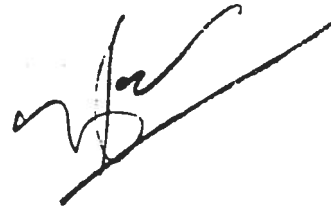


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JOINT REPORT  
ON  
THE WATER SUPPLY IN CHARNOCK GROUNDWATER BASIN  
TO  
CITY COUNCIL, CITY OF SANTA MONICA  
AND  
BOARD OF DIRECTORS, SOUTHERN CALIFORNIA WATER COMPANY

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August, 1965

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### PURPOSE OF REPORT

The City of Santa Monica has pumped water from the Charnock Groundwater Basin since September, 1924. The Southern California Water Company has pumped water from this same basin since March of 1931. Following a discussion between the two managements on February 13, 1964, it was agreed that joint studies should be undertaken with the aim of reaching a stipulated agreement proportioning the water of the Charnock Basin and developing the most economic and equitable management program of that available supply through proper basin management. It was proposed that this agreement should then be ratified by the Court which, in turn, would affirm a practical engineering solution to apportion the permissible pumping, within the limits of the supply available in the Charnock Groundwater Basin, to the City of Santa Monica and the Southern California Water Company.

The alternative to such an agreement might be protracted litigation to determine the water rights of each party. The time and expense involved in such litigation would be enormous and would not be to the best interest of either party nor in the interest of any third party. Rather, a stipulated agreement would be advantageous to both parties and would have no effect on any other possible entity. Further, such an agreement would permit the maximum utilization by the City of Santa Monica and by the Southern California Water Company of the water available to them within the Charnock Basin.

## CHARNOCK GROUNDWATER BASIN STUDY

### General

The implementation of an agreement resulting in the best basin management required studies to develop as far as possible the basic facts relating to the area and its available water supply.

The Charnock Basin is in the westerly part of Los Angeles County. It has a mild climate and has substantial variations in culture and considerable changes in topography. The valley floor is a highly developed urban area and includes parts of the cities of Los Angeles, Santa Monica and Culver City. The mountain area, a portion of the Santa Monica Mountains, has not been subject to the same intensive development. Nevertheless it is expected that these mountain areas will develop into a high class residential area.

### Climate

The mean temperature within the basin varies from 50° to 60° with the long term mean annual rainfall of about 17.45 inches on the valley floor and 21.17 inches in the mountain area. Most of the rainfall occurs in the winter months and often produces flood flows which are carried to the ocean by way of the Sawtelle and Ballona storm drain channels constructed by the Los Angeles County Flood Control District.

## Culture

In the past half century the Charnock area has experienced radical changes. In 1904 when Mendenhall made a survey (U.S.G.S. Water Supply Paper #139) of the groundwater conditions in Southern California including the Charnock area, he found a predominantly agricultural development with a large number of wells serving small overlying users. Since that time agriculture has given way to rapid urban expansion. This development includes the vast complex of the University of California at Los Angeles and a few small industrial areas, but in the main the area is residential. As this urban development occurred, portions of the area became parts of the cities of Los Angeles, Santa Monica and Culver City. This resulted in the abandonment of most of the wells in the area as water service was supplied to the growing communities by Municipal Water and investor-owned systems.

## Water Utility Systems

There are three water utility systems serving the Charnock Basin area. That segment within the City of Los Angeles receives service by the Department of Water and Power using almost exclusively water imported by the Owens River aqueduct. Water supplied by the City of Santa Monica is obtained from two well fields and water imported by the Metropolitan Water District from the Colorado River. Water produced by the City of Santa Monica from the Charnock groundwater area is exported to areas of the City of Santa Monica and a small portion of the City of

Los Angeles westerly across the Charnock Fault and out of the groundwater area. The Culver City segment is served by the Southern California Water Company. Prior to 1951 water produced by the Southern California Water Company was used in part within the corporate limits of the City of Los Angeles as well as the corporate limits of Culver City. Subsequent to 1951 the water produced by the Southern California Water Company from the Charnock Basin has been used exclusively within the corporate limits of the City of Culver City and is being used on areas overlying the groundwater area and also exported to the east across the Overland Fault.

#### Groundwater Development

The hydrographic survey made by Mendenhall of the United States Geological Survey in 1904 indicated that there was a relatively small quantity of water produced from the Charnock groundwater region. This water was produced from relatively shallow wells and was used mainly for agricultural purposes by local developers. Subsequent to that survey there have been wells drilled for agricultural and industrial purposes, many of which have since been abandoned. In 1923 the engineering firm of Olmsted and Gillellan recommended that the City of Santa Monica drill wells in the Charnock area to supply water to the city. The first well drilled by Santa Monica in the Charnock well field was in September 1924. In 1929 the Venice Consumers Water Company, predecessor to Southern California Water Company, also drilled wells in the Charnock groundwater area. In 1926 the Peoples Water Company of Palms, also a predecessor of Southern California Water Company, drilled wells at the Sepulveda Plant. Subsequent

to the development of these well fields and the availability of imported water the industrial and agricultural use of well water by individual producers has largely been discontinued.

In 1941 the City of Santa Monica obtained Metropolitan Water District water and at that time, because of the overdraft condition of the Charnock Basin and in the interest of the preservation of that basin, the City discontinued pumping and did not begin pumping until 1958 when the groundwater basin had fully recovered.

In 1951 the Southern California Water Company sold a large portion of its system to the City of Los Angeles and following that, drastically reduced its pumping from the Charnock Basin. In 1955 the City of Culver City was annexed to the West Basin Municipal Water District, thereby becoming eligible to obtain Metropolitan Water District water; and as soon thereafter as possible the Southern California Water Company further reduced its pumping from the Charnock Basin and substituted Metropolitan Water District water for the quantities of water previously produced from the Charnock Basin.

#### Boundaries

In the early development of well water supplies for domestic or agricultural uses little concern was expressed about the long term availability of the water supply. In the last 30 years it has become increasingly evident that neither the water supply nor the extent of the groundwater basin were unlimited. It has now become necessary that the boundary of the groundwater basin be determined in order that its capacity

may be utilized for carry-over storage and its further use in supplying water for pumping to meet peaking demands, supplementing and equalizing flows of imported water.

The map on Plate A (page 11) shows the boundary of the ground-water basin which agrees with the boundary shown in U.S.G.S. Water Supply Paper #1461 published in 1959.

Surface drainage is measured in part at the gauging station located a short distance northerly of Culver Boulevard on the Sawtelle Drain. This drain discharges into the Ballona Creek Flood Channel which collects the remaining portion of surface drainage. Water from the Ballona Drain is discharged out of the area into the Ocean. These drains are operated by the Los Angeles County Flood Control District.

The geological investigation of the Charnock Basin has been limited to a review of various publications (two in particular) having to do with the geology in this area. The California Department of Water Resources Bulletin 104 has a general discussion. The United States Geological Survey Water Supply Paper 1461 has a comprehensive discussion of the geology and hydrology of this area.

The Charnock Basin is within the general Ballona Gap area north of the Ballona Escarpment. This escarpment is the southerly boundary of the Charnock Basin and also divides the West Basin area from the Culver City sub-area. There are three major faults which further sub-divide the Culver City sub-area into sub-basins. Of the three faults, the Inglewood Fault is the farthest inland and passes across the Gap about six miles from the Coast and forms the westerly boundary of the interior or Central

Basin groundwater area. The Overland Fault, about two miles coastward from the Inglewood Fault, creates a sub-basin where the formation is an up thrown block of the San Pedro aquifer and contains water bearing formations of relatively shallow depth. The Charnock Fault is a little over a mile west of the Overland Fault and about three miles inland from the Coast. Between these two faults, the San Pedro water bearing formation is a depressed block with the main water bearing horizon as much as 350 feet thick in places. Pumping within the Charnock Basin has produced a perennial zone of drawdown that is terminated abruptly on the west by the Charnock Fault and is limited on the east by the Overland Fault. The differences in static water levels to the east and west of the Charnock Basin have been surprisingly uniform and indicate complete independence. This attests the lack of hydraulic continuity within the San Pedro formation across either the Charnock or Overland Faults. These hydraulic discontinuities are caused by displacement resulting from movement of these two faults and cementing in the fault zones. It is apparant, therefore, that the useable water bearing formation is confined between the Charnock and the Overland Faults and is limited on the south by the Ballona Escarpment. The Basin is limited on the north by the impervious formation of the Santa Monica Mountains.

Overlying the San Pedro formation and separated from it by a more or less impervious clay cap is a bed of recent alluvium along the line of the Ballona Creek Channel. The extent of this bed (the 50 foot sand) is unknown. It is suspected that this 50 foot sand receives some

waste water from easterly of the Inglewood Fault and also drainage from the Baldwin Hills oil field. The quality of water in this 50 foot sand is of poor quality as shown in Table B-2 (page B-7) of Appendix B. Further, the water levels are above sea level.

The trace of the Overland Fault is a straight line approximately paralleling Overland Avenue, extending from Baldwin Hills to the Santa Monica Mountains. Surface indications of this fault have been found by the U.S.G.S. and therefore fairly located. This has been verified by comparison of water levels available as shown on Table 1 (page 10) which indicate a difference of 60 feet or more in the static water level across this fault.

The trace of the Charnock Fault begins in the area southerly of the Ballona Escarpment and runs in the northwesterly direction approximately parallel to but southwesterly of Inglewood Boulevard to about National Boulevard, where it turns in a more northerly direction toward the impervious formations on the south side of the Santa Monica Mountains. This fault has no surface indication but has been fairly located by the water levels on either side of the fault. Wells westerly of the fault have water levels generally near or above sea level, while those in the Charnock Basin are generally below sea level. A hydrograph of the Charnock and the Sepulveda wells in the Charnock Basin have been shown on Plate B (page 12).

The waters within the Charnock Basin as compared with the waters on either side of the Charnock Basin have been the subject of a special study relative to the character and quality of the waters in this region.

This detailed study is included as Appendix B which coupled with the geology indicated that the boundary of the groundwater basin as shown on Plate A (page 11) may be accepted and defined as bounded on the east by the Overland Fault, on the west by the Charnock Fault, on the south by the Ballona Escarpment and on the north by the Santa Monica Mountains.

It therefore is an accepted fact that the groundwater basins or sub-basins to the east, west or south of the delineated boundaries are not now, nor could not be part of the Charnock Basin, nor could waters in those basins contribute to the supply of the Charnock Basin, nor would waters of the Charnock Basin percolate to the basins east, west or south.

This groundwater basin underlays an area of about 3,475 acres.

Table 1

Static Water Levels in and on Either Side  
of Charnock Basin

Comparison of Static Water Levels Westerly of Charnock Fault  
With Wells Within Charnock Basin

| <u>Date</u> | <u>L.A.<br/>County<br/>Well #</u> | <u>Location</u>                               | <u>S.W.L.<br/>in<br/>Well</u> | <u>Charnock<br/>S.W.L.</u> |
|-------------|-----------------------------------|-----------------------------------------------|-------------------------------|----------------------------|
| 1941        | 2556-G )                          | Near Pico and Gateway Boulevard               | 78                            | -98                        |
| 1950        | 2556-G )                          |                                               | 75                            | -85                        |
| 1960        | 2556-G )                          |                                               | 93                            | -23                        |
| 1951        | 2544 )                            | 600' West Sepulveda 800' N. Wilshire          | 80                            | -95                        |
| 1960        | 2544 )                            |                                               | 74                            | -23                        |
| 1963        | 2544 )                            |                                               | 73                            | -42                        |
| 1935        | Pacific)                          | 400' South Washington 200' E. Centin-<br>ella | -12                           | -54                        |
| 1945        | Pacific)                          |                                               | -12                           | -52                        |
| 1952        | Pacific)                          |                                               | - 2                           | -65                        |

- - - - -

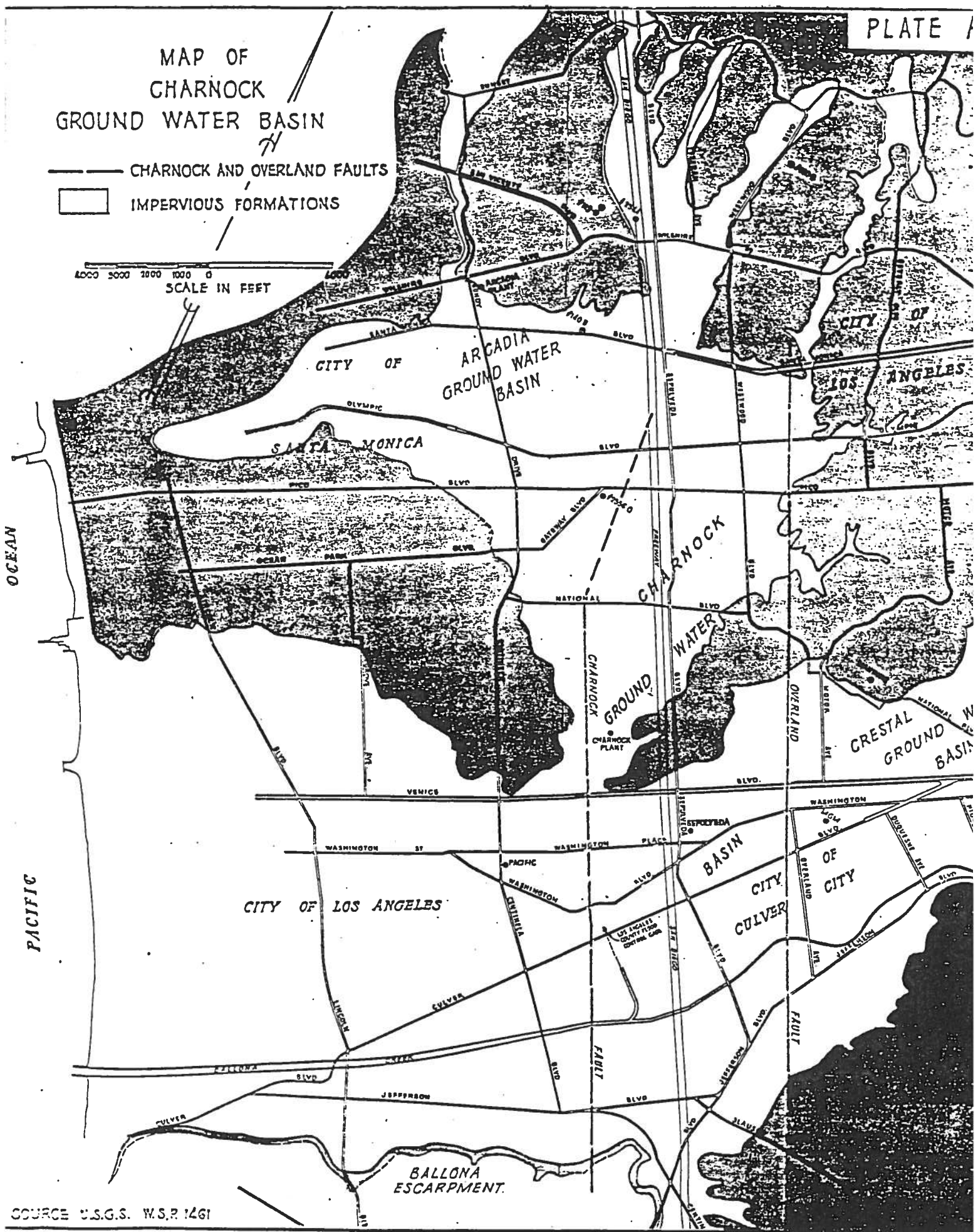
Comparison of Static Water Levels Easterly of Overland Fault  
With Wells Within Charnock Basin

|      |          |                                      |    |     |
|------|----------|--------------------------------------|----|-----|
| 1963 | MGM      | South of Washington East of Overland | 13 | -45 |
| 1945 | Manning) | Manning and Woodbine                 | 54 | -53 |
| 1950 | Manning) |                                      | 54 | -86 |
| 1952 | Manning) |                                      | 54 | -66 |

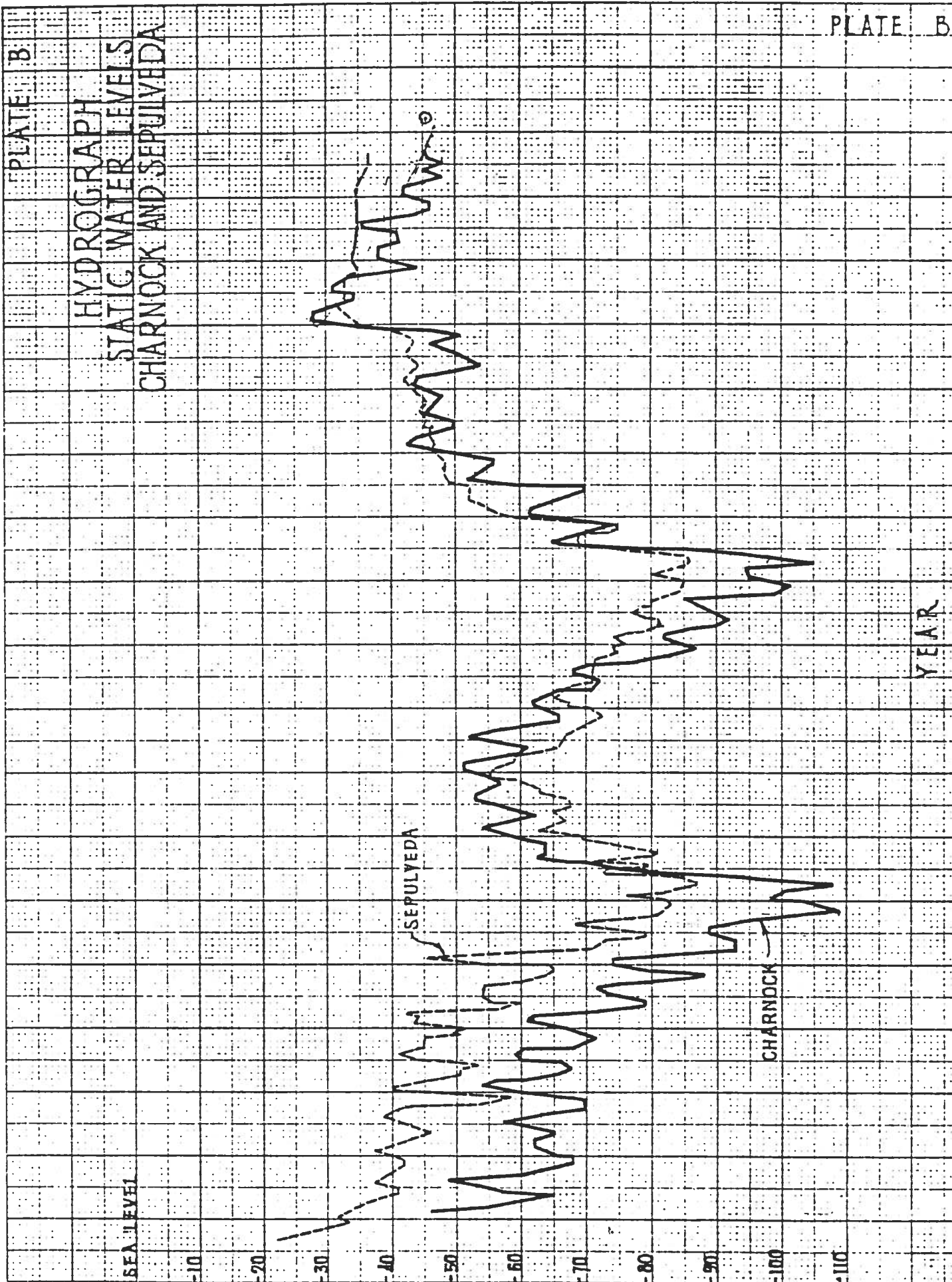
# MAP OF CHARNOCK GROUND WATER BASIN

— CHARNOCK AND OVERLAND FAULTS  
□ IMPERVIOUS FORMATIONS

8000 5000 2000 1000 0  
SCALE IN FEET



SOURCE U.S.G.S. W.S.P. 1461



### AVAILABLE SUPPLY

It is realized that the magnitude of the available supply within the Charnock Groundwater Basin is at the best an interpretation of observations and detailed studies made to date which consist of investigation of geologic and topographic features and considers records of rainfall, runoff, pumping and change in storage as reflected in change in Static Water levels. This report is a study of the Charnock Groundwater Basin making use of all available data, and represents a sound engineering solution of the problem of apportioning to both parties of the water supply available to them in the Charnock Groundwater Basin only. In this study, use has been made of records and reports from the City of Santa Monica; the Southern California Water Company; State of California, Division of Water Resources; the Los Angeles County Flood Control District; the United States Department of Interior-Geological Survey; Superior Court of the State of California, Report of the Referee 506806, along with a number of other available reports. This report is an attempt to properly evaluate the known facts and support the determination of the available water supply that may accrue to both the parties.

