depth of ground water in the area. The ground-water elevation at the Whittier Narrows area is usually just a few feet below surface elevation. Even during drought periods, the ground-water elevation has not fallen below 15 feet below surface elevation.

Offshore Sediment Deposits as Alternative

Sand and gravel has been successfully mined for several years from marine sources, notably offshore from the United Kingdom, Holland, the Virgin Islands, and the Bahama Islands. Two potential offshore localities that are adjacent to the San Gabriel Valley P-C Region (Plate 4.1) have been identified in the San Pedro area. Other offshore sand and gravel localities have been identified within the Santa Monica Bay adjacent to the San Fernando Valley P-C Region (Anderson and others, 1979, p. 31), and the San Clemente area adjacent to the Orange County-

Temescal Valley P-C Region (Miller and others, 1981, p. 17). Special Report 143, Part II (page 31) discusses some of the feasibility factors of mining offshore aggregate. The environmental factors concerning damage to marine life might be some of the most difficult to overcome. Nevertheless, because the technology for extraction of offshore deposits is available, they are potential alternative sources of aggregate.

Several deposits of aggregate are also known to occur in the near-shore environment at shallow depths adjacent to Santa Catalina, San Clemente, and Santa Barbara Islands. Neither the quantity nor quality of these deposits has been assessed.

CONCLUSIONS

Over 3 billion tons of aggregate *resources* are believed to exist in the San Gabriel Valley P-C Region. However, current *reserves* which are available within the San Gabriel Valley P-C Region are not adequate for supplying construction aggregate for the 50-year projected population of over 4 million inhabitants. Based on a projected population increase for the region (Table 4.3) and the projected per capita consumption for each five-year period, approximately 780 million tons of aggregate will be required to satisfy demand to the year 2030. Only 280 million tons of aggregate *reserves* remain within the San Gabriel Valley P-C Region (Table 4.2), an amount which is projected to be depleted in approximately 18 years. The 500 million ton deficit can be supplied by (1) extending the operating life of existing operations where there are *resources* available beneath the permitted depth of mining; (2) opening new operations; and/or (3) importing material from adjacent areas. All of these alternative actions have potential economic and environmental drawbacks.

To extend the life of existing aggregate operations (if that is desired) would necessitate extracting material from greater depths than is currently permitted. This would require a careful assessment of the environmental consequences of excavating sand and gravel to greater depths.

The *reserve* figures for the adjacent P-C regions (Table 4.4) indicate that, like the San Gabriel Valley, none of these P-C regions have an adequate supply of *reserves* to meet their respective total projected needs to the year 2030 (Table 4.3). In fact, these data indicate that two of the adjacent P-C regions (the San Fernando Valley and the Upland-Claremont P-C regions) will exhaust their *reserves* before the San Gabriel Valley does. Consequently, it is likely that these adjacent P-C regions will need to import material from the San Gabriel Valley P-C Region, in which case its 18-year supply of reserves will be prematurely depleted. In the event of massive reconstruction following a catastrophic earthquake, the San Gabriel Valley P-C Region as well as the adjacent P-C regions could experience a shortage of aggregate within the next 10 years.

SUMMARY OF DESIGNATION FACTORS

Table 4.5 shows the eight aggregate resource sectors listed from top to bottom in order of their importance to the San Gabriel Valley P-C Region over the next 50 years as determined by the amount of aggregate resource contained within each sector and the ease with which that resource can be made available to the market. The latter depends on such factors as whether or not the resource is already permitted for extraction, its proximity to a market area, and whether or not there are any land-use conflicts.

Table 4.5 Summary of Designation Factors for the Resource Sectors in the San Gabriel Valley P-C Region.

Sectors	Percent of the total P-C region reserves within the sectors	Percent of the total P-C region non-permitted resources within the sectors	Active mining within sector	Remarks
A,D,E	>98	43	YES	Almost all land owned or leased by aggregate producers
B,C	NONE	55	NO	All land located within the Santa Fe Dam Recreational area
I	*	<1	YES	One active mine Local source Sand mining only
H	*	1	YES	One active mine Channel maintenance
F	NONE	<1	NO	Some channel maintenance

* Cannot be shown due to confidentiality of producer data.

The most significant sectors within the San Gabriel Valley P-C Region are Sectors A, D, and E. They contain over 98% of the *reserves* and over 40% of the non-permitted *resources* in the region. The total *resources* contained within these sectors add up to over 1,300 million tons, which is more than adequate to supply the San Gabriel Valley P-C Region's 50-year demand of 780 million tons. These resources lie between 0-400 feet depths. The actual tonnage of material which will be extracted from Sectors A, D, and E depends on future land uses and permitted depths of mining.

Sectors B and C are also significant *resource* sectors in terms of tonnage of contained aggregate material. These two sectors have no *reserves*, but they do contain almost 1,700 million tons of non-permitted *resources*, which makes up over 50% of the total resources within the San Gabriel Valley P-C Region.

Sector I has less than 1% of the total non-permitted *resources* for the San Gabriel Valley P-C Region, yet it is a significant resource area because it provides a local source of sand to the Palos Verdes Hills and vicinity.

Sector H has approximately 1% of the total non-permitted *resources*. It is occupied by one producer. Besides supplying aggregate, mining within sector H also provides channel maintenance.

Sector F, which contains less than 1% of all non-permitted resources and no reserves, is the least significant sector within the San Gabriel Valley P-C Region. There is currently no mining taking place within this sector. Occasionally, flood debris is excavated from Sector F in the main channel above Eaton Dam.