There is the recognition that as further and future data develop, adjustments of the present interpretation of available water supply of the Charnock Groundwater Basin may be necessary by the Watermaster. Nevertheless, to approach the solution of this problem a "Permissible Pumping Curve" Plate C (page 16) has been developed. This curve is based on the 10-year running

average rainfall which will produce an estimated available total water supply for each ensuing year for the City of Santa Monica and the Southern California Water Company. This curve has been developed in Appendix A (Curve D4, page A-36) and is the result of the studies made and outlined as follows:

1. Supply

This study attempts to evaluate the net average annual supply from the records available, the rainfall on the valley floor overlying the Charnock Groundwater Basin and the mountain drainage area tributary to that groundwater basin.

2. Disposal

This is a study of the outflow of the surface drainage, pumping and change in storage in order to arrive at an estimated yield. This study also develops the estimated storage capacity per foot of alluvial fill in the groundwater basin.

3. Historic Yield

In this study the past pumping combined into good, selective precipitation periods has been used to arrive at an estimated historic yield. It was found that in six different studies the estimated annual yield from the Charnock Groundwater Basin varied from 6,474 acre feet to 7,406 acre feet. These limits overlap the estimate by the U.S.G.S. which, in Water Supply Paper 1461, made the statement that, "The draft (pumping) from the Charnock sub-basin is estimated to have ranged from

12,500 acre feet in 1941 to 7,000 acre feet in 1945. Hydrographs for... certain wells... suggest that in 1945 the replenishment was about equal to the estimated draft of 7,000 acre feet."

#### 4. Water Quality and Characteristics

This is a study of the quality and character of water obtained from various wells. Chemical analyses have been used of water from wells within the Charnock Groundwater Basin and wells east of the Overland Fault, (the easterly boundary of the Charnock Groundwater Basin) and westerly of the Charnock Fault (the westerly boundary of the Charnock Groundwater Basin). This study, in some detail, is attached as Appendix B. It was made to verify the geologic findings of this report and those of U.S.G.S. Water Supply Paper No. 1461.

#### 5. Available Water Supply

The result of this study is a correlation of the previous studies and is an attempt to derive the most economical management pattern which, in turn, would provide the City of Santa Monica and the Southern California Water Company an index to determine each year the estimated available water supply, available to them, for the ensuing year. The final result of this study is the development of the Curve Plate C (page 16). It is recognized that this curve may, of necessity, be adjusted as future information becomes available to the Watermaster appointed to control the permissible pumping based on estimated available water supply.

CHARNOCK  
GROUND WATER BASIN

PERMISSABLE PUMPING CURVE

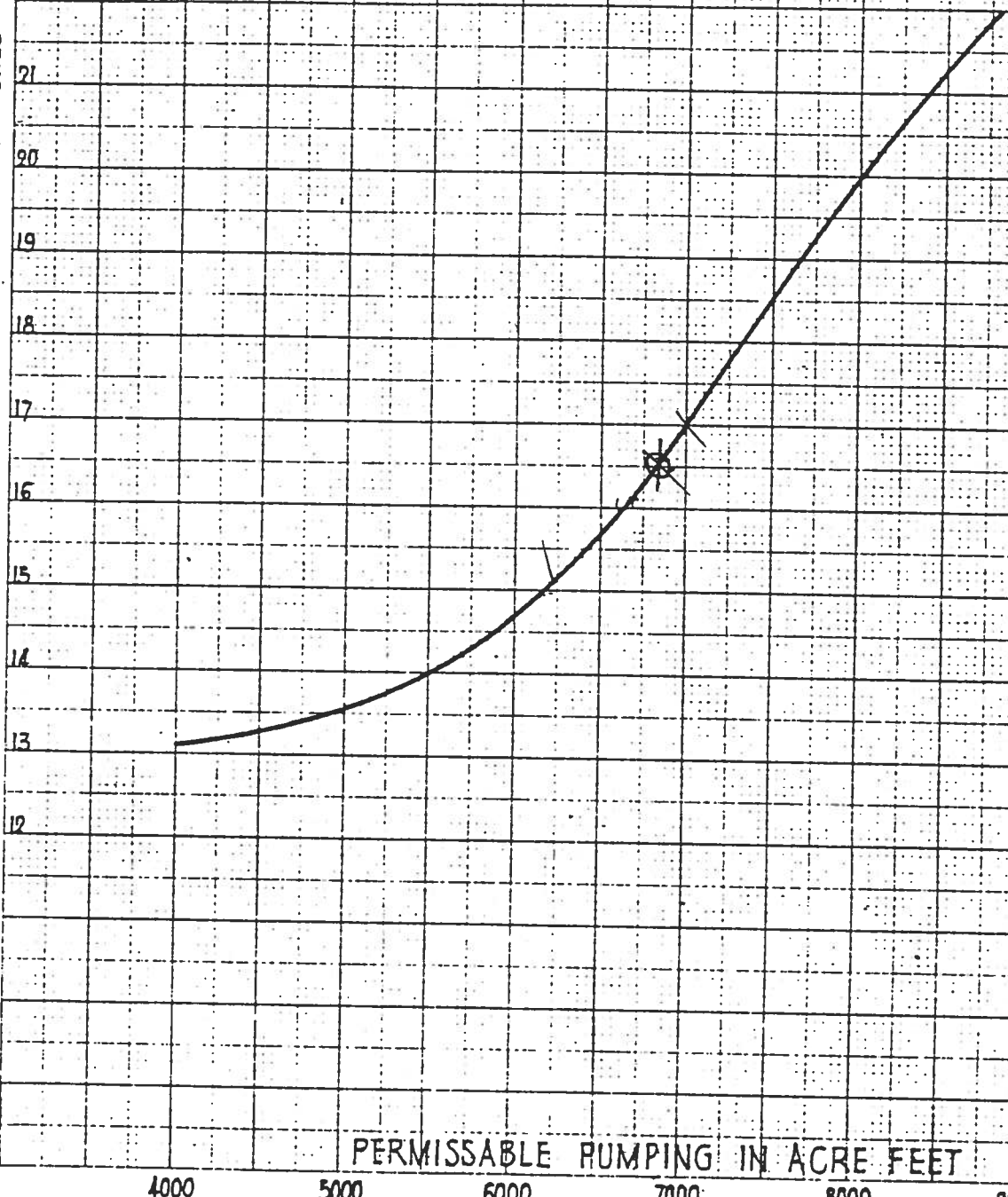
REPRODUCED FROM CURVE D-1  
IN APPENDIX A

10 YEAR RUNNING AVERAGE RAINFALL IN INCHES

23  
22  
21  
20  
19  
18  
17  
16  
15  
14  
13  
12

PERMISSABLE PUMPING IN ACRE FEET

4000 5000 6000 7000 8000 9000



### Basin Management

Groundwater basins are enormous storage reservoirs. As such, these reservoirs are a valuable natural resource in terms of water supply. Certainly, well-managed, they are the cheapest possible source of water supply and provide the most economical means of equating supply and demand.

Groundwater basins are subject to destruction from the encroachment of sea water as is occurring along the coast of Southern California or by possible subsidence as occurred in the area south of San Jose. Either, or both, may be the result of overpumping.

In the Charnock Basin there is no immediate concern over the possible destruction of the groundwater basin from the intrusion of sea water because it is well protected against such inflow by the geological structure of the Charnock Fault between the groundwater basin and the ocean. Evidence of this protection is the difference in elevation of the water table either side of the fault as shown in Table I. Nor has pumping been of such magnitude that subsidence is likely to occur.

To prevent destruction from any cause the courts have several times had to determine the rights of producers and quiet title to water rights within the groundwater basin. Such determinations in the past have resulted in some semblance of basin management and the maximum utilization of available supply. Generally, action by the courts has resulted in a reduction in pumping to a fixed amount and thus has attempted to bring the basin into some semblance of balance between supply and demand. The basis of these attempts has been to estimate the historic safe yield of that basin and then determine limits of pumping.

Recharge of the groundwater basin may also be considered in arriving at permissible pumping as is done in the Central and West Basin Replenishment District.

There is no need to consider artificial recharge to the Charnock Basin because there is no indication of inflow of sea water and probably no danger of subsidence. Further, because of the high quality and high cost of Metropolitan Water District water available, it is cheaper to take direct delivery than to recharge and pump. In addition, there are no areas available for the construction of spreading basins for such recharge or replenishment.

Nevertheless, with the magnitude of storage generally available in a groundwater basin, it is possible to overpump for short periods. In other words, borrow from the bank when the supply is insufficient and repay the bank when the supply is plentiful providing that over a period of years the pumping should equal the available supply. This is the case in the Charnock Basin, therefore, under a good management policy it doesn't necessarily follow that the pumping demand must be held within specific limits each year.

Proper basin management and maximum usage of available supply dictate that regardless of the estimated historic yield the total production should be such that the groundwater table remains nearly constant over a period of years. This theory makes it possible, through basin management, to overpump the groundwater basin if the need arose and in subsequent years to underpump and allow the natural replenishment or recharge of the basin to occur.

Good basin management further dictates that there must be some entity charged with the problems of management. In the Pasadena litigation, as well as the West Basin litigation and the Central Basin litigation, a Watermaster was appointed by the court. In these three instances where there were a large number of pumpers, the Watermaster was the State Department of Water Resources. The reason for this is that some independent agency had to be in control of the verification of measurements, reports, and the accuracy of gauges and all such pertinent matters. Management, however, remained under control of the local entity and not the Watermaster. In the Pasadena case, control is by a committee of operators while in the Central and West Basins, it is the Central and West Basin Replenishment District.

In the Long Beach-SanGabriel litigation, the final settlement was between two basic entities; that is the Central Basin Municipal Water District for the lower area pumpers and the Upper San Gabriel Valley Municipal Water District for the upper area pumpers. It was agreed that the Watermaster should be a committee of three, one chosen by the lower basin, one chosen by the upper basin and a third chosen jointly. Management problems in this case consist primarily of determining the amount of water that it is the obligation of the upper area to deliver to the lower area each year.

In the Charnock Basin the City of Santa Monica and the Southern California Water Company will each control its own pumping within the limits of the water supply available to them as established by the Watermaster. Management therefore will be accomplished by the use, as a tool, of the "Permissible Pumping Curve" Plate C (page 16) as developed in Appendix A. In developing this curve, studies

were made to determine:

- a. The net average annual supply from available records.
- b. The disposal of the total available supply by evaporation, transpiration, runoff and pumping resulting in a change of storage.
- c. The historic yield of the groundwater basin available to the City of Santa Monica and to the Southern California Water Company.
- d. The water quality characteristics in the Charnock Basin as compared with the quality and characteristics of other waters outside the Charnock Basin.
- e. From these studies and the correlation of them the "Permissible Pumping Curve" Plate C (page 16) was developed.

#### Watermaster

Management of the available water supply should therefore be under the control of a Watermaster. The Watermaster should be a committee consisting of an appointee by the City of Santa Monica, an appointee by the Southern California Water Company, with a third chosen jointly. The Watermaster then should have the following duties and powers and should take all steps necessary to make the following determinations for each year promptly after the 15th day of February each year.

- a. Compute the ten-year running average rainfall. This is done by extending Columns 3 and 4 of Table 8 (page A-28) of Appendix A.
- b. Determine the total quantity of water that may be pumped out of the Charnock Basin by both the City of Santa Monica and the Southern California Water Company from the "Permissible Pumping Curve".

- c. Determine the change, if any, in the static water level from the previous February 15th.
- d. Adjust, if necessary, the amount of permissible pumping due to change in the static water level and the resulting change in available storage.
- e. Periodically check the accuracy of the measuring devices for determining quantity of water produced and measuring devices for determining static water levels.
- f. Have the power of permitting either party to pump more than its percentage of the permissible pumping in any year due to special request or unusual circumstances. If such permission is granted to either party to pump more or less than his allocated percentage of permissible pumping, then the Watermaster shall charge that quantity against that party's permissible pumping in the following year. Or, the Watermaster with approval of both parties, credit such overpumping by one party to the right of the other party's share of permissible pumping.
- g. Make a tentative budget which shall be mailed to each party on or before March 1st of each year. Such budget shall cover all expenses in preparing the necessary reports, the cost of doing such work as may be required and the cost of constructing such projects as may become necessary to comply with the Judgment issued by the court. This budget shall be revised if necessary and approved by both parties

prior to April 1st of each year.

- h. Develop such recommendations as may be necessary from time to time to insure complete compliance with the Judgment.
- i. Report to the court and to each party in writing at the same time and not later than April 15th of each year.
- j. Compensation and expenses of the Watermaster shall be borne in the following proportions: The fees and expenses of the Watermaster appointed by each party shall be borne by that party. The fees and expenses of the third member of the Watermaster team shall be borne equally by the City of Santa Monica and the Southern California Water Company.

STATEMENT OF PRINCIPLES  
BETWEEN  
THE CITY OF SANTA MONICA  
AND  
THE SOUTHERN CALIFORNIA WATER COMPANY

ON THE BASIS OF  
AN EQUITABLE DIVISION OF AVAILABLE WATER IN  
THE CHARNOCK GROUNDWATER BASIN

Representatives of the principals met on February 13, 1964 and agreed that a determination of the rights of each party in the Charnock Basin area should be established and that there was need for the development of a physical solution to the problem of providing the best Basin Management, in order to obtain the most economic utilization of the water supply available to the City of Santa Monica and the Southern California Water Company.

The implementation of this agreement to seek the best Basin Management required joint studies to develop, as far as possible, the basic facts relating to the area and its available water supply. Such studies have been made and are embodied in a report entitled "Joint Report on the Water Supply in Charnock Basin" which is attached hereto and hereby made a part of this statement.

The purpose of this statement is to summarize the principles which the parties have agreed should govern their respective interests in the development of water from the Charnock Groundwater Basin.

A. BACKGROUND AND PURPOSES:

1. Representatives of the City of Santa Monica and Southern California Water Company have met and agreed a means of apportioning the water in the Charnock Groundwater Basin available to both should be established.

2. Agreement was reached that there was a need to develop a physical solution to the problem of obtaining the best Basin Management, thereby obtaining the most economic utilization of the supply of water available to both.
3. It was agreed that a joint report should be prepared developing as far as possible the basic facts relating to the Charnock Groundwater Basin and the available water supply therein.
4. Such a report has been prepared jointly by Bartlett L. Kennedy and John R. Patten for the City of Santa Monica and L. J. Alexander and Samuel H. Keller for the Southern California Water Company.
5. This "Joint Report on the Available Water Supply in the Charnock Groundwater Basin" is attached hereto, designated as Exhibit A.

B. DEFINITIONS AS USED IN THIS AGREEMENT

The following words and clauses shall have the following meaning:

1. The City of Santa Monica, hereafter called the City, is an incorporated municipality, incorporated under the Laws of the State of California in November, 1886.
2. The Southern California Water Company, hereafter called the Company, is an investor-owned utility incorporated under the laws of the State of California on December 31, 1929.
3. Charnock Groundwater Basin is located in the westerly part of Los Angeles County. Geological investigation by both the United States Geological Survey in Water Supply Paper 1461 and the California Department of Water Resources Bulletin 104, indicate that the

boundaries of this Groundwater Basin consist of that area between the Charnock Fault on the West and the Overland Fault on the East, the Ballona Escarpment on the South and the Santa Monica Mountains on the North. This Groundwater Basin underlies approximately 3,475 acres.

4. Basin Management, means the best possible control of the water within the Charnock Groundwater Basin available to both parties, thereby insuring the maximum economic benefit to each party.
5. The water year is the twelve month period commencing January 1 of each year and ending December 31 of the same calendar year.
6. Watermaster shall be a committee of three, one appointed by the City, one appointed by the Company and third chosen jointly by the two so appointed.
7. Relative right of each of the parties is their percentage of the total available water supply as set forth below, applies to the "Permissible Pumping Curve".
8. Permissible Pumping Curve is that curve in the Exhibit A and shown on Page 16, Plate "C" thereof and has been developed in Appendix A of that exhibit.

C. RELATED FACTS AND INFORMATION:

1. Extraction or pumping from the Charnock Basin by both parties since 1924 has been intermittent in total quantity each year, and several times during the period of record pumping by both the City of Santa Monica and the Southern California Water Company has caused the groundwater basin to be in a condition of overdraft. Subsequent to these periods of overdraft, a reduction of pumping by either or both entities, not always occurring at the same time, has permitted some

recharge from the runoff of the Santa Monica Mountains and rain falling on the valley floor.

2. Charnock Basin is an enormous storage reservoir and as such is a valuable natural resource in terms of water supply.
  3. Good Basin Management will provide the cheapest possible source of water supply and will provide the most economical means of equating supply and demand.
  4. The Joint Report (Exhibit A) proposed an engineering solution to an equitable method of Basin Management which would thereby provide the maximum benefit to the City and the Company.
  5. Investigation has determined that, with one exception, all of the parties which had previous pumping records within the groundwater basin and that now may be active, are now pumping less than 10 per cent of the estimated historic yield. For that reason the City and the Company can enter into an agreement which will have the practical effect of establishing Basin Management.
  6. With economic Basin Management, the aggregate amounts of water produced by and for the use of each party will prevent the irreparable injury of overdraft that might otherwise occur with unregulated management.
- D. PRINCIPLES OF AGREEMENT: This agreement shall become effective when the following events have occurred:
1. The principles set forth in this statement have been embodied in a formal agreement consistent with these principles and subject to such changes as the parties may hereinafter agree upon.

2. The agreement referred to in paragraph number 1 above has been approved by the City Council of City, and all other approvals required by law to be obtained by City have been obtained and are effective and such agreement has been approved by the Board of Directors of the Company.
3. The Public Utilities Commission of the State of California has approved performance of such agreement by Southern California Water Company.
4. Each of the parties has received an opinion from its counsel to the effect that the agreement embodying the terms set forth in this Statement of Principles is valid and binding upon the other party and its successors and assigns.

E. THE WATERMASTER SHALL HAVE THE FOLLOWING DUTIES AND POWERS:

1. The Watermaster shall take all steps necessary to make the following determinations promptly after the 15th of February each year.
2. Compute the ten year running average rainfall by the continuation of Table 8 of the Report.
3. Determine permissible pumping for the ensuing year from Plate C of the Report.
4. Determine the change, if any, in the static water level from the previous February 15.
5. Adjust, if necessary, the amount of permissible pumping due to the change of static water level and the resulting change in available storage.
6. Periodically check the accuracy of measuring devices for determining the quantity of water produced and measuring devices for the determination of static water levels.

7. Have the power to permit either party to pump more than its percentage of permissible pumping in any year due to special request or unusual circumstances. If such permission is granted to either party to pump more or less than his allocated percentage of permissible pumping the Watermaster then shall charge that quantity against the party's permissible pumping in the following year. Or, the Watermaster, with approval of both parties, shall credit such over-pumping by one party to the right of the other party's share of permissible pumping.
8. Shall make a tentative budget, which shall be mailed to each party on or before March 1st of each year. Such budget shall cover all expenses in preparing the necessary report, the cost of doing such work as may be necessary to comply with adequate Basin Management as defined herein. This budget shall be revised if necessary and approved by both parties prior to April 1st of each year.
9. Develop such recommendations as will be necessary from time to time to insure complete compliance with the program of Basin Management.
10. Report to the court and to each party in writing at the same time and not later than April 15th of each year.
11. Compensation and expenses of the Watermaster shall be born in the following proportions: The fees and expenses of the Watermaster appointed by each party shall be born by that party. The fees and expenses of the third member of the Watermaster team and all costs of tests, reports and studies undertaken by the Watermaster in accordance with their duties under the agreement shall be born equally by the City and the Company.

F. DIVISION OF PERMISSIBLE PUMPING:

1. City and Company agree that the total water production by both City and Company shall be that quantity of water as determined by the Watermaster for each future year from the Permissible Pumping Curve, adjusted if necessary because of change in storage as indicated by Static Water Levels.
2. City and the Company will manage their own pumping within the limits set by the Watermaster.
3. City and the Company further agree that City's share of the Permissible Pumping shall be 50 % and that the Company's share shall be 50 % of the total each year as determined by the Watermaster.

## CHARNOCK BASIN STUDY

### Appendix A

#### Derivation of Curve (Plate C) Permissible Pumping

|           |                          |
|-----------|--------------------------|
| Chapter 1 | Water Supply             |
| Chapter 2 | Disposal of Water Supply |
| Chapter 3 | Historic Yield           |
| Chapter 4 | Available Water Supply   |

## CHAPTER 1 - WATER SUPPLY

The water supply for the Charnock Groundwater Basin is basically derived from rainfall. Rainfall records for the study period are shown on Table 2 (page A-4). These records were obtained from the Los Angeles County Flood Control District.

The studies have been developed in two divisions, the valley floor area where there are three stations with recorders and the mountain area where there are two stations with recorders. For the same study period the rainfall at the City of Los Angeles was investigated. The long term record for the City of Los Angeles from 1877 through 1964 is 15.34 inches per year. The ratio of the long term to the 34-year study period is 1.0675. Using this relationship of the study period to the long term period of the City of Los Angeles, the long term rainfall on the valley floor was computed to be 17.45 inches and in the mountain area it was computed to be 21.17 inches per year. Shown on Table 2 (page A-4) is the departure from the long term mean from which the accumulated departure from this mean has been computed for the City of Los Angeles and for both the valley floor area and the mountain area. The graphs plotted on Plate D (page A-7) are the traces of the accumulated departure from the mean and show a definite relationship for both the valley floor and the mountain area to that of the City of Los Angeles.

A portion of the rainfall is lost by evaporation immediately following each storm. There is also transpiration by plant growth and loss of soil moisture from evaporation of water induced through capillary attraction; some minor or negligible amount is gained from water returned

to the basin from over-irrigation of lawns and other uses. The net loss has been computed to be nearly half of the total rainfall.

A study was made as shown on Table 3 (page A-5) to determine the ratio of remaining supply to total rainfall. The individual storms within a twenty-six year period were studied and were divided into three groups: first, those storms having less than one-half inch of rainfall; second, those storms having between one-half and one inch of rainfall and; third, those storms having over one inch of rainfall. For the twenty-six year period there were 1,026 storms of less than one-half inch; there were 121 storms with one-half inch to one inch and 120 storms with over one inch of rain. The storms of less than one-half inch averaged 0.0914 inches per storm; those with one-half to one inch averaged 0.6991 per storm and those over one inch averaged 1.7846 per storm.

Tests made by the Department of Agriculture, under direction of Harry F. Blaney, indicated that there may be between 0.4 and 0.5 inch evaporated immediately following each storm. On the basis of 0.45 of an inch of evaporation immediately following each storm, those storms of less than one-half inch lost all of the rainfall by immediate evaporation. There was, however, approximately 0.2491 inches remaining for those storms of one-half to 1.0 inch of rainfall. For those storms over one inch there was 1.3346 inches of rainfall available. In the twenty-six year period there was an average of five storms in the one-half to one inch group and five storms of over one inch. As shown by Table 3 (page A-5) the total rainfall available each year averaged 7.919 inches. There was in the twenty-six year study period an average of 15.11 inches each year. The ratio between the 7.919 and 15.11 is 0.5241. Therefore, the total rainfall on the area multiplied by this

factor indicates the available supply.

Thus, the total rainfall for the 31 year study period as shown on Table 4 (page A-6) expressed in acre feet amounted to 641,432 or an average of 20,691 acre feet per year which when multiplied by the factor 0.5241 provides the average annual available water supply of 10,844 acre feet. From this must be subtracted the average annual runoff. For this period of record as shown on Table 4 (page A-6) there is thus provided a net average annual supply of 6,250 acre feet.

CHIARNOCK EASTIN STUDY  
RAINFALL - CHIARNOCK AREA

Table 2

| VALLEY FLOOR AREA |       |       |       |        |       |                     |                     |       |       | MOUNTAIN AREA |       |                     |                     |       |                     |                     |         |          |                                                             | LOS ANGELES |  |  |  |  |  |  |  |  |  |
|-------------------|-------|-------|-------|--------|-------|---------------------|---------------------|-------|-------|---------------|-------|---------------------|---------------------|-------|---------------------|---------------------|---------|----------|-------------------------------------------------------------|-------------|--|--|--|--|--|--|--|--|--|
| Season            | 119-D | 140-B | 680-B | Total  | Ave.  | Departure from Mean | Cumulated Departure | 237-C | 285-C | Total         | Ave.  | Departure from Mean | Cumulated Departure | 577-F | Departure from Mean | Cumulated Departure | Station | Rainfall | Location                                                    |             |  |  |  |  |  |  |  |  |  |
| 1929-30           | 8.99  | 10.93 | 10.56 | 30.48  | 10.16 | -                   | - 18.14             | 13.14 | Inc.  | 13.14         | 13.14 | - 6.48              | - 21.99             | 11.21 | - 4.13              | - 17.20             | 119-D   |          | Saville - National Military Home                            |             |  |  |  |  |  |  |  |  |  |
| -31               | 12.78 | 15.35 | 14.92 | 43.05  | 14.35 | - 1.83              | - 19.97             | 17.49 | 16.90 | 34.39         | 17.20 | - 2.42              | - 24.41             | 12.78 | - 2.56              | - 19.76             |         |          |                                                             |             |  |  |  |  |  |  |  |  |  |
| -32               | 15.47 | 17.70 | 17.58 | 50.75  | 16.92 | + .74               | - 19.23             | 23.92 | Inc.  | 23.92         | 23.92 | 4.30                | - 20.11             | 16.83 | + 1.49              | - 18.21             | 140-B   |          | 11550 Santa Monica West Los Angeles                         |             |  |  |  |  |  |  |  |  |  |
| -33               | 13.60 | 13.53 | 13.60 | 40.73  | 13.58 | - 2.60              | - 21.83             | 17.02 | 12.07 | 29.09         | 14.55 | - 5.07              | - 25.18             | 11.75 | - 3.59              | - 21.86             |         |          |                                                             |             |  |  |  |  |  |  |  |  |  |
| -34               | 16.65 | 16.07 | 17.72 | 50.44  | 16.81 | + .63               | - 21.20             | 20.48 | 15.62 | 36.10         | 18.05 | - 1.57              | - 26.75             | 14.68 | - .66               | - 22.52             | 680-B   |          | Westwood - U.C.L.A.                                         |             |  |  |  |  |  |  |  |  |  |
| -35               | 21.56 | 21.36 | 22.77 | 65.69  | 21.90 | + 5.72              | - 15.48             | 24.55 | 21.39 | 45.94         | 22.97 | + 3.35              | - 23.40             | 21.63 | + 6.29              | - 16.23             | 237-C   |          | Stone Canyon Reservoir                                      |             |  |  |  |  |  |  |  |  |  |
| -36               | 15.24 | 13.82 | 15.30 | 44.36  | 14.79 | - 1.39              | - 16.87             | 17.40 | 16.41 | 33.81         | 16.91 | - 2.71              | - 26.11             | 12.02 | - 3.32              | - 19.55             |         |          |                                                             |             |  |  |  |  |  |  |  |  |  |
| -37               | 28.13 | 24.50 | 25.51 | 74.14  | 26.05 | + 9.87              | - 7.00              | 29.44 | 26.81 | 56.25         | 28.13 | + 8.51              | - 17.60             | 22.35 | + 7.01              | - 12.54             | 285-C   |          | Mount St. Mary's College                                    |             |  |  |  |  |  |  |  |  |  |
| -38               | 27.55 | 26.40 | 28.09 | 82.04  | 27.35 | + 11.17             | + 4.17              | 33.72 | 31.93 | 65.65         | 32.83 | + 13.21             | - 4.39              | 23.44 | + 8.10              | - 4.44              |         |          |                                                             |             |  |  |  |  |  |  |  |  |  |
| -39               | 18.09 | 15.57 | 18.68 | 54.34  | 18.11 | + 1.93              | + 6.10              | 21.63 | 20.99 | 42.62         | 21.31 | + 1.56              | - 2.83              | 18.74 | + 3.40              | - 1.04              |         |          |                                                             |             |  |  |  |  |  |  |  |  |  |
| 1939-40           | 17.42 | 16.38 | 17.54 | 51.34  | 17.11 | + .93               | + 7.03              | 18.59 | 19.88 | 38.47         | 19.24 | - .38               | - 3.21              | 13.54 | - 1.80              | - 2.84              | 577-F   |          | Los Angeles U.S.N.B. Federal Building                       |             |  |  |  |  |  |  |  |  |  |
| -41               | 34.19 | 35.58 | 39.28 | 109.05 | 36.35 | + 20.17             | + 27.20             | 45.32 | 44.46 | 89.70         | 44.89 | + 25.27             | + 22.06             | 32.79 | + 14.45             | + 14.61             |         |          |                                                             |             |  |  |  |  |  |  |  |  |  |
| -42               | 13.17 | 13.42 | 13.74 | 40.33  | 13.44 | - 2.74              | + 24.46             | 14.98 | Inc.  | 14.98         | 14.98 | - 4.64              | + 17.42             | 11.37 | - 3.97              | + 10.64             |         |          | Rainfall                                                    |             |  |  |  |  |  |  |  |  |  |
| -43               | 19.42 | 18.31 | 21.22 | 58.95  | 19.65 | + 3.47              | + 27.93             | 27.08 | 27.79 | 54.87         | 27.44 | + 7.82              | + 25.24             | 17.93 | + 2.59              | + 13.23             |         |          | Los Angeles--                                               |             |  |  |  |  |  |  |  |  |  |
| -44               | 18.38 | 18.99 | 21.39 | 58.76  | 19.59 | + 3.41              | + 31.34             | 22.95 | 23.27 | 46.22         | 23.11 | + 3.49              | + 28.73             | 19.23 | + 3.89              | + 17.12             |         |          | Long term yearly mean = 15.34 inches                        |             |  |  |  |  |  |  |  |  |  |
| -45               | 16.03 | 17.08 | 17.73 | 50.84  | 16.95 | + .77               | + 32.11             | 19.00 | 19.88 | 38.88         | 19.44 | - .18               | + 28.55             | 11.62 | - 3.72              | + 13.40             |         |          |                                                             |             |  |  |  |  |  |  |  |  |  |
| -46               | 12.86 | 13.47 | 13.50 | 39.83  | 13.28 | - 2.90              | + 29.21             | 17.47 | 16.67 | 34.14         | 17.07 | - 2.55              | + 26.00             | 11.63 | - 3.71              | + 9.69              |         |          | 34-year yearly mean = 14.22 inches                          |             |  |  |  |  |  |  |  |  |  |
| -47               | 15.33 | 15.00 | 16.15 | 46.48  | 15.49 | - .69               | + 28.52             | 16.99 | 17.05 | 34.04         | 17.02 | - 2.60              | + 23.40             | 12.74 | - 2.60              | + 7.09              |         |          |                                                             |             |  |  |  |  |  |  |  |  |  |
| -48               | 7.19  | 7.33  | 7.72  | 22.24  | 7.41  | - 8.77              | + 19.75             | 8.41  | 9.49  | 17.90         | 8.95  | - 10.67             | + 12.73             | 7.12  | - 8.22              | - 1.13              |         |          | Ratio = $\frac{15.34}{14.22} = 1.0788$                      |             |  |  |  |  |  |  |  |  |  |
| -49               | 10.00 | 10.39 | 11.53 | 31.92  | 10.64 | - 5.54              | + 14.21             | 10.21 | 11.74 | 21.95         | 10.98 | - 8.64              | + 4.09              | 8.01  | - 7.33              | - 8.46              |         |          |                                                             |             |  |  |  |  |  |  |  |  |  |
| 1949-50           | 12.24 | 11.74 | 13.72 | 37.70  | 12.57 | - 3.61              | + 10.60             | 15.50 | 16.15 | 31.65         | 15.83 | - 3.79              | + .30               | 10.97 | - 4.37              | - 12.83             |         |          | Valley Floor--                                              |             |  |  |  |  |  |  |  |  |  |
| -51               | 9.14  | 8.94  | 9.62  | 27.70  | 9.23  | - 6.95              | + 3.65              | 10.90 | 11.11 | 22.01         | 11.01 | - 8.61              | - 8.31              | 7.97  | - 7.37              | - 20.20             |         |          | 34 yearly mean = 16.18 inches                               |             |  |  |  |  |  |  |  |  |  |
| -52               | 27.92 | 25.29 | 31.95 | 53.21  | 17.74 | + 1.56              | + 5.21              | 33.01 | 35.27 | 68.28         | 34.14 | + 14.52             | + 6.21              | 26.20 | + 10.86             | - 9.34              |         |          | Long term yearly mean equals 16.18 x 1.0788 = 17.45 in.     |             |  |  |  |  |  |  |  |  |  |
| -53               | 11.27 | 11.07 | 12.47 | 34.81  | 11.60 | - 4.58              | + .63               | 14.20 | 14.81 | 29.01         | 14.51 | - 5.11              | + 1.11              | 9.33  | - 6.01              | - 15.35             |         |          | Mountain Area--                                             |             |  |  |  |  |  |  |  |  |  |
| -54               | 16.63 | 15.55 | 18.05 | 50.23  | 16.74 | + .56               | + 1.19              | 18.70 | 18.66 | 37.36         | 18.68 | - .94               | + .16               | 11.99 | - 3.35              | - 18.70             |         |          | 34 yearly mean = 19.62 inches                               |             |  |  |  |  |  |  |  |  |  |
| -55               | 13.04 | 13.04 | 14.03 | 40.11  | 13.37 | - 2.81              | - 1.62              | 15.33 | 14.74 | 30.07         | 15.04 | - 4.58              | - 4.42              | 11.99 | - 3.35              | - 22.05             |         |          | Long term yearly mean equals 19.62 x 1.0788 = 21.17 in.     |             |  |  |  |  |  |  |  |  |  |
| -56               | 17.61 | 17.58 | 18.16 | 53.35  | 17.78 | + 1.60              | - .02               | 19.81 | 21.99 | 41.80         | 20.90 | + 1.28              | - 3.14              | 15.95 | + .61               | - 21.44             |         |          | Cumulative Departure                                        |             |  |  |  |  |  |  |  |  |  |
| -57               | 13.13 | 13.61 | 14.96 | 41.70  | 13.90 | - 2.28              | - 2.30              | 16.15 | 16.93 | 33.08         | 16.54 | - 3.08              | - 6.22              | 9.54  | - 5.80              | - 27.24             |         |          | Los Angeles--                                               |             |  |  |  |  |  |  |  |  |  |
| -58               | 27.00 | 25.76 | 25.17 | 77.93  | 25.98 | + 9.80              | + 7.50              | 30.16 | 32.03 | 62.19         | 31.10 | + 11.48             | + 5.26              | 21.59 | + 6.25              | - 20.99             |         |          | 17.20 Cumulative Average 15.34 Mean = $\frac{15.34}{1.121}$ |             |  |  |  |  |  |  |  |  |  |
| -59               | 7.52  | 7.42  | 8.43  | 23.37  | 7.79  | - 8.39              | - .89               | 11.51 | 10.64 | 22.15         | 11.08 | - 8.54              | - 3.29              | 5.17  | - 9.97              | - 30.96             |         |          | Valley Floor--                                              |             |  |  |  |  |  |  |  |  |  |
| 1959-60           | 11.69 | 10.39 | 11.18 | 33.26  | 11.09 | - 5.09              | - 5.98              | 12.13 | 13.84 | 25.97         | 12.99 | - 6.63              | - 9.92              | 8.17  | - 7.76              | - 38.13             |         |          | Long term yearly mean equals 19.62 x 1.121 = 18.14          |             |  |  |  |  |  |  |  |  |  |
| -61               | 6.22  | 5.52  | 6.43  | 18.17  | 6.06  | - 10.12             | - 16.10             | 7.94  | 8.87  | 16.81         | 8.41  | - 11.21             | - 21.13             | 4.93  | - 10.41             | - 48.54             |         |          | Mountain Area--                                             |             |  |  |  |  |  |  |  |  |  |
| -62               | 25.01 | 28.70 | 24.76 | 78.47  | 26.16 | + 9.98              | - 6.12              | 30.06 | 32.51 | 62.57         | 31.29 | + 11.67             | - 9.46              | 18.71 | + 3.37              | - 45.17             |         |          | 19.62 x 1.121 = 21.99                                       |             |  |  |  |  |  |  |  |  |  |
| 1962-63           | 9.33  | 11.20 | 10.37 | 30.90  | 10.30 | - 5.88              | - 12.00             | 13.18 | 13.72 | 26.90         | 13.45 | - 6.17              | - 15.63             | 9.71  | - 5.63              | - 50.80             |         |          |                                                             |             |  |  |  |  |  |  |  |  |  |
| 34-Year Average   |       |       |       |        | 16.18 |                     |                     |       |       |               |       |                     |                     |       |                     |                     |         |          | 14.22                                                       |             |  |  |  |  |  |  |  |  |  |

A-4

56 YR. AVE.

15.07

Table 3

CHARNOCK BASIN STUDY

Computation to obtain ratio of  
Available supply to total rain

|                | Yearly<br>Total<br>Rainfall | Magnitude of Storms |                  |                       |          |                |                  |
|----------------|-----------------------------|---------------------|------------------|-----------------------|----------|----------------|------------------|
|                |                             | Below<br>Storms     | 0.5"<br>Quantity | 0.5" - 1.0"<br>Storms | Quantity | Over<br>Storms | 1.0"<br>Quantity |
| 1932-33        | 11.88                       | 41                  | 4.28             | 2                     | 1.13     | 3              | 6.47             |
| 1933-34        | 14.55                       | 33                  | 2.27             | -                     | -        | 6              | 12.24            |
| 1934-35        | 21.66                       | 44                  | 4.34             | 10                    | 6.58     | 7              | 10.73            |
| 1935-36        | 12.07                       | 48                  | 3.21             | 6                     | 4.26     | 4              | 4.60             |
| 1936-37        | 22.41                       | 49                  | 4.93             | 7                     | 4.57     | 7              | 12.90            |
| 1937-38        | 23.43                       | 43                  | 5.46             | 6                     | 3.86     | 5              | 14.05            |
| 1938-39        | 13.07                       | 44                  | 1.88             | 5                     | 3.98     | 4              | 7.20             |
| 1939-40        | 19.21                       | 48                  | 4.48             | 5                     | 3.72     | 6              | 11.01            |
| 1940-41        | 32.76                       | 59                  | 6.78             | 11                    | 8.30     | 11             | 17.63            |
| 1941-42        | 11.18                       | 60                  | 6.09             | 3                     | 2.48     | 2              | 2.61             |
| 1942-43        | 18.17                       | 48                  | 3.84             | 6                     | 4.03     | 5              | 10.30            |
| 1943-44        | 19.22                       | 60                  | 4.45             | 10                    | 6.55     | 4              | 8.21             |
| 1944-45        | 11.59                       | 57                  | 5.06             | 4                     | 2.67     | 3              | 3.86             |
| 1945-46        | 11.65                       | 54                  | 2.79             | 3                     | 2.40     | 4              | 6.46             |
| 1946-47        | 12.66                       | 53                  | 3.79             | 5                     | 3.86     | 3              | 5.01             |
| 1947-48        | 7.22                        | 57                  | 3.24             | 1                     | 0.59     | 3              | 3.39             |
| 1948-49        | 8.45                        | 29                  | 3.40             | 2                     | 1.17     | 4              | 3.88             |
| 1949-50        | 9.57                        | 25                  | 1.77             | 1                     | .55      | 5              | 7.25             |
| 1950-51        | 6.04                        | 25                  | 3.10             | 3                     | 1.93     | 1              | 1.01             |
| 1951-52        | 26.18                       | 33                  | 3.38             | 6                     | 4.68     | 8              | 18.04            |
| 1952-53        | 11.62                       | 22                  | 4.34             | 3                     | 2.12     | 3              | 5.16             |
| 1953-54        | 10.34                       | 14                  | 1.59             | 1                     | .52      | 4              | 8.23             |
| 1954-55        | 11.03                       | 14                  | 1.48             | 8                     | 5.87     | 3              | 3.67             |
| 1955-56        | 12.79                       | 13                  | 2.67             | 2                     | 1.54     | 3              | 8.58             |
| 1956-57        | 11.09                       | 27                  | 2.57             | 6                     | 4.13     | 2              | 4.39             |
| 1957-58        | 23.03                       | 26                  | 2.61             | 5                     | 3.11     | 10             | 17.27            |
| Totals         | 392.87                      | 1026                | 93.80            | 121                   | 84.60    | 120            | 214.15           |
| Ave. In/Season | 15.11                       |                     | 3.608            |                       | 3.254    |                | 8.237            |
| Ave. No/Storms |                             | 39                  |                  | 5                     |          | 5              |                  |
| Ave. In/Storm  | 0.3101                      |                     | 0.0914           |                       | 0.6991   |                | 1.7846           |
| Evap/Storm     | 0.45                        |                     | 0.45             |                       | 0.45     |                | 0.45             |
| Avail/Storm    | -                           |                     | -                |                       | 0.2491   |                | 1.3346           |
| Avail/Season   | -                           |                     | -                |                       | 1.246    |                | 6.673            |

Total available per season  $1.246 + 6.673 = 7.919$

Available 7.919 divided by total 15.11 Ratio equals .5241

- Note: 1) Daily precipitation prior to July 1948 from Los Angeles, others from Santa Mon.  
2) Number of storms indicated in whole figures but computations carried out in numbers and decimals.