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REFERENCES - PART IV

Anderson, T.P., Loyd, R.C., Clark, W.B., Miller, R.V., Corbaley, R., Kohler, S., and Bushnell, M., 1979, Mineral land classification of the greater Los Angeles area; Description of the mineral land classification project of the greater Los Angeles area: Division of Mines and Geology Special Report 143, Part I, 51 p.

Anderson, T.P., Loyd, R.C., Clark, W.B., Miller, R.V., Corbaley, R., Kohler, S., and Bushnell, M., 1979, Mineral land classification of the greater Los Angeles area; Part I, Description of the mineral land classification project of the greater Los Angeles area; Part II, Classification of sand and gravel resource areas, San Fernando Valley Production-Consumption Region, Division of Mines and Geology Special Report 143, Parts I and II, 79 p.

California Department of Transportation, 1975, Standard specifications, 620 p.

California Department of Water Resources, 1934, Geology and ground water storage capacity of valley fill: Bulletin no. 45.

California Department of Water Resources, 1966, Planned utilization of ground water basins, San Gabriel Valley: Bulletin no. 104-2.

California Division of Mines and Geology, 1979, California surface mining and reclamation policies and procedures: Special Publication 51, 40 p.

Durham, D.L., and Yerkes, R.F., 1964, Geology and oil resources of the eastern Puente Hills area, southern California: U.S. Geological Survey Professional Paper 420-B, map scale 1:24,000, 62 p.

Evans, J.R., Anderson, T.P., Manson, M.W., Maud, R.L., Clark, W.B., and Fife, D.L., 1979, Aggregates in the greater Los Angeles area, California: California Division of Mines and Geology Special Report 139, 96 p.

Gay, T.E., Jr., and Hoffman, S.R., 1954, Mines and Mineral Deposits of Los Angeles County, California, California Journal of Mines and Geology, California Division of Mines, v. 50, no. 3 and 4, p. 467-607.

Jennings, C.W., and Strand, R.G., 1969, Geologic Map of California, Los Angeles sheet: California Division of Mines and Geology, scale 1:250,000.

Kundert, C.J., 1952, Geology of the Whittier-La Habra area: California Division of Mines and Geology Special Report 18, 21 p.

Lamar, D.L., 1970, Geology of the Elysian Park-Repetto Hills Area, Los Angeles County, California: California Division of Mines and Geology Special Report 101, 45 p.

Lockman and Associates, 1975, City of Irwindale quarry rehabilitation plan, phase I basis for planning: Unpublished consultant report, 23 p.

Lockman and Associates, 1976, Draft City of Irwindale quarry rehabilitation plan: Unpublished consultant report, 30 p.

Lockman and Associates, 1976, Environmental impact report, city industrial redevelopment project: Unpublished consultant report, 55 p.

Los Angeles County Flood Control, 1974, Setback criteria for rock quarries adjacent to San Gabriel River from lower Azusa Road to Arrow Highway: Unpublished, 24 p.

Miller, R.V., and Corbaley, R., 1980, Mineral land classification of the greater Los Angeles area; Part III, Description of the mineral land classification of the Orange County-Temescal Valley P-C Region: California Division of Mines and Geology Special Report 143, Part III, 20 p.

Morton, D.M., 1973, Geology of parts of the Azusa and Mount Wilson quadrangles, San Gabriel, Mountains, Los Angeles County, California: California Division of Mines and Geology Special Report 105, p. 21.

Olmsted, F.H., 1950, Geology and oil prospects of western San Jose Hills, Los Angeles County, California: California Journal of Mines and Geology, California Division of Mines and Geology, v. 46, no. 2, p. 191-212.

Quarles, M., Jr., 1941, Geology of the Repetto and Montebello Hills: California Institute of Technology, Unpublished M.S. thesis, map scale 1:24,000.

Reese, R.G., 1943, Montebello area of the Montebello oil field, geologic formations and economic development of the oil and gas fields of California: California Division of Mines Bulletin 118, p. 340-342.

Rogers, T.H., 1967, Geologic map of California, San Bernardino sheet: California Division of Mines and Geology, scale 1:250,000.

Shelton, J.S., 1955, Glendora volcanic rocks, Los Angeles basin, California: Bulletin of the Geological Society of America, v. 66, p. 45-90, map scale 1:24,000.

Southern California Rock Products Association, 1974, Tour of Los Angeles and Orange Counties: Unpublished, 29 p.

Southern California Association of Governments, 1978, Draft growth forecast policy, 72 p.

The Pipestone Group, 1977, Chandlers Palos Verdes Sand and Gravel Company Lomita Pit reclamation plan: Unpublished consultant report, 23 p.

Woodford, A.O., and others, 1954: Geology of the Los Angeles Basin: California Division of Mines Bulletin 170, v. 1, chapter II, p. 65-81.

Woodring, W.O., and others, 1946, Geology and paleontology of the Palos Verdes Hills, California: U.S. Geological Survey Professional Paper 207, 145 p.

U.S. Army Engineer District Los Angeles, Corps of Engineers, 1975, Los Angeles County drainage area, California, San Gabriel River, Santa Fe Dam recreation master plan: 61 p.

Yerkes, R.F., 1972, Geology and oil resources of the western Puente Hills area, southern California: U.S. Geological Survey Professional Paper 420-C, 62 p., scale 1:24,000.

Yerkes, R.F., McCulloh, E.H., Schoellhamer, J.E., and Vedder, J.G., 1965, Geology of the Los Angeles Basin, California: U.S. Geological Survey Professional Paper 420-A, 57 p., scale 1:24,000.