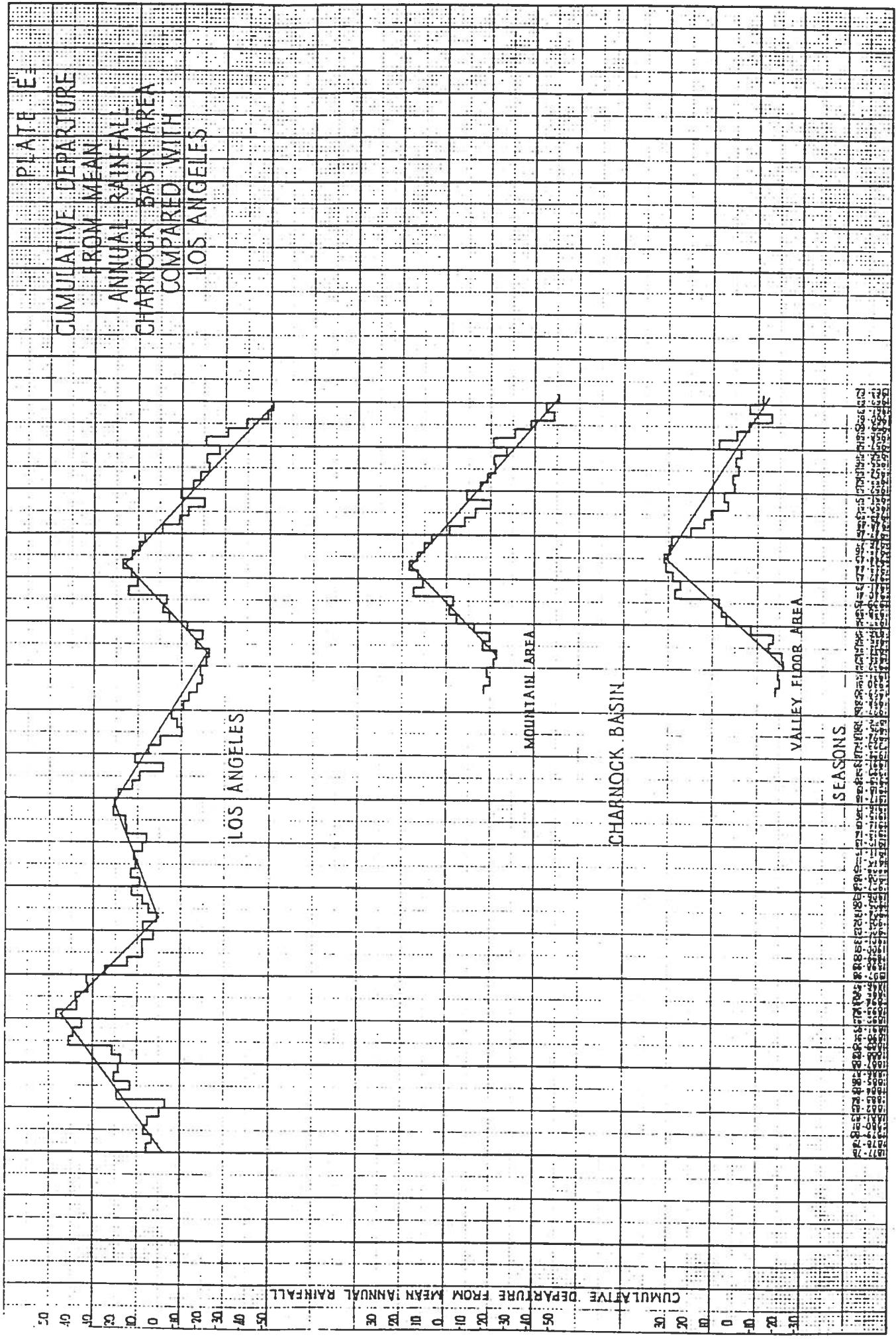
Table 4

CHARNOCK BASIN STUDY

## Computation of Net Available Supply from Rainfall

|         | 1                   | 2                | 3                    | 4                | 5                | 6                                      | 7                    | 8                          |
|---------|---------------------|------------------|----------------------|------------------|------------------|----------------------------------------|----------------------|----------------------------|
|         | <u>VALLEY FLOOR</u> |                  | <u>MOUNTAIN AREA</u> |                  | <u>TOTAL</u>     | Net<br>Available<br>Col. 5 x<br>0.5241 | Run Off<br>Acre Feet | Net<br>Available<br>Supply |
|         | <u>Inches</u>       | <u>Acre Feet</u> | <u>Inches</u>        | <u>Acre Feet</u> | <u>Acre Feet</u> |                                        |                      |                            |
| 1932-33 | 13.58               | 7556             | 14.55                | 8507             | 16063            | 8419                                   | 2180                 | 6239                       |
| -34     | 16.81               | 9353             | 18.05                | 10554            | 19907            | 10433                                  | 2540                 | 7893                       |
| -35     | 21.90               | 12185            | 22.97                | 13431            | 25616            | 13425                                  | 2950                 | 10475                      |
| -36     | 14.79               | 8229             | 16.91                | 9887             | 18116            | 9495                                   | 2920                 | 6575                       |
| -37     | 26.05               | 14494            | 28.13                | 16448            | 30942            | 16217                                  | 6500                 | 9717                       |
| -38     | 27.35               | 15218            | 32.83                | 19196            | 34414            | 18036                                  | 7000                 | 11036                      |
| -39     | 18.11               | 10076            | 21.31                | 12460            | 22536            | 11811                                  | 2170                 | 9641                       |
| 1939-40 | 17.11               | 9520             | 19.24                | 11250            | 20770            | 10886                                  | 2780                 | 8106                       |
| -41     | 36.35               | 20225            | 44.89                | 26247            | 46472            | 24356                                  | 9460                 | 14896                      |
| -42     | 13.44               | 7478             | 14.98                | 8759             | 16237            | 8510                                   | 1990                 | 6520                       |
| -43     | 19.65               | 10933            | 27.44                | 16044            | 26977            | 14139                                  | 4560                 | 9579                       |
| -44     | 19.59               | 10900            | 23.11                | 13512            | 24412            | 12794                                  | 4030                 | 8764                       |
| -45     | 16.95               | 9431             | 19.44                | 11367            | 20798            | 10900                                  | 2870                 | 8030                       |
| -46     | 13.28               | 7389             | 17.07                | 9981             | 17370            | 9104                                   | 3740                 | 5364                       |
| -47     | 15.49               | 8619             | 17.02                | 9952             | 18571            | 9733                                   | 4260                 | 5473                       |
| -48     | 7.41                | 4123             | 8.95                 | 5233             | 9356             | 4903                                   | 1820                 | 3083                       |
| -49     | 10.64               | 5920             | 10.98                | 6420             | 12340            | 6467                                   | 2410                 | 4057                       |
| 1949-50 | 12.57               | 6994             | 15.83                | 9256             | 16250            | 8517                                   | 2560                 | 5957                       |
| -51     | 9.23                | 5136             | 11.01                | 6438             | 11574            | 6066                                   | 2410                 | 3656                       |
| -52     | 17.74               | 9871             | 34.14                | 19962            | 29833            | 15635                                  | 10180                | 5455                       |
| -53     | 11.60               | 6454             | 14.51                | 8484             | 14938            | 7829                                   | 2790                 | 5039                       |
| -54     | 16.74               | 9314             | 18.68                | 10922            | 20236            | 10606                                  | 6960                 | 3646                       |
| -55     | 13.37               | 7439             | 15.04                | 8794             | 16233            | 8508                                   | 3130                 | 5378                       |
| -56     | 17.78               | 9893             | 20.90                | 12220            | 22113            | 11589                                  | 6450                 | 5139                       |
| -57     | 13.90               | 7734             | 16.54                | 9671             | 17405            | 9122                                   | 5200                 | 3922                       |
| -58     | 25.98               | 14455            | 31.10                | 18184            | 32639            | 17106                                  | 8410                 | 8696                       |
| -59     | 7.79                | 4334             | 11.08                | 6478             | 10812            | 5667                                   | 3440                 | 2227                       |
| 1959-60 | 11.09               | 6170             | 12.99                | 7595             | 13765            | 7214                                   | 4070                 | 3144                       |
| -61     | 6.06                | 3372             | 8.41                 | 4917             | 8289             | 4344                                   | 2820                 | 1524                       |
| -62     | 26.16               | 14557            | 31.29                | 18295            | 32852            | 17218                                  | 14520                | 2698                       |
| -63     | 10.30               | 5732             | 13.45                | 7864             | 13596            | 7126                                   | 5300                 | 1826                       |
| Totals  | 508.81              | 283104           | 612.84               | 358328           | 641432           | 336175                                 | 142420               | 193755                     |
| Average | 16.41               | 9132             | 19.77                | 11559            | 20691            | 10844                                  | 4594                 | 6250                       |

Note: Curve  $C_1$  (page 35) plotted - Column 1 vs. Column 8



## CHAPTER 2 - DISPOSAL OF WATER SUPPLY

The disposal of the available supply occurs as outflow due to surface drainage, pumping and change in storage.

Surface discharge has been measured by the Los Angeles County Flood Control District at the gauging station on Sawtelle Drain just upstream from Culver Boulevard. The total discharge for the 31-year period 1932-33 - 1962-63 inclusive amounted to 142,420 acre feet and has averaged 4,594 acre feet per year as shown on Table 4 (page A-6).

The combined pumping of both the City of Santa Monica and of the Southern California Water Company within the Charnock Basin for the same 31-year period amounted to 188,975 acre feet or an average of 6,096 acre feet per year as shown on Table 5 (page A-11).

The difference between available supply and measured disposal is change in storage. Bulletin 45 of the Division of Water Resources entitled, "South Coastal Basin Investigation, Geology and Groundwater Storage Capacity of the Valley Fill" states that "North of Ballona Creek the alluvial deposits have been derived almost entirely from the Santa Monica Mountains". A study of the well logs by the Department in this area indicate that 54% of this alluvial deposit is a clayey material, 18% sand and 28% gravel. In a small portion of this area, there are marine deposits which contain smaller amounts of clay or about 29%, with sand 46% and gravel 25%. In another segment of the area it shows 65% clay, 21% sand and 14% gravel.

From these figures the porosity of open spaces of the alluvial fill may be determined. This in turn provides means of estimating the capacity of the groundwater basin. The specific yield, however, of a groundwater basin

is the amount of water which the porosity of the alluvial fill will yield by gravity. Lines of specific yield were developed in Bulletin 45 and indicate variations of from 5% near the mountain edge to over 12% for a large portion of the area. Weighting these and intermediate figures, the specific yield is approximately 10% within the boundaries of the Charnock Groundwater Basin which has a surface area of about 3,475 acres. Using the 10% specific yield, the groundwater basin will yield, for each foot of valley fill, about 347.5 acre feet. Stated another way, the valley fill has an average storage capacity of 347.5 acre feet per foot of depth of the groundwater basin.

The static water level from March 1933 to March 10, 1963, averaged between Charnock and Sepulveda rose about 14 feet. On the basis of an average storage capacity of 347.5 acre feet per foot there is the indication of an increase in storage capacity of

$$347.5 \times 14 = 4,865 \text{ acre feet.}$$

The supply and disposal for the years 1933-63 for the Charnock Basin may also be computed as follows:

|                                                                                                        |                      |                      |
|--------------------------------------------------------------------------------------------------------|----------------------|----------------------|
| Total rainfall in the period<br>1933-63 equals 641,452 acft.<br>multiplied by 0.5241<br>(Table 4)      |                      | 336,175 acft.        |
| Total runoff as measured by<br>Los Angeles County Flood<br>Control District<br>(Table 4)               | 142,420 acft.        |                      |
| Total pumping by the City of<br>Santa Monica and the Southern<br>California Water Company<br>(Table 5) | <u>188,975 acft.</u> |                      |
| Sub Total                                                                                              |                      | <u>331,395 acft.</u> |
| Total Supply less measured<br>disposal shows the change in<br>storage                                  |                      | 4,780 acft.          |

The difference in results of these two methods of determining the volumetric change in storage is within the limits of such estimates.

It is interesting to note that on the basis of Supply, the yield during the study period of the Charnock Basin was 6,250 (Table 4, page A-6) as compared with 6,250 acre feet as shown in the following computation:

|                        |                    |
|------------------------|--------------------|
| Total Pumping          | 188,975 acft.      |
| Change in Storage      | <u>4,780 acft.</u> |
| Total Water Available  | 193,755 acft.      |
| 31-year average equals | 6,250 acft.        |

Table 5

CHARNOCK BASIN STUDY

## WATER PRODUCTION

in acre feet by

CITY of SANTA MONICA and SOUTHERN CALIFORNIA WATER COMPANY

| <u>YEAR</u>      | <u>TOTAL</u> | <u>YEAR</u> | <u>TOTAL</u> |
|------------------|--------------|-------------|--------------|
| 1933             | 7,375✓       | 1949        | 8,970        |
| 1934             | 7,838✓       | 1950        | 8,750        |
| 1935             | 7,898✓       | 1951        | 8,113        |
| 1936             | 8,103✓       | 1952        | 3,247        |
| 1937             | 8,951        | 1953        | 3,635✓       |
| 1938             | 9,283        | 1954        | 3,662✓✓      |
| 1939             | 10,107       | 1955        | 3,599        |
| 1940             | 10,489       | 1956        | 3,909        |
| 1941             | 7,257✓       | 1957        | 4,331        |
| 1942             | 3,626        | 1958        | 3,084        |
| 1943             | 4,745        | 1959        | 2,210        |
| 1944             | 5,133        | 1960        | 3,839        |
| 1945             | 5,724        | 1961        | 3,776        |
| 1946             | 6,578✓       | 1962        | 4,311        |
| 1947             | 7,360✓       | 1963        | 4,475        |
| 1948             | 8,607        |             |              |
| Total Production |              | 188,975     |              |
| Average Yearly   |              | 6,096       |              |

### CHAPTER 3 - HISTORIC YIELD OF THE GROUNDWATER BASIN

The estimated safe yield expressed in acre feet is the amount of water that may be withdrawn from an underground basin year after year without creating an overdraft. This, of course, is dependent upon a long term period when rainfall has progressed through one or more cycles with reasonably accurate records of rainfall, runoff and production within these cycles.

No such long term records are available for the Charnock Basin. The available records have been plotted on Plate E (page A-15).

It must be pointed out that due to urbanization, variations in rainfall and many other factors that the historic yield as differentiated from safe yield is only a guide to available supply. Further, the available supply in the Charnock Basin may vary year to year and should not be related to safe yield but to the available water in the Charnock Basin in the solution of Basin Management.

For use as a guide in developing available water, the historic yield of Charnock Basin may be estimated by considering periods when the static water level is at the same elevation. The period 1934-1953 was used when the water level of Charnock and Sepulveda were averaged and at the same elevation. This period was used as a whole and subdivided into the sub-periods of 1934-43 and 1943-53 for a total of all periods aggregating 41 years. This is Study A (page A-17). Rainfall in each of these periods was computed and related to the long term mean. Production in each period was also computed. In each case the production was corrected by the relationship of rainfall in the period to long term mean on the Valley Floor. Each period was then used to compute the weighted average over the 41 year summation of periods which amounted to 7,406 acre feet average yield.

Study B (page A-18) was made in a similar pattern using only the static water level at Charnock as a control. This produced a weighted average for 31 years of 6,474 acre feet of yearly yield.

The record indicates that from 1931 through 1963 there was a change in storage of approximately 3,475 acre feet when the static water levels at Charnock and Sepulveda were averaged. Rainfall for the period was computed to be 94.8% of the long term mean. The average production was therefore corrected accordingly and increase in storage added to obtain a probable yield in that 33 year period of 6,980 acre feet as shown in Study C (page A-19).

The net available supply as shown in the chapter on "Supply" has also been computed in Column 8, Table 4 (page A-6) for an average of 6,250 acre feet. The rainfall in this period averaged 16.41 inches or 95.0% of the long term mean. The result of this computation following the pattern of the other studies is shown in Study D (page A-19) and amounts to 6,578 acre feet.

The ten-year running average net available supply, as computed in Table 9 (page 29) for the years 1932 to 1963, amounted to 6,560 acre feet. For the same period the ten-year running average rainfall was 16.48. Following the same pattern of computation, the yield amounted to 6,876 acre feet. This is Study E (page A-20).

In the chapter on "Disposal" (page A-8) of the total supply to the Charnock Basin for the 31-year period 1933 to 1963 when change in storage, runoff and production were considered indicating a possible average yield of 6,250 acre feet (page A-10). Again relating this to the average rainfall for the period, which was 16.41, a yield of 6,575 acre feet was indicated as shown in Study F (page A-20).

These six detailed studies, A, B, C, D, E and F, using available records, involved ten different periods for a total of 199 years. Using the results of these studies to obtain a weighted average yield there is an indicated yield of approximately 6,847 acre feet per year as shown on Table 6 (page A-16).

# PLATE F CHARNOCK BASIN

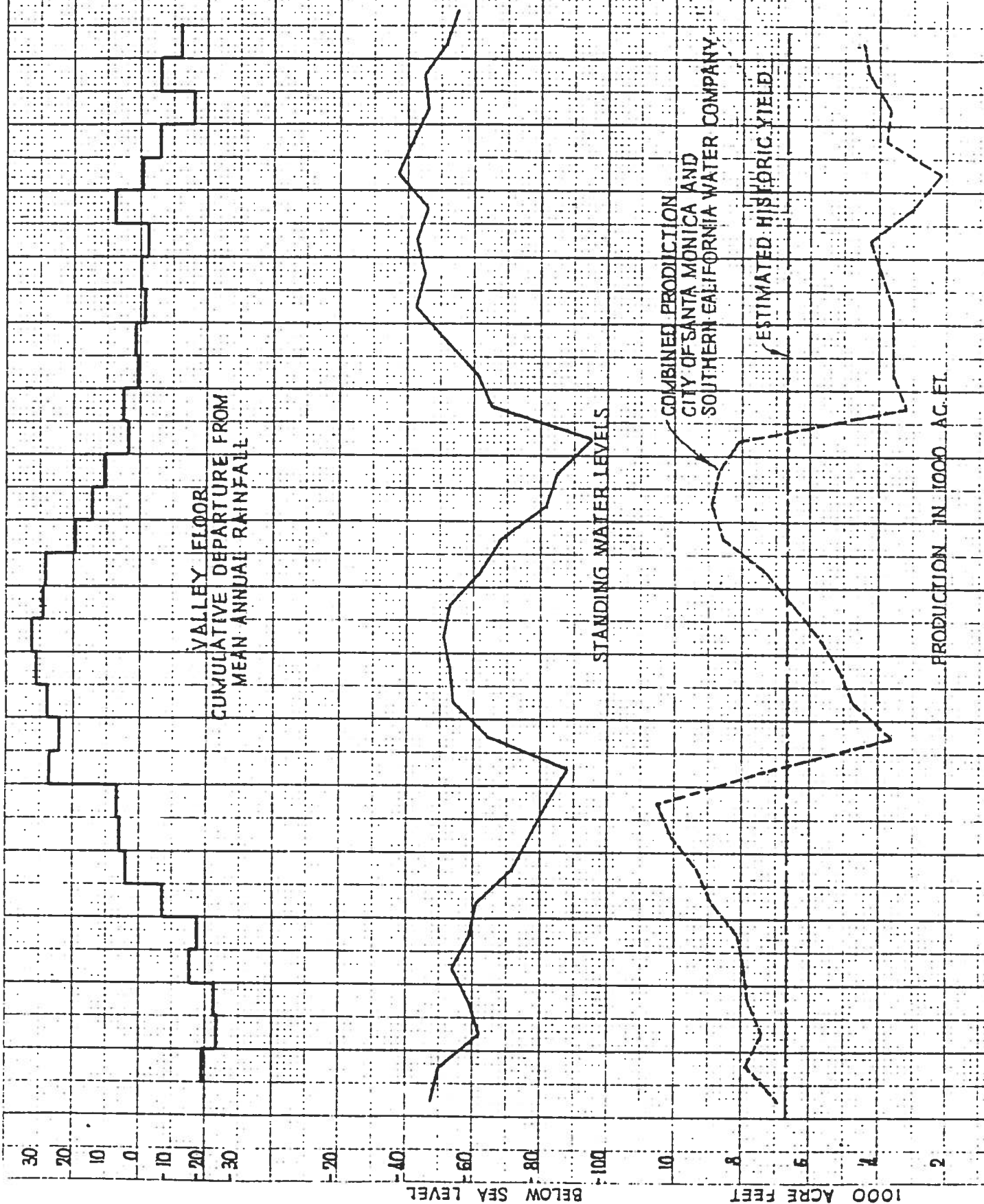


Table 6

CHARNOCK BASIN STUDY

## Summary of Historic Yield Studies

|         |                                                                          |   |                |
|---------|--------------------------------------------------------------------------|---|----------------|
| Study A | - Static Water Levels averaged between Charnock and Sepulveda            |   |                |
|         | 7,406 acft. x 42 yrs.                                                    | = | 303,646        |
| Study B | - Static Water Levels at Charnock only                                   |   |                |
|         | 6,474 acft. x 31 yrs.                                                    | = | 200,694        |
| Study C | - Static Water Levels and change in storage                              |   |                |
|         | 6,980 acft. x 33 yrs.                                                    | = | 230,340        |
| Study D | - Available Supply as computed in Table 4                                |   |                |
|         | 6,578 acft. x 31 yrs.                                                    | = | 203,918        |
| Study E | - 10-year running average rainfall and available supply computed Table 8 |   |                |
|         | 6,876 acft. x 32 yrs.                                                    | = | 220,032        |
| Study F | - Supply as computed in chapter on "Disposal"                            |   |                |
|         | 6,575 acft. x <u>31 yrs.</u>                                             | = | <u>203,825</u> |
|         | 199 yrs.                                                                 | = | 1,362,455      |
|         | Weighted Average Annual Yield                                            | = | 6,847 acft.    |

CHARNOCK BASIN STUDY

## Historic Yield

Periods when averaged Static Water Levels at Charnock and Sepulveda  
were at minus 63.

-----

1. Period October 1934 - October 1943 inclusive  
Rainfall (1933-34) - (1942-43)  
211.58 inches + 10 = 21.16 inches average  
21.16 inches to long term mean 17.27 = 122.5%  
Production 1934 - 1943 inclusive  
78,287 acft. + 10 = 7829 acft. average  
7829 + 122.5 = 6391 acft.
  
  2. Period October 1943 - October 1953 inclusive  
Rainfall (1942-43) - (1952-53)  
154.15 inches + 11 = 14.01 inches average  
14.01 inches to long term mean 17.27 = 81.1%  
Production 1943 - 1953 inclusive  
70,862 acft. + 81.1 = 8738 acft.
  
  3. Period October 1934 - October 1953 inclusive  
Rainfall (1933-34) - (1952-53)  
346.06 inches + 20 = 17.30 inches average  
17.30 inches to long term mean 17.27 = 100.2%  
Production 1934 - 1953 inclusive  
144,404 acft. + 20 = 7220 acft. average  
7220 + 100.2 = 7206 acft.
- 

4. Period 1934-43 - 6391 acft. x 10 = 63,410  
1943-53 - 8738 acft. x 11 = 96,118  
1934-43 - 7206 acft. x 20 = 144,120  
41 303,648

Weighted Average Yield = 7406 acft. per year

CHARNOCK BASIN STUDY

## Historic Yield

Periods where the Static Water Levels at Charnock were at minus 60.  
 -----

1. Period October 1931 - October 1943  
     Rainfall (1930-31) - (1942-43) inclusive  
         256.41 inches + 13 = 19.72 inches average  
         19.72 inches to long term mean 17.27 = 114.2%  
     Production 1931 - 1943 inclusive  
         100,412 acft. + 13 = 7724 acft.  
         7724 + 114.2 = 6764 acft.
  
2. Period October 1943 - October 1945  
     Rainfall (1942-43) - (1944-45)  
         56.19 inches + 3 = 18.73 inches average  
         18.73 inches to long term mean 17.27 = 108.5%  
     Production 1943 - 1945 inclusive  
         15,602 acft. + 3 = 5201 acft.  
         5201 + 108.5 = 4794 acft.
  
3. Period October 1931 - October 1945  
     Rainfall (1930-31) - (1944-45)  
         292.95 inches + 15 = 19.53 inches average  
         19.53 inches to long term mean 17.27 = 113.1%  
     Production 1931 - 1945 inclusive  
         111,269 acft. + 15 = 7418 acft.  
         7418 + 113.1 = 6559 acft.  
         -----
  
4. Period 1931-43 - 6764 x 13 yrs. = 87.932  
     1943-45 - 4794 x 3 yrs. = 14.382  
     1931-45 - 6559, x 15 yrs. = 98.385  
                                 31           200.699

Weighted Average Yield = 6474 acft.

CHARNOCK BASIN STUDY

## Historic Yield

Period where averaged Static Water Levels at Charnock and Sepulveda were taken and change in storage computed for rise in Water Table.

-----

1. Period (1930-31) - (1962-63) inclusive  
 Rainfall (1930-31) - (1962-63) inclusive  
 $540.08 \div 33 = 16.37$  inches average  
 $16.37$  inches to long term mean  $17.27 = 94.8\%$   
 Production 1931 - 1963 inclusive  
 $203.725 \text{ acft.} \div 33 = 6173 \text{ acft.}$  average  
 $6173 + 94.8 = 6512 \text{ acft.}$

Storage October 1931 - October 1963  
 Increase of 10 feet  
 $10 \times 347.5 = 3475 \text{ acft.}$   
 $3475 \div 33 = 105 \text{ acft. per year}$

|            |            |
|------------|------------|
| Production | 6512       |
| Storage    | <u>105</u> |
|            | 6617 acft. |

Probable Yield  $6617 \text{ acft.} + 94.8\% = 6980 \text{ acft.}$

-----

CHARNOCK BASIN STUDY

## Historic Yield

The net available supply was computed in Table 4 and shown in Column 8. This indicated an average yield of 6274 acft. For the same period the average annual rainfall was 16.41 inches. (Column 1, Table 4)

-----

- Period (1932-33) - (1962-63)  
 Rainfall  
 $508.81 \div 31 = 16.41$  inches average  
 $16.41$  inches to long term mean of  $17.27 = 95.0\%$   
 Net Available Supply  
 Average 6250 acft. + 95.0 = 6578 acft.

CHARNOCK BASIN STUDY

## Historic Yield

The 10-year running average net available supply computed in Column 8, Table 9 is the 10-year running average rainfall and Column 7 is net supply from Curve C. This table has been computed on the basis of change in storage for the 32-year period (1931-32) - (1962-63).

Average 10-year running average rainfall = 16.48 inches

16.48 to long term mean 17.27 = 95.4%

Average 10-year running average available supply 6560 acft.

6560 acft. + 95.4 = 6876 acft.

---

CHARNOCK BASIN STUDY

## Historic Yield

Chapter on "Disposal" of the total supply to the Charnock Basin. For the 31-year period 1933-1963 inclusive when rainfall, runoff, production and change of storage were considered.

Total Pumping (Table 5) = 188,975 acft.

Total added to Storage = 4,790  
Chapter on "Disposal"           

Available Supply = 193,765

Average Annual Available  
Supply 193,765 + 31 = 6,250 acft.

Rainfall for 31-year period (1932-33) - (1962-63)

Averaged 16.41" or 95.0% of long term mean  
as shown in Study E

6247 + 95.0% = 6,575 acft.

#### CHAPTER 4 - AVAILABLE WATER SUPPLY

It is recognized that even though the estimated historic yield has been indicated for Charnock Basin to be 6,847 acre feet, this will not necessarily continue to be the available supply or the permissible pumping year after year within the basin. The reason is that, as urban development occurs, more impervious cover is provided which results in less penetration of rainfall to the groundwater basin, thereby lessening the yearly recharge and the result of loss of some of the available supply. On the other hand, the remaining few wells pumping relatively small quantities of water will be abandoned and thereby through attrition contribute to the available supply. In the relatively confined Charnock groundwater basin as indicated by the geology there seems to be little opportunity of underflow into or out of the groundwater basin. This is further born out in the Water Quality Studies. (Appendix B)

The prediction of the volume of water that may be produced in any period of time from the Charnock Basin is dependent on past experience because it is impossible to accurately forecast the volume of rain that will occur or the possible recharge that will enter the Charnock Groundwater Basin.

In the attempt to arrive at the most economical management pattern a study of the record period from 1932-33 to 1962-63 has been made of the amount of water that may be the available supply.

A curve has been plotted of the computed volume of water that is derived from rain within the area for each inch of rainfall. This is Curve A (page A-33) plotted using the values in Column 1 vs Column 5, Table 4 (page A-6). Through the various points a "best fit" curve has been

drawn to indicate the average available supply for each inch of rainfall using the record of the valley floor stations as the index of rainfall.

The amount of runoff from any area varies tremendously due to the number, intensity and duration of the storms. Curve B (page A-34) indicates the variations. The points shown have been plotted using values in Column 1 vs Column 7, Table 4 (page A-6). Column 7 is from records of the Los Angeles County Flood Control District. However, a "best fit" curve has been drawn through the various measured points to obtain as nearly as possible the average runoff per inch of rain.

The estimate of available supply to support the most economical production has been developed in two ways; first, as computed in Column 8 vs Column 1, Table 4 (page A-6) and plotted as Curve<sub>1</sub> (page A-35); and second, using the values obtained from Curves A and B, and computed in Column 5, Table 7 (page A-26). From these values vs Column 1, Table 7, Curve C<sub>2</sub> (page A-35) has been plotted. It will be noted that the values indicated by these two curves which are based on estimates coincide reasonably well, indicated in Columns 5 and 6, Table 7. Curve C (page A-35) is the "best fit" curve.

Available production over the long term may be related to running averages. The 10-year running average of rainfall, runoff and production is one criteria. Three studies were made as shown on Curve D (page A-36). The 10-year running average of rainfall - Column 4, Table 8 (page A-27) has been computed from the projection back to 1914-15 by relating the valley floor rainfall to the recorded rainfall at Los Angeles and is used in plotting Curves D<sub>1</sub> and D<sub>2</sub> (page A-36).

Curve D<sub>1</sub> has been plotted using the values shown in Column 4 and Column 6 of Table 8, which are the 10-year running averages of rainfall and

net available supply. Net available supply shown in Column 6, Table 8 has been computed from Column 5 (which is Column 8; Table 4, Page A-6).

Curve  $D_2$  (page A-36) has been plotted using the values shown in Column 4 and Column 8 of Table 8 (page A-27). Column 8 was derived from Column 7 which in turn was taken from the "best fit" Curve C (page A-35).

Curve  $D_3$  has been developed by Table 9 (page A-29). This table, based on change in storage, develops the net available supply in the following manner: Column 2 is the recorded static water level at the Charnock Plant, (Plate B) in March of each year. Column 3 is the change in S.W.L. from the previous March. Column 4 the change in the volume of storage is change in S.W.L. multiplied by the volume of storage per acre foot of alluvial fill. Column 5 is the record production by Santa Monica and Southern California Water Company as shown on Table 5 (page A-11). Column 7 is the 10-year running average net available supply computed from Column 6 which was taken from Column 8 which is the 10-year running average rainfall as shown on Column 4, Table 8 (page A-27). The relationship of columns 7 and 8, Table 9, has been plotted as Curve  $D_3$  (page A-36).

Curve  $D_4$  is the "best fit" curve drawn on relationships of Curves  $D_1$ ,  $D_2$ ,  $D_3$ . The values shown on Curve  $D_4$  have been tabulated in Table 10 (page A-30). Curve  $D_4$ , the Permissible Pumping Curve, is also shown on Plate C (page 16) of the Report.

Table 10 (page A-30) shows the available production based on the 10-year running average rainfall based on the valley floor index. For example - if the running average rainfall is 16.5 inches then the Permissible Pumping is estimated to be 6,810 acre feet in the next year.

Proof of the validity of using Curve  $D_4$  to obtain Permissible Pumping has been developed in Table 11 (page A-31). Column 2 is the 10-year

running average rainfall shown in Column 4, Table 8 (page A-27). Column 3 is Permissible Pumping taken from Curve D<sub>4</sub>. The net supply available is taken from Curve C and as tabulated in Column 7, Table 8. Column 5 is the algebraic difference between Column 3 and Column 4. This indicates that the total available supply is 6,635 acre feet more than permissible pumping which is the algebraic sum of Column 5. For the 40 years of the computation this averages about 166 acre feet per year more supply than would be indicated by the Permissible Pumping Curve and is well within the limits of error. Column 6 indicates the change in static water level resulting from a greater or lesser supply than production. The total change indicates a rise in static water level of about 0.5 feet per year for the 40-year period. Column 7 has assumed a starting static water level of minus 100 (100 feet below ground surface) and indicates the range of 66.6 feet from the lowest to highest level. Column 7 over the 40-year period would indicate a 19.3 foot rise in water table or an increase in reserve supply of about 6,700 acre feet.

As a further check, Table 12 (page A-32) has been prepared using historical pumping (Table 5) and available supply from Column 7, Table 8, which is Curve C. This study indicated a total available supply of 219,535 acre feet or about 15,800 acre feet more than the actual production of 203,725 acre feet by the City of Santa Monica and the Southern California Water Company during the period. This resulted in a total rise in the groundwater table of about 45 feet or about 15,600 acre feet added to storage. The increase in storage thereby created when compared to the difference between available supply and actual pumping is within reasonable limits for such an estimate.

The results of this study have been plotted on the hydrograph of the water levels of the Charnock Plant as Plate F and indicates a similar pattern.

It is therefore believed that this method of determining Permissible Pumping is reasonably accurate.

It follows that for various reasons this method of estimating available supply should be verified by the Watermaster about February 1st each year. The Watermaster would then determine the amount of water that should be produced in the ensuing year without damage to the basin.

Table 7

CHARNOCK BASIN STUDY

## Computation of Net Available Supply

| 1                        | 2                                                    | 3                                               | 4                                        | 5                                                                      | 6                                                 |
|--------------------------|------------------------------------------------------|-------------------------------------------------|------------------------------------------|------------------------------------------------------------------------|---------------------------------------------------|
| Rainfall<br>in<br>Inches | Total<br>Available<br>from<br>Best Fit<br>Curve<br>A | Total<br>Available<br>Col. 2<br>Times<br>0.5241 | Runoff<br>from<br>Best Fit<br>Curve<br>B | Net Water Supply Available<br>Plotted<br>as<br>Curve<br>C <sub>2</sub> | Taken from<br>Best Fit<br>Curve<br>C <sub>1</sub> |
| 6                        | 8150                                                 | 4270                                            | 2000                                     | 2270                                                                   | 1950                                              |
| 7                        | 9300                                                 | 4875                                            | 2150                                     | 2725                                                                   | 2425                                              |
| 8                        | 10400                                                | 5450                                            | 2275                                     | 3175                                                                   | 2900                                              |
| 9                        | 11450                                                | 6000                                            | 2450                                     | 3550                                                                   | 3375                                              |
| 10                       | 12500                                                | 6550                                            | 2575                                     | 3975                                                                   | 3825                                              |
| 12                       | 14750                                                | 7730                                            | 2950                                     | 4780                                                                   | 4800                                              |
| 15                       | 18400                                                | 9640                                            | 3525                                     | 6115                                                                   | 6200                                              |
| 17.5                     | 21500                                                | 11270                                           | 4150                                     | 7120                                                                   | 7300                                              |
| 20                       | 24500                                                | 12840                                           | 4800                                     | 8040                                                                   | 8400                                              |
| 22.5                     | 27600                                                | 14465                                           | 5650                                     | 8815                                                                   | 9400                                              |
| 25                       | 31000                                                | 16250                                           | 6400                                     | 9850                                                                   | 10450                                             |
| 27.5                     | 34500                                                | 18080                                           | 7350                                     | 10730                                                                  | 11200                                             |
| 30                       | 37500                                                | 19655                                           | 8400                                     | 11255                                                                  | 12000                                             |
| 35                       | 44500                                                | 23320                                           | 10700                                    | 12620                                                                  | 13500                                             |

Col. 1 = Rainfall in inches

2 = Values from Curve A

3 = Col. 2 x 0.5241

4 = Values from Curve B

5 = Col. 3 minus Col. 4 = Col. 5, Col. 1 vs Col. 5 = Curve C<sub>2</sub>6 = Values from Curve C<sub>1</sub> which was obtained by plotting values in  
Table 4, Col. 8Note: Curve C<sub>2</sub> (page 35) plotted by Col. 1 vs Col. 5

Table 8

## CHARNOCK BASIN STUDY

## Net Available Supply From Rainfall

| 1       | 2         | 3            | 4               | 5                 | 6                    | 7                    | 8                   |
|---------|-----------|--------------|-----------------|-------------------|----------------------|----------------------|---------------------|
| SEASON  | RAINFALL  |              |                 | NET SUPPLY        |                      |                      |                     |
|         | L.A. Sta. | Ave. of *    | 10 Yr.          | Col. 8<br>Table 4 | 10 Yr.               | Best Fit             | 10 Yr.              |
|         | 577-F     | Valley Floor | Running<br>Ave. |                   | Running              | Curve C              | Running<br>Ave. "C" |
|         |           |              |                 |                   | Curve D <sub>1</sub> | Curve D <sub>2</sub> |                     |
| 1914-15 | 17.05     | 19.40        |                 |                   |                      | 8075                 |                     |
| -16     | 19.92     | 22.66        |                 |                   |                      | 9475                 |                     |
| -17     | 15.26     | 17.36        |                 |                   |                      | 7250                 |                     |
| -18     | 13.86     | 15.77        |                 |                   |                      | 6575                 |                     |
| -19     | 8.58      | 9.76         |                 |                   |                      | 3700                 |                     |
| -20     | 12.52     | 14.25        |                 |                   |                      | 5850                 |                     |
| -21     | 13.65     | 15.53        |                 |                   |                      | 6450                 |                     |
| -22     | 19.66     | 22.37        |                 |                   |                      | 9350                 |                     |
| -23     | 9.59      | 10.91        |                 |                   |                      | 4250                 |                     |
| -24     | 6.67      | 7.59         | 15.56           |                   |                      | 2675                 | 6365                |
| -25     | 7.94      | 9.03         | 14.52           |                   |                      | 3375                 | 5895                |
| -26     | 17.56     | 19.98        | 14.26           |                   |                      | 8300                 | 5778                |
| -27     | 17.76     | 20.21        | 14.54           |                   |                      | 9225                 | 5975                |
| -28     | 9.77      | 11.12        | 14.08           |                   |                      | 4375                 | 5755                |
| -29     | 12.66     | 14.40        | 14.54           |                   |                      | 5900                 | 5975                |
| -30     | 11.21     | 10.16        | 14.13           |                   |                      | 3900                 | 5780                |
| -31     | 12.78     | 14.35        | 14.01           |                   |                      | 5885                 | 5724                |
| -32     | 16.83     | 16.92        | 13.47           |                   |                      | 7015                 | 5490                |
| -33     | 11.75     | 13.58        | 13.73           | 6239              |                      | 5600                 | 5625                |
| -34     | 14.68     | 16.81        | 14.66           | 7893              |                      | 7000                 | 6058                |
| -35     | 21.63     | 21.90        | 15.94           | 10474             |                      | 9175                 | 6638                |
| -36     | 12.02     | 14.79        | 15.42           | 6575              |                      | 6150                 | 6423                |
| -37     | 22.35     | 26.05        | 16.01           | 9775              |                      | 10770                | 6577                |
| -38     | 23.44     | 27.35        | 17.63           | 11036             |                      | 11200                | 7260                |
| -39     | 18.74     | 18.11        | 18.00           | 9641              |                      | 7600                 | 7430                |
| -40     | 13.54     | 17.11        | 18.70           | 8086              |                      | 7175                 | 7757                |
| -41     | 32.79     | 36.35        | 20.90           | 14896             |                      | 13760                | 8545                |
| -42     | 11.37     | 13.44        | 20.55           | 6520              | 9114                 | 5450                 | 8388                |
| -43     | 17.93     | 19.65        | 21.16           | 9575              | 9447                 | 8225                 | 8651                |
| -44     | 19.23     | 19.59        | 21.43           | 8764              | 9534                 | 8210                 | 8772                |
| -45     | 11.62     | 16.95        | 20.94           | 8030              | 9290                 | 7050                 | 8559                |
| -46     | 11.63     | 13.28        | 20.79           | 5364              | 9169                 | 5375                 | 8482                |
| -47     | 12.74     | 15.49        | 19.73           | 5473              | 8739                 | 6400                 | 8045                |
| -48     | 7.12      | 7.41         | 17.74           | 3083              | 7943                 | 2625                 | 7187                |
| -49     | 8.01      | 10.64        | 16.99           | 4057              | 7385                 | 4175                 | 6845                |
| -50     | 10.97     | 12.57        | 16.54           | 5957              | 7172                 | 5125                 | 6640                |
| -51     | 7.97      | 9.23         | 13.83           | 3635              | 6046                 | 3475                 | 5611                |

Table 8 (Cont.)

CHARNOCK BASIN STUDY

## Net Available Supply From Rainfall

| 1       | 2         | 3            | 4       | 5                 | 6                    | 7                    | 8        |
|---------|-----------|--------------|---------|-------------------|----------------------|----------------------|----------|
| SEASON  | RAINFALL  |              |         | NET SUPPLY        |                      |                      |          |
|         | L.A. Sta. | Ave. of *    | 10 Yr.  | Col. 8<br>Table 4 | 10 Yr.               | Best Fit             | 10 Yr.   |
|         | 577-F     | Valley Floor | Running |                   | Running              | Curve C              | Running  |
|         |           |              | Ave.    |                   |                      |                      | Ave. "C" |
|         |           |              |         |                   | Curve D <sub>1</sub> | Curve D <sub>2</sub> |          |
| 1951-52 | 26.20     | 17.74        | 14.26   | 5185              | 5912                 | 7450                 | 5811     |
| -53     | 9.33      | 11.60        | 13.45   | 5039              | 5459                 | 4600                 | 5449     |
| -54     | 11.99     | 16.74        | 13.17   | 3646              | 4947                 | 7000                 | 5328     |
| -55     | 11.99     | 13.37        | 12.81   | 5378              | 4682                 | 5450                 | 5168     |
| -56     | 15.95     | 17.78        | 13.26   | 5135              | 4659                 | 7450                 | 5375     |
| -57     | 9.54      | 13.90        | 13.10   | 3922              | 4504                 | 5700                 | 5305     |
| -58     | 21.59     | 25.98        | 14.96   | 8696              | 5065                 | 10600                | 6103     |
| -59     | 5.17      | 7.79         | 14.67   | 2227              | 4882                 | 2770                 | 5962     |
| -60     | 8.17      | 11.09        | 14.52   | 3144              | 4601                 | 4350                 | 5885     |
| -61     | 4.93      | 6.06         | 14.21   | 1524              | 4390                 | 1975                 | 5735     |
| -62     | 18.71     | 26.16        | 15.05   | 10705             | 4942                 | 10775                | 6067     |
| -63     | 9.71      | 10.30        | 14.92   | 3965              | 4834                 | 3975                 | 6005     |
| 64      |           | 8.17         | 14.06   |                   |                      |                      |          |
| 65      |           | 14.98        | 14.22   |                   |                      |                      |          |

\* Average of Valley Floor is the average computed from three Stations 119-D, 140-D and 680-B as shown on Table 2. Records for these Stations are kept by the Los Angeles County Flood Control District.

Table 9

CHARNOCK BASIN STUDY

## Computation of Available Supply from Static Water Levels and Pumping

| 1           | 2                                                  | 3                                          | 4                                            | 5                                     | 6                                   | 7                                                                  | 8                                                   |
|-------------|----------------------------------------------------|--------------------------------------------|----------------------------------------------|---------------------------------------|-------------------------------------|--------------------------------------------------------------------|-----------------------------------------------------|
| <u>Year</u> | <u>SWL<br/>March<br/>Elev. Below<br/>Sea Level</u> | <u>Change<br/>From<br/>Prev.<br/>March</u> | <u>Change<br/>in Vol.<br/>of<br/>Storage</u> | <u>Recorded<br/>Total<br/>Pumping</u> | <u>Net<br/>Supply<br/>Available</u> | <u>10 Year<br/>Running Average<br/>of Net Available<br/>Supply</u> | <u>10 Year<br/>Running<br/>Average<br/>Rainfall</u> |
|             |                                                    |                                            |                                              |                                       |                                     |                                                                    | Curve = D <sub>3</sub>                              |
| 1931        | 47.3                                               |                                            |                                              |                                       |                                     |                                                                    |                                                     |
| 32          | 50.0                                               | - 2.7                                      | - 938                                        | 7826                                  | 6888                                |                                                                    |                                                     |
| 33          | 62.2                                               | - 12.2                                     | - 4240                                       | 7375                                  | 3135                                |                                                                    |                                                     |
| 34          | 59.0                                               | + 3.2                                      | + 1112                                       | 7828                                  | 8940                                |                                                                    |                                                     |
| 35          | 54.1                                               | + 4.9                                      | + 1703                                       | 7898                                  | 9601                                |                                                                    |                                                     |
| 36          | 59.3                                               | - 5.2                                      | - 1807                                       | 8103                                  | 6296                                |                                                                    |                                                     |
| 37          | 62.4                                               | - 3.1                                      | - 1077                                       | 8951                                  | 7874                                |                                                                    |                                                     |
| 38          | 71.6                                               | - 9.2                                      | - 3197                                       | 9283                                  | 6086                                |                                                                    |                                                     |
| 39          | 76.9                                               | - 5.3                                      | - 1842                                       | 10107                                 | 8265                                |                                                                    |                                                     |
| 1940        | 91.6                                               | - 14.7                                     | - 5108                                       | 10489                                 | 5381                                |                                                                    |                                                     |
| 41          | 98.2                                               | - 6.6                                      | - 2294                                       | 7257                                  | 4963                                | 6743                                                               | 20.90                                               |
| 42          | 65.1                                               | + 33.1                                     | +11502                                       | 3626                                  | 15128                               | 7567                                                               | 20.55                                               |
| 43          | 54.0                                               | + 11.1                                     | + 3857                                       | 4745                                  | 8602                                | 8114                                                               | 21.16                                               |
| 44          | 53.0                                               | + 1.0                                      | + 347                                        | 5133                                  | 5480                                | 7768                                                               | 21.43                                               |
| 45          | 51.0                                               | + 2.0                                      | + 695                                        | 5724                                  | 6419                                | 7449                                                               | 20.94                                               |
| 46          | 53.7                                               | - 2.7                                      | - 938                                        | 6578                                  | 5640                                | 7384                                                               | 20.79                                               |
| 47          | 62.0                                               | - 8.3                                      | - 2884                                       | 7360                                  | 4476                                | 7044                                                               | 19.73                                               |
| 48          | 68.4                                               | - 6.4                                      | - 2224                                       | 8607                                  | 6383                                | 7074                                                               | 17.74                                               |
| 49          | 82.0                                               | - 13.6                                     | - 4726                                       | 8970                                  | 4244                                | 6672                                                               | 16.99                                               |
| 1950        | 84.7                                               | - 2.7                                      | - 938                                        | 8750                                  | 7812                                | 6915                                                               | 16.54                                               |
| 51          | 94.9                                               | - 10.2                                     | - 3545                                       | 8113                                  | 4568                                | 6875                                                               | 13.83                                               |
| 52          | 65.2                                               | + 29.7                                     | +10321                                       | 3247                                  | 13568                               | 6719                                                               | 14.26                                               |
| 53          | 60.8                                               | + 4.4                                      | + 1529                                       | 3635                                  | 5164                                | 6375                                                               | 13.45                                               |
| 54          | 52.0                                               | + 8.8                                      | + 3058                                       | 3662                                  | 6720                                | 6499                                                               | 13.17                                               |
| 55          | 43.3                                               | + 8.7                                      | + 3023                                       | 3599                                  | 6622                                | 6520                                                               | 12.81                                               |
| 56          | 45.2                                               | - 1.9                                      | - 660                                        | 3909                                  | 3249                                | 6281                                                               | 13.26                                               |
| 57          | 43.4                                               | + 1.8                                      | + 626                                        | 4331                                  | 4957                                | 6329                                                               | 13.10                                               |
| 58          | 46.0                                               | - 2.6                                      | - 904                                        | 3084                                  | 2180                                | 5908                                                               | 14.96                                               |
| 59          | 27.9                                               | + 18.1                                     | + 6290                                       | 2210                                  | 8500                                | 6334                                                               | 14.67                                               |
| 1960        | 32.0                                               | - 4.1                                      | - 1425                                       | 3839                                  | 2414                                | 5794                                                               | 14.52                                               |
| 61          | 37.7                                               | - 5.7                                      | - 1981                                       | 3776                                  | 1795                                | 5517                                                               | 14.21                                               |
| 62          | 37.0                                               | + .7                                       | + 243                                        | 4311                                  | 4554                                | 4616                                                               | 15.05                                               |
| 63          | 41.6                                               | - 4.6                                      | - 1598                                       | 4475                                  | 2877                                | 4387                                                               | 14.92                                               |
| 64          |                                                    |                                            |                                              |                                       | Average                             | 6560                                                               |                                                     |

- Col. 2 - Elevation of Water Table Plate B  
 Col. 3 - Change in Water Table from previous year  
 Col. 4 - Col. 3 multiplied by 347.5 acre feet of water per foot of alluvium  
 Col. 5 - Recorded Total Pumping as shown on Table 5  
 Col. 6 - Is the Algebraic Sum of Col. 4 and Col. 5  
 Col. 7 - Is 10-year running average of Net Available Supply computed from Col. 6  
 Col. 8 - Is Col. 4 Table 8

Table 10

CHARNOCK BASIN STUDY

Permissible Pumping

From Curve D<sub>4</sub>

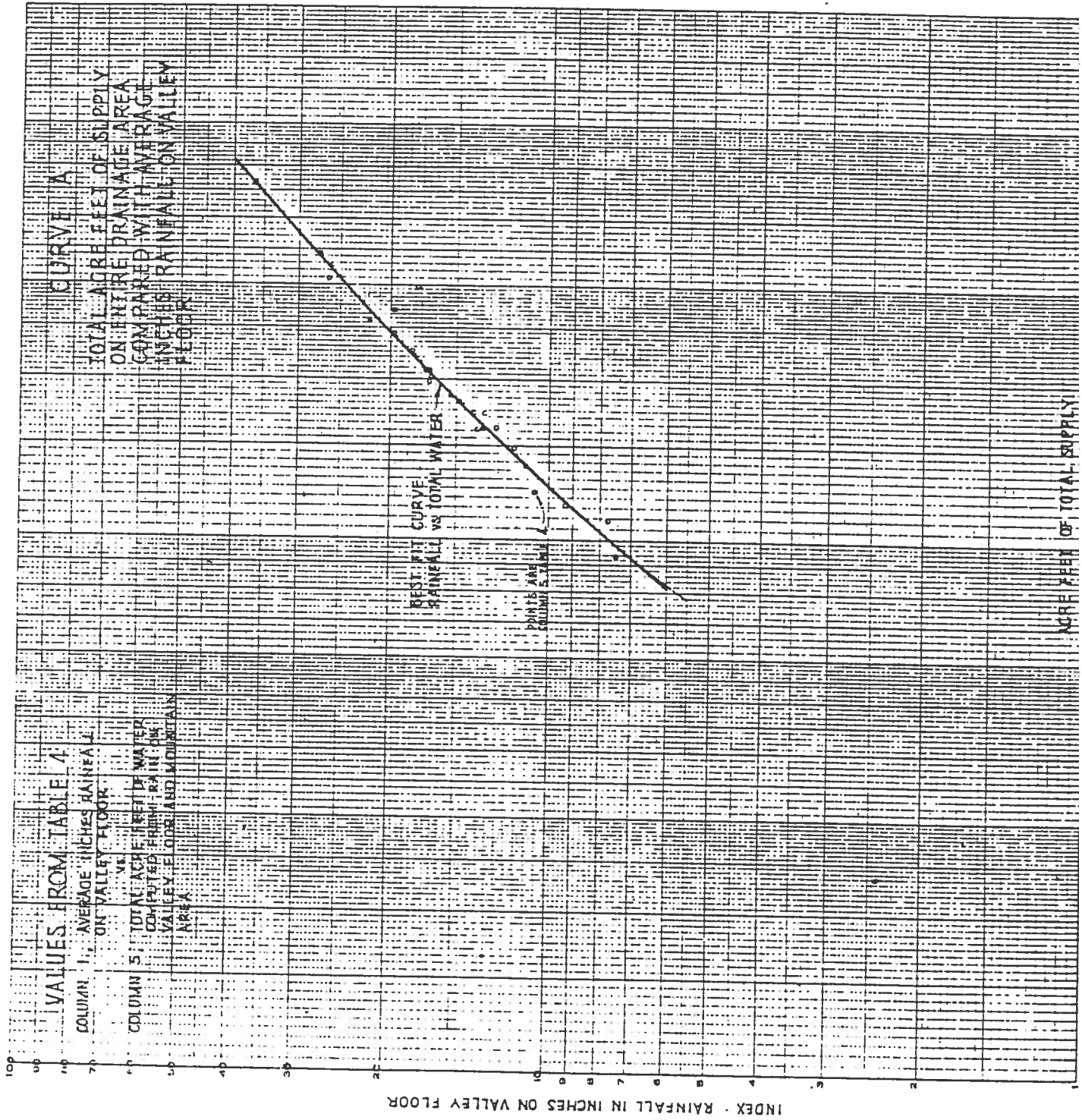
| 10 Year<br>Running<br>Average<br>Rainfall | Permissible<br>Pumping<br>In Following<br>Year | 10 Year<br>Running<br>Average<br>Rainfall | Permissible<br>Pumping<br>In Following<br>Year |
|-------------------------------------------|------------------------------------------------|-------------------------------------------|------------------------------------------------|
| 13.0                                      | 3600                                           |                                           |                                                |
| 13.5                                      | 4800                                           | 18.0                                      | 7350                                           |
| 14.0                                      | 5480                                           | 18.5                                      | 7530                                           |
| 14.5                                      | 5870                                           | 19.0                                      | 7700                                           |
| 15.0                                      | 6160                                           | 19.5                                      | 7870                                           |
| 15.5                                      | 6410                                           | 20.0                                      | 8030                                           |
| 16.0                                      | 6500                                           | 20.5                                      | 8190                                           |
| 16.5                                      | 6810                                           | 21.0                                      | 8340                                           |
| 17.0                                      | 7000                                           | 21.5                                      | 8500                                           |
| 17.5                                      | 7180                                           | 22.0                                      | 8650                                           |

Table 11

CHARNOCK BASIN STUDY

## Verification of Method of Obtaining Permissible Pumping

| 1                     | 2                                                              | 3                                                   | 4                                                     | 5                                     | 6                                        | 7                                                               |
|-----------------------|----------------------------------------------------------------|-----------------------------------------------------|-------------------------------------------------------|---------------------------------------|------------------------------------------|-----------------------------------------------------------------|
| Season                | 10-Year<br>Running<br>Average<br>Rainfall<br>Col. 4<br>Table 8 | Permis-<br>sible<br>Pumping<br>Curve D <sub>4</sub> | Net<br>Supply<br>Col. 7<br>Table 8<br>From<br>Curve C | Col. 4<br>+ over<br>- under<br>Col. 3 | Change<br>in<br>SWL<br>Col. 5<br>÷ 347.5 | Static<br>Water Level<br>in Feet<br>Below<br>Measuring<br>Point |
|                       |                                                                |                                                     |                                                       |                                       |                                          | 100                                                             |
| 1923-24               | 15.56                                                          | 6425                                                | 2675                                                  | -3750                                 | -10.8                                    | 110.8                                                           |
| -25                   | 14.52                                                          | 5860                                                | 3375                                                  | -2485                                 | - 7.2                                    | 118.0                                                           |
| -26                   | 14.26                                                          | 5680                                                | 8300                                                  | +2620                                 | + 7.5                                    | 110.5                                                           |
| -27                   | 14.54                                                          | 5900                                                | 9225                                                  | +3325                                 | + 9.6                                    | 100.9                                                           |
| -28                   | 14.08                                                          | 5520                                                | 4375                                                  | -1145                                 | - 3.3                                    | 104.2                                                           |
| -29                   | 14.54                                                          | 5900                                                | 5900                                                  | -                                     | -                                        | 104.2                                                           |
| 1929-30               | 14.13                                                          | 5580                                                | 3900                                                  | -1680                                 | - 4.8                                    | 109.0                                                           |
| -31                   | 14.01                                                          | 5480                                                | 5885                                                  | + 405                                 | + 1.2                                    | 107.8                                                           |
| -32                   | 13.47                                                          | 4760                                                | 7015                                                  | +2255                                 | + 6.5                                    | 101.3                                                           |
| -33                   | 13.73                                                          | 5160                                                | 5600                                                  | + 440                                 | + 1.3                                    | 100.0                                                           |
| -34                   | 14.66                                                          | 5970                                                | 7000                                                  | +1030                                 | + 3.                                     | 97.0                                                            |
| -35                   | 15.94                                                          | 6580                                                | 9175                                                  | +2595                                 | + 7.5                                    | 89.5                                                            |
| -36                   | 15.42                                                          | 6375                                                | 6150                                                  | - 225                                 | - 0.6                                    | 90.1                                                            |
| -37                   | 16.01                                                          | 6615                                                | 10770                                                 | +4155                                 | +12.                                     | 78.1                                                            |
| -38                   | 17.63                                                          | 7220                                                | 11200                                                 | +3980                                 | +11.5                                    | 66.6                                                            |
| -39                   | 18.00                                                          | 7350                                                | 7600                                                  | + 250                                 | + .7                                     | 65.9                                                            |
| 1939-40               | 18.70                                                          | 7590                                                | 7175                                                  | - 415                                 | - 1.2                                    | 67.1                                                            |
| -41                   | 20.90                                                          | 8310                                                | 13760                                                 | +5450                                 | +15.7                                    | 51.4                                                            |
| -42                   | 20.55                                                          | 8200                                                | 5450                                                  | -2750                                 | - 7.9                                    | 59.3                                                            |
| -43                   | 21.16                                                          | 8380                                                | 8225                                                  | - 155                                 | - 0.4                                    | 59.7                                                            |
| -44                   | 21.43                                                          | 8470                                                | 8210                                                  | - 260                                 | - 0.7                                    | 60.4                                                            |
| -45                   | 20.94                                                          | 8320                                                | 7050                                                  | -1270                                 | - 3.7                                    | 64.1                                                            |
| -46                   | 20.79                                                          | 8250                                                | 5375                                                  | -2875                                 | - 8.3                                    | 72.4                                                            |
| -47                   | 19.73                                                          | 7930                                                | 6400                                                  | -1530                                 | - 4.4                                    | 76.8                                                            |
| -48                   | 17.74                                                          | 7260                                                | 2625                                                  | -4635                                 | -13.3                                    | 90.1                                                            |
| -49                   | 16.99                                                          | 6980                                                | 4175                                                  | -2805                                 | - 8.1                                    | 98.2                                                            |
| 1949-50               | 16.54                                                          | 6815                                                | 5125                                                  | -1690                                 | - 4.9                                    | 103.1                                                           |
| -51                   | 13.83                                                          | 5280                                                | 3475                                                  | -1805                                 | - 5.2                                    | 108.3                                                           |
| -52                   | 14.26                                                          | 5680                                                | 7450                                                  | +1770                                 | + 5.1                                    | 103.2                                                           |
| -53                   | 13.45                                                          | 4760                                                | 4600                                                  | - 160                                 | - 0.5                                    | 103.7                                                           |
| -54                   | 13.17                                                          | 4180                                                | 7000                                                  | +2820                                 | + 8.1                                    | 95.6                                                            |
| -55                   | 12.81                                                          | 3500                                                | 5450                                                  | +1950                                 | + 5.6                                    | 90.0                                                            |
| -56                   | 13.26                                                          | 4400                                                | 7450                                                  | +3050                                 | + 8.8                                    | 81.2                                                            |
| -57                   | 13.10                                                          | 4060                                                | 5700                                                  | +1640                                 | + 4.7                                    | 76.5                                                            |
| -58                   | 14.96                                                          | 6140                                                | 10600                                                 | +4460                                 | +12.8                                    | 63.7                                                            |
| -59                   | 14.67                                                          | 5960                                                | 2770                                                  | -3190                                 | - 9.2                                    | 72.9                                                            |
| 1959-60               | 14.52                                                          | 5860                                                | 4350                                                  | -1510                                 | - 4.3                                    | 77.2                                                            |
| -61                   | 14.21                                                          | 5640                                                | 1975                                                  | -3665                                 | -10.5                                    | 87.7                                                            |
| -62                   | 15.05                                                          | 6190                                                | 10775                                                 | +4585                                 | +13.2                                    | 74.5                                                            |
| -63                   | 14.92                                                          | 6120                                                | 3975                                                  | -2145                                 | - 6.2                                    | 80.7                                                            |
| 40-Year Algebraic Sum |                                                                |                                                     |                                                       | +6635                                 | +19.3                                    |                                                                 |



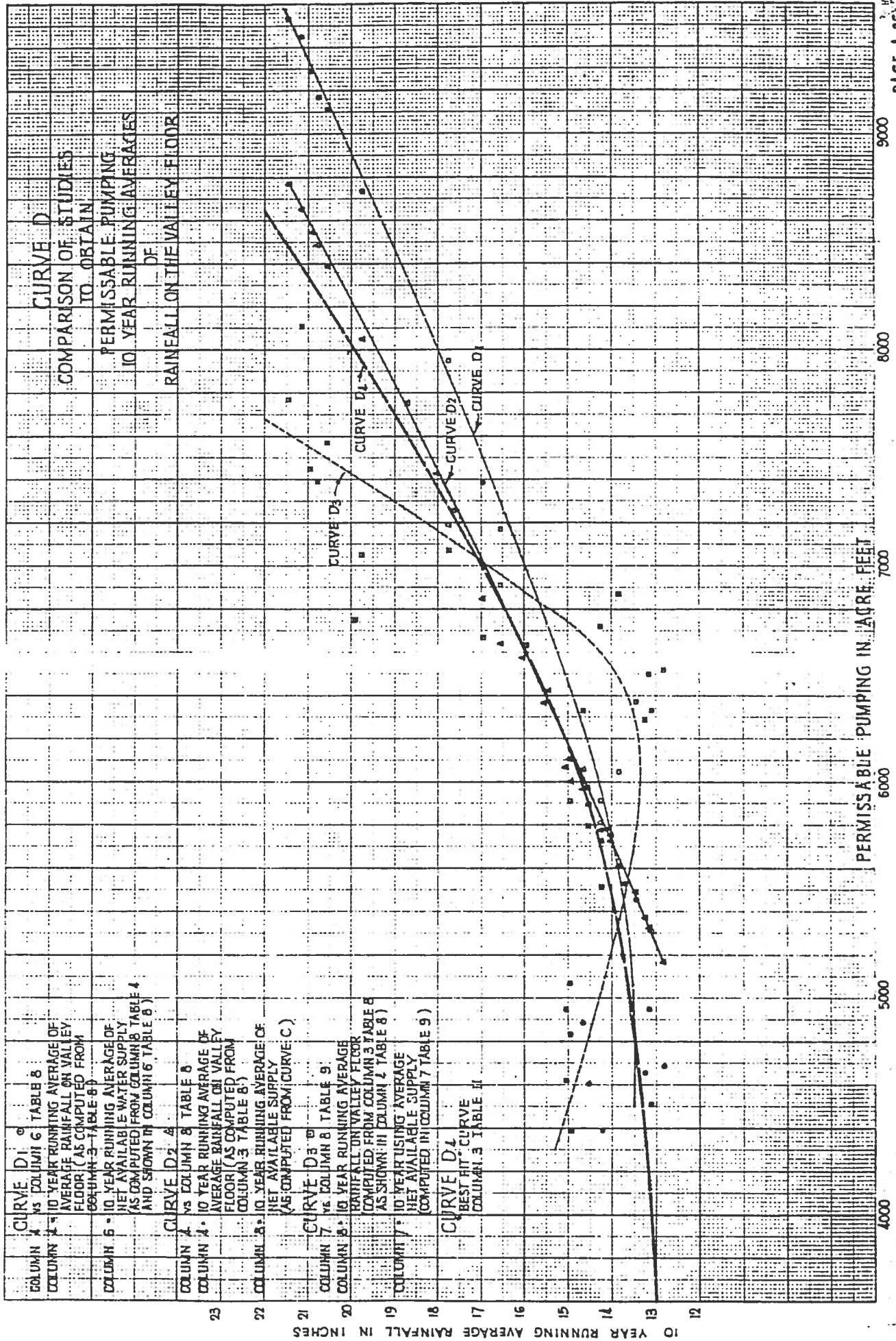
VALUES FROM TABLE 4

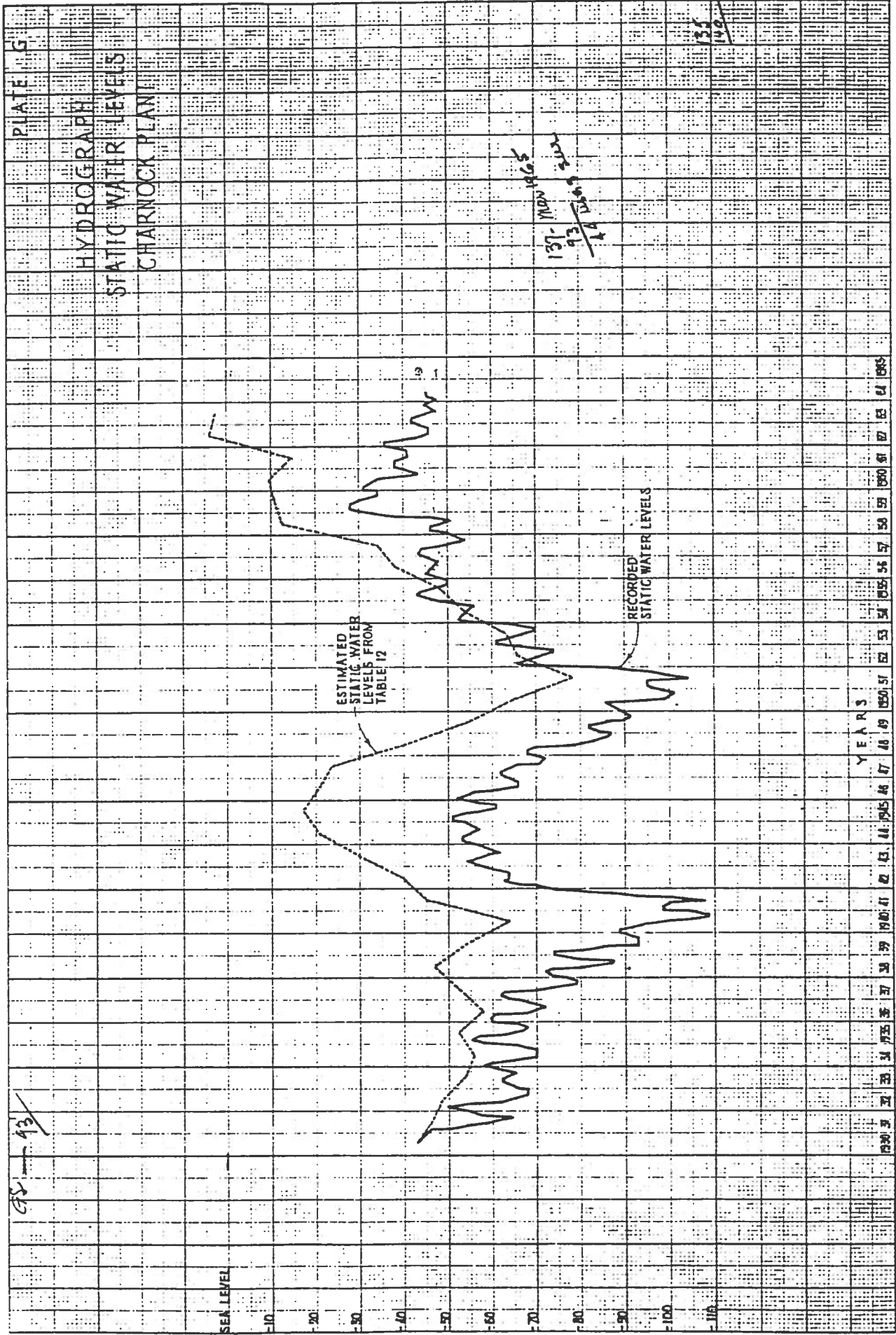
COUNTY 7 TOTAL TRIMPH IN ACRES  
FARM LOS ANGELES COUNTY  
FLOOD CONTROL DISTRICT  
RECORDS

POINTS ARE  
COLUMN 7, TABLE 4

TOTAL 1 ACRE FEET OF RUNOFF  
FROM ENTIRE DRAINAGE AREA  
COMPARED WITH AVERAGE  
RACHES OF RAIN ON VALLEY  
FLOOR

ACRE FEET RUNOFF AS MEASURED AT GAGING STATION ON SANTELLA CREEK





CHARNOCK BASIN STUDY

Appendix B

WATER QUALITY AND CHARACTER

General

- Chapter 1 Oil Field Brine and Ocean Water
- Chapter 2 Charnock-Ballona Creek-50 Foot Sand
- Chapter 3 Charnock and Waters Easterly and Westerly
- Chapter 4 Charnock and Arcadia
- Chapter 5 Waters within Charnock Basin

Conclusions

## WATER QUALITY AND CHARACTER

The terms, quality and character, should not be used synonymously, although they frequently are. Character is the relationship of the dissolved ions contained in solution one to another and to the whole; while quality is the relationship of the concentration of dissolved minerals and other impurities to the whole. To illustrate, ocean water has a definite character, although it may be diluted with distilled water until the final solution is potable. It will have the same character, but it will have a different quality.

All natural subsurface waters are dilute chemical solutions containing many dissolved minerals. The origin of these minerals is dependent upon the soil or rock formations through or over which the water flows. Subsurface water has two groups of minerals.

The minor group or the ions of iron, manganese, boron, copper, iodine, lead, silver, zinc, etc. which are often important in the study of quality, but have little or no effect on character because of the extremely low concentration of these elements. Not all of these elements are found in subsurface water.

The major group, each of which is found in nearly all natural subsurface water, are the ions of sodium, calcium, magnesium, <sup>CHLORIDE</sup> ~~chlorine~~ and the radicals of carbonates and sulphates or three bases and three acids. It is usually assumed that the three bases and the three acids are in combination in the form of their dissolved salts. There are therefore 12 possible combinations of dissolved salts that may be found. All 12 are not found in the same water. Whether or not these ions and radicals are in combination is of little importance. The important point is that these ions and radicals are present in

various proportions and produce waters of various types of character.

The chemist reports his analysis of groundwater in various ways. These are the ionic form, the hypothetical combination and the percentage of total salinity, i.e. percentage of each element in relation to the total dissolved six major elements. The chemist normally analyzes for calcium, magnesium, chloride and the radicals of carbonates, bicarbonates and sulphates. Sodium is usually obtained by deduction.

Inasmuch as the chemist analyzes for the various elements, his first results are shown in the ionic form. This is usually expressed as parts per million of each element, the hydrogen equivalent and the percentage that each bears to the whole. Thus, these three groups are those generally reported. Often, however, the chemist will report the hypothetical combinations of the various elements which are assumed to be in combination, progressing in the following manner, all calcium to the bicarbonate radical, the remaining bicarbonate to magnesium, the remaining magnesium to the sulphate radical and the remaining sulphate to sodium, and finally, sodium to chloride. Depending on the concentration of the bases, i.e., calcium, magnesium and sodium, various combinations can be obtained. For instance, some calcium, if the bicarbonate is low, would progress to sulphate, and if the sulphate is very low, magnesium might progress to the chloride with the remaining chlorides being taken up by the sodium.

In studying the character of water the hydrogen equivalent or milligram equivalent to the various elements are used. Using polar coordinate paper and the values of the milligram equivalents a diagram can be plotted giving a visual inspection of character.

CHAPTER 1  
COMPARISION OF GROUNDWATER, OIL FIELD BRINE AND OCEAN WATER

Table B-1 (page B-4) and diagram Plate B-1 (page B-5) have been tabulated and plotted for illustrative purposes only. The anions and cations have been recomputed so that the sum of each is approximately 50. The true character ranges from 11.6 for Charnock water illustrating subsurface water to 581.5 for ocean water. The point of the illustration, however, is to show the wide difference in proportion of both the bicarbonate radical and the calcium ion. In determining the difference between oil field brines and ocean water the relationship of calcium and magnesium is important. It is this relationship that first proved the infiltration of ocean water into the West Basin area rather than as was the first supposition that the contamination was from oil field brine. The Charnock water used in this table and diagram may be considered a typical groundwater unpolluted by either oil field brine or sea water.

Table B-1

CHARNOCK BASIN WATER QUALITY STUDY

Comparison of Charnock, Oil Field Brines, and Ocean Water

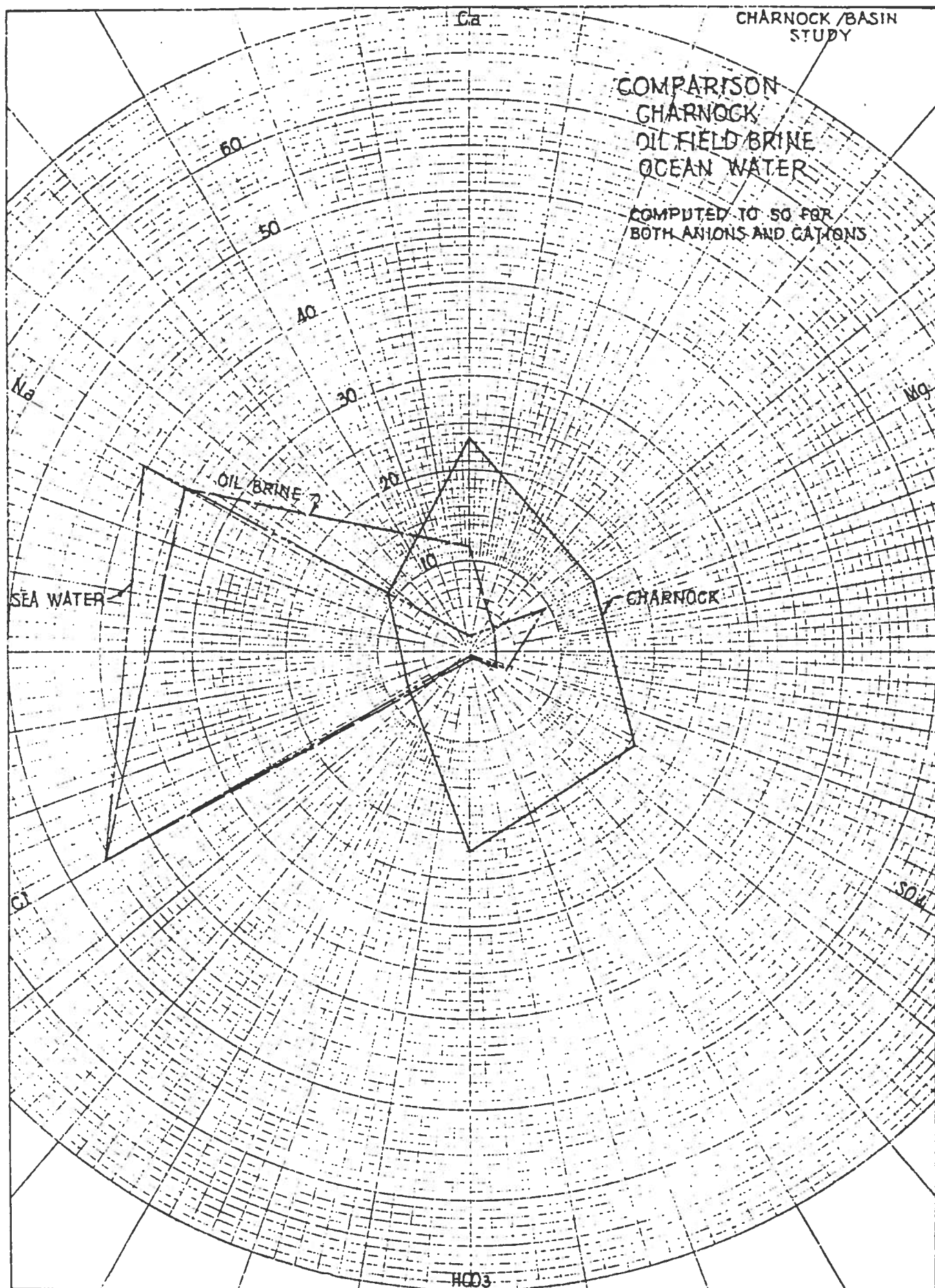
|             |                  | <u>Charnock (1)</u>          |                 | <u>Oil Brine (2)</u> |                 | <u>Sea Water (3)</u> |                 |
|-------------|------------------|------------------------------|-----------------|----------------------|-----------------|----------------------|-----------------|
|             |                  | <u>Actual</u>                | <u>Computed</u> | <u>Actual</u>        | <u>Computed</u> | <u>Actual</u>        | <u>Computed</u> |
|             |                  | <u>Milligram Equivalents</u> |                 |                      |                 |                      |                 |
| Sodium      | Na               | 2.55                         | 10.99           | 249.17               | 35.32           | 457.70               | 40.47           |
| Calcium     | Ca               | 5.45                         | 23.49           | 81.19                | 11.51           | 19.80                | 1.79            |
| Magnesium   | Mg               | 3.60                         | 15.52           | 23.12                | 3.28            | 104.00               | 9.40            |
| Total       |                  | 11.60                        | 50.00           | 353.48               | 50.11           | 581.50               | 51.66           |
| Bicarbonate | HCO <sub>3</sub> | 5.10                         | 21.98           | 3.86                 | 0.55            | 2.30                 | .20             |
| Sulphate    | SO <sub>4</sub>  | 4.76                         | 20.52           | 25.59                | 3.63            | 54.30                | 4.64            |
| Chloride    | Cl               | 1.74                         | 7.50            | 322.52               | 45.72           | 533.40               | 45.55           |
| Total       |                  | 11.60                        | 50.00           | 351.97               | 49.90           | 590.00               | 50.39           |

"Actual" is the milligram equivalents as found.

"Computed" value is for comparison where anions and cations have been related in each case to the sum of approximately 50 for the purpose of plotting.

- 1 - Average analysis Charnock #5, 6 and 7 of Southern California Water Company taken July 1958.
- 2 - Average of six analyses of oil field brines from USGS professional paper 440-F.
- 3 - Average of two analyses of ocean water from USGS Water Supply paper 1461

Note: Values are for plotting Plate B-1



CHAPTER 2  
COMPARISON OF WATERS FROM CHARNOCK, BALLONA CREEK AND 50 FOOT SAND

In plotting the true values of the milligram equivalents in Table B-2 (page B-7), Plate B-2 (page B-8), for Charnock water, Ballona Creek water and water in the fifty-foot sand, it is apparent that these are three different waters. Ballona Creek water seems to be influenced by contamination from drainage from the oil fields on Baldwin Hills. The fifty-foot sand is a combination of water from upstream of the Charnock Fault and seepage from the surface drainage.

While the concentration of magnesium and sulphate are similar in all three waters, there is wide variation in all other constituents showing a different character for all three waters. It seems apparent that there is little connection between the fifty-foot sand and the Charnock water.

Table B-2 also shows the hardness of these three waters. Hardness is determined by the calcium and magnesium ions and the radicals of bicarbonate and sulphate. The elements in combination with sulphate produce "permanent" hardness.

Table B-2

CHARNOCK BASIN WATER QUALITY STUDY

Comparison of Waters from Charnock (1), Ballona Creek (2), &amp; 50 ft. Sand (3)

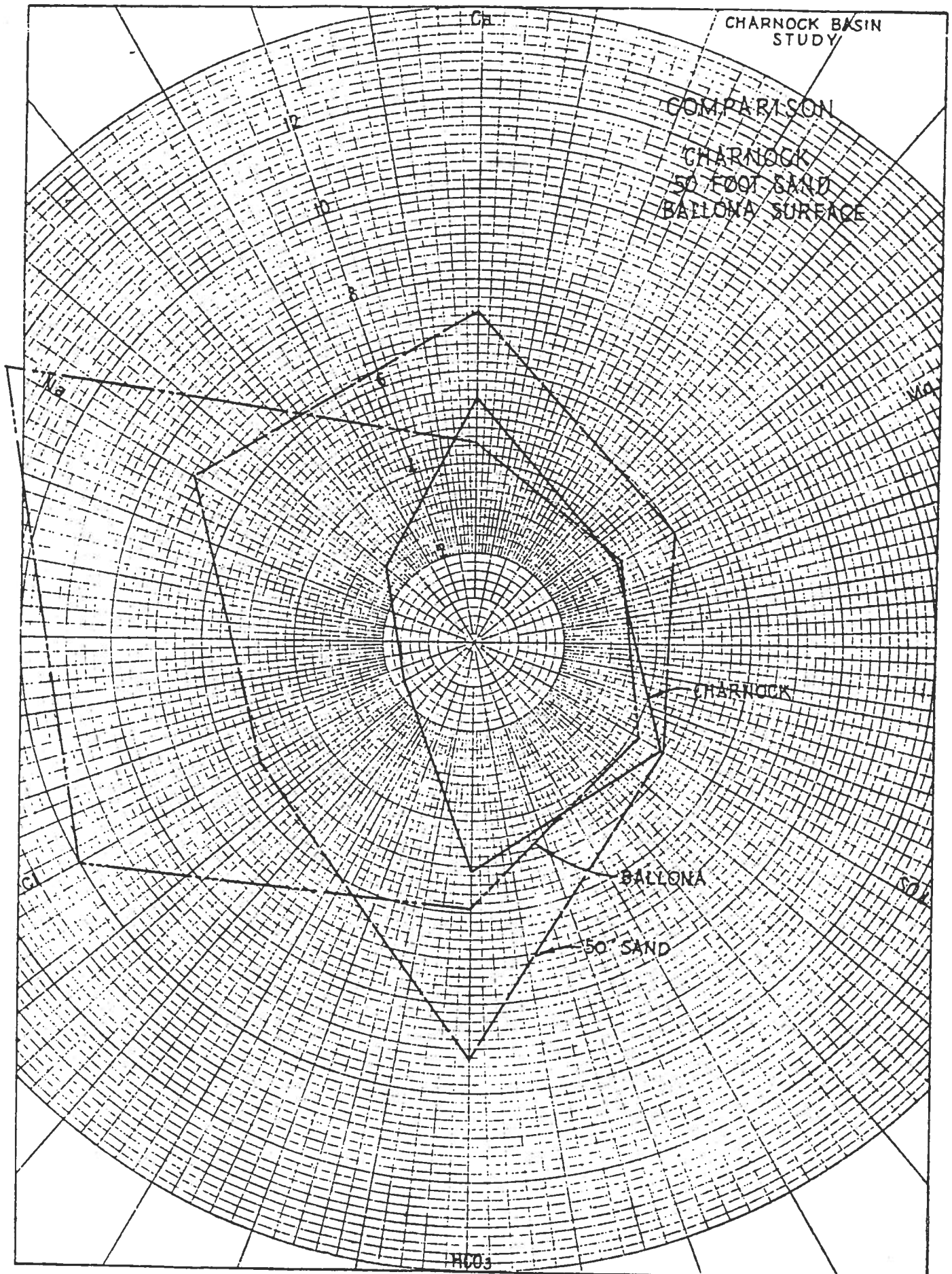
|                     |                  | <u>Charnock</u>              | <u>Ballona</u> | <u>50' Sand</u> |
|---------------------|------------------|------------------------------|----------------|-----------------|
|                     |                  | <u>Milligram Equivalents</u> |                |                 |
| Sodium              | Na               | 2.55                         | 11.83          | 7.17            |
| Calcium             | Ca               | 5.45                         | 4.45           | 7.29            |
| Magnesium           | Mg               | 3.60                         | 3.75           | 5.03            |
| Bicarbonate         | HCO <sub>3</sub> | 5.10                         | 5.90           | 9.24            |
| Sulphate            | SO <sub>4</sub>  | 4.76                         | 4.19           | 4.80            |
| Chloride            | Cl               | 1.74                         | 10.00          | 5.45            |
| Total Concentration |                  | 23.20                        | 40.12          | 38.98           |
|                     |                  | <u>In parts per million</u>  |                |                 |
| Hardness            | Carbonate        | 255                          | 295            | 462             |
|                     | Non Carbonate    | 197                          | 115            | 154             |
|                     | Total            | 452                          | 410            | 616             |

1 - Averages from Table B-1

2 - L. A. County Flood Control

3 - Average of three waters

Note: Values are for plotting Plate B-2



### CHAPTER 3

#### COMPARISON OF WATERS FROM CHARNOCK - EASTERLY OF OVERLAND - WESTERLY OF CHARNOCK

Table B-3 (page B-10), Plate B-3, (page B-11), shows the comparison of the Charnock water, the M.G.M. water which is upstream of the Overland Fault and the Pacific water which is downstream from the Charnock Fault. There is some similarity in the shape of the polar diagram, but there is a difference in concentration of dissolved minerals between the M.G.M. water and the Charnock water, and this is illustrated further in Table B-3 when the hardness of the two waters is analyzed. Comparison of Pacific and Charnock waters shows less variation than the comparison of Charnock and M.G.M. Nevertheless, the concentration of salts is somewhat greater in the Pacific water than in the Charnock water, but the largest difference is in the concentration of the carbonates and chlorides. It is therefore concluded that there is little, if any, interchange of water between the Charnock water and the waters either easterly of the Overland Fault or westerly of the Charnock Fault.

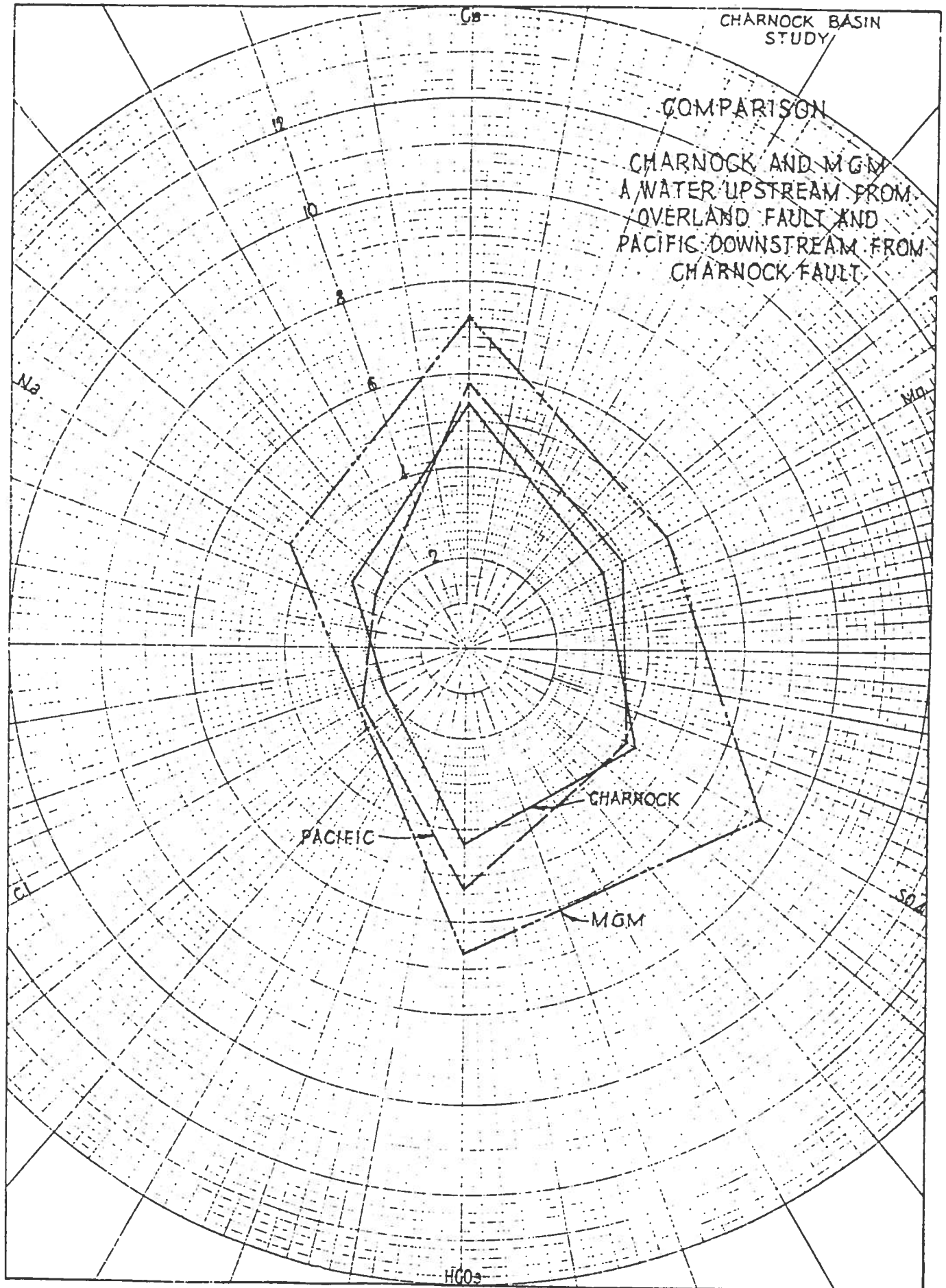
CHARNOCK BASIN WATER QUALITY STUDY

Comparison of Charnock and MGM Upstream from Overland Fault  
and Pacific Downstream from the Charnock Fault

|                     |                  | <u>Charnock (1)</u><br>#8    | <u>MGM (2)</u> | <u>Pacific (3)</u> |
|---------------------|------------------|------------------------------|----------------|--------------------|
|                     |                  | <u>Milligram Equivalents</u> |                |                    |
| Sodium              | Na               | 2.87                         | 4.49           | 2.32               |
| Calcium             | Ca               | 5.39                         | 7.21           | 5.80               |
| Magnesium           | Mg               | 3.45                         | 5.03           | 3.95               |
| Bicarbonate         | HCO <sub>3</sub> | 4.34                         | 6.72           | 5.30               |
| Sulphate            | SO <sub>4</sub>  | 4.31                         | 7.34           | 4.17               |
| Chloride            | Cl               | 2.03                         | 2.67           | 2.60               |
| Total Concentration |                  | 22.39                        | 33.46          | 24.14              |
|                     |                  | <u>In parts per million</u>  |                |                    |
| Hardness            | Carbonate        | 217                          | 336            | 265                |
|                     | Non Carbonate    | 225                          | 276            | 222                |
|                     | Total            | 442                          | 612            | 487                |

- 1 - Charnock #8 water taken 12-5-63
- 2 - Water upstream from Charnock MGM 4-17-64 easterly of the Overland Fault
- 3 - Water downstream from Charnock Pacific Plant westerly of the Charnock Fault

Note: Values are for plotting Plate B-3



CHAPTER 4  
COMPARISON OF WATERS FROM CHARNOCK AND FROM ARCADIA

Table B-4 (page B-13) and Plate B-4 (page B-14) shows the comparison of water from Charnock Plant of Southern California Water Company and the Arcadia Plant of the City of Santa Monica. While the diagrams are somewhat similar, there is a difference in the concentration of calcium and magnesium. This results in considerable difference in the non-carbonate and total hardness of the two waters. The Arcadia water is believed to be derived primarily from the Santa Monica Mountains without the influence of long travel underground through the finer clayey material of the Charnock Basin. On the other hand, Charnock water shows influence of absorbing into solution minerals from within the alluvial fill of the groundwater basin. The difference in concentration of calcium and magnesium and indicates this. It is therefore believed that Arcadia Plant waters are not interconnected with Charnock Basin waters.

Table B-4

CHARNOCK BASIN WATER QUALITY STUDY

Comparison of Charnock Water and Water From  
Santa Monica's Arcadia Plant

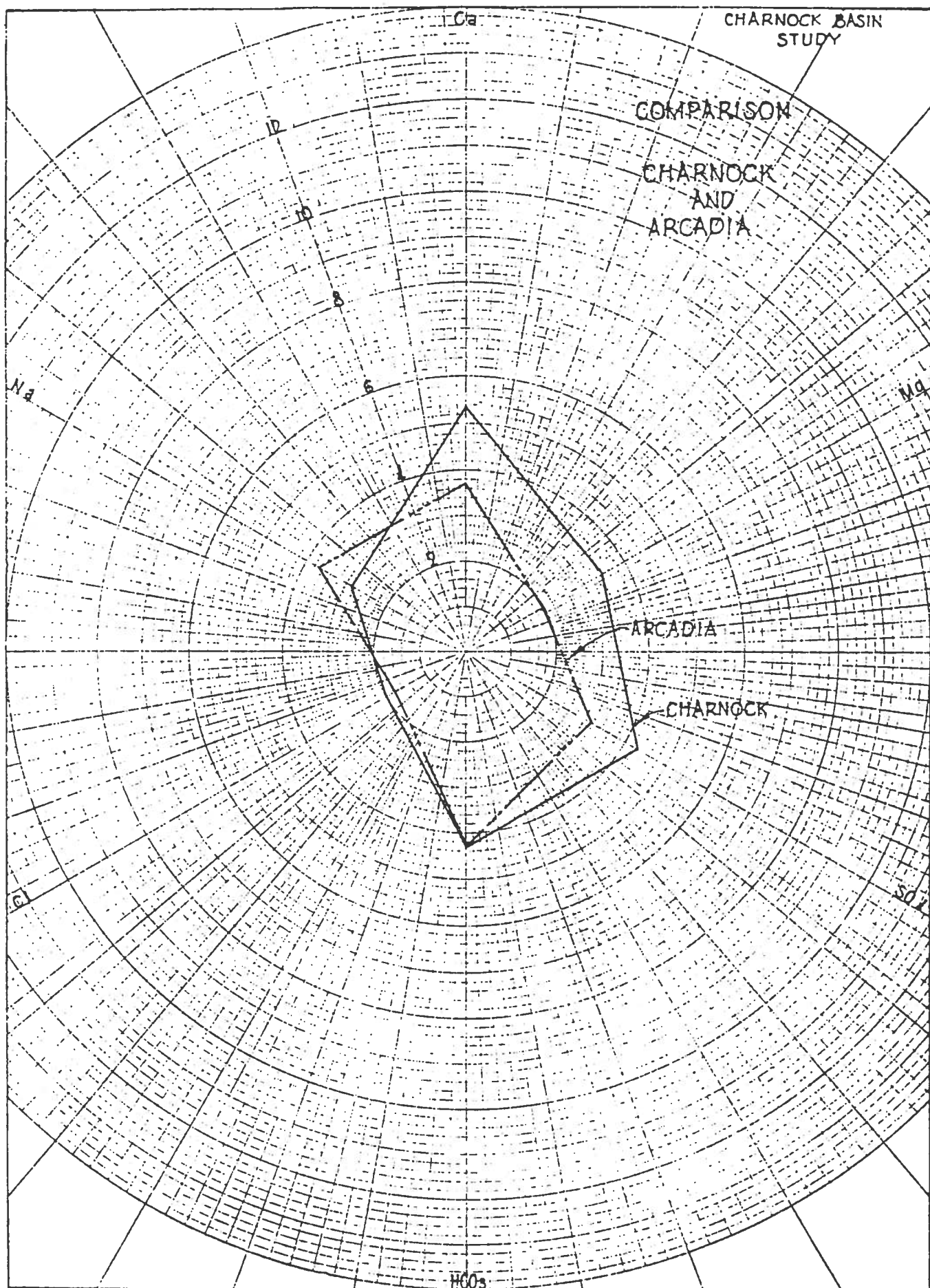
|                     |                  | <u>Charnock</u>              | <u>Arcadia</u> |
|---------------------|------------------|------------------------------|----------------|
|                     |                  | <u>Milligram Equivalents</u> |                |
| Sodium              | Na               | 2.87                         | 3.70           |
| Calcium             | Ca               | 5.39                         | 3.69           |
| Magnesium           | Mg               | 3.45                         | 1.97           |
| Bicarbonate         | HCO <sub>3</sub> | 4.34                         | 4.28           |
| Sulphate            | SO <sub>4</sub>  | 4.31                         | 3.18           |
| Chloride            | Cl               | 2.03                         | 1.78           |
| Total Concentration |                  | 22.39                        | 18.60          |

|          |               | <u>In parts per million</u> |     |
|----------|---------------|-----------------------------|-----|
| Hardness | Carbonate     | 217                         | 214 |
|          | Non Carbonate | 225                         | 69  |
|          | Total         | 442                         | 284 |

1 - Charnock #8 analyses of 12-5-63

2 - Arcadia #3 analyses of 11-7-63

Note: Values are for plotting Plate B-4



CHAPTER 5  
COMPARISON OF SEVERAL WATERS WITHIN CHARNOCK BASIN

Table B-5 (page B-16), Plate B-5 (page B-17), is the analysis of several waters within the Charnock Basin. All of these waters are similar in general pattern. The Sepulveda water with the high chlorides and resulting calculated sodium seems to be influenced by possible infiltration of water from the fifty-foot sand. This, however, is the only water found in the area that is so similarly affected.

It is therefore believed that all the waters within the Charnock Basin within the limits defined between the Overland and Charnock Faults are waters of similar character.

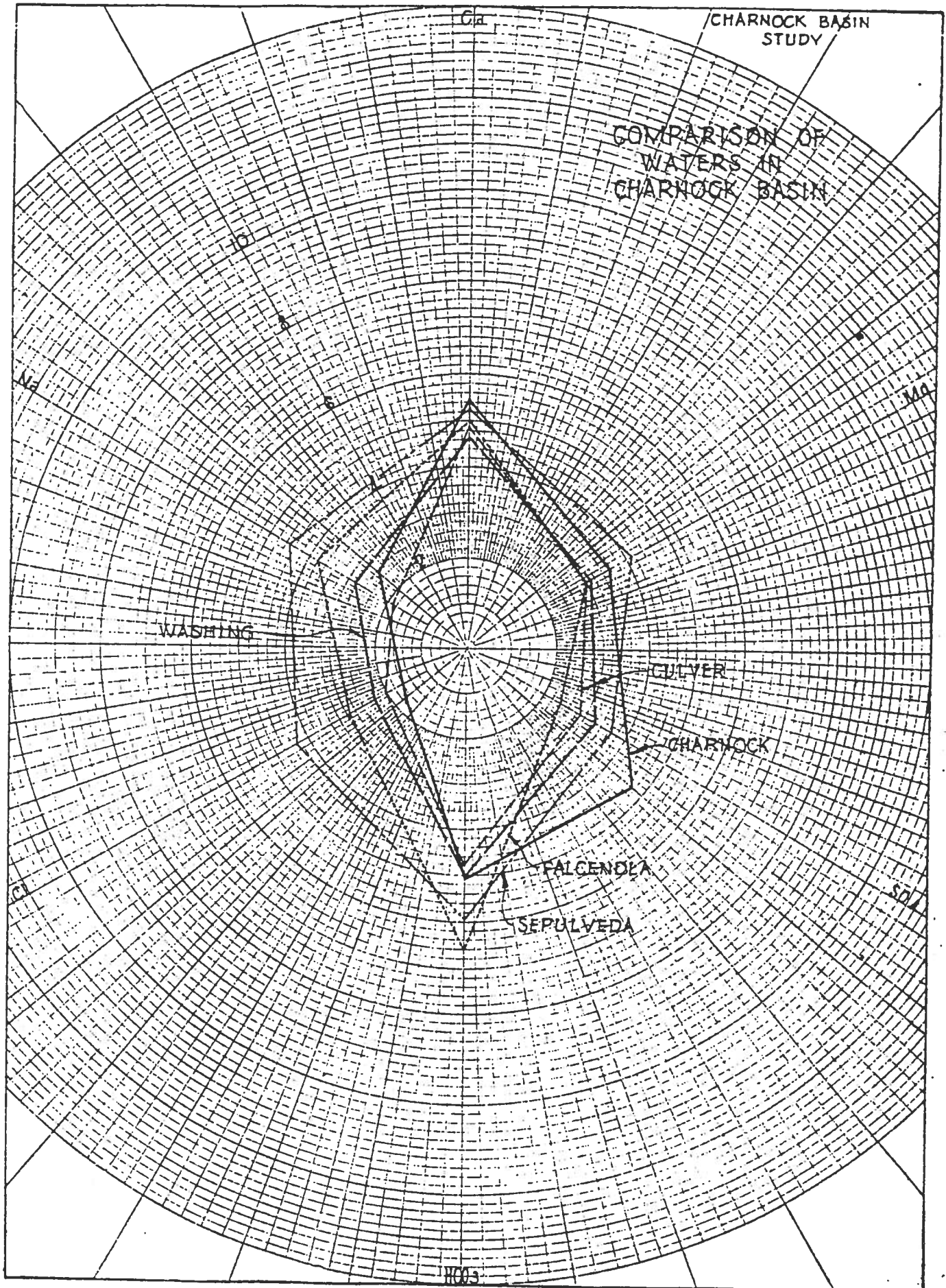
Table B-5

CHARNOCK BASIN WATER QUALITY STUDY

## Comparison of Waters in Charnock Basin

|                     |                  | (1)                          | (2)                    | (3)        | (4)    | (5)        |
|---------------------|------------------|------------------------------|------------------------|------------|--------|------------|
|                     |                  | Charnock<br>Ave. of          | Sepulveda<br>Ave. of 8 | Washington | Culver | Falcinella |
|                     |                  | <u>Milligram Equivalents</u> |                        |            |        |            |
| Sodium              | Na               | 2.55                         | 4.51                   | 2.82       | 1.89   | 3.80       |
| Calcium             | Ca               | 5.45                         | 5.27                   | 4.64       | 4.86   | 5.08       |
| Magnesium           | Mg               | 3.60                         | 4.12                   | 3.12       | 3.01   | 3.05       |
| Bicarbonate         | HCO <sub>3</sub> | 5.10                         | 5.96                   | 5.05       | 4.80   | 6.60       |
| Sulphate            | SO <sub>4</sub>  | 4.76                         | 3.65                   | 3.24       | 2.87   | 2.40       |
| Chloride            | Cl               | 1.74                         | 4.29                   | 2.29       | 2.09   | 2.93       |
| Total Concentration |                  | 23.20                        | 27.80                  | 21.16      | 19.52  | 23.86      |
|                     |                  | <u>In parts per million</u>  |                        |            |        |            |
| Hardness            | Carbonate        | 255                          | 298                    | 252        | 240    | 330        |
|                     | Non Carbonate    | 198                          | 172                    | 136        | 154    | 77         |
|                     | Total            | 453                          | 470                    | 388        | 394    | 407        |

Note: Values are for plotting Plate B-5



### CONCLUSIONS

Tables B-2, B-3 and B-4 and Plates B-2, B-3 and B-4, when taken together, indicate that the water in the Charnock Basin is different from water east of the Overland Fault, west of the Charnock Fault and from the Arcadia Plant near the foothills. Analysis further shows (Plate B-2) that there is little or no interconnection between the so-called fifty-foot sand and the waters in the Charnock Basin. There is also the indication that water in the fifty-foot sand is unrelated to the waters east of the Overland Fault and waters west of the Charnock Fault.

It is therefore concluded on the basis of chemical character that the boundary of the groundwater basin as shown on Plate A (page 11) can be accepted. It may be further concluded that there is no interchange of water between the Charnock Basin and those groundwater basins to the east, west or south.